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# ULTRIX 15.

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### Class 12th Physics

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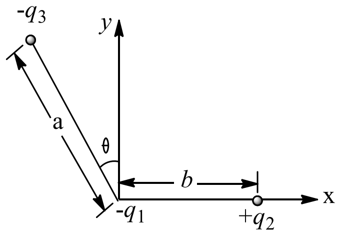
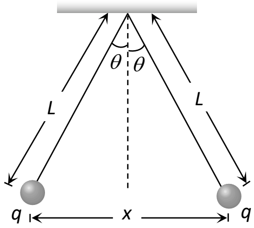
# Electric Charges and Fields

1. A polythene piece, rubbed with wool, is found to have negative charge of $4 \times 10^{-7}$C. the number of electrons transferred from wool to polythene is
 a) $1.5 \times 10^{12}$ b) $2.5 \times 10^{12}$ c) $2.5 \times 10^{13}$ d) $3.5 \times 10^{13}$
2. The intensity of electric field at a point between the plates of a charged capacitor
 a) Is directly proportional to the distance between the plates
 b) Is inversely proportional to the distance between the plates
 c) Is inversely proportional to the square of the distance between the plates
 d) Does not depend upon the distance between the plates
3. Three charges $-q_1, +q_2$ and $-q_3$ are placed as shown in figure. The $x$ component of the force on $-q_1$ is proportional to




 a) $\frac{q_2}{b^2} - \frac{q_3}{b^2} \sin \theta$ b) $\frac{q_2}{b^2} - \frac{q_3}{b^2} \cos \theta$ c) $\frac{q_2}{b^2} + \frac{q_3}{b^2} \sin \theta$ d) $\frac{q_2}{b^2} + \frac{q_3}{b^2} \cos \theta$
4. According to Gauss' Theorem, electric field of an infinitely long straight wire is proportional to
 a) $r$ b) $1/r^2$ c) $1/r^3$ d) $1/r$
5. Three charges each of $+ 1\mu$C are placed at the corners of an equilateral triangle. If the force between any two charges be $F$, then the net force on either charge will be
 a) $\sqrt{2}\, F$ b) $F\sqrt{3}$ c) 2F d) 3F
6. Two point charge $-q$ and $+q/2$ are situated at the origin and at the point $(a, 0,0)$ respectively. The point along the $X$-axis where the electric field vanishes is
 a) $x = \frac{a}{\sqrt{2}}$ b) $x = \sqrt{2}a$ c) $x = \frac{\sqrt{2}a}{\sqrt{2}-1}$ d) $x = \frac{\sqrt{2}a}{\sqrt{2}+1}$
7. A ring of radius $r$ carries a charge $Q$ uniformly distributed over its length. A charge $q$ is placed at its centre will experience a force equal to
 a) $\frac{qQ}{4\pi\varepsilon_0 r^2}$ b) $\frac{qQ}{8\pi\varepsilon_0 r^3}$ c) Zero d) None of these

8. In the given figure two tiny conducting balls of identical mass $m$ and identical charge $q$ hang from non-conducting threads of equal length $L$. Assume that $\theta$ is so small that $\tan\theta \approx \sin\theta$, then for equilibrium $x$ is equal to

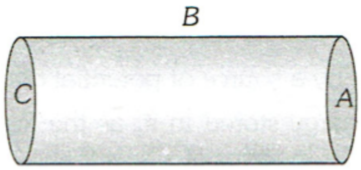



a) $\left(\dfrac{q^2L}{2\pi\varepsilon_0 mg}\right)^{\frac{1}{3}}$ b) $\left(\dfrac{qL^2}{2\pi\varepsilon_0 mg}\right)^{\frac{1}{3}}$ c) $\left(\dfrac{q^2L^2}{4\pi\varepsilon_0 mg}\right)^{\frac{1}{3}}$ d) $\left(\dfrac{q^2L}{4\pi\varepsilon_0 mg}\right)^{\frac{1}{3}}$

9. Charge $q_2$ of mass $m$ revolves around a stationary charge $q_1$ in a circular orbit of radius $r$. The orbital periodic time of $q_2$ would be

a) $\left[\dfrac{4\pi^3 mr^2}{kq_1q_2}\right]^{1/2}$ b) $\left[\dfrac{kq_1q_2}{4\pi^2 mr^2}\right]^{1/2}$ c) $\left[\dfrac{4\pi^2 mr^4}{kq_1q_2}\right]^{1/2}$ d) $\left[\dfrac{4\pi^2 mr^2}{kq_1q_2}\right]^{1/2}$

10. A hollow cylinder has a charge $q$ coulomb within it. If $\phi$ is the electric flux in units of $volt - meter$ associated with the curved surface $B$, the flux linked with the plane surface $A$ in units of $volt - meter$ will be




a) $\dfrac{1}{2}\left(\dfrac{q}{\epsilon_0} - \phi\right)$ b) $\dfrac{q}{2\,\epsilon_0}$ c) $\dfrac{\phi}{3}$ d) $\dfrac{q}{\epsilon_0} - \phi$

11. Two small conducting spheres of equal radius have charges $+10\ \mu C$ and $-20\mu C$ respectively and placed at a distance $R$ from each other experience force $F_1$. If they are brought in contact and separated to the same distance, they experience force $F_2$. The ratio of $F_1$ to $F_2$ is

a) 1 : 8 b) $-8:1$ c) 1 : 2 d) $-2:1$

12. The electric field at a distance $\frac{3R}{2}$ from the centre of a charged conducting spherical shell of radius $R$ is $E$. The electric field at a distance $\frac{R}{2}$ from the centre of the sphere is

a) Zero b) $E$ c) $\dfrac{E}{2}$ d) $\dfrac{E}{3}$

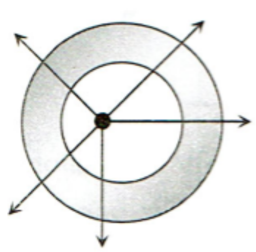
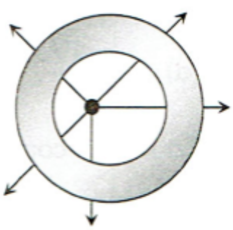
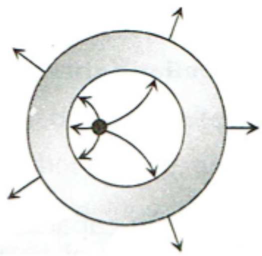
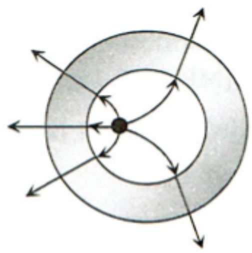
13. The unit of intensity of electric field is

a) $Newton/Coulomb$ b) $Joule/Coulomb$ c) $Volt - metre$ d) $Newton/metre$

14. An electric dipole is kept in non-uniform electric field. It experiences

a) A force and a torque b) A force but not a torque
c) A torque but not a torque d) Neither a force nor a torque

15. A metallic shell has a point charge $'q'$ kept inside its cavity. Which one of the following diagrams correctly represents the electric lines of forces

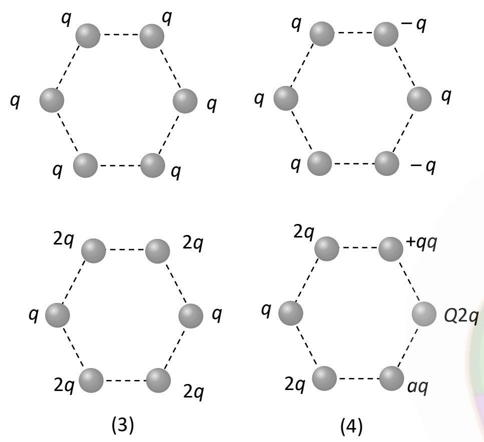
a)  b)  c)  d) 

16. An electron enters in an electric field with its velocity in the direction of the electric lines of force. Then
a) The path of the electron will be a circle
b) The path of the electron will be a parabola
c) The velocity of the electron will decrease
d) The velocity of the electron will increase

17. Two equal charges are separated by a distance $d$. A third charge placed on a perpendicular bisector at $x$ distance will experience maximum coulomb force when
a) $x = \frac{d}{\sqrt{2}}$
b) $x = \frac{d}{2}$
c) $x = \frac{d}{2\sqrt{2}}$
d) $x = \frac{d}{2\sqrt{3}}$

18. A simple pendulum of period $T$ has a metal bob which is negatively charged. If it is allowed to oscillate above a positively charged metal plate, its period will
a) Remains equal to $T$
b) Less than $T$
c) Greater than $T$
d) Infinite

19. Figures below show regular hexagons, which charges at the vertices. In which of the following cases the electric field at the centre is not zero



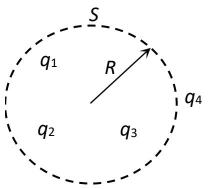

a) 1
b) 2
c) 3
d) 4

20. A total charge $Q$ is broken in two parts $Q_1$ and $Q_2$ and they are placed at a distance $R$ from each other. The maximum force of repulsion between them will occur, when
a) $Q_2 = \frac{Q}{R}, Q_1 = Q - \frac{Q}{R}$
b) $Q_2 = \frac{Q}{4}, Q_1 = Q - \frac{2Q}{3}$
c) $Q_2 = \frac{Q}{4}, Q_1 = \frac{3Q}{4}$
d) $Q_1 = \frac{Q}{2}, Q_2 = \frac{Q}{2}$

21. A charge $q$ is placed at the corner of a cube of side$a$. The electric flux through the cube is
a) $\frac{q}{\varepsilon_0}$
b) $\frac{q}{3\varepsilon_0}$
c) $\frac{q}{6\varepsilon_0}$
d) $\frac{q}{8\varepsilon_0}$

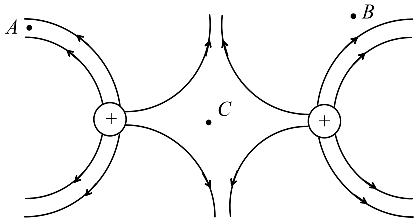
22. If $E_a$ be the electric field strength of a short dipole at a point on its axial line and $E_e$ that on equatorial line at the same distance, then
a) $E_e = 2E_a$
b) $E_a = 2E_e$
c) $E_a = E_e$
d) None of these

23. $q_1, q_2, q_3$ and $q_4$ are point charges located at points as shown in the figure and $S$ is a spherical Gaussian surface of radius $R$. Which of the following is true according to the Gauss's law




a) $\oint_s (\vec{E}_1 + \vec{E}_2 + \vec{E}_3).d\vec{A} = \frac{q_1 + q_2 + q_3}{2\varepsilon_0}$
b) $\oint_s (\vec{E}_1 + \vec{E}_2 + \vec{E}_3).d\vec{A} = \frac{(q_1 + q_2 + q_3)}{\varepsilon_0}$
c) $\oint_s (\vec{E}_1 + \vec{E}_2 + \vec{E}_3).d\vec{A} = \frac{(q_1 + q_2 + q_3 + q_4)}{\varepsilon_0}$
d) None of the above

24. The figure below shows the electric field lines due to two positive charges. The magnitudes $E_A, E_B$ and $E_C$ of the electric fields at points $A, B$ and $C$ respectively are related as




a) $E_A > E_B > E_C$ b) $E_B > E_A > E_C$ c) $E_A = E_B > E_C$ d) $E_A > E_B = E_C$

25. An electron of mass $m_e$ initially at rest moves through a certain distance in a uniform electric field in time $t_1$. A proton of mass $m_p$ also initially at rest takes time $t_2$ to move through and equal distance in this uniform electric field. Neglecting the effect of gravity, the ratio of $t_2/t_1$ is nearly equal to

a) 1 b) $(m_p/m_e)^{1/2}$ c) $(m_e/m_p)^{1/2}$ d) 1836

26. Two charged spheres separated at a distance $d$ exert a force $F$ on each other. If they are immersed in a liquid of dielectric constant 2, then what is the force (If all conditions are same)

a) $\frac{F}{2}$ b) $F$ c) $2F$ d) $4F$

27. Infinite charges of magnitude $q$ each are lying at $x = 1,2,4,8 \dots meter$ on X-axis. The value of intensity of electric field at point $x = 0$ due to these charges will be

a) $12 \times 10^9 q\ N/C$ b) Zero c) $6 \times 10^9 q\ N/C$ d) $4 \times 10^9 q\ N/C$

28. A spherical shell of radius $R$ has a charge$+q$ units. The electric field due to the shell at a point

a) Inside is zero and varies as $r^{-1}$ outside it b) Inside the constant and varies as $r^{-2}$ outside it
c) Inside is zero and varies as $r^{-2}$ outside it d) Inside is constant and varies as $r^{-1}$ outside it

29. Two identical charged spheres suspended from a common point by two massless strings of length $l$ are initially a distance $d(d << l)$ apart because of their mutual repulsion. The charge begins to leak from both the spheres at a constant rate. As a result charges approach each other with a velocity $v$ .Then as a function of distance $x$ between them

a) $v \propto x^{-1}$ b) $v \propto x^{1/2}$ c) $v \propto x$ d) $v \propto x^{-1/2}$

30. One of the following is not a property of field lines

a) Field lines are continuous curves without any breaks
b) Two field lines cannot cross each other
c) Field lines start at positive charge and end at negative charges
d) They form closed loop

31. Gauss's law of electrostatics would be invalid if

a) There were magnetic monopoles b) The speed of light was not a universal constant
c) The inverse square law was not exactly true d) The electrical charge was not quantized

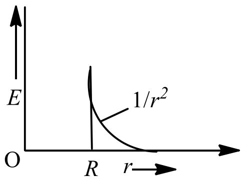
32. A charge $Q$ is placed at each of the opposite corners of a square. A charge $q$ is placed at each of the other two corners. If the net electrical force on $Q$ is zero, then the $\frac{Q}{q}$ eQuals

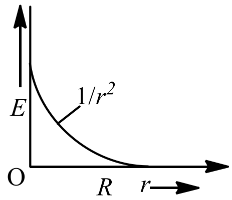
a) $-2\sqrt{2}$ b) $-1$ c) 1 d) $-\frac{1}{\sqrt{2}}$

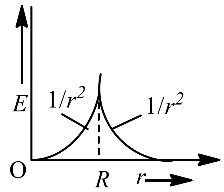
33. When the distance between the charged particles is halved, the force between them becomes

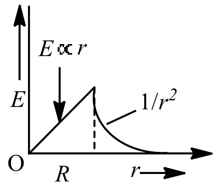
a) One-fourth b) Half c) Double d) Four times

34. Which of the following plots represents the variation of the electric field with distance from the centre of a uniformly charged non-conducting sphere of radius $R$?

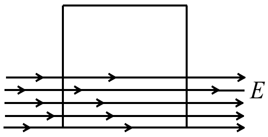
a) 


b) 


c) 


d) 


35. A square surface of side $L$ *meteres* is in the plane of the paper. A uniform electric field $\vec{E}$ $(volt/m)$, also in the plane of the paper, is limited only to the lower half of the square surface, (see figure). The electric flux is SI units associated with the surface is




a) Zero b) $EL^2$ c) $EL^2/(2\varepsilon_0)$ d) $EL^2/2$

36. The magnitude of electric field intensity $E$ is such that, an electron placed in it would experience an electrical force equal to its weight is given by

a) $mge$ b) $\frac{mg}{e}$ c) $\frac{e}{mg}$ d) $\frac{e^2}{m^2}g$

37. A simple pendulum has a length $l$ and the mass of the bob is $m$. The bob is given a charge $q$ coulomb. The pendulum is suspended between the vertical plates of a charged parallel plate capacitor. If $E$ is the electric field strength between the plates, the time period of the pendulum is given by

a) $2\pi\sqrt{\frac{1}{g}}$

b) $2\pi\sqrt{\frac{l}{\sqrt{g+\frac{qE}{m}}}}$

c) $2\pi\sqrt{\frac{l}{\sqrt{g-\frac{qE}{m}}}}$

d) $2\pi\sqrt{\frac{l}{\sqrt{g^2+\left(\frac{qE}{m}\right)^2}}}$

1 **(b)**

$$n=\frac{q}{e}=\frac{4\times10^{-7}}{1.6\times10^{-19}}=2.5\times10^{12}$$

2 **(d)**

Electric field between the plates of parallel plate capacitor is uniform and it doesn't depend upon distance

3 **(c)**

Force on $-q_1$ due to $q_2$ is

$F_2=\frac{kq_1q_2}{b^2}$ along $X$-axis

Force on $-q_1$ due to $-q_2$ is

$F_{13}=\frac{kq_1q_3}{a^2}$ at $\angle\theta$ With negative direction of $Y$-axis.

$\therefore$ $x$ component of force on $-q_1$ is

$F_x=F_{12}+F_{13}\sin\theta=kq_1\left[\frac{q_2}{b^2}+\frac{q_3}{a^2}\sin\theta\right]$

$ie,\ \ F_x\propto\left[\frac{q_2}{b^2}+\frac{q_3}{a^2}\sin\theta\right]$

4 **(d)**

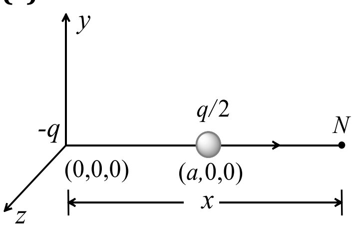
$$e=\frac{\lambda}{2\pi\varepsilon_0 r}\Rightarrow E\propto\frac{1}{r}$$

5 **(b)**

Angle between two forces due to individual charges is equal to $60^0$

$\therefore\ \ R=\sqrt{F^2+F^2+2F\,F\cos 60^0}=\ F\sqrt{3}$

6 **(c)**




Suppose the field vanishes at distance $x$, we have

$\frac{kq}{x^2}=\frac{kq/2}{(x-a)^2}$ or $2(x-a)^2=x^2$ or $\sqrt{2}(x-a)=x$

or $(\sqrt{2}-1)x=\sqrt{2}a$ or $x=\left(\frac{\sqrt{2}a}{\sqrt{2}-1}\right)$

7 **(c)**

The electric field (E) at the centre of circular charged ring of radius $R$ is zero

$\therefore$ Force $=qE=$ Zero

8 **(a)**

9 **(a)**

$$\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}=mr\omega^2=\frac{4\pi^2mr^2}{T^2}$$

$$T^2=\frac{(4\pi\varepsilon_0)r^2(4\pi^2mr)}{q_1q_2}$$

$$T=\left[\frac{4\pi^3mr^2}{kq_1q_2}\right]^{1/2}$$

10 **(a)**

$\phi_{\text{Total}}=\phi_A+\phi_B+\phi_C=\frac{q}{\epsilon_0}$;

$\because\ \phi_B=\phi$ and $\phi_A=\phi_C=\phi'$ [assumed]

$\therefore\ 2\phi'+\phi=\frac{q}{\epsilon_0}\Rightarrow\phi'=\frac{1}{2}\left(\frac{q}{\epsilon_0}-\phi\right)$

11 **(b)**

$$F\propto Q_1Q_2\Rightarrow\frac{F_1}{F_2}=\frac{Q_1Q_2}{Q_1'Q_2'}=\frac{10\times-20}{-5\times-5}=-\frac{8}{1}$$

12 **(a)**

Electric field inside shell is zero

13 **(a)**

14 **(a)**

As the dipole will feel two forces which are although opposite but not equal.

$\therefore$ A net force will be there and as these forces act at different points of a body. A torque is also present

15 **(c)**

Electric field is perpendicular to the equipotential surface and is zero every where inside the metal

16 **(c)**

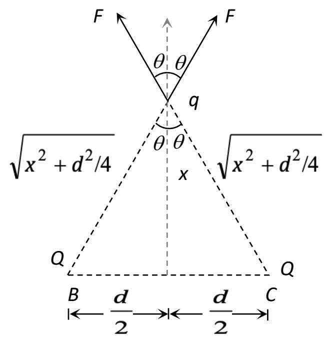
Because electric field applies the force on electron in the direction opposite to it's motion

17 **(c)**

Suppose third charge is similar to $Q$ and it is $q$

So net force on it

$F_{net}=2F\cos\theta$




Where $F=\frac{1}{4\pi\varepsilon_0}\cdot\frac{Qq}{\left(x^2+\frac{d^2}{4}\right)}$ and $\cos\theta=\frac{x}{\sqrt{x^2+\frac{d^2}{4}}}$

$$\therefore F_{net}=2\times\frac{1}{4\pi\varepsilon_0}\cdot\frac{Qq}{\left(x^2+\frac{d^2}{4}\right)}\times\frac{x}{\left(x^2+\frac{d^2}{4}\right)^{1/2}}$$

$$=\frac{2Qqx}{4\pi\varepsilon_0\left(x^2+\frac{d^2}{4}\right)^{3/2}}$$

For $F_{net}$ to be maximum $\frac{dF_{net}}{dx} = 0$

$$i.e. \frac{d}{dx}\left[\frac{2Qqx}{4\pi\varepsilon_0\left(x^2+\frac{d^2}{4}\right)^{3/2}}\right] = 0$$

$$\text{or} \left[\left(x^2+\frac{d^2}{4}\right)^{-3/2} - 3x^2\left(x^2+\frac{d^2}{4}\right)^{-5/2}\right] = 0$$

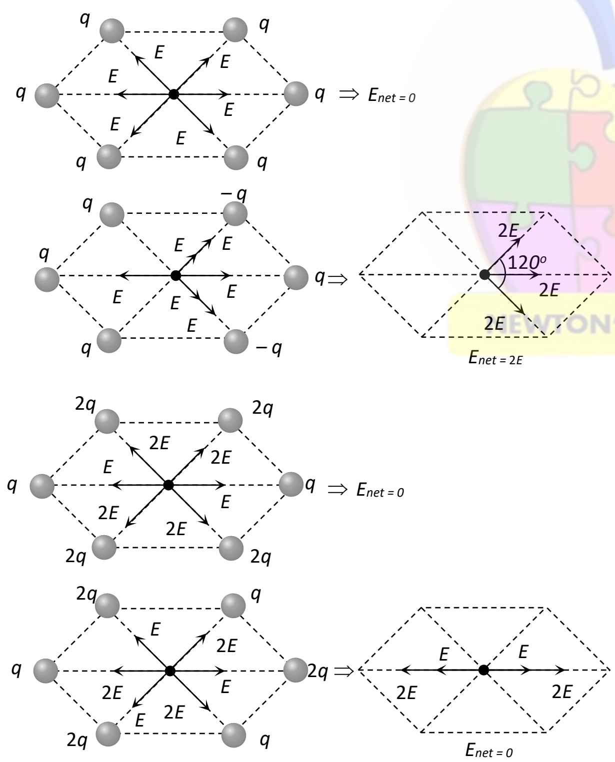
$$i.e.\ x = \pm\frac{d}{2\sqrt{2}}$$

18 **(b)**

When a negatively charged pendulum oscillates over a positively charged plate then effective value of $g$ increases so according to $T = 2\pi\sqrt{\frac{l}{g}}$, $T$ decreases

19 **(b)**

Electric field at a point due to positive charge acts away from the charge and due to negative charge it act's towards the charge




20 **(d)**

$Q_1 + Q_2 = Q$ ...(i) and $F = k\frac{Q_1Q_2}{r^2}$ ...(ii)

From (i) and (ii) $F = \frac{kQ_1(Q-Q_1)}{r^2}$

For $F$ to be maximum $\frac{dF}{dQ_1} = 0 \Rightarrow Q_1 = Q_2 = \frac{Q}{2}$

21 **(d)**

If charge $q$ is placed at a corner of cube, it will be divided into 8 such cubes. Therefore, electric flux through the cube is

$$\phi' = \frac{1}{8}\left(\frac{q}{\varepsilon_0}\right)$$

22 **(b)**

$$E_e = \frac{1}{2}E_a \quad \therefore E_a = 2E_e$$

23 **(b)**

By using $\int \vec{E}.\overrightarrow{dA} = \frac{1}{\varepsilon_0}[Q_{enc}]$

24 **(a)**

25 **(b)**

For electron $s = \frac{eE}{m_e}\times t_1^2$, For proton $s = \frac{eE}{m_p}\times t_2^2$

$$\therefore \frac{t_2^2}{t_1^2} = \frac{m_p}{m_e} \Rightarrow \frac{t_2}{t_1} = \sqrt{\frac{m_p}{m_e}} = \left(\frac{m_p}{m_e}\right)^{1/2}$$

26 **(a)**

$$F \propto \frac{1}{K}\ i.e. \frac{F_{\text{air}}}{F_{\text{medium}}} = K$$

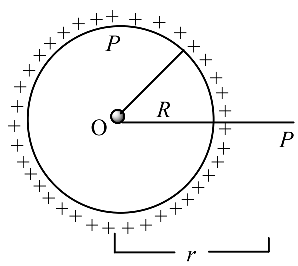
27 **(a)**

Net field at origin $E = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{1^2}+\frac{1}{2^2}+\frac{1}{4^2}+\ \dots.\infty\right]$

$$= \frac{q}{4\pi\varepsilon_0}\left[1+\frac{1}{4}+\frac{1}{16}+\ \dots.\infty\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{1-\frac{1}{4}}\right] = 12\times10^9 q\ N/C$$

28 **(c)**




The electric field due to the spherical shell at point $+P$.

$$E = \frac{1}{4\pi\varepsilon_0}.\frac{q}{r^2} \qquad (\because r > R)$$

$$\text{or}\quad E \propto \frac{1}{r^2}$$

$$\text{or}\quad E \propto r^{-2}$$

According to Gauss's law inside the shell electric field is zero.

ie, $\oint \boldsymbol{E}.\boldsymbol{ds} = 0$

or $E = 0$

the electric field due to the shell at a point inside is zero and varies as $r^{-2}$outside it.

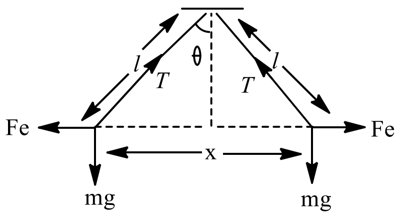
29 **(d)**

At an instants

$T \cos\theta = mg$ ..(i)

$T \sin\theta = F_e$ ...(ii)

$= \frac{ka^2}{x^2}$




From Eqs. (i) and (ii), we have

$\frac{ka^2}{x^2}$=$mg \tan\theta$

$\Rightarrow q^2 = \frac{mg}{k}\frac{x}{2l}x^2 \quad \left(\tan\theta \approx \frac{a}{2l}\right)$

$\Rightarrow q^2 = \frac{mg}{2kl}x^3$ ... (iii)

$\Rightarrow 2q\frac{dq}{dt} = \frac{3mg}{2kl}x^2\frac{dx}{dt}$

$\Rightarrow 2\left(\frac{mg}{2kl}x^3\right)^{\frac{1}{2}}\frac{dq}{dt} = \frac{3mg}{2kl}x^2 v$

$\left[\because q = \left(\frac{mg}{2kl}x^3\right)^{\frac{1}{2}}\right]$

$\Rightarrow \quad vx^{1/2}$=constant

$\Rightarrow v \propto x^{-1/2}$

30 **(d)**

Electric field lines do not form closed loop. This follows from the conservative nature of electric field

31 **(c)**

Gauss's law is based on the inverse square dependence on distance contained in the Coulomb's law. Any violation of Gauss's law will indicate departure from the inverse square law

32 **(a)**

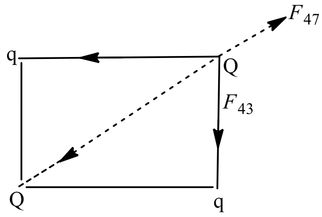
Three forces $F_{41}, F_{42}$ and $F_{43}$ acting on $Q$ as shown resultant of $F_{41} + F_{43}$

$= \sqrt{2}F_{\text{each}} = \sqrt{2}\frac{1}{4\pi\varepsilon_0}\frac{Qq}{d^2}$

Resultant on $Q$ becomes zero only when $q$ charges are of negative nature.

$F_{42} = \frac{1}{4\pi\varepsilon_0}\frac{Q \times Q}{(\sqrt{2d})^2}$

$\Rightarrow \sqrt{2}\frac{dQ}{d^2} = \frac{Q\times Q}{2d^2}$




$\sqrt{2} \times \text{q} = \frac{Q \times Q}{2}$

$\therefore q = \frac{Q}{2\sqrt{2}}$

or $\frac{Q}{q} = -2\sqrt{2}$

33 **(d)**

$F \propto \frac{1}{r^2}$; so when $r$ is halved the force becomes four times

34 **(d)**

The electric field intensity at a point lying outside the sphere (non-conducting) is

$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$

Where $r$ is the distance of that point from centre of sphere.

$E \propto \frac{1}{r^2}$ ....$(i)$

The electric field intensity at surface of sphere

$E = \frac{q}{4\pi\varepsilon_0 R^2}$

Or

$E \propto \frac{1}{R^2}$ ....(ii)

R, being the radius of sphere.

The electric field intensity at a point lying inside the sphere is

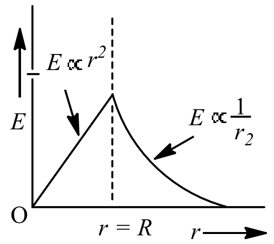
$$E = \frac{qr}{4\pi\varepsilon_0 R^3}$$

Or $E \propto r$ ……. (iii)

Also at the centre of sphere r=0.

Hence,

The graphical distribution is shown below




35 **(a)**

Electric flux, $\phi_E = \int \vec{E}.\overrightarrow{dS}$

$$= \int EdS\cos\theta = \int EdS\cos 90° = 0$$

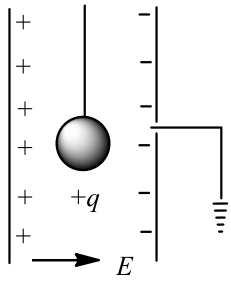
The lines are parallel to the surface

36 **(b)**

According to the question, $eE = mg \Rightarrow E = \frac{mg}{e}$

37 **(d)**

Time period of simple pendulum in air




$$T = 2\pi\sqrt{\frac{l}{g}}$$

When it is suspended between vertical plates of a charged parallel plate capacitor, then acceleration due to electric field,

$$a = \frac{qE}{m}$$

This acceleration is acting horizontally and acceleration due to gravity is acting vertically. So effective acceleration.

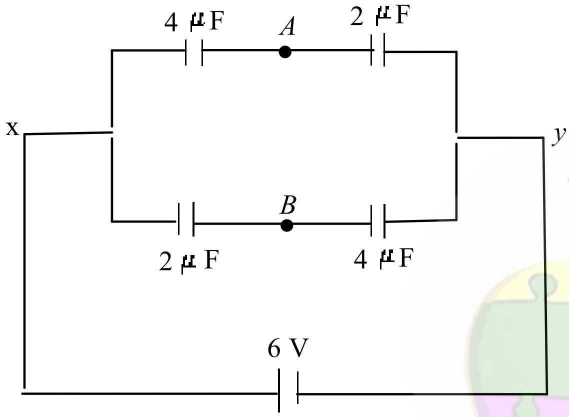
$$g' = \sqrt{g^2 + a^2} = \sqrt{g^2 + \left(\frac{qE}{m}\right)^2}$$

Hence,

$$T' = 2\pi\sqrt{\frac{1}{\sqrt{g^2 + \left(\frac{qE}{m}\right)^2}}}$$


# Electric Potential and Capacitance

1. What is the potential difference between points $A$ and $B$ in the circuit shown?

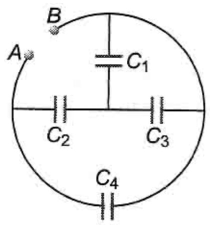



a) 2 V b) 4 V c) 3 V d) 12 V

2 A square of side $a$ has charge $Q$ at its centre and charge $q$ at one of the corners. The work required to be done in moving the charge $q$ from the corner to the diagonally opposite corner is

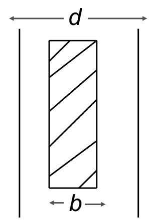
a) Zero b) $\frac{Qq}{4\pi\varepsilon_0 a}$ c) $\frac{Qq\sqrt{2}}{4\pi\varepsilon_0 a}$ d) $\frac{Qq}{2\pi\varepsilon_0 a}$

3. In the arrangement of capacitors shown in figure, each capacitor is of 9 μF, Then the equivalent capacitance between in points $A$ and $B$ is




a) 9 μF b) 18 μF c) 4.5 μF d) 15 μF

4. A slab of copper of thickness $b$ is inserted in between the plates of parallel plate capacitor as shown in figure. The separation between the plates is $d$ if $b = d/2$, then the ratio of capacities of capacitors after and before inserting the slab will be




a) $\sqrt{2}:1$ b) $2:1$ c) $1:1$ d) $1:\sqrt{2}$

5. In bringing an electron towards another electron, the electrostatic potential energy of the system

a) Decreases b) Increases c) Remains same d) Becomes zero

6. $C, V, U$ and $Q$ are capacitance, potential difference, energy stored and charge of a parallel plate capacitor respectively. The quantities that increase when a dielectric slab is introduced between the plates without disconnecting the battery are

a) $V$ and $C$ b) $V$ and $U$ c) $U$ and $Q$ d) $V$ and $Q$

7. Identify the wrong statement.

a) The electrical potential energy of a system of two protons shall increase if the separation between the two is decreased.

b) The electrical potential energy of a proton-electron system will increase if the separation between the two is decreased.

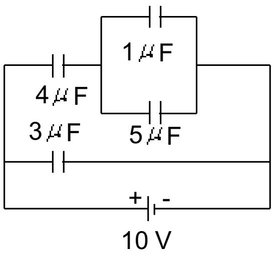
c) The electrical potential energy of a proton-electron system will increase if the separation between the two is increased.

d) The electrical potential energy of system of two electrons shall increase if the separation between the two is decreased.

8. A capacitor is charged to store an energy $U$. the charging battery is disconnected. An identical capacitor is now connected to the first capacitor in parallel. The energy in each of the capacitor is

a) $3\,U/2$ b) $U$ c) $U/4$ d) $U/2$

9. For the circuit shown in figure the charge on 4 μF capacitor is




a) 40 μC b) 30 μC c) 24 μC d) 54 μC

10. Two thin wire rings each having a radius $R$ are placed at a distance $d$ apart with their axes coinciding. The charges on the two rings are +q and −q. The potential difference between the centres of two rings is

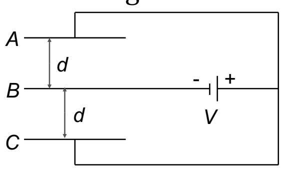
a) $\dfrac{qR}{4\pi\varepsilon_0 d^2}$

b) $\dfrac{q}{2\pi\varepsilon_0}\left[\dfrac{1}{R}-\dfrac{1}{\sqrt{R^2+d^2}}\right]$

c) Zero

d) $\dfrac{q}{4\pi\varepsilon_0}\left[\dfrac{1}{R}-\dfrac{1}{\sqrt{R^2+d^2}}\right]$

11. Consider the arrangement of three metal plates *A, B,* and *C* of equal surface area and separation d as shown in figure. The energy stored in the arrangement, when the plates are fully charged, is

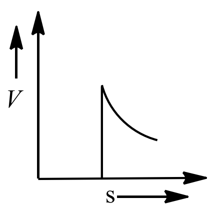


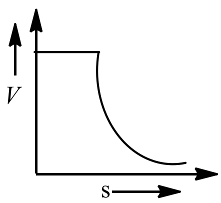

a) $\dfrac{\varepsilon_0 AV^2}{2d}$ b) $\dfrac{\varepsilon_0 AV^2}{d}$ c) $\dfrac{2\varepsilon_0 AV^2}{d}$ d) $\dfrac{3\varepsilon_0 AV^2}{2d}$

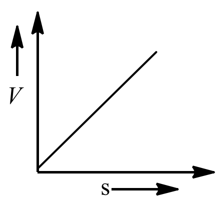
12. A dielectric of dielectric constant $K$ is introduced such that half of its area of a capacitor of capacitance $C$ is occupied by it. The new capacity is

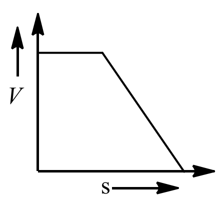
a) $2C$ b) $\dfrac{C}{2}$ c) $\dfrac{(1+K)C}{2}$ d) $2C(1+K)$

13. In the case of a charged metallic sphere, potential ( *V*) changes with respect to distance(*S*) from the I as

a) 


b) 


c) 


d) 

14. Two spheres of radii $R_1$ and $R_2$ joined by a fine wire are raised to a potential $V$. Let the surface charge densities at these two spheres be $\sigma_1$ and $\sigma_2$ respectively. Then the ratio $\frac{\sigma_2}{\sigma_1}$ has a value

a) $\frac{R_1}{R_2}$ b) $\frac{R_2}{R_1}$ c) 1 d) $\left(\frac{R_2}{R_1}\right)^2$

15. Charges $2q, -q$ and $-q$ lie at the vertices of a triangle. The value of $E$ and $V$ at the centroid of equilateral triangle will be

a) $\mathrm{E} \neq 0$ and $\mathrm{V} \neq 0$ b) $\mathrm{E} = 0$ and $\mathrm{V} = 0$ c) $\mathrm{E} \neq 0$ and $\mathrm{V} = 0$ d) $\mathrm{E} = 0$ and $\mathrm{V} \neq 0$

16. Two plates are 20 cm apart and the potential difference between them is 10 V. The electric field between the plates is

a) $50\ \mathrm{Vm}^{-1}$ b) $500\ \mathrm{Vm}^{-1}$ c) $0.5\ \mathrm{Vm}^{-1}$ d) $20\ \mathrm{Vm}^{-1}$

17. A hollow conducting sphere or radius R has a charge $(+Q)$ on its surface. What is the electric potential within the sphere at a distance $r = R/3$ from its I?

a) $\frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r}$ b) $\frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r^2}$ c) $\frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{R}$ d) Zero

18. The electric potential $V$ at any point $x, y, z$ (all the metre) in space is given by $V = 4x^2$ volt. The electric field at the point (1m, 0, 2m) in $\mathrm{Vm}^{-1}$ is

a) $-8\hat{\imath}$ b) $+8\hat{\imath}$ c) $-16\hat{\imath}$ d) $16\hat{k}$

19. Two charged spheres of radii $R_1$ and $R_2$ having equal surface charge density. The ratio of their potential is

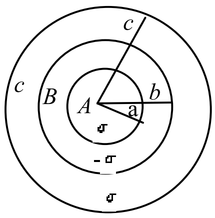
a) $R_1/R_2$ b) $R_2/R_1$ c) $\left(\frac{R_1}{R_2}\right)^2$ d) $\left(\frac{R_2}{R_1}\right)^1$

20. A soap bubble is charged to a potential of 16V. Its radius is, then doubled. The potential of the bubble now will be

a) 16V b) 8V c) 4V d) 2V

21. Consider three concentric shells of metal $A$, $B$ and $C$ are having radii $a$, $b$ and $c$ respectively as shown in the figure $(a < b < c)$. Their surface charge densities are $\sigma, -\sigma$ and $\sigma$ respectively. Calculate the electric potential on the surface of shell $A$



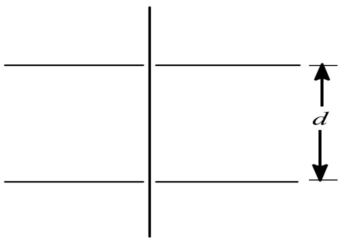



a) $\frac{\sigma}{\varepsilon_0}(a - b + c)$ b) $\frac{\sigma}{\varepsilon_0}(a - b - c)$ c) $\frac{\sigma}{\varepsilon_0}(a^2 + b^2 + c^2)$ d) $\frac{\sigma}{\varepsilon_0}(a + b - c)$

22. Two capacitors of capacitances $C_1$ and $C_2$ are connected in parallel across a battery. If $Q_1$ and $Q_2$ respectively be the charges on the capacitors, then $\frac{Q_1}{Q_2}$ will be equal to

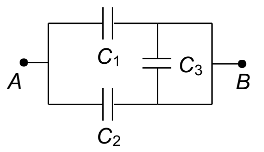
a) $\frac{C_2}{C_1}$ b) $\frac{C_1}{C_2}$ c) $\frac{C_1^2}{C_2^2}$ d) $\frac{C_2^2}{C_1^2}$

23. A capacitor of capacitance 1 μF is filled with two dielectrics of dielectric constant 4 and 6. What is the new capacitance?




a) 10 μF b) 5 μF c) 4 μF d) 7 μF

24. The equivalent capacitance of the combination of three capacitors, each of capacitance $C$ shown in figure between points $A$ and $B$ is




a) $\frac{C}{2}$ b) $\frac{3C}{2}$ c) $\frac{1}{3C}$ d) 2C

25. The energy stored in a capacitor is in the form of

a) Kinetic energy b) Potential energy c) Elastic energy d) Magnetic energy

26. A particle $A$ has charge $+q$ and particle $B$ has charge $+4q$ with each of them having the save mass $m$. When allowed to fall from rest through the same electrical potential difference, the ration of their steeds $v_A/v_B$ will become

a) 2 : 1 b) 1 : 2 c) 1 : 4 d) 4 : 1

27. Three capacitors of capacitances 4 μF, 6 μF and 12 μF are connected first in series and then in parallel. What is the ratio of equivalent capacitance in the two cases?

a) 2 : 3 b) 1 : 11 c) 11 : 1 d) 1 : 3

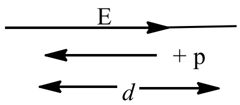
28. The ratio of momenta of an electron and proton which are accelerated from rest by a potential difference 50 V is

a) $\frac{m_e}{m_p}$ b) $\sqrt{\frac{m_e}{m_p}}$ c) $\frac{m_p}{m_e}$ d) $\sqrt{\frac{m_p}{m_e}}$

29. 27 small drops each having charge $q$ and radius $r$ coalesce to form big drop. How many times charge and capacitance will become?

a) 3, 27 b) 27, 3 c) 27, 27 d) 3, 3

30. In the figure, a proton moves a distance $d$ in a uniform electric field **E** as shown in the figure. Does the electric field do a positive or negative work on the proton? Does the electric potential energy of the proton increase or decrease?




a) Negative, increase b) Positive, decrease c) Negative, decrease d) Positive, increase

31. An air parallel plate capacitor has capacity $C$. The capacity and distance between plates are doubled when immersed in a liquid then dielectric constant of the liquid is

a) 1 b) 2 c) 3 d) 4

32. Work done in carrying a charge $Q_1$ once round a circle of radius $R$ with a charge $Q_2$ at the center is

a) $\frac{Q_1Q_2}{4\pi\varepsilon_0R^2}$ b) Zero c) $\frac{Q_1Q_2}{4\pi\varepsilon_0R}$ d) Infinite

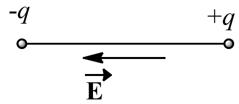
33. Two parallel plate capacitors of capacitance $C$ and $2C$ are connected in parallel and charged to a potential difference $V_0$. The battery is then disconnected and the region between the plates of the capacitor $C$ is completely filled with a material of dielectric constant 2. The potential difference across the capacitors now becomes

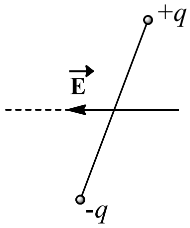
a) $\frac{F_0}{4}$ b) $\frac{V_0}{2}$ c) $\frac{3V_0}{4}$ d) $V_0$

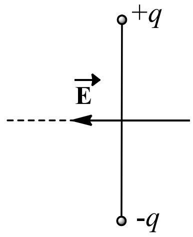
34. When two conductors of charges and potentials $C_1, V_1$ and $C_2, V_2$ respectively are joined, the common potential will be

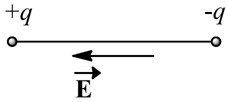
a) $\frac{C_1V_1 + C_2V_2}{V_1 + V_2}$ b) $\frac{C_1V_1^2 + C_2V_2^2}{V_1^2 + V_2^2}$ c) $C_1 + C_2$ d) $\frac{C_1V_1 + C_2V_2}{C_1 + C_2}$

35. In which of the states shown in figure is the potential energy of a electric dipole maximum?

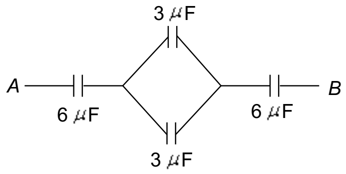
a) 


b) 


c) 


d) 


36. The equivalent capacitance between $A$ and $B$ in figure is




a) 4 μF b) 2 μF c) 10.5 μF d) 3 μF

37. A parallel plate air capacitor has a capacitance 18 μF.If the distance between the plates is trapled and a dielectric medium is introduced, the capacitance becomes 72 $\mu$F. The dielectric constant of the medium is

a) 4 b) 9 c) 12 d) 2

38. A parallel plate capacitor is made by stacking $n$ equally spaced plates connected alternatively. If the capacitance between any two adjacent plates is $C$, then the resultant capacitance is

a) $(n-1)C$ b) $(n+1)C$ c) $C$ d) $nC$

39. A parallel plate capacitor is charged. If the plates are pulled apart

a) The capacitance increases
b) The potential difference increases
c) The total charge increases
d) The charge and potential difference remain the same

40. If dielectric constant and dielectric strength be denoted by $K$ and X respectively, then a material suitable for use as a dielectric in a capacitor must have

a) High $K$ and high $X$ b) High $K$ and low $X$ c) Low $K$ and high $X$ d) Low $K$ and low $X$

41. The electric potential inside a conducting sphere

a) Increases from © to surface
b) Decreases from © to surface
c) Remains constant from © to surface
d) Is zero at every point inside

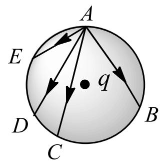
42. Two positive point charges of 12 μ C and 8 μC are placed 10 cm, apart in air. The work done to bring them 4 cm closer is

a) Zero b) 3.5 J c) 4.8 J d) 5.8 J

43. A charge $q$ is fixed. Another charge $Q$ is brought near it and rotated in a circle of radius $r$ around it. Work done during rotation is

a) Zero b) $\frac{Qq}{4\pi\varepsilon_0 r}$ c) $\frac{Qq}{2\pi\varepsilon_0 r}$ d) None of these

44. In the electric field of a point charge $q$, a certain point charges is carried from point $A$ to $B, C, D$ and $E$ as shown in figure. The work done is

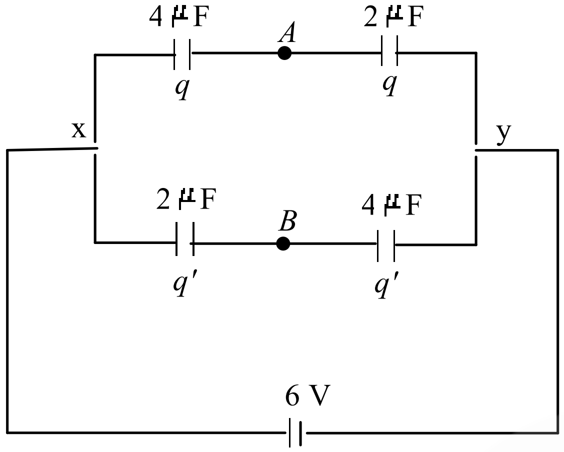



a) Least along the path $AE$
b) Least along the path $AC$
c) Zero along any one of the paths
d) Least along $AB$

45. The capacitance $C$ of a capacitor is
a) Independent of the charge and potential of the capacitor
b) Dependent on the charge and independent of potential
c) Independent of the geometrical configuration of the capacitor
d) Independent of the dielectric medium between the two conducting surface of the capacitor

1 **(a)**

Consider the charge distribution as shown.
Considering the branch on upper side, we have




$$\frac{q}{V_x - V_A} = 4 \times 10^{-6}$$

$$\frac{q}{V_A - V_y} = 2 \times 10^{-6}$$

Here, $V_x = 6$ volt, $V_y = 0$

$\therefore \quad \frac{q}{6 - V_A} = 4 \times 10^{-6}$

...(i)

$$\frac{q}{V_A - 0} = 2 \times 10^{-6}$$

...(ii)

From Eqs. (i) and (ii), we get

$$\frac{V_A}{6 - V_A} = 2$$

$\therefore \quad V_A = 4$volt

Similarly for the lower side branch

$$\frac{q'}{6 - V_B} = 2 \times 10^{-6}$$

...(iii)

$$\frac{q'}{V_B - 0} = 4 \times 10^{-6}$$

...(iv)

From Eqs. (iii) and (iv)

$$\frac{V_B}{6 - V_B} = \frac{1}{2}$$

$\therefore \; V_B = 2$ volt

$\therefore V_A - V_B = 4 - 2 = 2$ volt

2 **(a)**

The potential due to charge $q$ at distance $r$ is given by

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

If $W$ be the work done in moving the charge from $A$ to $B$ then the potential difference ($V$) is given by

$$V_A - V_B = \frac{W}{q}$$

Both work (W) and charge (q) are scalar quantities hence potential difference ($V_A - V_B$)will also be a scalar quantity.

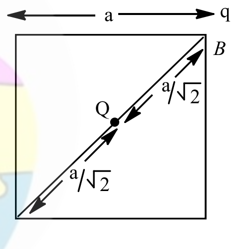
Here,

$$V_A = V_B = \frac{1}{4\pi\varepsilon_0}\frac{Q}{a/\sqrt{2}}$$

Since, $Q$is same for both,

$$V_A - V_B = 0$$

$$W = 0$$





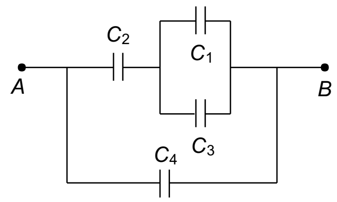

3 **(d)**

The arrangement can be redrawn as shown in the adjoining figure.

$C_{13} = C_1 + C_3 = 9 + 9 = 18\mu\text{F}$

$$C_{2-13} = \frac{C_2 \times C_{13}}{C_2 + C_{13}} = \frac{9\mu\text{F} \times 18\mu\text{F}}{(9 + 18)\mu\text{F}} = 6\mu\text{F}$$

$\therefore C = C_{2-13} + C_4 = 6\mu\text{F} \times 9\mu\text{F} = 15\mu\text{F}.$




4 **(b)**

$$C = \frac{A\varepsilon_0}{d}$$

After inserting the slab

$$C' = \frac{A\varepsilon_0}{(d - b)} = \frac{A\varepsilon_0}{d - \frac{d}{2}}$$

$C' = \frac{2A\varepsilon_0}{d} \quad \therefore \; \frac{C'}{C} = \frac{2}{1}$

5 **(b)**

Electrostatic potential energy of system of two electrons

$$U = \frac{1}{4\pi\varepsilon_0}\frac{(-e)(-e)}{r} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r}$$

Thus, as $r$ decreases, potential energy $U$ increases.

6 ©

When battery remains connected

$$C' = kC$$
$$Q' = kQ$$
$$V' = V$$
$$E' = E$$
$$U' = kU$$

$U$ and $Q$ Both increases.

7 ©

Potential energy

$$U = \frac{q_1 q_2}{4\pi\varepsilon_0 r}$$

Or $U \propto \frac{1}{r}$

When $r$ decreases $U$ increases and $vice - versa$. Moreover, potential energy as well as force is positive, if there is repulsion between the particles and negative if there is attraction.

8 ©

As battery is disconnected, total charge $Q$ is shared equally by two capacitors. Energy of each capacitor

$$= \frac{(Q/2)^2}{2C} = \frac{1}{4}\frac{Q^2}{2C} = \frac{1}{4}U$$

9 ©

Combined capacity of 1 μF and 5μF = 1 + 5=6 μF

Now, 4μF and 6μF are in series.

$$\therefore \frac{1}{C_s} = \frac{1}{4} + \frac{1}{6} + \frac{3+2}{12} = \frac{5}{12}$$

$$C_s = \frac{12}{5}\,\mu\text{F}$$

Charge in the arm containing 4μF capacitor is

$$q = C_s \times V = \frac{12}{5} \times 10 = 24\,\mu\text{C}$$

10 **(b)**

11 **(b)**

The arrangement behaves as a combination of 2 capacitors each of capacitance $C = \frac{\varepsilon_0 A}{d}$.

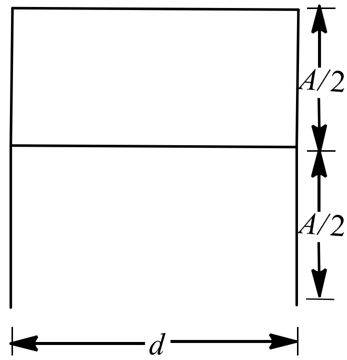
Thus, equivalent capacity $= 2C$

$\therefore$ total energy stored $U = \frac{1}{2} \times (2C)V^2 = CV^2 = \frac{\varepsilon_0 A}{d}V^2$

12 ©

The dielectric is introduced such that, half of its area is occupied by

It.




In the given case the two capacitors are in parallel.

$$\therefore \quad C' = C_1 + C_2$$
$$C_1 = \frac{A\varepsilon_0}{2d}$$

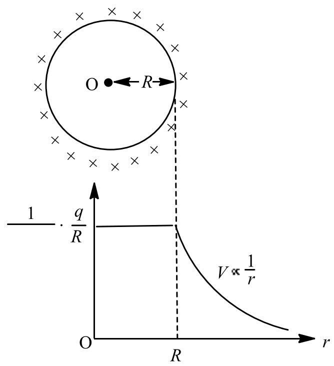
And $\quad C_2 = \frac{KA\varepsilon_0}{2d}$

Thus, $\quad C' = \frac{A\varepsilon_0}{2d} + \frac{KA\varepsilon_0}{2d}$

$$C' = \frac{C}{2}(1+K)$$

13 ©

If we take a charge from one point to another inside a charged spherical shell, then no work will be done. This means that inside a spherical charge the potential at all points is the same and its value is equal to that on the surface, that is




$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}\ \text{volt}$$

Also outside the metallic sphere

$$V = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{r}$$

$$V \propto \frac{1}{r}$$

14 **(a)**

Since the two spheres are joined by a wire, their potential are equal *ie*,

$$\frac{q_1}{4\pi\varepsilon_0 R_1} = \frac{q_2}{4\pi\varepsilon_0 R_2} \Rightarrow \frac{q_1}{q_2} = \frac{R_1}{R_2}$$

Now, $\sigma_1 = \frac{q_1}{4\pi\varepsilon_0 R_1^2}$

And $\sigma_2 = \frac{q_2}{4\pi\varepsilon_0 R_2^2}$,

Hence $\frac{\sigma_2}{\sigma_1} = \frac{\sigma_2}{\sigma_1} \times \frac{R_1^2}{R_2^2} = \left(\frac{R_2}{R_1}\right)\left(\frac{R_1}{R_2}\right)^2$

$\Rightarrow \frac{\sigma_2}{\sigma_1} = \frac{R_1}{R_2}$

15 ©

The potential due to charge q at a distance $r$ is given by

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

Since, potential is a scalar quantity, it can be added to find the sum due to individual charges.

$$\sum V = V_A + V_B + V_C$$

$$V_A = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2q}{x}$$

$$V_B = -\frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{x}$$

$$V_C = -\frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{x}$$

$$\therefore\ V = \frac{1}{4\pi\varepsilon_0}\left(\frac{2q}{x} - \frac{q}{x} - \frac{q}{x}\right) = 0$$

Electric field is a vector quantity, hence component along $OD$ is taken

$$E = \frac{1}{4\pi\varepsilon_0}\left(\frac{2q}{x^2} + \frac{2q}{x^2}\cos\theta\right) \neq 0$$

16 **(a)**

Potential gradient relates with electric field according to the relation, $E = -\frac{dV}{dr}$

$$= -\frac{10}{20 \times 10^{-2}} = 50\ \mathrm{Vm^{-1}}$$

17 ©

Electric potential inside the hollow conducting sphere is constant and equal to potential at the surface of the sphere $= \frac{Q}{4\pi\varepsilon_0 R}$.

18 **(a)**

$\because\ V = 4x^2$

Hence, $\vec{E} = -\frac{dV}{dr} = -8x\hat{\text{©}}$

Hence, value of $\vec{E}$ at (1m, 0, 2m) will be

$\vec{E} = -8 \times 1\hat{\imath} = -8\hat{\text{©}}\ \mathrm{Vm^{-1}}$

19 **(b)**

20 **(b)**

Potential on bubble,

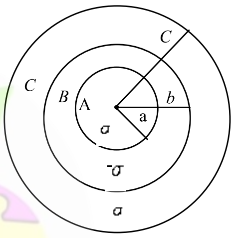
$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

$$\therefore \frac{V_1}{V_2} = \frac{r_2}{r_1}$$

$$\Rightarrow \frac{16}{V_2} = \frac{2}{1} \Rightarrow V_2 = 8\ V$$

21 **(a)**

The electric potential on the surface of shell $A$




$$V_A = V_a + V_b + V_c$$

$$V_A = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_a}{a} + \frac{1}{4\pi\varepsilon_0} + \frac{q_b}{b} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_c}{c}$$

Or

$$V_A = \frac{1}{4\pi\varepsilon_0} \cdot \frac{4\pi a^2\sigma}{a} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{4\pi b^2(-\sigma)}{b} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{4\pi c^2\sigma}{c}$$

$(\because q = 4\pi r^2\sigma)$

or $V_A = \frac{\sigma}{\varepsilon_0}(a - b + c)$

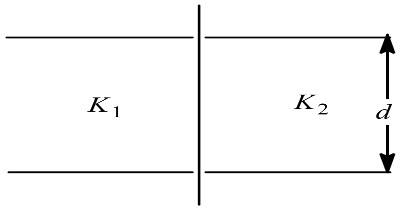
22 **(b)**

In parallel, potential is same, say $V$

$$\frac{Q_1}{Q_2} = \frac{C_1 V}{C_2 V} = \frac{C_1}{C_2}$$

23 **(b)**

Initially, the capacitance of capacitor



$$C = \frac{\varepsilon_0 A}{d}$$

$\therefore \quad \frac{\varepsilon_0 A}{d} = 1\mu F$

...(i)

When it is filled with dielectric of dielectric constant $K_1$ and $K_2$ as shown, then there are two capacitors connected is parallel. So,

$$C' = \frac{K_1\varepsilon_0\left(\frac{A}{2}\right)}{d} + \frac{K_2\varepsilon_0\left(\frac{A}{2}\right)}{d}$$

(as area becomes half)

$$C' = \frac{4\varepsilon_0 A}{2d} + \frac{6\varepsilon_0 A}{2d} = \frac{2\varepsilon_0 A}{d} + \frac{3\varepsilon_0 A}{d}$$

Using Eq. (i), we obtain

$$C' = 2 \times 1 + 3 \times 1 = 5\ \mu F$$

24 **(d)**

In the arrangement shown both plates of capacitors $C_3$ are joined to point $B$. Hence, it does not act as a capacitor and is superfluous. Now $C_1$ and $C_2$ are in parallel, hence $C_{AB} = C_1 + C_2 = C + C = 2C$

25 **(b)**

When a conductor of capacitance $C$ is given a charge $q$, it acquires a potential given by

$$V = \frac{q}{C}$$

The work done in charging the conductor is stored as potential energy in the electric field in the vicinity of the conductor.

26 **(b)**

$$\frac{E_A}{E_B} = \frac{\frac{1}{2}mv_A^2}{\frac{1}{2}mv_B^2} = \frac{W_A}{W_B} = \frac{(q)V}{(4q)V}$$

$$\frac{v_A}{v_B} = \frac{1}{2}$$

27 **(b)**

$$\frac{1}{C_s} = \frac{1}{4} + \frac{1}{6} + \frac{1}{12} = \frac{3+2+1}{12} = \frac{6}{12} = \frac{1}{2}$$

$C_s = 2\ \mu F$

$C_p = 4 + 6 + 12 = 22\ \mu F$

$$\frac{C_s}{C_p} = \frac{2}{22} = \frac{1}{11}$$

28 **(b)**

Linear momentum of electron, $p_e = \sqrt{2m_e eV}$

Linear momentum of photon, $p_p = \sqrt{2m_p eV}$

$$\frac{p_e}{p_p} = \frac{\sqrt{2m_e eV}}{\sqrt{2m_p eV}}$$

$$\frac{p_e}{p_p} = \sqrt{\frac{m_e}{m_p}}$$

29 **(b)**

Let $R$ and $r$ be the radii of bigger and each smaller drop. Charge remains conserved.

Hence, charge on bigger drop

$= 27 \times$charge on smaller drop

*ie*, $\quad q' = 27q$

Now, before and after coaleseing, volume remains same.

That is,

$\frac{4}{3}\pi R^3 = 27 \times \frac{4}{3}\pi r^3$

$\therefore\ R = 3r$

Hence, capacitance of bigger drop

$C' = 4\pi\varepsilon_0 R = 4\pi\varepsilon_0(3r)$

$= 3(4\pi\varepsilon_0 r) = 3C$

30 **(d)**

Since, the proton is moving against the direction of electric field so, work is done by the proton against electric field. It implies that electric field does negative work on the proton.

Again, proton is moving in electric field from low potential region to high potential region hence, its potential energy increases.

31 **(d)**

The capacitance of parallel plate air capacitor

$C = \frac{\varepsilon_0 A}{d}$ ...(i)

where $A$ is the area of each plate and $d$ is the distance between the plates. In a medium of dielectric constant $K$ and with given condition

$C' = \frac{K\varepsilon_0 A'}{d'}$

Given, $\quad A' = A, d' = 2d, C' = 2C$

$\therefore\ 2C = \frac{K\varepsilon_0 A}{2d}$ ...(ii)

Equating Eqs. (i) and (ii), we get

$K = 4$

32 **(b)**

Since electrical potential at any point of circle of radius $R$ due to charge $Q_2$ at its centre is same

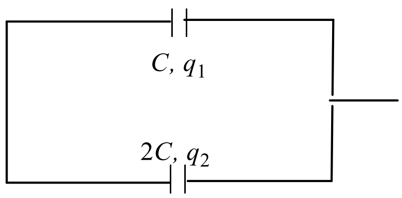
$V = \frac{Q_2}{4\pi\varepsilon_0 R}$, hence work done in carrying a charge $Q_1$ round the circle is zero.

33 **(c)**

The charge $q_1 = CV_0$

or

$V_0 = \frac{q_1}{C}$ ...(i)




∴ Capacitors are in parallel, in parallel $V_0$ is same for all capacitors.

∴ For second capacitor $V_0 = \frac{q_2}{2C}$ ...(ii)

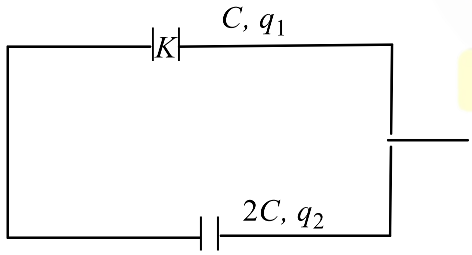
From Eqs. (i) and (ii),

$q_2 = 2q_1$ ...(iii)

After disconnecting the battery, the region between the plates of the capacitor $C$ is completely filled with a material of dielectric constant ($K = 2$).

Then, $V_1 = \frac{q_1}{CK} = \frac{q_1}{2C}$

and $V_1 = \frac{q_2}{2C} = \frac{2q_1}{2C} = \frac{q_1}{C}$ [from Eq. (iii)]




Charge will flow from 2 to 1 till

$\frac{q_2'}{2C} = \frac{q'_1}{KC}$

$\frac{q_2'}{2C} = \frac{q_1'}{2C}$

*ie*, $q_1' = q_2'$

Earlier potential $V_0 = \frac{q_1}{C}$

Now it is $V_0 = \frac{q_1'}{2C}$

Now, $q_1 + q_2 = 3q_1$ [from Eq.(iii)]

and $q_1' + q_2' = 3q_1$

or $2q_1' = 3q_1$ or $q_1' = \frac{3q_1}{2}$

∴ Now potential $\frac{q_1'}{2C} = \frac{3q_1}{4C}$

$V = \frac{3V_0}{4}$

$[\because q_1 = V_0 C]$

34 **(d)**

When two conductors of capacities $C_1$ and $C_2$ and potentials $V_1$ and $V_2$ are connected by a conducting wire, charge redistributes in these conductors till potential of both the conductors become equal, known as common potential.

Common potential $= \frac{\text{net charge}}{\text{total capacity}}$

*ie* $V = \frac{q_1 + q_2}{C_1 + C_2}$

or $V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$

35 **(a)**

Potential energy of electric dipole, $U = -\vec{p} . \vec{E} = -pE\cos\theta$.

In Fig. (a), $\theta = \pi$ rad hence $U = -pE\cos\pi = +pE$ = maximum.

36 **(b)**

$C_p = 3 + 3 = 6\ \mu F$

$\frac{1}{C_s} = \frac{1}{6} + \frac{1}{6} + \frac{1}{6} = \frac{3}{6} = \frac{1}{2}$

$C_s = 2\mu\ F$

37 ®

$C_0 = \frac{\varepsilon_0 A}{d} = 18$

$C_0 = \frac{K\varepsilon_0 A}{3d} = 72$

Dividing Eq. (ii) by Eq. (i)

$\frac{k}{3} = \frac{72}{18} = 4$

$K = 12$

38 **(a)**

Each plate is taking part in the formation of two capacitors except the plates at the ends.

These capacitors are in parallel and $n$ plates form $(n-1)$ 11apacitors.

Thus, equivalent capacitance between points $A$ and $B = (n-1)C$

39 **(b)**

The electric field between the plates is

$$E = \frac{V}{d}$$

or $V = Ed$ or $V \propto d$

Hence, if the plates are pulled apart the potential difference increases.

40 **(a)**

The material suitable for use as dielectric must have high dielectric strength $X$ and large dielectric constant $K$.

41 ®

Electric potential inside a conductor is constant and it is equal to that on the surface of conductor.

42 **(d)**

Work done $= U_2 - U_1 = \frac{q_1 q_2}{4\pi\varepsilon_0}\left[\frac{1}{r_2} - \frac{1}{r_1}\right]$

$$= 12 \times 10^{-6} \times 8 \times 10^{-6} \times 9 \times 10^{9}\left[\frac{10^2}{6} - \frac{10^2}{10}\right]$$

$$W = 96 \times 9 \times 10^{-3} \times 10^{2} \times \frac{4}{60} = 5.8\text{J}$$

43 **(a)**

Potential due to charge (q) at point ® is given by

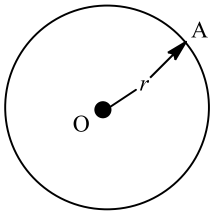
$$V = \frac{1}{4\pi e_0}.\frac{q}{r}$$

Since, charge $Q$ is rotated in a circle of radius $r$, hence its potential remains same at all points on the path, hence $\Delta V = 0$.

Also, work done $= q\Delta V$

Where q is charge and $\Delta V = 0$.

∴ Work done =0.




44 **(c)**

For charge $q$ placed at the centre of circle, the circular path is an equipotential surface and hence works done along all paths $AB$ or $AC$ or $AD$ or $AE$ is zero.

45 **(c)**

Capacitance $C = \frac{Q}{V}$

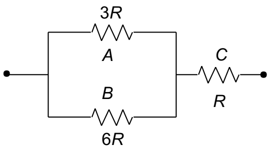
For a dielectric media $C = \frac{\varepsilon A}{d}$

∴ Capacitance $C$ of a capacitor is independent of the geometrical configuration of the capacitor.


# Current Electricity

## RED ZONE

1. Figure shows a network of three resistance. When some potential difference is applied across the network, the thermal powers dissipated by $A$,$B$ and $C$ in the ratio

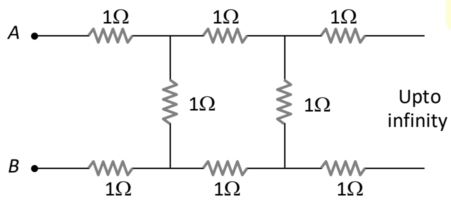



a) 2 : 3 : 4 b) 2 : 4 : 3 c) 4 : 2 : 3 d) 3 : 2 : 4

2. If an increase in length of copper wire is 0.5% due to stretching, the percentage increase in its resistance will be

a) 0.1% b) 0.2% c) 1% d) 2%

3. The resistance between the terminal points $A$ and $B$ of the given infinitely long circuit will be




a) $(\sqrt{3}-1)$ b) $(1-\sqrt{3})$ c) $(1+\sqrt{3})$ d) $(2+\sqrt{3})$

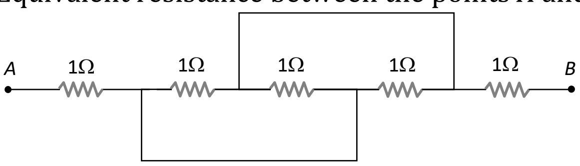
4. A battery having e.m.f. $5V$ and internal resistance 0.5 Ω is connected with a resistance of 4.5 Ω then the voltage at the terminals of battery is

a) 4.5 $V$ b) 4 $V$ c) 0 $V$ d) 2 $V$

5. The length of a conductor is doubled and its radius is halved, its specific resistance is

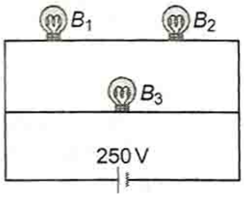
a) Unchanged b) Halved c) Doubled d) Quadrupled

6. Equivalent resistance between the points $A$ and $B$ is (in Ω)



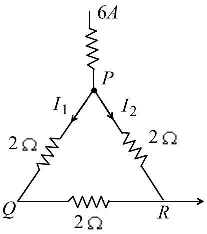

a) $\frac{1}{5}$ b) $1\frac{1}{4}$ c) $2\frac{1}{3}$ d) $3\frac{1}{2}$

7. A 100 W bulb $B_1$ and two 60 W bulbs $B_2$ and $B_3$ are connected to a 250 V source as shown in figure. Now $W_1, W_2$ and $W_3$ are the output powers of the bulbs $B_1, B_2$ and $B_3$ respectively, then




a) $W_1 > W_2 = W_3$ b) $W_1 > W_2 > W_3$ c) $W_1 < W_2 = W_3$ d) $W_1 < W_2 < W_3$

8. A current of $6A$ enters one corner $P$ of an equilateral triangle $PQR$ having 3 wires of resistances $2\Omega$ each and leaves by the corner $R$. Then the current $I_1$ and $I_2$ are




a) $2A, 4A$ b) $4A, 2A$ c) $1A, 2A$ d) $2A, 3A$

9. In a Wheatstone bridge, $P = 90\Omega, Q = 110\Omega, R = 40\Omega$ and $S = 60\Omega$ and a cell of 4 V emf. Then the potential difference between the diagonal along which a galvanometer is connected is

a) $-0.2$ V b) $+0.2$ V c) $-1$ V d) $+1$ V

10. Two electric bulbs, one of 200 *volt* 40 *watt* and the other 200 *volt* 100 *watt* are connected in a house wiring circuit

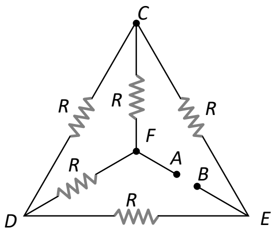
a) They have equal currents through them
b) The resistance of the filaments in both the bulbs is same
c) The resistance of the filament in 40 *watt* bulb is more than the resistance in 100 *watt* bulb
d) The resistance of the filament in 100 *watt* bulb is more than the resistance in 40 *watt* bulb

11. Masses of the three wires of same material are in the ratio of $1:2:3$ and their lengths in the ratio of $3:2:1$. Electrical resistance of these wires will be in the ratio of

a) $1:1:1$ b) $1:2:3$ c) $9:4:1$ d) $27:6:1$



12. Five equal resistances each of resistance $R$ are connected as shown in the figure. A battery of $V$ volts is connected between $A$ and $B$. The current flowing in $AFCEB$ will be

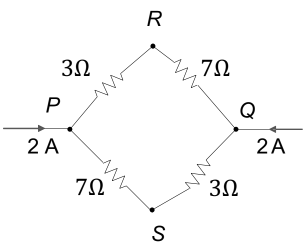



a) $\frac{3V}{R}$ b) $\frac{V}{R}$ c) $\frac{V}{2R}$ d) $\frac{2V}{R}$

13. The power of heater is 750 W at 1000°C. What will be its power at 200°C if $a = 4 \times 10^{-4}$ per°C ?

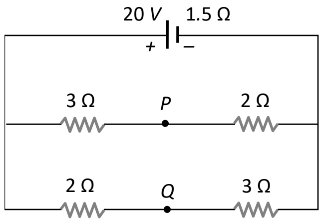
a) 400 W b) 990 W c) 250 W d) 1500 W

14. A current of 2A flows in an electric circuit as shown in figure. The potential difference$(V_R - V_S)$, in volts( $V_R - V_S$ are potentials at R and S respectively) is




a) -4 b) +2 c) +4 d) -2

15. If in the circuit shown below, the internal resistance of the battery is 1.5 Ω and $V_P$ and $V_Q$ are the potentials at $P$ and $Q$ respectively, what is the potential difference between the points $P$ and $Q$

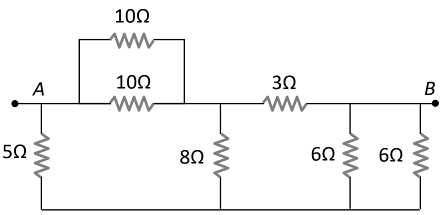



a) Zero b) 4 $volts$ $(V_P > V_Q)$ c) 4 $volts$ $(V_Q > V_P)$ d) 2.5 $volts$ $(V_Q > V_P)$

16. *Watt-hour* meter measures

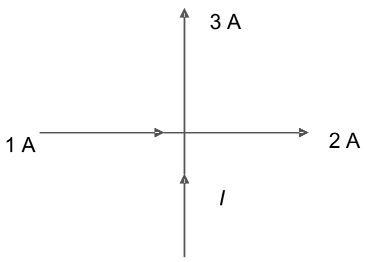
a) Electric energy b) Current c) Voltage d) Power

17. Seven resistance are connected as shown in the figure. The equivalent resistance between $A$ and $B$ is




a) 3 Ω b) 4 Ω c) 4.5 Ω d) 5 Ω

18. The value of current I in figure is




a) 4A b) 6A c) 3A d) 5A

19. The following four wires are made of the same material and are at the same temperature. Which one of them has the highest electrical resistance?

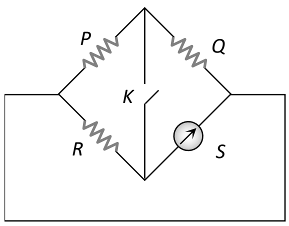
a) Length=50 cm, diameter=0.5 mm b) Length=100 cm, diameter=1 mm

c) Length=200 cm, diameter=2 mm d) Length=300 cm, diameter=3 mm

20. The current in a conductor varies with time $t$ as $I = 2t + 3t^2$ where $I$ is in *ampere* and $t$ in *seconds*. Electric charge flowing through a section of the conductor during $t = 2$ $sec$ to $t = 3$ $sec$ is

a) 10 $C$ b) 24 $C$ c) 33 $C$ d) 44 $C$

21. In the following Wheatstone bridge $P/Q = R/S$. If key $K$ is closed, then the galvanometer will show deflection




a) In left side b) In right side c) No deflection d) In either side

22. An electric heater of 1.08 Kw is immersed in water. After the water has reached a temperature of 100°C, how much time will be required to produce 100 g of steam?

a) 420 s b) 210 s c) 105 s d) 50 s

23. 160W-60V lamp is connected at 60 V DC supply. The number of electrons passing through the lamp in 1 min is (the charge of electron $e = 1.6 \times 10^{-19}$C)

a) $10^{19}$ b) $10^{21}$ c) $1.6 \times 10^{19}$ d) $1.4 \times 10^{20}$

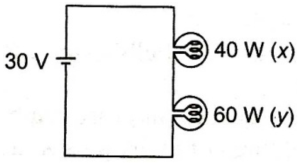
24. Two heater wires of equal length are first connected in series and then in parallel. The ratio of heat produced in the two cases is

a) 1 : 4 b) 4 : 1 c) 1 : 2 d) 2 : 1

25. A conductor wire having $10^{29}$ free electrons/$m^3$ carries a current of 20A. If the cross-section of the wire is $1mm^2$, then the drift velocity of electrons will be

a) $6.25 \times 10^{-3} ms^{-1}$ b) $1.25 \times 10^{-5} ms^{-1}$ c) $1.25 \times 10^{-3} ms^{-1}$ d) $1.25 \times 10^{-4} ms^{-1}$

26. Two bulbs $X$ and $Y$ having same voltage rating and of power 40 W and 60 W respectively are connected in series across a potential difference of 300 V, then



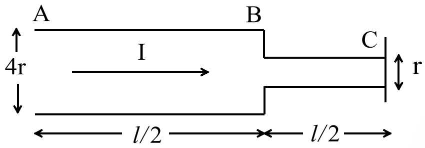

a) $X$ will glow brighter b) Resistance of $Y$ will be greater than $X$

c) Heat produced in $Y$ will be greater than $X$ d) Voltage drop in $X$ will be greater than $Y$

27. A potential difference of $V$ is applied at the ends of a copper wire of length $l$ and diameter $d$. On doubling only $d$, the drift velocity,

a) Becomes two times b) Becomes half c) Does not change d) Becomes one-fourth

28. Consider a cylindrical element as shown in the figure. Current flowing through element is I and resistivity of material of the cylinder is $\rho$. Choose the correct option out the following



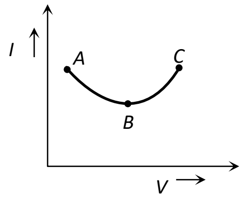

a) Power loss is second half is four times the power loss in first half

b) Voltage drop in first is twice of voltage drop in second half

c) Current density in both halves are equal

d) Electric field in both halves is equal

29. Resistance as shown in figure is negative at




a) $A$ b) $B$ c) $C$ d) None of these

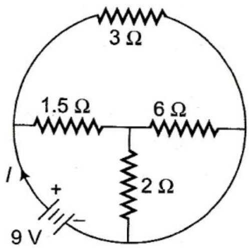
30. A thin wire of resistance 4 Ω is bent to form a circle. The resistance across any diameter is

a) 4 Ω b) 2 Ω c) 1 Ω d) 8 Ω

31. The current flowing through a wire depends on time as $I = 3t^2 + 2t + 5$. The charge flowing through the cross-section of the wire in time from $t = 0$ to $t = 2$ sec. is

a) 22 C b) 20 C c) 18 C d) 5 C

32. The total current supplied to the given circuit by the battery is




a) 9 A b) 6 A c) 2 A d) 4 A

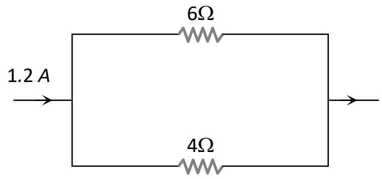
33. Two electric bulbs rated $P_1$ watt $V$ volts and $P_2$ watt $V$ volts are connected in parallel and $V$ volts are applied to it. The total power will be

a) $P_1 + P_2 watt$ b) $\sqrt{P_1 P_2}\ watt$ c) $\frac{P_1 P_2}{P_1 + P_2} watt$ d) $\frac{P_1 + P_2}{P_1 P_2} watt$

34. To get a maximum current through a resistance of $2.5\Omega$, one can use $m$ rows of cells each row having $n$ cells. The internal resistance of each cell is $0.5\Omega$. What are the values of $m$ and $n$ if the total number of cells are 20?

a) $m = 2, n = 10$ b) $m = 4, n = 5$ c) $m = 5, n = 4$ d) $n = 2, m = 10$

35. In the figure given below, the current passing through $6\Omega$ resistor is

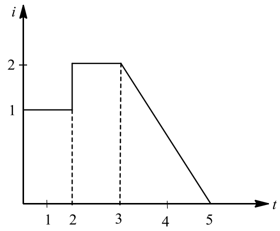



a) 0.40 *ampere* b) 0.48 *ampere* c) 0.72 *ampere* d) 0.80 *ampere*

36. A wire is broken in four equal parts. A packet is formed by keeping the four wires together. The resistance of the packet in comparison to the resistance of the wire will be

a) Equal b) One fourth c) One eight d) $\frac{1}{16}th$

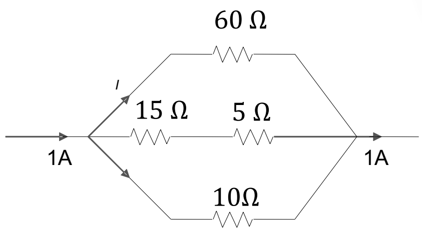
37. The plot represents the flow of current through a wire at three different times.




The ratio of charges flowing through the wire at different times is

a) 2 : 1 : 2 b) 1 : 3 : 3 c) 1 : 1 : 1 d) 2 : 3 : 4

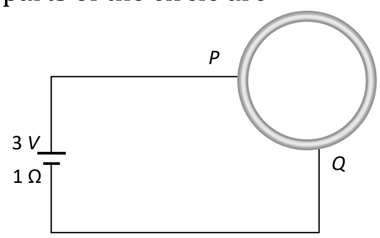
38. The magnitude of I in ampere is





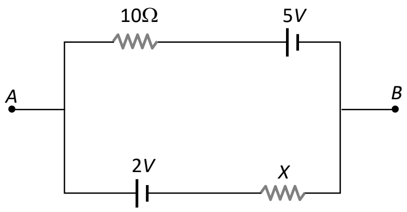

a) 0.1 b) 0.3 c) 0.6 d) None of the above

39. A wire of resistance 10 Ω is bent to form a circle. $P$ and $Q$ are points on the circumference of the circle dividing it into a quadrant and are connected to a battery of 3 $V$ and internal resistance 1 Ω as shown in the figure. The currents in the two
parts of the circle are




a) $\frac{6}{23}A$ and $\frac{18}{23}A$ b) $\frac{5}{26}A$ and $\frac{15}{26}A$ c) $\frac{4}{25}A$ and $\frac{12}{25}A$ d) $\frac{3}{25}A$ and $\frac{9}{25}A$

40. If $V_{AB} = 4V$ in the given figure, then resistance $X$ will be




a) 5 Ω b) 10 Ω c) 15 Ω d) 20 Ω

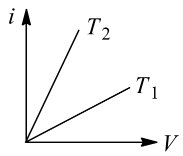
41. As the temperature rises the resistance offered by metal

a) Increase b) Decrease c) Remains same d) None of these

42. The drift velocity of free electrons in a conductor is $'v'$ when a current $'i'$ is flowing in it. If both the radius and current are doubled, then drift velocity will be

a) $v$ b) $\frac{v}{2}$ c) $\frac{v}{4}$ d) $\frac{v}{8}$

43. The current $i$ and voltage $V$ graphs for a given metallic wire at two different temperatures $T_1$and $T_2$ are shown in the figure. It is concluded that

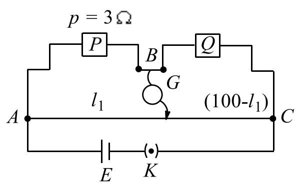



a) $T_1 > T_2$ b) $T_1 < T_2$ c) $T_1 = T_2$ d) $T_1 = 2T_1$

44. If $t_1$ and $t_2$ are the times taken by two different coils for producing same heat with same supply, then the time taken by them to produce the same heat when connected in parallel will be

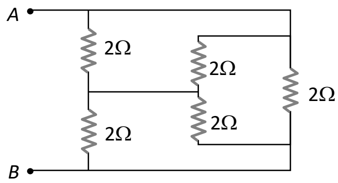
a) $t_1 + t_2$ b) $\frac{t_1 t_2}{t_1 + t_2}$ c) $\frac{2t_1 t_2}{t_1 + t_2}$ d) $t_1 t_2$

45. In a metre bridge experiment, resistances are connected as shown in figure. The balancing length $l_1$ is 55 $cm$. Now an unknown resistance $x$ is connected in series with $P$ and the new balancing length is found to be 75 $cm$. The value of $x$ is




a) $\frac{54}{12}\Omega$ b) $\frac{20}{11}\Omega$ c) $\frac{48}{11}\Omega$ d) $\frac{11}{48}\Omega$

46. Find the equivalent resistance across $AB$




a) 1 Ω b) 2 Ω c) 3 Ω d) 4 Ω

47. The temperature coefficient of resistance for a wire is 0.00125° $C^{-1}$.At 300 K its resistance is 1 Ω.The temperature at which the resistance becomes 1.5 Ω is?

a) 450 K b) 727 K c) 454 K d) 900 K

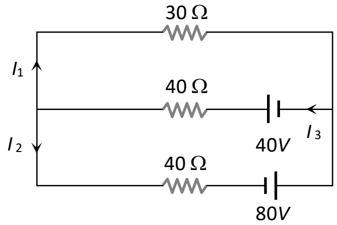
48. A source of emf E=15V and having negligible internal resistance, is connected to a variable resistance, so that the current in the circuit increases with time as I=1.2t+3. Then, the total charge that will flow in first 5s will be

a) 10C b) 20C c) 30C d) 40C

49. Three electric bulbs of rating 60$W$ each are joined in series and then connected to electric mains. The power consumed by these three bulbs will be

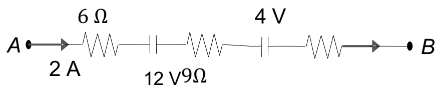
a) 180 $W$ b) 60 $W$ c) 20 $W$ d) $\frac{20}{3}W$

50. In the given circuit the current $I_1$ is




a) 0.4 $A$ b) −0.4 $A$ c) 0.8 $A$ d) −0.8 $A$

51. The potential difference between A and B in the following figure is

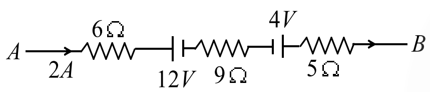



a) 32 V b) 48 V c) 24 V d) 14 V

52. If current in an electric bulb changes by 1%, then the power will change by

a) 1% b) 2% c) 4% d) $\frac{1}{2}$%

53. The potential difference between $A$ and $B$ in the following figure is

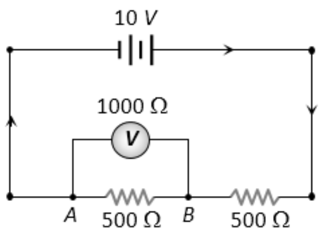



a) 24 $V$ b) 14 $V$ c) 32 $V$ d) 48 $V$

54. If potential $V = 100 \pm 0.5\ Volt$ and current $I = 10 \pm 0.2\ amp$ are given to us, then what will be the value of resistance

a) $10 \pm 0.7\ ohm$ b) $5 \pm 2\ ohm$ c) $0.1 \pm 0.2\ ohm$ d) None of these

55. What is the reading of voltmeter in the following figure

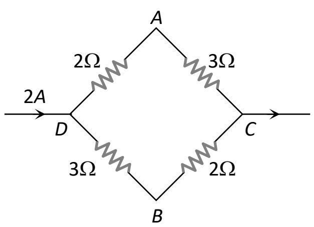



a) 3 $V$ b) 2 $V$ c) 5 $V$ d) 4 $V$

56. The resistance of a wire is 5Ω at 50°C and 6Ω at 100°C.The resistance of the wire at 0°C will be

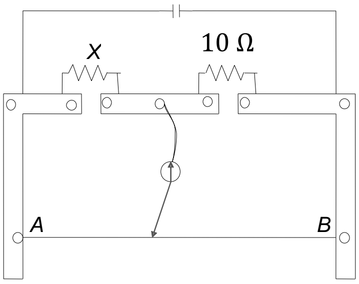
a) 2Ω b) 1Ω c) 4Ω d) 3Ω

57. A current of 2 $A$ flows in a system of conductors as shown. The potential difference $(V_A - V_B)$ will be



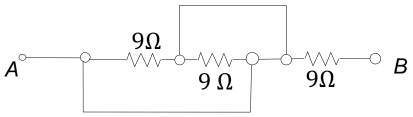

a) $+2V$ b) $+1V$ c) $-1V$ d) $-2V$

58. A meter bridge is set-up as shown in figure, to determine an unknown resistance X using a standard 10 Ω resistor. The galvanometer shows null point when tapping key is at 52cm mark. The end-corrections are 1cm and 2cm respectively for the ends A and B. the determined value of x is



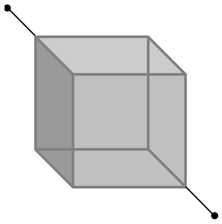

a) 10.2 Ω b) 10.6 Ω c) 10.8 Ω d) 11.1 Ω

59. In the circuit shown the equivalent resistance between $A$ and $B$ is




a) 27 Ω b) 18 Ω c) 9 Ω d) 3 Ω

60. Twelve wires of equal length and same cross-section are connected in the form of a cube. If the resistance of each of the wires is $R$, then the effective resistance between the two diagonal ends would be



a) $2\ R$ b) $12\ R$ c) $\frac{5}{6}R$ d) $8\ R$

61. If $\sigma_1, \sigma_2$ and $\sigma_3$ are the conductances of three conductors, then their equivalent conductance, when they are joined in series, will be

a) $\sigma_1 + \sigma_2 + \sigma_3$ b) $\frac{1}{\sigma_1} + \frac{1}{\sigma_2} + \frac{1}{\sigma_3}$ c) $\frac{\sigma_1\sigma_2\sigma_3}{\sigma_1 + \sigma_2 + \sigma_3}$ d) None of these



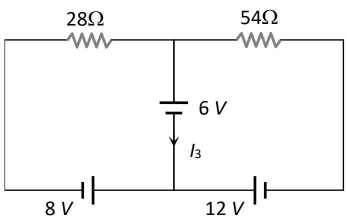
62. A heater coil is cut into two equal parts and only one part is now used in the heater. The heat generated will now be

a) Doubled b) Four times c) One-fourth d) Halved

63. If $n, e, \tau$ and $m$ respectively represent the density, charge relaxation time and mass of the electron, then the resistance of a wire of length $l$ and area of cross-section $A$ will be

a) $\frac{ml}{ne^2\tau A}$ b) $\frac{m\tau^2 A}{ne^2 l}$ c) $\frac{ne^2\tau A}{2ml}$ d) $\frac{ne^2 A}{2m\tau l}$

64. Consider the circuit shown in the figure. The current $I_3$ is equal to

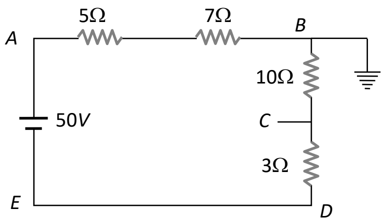



a) $5\ amp$ b) $3\ amp$ c) $-3\ amp$ d) $-5/6\ amp$

65. A coil of wire of resistance 50 Ω is embedded in a block of ice and a potential difference of 210 V is applied across it. The amount of ice which melts in 1 sec is

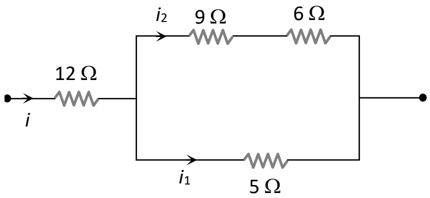
a) 0.262 g b) 2.62 g c) 26.2 g d) 0.0262 g

66. In the circuit shown, the point $'B'$ is earthed. The potential at the point $'A'$ is



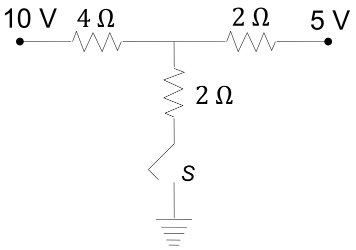

a) 14 $V$ b) 24 $V$ c) 26 $V$ d) 50 $V$

67. In the following circuit, 5Ω resistor develops 45 $J/s$ due to current flowing through it. The power developed per second across 12 Ω resistor is




a) 16 $W$ b) 192 $W$ c) 36 $W$ d) 64 $W$

68. As the switch $S$ is closed in the circuit shown in figure, current passed through it is

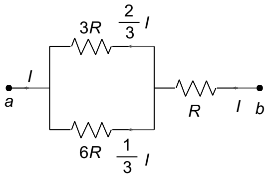



a) Zero b) 1 A c) 2 A d) 1.6 A

# : HINTS AND SOLUTIONS :

1 **(c)**

Let current flow from $b$ to $a$ as shown




Ratio of thermal power is $\left(\frac{2}{3}I\right)^2 3R : \left(\frac{1}{3}I\right)^2 6R :$ $I^2R$

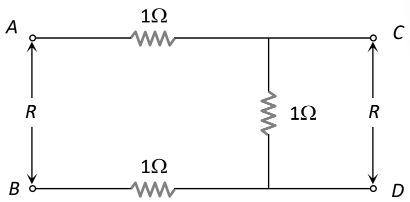
or $\frac{4}{3} : \frac{2}{3} : 1$ or $4:2:3$.

2 **(c)**

Approximate change in resistance=$2 \times \%$ change in length by stretching

3 **(c)**

Let equivalent resistance between $A$ and $B$ be $R$, then equivalent resistance between $C$ and $D$ will also be $R$




$$R' = \frac{R}{R+1} + 2 = R$$

$$\Rightarrow R^2 - 2R - 2 = 0$$

$$\therefore R = \frac{2 \pm \sqrt{4+8}}{2} = \sqrt{3} + 1$$

4 **(a)**

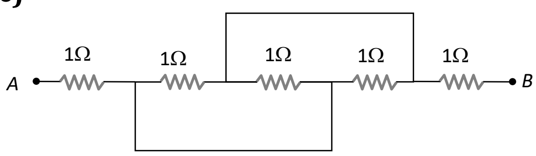
$$i = \frac{E}{R+r} = \frac{5}{4.5+0.5} = 1A$$

$$V = E - ir = 5 - 1 \times 0.5 = 4.5 \text{ Volt}$$

5 **(a)**

Specific resistance is independent of dimensions of conductor but depends on nature of conductor.

6 **(c)**




$$R_{AB} = 2 + \frac{1}{3} = 2\frac{1}{3}\Omega$$

7 **(d)**

As resistance of a bulb $R = \frac{V^2}{P}$,

Hence $R_1 : R_2 : R_3 = \frac{1}{100} : \frac{1}{60} : \frac{1}{60}$

Now the combined potential difference across $B_1$ and $B_2$is same as the potential difference across $B_3$. Hence, $W_3$ is more than $W_1$ and $W_2$, being in series, carry same current and $R_1 < R_2$, therefore $W_1 < W_2$,

$\therefore \; W_1 < W_2 < W_3$

8 **(a)**

$$I_1 = \frac{2}{2+4} \times 6 = 2A$$

$$I_2 = 4 \; amp$$

9 **(a)**

Current through resistance $P$ and $Q$,

$$i_1 = \frac{4}{90+110} = \frac{1}{50}\text{A}$$

$$V_A - V_B = Pi_1 = 90 \times \frac{1}{50} = 1.8 \text{ V}$$

Current through resistance $R$ and $S$,

$$i_2 = \frac{4}{40+60} = \frac{1}{25}\text{A}$$

$$V_A - V_D = Ri_2 = 40 \times \frac{1}{25} = 1.6 \text{ V}$$

$$V_B - V_D = (V_A - V_D) - (V_A - V_B)$$

$$= 1.6 - 1.8 = -0.2\text{V}$$

10 **(c)**

$$P = \frac{V^2}{R} \Rightarrow R_1 = \frac{V_1^2}{P_1} = \frac{(200)^2}{40} = 1000\Omega$$

and $R_2 = \frac{V_2^2}{P_2} = \frac{(200)^2}{100} = 400\Omega$

11 **(d)**

Mass, $M = \text{volume} \times \text{density} = Al \times d$

or $\quad A = M/ld$

Resistance $R = \rho l/A = \rho l/(M/ld)$

$$= \frac{\rho l^2 d}{M}$$

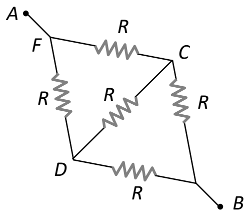
So $R \propto l^2/M$

Thus, $R_1 : R_2 : R_3 = \frac{l_1^2}{M_1} : \frac{l_2^2}{M_2} : \frac{l_3^2}{M_3}$

$= \frac{3^2}{1} : \frac{2^2}{2} : \frac{1^2}{3} = 27 : 6 : 1$

12 **(b)**

The given circuit can be redrawn as follows




Equivalent resistance between $A$ and $B$ is $R$ and current $i = \frac{V}{R}$

13 **(b)**

$R_{1000} = V^2/750$ and $R_{200} = V^2/P$;

Now, $R_{1000} = R_{200}(1 + \alpha \times 800)$

So, $\frac{V^2}{750} = \frac{V^2}{P}(1 + 4 \times 10^{-4} \times 800)$

or $P = 750(1 + 0.32) = 990$ W

14 **(c)**

Current through each arm

PRQ and PSQ=1A

$V_p - V_R = 3v$

$V_p - V_s = 7V$

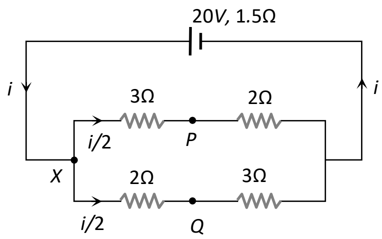
From Eqs. (i) and (ii), we get

$V_R - V_s = +4V$

15 **(d)**

$R_{eq} = \frac{5}{2}\Omega$

$i = \frac{20}{\frac{5}{2} + 1.5} = 5A$




Potential difference between $X$ and $P$,

$V_X - V_P = \left(\frac{5}{2}\right) \times 3 = 7.5V$ ....(i)

$V_X - V_Q = \frac{5}{2} \times 2 = 5V$ ....(ii)

On solving (i) and (ii) $V_P - V_Q = -2.5\ volt; V_Q > V_P$

**Short Trick :** $(V_P - V_Q) = \frac{i}{2}(R_2 - R_1) = \frac{5}{2}(2 - 3) = -2.5$

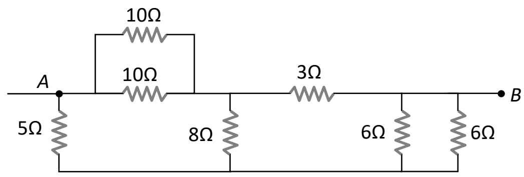
$\Rightarrow V_Q > V_P$

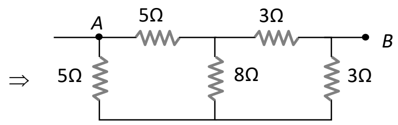
16 **(a)**

*Watt-hour meter* measures electric energy

17 **(b)**

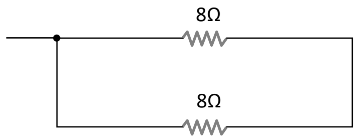
The given circuit can be simplified as follows




Now it is a balanced Wheatstone bridge

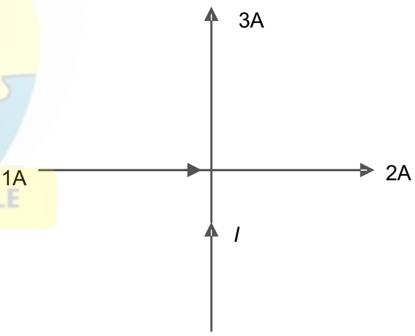
So,




$\Rightarrow R_{AB} = \frac{8 \times 8}{8 + 8} = \frac{64}{16} = 4\Omega$

18 **(a)**

From Kirchhoff's first law, in an electric circuit the algebraic sum of the currents meeting at any junction is zero,




*ie.*, $\sum i = 0$

∴ Taking inward direction of current as positive and outward as negative, we have

$1A - 3A - 2A + I = 0$

$\Longrightarrow \quad I = 4A$

19 **(a)**

Resistance of a wire $R = \frac{\rho L}{A} = \frac{4\rho L}{\pi D^2}$ where $D$ is diameter of wire

As $R \propto L$ and $R \propto \frac{1}{D^2}$, hence it is clear that resistance will be maximum if $\frac{L}{D^2}$ is maximum. On calculation we find

$\frac{L}{D^2}$ maximum when, $L = 50$ cm and $D = 0.5$ mm

20 **(b)**

21 **(d)**

Pressing the key does not disturb current in all resistances as the bridge is balanced. Therefore, deflection in the galvanometer in whatever direction it was, will stay

22 **(b)**

Heat produced by heater per second $= 1.08 \times 10^3$J

Heat taken by water to form steam $mL$

$= 100 \times 540$ cal

$= 100 \times 540 \times 4.2$ J

$\therefore 1.08 \times 10^3 \times t = 100 \times 540 \times 4.2$

or $t = \frac{100\times540\times4.2}{1.08\times10^3} = 210$ s

23 **(b)**

Power, $P = \frac{V^2}{R}$

$$R = \frac{V^2}{P} = \frac{(60)^2}{160} = 22.5\Omega$$

Now, according to Ohm's law

V=IR

$$\therefore\ I = \frac{60}{22.5}$$

$\Rightarrow I = 2.6A$

Here, $t = 60s$

As $\quad I = \frac{ne}{t}$

$$\Rightarrow\ n = \frac{I \times t}{e}$$

$$= \frac{26 \times 60}{1.6 \times 10^{-19}} \approx 10^{21}$$

24 **(a)**

Let the resistance of each heater wire is $R$. When two wires are connected in series, the heat developed is

$$H_1 = \frac{V^2 t}{2R} \qquad \ldots \text{(i)}$$

When two heater wires are connected in parallel, the heat developed is

$$H_2 = \frac{V^2 t}{R/2} = \frac{2V^2 t}{R} \qquad \ldots \text{(ii)}$$

Dividing Eq. (i) by Eq. (ii), we get

$$\frac{H_1}{H_2} = \frac{1}{4} \text{ or } H_1 : H_2 = 1 : 4$$

25 **(c)**

$$v_d = \frac{I}{nAe} = \frac{20}{10^{29} \times 10^{-6} \times 1.6 \times 10^{-19}}$$
$$= 1.25 \times 10^{-3} \text{m/s}$$

26 **(a)**

Resistance of bulb $R = \frac{V^2}{P}$

$$R \propto \frac{1}{P}$$

Here $P_X = 40$ W, and $P_Y = 60$ W

$\therefore \quad R_X > R_Y$

So, potential drop across bulb $X$ *ie*, of 40 W bulb will be greater and it will glow brighter.

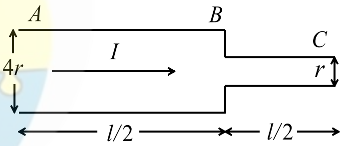
27 **(c)**

$$v_d = \frac{I}{nAl} = \frac{1}{nAe} \times \frac{V}{R}$$

$$= \frac{1}{nAe} \times \frac{V}{(\rho l/A)} = \frac{V}{ne\rho l}$$

As $v_d$ is independent of area of cross-section hence drift velocity will not change, when diameter is doubled

28 **(a)**




$$V_{AB} = I.R_{AB} = \frac{I.\rho.L_{AB}}{A_1} = \frac{I.\rho\left(\frac{L}{2}\right)}{\pi(2r)^2} = \frac{I\ \rho.\left(\frac{L}{2}\right)}{\pi 4r^2}$$

$$V_{AB} = \frac{I\ \rho.L}{8\pi r^2}$$

$$V_{BC} = I.R_{BC} = \frac{I.\rho.L}{A_2}$$

$$= \frac{I.\rho.\frac{L}{2}}{\pi(r^2)} = \frac{I.\rho.L}{2\pi r^2} \Rightarrow \frac{V_{AB}}{V_{BC}} = \frac{\frac{I.\rho.L}{8\pi r^2}}{\frac{I.\rho.L}{2\pi r^2}} = \frac{2}{8} = \frac{1}{4}$$

$$V_{AB} = \frac{V_{BC}}{4}$$

Now for power loss

$P_{AB} = V_{A.B}.I$

$P_{BC} = V_{BC}.I$

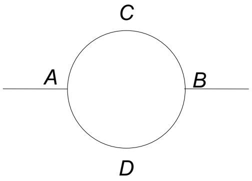
$$\frac{P_{AB}}{P_{BC}} = \frac{V_{AB}}{V_{BC}} = \frac{1}{4} \Rightarrow V_{AB} = \frac{P_{BC}}{4}$$

29 **(a)**

At point $A$ the slope of the graph will be negative. Hence resistance is negative

30 **(c)**

Given that the resistance of the total wire is 4Ω.




Here, $ACB(2\Omega)$ and $ADB\,(2\Omega)$ are in parallel.
So, the resistance across any diameter is

$$\Rightarrow \quad \frac{1}{R} = \frac{1}{2} + \frac{1}{2} = \frac{2}{2} = 1$$

$$\Rightarrow \quad R = 1\Omega$$

31 **(a)**

$$I = \frac{dq}{dt} = 3t^2 + 2t + 5$$

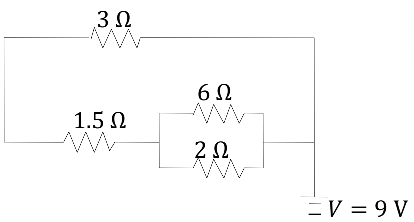
$$\therefore dq = (3t^2 + 2t + 5)dt$$

$$\therefore q = \int_{t=0}^{t=2} (3t^2 + 2t + 5)dt$$

$$= \frac{3t^3}{3} + \frac{2t^2}{2} + 5t\Big|_0^2 = t^3 + t^2 + 5t\Big|_0^2 = 22\,C$$

32 **(b)**

The equivalent circuit of the given circuit is as shown




Resistances $6\Omega$ and $2\Omega$ are in parallel

$$\therefore \quad R' = \frac{6 \times 2}{6 + 2} = \frac{3}{2}\Omega$$

Resistances $\frac{3}{2}\Omega$ and $1.5\Omega$ are in series

$$\therefore \quad R'' = \frac{3}{2} + 1.5 = 3\Omega$$

Resistances $3\Omega$ and $3\Omega$ are in parallel

$$\therefore \quad R = \frac{3 \times 3}{3 + 3} = \frac{3}{2}$$

The current, $I = \frac{V}{R}$

$$= \frac{9}{3/2} = 6A$$

33 **(a)**

If resistances of bulbs are $R_1$ and $R_2$ respectively then in parallel

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow \frac{1}{\left(\frac{V^2}{P_p}\right)} = \frac{1}{\left(\frac{V^2}{P_1}\right)} + \frac{1}{\left(\frac{V^2}{P_2}\right)}$$

$$\Rightarrow P_P = P_1 + P_2$$

34 **(a)**

$m\,n = 20$ ...(i)

For maximum current $R = n\,r/m$

or $2.5 = n \times 0.5/m$ or $n = 5m$

From Eq.(i), $m \times 5m = 20$ or $m^2 = 4$

or $m = 2$. Therefore, $n = 5 \times 2 = 10$

35 **(b)**

P.d. across the circuit $= 1.2 \times \frac{6\times4}{6+4} = 2.88\ volt$

Current through 6 $ohm$ resistance $= \frac{2.88}{6} = 0.48\,A$

36 **(d)**

Let the resistance of the wire be $R$, then we know that resistance is proportional to the length of the wire. So each of the four wires will have $R/4$ resistance and they are connected in parallel. So the effective resistance will be

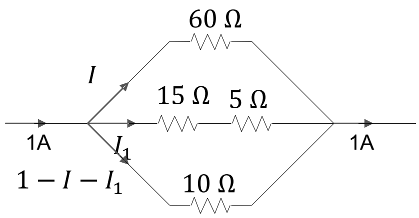
$$\frac{1}{R_1} = \left(\frac{4}{R}\right)4 \Rightarrow R_1 = \frac{R}{16}$$

37 **(c)**

Since, charge ($q$)=current ($i$) × times ($t$)
Therefore, charge is equal to area under the curve.
∴ Ist rectangle $= q = lb = 2$
IInd rectangle $= q = lb = 2$
IIIrd triangle $= q = \frac{1}{2}lb = 2$
Hence, ratio is 1:1:1.

38 **(a)**

All the resistances are in parallel order, so voltage across them will be equal.




$$\therefore \quad 60I = (15 + 5)I_1$$

$$\Rightarrow \quad 60I = 20I_1$$

$$\Rightarrow \quad I_1 = 3I$$

Again $\quad (15 + 5)I_1 = 10(1 - I - I_1)$

$$\Rightarrow \quad 2I_1 = 1 - I - I_1$$

$$\Rightarrow \quad 2(3I) = 1 - I - 3I$$

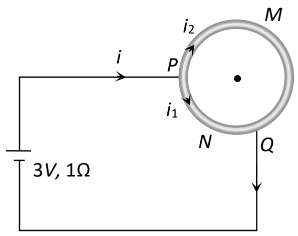
$$\Rightarrow \quad 6I + 4I = 1$$

$$\Rightarrow \quad 10I = 1$$

$$\therefore \quad I = \frac{1}{10} = 0.1A$$

39 **(a)**

In the following figure
Resistance of part $PNQ$;




$R_1 = \frac{10}{4} = 2.5\Omega$ and

Resistance of part $PMQ$;

$$R_2 = \frac{3}{4} \times 10 = 7.5\Omega$$

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2} = \frac{2.5 \times 7.5}{(2.5 + 7.5)} = \frac{15}{8}\Omega$$

Main Current $i = \frac{3}{\frac{15}{8}+1} = \frac{24}{23}A$

So, $i_1 = i \times \left(\frac{R_2}{R_1+R_2}\right) = \frac{24}{23} \times \left(\frac{7.5}{2.5+7.5}\right) = \frac{18}{23}A$

and $i_2 = i - i_1 = \frac{24}{23} - \frac{18}{23} = \frac{6}{23}A$

40 **(d)**

$$V_{AB} = 4 = \frac{5X + 2 \times 10}{X + 10} \Rightarrow X$$
$$= 20\Omega, \left[v = \frac{E_2 r_1 + E_1 r_2}{r_1 + r_2}\right]$$

41 **(a)**

Near room temperature, the electric resistance of a typical metal conductor increases linearly with temperature.

$R = R_0(1 + \alpha T)$

Where $\alpha$ is the thermal resistance coefficient.

42 **(b)**

$$v_d = \frac{i}{ne\pi r^2} \Rightarrow v_d \propto \frac{i}{r^2} \Rightarrow \frac{v}{v'} = \frac{i_1}{i_2} \times \left(\frac{r_2}{r_1}\right)^2 \Rightarrow v'$$
$$= \frac{v}{2}$$

43 **(a)**

Slope of the graph will give us reciprocal of resistance. Here resistance at temperature $T_1$is greater than that at $T_2$. Since resistance of metallic wire is more at higher temperature then at lower temperature, hence $T_1 > T_2$

44 **(b)**

In parallel $\frac{1}{t_p} = \frac{1}{t_1} + \frac{1}{t_2}$

$$t_p = \frac{t_1 t_2}{t_1 + t_2}$$

45 **(c)**

For the given meter bridge

$$\frac{P}{Q} = \frac{l_1}{100 - l_1}$$

$l_1 = 55cm \Rightarrow 100 - l_1 = 45cm$

$\because P = 3Q$

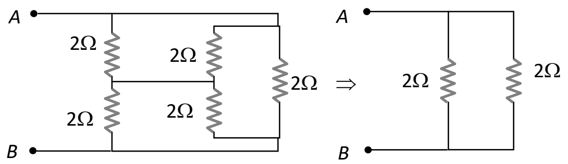
$$\Rightarrow Q = 3 \times \frac{45}{55} = 3 \times \frac{9}{11} = \frac{27}{11}\Omega$$

When $x$ is connected in series with $P$, $l_1 = 75cm$

$$\Rightarrow \frac{P + x}{Q} = \frac{75\ cm}{25\ cm} \Rightarrow 3 + x = 3 \times \frac{27}{11}$$

$$\Rightarrow x = \frac{81}{11} - 3 \Rightarrow x = \frac{48}{11}\Omega$$

46 **(a)**




$$R_{AB} = \frac{2 \times 2}{2 + 2} = 1\Omega$$

47 **(b)**

$R_2 = R_o(1 + \alpha t_2)$ and $R_{t_1} = R_o(1 + \alpha t_1)$

$$\therefore \frac{R_{t_2}}{R_{t_1}} = \frac{1 + \alpha t_2}{1 + \alpha t_1}$$

or $\frac{1.5}{1} = \frac{1+0.00125\times t_2}{1+0.00125\times 27}$

On solving we get; $t_2 = 454°C = 454 + 273 = 727K$

48 **(c)**

Charge ($q$) is given by

$$q = \int Idt$$

Given, $I = 1.2t + 3$

Integrating the expression using

$$\int x^n\,dx = \frac{x^{n+1}}{n+1}$$

We have

$$q = \int Idt = 1.2 \int t\,dt + 3\int dt$$

$$q = 1.2\left[\frac{t^2}{2}\right]_0^5 + 3[t]_0^5$$

$$q = \frac{1.2}{2} \times 25 + 3 \times 5$$

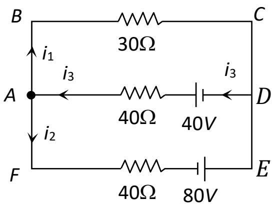
$$q = 15 + 15 = 30C$$

49 **(c)**

In series $P' = \frac{P}{n} = \frac{60}{3} = 20\ watts$

50 **(b)**

The circuit can be simplified as follows



Applying $KCL$ at junction $A$

$i_3 = i_1 + i_2$ ...(i)

Applying Kirchhoff's voltage law for the loop $ABCDA$

$-30i_1 - 40i_3 + 40 = 0$

$\Rightarrow -30i_1 - 40(i_1 + i_2) + 40 = 0$

$\Rightarrow 7i_1 + 4i_2 = 4$ ...(ii)

Applying Kirchhoff's voltage law for the loop $ADEFA$

$-40i_2 - 40i_3 + 80 + 40 = 0$

$\Rightarrow -40i_2 - 40(i_1 + i_2) = -120$

$\Rightarrow i_1 + 2i_2 = 3$ ...(iii)

On solving equation (ii) and (iii) $i_1 = -0.4A$

51 **(b)**

From the given circuit

$V_A - (6 \times 2) - 12 - (9 \times 2) + 4 - (5 \times 2) = V_B$

Or $V_A - 12 - 12 - 18 + 4 - 10 = V_B$

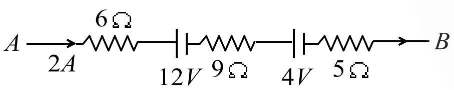
Or $V_A - V_B$ =48 volt

52 **(b)**

$P = i^2 R \Rightarrow \dfrac{\Delta P}{P} = \dfrac{2\Delta i}{i}$ $[R \to \text{Constant}]$

$\Rightarrow$ % change in power $= 2 \times$ % change in current $= 2 \times 1 = 2\%$

53 **(d)**




This is a series connection. Further, whatever current enters $A$ has to pass . $I = 2\ A$.

The total resistance $= 6 + 9 + 5 = 20\Omega$. The effective potential across the resistances is $20\Omega \times 2\text{A} = 40V$. But $(+12 - 4)V$ is opposing the potential difference caross $AB$ therefore the potential difference applied across $AB$ is $40V + 8V = 48V$

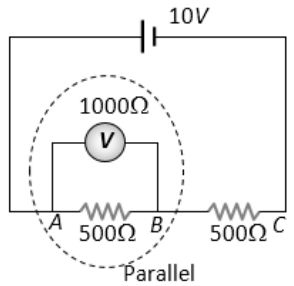
54 **(d)**

$$R = \frac{V}{i} = \frac{100 \pm 0.5}{10 \pm 0.2} = 10 \pm 0.25\Omega$$

55 **(d)**

Resistance between $A$ and $B = \frac{1000 \times 500}{(1500)} = \frac{1000}{3}$

So, equivalent resistance of the circuit




$$R_{eq} = 500 + \frac{1000}{3} = \frac{2500}{3}$$

∴ Current drawn from the cell

$$i = \frac{10}{(2500/3)} = \frac{3}{250}A$$

Reading of voltmeter $i.e.$

Potential difference across $AB = \frac{3}{250} \times \frac{1000}{3} = 4\ V$

56 **(c)**

From

$R_t = R_0(1 + \alpha t)$

$5 = R_o(1 + 50\alpha)$ ... $(i)$

and $6 = R_o(1 + 100\alpha)$ ... $(ii)$

$$\therefore \frac{5}{6} = \frac{1 + 50\alpha}{1 + 100\alpha}$$

$$\Longrightarrow \alpha = \frac{1}{200}$$

Putting value of $\alpha$in Eq. (i), we get

$$5 = R_0\left(1 + 50 \times \frac{1}{200}\right)$$

$\therefore R_0 = 4\Omega$

57 **(b)**

Current through each arm $DAC$ and $DBC = 1A$

$V_D - V_A = 2$ and $V_D - V_B - 3 \Rightarrow V_A - V_B = +1V$

58 **(b)**

Using the concept of balanced wheat stone bridge, we have

$$\frac{P}{Q} = \frac{R}{S}$$

$$\frac{x}{52 + 1} = \frac{10}{48 + 2}$$

$$x = \frac{10 \times 53}{50}$$

$$= 10.6\Omega$$

59 **(d)**

The three resistances between $A$ and $B$ are parallel,

$$\frac{1}{R_{\text{comb}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

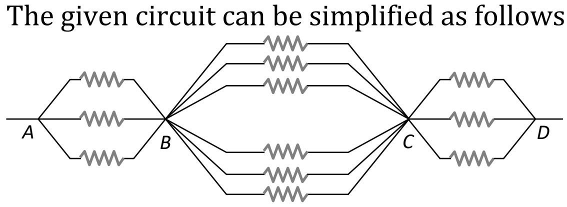
$$= \frac{1}{9} + \frac{1}{9} + \frac{1}{9}$$

$$\frac{1}{R_{\text{comb}}} = \frac{3}{9}$$

$\Longrightarrow$ $R_{\text{comb}} = 3\Omega$

60 **(c)**

The given circuit can be simplified as follows




$$\therefore R_{AD} = \frac{5R}{6}$$

61 **(d)**

In series, effective resistance,

$$R_{eff} = R_1 + R_2 + R_3 \Rightarrow \frac{1}{\sigma_{eff}} = \frac{1}{\sigma_1} + \frac{1}{\sigma_2} + \frac{1}{\sigma_3}$$
$$= \frac{\sigma_2\sigma_3 + \sigma_1\sigma_3 + \sigma_1\sigma_2}{\sigma_1\sigma_2\sigma_3}$$
$$\therefore \sigma_{eff} = \frac{\sigma_1\sigma_2\sigma_3}{\sigma_2\sigma_3 + \sigma_1\sigma_3 + \sigma_1\sigma_2}$$

62 **(a)**

$$H_1 = \frac{V^2}{R}t$$

$$H_2 = \frac{V^2}{R/2}t$$

$$\therefore \frac{H_2}{H_1} = 2$$

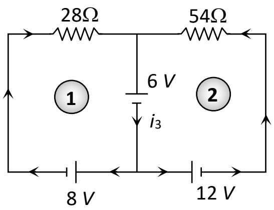
$$\Rightarrow H_2 = 2H_1$$

63 **(a)**

$$R = \rho\frac{l}{A} = \frac{m}{ne^2\tau}.\frac{l}{A}$$

64 **(d)**

Suppose current though different paths of the circuit is allows :




After applying $KVL$ for loop (1) and loop (2)

We get $28i_1 = -6 - 8 \Rightarrow i_1 = -\frac{1}{2}A$

and $54i_2 = -6 - 12 \Rightarrow i_2 = -\frac{1}{3}A$

hence $i_3 = i_1 + i_2 = -\frac{5}{6}A$

65 **(b)**

Heat produced $= \frac{V^2t}{4.2\,R} = mL$

or $m = \frac{V^2}{4.2\,R\,L} = \frac{(210)^2 \times 1}{4.2 \times 50 \times 80} = 2.62$ g

66 **(b)**

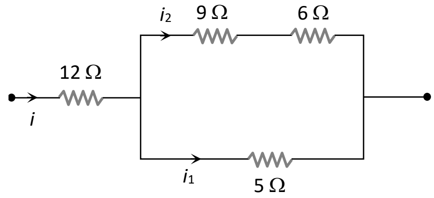
Current in the given circuit $i = \frac{50}{(5+7+10+3)} = 2A$

Potential difference between $A$ and $B$, $V_A - V_B = 2 \times 12$

$\Rightarrow V_A - 0 = 24V \Rightarrow V_A = 24\,V$

67 **(b)**

$$\frac{i_1}{i_2} = \frac{15}{5} = \frac{3}{1} \quad ...(i)$$




Also $\frac{H}{t} = i^2R \Rightarrow 45 = (i_1)^2 \times 5$

$\Rightarrow i_1 = 3\,A$ and from equation (i) $i_2 = 1\,A$

So $i = i_1 + i_2 = 4\,A$

Hence power developed in 12 Ω resistance

$P = i^2R = (4)^2 \times 12 = 192W$

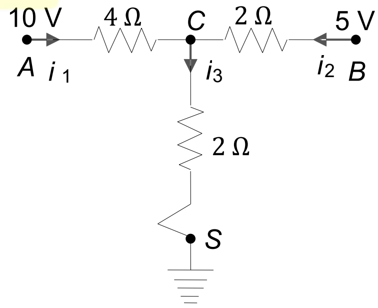
68 **(c)**

Let $V$ be the potential at $C$

Using Kirchhoff's first law $i_1 + i_2 = i_3$

$$\frac{10 - V}{4} + \frac{5 - V}{2} = \frac{V - 0}{2}$$

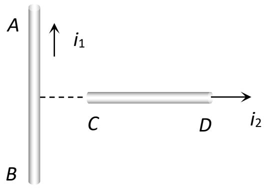
On solving, $V = 4$ Volt, $i_3 = \frac{V}{2} = \frac{4}{2} = 2$A




# Moving Charges and Magnetism

## RED ZONE

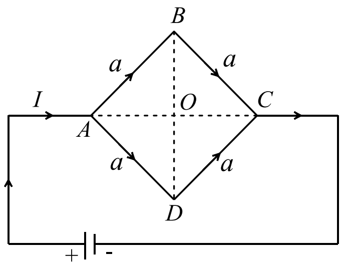
1. A particle moving in a magnetic field increases its velocity then its radius of the circle
   a) Decreases b) Increases c) Remains the same d) Becomes half
2. A wire carrying current $I$ and other carrying $2I$ in the same direction produces a magnetic field $B$ at the mid point. What will be the field when $2I$ wire is switched off
   a) $B/2$ b) $2B$ c) $B$ d) $4B$
3. An infinitely long straight conductor $AB$ is fixed and a current is passed through it. Another movable straight wire $CD$ of finite length and carrying current is held perpendicular to it and released. Neglect weight of the wire




   a) The rod $CD$ will move upwards parallel to itself
   b) The rod $CD$ will move downward parallel to itself
   c) The rod $CD$ will move upward and turn clockwise at the same time
   d) The rod $CD$ will move upward and turn anti-clockwise at the same time
4. Two similar coils of radius $R$ are lying concentrically with their planes at right angles to each other. The currents flowing in them are $I$ and $2I$, respectively. The resultant magnetic field induction at the centre will be
   a) $\frac{\sqrt{5}\mu_0 I}{2R}$ b) $\frac{3\mu_0 I}{2R}$ c) $\frac{\mu_0 I}{2R}$ d) $\frac{\mu_0 I}{R}$
5. A current of $i$ ampere flows in a circular area of wire which subtends an angle of $(3\pi/2)$ radian at its centre, whose radius is $R$. The magnetic induction $B$ at the centre is
   a) $\mu_0\, i/R$ b) $\mu_0\, i/2R$ c) $2\mu_0\, i/R$ d) $3\mu_0\, i/8R$
6. A wire in the form of a circular loop of one turn carrying a current produces a magnetic field $B$ at the centre. If the same wire is looped into a coil of two turns and carries the same current, the new value of magnetic induction at the centre is
   a) $3B$ b) $5B$ c) $4B$ d) $2B$

7. Two charged particles are projected into a region in which a magnetic field is perpendicular to their velocities. After they enter the magnetic field, you can conclude that
a) The charges are deflected in opposite directions
b) The charges continue to move in a straight line
c) The charges move in circular paths
d) The charges move in circular paths but in opposite directions
8. A thin circular wire carrying a current $I$ has a magnetic moment $M$. The shape of the wire is changed to a square and it carries the same current. It will have a magnetic moment
a) $M$ b) $\frac{4}{\pi^2}M$ c) $\frac{4}{\pi}M$ d) $\frac{\pi}{4}M$
9. Two parallel long wires carry currents $i_1$ and $i_2$ with $i_1 > i_2$. When the currents are in the same direction, the magnetic field midway between the wires is $10\mu T$. When the direction of $i_2$ is reversed, it becomes $40\ \mu T$. The ratio $i_1/i_2$ is
a) 3 : 4 b) 11 : 7 c) 7 : 11 d) 5 : 3

10. A circular current carrying coil has a radius $R$. The distance from the centre of the coil on the axis of the coil, where the magnetic induction is $\frac{1}{8}$th of its value at the centre of the coil is
a) $\sqrt{3}R$ b) $R/\sqrt{3}$ c) $\left(\frac{2}{\sqrt{3}}\right)R$ d) $\frac{R}{2\sqrt{3}}$
11. The coil of a galvanometer consists of 100 turns and effective area of 1 *square cm*. The restoring couple is $10^{-8} N - m/radian$. The magnetic field between the pole pieces is 5 $T$. The current sensitively of this galvanometer will be
a) $5 \times 10^{-4} rad/\mu\ amp$ b) $5 \times 10^{-6}\ per\ amp$ c) $2 \times 10^{-7} per\ amp$ d) $5\ rad/\mu\ amp$
12. A charged particle of mass $m$ and charge $q$ travels in a circular path of radius $r$ that is perpendicular to a magnetic field $B$. The time taken by the particle to complete one revolution is
a) $\frac{2\pi B}{m}$ b) $\frac{2\pi\ m}{q\ B}$ c) $\frac{2\pi\ mq}{B}$ d) $\frac{2\pi\ q^2 B}{m}$
13. A charged particle of mass $m$ and charge $q$ describes circular motion of radius $r$ in a uniform magnetic field of strength $B$. The frequency of revolution is
a) $\frac{Bq}{2\pi m}$ b) $\frac{Bq}{2\pi rm}$ c) $\frac{2\pi m}{Bq}$ d) $\frac{Bm}{2\pi q}$
14. The magnetic force acting on a charge particle of charge $-2\mu c$ in a magnetic field of $2T$ actin in $y$ direction, when the particle velocity is $(2i + 3j) \times 10^6 ms^{-1}$ is
a) 8 $N$ in $-z$ direction b) 8 $N$ in $z$ direction c) 8 $N$ in $y$ direction d) 8 $N$ in $z$ direction
15. Magnetic field induction at the centre $O$ of a square loop of side '$a$' carrying current $I$ as shown in figure is




a) $\frac{\mu_0 I}{\sqrt{2}\pi a}$ b) $2\sqrt{2}\frac{\mu_0 I}{\pi a}$ c) $\frac{2\mu_0 I}{\pi a}$ d) 0

16. A charge moves in a circle perpendicular to a magnetic field. The time period of revolution is independent of
a) Magnetic field b) Charge
c) Mass of the particle d) Velocity of the particle

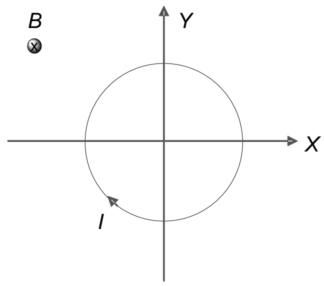
17. A stream of electrons is projected horizontally to the right. A straight conductor carrying a current is supported parallel to electron stream and above it. If the current in the conductor is from left to right, then what will be the effect on electron stream?

a) The electron stream will be speeded up towards the right
b) The electron stream will be retarded
c) The electron stream will be pulled upward
d) The electron stream will be pulled downward

18. The magnetic field at the centre of a circular current carrying conductor of radius $r$ is $B_c$. The magnetic field on its axis at a distance $r$ from the centre is $B_a$. The value of $B_c : B_a$ will be

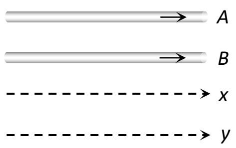
a) $1 : \sqrt{2}$
b) $1 : 2\sqrt{2}$
c) $2\sqrt{2} : 1$
d) $\sqrt{2} : 1$

19. A conducting loop carrying a current $I$ is placed in a uniform magnetic field pointing into the plane of the paper as shown. The loop will have a tendency to




a) Contract
b) Expand
c) Move towards +ve $x$ − axis
d) Move towards −ve $x$ − axis

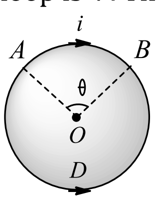
20. $A$ and $B$ are two conductors carrying a current $i$ in the same direction. $x$ and $y$ are two electron beams moving in the same direction





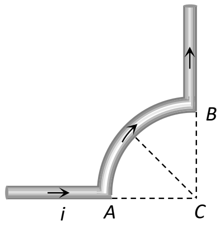

a) There will be repulsion between $A$ and $B$ attraction between $x$ and $y$
b) There will be attraction between $A$ and $B$ repulsion between $x$ and $y$
c) There will be repulsion between $A$ and $B$ and also $x$ and $y$
d) There will be attraction between $A$ and $B$ and also $x$ and $y$

21. Equal current $i$ flows in two segments of a circular loop in the direction shown in figure. Radius of the loop is $r$. The magnitude of magnitude field induction at the centre of the loop is




a) zero
b) $\frac{\mu_0}{4\pi}\frac{i\theta}{r}$
c) $\frac{\mu_0}{2\pi}\frac{i}{r}(\pi-\theta)$
d) $\frac{\mu_0}{2\pi}\frac{i}{r}(2\pi-\theta)$

22. A wire carrying current $i$ is shaped as shown. Section $AB$ is a quarter circle of radius $r$. The magnetic field is directed

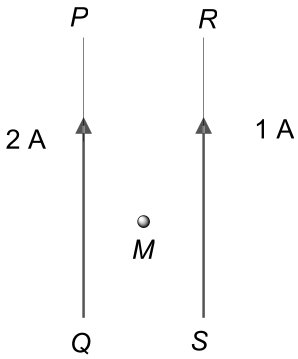



a) At an angle $\pi/4$ to the plane of the paper
b) Perpendicular to the plane of the paper and directed in to the paper
c) Along the bisector of the angle $ACB$ towards $AB$
d) Along the bisector of the angle $ACB$ away from $AB$

23. If same current $I$ passing through two parallel wires separated by a distance $b$, then force per unit length will be

a) $\frac{\mu_0}{4\pi}\frac{2I^2}{b}$ b) $\frac{\mu_0 I}{4\pi b^2}$ c) $\frac{\mu_0 I^2}{4\pi b^2}$ d) $\frac{\mu_0 I^2}{4\pi b}$

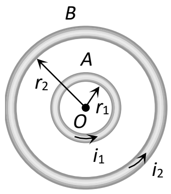
24. $PQ$ and $RS$ are long parallel conductors separated by certain distance. $M$ is the mid-point between them (see the figure). The net magnetic field at $M$ is $B$. Now, the current 2 A is switched off. The field at $M$ now becomes





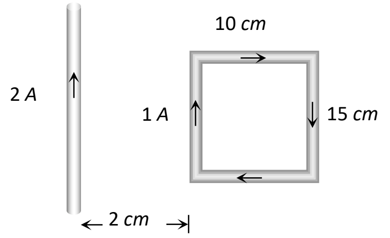

a) $2B$ b) $B$ c) $\frac{B}{2}$ d) $3B$

25. $A$ and $B$ are two concentric circular conductors of centre $O$ and carrying currents $i_1$ and $i_2$ as shown in the adjacent figure. If ratio of their radii is 1 : 2 and ratio of the flux densities at $O$ due to $A$ and $B$ is 1 : 3, then the value of $i_1/i_2$ is




a) 1/6 b) ¼ c) 1/3 d) ½

26. What is the net force on the square coil




a) $25 \times 10^{-7} N$ moving towards wire
b) $25 \times 10^{-7} N$ moving away from wire
c) $35 \times 10^{-7} N$ moving towards wire
d) $35 \times 10^{-7} N$ moving away from wire

27. An electron and a proton of equal linear momentum enter in the direction perpendicular to uniform magnetic field. If the radii of their circular paths be $r_e$ and $r_p$ respectively, then $\frac{r_e}{r_p}$, is equal to $m_e$ = mass of electron, $m_p$ = mass of proton.

a) $\left(\frac{m_p}{m_e}\right)^{1/2}$ b) $\frac{m_p}{m_e}$ c) $\left(\frac{m_e}{m_p}\right)^{1/2}$ d) 1

28. An electron of mass $m$ and charge $q$ is travalling with a speed $v$ along a circular path of radius $r$ at right angles to a uniform of magnetic field $B$. If speed of the electron is doubled and the magnetic field is halved, then resulting path would have a radius of

a) $\frac{r}{4}$ b) $\frac{r}{2}$ c) $2r$ d) $4r$

29. A charged particle enters in a magnetic field whose direction is parallel to velocity of the particle, then the speed of this particle

a) In straight line b) In coiled path c) In circular path d) In ellipse path

30. A long solenoid has 200 turns/cm and carries a current $i$. The magnetic field at its centre is $6.28 \times 10^{-2}$ Wb/m$^2$. Another long solenoid has 100 turns/cm and it carries a current $i/3$. The value of the magnetic field at its centre is

a) $1.05 \times 10^{-2}$ Wbm$^{-2}$ b) $1.05 \times 10^{-5}$ Wbm$^{-2}$ c) $1.05 \times 10^{-3}$ Wbm$^{-2}$ d) $1.05 \times 10^{-4}$ Wbm$^{-2}$

31. A charge $+Q$ is moving upwards vertically. It enters a magnetic field directed to north. The force on the charge will be towards

a) North b) South c) East d) West

32. The magnetic moment of a circular coil carrying current is

a) Directly proportional to the length of the wire in the coil
b) Inversely proportional to the length of the wire in the coil
c) Directly proportional to the square of the length of the wire in the coil
d) Inversely proportional to the square of the length f the wire in the coil

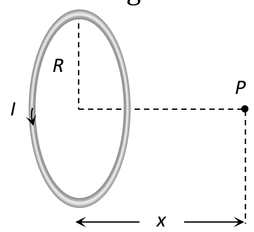
33. A galvanometer of resistance 100 Ω gives a full scale deflection for a current of $10^{-5}$ A. To convert it into a ammeter capable of measuring upto 1A, we should connect a resistance of

a) 1 Ω in parallel b) $10^{-3}$ Ω in parallel c) $10^{5}$ Ω in series d) 100 Ω in series

34. Two wires of same length are shaped into a square and a circle. If they carry same current, ratio of the magnetic moment is

a) $2 : \pi$ b) $\pi : 2$ c) $\pi : 4$ d) $4 : \pi$

35. A coil having $N$ turns carry a current $I$ as shown in the figure. The magnetic field intensity at point $P$ is




a) $\dfrac{\mu_0 NIR^2}{2(R^2+x^2)^{3/2}}$ b) $\dfrac{\mu_0 NI}{2R}$ c) $\dfrac{\mu_0 NIR^2}{(R+x)^2}$ d) Zero

36. In a cyclotron, the angular frequency of a charged particle is independent of
a) Mass b) Speed c) Charge d) Magnetic field

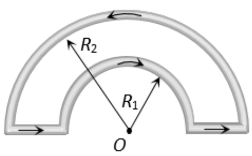
37. An electron and a proton are projected at right angles to a uniform magnetic field with the same kinetic energy. Then
a) The electron trajectory will be less curved than proton trajectory
b) The electron trajectory will be more curved than proton trajectory
c) Both the trajectories will be equally curved
d) Both particles continue to move along a straight line

38. An electron and a proton with equal momentum enter perpendicularly into a uniform magnetic field, then
a) The path of proton shall be more curved than that of electron
b) The path of proton shall be less curved than that of electron
c) Both are equally curved
d) Path of both will be straight line

39. A proton (mass $m$ and charge $+e$) and an $\alpha$-particle (mass $4m$ and charge $+2e$) are projected with the same kinetic energy at right angles to the uniform magnetic field. Which one of the following statements will be true
a) The $\alpha$-particle will be bent in a circular path with a small radius that for the proton
b) The radius of the path of the $\alpha$-particle will be greater than that of the proton
c) The $\alpha$-particle and the proton will be bent in a circular path with the same radius
d) The $\alpha$-particle and the proton will go through the field in a straight line

40. When a magnetic field is applied in a direction perpendicular to the direction of cathode rays, then their
a) Energy decreases
b) Energy increases
c) Momentum increases
d) Momentum and energy remain unchanged

41. The magnetic induction at the centre $O$ in the figure shown is



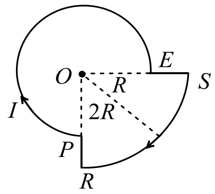

a) $\dfrac{\mu_0 i}{4}\left(\dfrac{1}{R_1}-\dfrac{1}{R_2}\right)$ b) $\dfrac{\mu_0 i}{4}\left(\dfrac{1}{R_1}+\dfrac{1}{R_2}\right)$ c) $\dfrac{\mu_0 i}{4}(R_1-R_2)$ d) $\dfrac{\mu_0 i}{4}(R_1+R_2)$

42. A proton, a deuteron and an α – particle with the same kinetic energy enter a region of uniform magnetic field moving at right angles to $B$. What is the ratio of the radii of their circular paths?
a) $1:\sqrt{2}:\sqrt{2}$ b) $1:\sqrt{2}:1$ c) $\sqrt{2}:1:1$ d) $\sqrt{2}:\sqrt{2}:1$

43. The forces existing between two parallel current carrying conductors is $F$. If the current in each conductor is doubled, then the value of force will be
a) $2F$ b) $4\,F$ c) $5\,F$ d) $F/2$

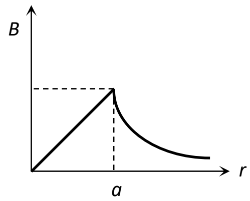
44. A beam of electrons and protons move parallel to each other in the same direction, then they
a) Attract each other
b) Repel each other
c) No relation
d) Neither attract nor repel

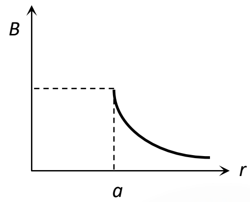
45. A current $I$ flowing through the loop as shown in figure. The magnetic field at centre $O$ is

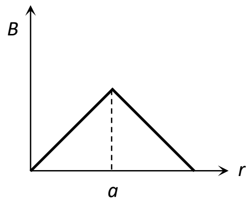


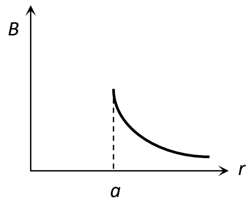

a) $\frac{7\,\mu_0 I}{16R}\otimes$
b) $\frac{7\,\mu_0 I}{16R}\odot$
c) $\frac{7\,\mu_0 I}{16R}\odot$
d) $\frac{5\,\mu_0 I}{16R}\odot$

46. The magnetic field due to a straight conductor of uniform cross section of radius $a$ and carrying a steady current is represented by

a) 

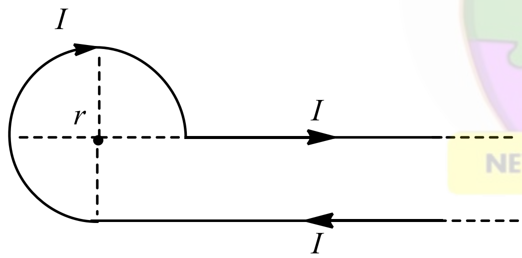

b) 


c) 


d) 


47. The deflection in a galvanometer falls from 50 division to 20 when a 12 Ω shunt is applied. The galvanometer resistance is
a) 18 Ω
b) 36 Ω
c) 24 Ω
d) 30 Ω

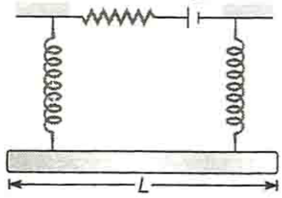
48. Current $I$ is flowing in conductor shaped as shown in the figure. The radius of the curved part is $r$ and the length of straight portion is very large. The value of the magnetic field at the centre $O$ will be






a) $\frac{\mu_0 I}{4\pi r}\left(\frac{3\pi}{2}+1\right)$
b) $\frac{\mu_0 I}{4\pi r}\left(\frac{3\pi}{2}-1\right)$
c) $\frac{\mu_0 I}{4\pi r}\left(\frac{\pi}{2}+1\right)$
d) $\frac{\mu_0 I}{4\pi r}\left(\frac{\pi}{2}-1\right)$

49. A straight rod of mass $m$ and length $L$ is suspended from the identical springs as shown in figure. The spring is stretched a distance $x_0$ due to the weight of the wire. The circuit has total resistance$R$. When the magnetic field perpendicular to the plane of paper is switched on, springs are observed to extend further by the same distance. The magnetic field strength is

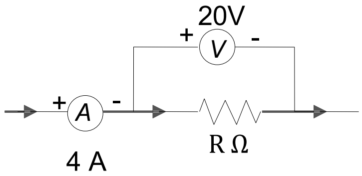



a) $\frac{2mgR}{LE}$
b) $\frac{mgR}{LE}$
c) $\frac{mgR}{2LE}$
d) $\frac{mgR}{E}$

50. Ampere's circuital law is equivalent to
a) Biot-Savart law
b) Coulomb's law
c) Faraday's law
d) Kirchhoff's law

51. We have a galvanometer of resistance 25 Ω. It is shunted by a 2.5 Ω wire. The part of total current $i_0$ that flows through the galvanometer is given as
a) $(i/i_0) = (1/11)$
b) $(i/i_0) = (1/10)$
c) $(i/i_0) = (1/9)$
d) $(i/i_0) = (2/11)$

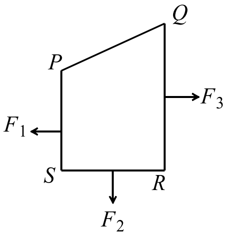
52. A candidate connects a moving coil ammeter $A$ and a moving coil voltmeter $V$ and a resistance $R$ as shown in figure




If the voltmeter reads 20 V and the ammeter reads 4 $A$, then $R$ is

a) Equal to 5 Ω
b) Greater than 5 Ω
c) Less than 5 Ω
d) Greater or less than 5 Ω depending upon its material

53. A closed loop $PQRS$ carrying a current is placed in a uniform magnetic field. If the magnetic forces on segment PS, SR and RQ are $F_1, F_2$ and $F_3$ respectively and are in the plane of the paper and along the directions shown, the force on the segment QP is




a) $\sqrt{(F_3 - F_1)^2 - F_2^2}$
b) $F_3 + F_1 - F_2$
c) $F_3 - F_1 + F_2$
d) $\sqrt{(F_3 - F_1)^2 + F_2^2}$

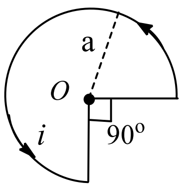
54. The relation between voltage sensitivity $(\sigma_v)$ and current sensitivity $(\sigma_i)$ of a moving coil galvanometer is (Resistance of galvanometer $= G$)

a) $\frac{\sigma_i}{G} = \sigma_v$
b) $\frac{\sigma_v}{G} = \sigma_i$
c) $\frac{G}{\sigma_v} = \sigma_i$
d) $\frac{G}{\sigma_i} = \sigma_v$

55. Which is a vector quantity

a) Density
b) Magnetic flux
c) Intensity of magnetic field
d) Magnetic potential

56. For the arrangement as shown in the figure, the magnetic induction at the centre is

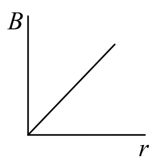


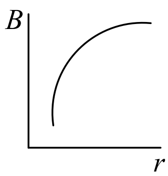

a) $\frac{3\mu_0 i\pi}{4a}$
b) $\frac{\mu_0 i}{4\pi a}(1+\pi)$
c) $\frac{\mu_0 i}{4\pi a}$
d) $\frac{3\mu_0 i}{8al}$

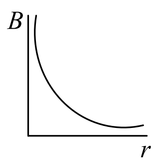
57. A proton, a deutron and an $\alpha -$ particle having the same kinetic energy are moving in circular trajectories in a constant magnetic field. If $r_p, r_d$ and $r_\alpha$ denote respectively the radii of the trajectories of these particles, then

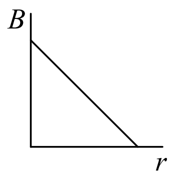
a) $r_\alpha = r_d > r_p$
b) $r_\alpha = r_d = r_p$
c) $r_\alpha < r_d < r_p$
d) $r_\alpha = r_p < r_d$

58. Which of the following graph represents the variation of magnetic flux density $B$ with distance $r$ for a straight long wire carrying an electric current?

a) 


b) 


c) 


d) 

59. An electron is revolving around a proton in a circular path of diameter 0.1 nm. It produces a magnetic field 14 T at a proton. Then the angular speed of the electron is

a) $8.8 \times 10^{6}$ rad $s^{-1}$ b) $4.4 \times 10^{16}$ rad $s^{-1}$ c) $2.2 \times 10^{16}$ rad $s^{-1}$ d) $1.1 \times 10^{16}$ rad $s^{-1}$

60. A uniform electric field and a uniform magnetic field exist in a region in the same direction. An electron is projected with a velocity pointed in the same direction. Then the electron will

a) Be deflected to the left without increase in speed

b) Be deflected to the right without increase in speed

c) Not be deflected but its speed will decrease

d) Not be deflected but its speed will increase

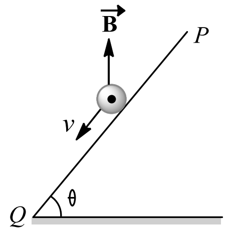
61. A particle of mass $m$, charge $Q$ and kinetic energy $T$ enters a transverse uniform magnetic field of induction $\vec{B}$. After 3 seconds the kinetic energy of the particle will be

a) $T$ b) $4T$ c) $3T$ d) $2T$

62. A charged particle is moving in a circular orbit of radius 6 cm with a uniform speed of $3 \times 10^{6} m/s$ under the action of a uniform magnetic field $2 \times 10^{-4} wb/m^{2}$ at right angles to the plane of the orbit. The charge to mass ratio of the particle is

a) $5 \times 10^{9} C/kg$ b) $2.5 \times 10^{11} C/kg$ c) $5 \times 10^{11} C/kg$ d) $5 \times 10^{12} C/kg$

63. A conducting rod of length $l$ and mass $m$ is moving down a smooth inclined plane of inclination θ with constant speed $v$. A vertically upward magnetic field $\vec{B}$ exists in space there. The magnitude of magnetic field $\vec{B}$ is




a) $\frac{mg}{il} \sin\theta$ b) $\frac{mg}{il} \cos\theta$ c) $\frac{mg}{il} \tan\theta$ d) $\frac{mg}{il \sin\theta}$

64. A beam of electrons passes undeflected through mutually perpendicular electric and magnetic fields. If the electric field is switched off and the same magnetic field is maintained the electrons move

a) In an elliptical orbit b) In a circular orbit

c) Along a parabolic path d) Along a straight line

65. A charged particle is projected in a plane perpendicular to a uniform magnetic field. The area bounded by the path described by the particle is proportional to

a) The velocity b) The momentum c) The kinetic energy d) None of these

66. A voltmeter with a resistance $50 \times 10^{3} \Omega$ is used to measure voltage in a circuit. To increase its range to 3 times, the additional resistance to be put in series is

a) $9 \times 10^{6} \Omega$ b) $10^{5} \Omega$ c) $1.5 \times 10^{5} \Omega$ d) $9 \times 10^{5} \Omega$

67. A galvanometer has a resistance $G$ and a current $i_g$ flowing in it produces full scale deflection. $S_1$ is the value of the shunt which converts it into a ammeter or range 0 to $i$ and $S_2$ is the value of the shunt for the range 0 to 2 $i$. The ratio $\frac{S_1}{S_2}$ is

a) $\left(\frac{2i - i_g}{i - i_g}\right)$ b) $\frac{1}{2}\left(\frac{i - i_g}{2i - i_g}\right)$ c) 2 d) 1

68. Energy in a current carrying coil is stored in the form of

a) Electrical energy b) Magnetic field c) Heat d) None of these

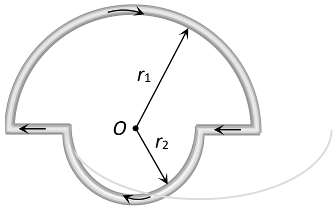
69. The dimension of the magnetic field intensity $B$ is

a) $MLT^{-2}A^{-1}$ b) $MT^{-2}A^{-1}$ c) $ML^{2}TA^{-2}$ d) $M^{2}LT^{-2}A^{-1}$

70. If in a circular coil $A$ of radius $R$, current $i$ is flowing and in another coil $B$ of radius $2R$ a current $2i$ is flowing, then the ratio of the magnetic fields, $B_A$ and $B_B$ produced by them will be

a) 1 b) 2 c) $\frac{1}{2}$ d) 4

71. In the figure shown there are two semicircles of radii $r_1$ and $r_2$ in which a current $i$ is flowing. The magnetic induction at the centre $O$ will be



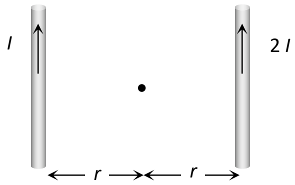

a) $\frac{\mu_0 i}{r}(r_1 + r_2)$ b) $\frac{\mu_0 i}{4}(r_1 - r_2)$ c) $\frac{\mu_0 i}{4}\left(\frac{r_1 + r_2}{r_1 r_2}\right)$ d) $\frac{\mu_0 i}{4}\left(\frac{r_2 - r_1}{r_1 r_2}\right)$

72. A uniform electric field and a uniform magnetic field are produced, pointing in the same direction. If an electron is projected with its velocity pointing in the same direction

a) The electron will turn to its right
b) The electron will turn to its left
c) The electron velocity will increase in magnitude
d) The electron velocity will decrease in magnitude

1 **(b)**
For motion of a charged particle in a magnetic field, we have $r = mv/qB$ $i.e. r \propto v$

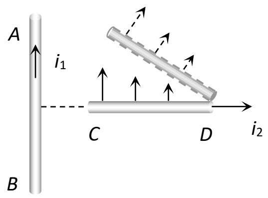
2 **(c)**
When two parallel conductors are carrying current $I$ and $2I$ in same direction, then magnetic field at the midpoint is




$$B = \frac{\mu_0 2l}{2\pi r} - \frac{\mu_0 I}{2\pi r} = \frac{\mu_0 I}{2\pi r}$$

When current $2I$ is switched off then magnetic field due to conductor carrying current $I$ is $B = \frac{\mu_0 I}{2\pi r}$

3 **(c)**
Since the force on the rod $CD$ is non-uniform it will experience force and torque. From the left hand side it can be seen that the force will be upward and torque is clockwise




4 **(a)**

$$B_1 = \frac{\mu_0 I}{2R}$$

$$B_2 = \frac{\mu_0 (2I)}{2R}$$

$$B_{net} = \sqrt{B_1^2 + B_2^2}$$

$$= \frac{\mu_0 (I)}{2R}\sqrt{1+4} = \frac{\sqrt{5}\mu_0 I}{2R}$$

5 **(d)**
For a loop, magnetic induction at centre,

$$B = \frac{\mu_0}{4\pi} \times \frac{2\pi i}{R}$$

When loop subtends angle θ at centre, then

$$B = \frac{\mu_0}{4\pi} \times \frac{\theta i}{R}$$

In the given problem, $\theta = 3\pi/2$

$$\therefore b = \frac{\mu_0}{4\pi} \times \frac{3\pi}{2} \times \frac{i}{R} = \frac{3\mu_0 i}{8R}$$

6 **(c)**
Magnetic field at the centre of a current carrying loop is given by

$$B = \frac{\mu_0 n i}{2r}$$

Here, $n =$ no. of turns in loop

$i =$ current, $r_1 =$ radius of loop, $r_1 = r$

For $n = 1$ turn

$$B = \frac{\mu_0 i}{2r_1} \qquad \text{...(i)}$$

When $n = 2$ turns and radius $r_2 = \frac{r}{2}, i_2 = i$

$$B_2 = \frac{\mu_0 \times 2 \times i}{2\left(\frac{r}{2}\right)}$$

or $B_2 = \frac{2\mu_0 i \times 2}{2r}$ ...(ii)

Now, from Eqs. (i) and (ii)

$$\frac{B_2}{B} = 4$$

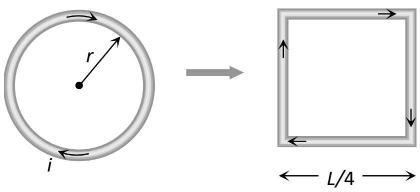
Hence, $B_2 = 4B$

7 **(c)**
When a charged particle is projected into a region of magnetic field such that magnetic field is perpendicular to the velocity vector of charged particles then charged particles will follow circular path.

8 **(d)**
Initially for circular coil $L = 2\pi r$ and $M = 1 \times \pi r^2$

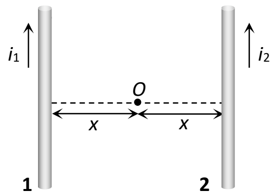
$$= i \times \pi \left(\frac{L}{2\pi}\right)^2 = \frac{iL^2}{4\pi} \qquad \text{... (i)}$$

Finally for square coil $M' = i \times \left(\frac{L}{4}\right)^2 = \frac{iL^2}{16}$ ... (ii)




Solving equation (i) and (ii) $M' = \frac{\pi M}{4}$

9 **(d)**
Initially when wires carry currents in the same direction as shown:
Magnetic field at mid point $O$ due to wires 1 and 2 are respectively



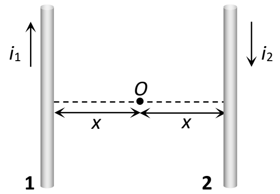

$B_1 = \frac{\mu_0}{4\pi}.\frac{2i_1}{x} \otimes$

and $B_2 = \frac{\mu_0}{4\pi}.\frac{2i_2}{x} \odot$

Hence net magnetic field at $O$ $B_{net} = \frac{\mu_0}{4\pi} \times \frac{2}{x} \times (i_1 - i_2)$

$\Rightarrow 10 \times 10^{-6} = \frac{\mu_0}{4\pi}.\frac{2}{x}(i_1 - i_2)$ ... (i)

If the direction of $i_2$ is reversed then




$B_1 = \frac{\mu_0}{4\pi}.\frac{2i_1}{x} \otimes$

and $B_2 = \frac{\mu_0}{4\pi}.\frac{2i_2}{x} \otimes$

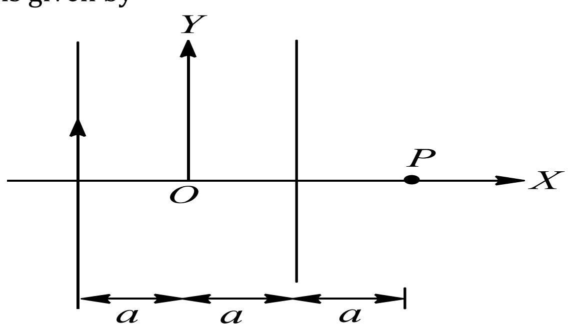
So $B_{net} = \frac{\mu_0}{4\pi}.\frac{2}{x}(i_1 + i_2)$

$\Rightarrow 40 \times 10^{-6} = \frac{\mu_0}{4\pi}.\frac{2}{x}(i_1 + i_2)$ ... (ii)

Dividing equation (ii) by (i) $\frac{i_1+i_2}{i_1-i_2} = \frac{4}{1} \Rightarrow \frac{i_1}{i_2} = \frac{5}{3}$

10 **(a)**

For a circular coil of radius $a$ carrying a current $i$, the magnetic field at point $P$, distance $x$ from coil is given by




$B = \frac{\mu_0 i a^2}{2(a^2 + x^2)^{3/2}}$ NA$^{-1}$ m$^{-1}$ ... (i)

At the centre of coil $x = 0$

$\therefore B' = \frac{\mu_0 i}{2a}$ NA$^{-1}$ m$^{-1}$ ... (ii)

Given, $B = \frac{1}{8} B'$

$\therefore \frac{\mu_0 i a^2}{2(a^2 + x^2)^{3/2}} = \frac{1}{8}\left(\frac{\mu_0 i}{2a}\right)$

$\Rightarrow \frac{a^2}{(a^2 + x^2)^{3/2}} = \frac{1}{8a}$

$\Rightarrow 8a^3 = (a^2 + x^2)^{3/2}$

$\Rightarrow a^2 + x^2 = 4a^2$

$\Rightarrow x = \sqrt{3}.a$

Given, $a = R$

$\therefore x = \sqrt{3}R$

11 **(d)**

Current sensitivity $\frac{\theta}{i} = \frac{NBA}{C}$

$\Rightarrow \frac{\theta}{i} = \frac{100 \times 5 \times 10^{-4}}{10^{-8}} = 5\, rad/\mu\, amp$

12 **(b)**

13 **(a)**

Time period is given by $T = \frac{2\pi m}{qB}$

$\Rightarrow$ Frequency $v = \frac{1}{T} = \frac{qB}{2\pi m}$

14 **(a)**

$\vec{F} = q(\vec{v} \times \vec{B}) = -2 \times 10^{-6}[\{(2\hat{\imath} + 3\hat{\jmath}) \times 10^6\} \times 2\hat{\jmath}]$

$\vec{F} = -8\hat{k}$

15 **(d)**

$AB$ and $DC$, $AD$ and $BC$ are in the opposite direction pairs. They are so situated that currents of each pair produce equal and opposite magnetic fields at the centre $O$ of the loop. Hence, the resultant magnetic field induction at the centre $O$ of the loop is zero

16 **(d)**

$T = \frac{2\pi m}{qB} \Rightarrow T\ \alpha\ v^o$

17 **(d)**

Magnetic field due to current through a linear conductor from the left to right at a point below the conductor is acting horizontally upwards. The electron beam moving from left to right will cause current right to left. The force on the electron will be vertically downwards according to Fleming's hand rule.

18 **(c)**

Magnetic induction at the centre of the coil of radius $r$ is

$B_c = \frac{\mu_0 n I}{2r}$ ... (i)

Magnetic induction on the axial line of a circular coil at a distance $x$ from the centre is

$B_a = \frac{\mu_0 n r^2 I}{2(r^2 + x^2)^{3/2}}$

Given $x = r$

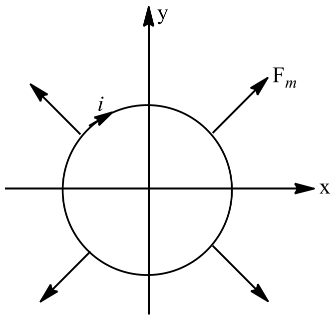
$\therefore\ B_a = \frac{\mu_0 n r^2 I}{2(2r^2)^{3/2}}$ ... (ii)

From Eqs. (i) and (ii), we get

$\frac{B_c}{B_a} = \frac{2\sqrt{2}}{1}$

19 **(b)**

Net force on a current carrying loop in uniform magnetic field is zero. Hence the loop can't translate. So, options (c) and (d) are wrong. From Fleming's left hand rule we can see that if magnetic field is perpendicular to paper inwards and current in the loop is clockwise (as shown) the magnetic force $\mathbf{F}_m$ on each element of the loop is radially outwards, or the loops will have a tendency to expand.




20 **(b)**

Current carrying conductors will attract each other, while electron beams will repel each other

21 **(c)**

Magnetic field induction at $O$ due to current through $ACB$ is $B_1 = \frac{\mu_0 i\theta}{4\pi r}$

It is acting perpendicular to the paper downwards.

Magnetic field induction at $O$ due to current through $ABD$ is $B_2 = \frac{\mu_0}{4\pi} \frac{i(2\pi-\theta)}{r}$

It is acting perpendicular to paper upwards.

$\therefore$ Total magnetic field at $O$ due to current loop is

$B = B_2 - B_1 = \frac{\mu_0}{4\pi}\frac{i}{r}(2\pi - \theta)\frac{\mu_0}{4\pi}\frac{i}{r}\theta$

$= \frac{\mu_0}{2\pi}\frac{i}{r}(\pi - \theta)$

22 **(b)**

Use Right hand palm rule or Maxwell's Cork screw rule

23 **(a)**

24 **(b)**

Magnetic field at mid-point $M$ in first case is $B = B_{PQ} - B_{RS}$

($\therefore B_{PQ}$ and $B_{RS}$ are in opposite directions)

$= \frac{4\,\mu_0}{4\pi d} - \frac{2\,\mu_0}{4\pi d} = \frac{2\,\mu_0}{4\pi d}$

When the current 2 A is switched off, the net magnetic field at $M$ is due to current 1 A

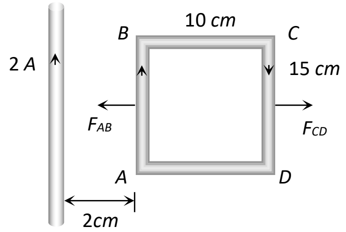
$B' = \frac{\mu_0 \times 2 \times 1}{4\pi d} = B$

25 **(a)**

$r_1 : r_2 = 1:2$ and $B_1 : B_2 = 1:3$. We know that $B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi n i}{r} \Rightarrow \frac{i_1}{i_2} = \frac{B_1 r_1}{B_2 r_2} = \frac{1 \times 1}{3 \times 2} = \frac{1}{6}$

26 **(a)**

Force on side $BC$ and $AD$ are equal but opposite so their net will be zero




But $F_{AB} = 10^{-7} \times \frac{2\times2\times1}{2\times10^{-2}} \times 15 \times 10^{-2} = 3 \times 10^{-6} N$

and $F_{CD} = 10^{-7} \times \frac{2\times2\times1}{(12\times10^{-2})} \times 15 \times 10^{-2} = 0.5 \times 10^{-6} N$

$\Rightarrow F_{net} = F_{AB} - F_{CD} = 2.5 \times 10^{-6} N$

$= 25 \times 10^{-7} N$, towards the wire

27 **(d)**

Given, linear momentum of electron = linear momentum of proton.

or $\quad m_e v_e = m_p v_p$

The radius of circular path is

$r = \frac{mv}{qB}$

For an electron the radius of circular path is

$r_e = \frac{m_e v_e}{qB}$

For a proton the radius of circular path is

$r_p = \frac{m_p v_p}{qB}$

Hence, $\frac{r_e}{r_p} = 1$

28 **(d)**

In a perpendicular magnetic field,

Magnetic force = centripetal force

$ie, \quad Bqv = \frac{mv^2}{r}$

$\Rightarrow \quad r = \frac{mv}{Br} \Rightarrow r \propto v^2$

$\therefore \frac{r_2}{r} = \frac{v_2^2}{v_1^2} = \left(\frac{2v}{v}\right)^2 = 4$

$\Rightarrow r_2 = 4r$

29 **(a)**

If the particle enters in the magnetic field parallel to the direction of the field, then it will move in a straight line.

30 **(a)**

Magnetic field due to a long solenoid is given by

$$B = \mu_0 ni$$

From given data,

$6.28 \times 10^{-2} = \mu_0 \times 200 \times 10^2 \times i$ ...(i)

and $\quad B = \mu_0 \times 100 \times 10^2 \times \left(\frac{i}{3}\right)$ ...(ii)

Solving Eqs. (i) and (ii), we get

$$B = 1.05 \times 10^{-2}\ \text{Wb/m}^2$$

31 **(d)**

32 **(c)**

$M = NiA \Rightarrow M \propto A \Rightarrow M \propto r^2$ [As $l = 2\pi r \Rightarrow l \propto r$]

$\Rightarrow M \propto l^2$

33 **(b)**

$G = 100\ \Omega$

$I_g = 10^{-5}$ A

$I = 1$ A

$S = ?$

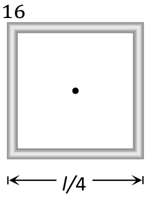
$I_g \times G = (I - I_g) \times S$

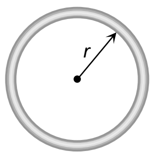
$S = \left(\frac{I_g}{I - I_g}\right) \times G = \frac{10^{-5}}{1 - 10^{-5}} \times 100$

Or $= \frac{10^{-3}}{1 - 0.00001} = 10^{-3}\ \Omega$

34 **(c)**

Suppose length of each wire is $l$. $A_{square} = \left(\frac{l}{4}\right)^2 = \frac{l^2}{16}$




$A_{circle} = \pi r^2 = \pi\left(\frac{l}{2\pi}\right)^2 = \frac{l^2}{4\pi}$

$\because$ Magnetic moment

$M = iA$

$\Rightarrow \frac{M_{square}}{M_{circle}} = \frac{A_{square}}{A_{circle}}$

$= \frac{l^2/16}{l^2/4\pi} = \frac{\pi}{4}$

35 **(a)**

36 **(b)**

$\omega = \frac{2\pi}{T} = \frac{qB}{m} \Rightarrow \omega \propto v^\circ \left[\because T = \frac{2\pi m}{qB}\right]$

37 **(b)**

$r = \frac{mv}{qB} = eV = evB \Rightarrow v = \frac{E}{B}$

Radius of electron's orbit will be more, so proton's trajectory will be less curved.

38 **(c)**

$r = mv/qB$

Since both have same momentum, therefore the circular path of both will have the same radius

39 **(c)**

$r = \frac{\sqrt{2mK}}{qB}$ i.e. $r \propto \frac{\sqrt{m}}{q}$

Here kinetic energy $K$ and $B$ are same

$\therefore \frac{r_p}{r_\alpha} = \frac{\sqrt{m_p}}{\sqrt{m_\alpha}} \cdot \frac{q_\alpha}{q_p} = \frac{\sqrt{m_p}}{\sqrt{4m_p}} \cdot \frac{2q_p}{q_p} = 1$

40 **(d)**

Since force is perpendicular to direction of motion, energy and magnitude of momentum remains constant

41 **(a)**

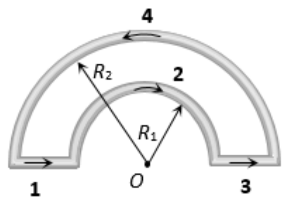
In the following figure, magnetic fields at $O$ due to section 1, 2, 3 and 4 are considered as $B_1, B_2, B_3$ and $B_4$ respectively

$B_1 = B_3 = 0$

$B_2 = \frac{\mu_0}{4\pi} \cdot \frac{\pi i}{R_1} \otimes$

$B_4 = \frac{\mu_0}{4\pi} \cdot \frac{\pi i}{R_2} \odot$ As $|B_2| > |B_4|$

So $B_{net} = B_2 - B_4 \Rightarrow B_{net} = \frac{\mu_0 i}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \otimes$




42 **(b)**

$\frac{mv^2}{R} = qvB$

For proton, $R_p = \frac{mv}{Bq} = \frac{\sqrt{2M_p E}}{q_p B}$

Similarly for deuteron and α-particle

$R_d = \frac{\sqrt{2M_d E}}{q_p B}$ and $R_\alpha = \frac{\sqrt{2M_\alpha E}}{q_\alpha B}$

According to the question

$\therefore R_p : R_d : R_\alpha$

or $\frac{\sqrt{M_p}}{q_p} : \frac{\sqrt{M_d}}{q_d} : \frac{\sqrt{M_\alpha}}{q_\alpha}$

$\therefore \frac{\sqrt{1}}{1} : \frac{\sqrt{2}}{1} : \frac{\sqrt{4}}{2}$ or $1 : \sqrt{2} : 1$

43 **(b)**

As, $F = \frac{\mu_0}{4\pi}\frac{2i_1i_2}{r}$ $ie, F \propto i_1 i_2$. Therefore force will becomes four time $ie$, $4F$.

44 **(a)**

45 **(a)**

The effective magnetic field at $O$

$$B = B_{PE} + B_{RS} = \frac{\mu_0}{4\pi}\cdot\frac{3}{2}\frac{\pi I}{R} + \frac{\mu_0}{4\pi}\cdot\frac{\pi}{2}\cdot\frac{I}{2R}$$

$$\Rightarrow B = \frac{\mu_0 I}{4R}\left[\frac{3}{2}+\frac{1}{4}\right] = \frac{7}{16}\frac{\mu_0 I}{R}$$

As per Fleming's Right Hand rule, direction of magnetic field is perpendicular and in the plane of paper

46 **(a)**

Magnetic field inside the conductor $B_{in} \propto r$ and magnetic field outside the conductor $B_{\text{out}} \propto \frac{1}{r}$

[where $r$ is the distance of observation point from axis]

47 **(a)**

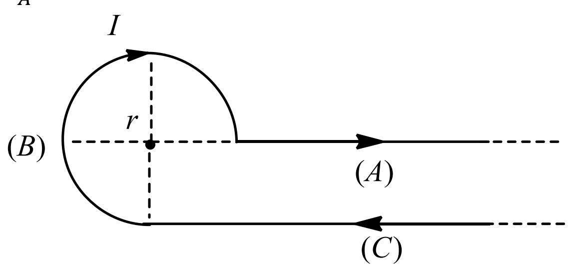
$i = 50\ k$; $i_g = 20k$, where $k$ is the figure of metit of galvanometer; $S = i_g G/(i - i_g)$;

So, $12 = \frac{20k.G}{(50k-20k)}$

On solving we get $G = 18\Omega$.

48 **(a)**

$B_A = 0$




$$B_B = \frac{\mu_0}{4\pi}\frac{(2\pi - \pi/2)I}{r} \otimes = \frac{\mu_0}{4\pi}\frac{3\pi I}{2r}$$

$$B_C = \frac{\mu_0 I}{4\pi r}\otimes$$

So, net magnetic field at the centre

$= B_A + B_B + B_C$

$$= 0 + \frac{\mu_0}{4\pi}\frac{3\pi I}{2r} + \frac{\mu_0 I}{4\pi r} = \frac{\mu_0}{4\pi}\frac{I}{r}\left(\frac{3\pi}{2}+1\right)$$

49 **(b)**

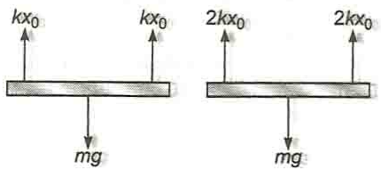
In the absence of magnetic field

$$mg = 2kx_0$$

.....(i)

the current in the rod is $i = \frac{E}{R}$

$\therefore$ Magnetic force on the rod is $F_m = BiL = \frac{ELB}{R}$




In downward direction

$\therefore$ $2kx_0 = mg + \frac{BLE}{LE}$

.....(ii)

From Eqs. (i) and (ii); we get $4kx_0 = 2kx_0 + \frac{BLE}{R}$

$$B = \frac{2kx_0R}{EL} = \frac{mgR}{LE}$$

50 **(a)**

51 **(c)**

$$i_g = \frac{iS}{G+S} = \frac{i_0 \times 2.5}{25+2.5} = \frac{i_0}{9}.$$

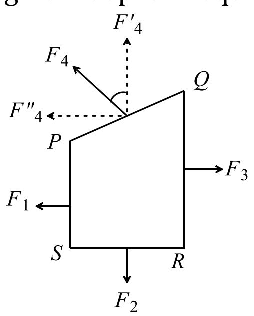
52 **(b)**

Here, $i = 4$A; V = 20 Volt; so,

$R = \frac{V}{I} = \frac{20}{4} = 5$A. Since, voltmeter is connected in parallel with resistance $R$, the effective resistance of this combination is 5 Ω only if the resistance $R$ is greater than 5Ω, since total resistance in parallel combination becomes less than individual resistance.

53 **(d)**

Since all the given forces are lying in plane, so the given loop is in equilibrium




$F_4'' = F_4 \cos\phi = F_2$

$F_4'''' = F_4 \sin\phi = F_3 - F_1$

$\Rightarrow F_4^2 = F_2^2 + (F_3 - F_1)^2$

$$\Rightarrow F_4 = \sqrt{F_2^2 + (F_3 - F_1)^2}$$

54 **(a)**

$$\sigma_i = \frac{\theta}{i} = \frac{\theta}{iG}.G = \sigma_v\ G{:}\ \frac{\sigma_i}{G} = \sigma_v$$

55 **(c)**

56 **(d)**

$$B = \frac{\mu_0 ia}{4\pi r} = \frac{\mu_0}{4\pi a}.\frac{3\pi}{2}$$
$$= \frac{3\mu_0 i}{8a}$$

57 **(a)**

58 **(c)**

Magnetic field induction at a point due to a long current carrying wire is related with distance $r$ by relation $B \propto 1/r$. Therefore graph (c) is correct.

59 **(b)**

Here, $2r = 0.1$ nm $= 0.1 \times 10^{-9}$ m $= 10^{-10}$ m;

$$i = \frac{e}{T} = \frac{e\omega}{2\pi}$$

Now, $B = \frac{\mu_0}{4\pi}\frac{2\pi ni}{r} = \frac{\mu_0}{4\pi}\frac{2\pi n}{r}\left(\frac{e\omega}{2\pi}\right)$

$$= \frac{\mu_0}{4\pi}\frac{ne\omega}{r}$$

Or $\omega = B.\left(\frac{4\pi}{\mu_0}\right) \times \frac{r}{ne}$

$$= 14 \times \frac{1}{10^{-7}} \times \frac{(10^{-10})/2}{1 \times 1.6 \times 10^{-19}}$$
$$= 4.4 \times 10^{16} \text{ rads}^{-1}.$$

60 **(c)**

Magnetic force on electron $= Bev \sin\theta$

$= Bev \sin 0 =$ zero

Electron will not be deflected due to magnetic field. Electric force on electron $= Ee$

This force is opposite to direction of motion of the electron. The speed of electron will decrease.

Hence the electron will not be deflected but its speed is decreased

61 **(a)**

When a charged particle having K.E. $T$ is subjected to a transverse uniform magnetic field, it describes a circular path in the magnetic field without any change in its speed. Thus, the K.E. of the charged particle remains $T$ at all times

62 **(b)**

Here, $v = 3 \times 10^6 ms^{-1}$,

$B = 2 \times 10^{-4} wb\ m^{-2} = 2 \times 10^{-4} T$

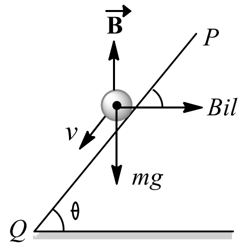
$R = 6cm = 6 \times 10^{-2} m$. As $Bqv = \frac{mv^2}{R}$ or $\frac{q}{m} = \frac{v}{BR}$

Substituting the given values, we get

$$\frac{q}{m} = \frac{3 \times 10^6}{2 \times 10^{-4} \times 6 \times 10^{-2}} = 0.25 \times 10^{12} C/kg$$
$$= 2.5 \times 10^{11} C/kg$$

63 **(c)**

Magnetic force on the rod $F_m = Bil$. It acts in the direction as shown in figure. The rod will move with a constant speed if the net force on the rod is zero. It will be so if

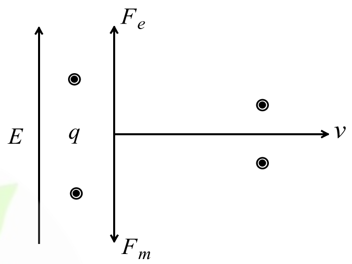



$Bil \cos\theta = mg \sin\theta$

Or $B = \frac{mg}{il}\frac{\sin\theta}{\cos\theta} = \frac{mg}{il} \tan\theta$

64 **(b)**

If both electric and magnetic fields are present and perpendicular to each other and the particle is moving perpendicular to both of them with $F_e = F_m$. In this situation $\vec{\mathbf{E}} \neq 0$ and $\vec{\mathbf{B}} \neq 0$.




But if electric field becomes zero, then only force due to magnetic field exists. Under this force, the charge moves along a circle

65 **(c)**

$r = \frac{\sqrt{2mK}}{qB}$ and $A = \pi r^2 \Rightarrow A = \frac{\pi(2mK)}{q^2B^2} \Rightarrow A \propto K$

66 **(b)**

$V = i_g R$ and $V' = i_g R'$ or $\frac{R'}{R} = \frac{V'}{V}$

Or $R' = \frac{V'}{V}R = \frac{3V}{V} \times 50 \times 10^3 = 1.5 \times 10^5 \Omega$

∴ Additional resistance

$= 1.5 \times 10^5 - 0.5 \times 10^5 = 10^5\ \Omega$

67 **(a)**

$$S_1 = \frac{i_g G}{i - i_g}; S_2 = \frac{i_g G}{2i - i_g}; \text{so}, \frac{S_1}{S_2} = \left(\frac{2i - i_g}{i - i_g}\right)$$

68 **(b)**

69 **(b)**

$$F = Bil \Rightarrow [B] = \frac{[F]}{[i][l]} = \frac{MLT^{-2}}{AL} = MT^{-2}A^{-1}$$

70 **(a)**

Magnetic field in circular coil $A$ is

Similarly, $B_A = \frac{\mu_0 Ni}{2R}$

$R$ is radius and $i$ is current flowing in coil.

$$B_B = \frac{\mu_0 N(2i)}{2.(2R)}$$

$$= \frac{\mu_0 Ni}{2R}$$

$$\frac{B_A}{B_B} = \frac{1}{1} = 1$$

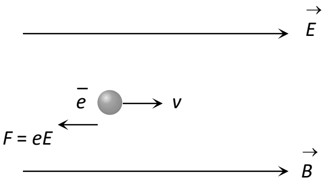
71 **(c)**

The magnetic induction due to both semicircular parts will be in the same direction perpendicular to the paper inwards

$$\therefore B = B_1 + B_2 = \frac{\mu_0 i}{4r_1} + \frac{\mu_0 i}{4r_2} = \frac{\mu_0 i}{4}\left(\frac{r_1 + r_2}{r_1 r_2}\right) \otimes$$

72 **(d)**

Since electron is moving parallel to the magnetic field, hence magnetic force on it $F_m = 0$




The only force acting on the electron is electric force which reduces it's speed


# Magnetism and Matter

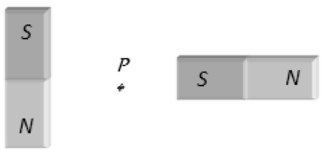
1. A solenoid has core of a material with relative permeability 500 and its windings carry a current of $1A$. The number of turns of the solenoid is 500 per metre. The magnetization of the material is nearly
a) $2.5 \times 10^3\ Am^{-1}$ b) $2.5 \times 10^5\ Am^{-1}$ c) $2.0 \times 10^3\ Am^{-1}$ d) $2.0 \times 10^5\ Am^{-1}$

2. Curie's law can be written as
a) $\chi \propto (T - T_c)$ b) $\chi \propto \frac{1}{T - T_c}$ c) $\chi \propto \frac{1}{T}$ d) $\chi \propto T$

3. A magnet of magnetic moment $M$ is rotated through 360° in a magnetic field $H$. The work done will be
a) $MH$ b) $2MH$ c) $2\pi MH$ d) Zero

4. The force between two magnetic poles is $F$. If the distance between the poles and pole strengths of each pole are doubled, then the force experienced is
a) $2F$ b) $\frac{F}{2}$ c) $\frac{F}{4}$ d) $F$

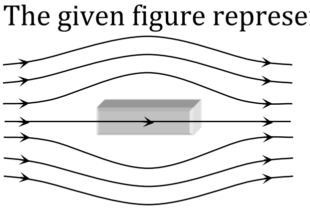
5. Two equal bar magnets are kept as shown in the figure. The direction of resultant magnetic field, indicated by arrowhead at the point $P$ is (approximately)




a) $\longrightarrow$ b) $\nearrow$ c) $\searrow$ d) $\uparrow$

6. A magnetic dipole is placed at right angles to the direction of lines of force of magnetic induction $B$. If it is rotated through an angle of 180°, then the work done is
a) $MB$ b) $2\ MB$ c) $-2\ MB$ d) Zero

7. The given figure represents a material which is



a) Paramagnetic b) Diamagnetic c) Ferromagnetic d) None of these

8. The magnetic field of a small bar magnet varies in the following manner by the influence of a magnet placed at a large distance $d$.
a) $\frac{1}{d}$ b) $\frac{1}{d^2}$ c) $\frac{1}{d^3}$ d) $\frac{1}{d^4}$

9. The effect due to uniform magnetic field on a freely suspended magnetic needle is as follows
a) Both torque and net force are present b) Torque is present but no net force
c) Both torque and net force are absent d) Net force is present but not torque

10. Two magnets, each of magnetic moment '$M$' are placed so as to form a cross at right angles to each other. The magnetic moment of the system will be

a) $2\ M$ b) $\sqrt{2}\ M$ c) $0.5\ M$ d) $M$

11. Which of the following is true

a) Diamagnetism is temperature dependent

b) Paramagnetism is temperature dependent

c) Paramagnetism is temperature dependent

d) None of these

12. A steel wire of length $l$ has a magnetic moment $M$. It is bent at its middle point at an angle of 60°. Then the magnetic moment of new shape of wire will be

a) $M/\sqrt{2}$ b) $M/2$ c) $M$ d) $\sqrt{2}M$

13. Two bar magnets having same geometry with magnetic moments $M$ and $2\ M$ are firstly placed in such a way that their poles are same side. Time period of oscillations is $T_1$. Now the polarity of one of the magnets is reversed, and time period of oscillations is $T_1$. Now the polarity of one of the magnets is reversed, and time period of oscillations is $T_2$.

a) $T_1 < T_2$ b) $T_1 = T_2$ c) $T_1 > T_2$ d) $T_2 = \infty$

14. The incorrect statement regarding the lines of force of the magnetic field $B$ is

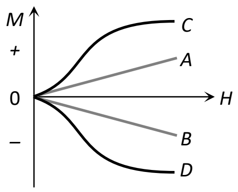
a) Magnetic intensity is a measure of lines of force passing through unit area held normal to it

b) Magnetic lines of force form a closes curve

c) Inside a magnet, its magnetic lines of force move from north pole of a magnet towards its south pole

d) Due to a magnet magnetic lines of force never cut each other

15. The most appropriate magnetization $M$ versus magnetizing field $H$ curve for a paramagnetic substance is




a) $A$ b) $B$ c) $C$ d) $D$

16. Resultant force acting on a diamagnetic material in a magnetic field is in direction

a) From stronger to the weaker part of the magnetic field

b) From weaker to the stronger part of the magnetic field

c) Perpendicular to the magnetic field

d) In the direction making 60° to the magnetic field

17. The dimensions of magnetic permeability are

a) $[\mathrm{MLT^{-2}A^{-2}}]$ b) $[\mathrm{ML^2T^{-2}A^{-2}}]$ c) $[\mathrm{ML^2T^{-2}A^{-1}}]$ d) $[\mathrm{M^{-1}LT^{-2}A^{-2}}]$

18. Choose the correct statement

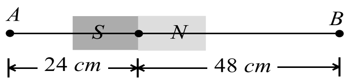
a) A paramagnetic material tends to move from a strong magnetic field to weak magnetic field

b) A magnetic material is in the paramagnetic phase below its Curie temperature

c) The resultant magnetic moment in an atom of a diamagnetic substance is zero

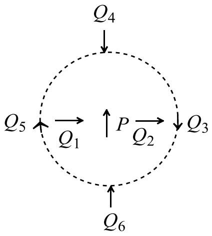
d) Typical domain size of a ferromagnetic material is 1 nm

19. A bar magnet of length 3 $cm$ has points $A$ and $B$ along its axis at distances of 24 $cm$ and 48 $cm$ on the opposite sides. Ratio of magnetic fields at these points will be




a) 8 b) $1/2\sqrt{2}$ c) 3 d) 4

20. The figure shows the various positions (labelled by subscripts) of small magnetised needless $P$ and $Q$. The arrows show the direction of their magnetic moment. Which configuration corresponds to the lowest potential energy among all the configurations shown




a) $PQ_3$ b) $PQ_4$ c) $PQ_5$ d) $PQ_6$

21. Ferromagnetic show their properties due to

a) Filled inner subshells
b) Vacant inner subshells
c) Partially filled inner subshells
d) All the subshells equally filled

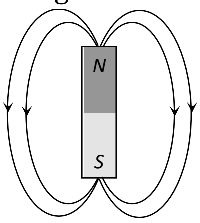
22. The strength of the magnetic field in which the magnet of a vibration magnetometer is oscillating is increased 4 times its original value. The frequency of oscillation would then become

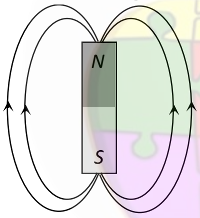
a) Twice its original value
b) Four times it original value
c) Half its original value
d) One-fourth its original value

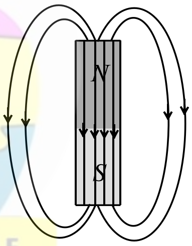
23. The magnetic susceptibility of any paramagnetic material changes with absolute temperature $T$ as

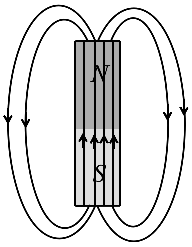
a) Directly proportional to $T$
b) Remains constant
c) Inversely proportional to $T$
d) Exponentially decaying with $T$

24. The magnetic field lines due to a bar magnet are correctly shown in

a)


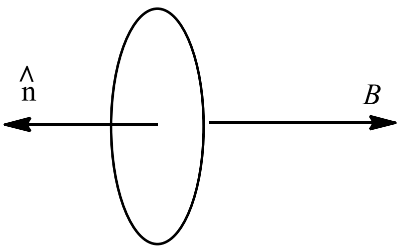

b)


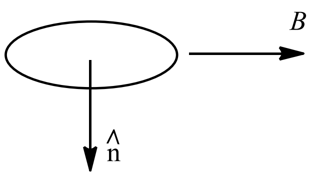

c)



d)


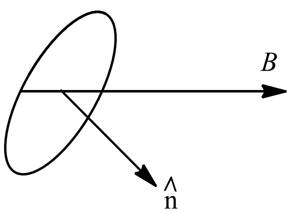


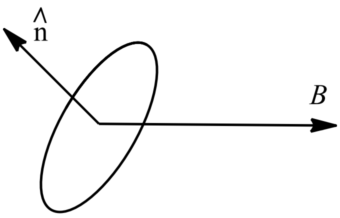

25. A current carrying loop is placed in a uniform magnetic field in four different orientations, I, II, III and IV, arrange them in the decreasing order of potential energy

I.



II.



II. IV.




a) I $> III > II > IV$ b) I $> II > III > IV$ c) I $> IV > II >$ III d) III $> IV > I > II$

26. Magnetic lines of force
a) Always intersect
b) Are always closed
c) Tend to crowd far away from the poles of magnet
d) Do not pass through vacuum

27. With a standard rectangular bar magnet the time period of a vibration magnetometer is 4 s. The bar magnet is cut parallel to its length into four equal pieces. The time period of vibration magnetometer when one piece is used (in second) (bar magnet breadth is small) is
a) 16
b) 8
c) 4
d) 2

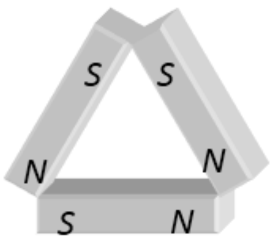
28. The time period of oscillation of a bar magnet suspended horizontally along the magnetic meridian is $T_0$. If this magnet is replaced by another magnet of the same size and pole strength but with double the mass, the new time period will be
a) $\frac{T_0}{2}$
b) $\frac{T_0}{\sqrt{2}}$
c) $\sqrt{2}T_0$
d) $2T_0$

29. If a ferromagnetic material is inserted in a current carrying solenoid, the magnetic field of solenoid
a) Large increases
b) Slightly increases
c) Largely decreases
d) Slightly decreases

30. Which one of the following characteristics is not associated with a ferromagnetic material?
a) It is strongly attracted by a magnet
b) It tends to move from a region of strong magnetic field to a region of low magnetic field
c) Its origin is the spin of electrons
d) Above the Curie temperature, it exhibits paramagnetic properties

31. If a magnetic substance is kept in a magnetic field then which of the following substance is thrown out?
a) Paramagnetic
b) Ferromagnetic
c) Diamagnetic
d) Antiferromagnetic

32. Three identical bar magnets each of magnetic moment $M$ are placed in the form of an equilateral triangle as shown. The net magnetic moment of the system is




a) Zero
b) $2M$
c) $M\sqrt{3}$
d) $\frac{3M}{2}$

33. A magnet of magnetic moment $M$ and pole strength $m$ is divided in two equal parts, then magnetic moment of each part will be
a) $M$
b) $M/2$
c) $M/4$
d) $2M$

1 **(b)**

Here, $n = 500$ turns/m, $I = 1A, \mu_r = 500$

Magnetic intensity, $H = nI = 500m^{-1} \times 1A = 500Am^{-1}$

As $\mu_r = 1 + \chi$, where $\chi$ is the magnetic susceptibility of the material

or $\chi = (\mu_r - 1)$

Magnetisation, $M = \chi H = (\mu_r - 1)H$

$= (500 - 1) \times 500Am^{-1} = 499 \times 500Am^{-1}$

$= 2.495 \times 10^5\ Am^{-1}$

$= 2.5 \times 10^5\ Am^{-1}$

2 ©

3 **(d)**

$W = MB(\cos\theta_1 - \cos\theta_2);\ \theta_1 = 0°$ and $\theta_2 = 360° \Rightarrow W = 0$

4 **(d)**

$$F = \frac{\mu_0}{4\pi}.\frac{m_1 m_2}{r^2} \qquad \text{... (i)}$$

When pole strength of each pole become double.

$$\therefore\ F' = \frac{\mu_0}{4\pi}.\frac{(2m_1)(2m_2)}{(2r)^2} = F$$

5 **(b)**

6 **(d)**

$\theta_1 = 90°, \theta_2 = 270°,$

$W = -MB[\cos 270° - \cos 90°]$ =zero

7 **(b)**

8 ©

Magnetic field due to short magnet

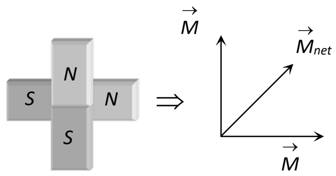
$$B = 10^{-7}\frac{2M}{d^3}$$

Or $B \propto \frac{1}{d^3}$

9 **(b)**

When a magnetic needle is placed in a uniform magnetic field, equal and opposite forces act on the poles of the needle which give rise to a torque, but not net force.

10 **(b)**



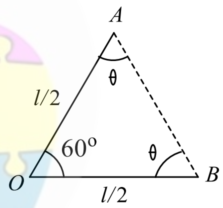

$\Rightarrow M_{net} = \sqrt{M^2 + M^2} = \sqrt{2}\,M$

11 **(b)**

With rise in temperature their magnetic susceptibility decrease, $i.e., \chi_m \propto \frac{1}{T}$

12 **(b)**

Pole strength $= m = \frac{M}{l}$. When the wire is bent at its middle point $O$ at 60°, then as is clear from figure.




$60° + \theta + \theta = 180°$

$2\theta = 180° - 60° = 120°,$

$\therefore OAB$ is an equilateral triangle.

$\therefore AB = 2l' = l/2$

New magnetic moment

$$M' = m(2l') = \frac{ml}{2} = \frac{M}{2}$$

13 **(a)**

When polarity is reversed, net magnetic moment $2M - M = M$, decreases. Therefore time period of oscillation increases $ie, T_2 > T_1$ or $T_1 < T_2$.

14 ©

Inside a magnet, magnetic lines of force move from south pole to north pole

15 **(a)**

For paramagnetic substance magnetization $M$ is proportional to 5agnetizing field $H$, and $M$ is positive

16 **(a)**

Resultant force acting on a diamagnetic material in a magnetic field is in direction from stronger to the weaker part of the magnetic field.

17 **(a)**

From Coulomb's law, $F = \frac{\mu_0}{4\pi}\frac{m_1 m_2}{r^2}$; where, $m_1, m_2$ are pole strengths

$\therefore \mu_0 = \frac{4\pi r^2 F}{m_1 m_2} = \frac{[L^2(MLT^{-2})]}{(AL)^2} = [MLT^{-2}A^{-2}]$

18 ©

Diamagnetic substances are those substances in which resultant magnetic moment in an atom is zero.

A paramagnetic material tends to move from a weak magnetic field to strong magnetic field.

A magnetic material is in the paramagnetic phase above its Curie temperature.

Typical domain size of a ferromagnetic material is 1 mm.

The susceptibility of a ferromagnetic material is $\chi >> 1$

19 **(a)**

Both points $A$ and $B$ lie on axial position

$B \propto \frac{1}{d^3} \Rightarrow \frac{B_A}{B_B} = \left(\frac{d_B}{d_A}\right)^3 = \left(\frac{48}{24}\right)^3 = \frac{8}{1}$

20 **(d)**

$PQ_6$ corresponds to the lowest potential energy among all the configurations shown

21 ©

Partially filled inner subshells are responsible for ferro-magnetic behaviour of such substances.

22 **(a)**

Frequency $v \propto \sqrt{B_H}$

23 **( c)**

24 **(d)**

25 ©

Potential energy, $U = \boldsymbol{M}.\boldsymbol{B} = -MN\cos\theta$

Here **M =** magnetic moment of the loop

$\theta$ = angle between **M** and **B**

$U$ is maximum when $\theta = 180°$ and minimum when $\theta = 0°$. So as $\theta$ decrease from 180° to 0° its PE also decreases.

26 **(b)**

27 **(c)**

Time period of magnet, $T = 2\pi\sqrt{\frac{I}{MB_H}}$

When magnet is cut parallel to its length into four equal pieces. Then new magnet moment, $M' = \frac{M}{4}$

New moment of inertia, $I' = \frac{I}{4}$

$\therefore$ New time period, $T' = 2\pi\sqrt{\frac{I'}{M'B_H}}$

$\Rightarrow \qquad T = T' = 4s$

28 **(c)**

$T = 2\pi\sqrt{\frac{1}{MB_H}} \Rightarrow T \propto \sqrt{I} \propto \sqrt{w} \Rightarrow T' = \sqrt{2}\,T_0$

29 **(a)**

30 **(b)**

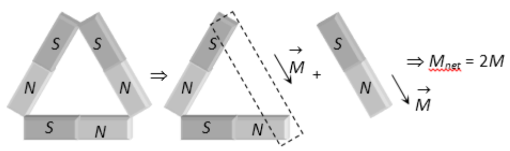
Ferromagnetic material moves from a region of small magnetic field to a region of strong magnetic field.

31 **(c)**

Magnetic substance when kept in a magnetic field is feebly repelled or thrown out if the substance is diamagnetic.

32 **(b)**

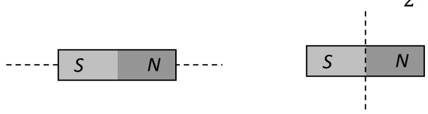
The resultant magnetic moment can be calculated as follows:




33 **(b)**

If cut along the axis of magnet of length $l$, then new pole strength $m' = \frac{m}{2}$ and new length $l' = l$

$\therefore$ New magnetic moment $M' = \frac{m}{2} \times l = \frac{ml}{2} = \frac{M}{2}$

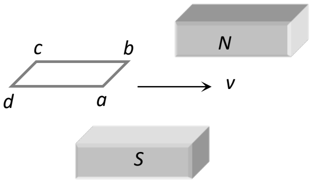


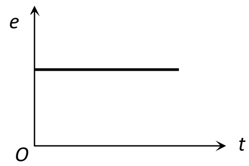
If cut perpendicular to the axis of magnet, then new pole strength $m' = m$ and new length, $l' = l/2$

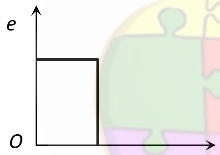
$\therefore$ New magnetic moment $M' = m \times \frac{l}{2} = \frac{ml}{2} = \frac{M}{2}$

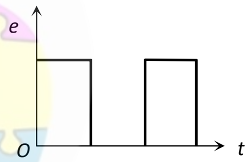

# Electromagnetic Induction

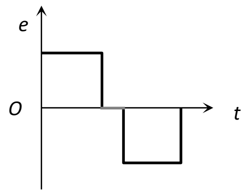
1. A horizontal loop $abcd$ is moved across the pole pieces of a magnet as shown in fig. with a constant speed $v$. When the edge $ab$ of the loop enters the pole pieces at time $t = 0\ sec$, which one of the following graphs represents correctly the induced emf in the coil




a) 

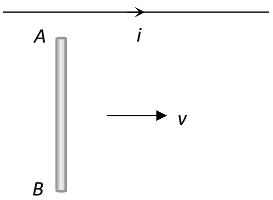

b) 


c) 


d) 


2. Which of the following is not an application of eddy currents
   a) Induction furnace  b) Galvanometer damping
   c) Speedometer of automobiles  d) X-ray crystallography
3 When the current changes from +2 A to -2 A in 0.05 s, an emf of 8 V is induced in a coil. The coefficient of self-induction of the coil is
   a) 0.2 H  b) 0.4 H  c) 0.8 H  d) 0.1 H
4. A coil having an area $A_0$ is placed in a magnetic field which changes from $B_0$ to $4B_0$ in a time interval $t$. The e.m.f. induced in the coil will be
   a) $\frac{3A_0B_0}{t}$  b) $\frac{4A_0B_0}{t}$  c) $\frac{3B_0}{A_0t}$  d) $\frac{4B_0}{A_0t}$
5. Two conducting circular loops of radii $R_1$ and $R_2$ are placed in the same plane with their centres coinciding. If $R_1 \gg R_2$, the mutual inductance $M$ between them will be directly proportional to
   a) $R_1/R_2$  b) $R_2/R_1$  c) $R_1^2/R_2$  d) $R_2^2/R_1$
6. If the current is halved in a coil, then the energy stored is how much times the previous value
   a) $\frac{1}{2}$  b) $\frac{1}{4}$  c) 2  d) 4
7. A 50 mH coil carries a current of 2 A, the energy stored in joule is
   a) 1  b) 0.05  c) 10  d) 0.1
8. Voltage in the secondary coil of a transformer does not depend upon
   a) Voltage in the primary coil  b) Ratio of number of turns in the two coils
   c) Frequency of the source  d) Both (a) and (b)

9. The current carrying wire and the rod $AB$ are in the same plane. The rod moves parallel to the wire with a velocity $v$. Which one of the following statements is true about induced emf in the rod

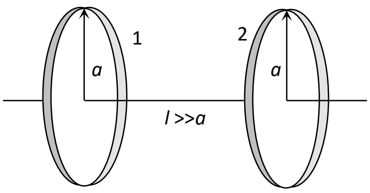



a) End $A$ will be at lower potential with respect to $B$
b) $A$ and $B$ will be at the same potential
c) There will be no induced e.m.f. in the rod
d) Potential at $A$ will be higher than that at $B$

10. The flux linked with circuit is given by $\phi = t^3 + 3t - 7$. The graph between time ($x$ − axis) and induced emf ($y$ − axis) will be a
a) Straight line through the origin
b) Straight line with positive intercept
c) Straight line with negative intercept
d) Parabola not through the origin

11. The total charge, induced in a conducting loop, when it is moved in a magnetic field depends on
a) Rate of change of magnetic on
b) Initial magnetic flux only
c) Total change in magnetic flux and resistance
d) Final magnetic flux only

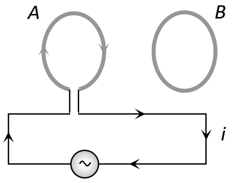
12. What is the mutual inductance of a two-loop system as shown with centre separation $l$




a) $\frac{\mu_0 \pi a^4}{8l^3}$
b) $\frac{\mu_0 \pi a^4}{4l^3}$
c) $\frac{\mu_0 \pi a^4}{6l^3}$
d) $\frac{\mu_0 \pi a^4}{2l^3}$

13. A circular metal plate of radius $R$ is rotating with a uniform angular velocity $\omega$ with its plane perpendicular to a uniform magnetic field $B$. Then the emf developed between the centre and the rim of the plate is
a) $\pi\omega BR^2$
b) $\omega BR^2$
c) $\pi\omega BR^2/2$
d) $\omega BR^2/2$

14. Two circular coils $A$ and $B$ are facing each other as shown in figure. When the current $i$ through $A$ is altered



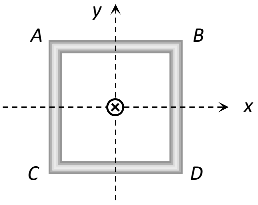

a) There will be repulsion between $A$ and $B$ if $i$ is increased
b) There will be attraction between $A$ and $B$ if $i$ is increased
c) There will be neither attraction nor repulsion when $i$ is changed
d) Attraction or repulsion between $A$ and $B$ depends on the direction of current. It does not depend whether the current is increased or decreased

15. A rectangular loop of length $l$ and breadth $b$ is placed at distance of $x$ from infinitely long wire carrying current i such that the direction of current is parallel to breadth. If the loop moves away from the current wire in a direction perpendicular to it with a velocity $v$, the magnitude of the emf in the loop is ($\mu$ =permeability of free space)
a) $\frac{\mu_0 iv}{2\pi x}\left(\frac{1+b}{b}\right)$
b) $\frac{\mu_0 i^2 v}{4\pi^2 x}\log\left(\frac{b}{l}\right)$
c) $\frac{\mu_0 ilbv}{2\pi x(l+x)}$
d)

16. In what form is the energy stored in an inductor **or**
A coil of inductance $L$ is carrying a steady current $i$. What is the nature of its stored energy
a) Magnetic b) Electrical
c) Both magnetic and electrical d) Heat

17. Flux $\phi$ (in weber) in a closed circuit of resistance $20\Omega$ varies with time $t$ (in second) according to equation $\phi = 6t^2 - 5t + 1$.
The magnitude of the induced current at $t$=0.25 s is
a) 1.2 A b) 0.8 A c) 0.6 A d) 0.1 A

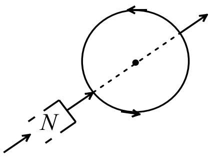
18. A square coil $ABCD$ lying in $x - y$ plane with it's centre at origin. A long straight wire passing through origin carries a current $i = 2t$ in negative $z$-direction. The induced current in the coil is

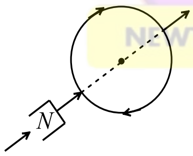


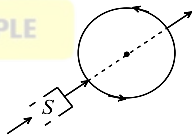

a) Clockwise b) Anticlockwise c) Alternating d) Zero

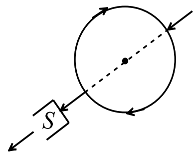
19. According to Faraday's law of electromagnetic induction
a) The direction of induced current is such that it opposes the cause producing it
b) The magnitude of induced e.m.f. produced in a coil is directly proportional to the rate of change of magnate flux
c) The direction of induced e.m.f. is such that it opposes the cause producing it
d) None of the above

20. Which of the following figure correctly depicts the Lenz's law. The arrows show the movement of the labelled pole of a bar magnet into a closed circular loop and the arrows on the circle show the direction of the induced current

a) 

b) 

c) 

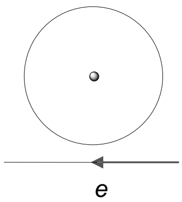
d) 


21. In step-up transformer, relation between number of turns in primary ($N_p$) and number of turns is secondary ($N_s$) coils is
a) $N_s$ is greater than $N_p$ b) $N_p$ is greater than $N_s$ c) $N_s$ is equal to $N_p$ d) $N_p = 2N_s$

22. In a transformer, the number of turns in primary coil and secondary coil are 5 and 4 respectively. If 240 $V$ is applied on the primary coil, then the ratio of current in primary and secondary coil is
a) 4 : 5 b) 5 : 4 c) 5 : 9 d) 9 : 5

23. A transformer has an efficiency of 80%. It is connected to a power input of 5kW at 200 V. If the secondary voltage is 250 V, the primary and secondary currents are respectively
a) 25 A, 20 A b) 20 A, 16 A c) 25 A, 16 A d) 40 A, 25 A

24. Near a circular loop of conducting wire as shown in the figure an electron moves along a straight line. The direction of the induced current if any in the loop is




a) Variable b) Clockwise c) Anticlockwise d) Zero

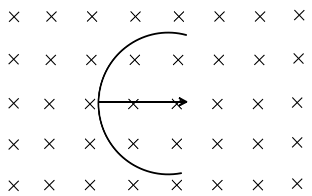
25. A 100% efficient transformer has 100 turns in the primary and 25 turns in its secondary coil. If the current in the secondary coil is 4 amp, then the current in the primary coil is

a) 1 $amp$ b) 4 $amp$ c) 8 $amp$ d) 16 $amp$

26. Core of transformer is made up of

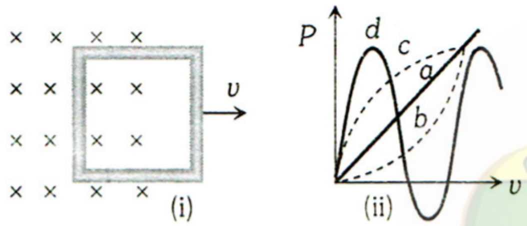
a) Soft iron b) Steel c) Iron d) Alnico

27. A straight wire of length $L$ is bent into a semicircle. It is moved in a uniform magnetic field with speed $v$ with diameter perpendicular to the field. The induced emf between the ends of the wire is



a) $BLv$ b) $2BLv$ c) $2\pi BLv$ d) $\frac{2BvL}{\pi}$

28. Figure (i) shows a conducting loop being pulled out of a magnetic field with a speed $v$. Which of the four plots shown in figure (ii) may represent the power delivered by the pulling agent as a function of the speed $v$




a) $a$ b) $b$ c) $c$ d) $c'$

29. Two similar circular loops carry equal currents in the same direction. On moving coils further apart, the electric current will

a) Increase in both b) Decrease in both

c) Remain unaltered d) Increases in one and decreases in the second

30. A varying magnetic flux linking a coil is given by $\phi - X\,t^2$. If at time $t$=3 s, the emf induced is 9V, then the value of $X$is

a) 0.66 $\text{Wbs}^{-2}$ b) 1.5 $\text{Wbs}^{-2}$ c) $-0.66$ $\text{Wbs}^{-2}$ d) $-1.5$ $\text{Wbs}^{-2}$

31. A moving conductor coil in a magnetic field produces an induced e.m.f. This is in accordance with

a) Ampere's law b) Coulomb's law c) Lenz's law d) Faraday's law

32. A solenoid is placed inside another solenoid, the length of both being equal carrying same magnitude of current. The parameters like radius and number of turns are in the ratio 1 : 2 for the two solenoids. The mutual inductance on each other would be

a) $M_{12} = M_{21}$ b) $M_{12} = 2M_{21}$ c) $2M_{12} = M_{21}$ d) $M_{12} = 4M_{21}$

33. Quantity that remains unchanged in a transformer is

a) Voltage b) Current c) Frequency d) None of these

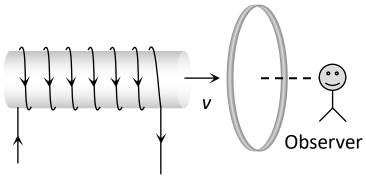
34. A short solenoid of length 4 cm, radius 2 cm and 100 turns is placed inside and on the axis of a long solenoid of length 80 cm and 1500 turns. A current of 3 A flows through the short solenoid. The mutual inductance of two solenoids is

a) $2.96 \times 10^{-4}$H b) $5.3 \times 10^{-5}$H c) $3.52 \times 10^{-3}$H d) $8.3 \times 10^{-5}$H

35. A step up transformer connected to a 220 $V$ $AC$ line is to supply 22 $kV$ a neon sign in secondary circuit. In primary circuit a fuse wire is connected which is to blow when the current in the secondary circuit exceeds 10 $mA$. The turn ratio of the transformer is

a) 50 b) 100 c) 150 d) 200

36. A current carrying solenoid is approaching a conducting loop as shown in the figure. The direction of induced current as observed by an observer on the other side of the loop will be




a) Anticlockwise  b) Clockwise  c) East  d) West

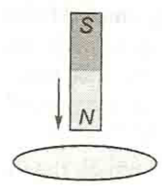
37. A generator at a utility company produces 100 A of current at 4000 V. The voltage is stepped up to 240000 V by a transformer before it is sent on a high voltage transmission line. The current in transmission line is

a) 3.67 A  b) 2.67 A  c) 1.67 A  d) 2.40 A

38. In a uniform magnetic field of induction$B$, a wire in the form of semicircle of radius $r$ rotates about the diameter of the circle with angular frequency $\omega$. If the total resistance of the circuit is $R$, the mean power generated per period of rotation is

a) $\frac{B\pi r^2\omega}{2R}$  b) $\frac{(B\pi r^2\omega)^2}{5\,Rt}$  c) $\frac{(B\pi r\omega)^2}{2\,R}$  d) $\frac{(B\pi r\omega^2)^2}{8\,R}$

39. A copper ring having a cut such as not to form a complete loop is held horizontally ad a bar magnet is dropped through the ring with its length along the axis of the ring, figure. The acceleration of the falling magnet is




a) G  b) Less than g  c) More than g  d) Zero

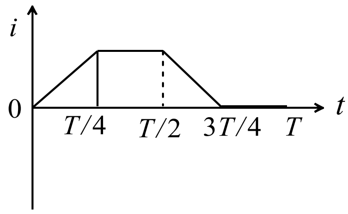
40. Self-inductance of a coil is 50 $mH$. A current of 1 $A$ passing through the coil reduces to zero at steady rate in 0.1 sec., the self-induced $emf$ is

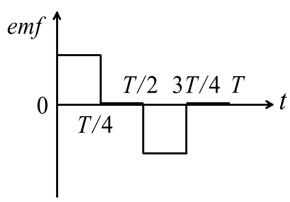
a) 5 volts  b) 0.05 volts  c) 50 volts  d) 0.5 volts

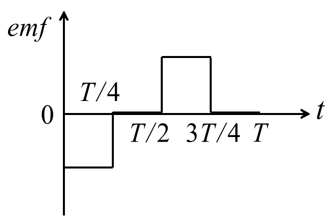
41. The magnitude of the earth's magnetic field at a place is $B_0$ and the angle of dip is $\delta$. A horizontal conductor of length $l$, lying north-south, moves eastwards with a velocity $v$. The emf induced across the rod is

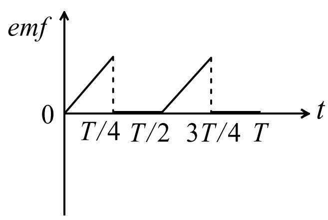
a) Zero  b) $B_0lv$  c) $B_0lv\sin\delta$  d) $B_0lv\cos\delta$

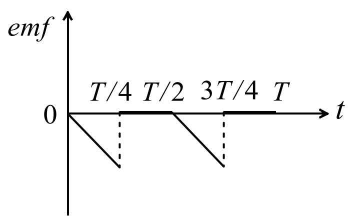
42. The current $i$ in a coil varies with time as shown in the figure. The variation of induced emf with time would be




a)



b)



c)



d)


43. A loop of area 0.1 $m^2$ rotates with a speed of 60 rps perpendicular to a magnetic field of 0.4 T. If there are 100 turns in the loop, maximum voltage induced in the loop is

a) 15.07 V b) 1507 V c) 250 V d) 150 V

1 **(d)**
When loop enters in field between the pole pieces, flux linked with the coil first increases (constantly) so a constant emf induces. When coil enters completely within the field, there is no flux change, so $e = 0$
When coil exists, flux linked with the coil decreases, hence again emf induces, but in opposite direction

2 **(d)**

3 **(d)**
Induced emf, $e = -L\frac{di}{dt} = -L\frac{(-2-2)}{0.05}$

$$8 = L\frac{(4)}{0.05}$$

$$\therefore \quad L = \frac{8 \times 0.05}{4} = 0.1 \text{ H}$$

4 **(a)**

$$e = -\frac{d\phi}{dt} = \frac{-3B_0A_0}{t}$$

5 **(d)**
Mutual inductance between two coil in the same plane with their centers coinciding is given by

$$M = \frac{\mu_0}{4\pi}\left(\frac{2\pi^2R_2^2N_1N_2}{R_1}\right) henry$$

6 **(b)**

$$U = \frac{1}{2}Li^2, i.e., \frac{U_2}{U_1} = \left(\frac{i_2}{i_1}\right)^2 = \left(\frac{1}{2}\right)^2 = \frac{1}{4} \Rightarrow U_2$$
$$= \frac{1}{4}U_1$$

7 **(d)**
Energy stored,

$$U = \frac{1}{2}Li^2$$
$$= \frac{1}{2} \times 50 \times 10^{-3} \times 2 \times 2 = 0.1 \text{ J}$$

8 **(c)**

9 **(d)**
By Fleming's right hand rule

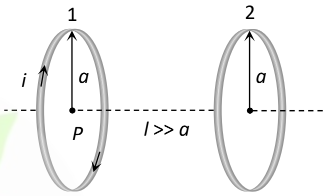
10 **(d)**
$\phi = t^2 + 3t - 7$
$\therefore$ Induced emf

$$e = -\frac{d\phi}{dt} = -(3t^2 + 3) = -3t^2 - 3$$

At $t = 0$; $e = -3$ V
Therefore, shape of graph will be a parabola not through origin.

11 **(c)**
Total charge induced in a loop depends on resistance and change in magnetic flux linked with the loop.

12 **(d)**
Magnetic field at the location of coil (2) produced due to coil (1)



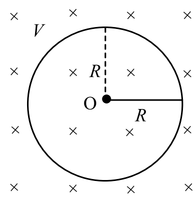

$$B_1 = \frac{\mu_0}{4\pi}.\frac{2M}{l^3}$$

Flux linked with coil (2)

$$\phi = B_1A_2 = \frac{\mu_0}{4\pi}\frac{2i(\pi a^2)}{l^3} \times (\pi a^2)$$

Also $\phi_2 = Mi \Rightarrow M = \frac{\mu_0\pi a^4}{2l^3}$

13 **(d)**
From Faraday's law of electromagnetic induction, the emf induced between center and rim is equal to rate of change of magnetic flux.




$$e = -\frac{d\phi}{dt}$$

Where, $d\phi = B\,dA$,where $B$ is magnetic field and $dA$ the area.

$$\therefore \quad e = -\frac{B\int_0^R dA}{T}$$
$$e = -\frac{B \times \pi R^2}{T}$$

Also, $\omega = \frac{2\pi}{T}$, where $T$ is periodic time,

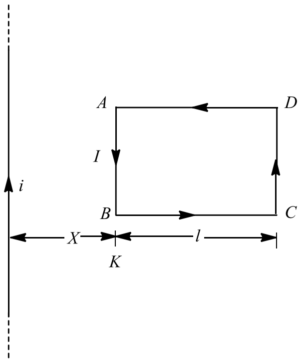
$$e = -\frac{B\pi R^2}{2\pi/\omega}$$
$$= -\frac{BR^2\omega}{2}$$

14 **(a)**

With rise in current in coil $A$ flux through $B$ increases. According to Lenz's law repulsion occurs between $A$ and $B$

15 **(d)**

We can show the situation as




Since, loop is moving away from the wire, so the direction of current in the loop will be as shown in the figure.

Net magnetic field on the loop due to wire

$$B = \frac{\mu_0 i}{2\pi}\left(\frac{1}{x} - \frac{1}{l+x}\right)$$
$$= \frac{\mu_0 il}{2\pi x(l+x)}$$

So, the magnitude of the emf in the loop

$$e = vBb = \frac{\mu_0 il\ v\ b}{2\ \pi\ x\ (1+x)}$$

16 **(a)**

Energy stored $= \frac{1}{2}Li^2$, where $Li$ is magnetic flux

17 **(d)**

From, Faraday's second law, $e = -\frac{d\phi}{db}$

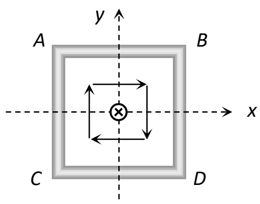
$= -[12t - 5]$

$= -[12 \times (0.25) - 5] = +2$

Now, $i = \frac{e}{R} = \frac{2}{20} = 0.1$ A

18 **(d)**

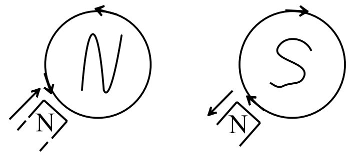
Magnetic lines are tangential to the coil as shown in figure. Thus net magnetic flux passing through the coil is always zero or the induced current will be zero




19 **(b)**

20 **(a)**

When a north pole of a bar magnet moves towards the coil, the induced current in the coil flows in a direction such that the coil presents its north pole to the bar magnet as shown in figure (a). Therefore, the induced current flows in the coil in the anticlockwise direction. When a north pole of a bar magnet moves away from the coil, the induced current in the coil flows in a direction such that the coil presents its such pole to the bar magnet as shown in figure (b)




Therefore induced current flows in the coil in the clockwise direction

21 **(a)**

In step-up transformer, number of turns in primary coil is less than the number of turns in secondary coil.

*ie,* $\frac{N_s}{N_p} > 1$

22 **(a)**

$$\frac{N_s}{N_p} = \frac{i_p}{i_s} \Rightarrow \frac{i_p}{i_s} = \frac{4}{5}$$

23 **(c)**



Efficiency $= \frac{\text{Output power}}{\text{Input power}}$

Input power=5000 W

Input voltage=200 V

∴ primary current, $I_p = \frac{5000}{200} = 25$ A

Output power $= 5000 \times \frac{80}{100} = 4000$ W

Output voltage =250 V

Secondary current, $I_s = \frac{4000}{250} = 16$ A

24 **(a)**

Since, electron is moving from left to right, the flux linked with loop will first increase and then decrease as the electron passes by. Therefore, induced current $I$ in the loop will be first clockwise and then will move in anticlockwise direction as the electron passes by.

25 **(a)**

For 100% efficient transformer

$$V_s i_s = V_p i_p \Rightarrow \frac{V_s}{V_p} = \frac{i_p}{i_s} = \frac{N_s}{N_p} \Rightarrow \frac{i_p}{4} = \frac{25}{100} \Rightarrow i_p$$
$$= 1\ A$$

26 **(a)**

27 **(d)**

Induced emf $e = Bvl \Rightarrow e = Bv(2R) = \frac{2BvL}{\pi}$

28 **(b)**

$$P = Fv = Bil \times v = B\left(\frac{Bvl}{R}\right)l \times v = \frac{B^2v^2l^2}{R} \Rightarrow P \propto v^2$$

29 **(a)**

On moving the coils further apart initially the flux linked will reduced.

Then, according to Lenz's law current will increase in both the coils to increase the linked flux.

30 **(b)**

From Faraday's law, induced emf is

$$e = -\frac{d\phi}{dt}$$

Given , $\phi = Xt^2$

$$\therefore \quad e = \frac{-d(Xt^2)}{dt} = -2tX$$

Given, $t = 3$, $\quad e = 9\text{V}$

$$\therefore \quad X = \frac{9}{3 \times 2} = 1.5\text{Wbs}^{-2}$$

31 **(d)**

32 **(a)**

$M = K\sqrt{L_1L_2}$

For perfect coupling $K = 1$

$M_{12} = M_{21}$

33 **(c)**

34 **(a)**

$$M_{21} = \frac{\mu_0 N_1 N_2 A_2}{l_2}$$

$$\therefore M_{21} = \frac{(4 \times 3.14 \times 10^{-7}) \times 1500 \times 100 \times \{3.14(2 \times 10^{-2})^2\}}{80 \times 10^{-2}}$$

$$M_{21} = 2.96 \times 10^{-4}\text{H}$$

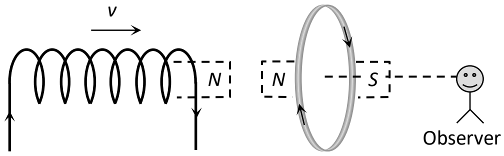
$$\Rightarrow \quad M_{12} = M_{21} = 2.96 \times 10^{-4}\text{H}$$

35 **(b)**

$$\frac{N_s}{N_p} = \frac{V_s}{V_p} = \frac{22000}{220} = 100$$

36 **(b)**

The direction of current in the solenoid is anti-clockwise as seen by observer. On displacing it towards the loop a current in the loop will be induced in a direction so as to oppose the approach of solenoid. Therefore the direction of induced current as observed by the observer will be clockwise




37 **(c)**

For step-up transformer,

$$V_s > V_p \text{ and } I_s < I_p$$

For an ideal transformer,

$$V_sI_s = V_pI_p$$

$$\therefore \quad 240000I_s = 100 \times 4000$$

$$\text{or} \quad I_s = 1.67\text{ A}$$

38 **(b)**

The flux associated with coil of area $A$ and magnetic induction $B$ is

$\phi = BA\cos\theta$

$$= \frac{1}{2}B\pi r^2 \cos\omega t \qquad \left[\because A = \frac{1}{2}\pi r^2\right]$$

$$\therefore e_{\text{induced}} = -\frac{d\phi}{dt}$$

$$= -\frac{d}{dt}\left(\frac{1}{2}B\pi r^2 \cos\omega t\right)$$

$$= \frac{1}{2}B\pi r^2\omega \sin\omega t$$

$$\therefore \text{power } p = \frac{e^2_{\text{induced}}}{R}$$

$$= \frac{B^2\pi^2r^4\omega^2\sin^2\omega t}{4R}$$

Hence,$P_{\text{mean}} = \langle p \rangle$

$$= \frac{B^2\pi^2r^4\omega^2}{4R}.\frac{1}{2} \qquad \left(\because \langle \sin\omega t \rangle = \frac{1}{2}\right)$$

$$= \frac{(B\pi r^2\omega)^2}{8R}$$

39 **(a)**

Though emf is induced in the copper ring, but there is no induced current because current because of cut in the ring. Hence nothing opposes the free fall of the magnet. Therefore, $a = \text{g}$.

40 **(d)**

$L = 50 \times 10^{-3}H$

$$\frac{dI}{dt} = \frac{(1-0)}{0.1} = 10$$

$$\varepsilon = \frac{L.dI}{dt} = 50 \times 10^{-3} \times 10 = 50 \times 10^{-2}$$

$$= 0.5\ volt$$

41 **(c)**

Horizontal conductor intercepts vertical component $= B_0 \sin\delta$

$\therefore \; e = (B_0 \sin\delta)lv$

42 **(b)**

$$\varepsilon \propto -\frac{di}{dt}$$

43 **(b)**

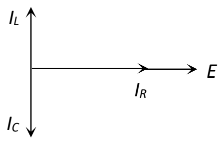
$$e_0 = nAB\omega$$
$$= 100 \times 0.1 \times 0.4 \times (2\pi \times 60) = 150\text{V}$$

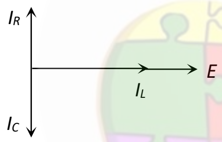
# Alternating Current

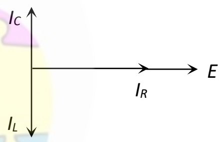
1 The impedance of a circuit consists of 3 *ohm* resistance and 4 *ohm* reactance. The power factor of the circuit is

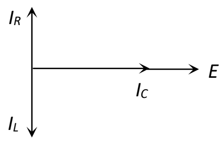
a) 0.4 b) 0.6 c) 0.8 d) 1.0

2. An alternating *e*mf is applied across a parallel combination of a resistance $R$, capacitance $C$ and an inductance $L$. If $I_R, I_L, I_C$ are the current through $R$, $L$ and $C$ respectively, then the diagram which correctly represents the phase relationship among $I_R, I_L, I_C$ and source *e*mf $E$, is given by

a) 


b) 


c) 


d) 


3. In $AC$ series circuit, the resistance, inductive reactance and capacitive reactance are $3\Omega$, $10\Omega$ and $14\Omega$ respectively. The impedance of the circuit is

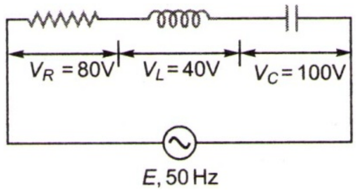
a) $5\Omega$ b) $4\Omega$ c) $7\Omega$ d) $10\Omega$



4. The values of $L$, $C$ and $R$ for a circuit are 1H, 9F and $3\Omega$. What is the quality factor for the circuit at resonance?

a) 1 b) 9 c) $\frac{1}{9}$ d) $\frac{1}{3}$

5. The value of alternating emf $E$ in the given circuit will be




a) 220 V b) 140 V c) 100 V d) 20 V

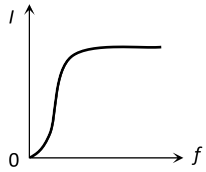
6. At high frequency, the capacitor offers

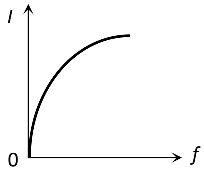
a) More reactance b) Less reactance c) Zero reactance d) Infinite reactance

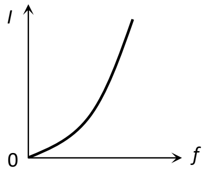
7. An $LCR$ series circuit with $R = 100\Omega$ is connected to a 200 $V$, 50 $Hz$ a.c. source when only the capacitance is removed, the current leads the voltage by 60°. When only the inductance is removed, the current leads the voltage by 60°. The current in the circuit is

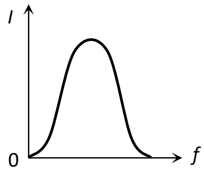
a) $2A$ b) $1A$ c) $\frac{\sqrt{3}}{2}A$ d) $\frac{2}{\sqrt{3}}A$

8. An ac source of variable frequency $f$ is connected to an $LCR$ series circuit. Which of the graphs in figure represents the variation of current $I$ in the circuit with frequency $f$

a) 


b) 


c) 


d) 


9. The current in series $LCR$ circuit will be maximum when $\omega$ is

a) As large as possible
b) Equal o natural frequency of $LCR$ system
c) $\sqrt{LC}$
d) $\sqrt{1/LC}$

10. An alternating voltage (in volt) given by $V = 200\sqrt{2}\sin(100t)$ is connected to$1\mu F$ capacitor through an AC ammeter. The reading of the ammeter will be

a) 10 mA
b) 20 m A
c) 40 mA
d) 80 mA

11. The instantaneous values of current and emf in an ac circuit are $I = 1/\sqrt{2}\ \sin 314\, t\ amp$ and $E = \sqrt{2}\sin(314\, t - \pi/6)\, V$ respectively. The phase difference between $E$ and $I$ will be

a) $-\pi/6\ rad$
b) $-\pi/3\ rad$
c) $\pi/6\ rad$
d) $\pi/3\ rad$

12. The time taken by an alternating current of 50 Hz in reaching from zero to its maximum value will be

a) 0.5 s
b) 0.005 s
c) 0.05 s
d) 5 s

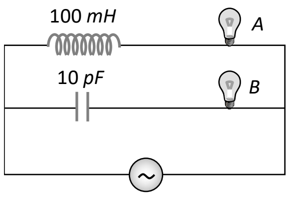
13. The voltage of domestic ac is 220 $volt$. What does the represent

a) Mean voltage
b) Peak voltage
c) Root mean voltage
d) Root mean square voltage

14. The initial phase angle for $i = 10\sin\omega t + 8\cos\omega t$ is

a) $\tan^{-1}\left(\frac{4}{5}\right)$
b) $\tan^{-1}\left(\frac{5}{4}\right)$
c) $\sin^{-1}\left(\frac{4}{5}\right)$
d) $90°$

15. If $A$ and $B$ are identical bulbs, which bulb glows brighter




a) $A$
b) $B$
c) Both equally bright
d) Cannot say

16. In an AC circuit the voltage applied is $E = E_0\sin\omega t$. The resulting current in the circuit is $I = I_0\sin\left(\omega t - \frac{\pi}{2}\right)$. The power consumption in the circuit is given by

a) $P = \frac{E_0 I_0}{\sqrt{2}}$
b) $P =$zero
c) $P = \frac{E_0 I_0}{2}$
d) $P = \sqrt{2}E_0 I_0$

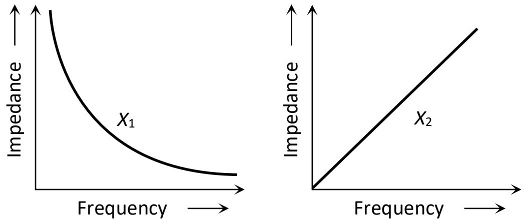
17. The phase difference between the voltage and the current in an ac circuit is $\pi/4$. If the frequency is 50 $Hz$ then this phase difference will be equivalent to a time of

a) 0.02 $s$
b) 0.25 $s$
c) 2.5 $ms$
d) 25 $ms$

18. In the non-resonant circuit, what will be the nature of the circuit for frequencies higher than the resonant frequency

a) Resistive
b) Capacitive
c) Inductive
d) None of the above

19. The graphs given below depict the dependence of two reactive impedances $X_1$ and $X_2$ on the frequency of the alternating e.m.f. applied individually to them. We can then say that




a) $X_1$ is an inductor and $X_2$ is a capacitor
b) $X_1$ is a resistor and $X_2$ is a capacitor
c) $X_1$ is a capacitor and $X_2$ is an inductor
d) $X_1$ is an inductor and $X_2$ is a resistor

20. In an electrical circuit $R, L, C$ and an a.c. voltage source are all connected in series. When $L$ is removed from the circuit, the phase difference between the voltage and the current in the circuit is $\pi/3$. If instead, $C$ is removed from the circuit, the phase difference is again $\pi/3$. The power factor of the circuit is

a) $1/2$ b) $1/\sqrt{2}$ c) $1$ d) $\sqrt{3}/2$

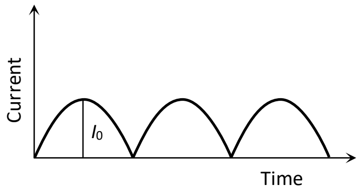
21. The phase difference between the alternating current and emf is $\pi/2$. Which of the following cannot be the constituent of the circuit?

a) $C$ alone b) $R, L$ c) $L, C$ d) $L$ alone

22. In a series $L-C-R$ circuit, resistance $R = 10\ \Omega$ and the impedance $Z = 10\ \Omega$. The phase difference between the current and the voltage is

a) 0° b) 30° c) 45° d) 60°

23. The output current versus time curve of a rectifier is shown in the figure. The average value of output current in this case is




a) 0 b) $\frac{I_0}{2}$ c) $\frac{2I_0}{\pi}$ d) $I_0$

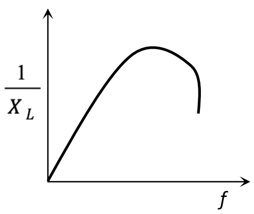
24. A transistor-oscillator using a resonant circuit with an inductor $L$ (of negligible resistance) and a capacitor $C$ in series produce oscillation of frequency $f$. If $L$ is doubled and $C$ is changed to $4C$, the frequency will be

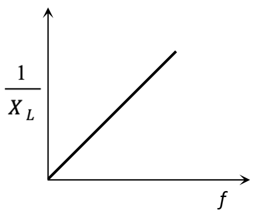
a) $f/2\sqrt{2}$ b) $f/2$ c) $f/4$ d) $8f$

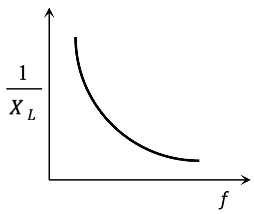
25. In a series $LCR$ circuit, operated with an ac of angular frequency $\omega$, the total impedance is

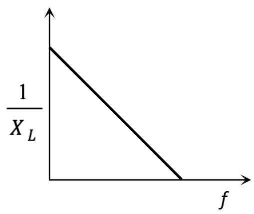
a) $[R^2 + (L\omega - C\omega)^2]^{1/2}$
b) $\left[R^2 + \left(L\omega - \frac{1}{C\omega}\right)^2\right]^{1/2}$
c) $\left[R^2 + \left(L\omega - \frac{1}{C\omega}\right)^2\right]^{-1/2}$
d) $\left[(R\omega)^2 + \left(L\omega - \frac{1}{C\omega}\right)^2\right]^{1/2}$

26. In pure inductive circuit, the curves between frequency $f$ and reciprocal of inductive reactance $1/X_L$ is

a) 


b) 


c) 


d) 


27. The maximum voltage in DC circuit is 282V. The effective voltage in AC circuit will be

a) 200 V b) 300 V c) 400 V d) 564 V

28. A resistor 30 Ω, inductor of reactance 10 Ω and capacitor of reactance 10 Ω are connected in series to an AC voltage source $e = 300\sqrt{2}\sin(\omega t)$. The current in the circuit is

a) $10\sqrt{2}$ A　　b) 10 A　　c) $30\sqrt{11}$ A　　d) $30/\sqrt{11}$ A

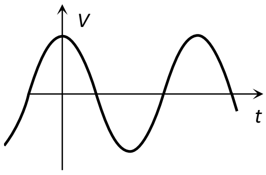
29. Q-factor can be increased by having a coil of

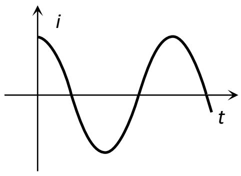
a) Large inductance, small ohmic resistance
b) Large inductance, large ohmic resistance
c) Small inductance, large ohmic resistance
d) Small inductance, small ohmic resistance

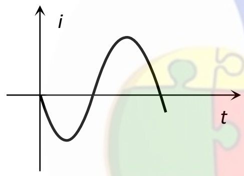
30. An alternating voltage is represented as $E = 20\sin 300t$. The average value of voltage over one cycle will be

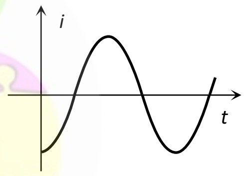
a) Zero　　b) 10 $volt$　　c) $20\sqrt{2}$ $volt$　　d) $\frac{20}{\sqrt{2}}volt$

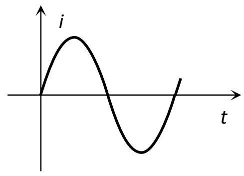
31. The voltage across a pure inductor is represented by the following diagram. Which of the following diagrams will represent the current




a) 

b) 

c) 

d) 


32. The current which does not contribute to the power consumed in an AC circuit is called

a) non-ideal current　　b) wattles current
c) convectional current　　d) inductance current



33. In a purely resistive ac circuit, the current

a) Lags behind the $e$.m.f. in phase
b) Is in phase with the $e$.m.f.
c) Leads the $e$.m.f. in phase
d) Leads the $e$.m.f. in half the cycle and lags behind it in the other half

34. An alternating voltage is connected in series with a resistance $R$ and an inductance $L$. If the potential drop across the resistance is 200 $V$ and across the inductance is 150 $V$, then the applied voltage is

a) 350 $V$　　b) 250 $V$　　c) 500 $V$　　d) 300 $V$

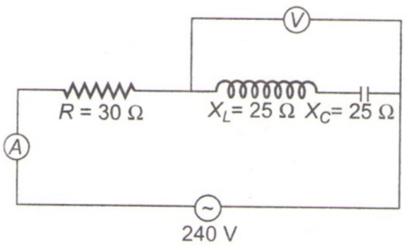
35. An $LCR$ series ac circuit is at resonance with 10 $V$ each across $L, C$ and $R$. If the resistance is halved, the respective voltage across $L, C$ and $R$ are

a) 10 V, 10 V and 5 V　　b) 10 V, 10 V and 10 V　　c) 20 V, 20 V and 5 V　　d) 20 V, 20 V and 10 V

36. If $L$ and $R$ represent inductance and resistance respectively, then dimension of $L/R$ will be

a) $[ML^0T^0]$　　b) $[M^0L^0T^{-1}]$　　c) $[M^0L^0T^{-2}]$　　d) $[M^0LT^{-2}]$

37. In the circuit shown in figure neglecting source resistance, the voltmeter and ammeter readings will be respectively




a) 0 V, 3 A　　b) 150 V, 3 A　　c) 150 V, 6 A　　d) 0 V, 8 A

38. The resistance of a coil for dc is in ohms. In ac, the resistance

a) Will remain same  b) Will increase  c) Will decrease  d) Will be zero

39. An $LCR$ series circuit is at resonance. Then

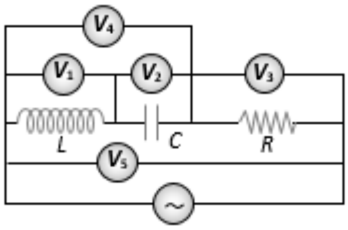
a) The phase difference between current and voltage is 90°

b) The phase difference between current and voltage is 45°

c) Its impedance is purely resistive

d) Its impedance is zero

40. In the adjoining ac circuit the voltmeter whose reading will be zero at resonance is




a) $V_1$  b) $V_2$  c) $V_3$  d) $V_4$

41. In an ac circuit the reactance of a coil is $\sqrt{3}$ times its resistance, the phase difference between the, voltage across the coil to the current through the coil will be

a) $\pi/3$  b) $\pi/2$  c) $\pi/4$  d) $\pi/6$

42. In a pure inductive circuit **or** In an ac circuit containing inductance only, the current

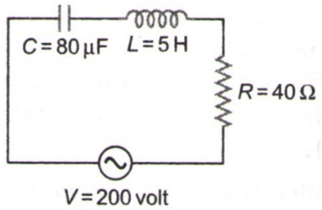
a) Leads the $e$.m.f. by 90°  b) Lags behind the $e$.m.f. by 90°

c) Sometimes leads and sometimes lags behind the $e$.m.f.  d) Is in phase with the $e$.m.f.

43. In $L - R$ circuit, resistance is 8 Ω and inductive reactance is 6 Ω , then impedance is

a) 2 Ω  b) 14 Ω  c) 4 Ω  d) 10 Ω

44. From figure shown below a series $L - C - R$ circuit connected to a variable frequency 200 V source. $C = 80\ \mu F$ and $R = 40\ \Omega$. Then the source frequency which drive the circuit at resonance is




a) 25 Hz  b) $\frac{25}{\pi}$ Hz  c) 50 Hz  d) $\frac{50}{\pi}$ Hz

45. An AC voltage source of variable angular frequency $\omega$ and fixed amplitude $V_0$ is connected in series with a capacitance $C$ and an electric bulb of resistance $R$ (inductance zero). When $\omega$ is increased

a) The bulb glows dimmer  b) The bulb glows brighter

c) Total impedance of the circuit is unchanged  d) Total impedance of the circuit increases

1 **(b)**

$Z = \sqrt{R^2 + X^2} = \sqrt{4^2 + 3^2} = 5$

$\therefore \cos\phi = \frac{R}{Z} = \frac{3}{5} = 0.6$

2 **(c)**

$I_L$ lags behind $I_R$ by a phase of $\frac{\pi}{2}$, while $I_C$ leads by a phase of $\frac{\pi}{2}$

3 **(a)**

Here, Resistance, $R = 3\Omega$

Inductive reactance, $X_L = 10\Omega$

Capacitive reactance, $X_C = 14\Omega$

The impedance of the series $LCR$ circuit is

$Z = \sqrt{R^2 + (X_C + X_L)^2} = \sqrt{(3)^2 + (14 - 10)^2}$

$Z = 5\Omega$

4 **(c)**

$Q = \frac{\omega L}{R} = \frac{1}{R} \times \frac{1}{\sqrt{LC}} \times L$

$= \frac{1}{R}\sqrt{\frac{L}{C}}$

$= \frac{1}{3} \times \sqrt{\frac{1}{9}} = \frac{1}{9}$

5 **(c)**

For series $L - C - R$ circuit

$$V = \sqrt{V_R^2 + (V_L - V_C)^2}$$
$$= \sqrt{(80)^2 + (40 - 100)^2}$$
$$= 100 \text{ V}$$

6 **(b)**

Capacitive reactance is given by

$$X_C = \frac{1}{\omega C}$$

Where $C$ is capacitance and $\omega$ the angular frequency $(\omega = 2\pi f)$.

$\therefore \quad X_C = \frac{1}{2\pi f C}$

$\Rightarrow \quad X_C \propto \frac{1}{f}$

Hence, when frequency $f$ increases capacitive reactance decreases.

7 **(a)**

If the capacitance is removed, it is an $L - R$ circuit

$\phi = 60°$

$\tan\phi = \frac{X_L}{R} = \tan 60° = \sqrt{3}$

If inductance is removed, it is a capacitative circuit or $R - C$ circuit. $|\phi|$ is the same

$\therefore L\omega = \frac{1}{C\omega}$ This is a resonance circuit

$Z = R; I_{rms} = \frac{E_{rms}}{R}, E_{rms} = 200\ V$

$\therefore I_{rms} = \frac{200V}{100\Omega} = 2A$

8 **(d)**

As explained in solution (1) for frequency $0 - f_r, Z$ decreases hence $(i = V/Z)$ increases and for frequency $f_r - \infty, Z$ increases hence $i$ decreases

9 **(d)**

At resonant frequency current in series $LCR$ circuit is maximum

10 **(b)**

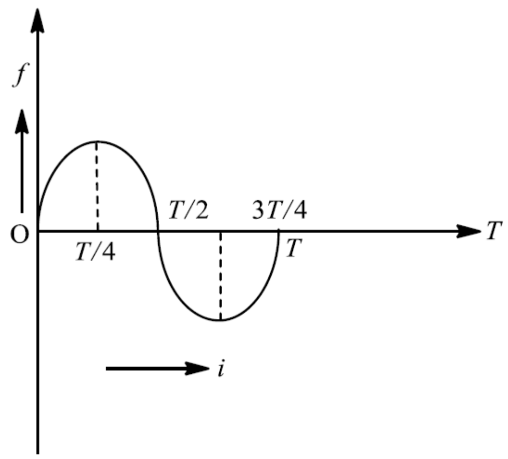
11 **(a)**

Phase difference relative to the current

$\phi = \left(314t - \frac{\pi}{6}\right) - (314\ t) = -\frac{\pi}{6}$

12 **(b)**

An alternating current is one whose magnitude changes continuously with time between zero and a maximum value and whose direction reverses periodically. The relation between frequency $(f)$ and time $(T)$ is.




$T = \frac{1}{f} = \frac{1}{50} = 0.02\ s$

As is clear from the figure time taken to reach the maximum value is

$$\frac{T}{4} = \frac{0.02}{4} = 0.005 \text{ s}$$

13 **(d)**

14 **(a)**

Current $i = i_0 \sin(\omega t + \phi)$

$i_p = i_0 \sin \omega t \cos \phi + i_0 \cos \omega t \sin \phi$

Thus, $\quad i_0 \cos \phi = 10$

$\quad i_0 \sin \phi = 8$

Hence, $\quad \tan \phi = \frac{4}{5}$

15 **(a)**

$\because (X_C) >> (X_L)$

16 **(b)**

For given circuit current is lagging the voltage by $\pi/2$, so circuit is purely inductive and there is no power consumption in the circuit. The work done by battery is stored as magnetic energy in the inductor.

17 **I**

Time difference $= \frac{T}{2\pi} \times \phi = \frac{(1/50)}{2\pi} \times \frac{\pi}{4} = \frac{1}{400} s =$ 2.5$m$-$s$

18 **(b)**

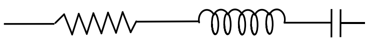
In non resonant circuits

Impedance $Z = \frac{1}{\sqrt{\frac{1}{R^2} + \left(\omega C - \frac{1}{\omega L}\right)^2}}$, with rise in frequency $Z$ decreases, $i.e.$, current increases so circuit behaves as capacitive circuit

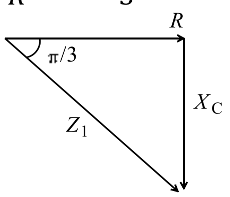
19 **I**

We have $X_C = \frac{1}{C \times 2\pi f}$ and $X_L = L \times 2\pi f$

20 **I**

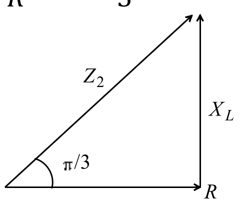


$$\frac{X_C}{R} = \tan\frac{\pi}{3}$$




$$X_C = R \tan\frac{\pi}{3} \qquad \text{... (i)}$$

$$\frac{X_L}{R} = \tan\frac{\pi}{3}$$




$$X_L = R \tan\frac{\pi}{3} \qquad \text{... (ii)}$$

Net impedance $Z = \sqrt{R^2 + (X_L - X_C)^2} = R$

Power factor $\cos \phi = \frac{R}{Z} = 1$

21 **(c)**

(i) In a circuit having $C$ alone, the voltage lags the current by $\frac{\pi}{2}$.

(ii) In a circuit containing $R$ and $L$, the voltage leads the current by $\frac{\pi}{2}$.

(iii) In $L$ – $C$ circuit, the phase difference between current and voltage can have any

value between 0 to $\frac{\pi}{2}$ depending on the values of $L$ and $C$.

(iv) In a circuit containing $L$ alone, the voltage leads the current by $\frac{\pi}{2}$.

22 **(a)**

Impedance,

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$\therefore \quad 10 = \sqrt{(10^2 + (X_L - X_C)^2}$$

$$\Rightarrow \quad 100 = 100 + (X_L - X_C)^2$$

$$\Rightarrow \quad X_L - X_C = 0$$

...(i)

Let $\phi$ is the phase difference between current and voltage

$$\tan \phi = \frac{X_L - X_C}{R}$$

$$\therefore \quad \tan \phi = \frac{0}{R}$$

$$\Rightarrow \quad \phi = 0 \qquad \text{[From Eq.(i)]}$$

23 **(c)**

$$I_{av} = \frac{\int_0^{T/2} i\, dt}{\int_0^{T/2} dt} = \frac{\int_0^{T/2} I_0 \sin(\omega t) dt}{T/2}$$

$$= \frac{2I_0}{T}\left[\frac{-\cos \omega t}{\omega}\right]_0^{T/2} = \frac{2I_0}{T}\left[-\frac{\cos\left(\frac{\omega T}{2}\right)}{\omega} + \frac{\cos 0°}{\omega}\right]$$

$$= \frac{2I_0}{\omega T}[-\cos \pi + \cos 0°] = \frac{2I_0}{2\pi}[1+1] = \frac{2I_0}{\pi}$$

24 **(a)**

Frequency of $LC$ oscillation $= \frac{1}{2\pi\sqrt{LC}}$

$$\Rightarrow \frac{f_1}{f_2} = \frac{1}{\sqrt{L_1 C_1}}\sqrt{L_2 C_2} = \left(\frac{L_2 C_2}{L_1 C_1}\right)^{1/2}$$

$$= \left(\frac{2L \times 4C}{L \times C}\right)^{1/2} = (8)^{1/2}$$

$\therefore \frac{f_1}{f_2} = 2\sqrt{2} \Rightarrow f_2 = \frac{f_1}{2\sqrt{2}}$ or, $f_2 = \frac{f}{2\sqrt{2}}$ $[\because f_1 = f]$

25 **(b)**

26 **(c)**

$X_L = 2\pi f$

$\Rightarrow X_L \propto f$

$\Rightarrow \frac{1}{X_L} \propto \frac{1}{f}$

$i.e.$, graph between $\frac{1}{X_L}$ and $f$ will be a hyperbola

27 **(a)**

Maximum voltage is AC circuit

$V_0 = 282\,V$

$V = \frac{V_0}{\sqrt{2}} = \frac{282}{\sqrt{2}}$

$V = \frac{282}{1.41} = \frac{28200}{141}$

$V = 200\,V$

28 **(b)**

$e = 300\sqrt{2}\sin\omega t$

$I_0 = \frac{e_0}{Z} = \frac{300\sqrt{2}}{\sqrt{(30)^2 + (10-10)^2}}$

$\{\because Z = \sqrt{R^2 + (X_L - X_C)^2}\}$

$= \frac{300\sqrt{2}}{30} = 10\sqrt{2}$ A

$\therefore$ Current $I = \frac{I_0}{\sqrt{2}} = 10$ A

29 **(a)**

$Q$ factor is given by $\frac{1}{R}\sqrt{\frac{L}{C}}$

So, for large quality factor the inductance should be large and resistance and capacitance must be small

30 **(a)**

31 **(d)**

In purely inductive circuit voltage leads the current by 90°

32 **(b)**

As, power factor $= \frac{\text{true power}}{\text{apparent power}}$

$= \cos\phi$

$= \frac{R}{\sqrt{R^2 + (X_L - X_C)^2}}$

$\therefore$ power factor$= \cos\phi = \frac{R}{Z}$

In a non-inductive circuit, $X_L = X_C$

$\therefore$ Power factor $= \cos\phi = \frac{R}{\sqrt{R^2}} = \frac{R}{R} = 1$

$\therefore$ $\phi = 0°$

This is the maximum value of power factor. In a pure inductor or an ideal capacitor

$\phi = 90°$

$\therefore$ Power factor$= \cos\phi = \cos 90° = 0$

Average power consumed in a pure inductor or ideal capacitor

$P = E_v . I_v \cos 90° =$ zero

Therefore, current through pure $L$ or pure $C$, which consumes no power for its maintenance in the circuit is called ideal current or wattles current.

33 **(b)**

34 **(b)**

The applied voltage is given by $V = \sqrt{V_R^2 + V_L^2}$

$V = \sqrt{(200)^2 + (150)^2} = 250\ volt$

35 **(d)**

36 **(b)**

$L/R$ represents time constant of R-L circuit. Therefore, its dimensions are $[M^0 L^0 T^1]$.

37 **(d)**

The voltage $V_L$ and $V_C$ are equal and opposite so, voltmeter reading will be zero.

Also, $R = 30\,\Omega, X_L = X_C = 25\,\Omega$

So, $i = \frac{V}{\sqrt{R^2 + (X_L - X_C)^2}}$

$= \frac{V}{R} = \frac{240}{30} = 8$A

38 **(b)**

The coil has inductance $L$ besides the resistance $R$. Hence for ac it's effective resistance $\sqrt{R^2 + X_L^2}$ will be larger than it's resistance $R$ for dc

39 **(c)**

In series LCR, the impedance of the circuit is given by

$Z = \sqrt{R^2 + (X_L - X_C)^2}$

At resonance, $X_L = X_C$

$\therefore Z = R$

At resonance, the phase difference between the current and voltage is 0°. Current is maximum at resonance

40 **(d)**

At resonance net voltage across $L$ and $C$ is zero

41 **(a)**

$\tan\phi = \frac{X_L}{R} = \frac{\sqrt{3}\,R}{R} = \sqrt{3} \Rightarrow \phi = 60° = \pi/3$

42 **(b)**

43 **(d)**

In series $L - R$ circuit, impedance is given by

$$Z = \sqrt{R^2 + X_L^2}$$

Where R is the resistance and $X_L$ the inductive reactance.

Given, $R = 8\Omega, X_L = 6\Omega$

$\therefore$ $Z = \sqrt{(8)^2 + (6)^2}$

$= \sqrt{64 + 36}$

$= \sqrt{100} = 10\ \Omega$

44 **(b)**

45 **(b)**

$$Z = \sqrt{R^2 + X_C^2} : I_{rms} = \frac{V_{rms}}{Z} : P = I_{rms}^2 R$$

Where $X_C = \frac{1}{\omega C}$

As $\omega$ is increased, $X_C$ will decrease or $Z$ will decrease. Hence $I_{rms}$ *or* $P$ will increase.

Therefore, bulb glows brighter.

Hence the correct option is (b).


# Electromagnetic Waves

1. The average value of electric energy density in an Electromagnetic Waves is ($E_0$ is peak value)
   a) $\frac{1}{2}\varepsilon_0 E_0^2$  b) $\frac{E_0^2}{2\varepsilon_0}$  c) $\varepsilon_0 E_0^2$  d) $\frac{1}{4}\varepsilon_0 E_0^2$
2. The speed of electromagnetic Wave in vacuum depends upon the source radiation. It
   a) Increases as we move from $\gamma - rays$ to radio waves
   b) Decreases as we move from $\gamma - rays$ to radio waves
   c) Is same for all of them
   d) None of the above
3. Which is having minimum wavelength?
   a) X-rays  b) Ultraviolet rays  c) $\gamma$-rays  d) Cosmic rays
4. Which of the following shows green house effect?
   a) Ultraviolet rays  b) Infrared rays  c) X-rays  d) None of these
5. For EM wave prorogating along $x$-axis, $E_{\max} = 30\ \mathrm{Vm}^{-1}$. what is maximum value of magnetic field?
   a) $10^{-7}$ T  b) $10^{-8}$ T  c) $10^{-9}$ T  d) $10^{-6}$ T
6. What is order of energy of X-rays ($E_X$), radio waves ($E_R$) and microwave ($E_M$)?
   a) $E_X < E_R < E_M$  b) $E_X < E_M > E_R$  c) $E_M > E_X > E_R$  d) $E_M < E_R < E_X$
7. The magnetic field of an Electromagnetic Wave is given by
   $B_Y = 3 \times 10^{-7} \sin(10^3 x + 6.29 \times 10^{12} t)$.
   The wavelength of the Electromagnetic Wave is
   a) 6.28 cm  b) 3.14 cm  c) 0.63 cm  d) 0.32 cm
8. The amplitude of electric field in a parallel beam of light of intensity $4\ \mathrm{Wm}^{-2}$ is
   a) $40.5\ \mathrm{NC}^{-1}$  b) $45.5\ \mathrm{NC}^{-1}$  c) $50.5\ \mathrm{NC}^{-1}$  d) $55.5\ \mathrm{NC}^{-1}$
9. According to Maxwell's hypothesis, a changing electric field gives rise to
   a) An emf  b) Electric current  c) Magnetic field  d) Pressure radiant
10. If $c$ is the speed of Electromagnetic Waves in vacuum, its speed in a medium of dielectric constant $K$ and relative permeability μ, is
   a) $v = \frac{1}{\sqrt{\mu_r, K}}$  b) $v = c\sqrt{\mu_{r_c} K}$  c) $v = \frac{c}{\sqrt{\mu_r, K}}$  d) $v = \frac{K}{\sqrt{\mu_r, c}}$

11. According to Maxwell's equation the velocity of light in any medium is expressed as

a) $\frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ b) $\frac{1}{\sqrt{\mu\varepsilon}}$ c) $\sqrt{\mu/\varepsilon}$ d) $\sqrt{\frac{\mu_0}{\varepsilon}}$

12. An Electromagnetic Wave has

a) Electric vector only

b) Magnetic vector only

c) Electric and Magnetic vector Perpendicular to each other

d) Neither the Electric vector nor the Magnetic vector

13. A radiation of energy $E$ falls normally on a perfectly reflecting surface. The momentum transferred to the surface is

a) $\frac{E}{c}$ b) $\frac{2E}{c}$ c) $Ec$ d) $\frac{E}{c^2}$

14. A point source of electromagnetic radiation has an average power output of 800 W. The maximum value of electric filed at a distance 4.0 m from the source is

a) $64.7 \text{ Vm}^{-1}$ b) $57.8 \text{ Vm}^{-1}$ c) $56.72 \text{ Vm}^{-1}$ d) $54.77 \text{ Vm}^{-1}$

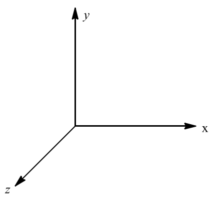
15. The electric field of plane electromagnetic wave in vacuum is represented by $\vec{\mathbf{E}}_x = 0; \vec{\mathbf{E}}_y = 0.5\cos[2\pi \times 10^8 (t - x/c)]: \vec{\mathbf{E}}_z = 0$

What is the direction of propagation of electromagnetic waves?

a) Along $x - z$ direction b) Along $y$-direction

c) Along $x$-direction d) A long $y - z$ direction

16. Light wave is travelling along $y$-direction. If the corresponding **E** vector at any time is along the $x$-axis, the direction of **B** vector at that time is along




a) $y$-axis b) $x$- axis c) $+z$- axis d) $-z$- axis

17. Radiations of intensity 0.5 Wm$^{-2}$ are striking a metal plate. The pressure on the plate is

a) $0.166 \times 10^{-8} \text{ Nm}^{-2}$ b) $0.332 \times 10^{-8} \text{ Nm}^{-2}$ c) $0.111 \times 10^{-8} \text{ Nm}^{-2}$ d) $0.083 \times 10^{-8} \text{ Nm}^{-2}$

18. A large parallel plate capacitor, whose plates have an area of $1 \text{ m}^2$ and are separated from each other by 1 mm, is being charged at a rate of $25 \text{ Vs}^{-1}$. If the dielectric between the plates has the dielectric constant 10, then the displacement current at this instant is

a) $25 \ \mu\text{A}$ b) $11 \ \mu\text{A}$ c) $2.2 \ \mu\text{A}$ d) $1.1 \ \mu\text{A}$

19. Instantaneous displacement current of 1.0 A in the space between the parallel plate of $1 \ \mu\text{F}$ capacitor can be estabilished by changing potential difference of

a) $10^{-6}\text{Vs}^{-1}$ b) $10^{6}\text{Vs}^{-1}$ c) $1 \text{ Vs}^{-1}$ d) $0.1 \text{ Vs}^{-1}$

20. If $\varepsilon_0$ and $\mu_0$ are the electric permittivity and magnetic permeability of free space and $\varepsilon$ and $\mu$ are the corresponding quantities in the medium, the index of refraction of the medium in terms of above parameter is

a) $\frac{\varepsilon\mu}{\varepsilon_0\mu_0}$ b) $\left(\frac{\varepsilon\mu}{\varepsilon_0\mu_0}\right)^{1/2}$ c) $\left(\frac{\varepsilon_0\mu_0}{\varepsilon\mu}\right)$ d) $\left(\frac{\varepsilon_0\mu_0}{\varepsilon\mu}\right)^{1/2}$

21. All components of the Electromagnetic Spectrum in vacuum have the same

a) Energy b) Velocity c) Wavelength d) Frequency

22. A. The wavelength of microwaves is greater than that of UV-rays.

B. The wavelength of IR rays is lesser than that of UV-rays.

C. The wavelength of microwaves is lesser than that of IR-rays.

D. Gamma rays have shortest wavelength in the Electromagnetic Spectrum.

Of the above statements

a) A and B are true b) B and C are true

c) C and D are true d) A and D are true

23. In an electromagnetic wave, the electric and magnetizing fields are $100\ \mathrm{Vm^{-1}}$ and $0.265\ \mathrm{Am^{-1}}$. The maximum energy flow is

a) $26.5\ \mathrm{Wm^{-2}}$ b) $36.5\ \mathrm{Wm^{-2}}$ c) $46.7\ \mathrm{Wm^{-2}}$ d) $765\ \mathrm{Wm^{-2}}$

24. Which of the following electromagnetic waves have the longest wavelength?

a) Heat waves b) Light waves c) Radio waves d) Ultraviolet waves

[redacted]

1 **(d)**

Electric energy density

$$u_e = \frac{1}{2}\varepsilon_0 E_{\text{rms}}^2$$

$$E_{\text{rms}} = \frac{E_0}{\sqrt{2}}$$

$$u_e = \frac{1}{4}\varepsilon_0 E_0^2$$

2 **(c)**

Speed of Electromagnetic Waves in vacuum

$$= \frac{1}{\sqrt{\mu_0\varepsilon_0}} = \text{costant}$$

3 **(c)**

$E = \frac{hc}{\lambda}$; minimum the wavelength, the maximum the energy of a $\lambda$ ray. Therefore rays have minimum wave length

4 **(b)**

5 **(a)**

The amplitude of the electric and magnetic fields in free space are related by $\frac{E_0}{B_0} = c$

Here, $E_0 = 30\ \text{Vm}^{-1}, c = 3\ \times 10^8\ \text{ms}^{-1}$

$$\therefore \quad B_0 = \frac{E_0}{c} = \frac{30}{3\ \times\ 10^8} = 10^{-7}\ \text{T}$$

6 **(b)**

The wavelength of X-rays is of the order of $1\ \text{Å}$ to $100\ \text{Å}$. The wavelength of radiowaves is of the order of $10^9$Å to $10^{1.4}$Å. The wavelength of microwaves is of the order of $10^7$Å to $10^9$Å.

Thus, $\lambda_X < \lambda_M < \lambda_R$

The waves with less wave length will have more energy.

Hence,

$$E_X > E_M > E_R$$

7 **(c)**

Given, $B_y = 3\ \times\ 10^{-7}\sin(10^3x + 6.28\ \times\ 10^{12}t)$.

Comparing with the general equation

$$B_y = B_0\sin(kx + \omega t)$$

we get $k = 10^3$

or $\frac{2\pi}{\lambda} = 10^3$

$$\Rightarrow \quad \lambda = \frac{2\pi}{10^3}$$

$$= 6.28\ \times\ 10^{-3}\text{m}$$

$$= 0.63\ \text{cm}$$

8 **(d)**

$$I = \frac{1}{2}\ \varepsilon_0 E_0^2 c$$

or $E_2 = \sqrt{\frac{2I}{\varepsilon_0 c}}$

$$= \sqrt{\frac{2 \times 4}{(8.85 \times 10^{-12}) \times (3 \times 10^8)}}$$

$$= 55.5\ \text{NC}^{-1}$$

9 **(c)**

According to Maxwell, a changing electric field is a source of magnetic field

10 **(c)**

11 **(b)**

Velocity of light in a medium,

$$c = \frac{1}{\sqrt{\mu_0\varepsilon_0\mu_r\varepsilon_r}} = \frac{1}{\sqrt{\mu\varepsilon}}$$

12 **(c)**

A changing electric field produces a changing magnetic field and $vice - versa$ which gives rise to a transverse wave known as Electromagnetic Wave. The time varying electric and magnetic fields are mutually perpendicular to each other and also perpendicular to the direction of propagation of this wave.

13 **(b)**

Initial momentum of surface

$$P_i = \frac{E}{C}$$

Where, $c$ = velocity of light (constant). Since, the surface is perfectly, reflecting, so the same momentum will be reflected completely.

Final momentum

$$P_f = \frac{E}{c}$$ (negative value)

∴Change in momentum

$$\Delta p = p_f - p_i$$

$$= -\frac{E}{c} - \frac{E}{c} = -\frac{2E}{c}$$

Thus , momentum transferred to the surface is

$$\Delta p' = |\Delta p| = \frac{2E}{c}$$

14 **(d)**

Intensity of electromagnetic wave is $I = \frac{P_{av}}{4\pi \times r^2} = \frac{E_0^2}{2\mu_0 c}$

or $E_0 = \sqrt{\frac{\mu_0 c P_{av}}{2\pi r^2}}$

$$= \sqrt{\frac{(4\pi \times 10^{-7}) \times (3 \times 10^8) \times 800}{2\pi \times (4)^2}}$$

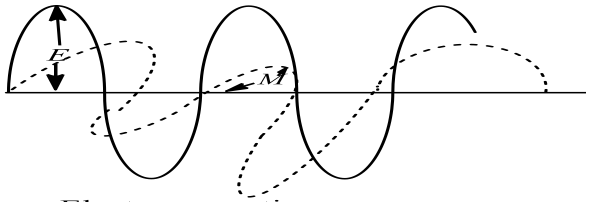
$= 54.77 \text{ Vm}^{-1}$

15 **(c)**

Equation second shows that the electromagnetic wave travels along the positive $x$-axis

16 **(c)**

The given wave in an Electromagnetic Waves. Electromagnetic radiation is a self propagating wave in space with electric and magnetic components. These components oscillate at right angles to each other and to the direction of propagation.



Electromagnetic wave

Hence, **B** is along the $z$-axis at that time.

17 **(a)**

Intensity or power per unit area of the radiations,

$$P = pv$$

$$\Rightarrow \quad p = \frac{P}{v}$$

$$= \frac{0.5}{3 \times 10^8} = 0.166 \times 10^{-8} \text{ Nm}^{-2}$$

18 **(c)**

$$C = \frac{\varepsilon_0 KA}{d} = \frac{(8.85 \times 10^{-12}) \times 10 \times 1}{10^{-3}}$$

$= 8.85 \times 10^{-8}$ F

$$i = \frac{d}{dt}(CV) = C\frac{dV}{dt} = 8.85 \times 10^{-8} \times 25$$

$= 2.2 \times 10^{-6}$ A

19 **(b)**

$$\frac{Q}{t} = \frac{CV}{t} \text{ or } i_D = C\left(\frac{V}{T}\right)$$

or $\frac{V}{t} = \frac{i_D}{C} = \frac{1.0}{10^{-6}} \text{ Vs}^{-1} = 10^6 \text{ Vs}^{-1}$

20 **(b)**

Velocity of light in vacuum

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$

velocity of light in medium

$$v = \frac{1}{\sqrt{\mu\, \varepsilon}}$$

$$\therefore \quad \mu = \frac{c}{v} = \left(\frac{\mu\varepsilon}{\mu_0 \varepsilon_0}\right)^{1/2}$$

21 **(b)**

All the component of electromagnetic spectrum have same velocity, $ie$, $3 \times 10^8 \text{ ms}^{-1}$.

22 **(d)**

The wavelength order of the given types of waves are given below

| **Waves** | **Wavelength Range (in meter)** |
|---|---|
| Gamma rays | $10^{-14} - 10^{-10}$ |
| IR-rays | $7 \times 10^{-7} = 10^{-3}$ |
| UV-rays | $10^{-9} - 4 \times 10^{-7}$ |
| Microwave | $10^{-4} - 10^{0}$ |

Hence, statements (A) and (D) are correct.

23 **(a)**

Here, amplitude of electric filed, $E_0 = 100\ \mathrm{Vm^{-1}}$; amplitude of magnetic field, $B_0 = 0.265\ \mathrm{Am^{-1}}$. We know that the maximum rate of energy flow

$S = E_0 \times B_0 = 100 \times 0.265 = 26.5\ \mathrm{Wm^{-2}}$

24 **(c)**

# Ray Optics

## RED ZONE

1. Relation between critical angles of water and glass is
a) $C_\omega > C_g$ b) $C_\omega < C_g$ c) $C_\omega = C_g$ d) $C_\omega = C_g = 0$

2. A fish, looking up through the water sees the outside world contained in a circular horizon. If the refractive index of water is 4/3 and the fish is 12 cm below the surface of water, the radius of the circle in centimetre is
a) $\dfrac{12 \times 3}{\sqrt{5}}$ b) $12 \times 3 \times \sqrt{5}$ c) $\dfrac{12 \times 3}{\sqrt{7}}$ d) $12 \times 3 \times \sqrt{7}$

3. In the formation of primary rainbow, the sunlight rays emerge at minimum deviation from rain-drop after
a) One internal reflection and one refraction
b) One internal reflection and two refraction
c) Two internal reflection and one refraction
d) Two internal reflection and one refraction

5. Two lenses of power – 15D and +5 D are in contact with each other. The focal length of the combination is
a) -20 cm b) -10 cm c) +20 cm d) +10 cm

6. A glass convex lens ($\mu_g = 1.5$) has a focal length of 8 $cm$ when placed in air. What would be the focal length of the lens what it is immersed in water ($\mu_\omega = 1.33$)
a) 2 $m$ b) 4 $cm$ c) 16 $cm$ d) 32 $cm$

7. Angle of deviation ($\delta$) by a prism (refractive index = $\mu$ and supposing the angle of prism $A$ to be small) can be given by
a) $\delta = (\mu - 1)A$ b) $\delta = (\mu + 1)A$ c) $\delta = \dfrac{\sin\frac{A+\delta}{2}}{\sin\frac{A}{2}}$ d) $\delta = \dfrac{\mu - 1}{\mu + 1}A$

8. The ratio of the refractive index of red light to blue light in air is
a) Less than unity
b) Equal to unity
c) Greater than unity
d) Less as well as greater than unity depending upon the experimental arrangement

9. The focal length of convex lens is 30 $cm$ and the size of image is quarter of the object, then the object distance is
a) 150 $cm$ b) 60 $cm$ c) 30 $cm$ d) 40 $cm$

10. If a lens is cut into two pieces perpendicular to the principal axis and only one part is used, the intensity of the image
a) Remains same b) $\frac{1}{2}$ times c) 2 times d) Infinite

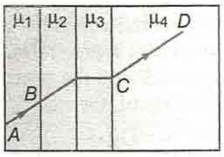
11. The focal length of the objective lens of a compound microscope is
a) Equal to the focal length of its eye piece
b) Less than the focal length of eye piece
c) Greater than the focal length of eye piece
d) Any of the above three

12. A thin lens made of glass of refractive index $\mu = 1.5$ has a focal length equals is 12 cm in air. It is now immersed in water $\left(\mu = \frac{4}{3}\right)$. Its new focal length is
a) 48 cm
b) 36 cm
c) 24 cm
d) 12 cm

13. If the focal length of the objective lens is increased then
a) Magnifying power of microscope will increase but that of telescope will decrease
b) Magnifying power of microscope and telescope both will increase
c) Magnifying power of microscope and telescope both will decrease
d) Magnifying power of microscope will decrease but that of telescope will increase

14. If in compound microscope $m_1$ and $m_2$ be the linear magnification of the objective lens and eye lens respectively, then magnifying power of the compound microscope will be
a) $m_1 - m_2$
b) $\sqrt{m_1 + m_2}$
c) $(m_1 + m_2)/2$
d) $m_1 \times m_2$

15. A ray of light passes through four transparent medium with refractive indices $\mu_1, \mu_2, \mu_3$and $\mu_4$ as shown in the figure. The surfaces of all media are parallel. If the emergent ray $CD$ is parallel to the incident ray AB. We must have




a) $\mu_1 = \mu_2$
b) $\mu_2 = \mu_3$
c) $\mu_3 = \mu_4$
d) $\mu_3 = \mu_1$

16. A person sees his virtual image by holding a mirror very close to the face. When he moves the mirror away from his face, the image becomes inverted. What type of mirror he is using?
a) Plane mirror
b) Convex mirror
c) Concave mirror
d) None of these

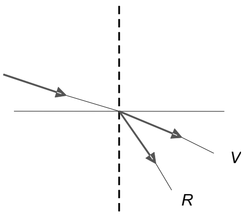
17. A plano convex lens of $(f = 20 \text{ cm})$ is silvered at plane surface. New $f$ will be
a) 20 cm
b) 40 cm
c) 30 cm
d) 10 cm

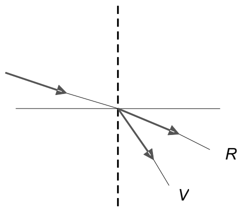
18. A double convex lens $(R_1 = R_2 = 100 \text{ cm})$ having focal length equal to the focal length of a concave mirror. The radius of the concave mirror is
a) 10 cm
b) 20 cm
c) 40 cm
d) 15 cm

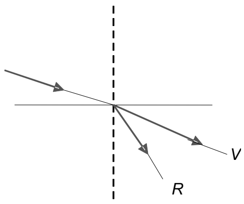
19. A light beam is being reflected by using two mirrors, as in a periscope used in submarines. If one of the mirrors rotates by an angle $\theta$, the reflected light will deviate from its original path by the angle
a) $2\theta$
b) $0°$
c) $\theta$
d) $4\theta$

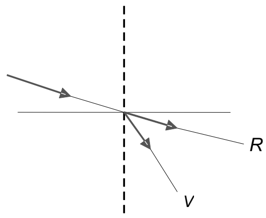
20. Two thin lenses of focal length 20 cm and 25 cm are placed in contact .The effective power of the combination is
a) 9 D
b) 2 D
c) 3 D
d) 7 D

21. A ray of light coming. Which of the following figures, shows dispersion of light?

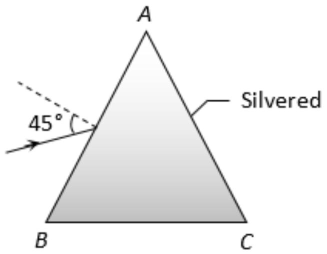
a)



b)



c)


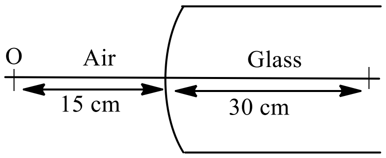

d)


23. A prism $ABC$ of angle 30° has its face $AC$ silvered. A ray of light incident at an angle of 45° at the face $AB$ retraces its path after refraction at face $AB$ and reflection at face $AC$. The refractive index of the material of the prism is



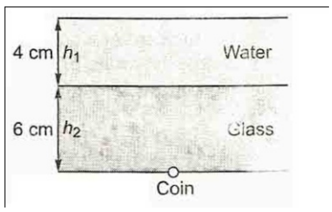

a) 1.5 b) $3/\sqrt{2}$ c) $\sqrt{2}$ d) 4/3

24. A point object $O$ is placed in front of a glass rod having spherical end of radius of curvature 30cm. The image would be formed at



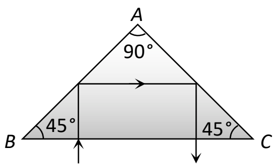

a) 30 cm left b) Infinity c) 1 cm to the right d) 18 cm to the left

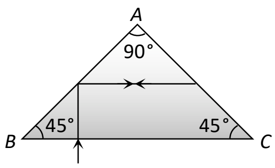
25. A 4 cm thick layer of water covers a 6 cm thick glass slab. A coin is placed at the bottom of the slab and is being observed from the air side along the normal to the surface. Find the apparent position of the coin from

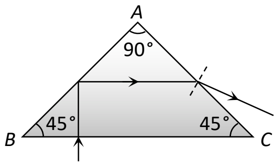


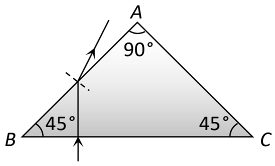

a) 7.0 cm b) 8.0 cm c) 10 cm d) 5 cm

26. The refractive index of a material of a prism of angles $45° - 45° - 90°$ is 1.5. The path of the ray of light incident normally on the hypotenuse side is shown in

a)



b)


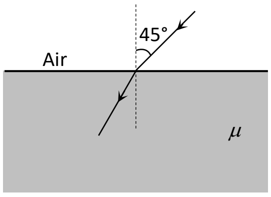

c)



d)



27. Monochromatic light of wavelength $\lambda_1$ travelling in medium of refractive index $n_1$ enters a denser medium of refractive index $n_2$. The wavelength in the second medium is

a) $\lambda_1 \left(\frac{n_1}{n_2}\right)$ b) $\lambda_1 \left(\frac{n_2}{n_1}\right)$ c) $\lambda_1$ d) $\lambda_1 \left(\frac{n_2 - n_1}{n_1}\right)$

28. In the figure shown, for an angle of incidence 45°, at the top surface, what is the minimum refractive index needed for total internal reflection at vertical face




a) $\frac{\sqrt{2}+1}{2}$ b) $\sqrt{\frac{3}{2}}$ c) $\sqrt{\frac{1}{2}}$ d) $\sqrt{2}+1$

29. A thin lens has focal length $f_1$ and its aperture has diameter $d$. It forms an image of intensity $I$. Now the central part of the aperture upto diameter $\frac{d}{2}$ is blocked by an opaque paper. The focal length and image intensity will change to

a) $\frac{f}{2}$ and $\frac{I}{2}$ b) $f$ and $\frac{I}{4}$ c) $\frac{3f}{4}$ and $\frac{I}{2}$ d) $f$ and $\frac{3I}{4}$

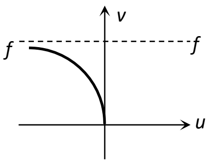
30. A plane mirror produces a magnification of

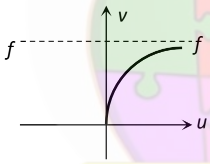
a) -1 b) +1 c) Zero d) Infinite

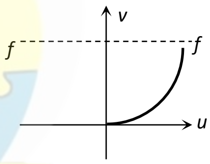
32. The objective lens of a compound microscope produces magnification of 10. In order to get an overall magnification of 100 when image is formed at 25 $cm$ from the eye, the focal length of the eye lens should be

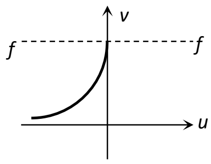
a) 4 $cm$ b) 10 $cm$ c) $\frac{25}{9}$ $cm$ d) 9 $cm$

33. The graph between $u$ and $v$ for a convex mirror is

a)



b)



c)



d)



35. Magnifying power of a simple microscope is (when final image is formed at $D = 25\ cm$ from eye)

a) $\frac{D}{f}$ b) $1+\frac{D}{f}$ c) $1+\frac{f}{D}$ d) $1-\frac{D}{f}$

36. Which of the following is not due to total internal reflection

a) Brilliance of diamond
b) Working of optical fibre
c) Difference between apparent and real depth of a pond
d) Mirage on hot summer days

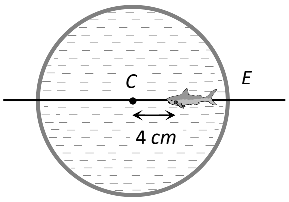
39. Two plane mirrors are inclined at an angleθ. It is found that a ray incident on one mirror at any angle is rendered parallel to itself after reflection from both the mirrors. The value of θ is

a) 30° b) 60° c) 90° d) 120°

40. When a ray of light enters a glass slab from air

a) Its wavelength decreases
b) Its wavelength increases
c) Its frequency increases
d) Neither its wavelength nor its frequency changes

41. In a thin spherical fish bowl of radius 10 $cm$ filled with water of refractive index 4/3 there is a small fish at a distance of 4 $cm$ from the centre $C$ as shown in figure. Where will the image of fish appear, if seen from $E$

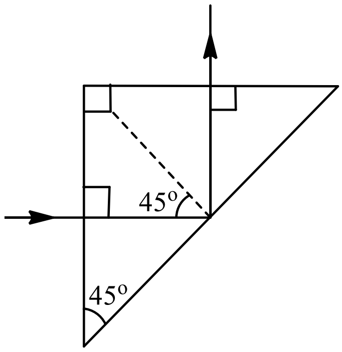



a) 5.2 $cm$ b) 7.2 $cm$ c) 4.2 $cm$ d) 3.2 $cm$

42. The radius of the convex surface of plano-convex lens is 20 $cm$ and the refractive index of the material of the lens is 1.5. The focal length of the lens is

a) 30 $cm$ b) 50 $cm$ c) 20 $cm$ d) 40 $cm$

43. A light ray is incident perpendicular to one face of a 90° prism and is totally internally reflected at the glass-air interface. If the angle of reflection is 45°, we conclude that the refractive index $n$




a) $n < \frac{1}{\sqrt{2}}$ b) $n > \sqrt{2}$ c) $n > \frac{1}{\sqrt{2}}$ d) $n < \sqrt{2}$

44. A ray of light is incident at 60° on one face of a prism which has angle 30°. The angle between the emergent ray and incident ray is 30°. What is the angle between the ray and the face from which its emerge?

a) 0° b) 30° c) 60° d) 90°

45. A convex lens is immersed in a liquid, whose refractive index is equal to the refractive index of the material of the lens. Then its focal length will

a) Decrease b) Become zero c) Become infinite d) Increase

46. The length of the tube of a microscope is 10 $cm$. The focal lengths of the objective and eye lenses are 0.5 $cm$ and 1.0 $cm$. The magnifying power of the microscope is about

a) 5 b) 23 c) 166 d) 500

48. $P$ is a point on the axis of a convex mirror. The image of $P$ formed by the mirror, coincides with $P$. A rectangular glass slab of thickness $t$ and refractive index μ is now introduced between $P$ and the mirror. For the image of $P$ to coincide with $P$ again, the mirror must be moves

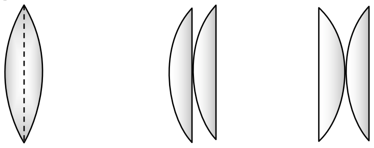
a) Towards $P$ by $(\mu - 1)t$ b) Away from $P$ by $(\mu - 1)t$

c) Towards $P$ by $t\left(1 - \frac{1}{\mu}\right)$ d) Away from $P$ by $t\left(1 - \frac{1}{\mu}\right)$

49. An object placed 10 $cm$ in front of a lens has an image 20 $cm$ behind the lens. What is the power of the lens (in $dioptres$)

a) 1.5 b) 3.0 c) −15.0 d) +15.0

50. Two similar plano-convex lenses are combined together in three different ways as shown in the adjoining figure. The ratio of the focal lengths in three cases will be



a) 2 : 2 : 1 b) 1 : 1 : 1 c) 1 : 2 : 2 d) 2 : 1 : 1

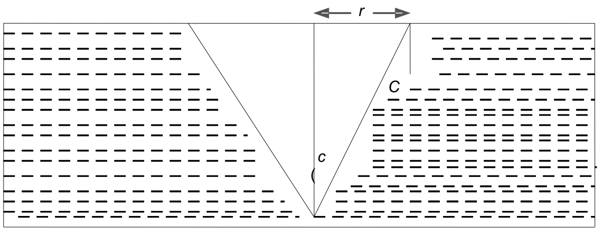
[redacted]

1 **(a)**

$\mu_w < \mu_g \Rightarrow c_w > c_g$

2 **(c)**

From figure, $\tan C = \frac{r}{12}$




or $r = 12 \tan C$

or $r = \dfrac{12 \sin C}{\sqrt{1-\sin^2 C}}$

$$r = \frac{12 \times \frac{1}{\mu}}{\sqrt{1-\frac{1}{\mu^2}}} = \frac{12}{\sqrt{\mu^2-1}} = \frac{12}{\sqrt{\left(\frac{4}{3}\right)^2 - 1}}$$

$ie, r = \dfrac{12 \times 3}{\sqrt{7}}$

3 **(b)**

5 **(b)**

Power of lens is reciprocal of its focal length. Power of combined lens is

$P = P_1 + P_2$

$= -15 + 5 = -10\, D$

$\therefore f = \dfrac{1}{P} = \dfrac{100}{-10} cm$

$f = -10\, cm$

6 **(d)**

$$\frac{f_l}{f_a} = \frac{({}_a\mu_g - 1)}{({}_l\mu_g - 1)}$$

$$\Rightarrow \frac{f_w}{f_a} = \frac{(1.5-1)}{\left(\frac{1.5}{1.33} - 1\right)} \Rightarrow f_w = 32\, cm$$

7 **(a)**

8 **(a)**

$\mu_{blue} > \mu_{red}$

9 **(a)**

$$m = \frac{f}{f+u} \Rightarrow -\frac{1}{4} = \frac{30}{30+u} \Rightarrow u = -150\, cm$$

10 **(a)**

Since light transmitting area is same, there is no effect on intensity

11 **(b)**

For a compound microscope $f_{objective} < f_{eye\ piece}$

12 **(a)**

Focal length in air is given by

$$\frac{1}{f_{a\mathrm{a}}} = \left({}_a\mu_g - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

The focal length of lens immersed in water is given by

$$\frac{1}{f_1} = \left({}_l n_g - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

When, $R_1, R_2$ are radii of curvatures of the two surfaces of lens and ${}_l n_g$ is refractive index of glass with respect to liquid.

Also, ${}_l\mu_g = \dfrac{{}_a n_g}{{}_{\mathrm{a}\,a} n_l}$

Given, ${}_{\mathrm{a}\,a}n_g = 1.5, f_{a\mathrm{a}} = 12$ cm, ${}_{\mathrm{a}\,a}n_l = \frac{4}{3}$

$$\therefore \frac{f_l}{f_{a\mathrm{a}}} = \frac{\left({}_{\mathrm{a}\,a}n_g - 1\right)}{\left({}_l n_g - 1\right)}$$

$$\frac{f_1}{12} = \frac{(1.5-1)}{\left(\frac{1.5}{4/3} - 1\right)} = \frac{0.5 \times 4}{0.5}$$

$\Rightarrow f_1 = 4 \times 12 = 48$ cm

13 **(d)**

A microscope consists of lens of small focal lengths. A telescope consists of objective lens of large focal length

14 **(d)**

Magnification of a compound microscope is given by

$$m = -\frac{v_o}{u_o} \times \frac{D}{u_e} \Rightarrow |m| = m_o \times m_e$$

15 **(a)**

As there is no deflection between medium 1 and 2. Therefore, $\mu_1 = \mu_2$

16 **(b)**

Plane mirror and convex mirror always from erect images. Image formed by concave mirror may be erected or inverted depending on position of object.

17 **(c)**

As $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$\therefore \frac{1}{20} = (1.5 - 1)\left(\frac{1}{\infty} - \frac{1}{R}\right)$

$\frac{1}{20} = \frac{-1}{2R}, R = -10$ cm

Refraction from rarer to denser medium

$-\frac{\mu_1}{u} + \frac{\mu_2}{v} = \frac{\mu_2 - \mu_1}{R}$, where $u = \infty, v = f$

$\therefore 0 + \frac{1.5}{f} = \frac{1.5 - 1}{10} = \frac{1}{20}, f = 30$ cm

18 **(b)**

Focal length of convex lens

$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$R_1 = 10$ cm, $R_2 = -10$ cm, $\mu = 1.5$ (for glass)

$\frac{1}{f} = (1.5 - 1)\left(\frac{1}{10} - \frac{1}{-10}\right)$

$= 0.5\left(\frac{2}{10}\right)$

$f = \frac{10}{2 \times 0.5}$

$\Rightarrow f = 10$ cm

$\therefore$ Focal length of concave mirror

$= 10$ cm

$\therefore$ Radius of curvature $= 2 \times 10 = 20$ cm

19 **(a)**

When a mirror is rotated by an angle $\theta$, the reflected ray deviates from its original path by angle $2\theta$

20 **(a)**

$P = P_1 + P_2$

$= \frac{1}{f_1} + \frac{1}{f_2} = \frac{100}{20} + \frac{100}{25}$

$= 5 + 4 = 9$D

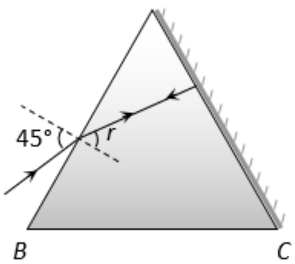
21 **(d)**

After refraction through a medium, red rays deviate less. Also, since air is rarer than water, so the rays bend towards the normal. So, the correct dispersion pattern is (b).

23 **(c)**

$A = r + 0 \Rightarrow r = 30°$

$\therefore \mu = \frac{\sin i}{\sin r} = \frac{\sin 45°}{\sin 30°} = \sqrt{2}$




24 **(a)**

By using formula,

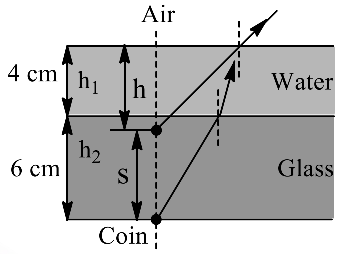
$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

$\Longrightarrow \frac{1.5}{v} - \frac{1}{(-15)} = \frac{1.5 - 1}{+30}$

$\Longrightarrow v = -30\ cm$

25 **(a)**

Using equation, the total apparent shift is




$s = h_1\left(1 - \frac{1}{\mu_1}\right) + h_2\left(1 - \frac{1}{\mu_2}\right)$

Or $s = 4\left(1 - \frac{1}{4/3}\right) + 6\left(1 - \frac{1}{3/2}\right)$

$= 3.0$ cm

Thus, $h = h_1 + h_2 - s = 4 + 6 - 3$

$= 7.0$ cm

26 **(a)**

According to given conditions TIR must take place at both the surfaces $AB$ and $AC$. Hence only option $(a)$ is correct

27 **(a)**

$n_1 = \frac{c}{v_1} = \frac{v\lambda}{v\lambda_1} = \frac{\lambda}{\lambda_1}$

$n_2 = \frac{c}{v_2} = \frac{v\lambda}{v\lambda_2} = \frac{\lambda}{\lambda_2}$

Now, $\frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1}$

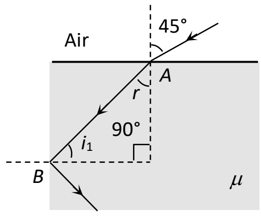
Or $\lambda_2 = \left(\frac{n_1}{n_2}\right)\lambda_1$

28 **(b)**

At point $A$, by Snell's law

$\mu = \frac{\sin 45}{\sin r} \Rightarrow \sin r = \frac{1}{\mu\sqrt{2}}$ ... (i)

At point $B$, for total internal reflection $\sin i_1 = \frac{1}{\mu}$




From figure, $i_1 = 90 - r$

$\therefore \sin(90° - r) = \dfrac{1}{\mu}$

$\Rightarrow \cos r = \dfrac{1}{\mu}$ ... (ii)

Now $\cos r = \sqrt{1 - \sin^2 r} = \sqrt{1 - \frac{1}{2\mu^2}}$

$= \sqrt{\dfrac{2\mu^2 - 1}{2\mu^2}}$ ... (iii)

From equation (ii) and (iii), $\frac{1}{\mu} = \sqrt{\frac{2\mu^2-1}{2\mu^2}}$

Squaring both side and then solving, we get $\mu = \sqrt{\frac{3}{2}}$

29 **(d)**

$I \propto A^2 \Rightarrow \dfrac{I_2}{I_1} = \left(\dfrac{A_2}{A_1}\right)^2 = \dfrac{\pi r^2 - \frac{\pi r^2}{4}}{\pi r^2} = \dfrac{3}{4}$

$\Rightarrow I_2 = \frac{3}{4} I_1$ and focal length remains unchanged

30 **(b)**

The image formed by a plane mirror is virtual, erect, laterally inverted, equal in size as that of the object and at a distance equal to the distance of the object in front of the mirror.

32 **(c)**

$m = m_o \times m_e \Rightarrow m = m_o \times \left(1 + \dfrac{D}{f_e}\right)$

$\Rightarrow 100 = 10 \times \left(1 + \dfrac{25}{f_e}\right) \Rightarrow f_e = \dfrac{25}{9}\, cm$

33 **(a)**

As $u$ goes from 0 to $-\infty$, $v$ goes from $+0$ to $+f$

35 **(b)**

36 **(c)**

Real & apparent depth are explained on the basis of refraction only. TIR not involved here

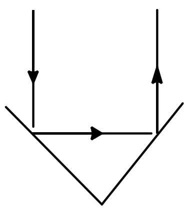
39 **(c)**

Incident ray and finally reflected ray are parallel to each other means $\delta = 180°$

From $\delta = 360° - 2\theta$

$\Rightarrow \quad 180° = 360° - 2\theta$

$\Rightarrow \quad \theta = 90°$



40 **(a)**

$\mu \propto \dfrac{1}{\lambda}$

$\mu_{water} < \mu$

$\therefore \lambda_{domer} < \lambda_{water}$

*ie*, wavelength decreases.

41 **(a)**

By using $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

where $\mu_1 = \frac{4}{3}, \mu = 1, u = -6cm, v = ?$

On putting values $v = -5.2\ cm$

42 **(d)**

$\dfrac{1}{F} = (1.5 - 1)\left(\dfrac{1}{20} - \dfrac{1}{\infty}\right) \Rightarrow F = 40\ cm$

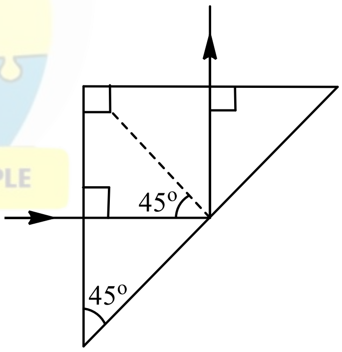
43 **(b)**

For total internal reflection from glass-air interface, critical angle $C$ must be less than angle of incidence.

*ie* $C < i$

*or* $C < 45°$ $(\because \angle i = 45°)$

*but* $n = \dfrac{1}{\sin C} \Longrightarrow C = \sin^{-1}\left(\dfrac{1}{n}\right)$




$\therefore \sin^{-1}\left(\dfrac{1}{n}\right) < 45°$

$\Longrightarrow \dfrac{1}{n} < \sin 45°$

$\Longrightarrow n > \dfrac{1}{\sin 45°}$

$\Longrightarrow n > \dfrac{1}{\left(\frac{1}{\sqrt{2}}\right)}$

$\Longrightarrow n > \sqrt{2}$

44 **(d)**

Here, $i_1 = 60°, A = 30°, \delta = 30°$

As $i_1 + i_2 = A + \delta,$

$i_2 = 0$

Hence, angle between the ray and the face from which it emerges $= 90° - 0° = 90°$

45 **(c)**

Given, ${}_a\mu_g = {}_a\mu_e$

The focal length of convex lens in liquid $f$ is given by

$$\frac{1}{f}=\left(\frac{a\mu_g}{a\,a\mu_{ee}}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1}{f}=(1-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1}{f}=0$$

Or $f=\infty$

Its focal length will become infinite.

46 **(d)**

$$m\simeq\frac{LD}{f_o f_e}\Rightarrow m=\frac{10\times 25}{0.5\times 1}=500$$

48 **(c)**

When a slab of thickness $t$ is introduced between $P$ and the mirror, the appearent position of $P$ shifts towards the mirror by $\left(t-\frac{t}{\mu}\right)$. Hence, the mirror must be moved in the same direction through the same distance

49 **(d)**

$u=-10\ cm, v=20\ cm$

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{20}-\left(-\frac{1}{10}\right)=\frac{3}{20}\Rightarrow f=\frac{20}{3}cm$$

Now $P=\frac{100}{f}=\frac{100}{20/3}=+15\ D$

50 **(b)**

In each case two plane-convex lens are placed close to each other, and $\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}$


# Wave Optics

1. The phenomenon of polarization of light indicates that
   a) Light is a longitudinal wave
   b) Light is a transverse wave
   c) Light is not a wave
   d) Light travels with the velocity of $3 \times 10^8$ ms$^{-1}$
2. The fringe width in Young's double slit experiment increases when
   a) Wavelength increases
   b) Distance between the slits increases
   c) Distance between the source and screen decreases
   d) The width of the slits increases
3. When the angle of incidence on a material is 60°, the reflected light is completely polarized. The velocity of the refracted ray inside the material is (in $ms^{-1}$)
   a) $3 \times 10^8$ b) $\left(\frac{3}{\sqrt{2}}\right) \times 10^8$ c) $\sqrt{3} \times 10^8$ d) $0.5 \times 10^8$
4. The principle of superposition is basic to the phenomenon of
   a) Total internal reflection b) Interference
   c) Reflection d) Refraction
5. Wavefront means
   a) All particles in it have same phase
   b) All particles have opposite phase of vibrations
   c) Few particles are in same phase, rest are in opposite phase
   d) None of these
6. In Young's double slit experiment we get 60 fringes in the field of view of monochromatic light of wavelength 4000Å. If we use monochromatic light of wavelength 6000 Å, then the number of fringes obtained in the same field of view are
   a) 60 b) 90 c) 40 d) 1.5
7. An unpolarised beam of intensity $I_0$ is incident on a pair of nicols making an angle of 60° with each other. The intensity of light emerging from the pair is
   a) $I_0$ b) $I_0/2$ c) $I_0/4$ d) $I_0/8$
8. In Young's double slit experiment, the $8th$ maximum with wavelength $\lambda_1$ is at a distance $d_1$ from the central maximum and the $6th$ maximum with a wavelength $\lambda_2$ is at a distance $d_2$. Then $(d_1/d_2)$ is equal to
   a) $\frac{4}{3}\left(\frac{\lambda_2}{\lambda_1}\right)$ b) $\frac{4}{3}\left(\frac{\lambda_1}{\lambda_2}\right)$ c) $\frac{3}{4}\left(\frac{\lambda_2}{\lambda_1}\right)$ d) $\frac{3}{4}\left(\frac{\lambda_1}{\lambda_2}\right)$
9. The phenomenon which does not take place in sound waves is
   a) Scattering b) Diffraction c) Interference d) Polarisation

10. Intensities of the two waves of light are $I$ and $4I$. The maximum intensity of the resultant wave after superposition is

a) $5\,I$ b) $9\,I$ c) $16\,I$ d) $25\,I$

11. Two identical radiators have a separation of $d = \lambda/4$ where $\lambda$ is the wavelength of the waves emitted by either source. The initial phase difference between the sources is $\pi/4$. Then the intensity on the screen at a distant point situated at an angle $\theta = 30°$ from the radiators is (here $I_o$ is intensity at that point due to one radiator alone)

a) $I_o$ b) $2I_o$ c) $3I_o$ d) $4I_o$

12. Huygen's principle of secondary wavelets may be used to

a) Find the velocity of light in vacuum b) Explain the particle behavior of light

c) Find the new position of the wavefront d) Explain photoelectric effect

13. The ratio of the intensity at the centre of a bright fringe to the intensity at a point one-quarter of the distance between two fringe from the centre is

a) 2 b) 1/2 c) 4 d) 16

14. $n$th Bright fringe if red light $(\lambda_1 = 7500\text{ Å})$ coincides with $(n+1)^{th}$ bright fringe of green light$(\lambda_2 = 6000\text{ Å})$. The value of $n = ?$

a) 4 b) 5 c) 3 d) 2

15. The Young' experiment is performed with the lights of blue ($\lambda = 4360$ Å) and green colour ($\lambda = 5460$Å), if the distance of the 4th fringe from the centre is $x$, then

a) $x$ (Blue) $= x$ (Green) b) $x$(Blue) $> x$(Green) c) $x$(Blue) $< x$(Green) d) $\frac{x(Blue)}{x(Green)} = \frac{5460}{4360}$

16. Refractive index of material is equal to tangent of polarizing angle. It is called

a) Brewster's law b) Lambert's law c) Malus's law d) Bragg's law

17. In the far field diffraction pattern of a single slit under polychromatic illumination, the first minimum with the wavelength $\lambda_1$ is found to be coincident with the third maximum at $\lambda_2$. So

a) $3\lambda_1 = 0.3\lambda_2$ b) $3\lambda_1 = \lambda_2$ c) $\lambda_1 = 3.5\lambda_2$ d) $0.3\lambda_1 = 3\lambda_2$

18. If two waves represented by $y_1 = 4\sin\omega t$ and $y_2 = 3\sin\left(\omega t + \frac{\pi}{3}\right)$ interfere at a point, the amplitude of the resulting wave will be about

a) 7 b) 6 c) 5 d) 3.5

19. Two light rays having the same wavelength $\lambda$ in vacuum are in phase initially. Then the first ray travels a path $L_1$ through a medium of refractive index $n_1$ while the second ray travels a path of length $L_2$ through a medium of refractive index $n_2$. The two waves are then combined to produce interference. The two waves are then combined to produce interference. The phase difference between the two waves is

a) $\frac{2\pi}{\lambda}(L_2 - L_1)$ b) $\frac{2\pi}{\lambda}(n_1L_1 - n_2L_2)$ c) $\frac{2\pi}{\lambda}(n_2L_1 - n_1L_2)$ d) $\frac{2\pi}{\lambda}\left(\frac{L_1 - L_2}{n_1 - n_2}\right)$

20. Two polaroids are placed in the path of unpolarised beam of intensity $I_0$ such that no light is emitted from the second polaroid. If a third polaroid whose polarization axis makes an angle $\theta$ with the polarization axis of first polaroid, is placed between these polaroids then the intensity of light emerging from the last polaroid will be

a) $\left(\frac{I_0}{8}\right)\sin^2 2\theta$ b) $\left(\frac{I_0}{4}\right)\sin^2 2\theta$ c) $\left(\frac{I_0}{2}\right)\cos^4 2\theta$ d) $I_0\cos^4\theta$

21. What will be the angular width of central maxima in Fraunhoffer diffraction when light of wavelength 6000Å is used and slit width is $12 \times 10^{-5}\,cm$

a) $2\,rad$ b) $3\,rad$ c) $1\,rad$ d) $8\,rad$

22. Two sources of same intensity interfere at a point and produced resultant $I$. When one source is removed, the intensity at that point will be

a) $I$ b) $I/2$ c) $I/4$ d) $I/3$

23. If the two waves represented by $y_1 = 4\,\sin\omega t$ and $y_2 = 3\sin(\omega t + \pi/3)$ interfere at a point, the amplitude of the resulting wave will be about

a) 7 b) 5 c) 6 d) 3.5

24. In Young's double slit experiment, if the widths of the slits are in the ratio 4 : 9, the ratio of the intensity at maxima to the intensity at minima will be
a) 169 : 25 b) 81 : 16 c) 25 : 1 d) 9 : 4

25. In the phenomenon of diffraction of light, when blue light is used in the experiment instead of red light, then
a) Fringes will become narrower
b) Fringes will become broader
c) No change in fringe width
d) None of the above

26. The angle of polarization for any medium is 60°, what will be critical angle for this
a) $\sin^{-1}\sqrt{3}$ b) $\tan^{-1}\sqrt{3}$ c) $\cos^{-1}\sqrt{3}$ d) $\sin^{-1}\frac{1}{\sqrt{3}}$

27. An unpolarised beam of intensity $2\,a^2$ passes through a thin Polaroid. Assuming zero absorption in the Polaroid, the intensity of emergent plane polarized light is
a) $2\,a^2$ b) $a^2$ c) $\sqrt{2}a^2$ d) $\frac{a^2}{2}$

28. Ray diverging from a point source form a wave front that is
a) Cylindrical b) Spherical c) Plane d) Cubical

29. Two light sources are said to be of coherent nature
a) When they have same frequency and a varying phase difference
b) When they have same frequency and a constant phase difference
c) When they have constant phase difference and different frequencies
d) When they have varying phase difference and different frequencies

30. Two waves $y_1 = A_1\sin(\omega t - \beta_1)$ and $y_2 = A_2\sin(\omega t - \beta_2)$ superimpose to form a resultant wave whose amplitude is
a) $\sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos(\beta_1 - \beta_2)}$
b) $\sqrt{A_1^2 + A_2^2 + 2A_1A_2\sin(\beta_1 - \beta_2)}$
c) $A_1 + A_2$
d) $|A_1 + A_2|$



31. Wave nature of light is verified by
a) Interference b) Photoelectric effect c) Reflection d) Refraction

32. In young's double slit experiment, the intensity of the maxima is$I$. If the width of each slit is doubled, the intensity if the maxima will be
a) $I/2$ b) $2I$ c) $4I$ d) $I$

33. An unpolarised beam of intensity $I_0$ falls on a polariod. The intensity of the emergent light is
a) $\frac{I_0}{2}$ b) $I_0$ c) $\frac{I_0}{4}$ d) Zero

34. 100 $\pi$ phase difference = ……. Path difference.
a) $10\lambda$ b) $25\lambda$ c) $50\lambda$ d) $100\lambda$

35. A narrow slit of width 2 mm is illuminated by monochromatic light of wavelength 500 nm. The distance between the first minima on either side on a screen at a distance of 1 m is
a) 5 mm b) 0.5 mm c) 1 mm d) 10 mm

36. In a Young's double slit experiment using red and blue lights of wavelengths 600 nm and 480 nm respectively, the value of $n$ from which the $n^{th}$ red fringe coincides with $(n+1)$ the blue fringe is
a) 5 b) 4 c) 3 d) 2

37. By corpuscular theory of light, the phenomenon which can be explained is
a) Refraction b) Interference c) Diffraction d) Polarization

38. When two coherent monochromatic beams of intensity $I$and $9I$interface, the possible maximum and minimum intensities of the resulting beam are
a) $9I$and $I$ b) $9I$and $4I$ c) $16I$and $4I$ d) $16I$and $I$

39. In Young's double slit experiment if monochromatic light used is replaced by white light, then
a) No fringes are observed
b) Only central fringe is white, all other fringes are coloured

c) All bright fringes become white

d) All bright fringes have colours between violet and red

40. In an interference pattern the position of zeroth order maxima is 4.8 mm from a certain point $P$ on the screen. The fringe width is 0.2 mm. The position of second maxima from point $P$ is

a) 5.1 mm b) 5 mm c) 40 mm d) 5.2 mm

41. Two coherent monochromatic light beams of intensities $I$ and $4I$ are superposed. The maximum and minimum possible intensities in the resulting beam are

a) $5I$ and $I$ b) $5I$ and $3I$ c) $9I$ and $I$ d) $9I$ and $3I$

42. In a Young's double slit experiment, the fringe width is found to be 0.4 $mm$. If the whole apparatus is immersed in water of refractive index 4/3 without disturbing the geometrical arrangement, the new fringe width will be

a) 0.30 $mm$ b) 0.40 $mm$ c) 0.53 $mm$ d) 450 $micron$

43. The diffraction effect can be observed in

a) Only sound waves b) Only light waves

c) Only ultrasonic waves d) Sound as well as light waves

44. Plane polarized light is passed through a polaroid. On viewing through the polaroid we find that when the polariod is given one complete rotation about the direction of the light, one of the following is observed

a) The intensity of light gradually decreases to zero and remains at zero

b) The intensity of light gradually increases to a maximum and remains at maximum

c) There is no change in intensity

d) The intensity of light is twice maximum and twice zero

45. What causes change in the colours of the soap or oil films for the given beam of light

a) Angle of incidence b) Angle of reflection c) Thickness of film d) None of these

[redacted]

1 **(b)**

The polarization is the property of electromagnetic waves such as light which describes the direction of their transverse electric field. More generally, the polarization of transverse wave describes the direction of oscillation, in the plane perpendicular to the direction of travel. Longitudinal waves such as sound waves do not exhibit polarization, becomes for these waves the direction of oscillation is along the direction of travel.

2 **(a)**

$$\beta = \frac{\lambda D}{d} \Rightarrow \beta \propto \lambda$$

3 **(c)**

From Brewster's law $\mu = \tan i_p \Rightarrow \frac{c}{v} = \tan 60° = \sqrt{3}$

$$\Rightarrow v = \frac{c}{\sqrt{3}} = \frac{3 \times 10^8}{\sqrt{3}} = \sqrt{3} \times 10^8 m/s$$

4 **(b)**

5 **(a)**

Wavefront is the locus of all the particles which vibrates in the same phase

6 **(c)**

As $x = n_1\beta_1 = n_2\beta_2 = n_2\lambda_1 = n_2\lambda_2$

$$\therefore n_2 = \frac{n_1\lambda_1}{\lambda_2} = \frac{60 \times 4000}{6000} = 40$$

7 **(c)**

According to Malus' law

$$I = I_0 \cos^2 \theta = I_0 (\cos^2 60°) = I_0 \times \left(\frac{1}{2}\right)^2 = \frac{I_0}{4}$$

8 **(b)**

Position of $n^{\text{th}}$ maxima from central maxima is given by $x_n = \frac{n\lambda D}{d}$

$$\Rightarrow x_n \propto n\lambda \Rightarrow \frac{d_1}{d_2} = \frac{n_1\lambda_1}{n_2\lambda_2} = \frac{8\lambda_1}{6\lambda_2} = \frac{4}{3}\left(\frac{\lambda_1}{\lambda_2}\right)$$

9 **(d)**

As sound waves are longitudinal, therefore, polarization of sound waves is not possible.

10 **(b)**

$I_{\text{max}} = I_1 + I_2 + 2\sqrt{I_1 I_2}$

So, $I_{\text{max}} = I + 4I + 2\sqrt{I.4I} = 9I$

11 **(b)**

The intensity at a point on screen is given by

$I = 4I_0 \cos^2(\phi/2)$

Where $\phi$ is the phase difference. In this problem $\phi$ arises (i) due to initial phase difference of $\pi/4$ and (ii) due to path difference for the observation point situated at $\theta = 30°$. Thus

$$\phi = \frac{\pi}{4} + \frac{2\pi}{\lambda}(d \sin \theta) = \frac{\pi}{4} + \frac{2\pi}{\lambda}.\frac{\lambda}{4}(\sin 30°)$$

$$= \frac{\pi}{4} + \frac{\pi}{4} = \frac{\pi}{2}$$

Thus $\frac{\phi}{2} = \frac{\pi}{4}$ and $I = 4I_0 \cos^2(\pi/4) = 2I_0$

12 **(c)**

13 **(a)**

$$I = 4I_0 \cos^2 \frac{\phi}{2}$$

At central position $I_1 = 4I_0$ ...(i)

Since the phase difference between two successive fringes is $2\pi$, the phase difference between two points separated by a distance equal to one quarter of the distance between the two, successive fringes is equal to

$\delta = (2\pi)\left(\frac{1}{4}\right) = \frac{\pi}{2}$ radian

$\Rightarrow I_2 = 4I_0 \cos^2\left(\frac{\frac{\pi}{2}}{2}\right) = 2I_0$ ...(ii)

Using (i) and (ii), $\frac{I_1}{I_2} = \frac{4I_0}{2I_0} = 2$

14 **(a)**

15 **(c)**

Distance of $n^{th}$ bright fringe $y_n = \frac{n\lambda D}{d}, i.e., y_n \propto \lambda$

$$\therefore \frac{x_{n_1}}{x_{n_2}} = \frac{\lambda_1}{\lambda_2} \Rightarrow \frac{x(\text{Blue})}{x(\text{Green})} = \frac{4360}{5460}$$

$\therefore x(\text{Green}) > x(\text{Blue})$

16 **(a)**

17 **(c)**

Position of first minima = position of third maxima $i.e.,$

$$\frac{1 \times \lambda_1 D}{d} = \frac{(2 \times 3 + 1)}{2} \frac{\lambda_2 D}{d} \Rightarrow \lambda_1 = 3.5\lambda_2$$

18 **(b)**

$\phi = \pi/3, a_1 = 4, a_2 = 3$

So, $A = \sqrt{a_1^2 + a_2^2 + 2a_1.a_2 \cos\phi} \Rightarrow A = 6$

19 **(b)**

The optical path between any two points is proportional to the time of travel.

The distance traversed by light in a medium of refractive index $\mu$ in time $t$ is given by

$d = vt \quad \ldots\ldots\ldots (i)$

Where $v$ is velocity of light in the medium. The distance traversed by light in a vacuum in this time.

$\Delta = ct$

$= c . \frac{d}{v} \qquad [From\ Eq. (i)]$

$= d\frac{c}{v} = \mu d \qquad (ii)$

$\left(\text{Since}, \mu = \frac{c}{v}\right)$

This distance is the equivalent distance in vacuum and is called optical path.

Here, optical path for first ray $= n_1 L_1$

Optical path for second ray $= n_2 L_2$

Path difference $= n_1 L_1 - n_2 L_2$

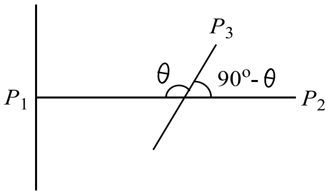
Now, phase difference

$= \frac{2\pi}{\lambda} \times$ path difference

$= \frac{2\pi}{\lambda} \times (n_1 L_1 - n_2 L_2)$

20 **(a)**

No light is emitted from the second polaroid, so $P_1$ and $P_2$ are perpendicular to each other




Let the initial intensity of light is $I_0$. So Intensity of light after transmission from first polaroid $= \frac{I_0}{2}$

Intensity of light emitted from $P_3$ $I_1 = \frac{I_0}{2}\cos^2\theta$

Intensity of light transmitted from last polaroid $i.e.$ from

$P_2 = I_1 \cos^2(90° - \theta) = \frac{I_0}{2}\cos^2\theta . \sin^2\theta$

$= \frac{I_0}{8}(2\sin\theta\cos\theta)^2 = \frac{I_0}{8}\sin^2 2\theta$

21 **(c)**

Angular width $= \frac{2\lambda}{d} = \frac{2\times6000\times10^{-10}}{12\times10^{-5}\times10^{-2}} = 1rad$

22 **(c)**

23 **(c)**

$y_1 = 4\sin\omega t$

$y_2 = 3\sin(\omega t + \pi/3)$

Here, $a = 4, b = 3, \phi = \pi/3$

$R = \sqrt{a^2 + b^2 + 2ab\cos\phi}$

$= \sqrt{4^2 + 3^2 + 2 \times 4 \times 3\cos\pi/3}$

$= \sqrt{37} = 6$

24 **(c)**

Slit width ratio $= 4:9$; hence $I_1 : I_2 = 4:9$

$\therefore \frac{a_1^2}{a_2^2} = \frac{4}{9} \Rightarrow \frac{a_1}{a_2} = \frac{2}{3}$

$\therefore \frac{I_{\max}}{I_{\min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{25}{1}$

25 **(a)**

Width of central maximum is given by

$w = \frac{2f\lambda}{a} \qquad \ldots(i)$

Where $f$ is focal length of lens, $a$ is width of slit and $\lambda$ is wavelength of light used.

From Eq. (i), it is clear that fringe width

$w \propto \lambda$

So, when blue light is used in the experiment instead of red light, the fringes will become narrower.

26 **(d)**

By using $\mu = \tan\theta_p \Rightarrow \mu = \tan 60 = \sqrt{3}$

Also $C = \sin^{-1}\left(\frac{1}{\mu}\right) \Rightarrow C = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$

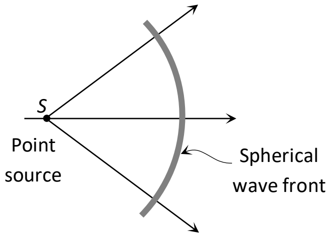
27 **(b)**

The intensity of plane polarised light is=$2a^2$.

$\therefore$ Intensity of polarised light from first nicol prism

$$= \frac{I_0}{2} = \frac{1}{2} \times 2a^2 = a^2$$

28 **(b)**




29 **(b)**

30 **(a)**

Amplitude $A_1$ and $A_2$ are added as vector. Angle between these vectors is the phase difference $(\beta_1 - \beta_2)$ between them

$$\therefore \quad R = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos(\beta_1 - \beta_2)}$$

31 **(a)**

Photoelectric effect verifies particle nature of light. Reflection and refraction verify both particle nature and wave nature of light

32 **(b)**

$$I_{max} = I = I_1 + I_2 + 2\sqrt{I_1I_2}$$

When width of each slit is doubled, intensity from each slit becomes twice *ie,*

$$I_1' = 2I_1 \text{ and } I_2' = 2I_2$$

$$\therefore \quad I'_{max} = I' = I_1' + I_2' + 2\sqrt{I_1' \times I_2'}$$

$$= 2I_1 + 2I_2 + 2\sqrt{2I_1 \times 2I_2}$$

$$= 2\left(I_1 + I_2 + 2\sqrt{I_1 \times I_2}\right) = 2I$$

33 **(a)**

If an unpolarised light is converted into plane polarized light by passing through a polaroid its intensity becomes half.

34 **(c)**

Path difference $= \frac{\lambda}{2\pi} \times$ phase difference

$$= \frac{\lambda}{2\pi} \times 100\pi = 50\lambda$$

35 **(b)**

Distance $= \frac{2\lambda}{b} \times d$

$$= \frac{2 \times 0.5 \times 10^{-4}}{2} \times 100 = 0.5 \text{ mm}$$

36 **(b)**

$$n\lambda_r = (n+1)\lambda_b$$

$$\frac{n+1}{n} = \frac{\lambda_r}{\lambda_b} = \frac{600}{480} = \frac{4}{5}$$

$$\frac{1}{n} = \frac{4}{5} - 1 = \frac{1}{4} n = 4$$

37 **(a)**

Corpuscular theory explains refraction of light

38 **(c)**

Given, $I_1 = I$ and $I_2 = 9I$

Maximum intensity $= \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$

$$= \left(\sqrt{I} + \sqrt{9I}\right)^2 = 16I$$

Minimum intensity

$$= \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 = \left(\sqrt{I} - \sqrt{9I}\right)^2 = 4I$$

39 **(b)**

In Young's double slit experiment if white light is used instead of monochromatic light, then we shall get a white fringe at the centre surrounded on either side with some coloured fringes, with violet fringe in the beginning and red fringe in the last.

40 **(a)**

The distance between zeroth order maxima and second order minima is

$$y_1 = \frac{\beta}{2} + \beta = \frac{3}{2}\beta$$

$$= \frac{3}{2} \times 0.2 \text{ mm} = 0.3 \text{ mm}$$

$\therefore$ The distance of second maxima from point $P$is

$$y = (4.8 + 0.3)\text{mm} = 5.1 \text{ mm}$$

41 **(c)**

$$I_{\max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \left(\sqrt{I} + \sqrt{4I}\right)^2 = 9I$$

$$I_{\min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 = \left(\sqrt{I} - \sqrt{4I}\right)^2 = I$$

42 **(a)**

$$\beta_{\text{water}} = \frac{B_{air}}{\mu} = \frac{0.4}{4/3} = 0.3mm$$

43 **(d)**

44 **(d)**

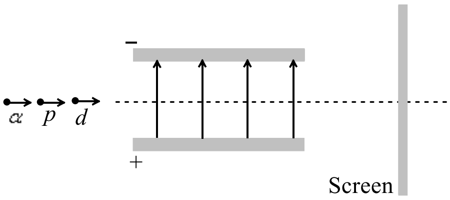
45 **(c)**

For viewing interference in oil films or soap bubble, thickness of film is of the order of wavelength of light


# Dual Nature of Radiation and Matter

## RED ZONE

1. A uniform electric field and a uniform magnetic field are acting along the same direction in a certain region. If an electron is projected along the direction of the fields with a certain velocity, then
   a) Its velocity will decrease
   b) Its velocity will increase
   c) It will turn towards right of direction of motion
   d) It will turns towards left of direction of motion
2. The de-Broglie wavelength $\lambda$ associated with an electron having kinetic energy $E$ is given by the expression
   a) $\frac{h}{\sqrt{2mE}}$ b) $\frac{2h}{mE}$ c) $2mhE$ d) $\frac{2\sqrt{2mE}}{h}$
3. Electric field and magnetic field in Thomson mass spectrograph are applied
   a) Simultaneously, perpendicular b) Perpendicular but not simultaneously
   c) Parallel but not simultaneously d) Parallel simultaneously
4. The linear momentum of photon is $p$. The wavelength of photon is $\lambda$ , then ($h$ is Planck constant)
   a) $\lambda = hp$ b) $\lambda = \frac{h}{p}$ c) $\lambda = \frac{p}{h}$ d) $\lambda = \frac{p^2}{h}$
5. A proton, a deuteron and an $\alpha$-particle having the same momentum, enters a region of uniform electric field between the parallel plates of a capacitor. The electric field is perpendicular to the initial path of the particles. Then the ratio of deflections suffered by them is




   a) 1 :2 :8 b) 1 :2 :4 c) 1 :1 :2 d) None of these
6. If the momentum of an electron is changed by $\Delta p$, then the de-Broglie wavelength associated with it changes by 0.50%. The initial momentum of the electron will be
   a) $\frac{\Delta p}{200}$ b) $\frac{\Delta p}{199}$ c) $199\ \Delta p$ d) $400\ \Delta p$
7. If the wavelength of incident light changes from 400 nm to 300 nm, the stopping potential for photoelectrons emitted from a surface becomes approximately
   a) 1.0 V greater b) 1.0 V smaller c) 0.5 V greater d) 0.5 V smaller
8. What is de-Broglie wavelength of electron having energy 10 ke V?
   a) 0.12Å b) 1.2Å c) 12.2Å d) None of these

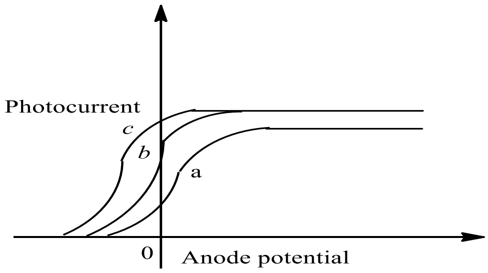
9. The de-Broglie wavelength is proportional to

a) $\lambda \propto \frac{1}{v}$ b) $\lambda \propto \frac{1}{m}$ c) $\lambda \propto \frac{1}{p}$ d) $\lambda \propto p$

10. The work functions of metals $A$ and $B$ are in the ratio 1:2. If light of frequencies $f$ and $2f$ are incident on the surfaces of $A$ and B respectively, the ratio of the maximum kinetic energies of photoelectrons emitted is ($f$ is greater than threshold frequency of $A$, $2f$ is greater than threshold of $B$)

a) 1 :1 b) 1 :2 c) 1 :3 d) 1 :4

11. The figure shows variation of photocurrent with anode potential for a photo-sensitive surface for three different radiations. Let $I_a, I_b$ and $I_c$ be the intensities and $v_a, v_b$ and $v_c$ be the frequencies for the curves $a, b$ and $c$ respectively. Then




a) $v_a = v_b and\ I_a \neq I_b$ b) $v_a = v_c$ and $I_a = I_c$ c) $v_a = v_b$ and $I_a = I_b$ d) $v_b = v_c$ and $I_b = I_c$

12. The frequency of the incident light falling on a photosensitive metal plate is doubled, the kinetic energy of the emitted photoelectron is

a) Double the earlier value b) Unchanged
c) More than doubled d) Less than doubled

13. For an electron in the second orbit of Bohr's hydrogen atom, the moment of linear momentum is

a) $\pi h$ b) $2\pi h$ c) $\frac{h}{\pi}$ d) $\frac{2h}{\pi}$

14. Kinetic energy of emitted cathode rays is dependent on

a) Only voltage b) Only work function
c) Both (a) and (b) d) It does not depend upon any physical quantity



15. What is the de-Broglie wavelength of the $\alpha$-particle accelerated through a potential difference $V$

a) $\frac{0.287}{\sqrt{V}}$Å b) $\frac{12.27}{\sqrt{V}}$Å c) $\frac{0.101}{\sqrt{V}}$Å d) $\frac{0.202}{\sqrt{V}}$Å

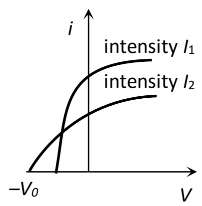
16. An electron with (rest mass $m_0$) moves with a speed of $0.8c$. Its mass when it moves with this speed is

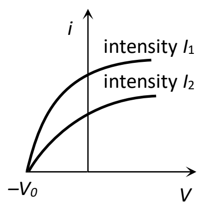
a) $m_0$ b) $m_0/6$ c) $5m_0/3$ d) $3m_0/5$

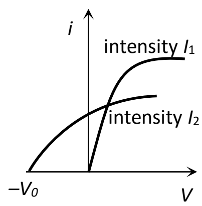
17. The de-Broglie wavelength of a neutron at 927°C is $\lambda$. What will be its wavelength at 27°C ?

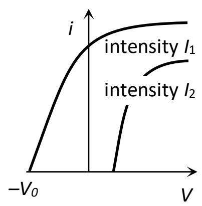
a) $\lambda/2$ b) $\lambda/4$ c) $4\lambda$ d) $2\lambda$

18. The curves (a), (b) (c) and (d) show the variation between the applied potential difference ($V$) and the photoelectric current ($i$), at two different intensities of light ($I_1 > I_2$). In which figure is the correct variation shown

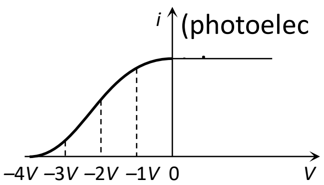
a) 


b) 


c) 


d) 


19. The value of stopping potential in the following diagram




a) $-4V$ b) $-3\ V$ c) $-2V$ d) $-1\ V$

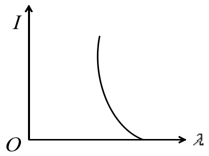
20. Work function of a metal is 2.51 $eV$. Its threshold frequency

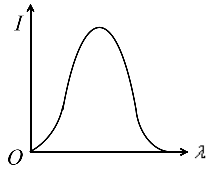
a) $5.9 \times 10^{14} cycles/s$ b) $6.5 \times 10^{14} cycles/s$ c) $9.4 \times 10^{14} cycles/s$ d) $6.08 \times 10^{14} cycles/s$

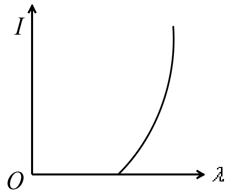
21. $\lambda_e, \lambda_p$ and $\lambda_\alpha$ are the de Broglie wavelengths of electron, proton and $\alpha$ particle. If all are accelerated by same potential, then

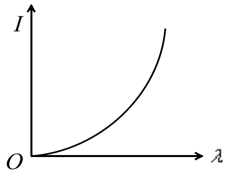
a) $\lambda_e < \lambda_p < \lambda_\alpha$ b) $\lambda_e < \lambda_p > \lambda_\alpha$ c) $\lambda_e > \lambda_p < \lambda_\alpha$ d) $\lambda_e > \lambda_p > \lambda_\alpha$

22. The anode voltage of a photocell is kept fixed. The wavelength $\lambda$ of the light falling on the cathode is gradually changed. The plate current 1 of the photocell varies as follows

a) 


b) 


c) 


d) 


23. Which one of the following statements regarding photo-emission of electrons is correct?

a) Kinetic energy of electrons increases with the intensity of incident light.

b) Electrons are emitted when the wavelength of the incident light is above a certain threshold wavelength.

c) Photoelectric emission is instantaneous with the incidence of light.

d) Photoelectrons are emitted whenever a gas is irradiated with ultraviolet light.

24. The threshold frequency for certain metal is $3.3 \times 10^{14}$ Hz. If light of frequency $8.2 \times 10^{14}$ Hz is incident on the metal, the cut-off voltage of the photoelectric current will be

a) 4.9 V b) 3.0 V c) 2.0 V d) 1 V

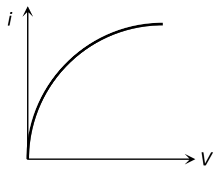
25. Light of wavelength 5000Å is falling on a sensitive surface.If the surface has received $10^{-7}$ J of energy, then the number of photons falling on the surface will be

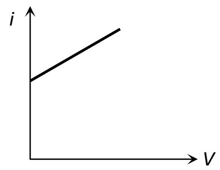
a) $5 \times 10^{11}$ b) $2.5 \times 10^{11}$ c) $3 \times 10^{11}$ d) None of these

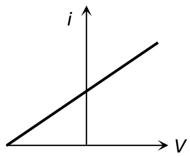
26. A proton and an $\alpha$-particle are accelerated through a potential difference of 100 $V$. The ratio of the wavelength associated with the proton to that associated with an $\alpha$-particle is

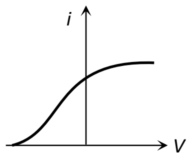
a) $\sqrt{2} : 1$ b) 2 :1 c) $2\sqrt{2} : 1$ d) $\frac{1}{2\sqrt{2}} : 1$

27. The curve between current $(i)$ and potential difference $(V)$ for a photo cell will be

a) 


b) 


c) 


d) 


28. Photons of energy of 6 eV are incident on a metal surface whose work function is 4 eV. The minimum kinetic energy of the emitted photoelectrons will be

a) Zero b) 1 eV c) 2 eV d) 10 eV

29. The wavelength of a 1 keV photon is 1.24 nm. The frequency of 1 MeV photon is

a) $1.24 \times 10^{15}$Hz b) $2.4 \times 10^{20}$ Hz c) $1.24 \times 10^{18}$ Hz d) $2.4 \times 10^{24}$ Hz

30. The minimum wavelength of X-ray emitted from X-ray machine operating at an accelerating potential of $V$ volts is

a) $\frac{hc}{eV}$ b) $\frac{Vc}{eh}$ c) $\frac{eh}{Vc}$ d) $\frac{eV}{hc}$

31. The kinetic energy of an electron gets tripled, then the de-Broglie wavelength associated with it changes by a factor

a) $\frac{1}{3}$ b) $\sqrt{3}$ c) $\frac{1}{\sqrt{3}}$ d) 3

32. An electron of mass $m$ and charge $e$ initially at rest gets accelerated by a constant electric field $E$. The rate of change of de-Broglie wavelength of this electron at time $t$ ignoring relativistic effects is

a) $\frac{-h}{eEt^2}$ b) $\frac{-e\,Et}{E}$ c) $\frac{-mh}{e\,Et^2}$ d) $\frac{-h}{e\,E}$

33. One electron and one proton is accelerated by equal potential. Ratio in their de-Broglie wavelength is

a) 1 b) $\frac{m_e}{m_p}$ c) $\sqrt{\frac{m_p}{m_e}}$ d) $\sqrt{\frac{m_e}{m_p}}$

34. Dual nature of radiation is shown by

a) Diffraction and reflection
b) Refraction and diffraction
c) Photoelectric effect alone
d) Photoelectric effect and diffraction

35. Gases begin to conduct electricity at low pressure because

a) At low pressure, gases turn to plasma
b) Colliding electrons can acquire higher kinetic energy due to increased mean free path leading to ionization of atoms
c) Atoms break up into electrons and protons
d) The electrons in atom can move freely at low pressure

36. The kinetic energy of electron and proton is $10^{-32}J$. Then the relation between their de-Broglie wavelength is

a) $\lambda_p < \lambda_e$ b) $\lambda_p > \lambda_e$ c) $\lambda_p = \lambda_e$ d) $\lambda_p = 2\lambda_e$

37. If $\lambda_1$ and $\lambda_2$ are the wavelengths of characteristic X-rays and gamma rays respectively, then the relation between them is

a) $\lambda_1 = \frac{1}{\lambda_2}$ b) $\lambda_1 = \lambda_2$ c) $\lambda_1 > \lambda_2$ d) $\lambda_1 < \lambda_2$

38. The electrons are emitted in the photoelectric effect from a metal surface

a) Only if the frequency of the incident radiation is above a certain threshold value
b) Only if the temperature of the surface is high
c) At a rate that is independent of the nature of the metal
d) With a maximum velocity proportional to the frequency of the incident radiation

39. In a photoelectric effect measurement, the stopping potential for a given metal is found to be $V_0$ volt when radiation of wavelength $\lambda_0$ is used. If radiation of wavelength $2\lambda_0$ is used with the same metal then the stopping potential (in volt ) will be

a) $\frac{V_0}{2}$ b) $2V_0$ c) $V_0 + \frac{hc}{2e\lambda_0}$ d) $V_0 - \frac{hc}{2e\lambda_0}$

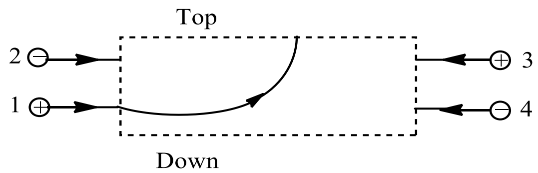
40. When monochromatic radiation of intensity $I$ falls on a metal surface, the number of photoelectron and their maximum kinetic energy are $N$ and $T$ respectively. If the intensity of radiation is $2I$, the number of emitted electrons and their maximum kinetic energy are respectively

a) $N$ and $2T$ b) $2N$ and $T$ c) $2N$ and $2T$ d) $N$ and $T$

41. An $\alpha$-particle and a proton are accelerated from rest by a potential difference of 100 V. After this, their de-Broglie wavelengths are $\lambda_\alpha$ and $\lambda_p$ respectively. The ratio $\frac{\lambda_p}{\lambda_\alpha}$, to the nearest integer, is

a) 3 b) 4 c) 2 d) 4.5

42. The figure shows the path of a positively charged particle 1 through a rectangular region of uniform electric field as shown in the figure. What is the direction of electric field and the direction of deflection of particles 2,3 and 4?




a) Top; down , top, down
b) Top; down, down, top
c) Down; top, top, down
d) Down; top, down, down

43. The de-Broglie wavelength of a neutron at 27°C is $\lambda$. What will be its wavelength at 927°C ?
a) $\lambda/4$ b) $\lambda/3$ c) $\lambda/2$ d) $3\,\lambda/2$

44. If in a photoelectric experiment, the wavelength of incident radiation is reduced from 6000 Å to 4000 Å then
a) Stopping potential will decrease
b) Stopping potential will increase
c) Kinetic energy of emitted electrons will decrease
d) The value of work function will decrease

45. The ratio of the de-Broglie wavelength of an $\alpha$-particle and a proton of same kinetic energy is
a) 1:2 b) 1:1 c) $1:\sqrt{2}$ d) 4:1

46. A photon of energy $E$ ejects a photoelectrons from a metal surface whose work function is $W_0$. If this electron enters into a uniform magnetic field of induction $B$ in a direction perpendicular to the field and describes a circular path of radius $r$, then the radius $r$, is given by, (in the usual notation)
a) $\sqrt{\dfrac{2m(E-W_0)}{eB}}$ b) $\sqrt{2m(E-W_0)eB}$ c) $\dfrac{\sqrt{2e(E-W_0)}}{mB}$ d) $\dfrac{\sqrt{2m(E-W_0)}}{eB}$

47. A particle of mass $M$ at rest decays into two masses $m_1$ and $m_2$ with non-zero velocities. The ratio of de-Broglie wavelengths of the particles $\frac{\lambda_1}{\lambda_2}$ is
a) $\dfrac{m_2}{m_1}$ b) $\dfrac{m_1}{m_2}$ c) $\dfrac{\sqrt{m_1}}{\sqrt{m_2}}$ d) 1:1

48. When the speed of electrons increase, then the value of its specific charge
a) Increases
b) Decreases
c) Remains unchanged
d) Increases upto some velocity and then begins to decrease

49. When intensity of incident light increases
a) Photo-current increases
b) Photo-current decreases
c) Kinetic energy of emitted photoelectrons increases
d) Kinetic energy of emitted photoelectrons decreases

50. Velocity ratio of the two cathode rays 1.2. They are applied to the same electric field. What is the deflection ratio of the two cathode rays
a) 1 :2 b) 1 :4 c) 4 :1 d) 8 :1

51. The frequency and intensity of a light source are doubled. Consider the following statements
I. Saturation photocurrent remains almost the same.
II. Maximum kinetic energy of the photoelectrons is doubled.
a) Both I and II are true b) I is true but II is false. c) I is false but II is true. d) Both I and II are false.

52. In photoelectric effect if the intensity of light is doubled, then maximum kinetic energy of photoelectrons will become
a) Double b) Half c) Four times d) No change

53. There are $n_1$ photons of frequency $v_1$ in a beam of light. In an equally energetic beam there are $n_2$ photons of frequency $v_2$. Then the correct relation
a) $\dfrac{n_1}{n_2}=\dfrac{v_1}{v_2}$ b) $\dfrac{n_1}{n_2}=1$ c) $\dfrac{n_1}{n_2}=\dfrac{v_2}{v_1}$ d) $\dfrac{n_1}{n_2}=\dfrac{v_2^2}{v_1^2}$

54. When the momentum of a proton is changed by an amount $P_0$, the corresponding change in the de-Broglie wavelength is found to be 0.25%. Then, the original momentum of the proton was
a) $p_0$ b) $100\,p_0$ c) $400\,p_0$ d) $4\,p_0$

55. The maximum kinetic energy of emitted electrons in a photoelectric effect does not depend upon
a) Wavelength b) Frequency c) Intensity d) Work function

56. A particle $A$ has a charge $q$ and particle $B$ has charge$+4q$ with each of them having the mass $m$. When they are allowed to fall from rest through same potential difference, the ratio of their speeds $v_A : v_B$ will be
a) 4:1 b) 1:4 c) 1:2 d) 2:1

57. A photo-sensitive material would emit electrons, if excited by photons beyond a threshold. To overcome the threshold, one would increase the

a) Voltage applied to the light source
b) Intensity of light
c) Wavelength of light
d) Frequency of light

58. Light of wavelength $\lambda$ strikes a photo-sensitive surface and electrons are ejected with kinetic energy $E$. If the kinetic energy is to be increased to $2E$, the wavelength must be changed to $\lambda'$ where

a) $\lambda' = \frac{\lambda}{2}$
b) $\lambda' = 2\lambda$
c) $\frac{\lambda}{2} < \lambda' < \lambda$
d) $\lambda' > \lambda$

59. A 5 W source emits monochromatic light of wavelength 5000Å. When placed 0.5 m away, it liberates photoelectrons from a photosensitive metallic surface. When the source is moved to a distance of 1.0m, the number of photoelectrons liberated will be reduced by a factor of

a) 4
b) 8
c) 16
d) 2

60. Light of energy 2.0 eV falls on a metal of work function 1.4 eV. The stopping potential is

a) 0.6 V
b) 2.0 V
c) 3.4 V
d) 1.4 V

61. When radiation of the wavelength $\lambda$ is incident on a metallic surface, the stopping potential is 4.8 V. If the same surface is illuminated with radiation of double the wavelength, then the stopping potential becomes 1.6 V. Then the threshold wavelength for the surface is

a) $2\lambda$
b) $4\lambda$
c) $6\lambda$
d) $8\lambda$

62. If an electron and proton are propagating in the form of waves having the same wavelength, it implies that they have the same

a) Energy
b) Momentum
c) Velocity
d) Angular momentum

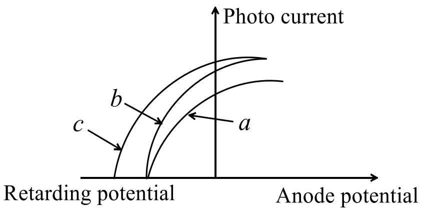
63. The stopping potential $V$ for photoelectric emission for a metal surface is plotted along $Y$-axis and frequency $v$ of incident light along $X$-axis. A straight line is obtained as shown. Planck's constant is given by

a) Slope of the line
b) Product of slope of the line and charge on the electron
c) Intercept along $Y$-axis divided by charge on the electron
d) Product of intercept along $X$-axis and mass of the electron

64. An electron of mass $m$ when accelerated through a potential difference $V$ has de-Broglie wavelength $\lambda$. The de-Broglie wavelength associated with a proton of mass $M$ accelerated through the same potential difference will be

a) $\lambda \frac{m}{M}$
b) $\lambda \sqrt{\frac{m}{M}}$
c) $\lambda \frac{M}{m}$
d) $\lambda \sqrt{\frac{M}{m}}$

65. The figure shows a plot of photo current versus anode potential for a photo sensitive for three different radiations. Which one of the following is a correct statement




a) Curves $(a)$ and $(b)$ represent incident radiations of different frequencies and different intensities
b) Curves $(a)$ and $(b)$ represents incident radiations of same frequency but of different intensities
c) Curves $(b)$ and $(c)$ represent incident radiations of different frequencies and different intensities
d) Curves $(b)$ and $(c)$ represent incident radiations of same frequency having same intensity

66. Which of the following event, support the quantum nature of light?

a) Diffraction
b) Polarization
c) Interference
d) Photoelectric effect

67. Two identical, photocathodes receive light of frequencies $f_1$ and $f_2$. If the velocities of the photoelectrons (of mass $m$) coming out are respectively $v_1$ and $v_2$, then

a) $v_1^2 - v_2^2 = \frac{2h}{m}(f_1 - f_2)$
b) $v_1 + v_2 = \left[\frac{2h}{m}(f_1 + f_2)\right]^{1/2}$
c) $v_1^2 + v_2^2 = \frac{2h}{m}(f_1 + f_2)$
d) $v_1 - v_2 = \left[\frac{2h}{m}(f_1 - f_2)\right]^{1/2}$

68. The potential difference applied to an $X$-ray tube is increased. As a result, in the emitted radiation

a) The intensity increases
b) The minimum wavelength increases
c) The intensity decreases
d) The minimum wavelength decreases

69. Ultraviolet radiation of 6.2 eV falls on an aluminium surface (work function 4.2 eV). The kinetic energy of the faster electron emitted is approximately

a) $3.2 \times 10^{-15}$ J
b) $3.2 \times 10^{-17}$ J
c) $3.2 \times 10^{-19}$ J
d) $3.2 \times 10^{-21}$ J

70. The de-Broglie wavelength of a particle moving with a velocity $2.25 \times 10^8\ m/s$ is equal to the wavelength of photon. The ratio of kinetic energy of the particle to the energy of the photon is (velocity of light is $3 \times 10^8 m/s$)

a) 1/8
b) 3/8
c) 5/8
d) 7/8

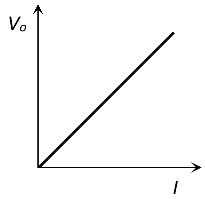
71. A photon and an electron have equal energy E. $\lambda_{\text{photon}}/\lambda_{\text{electron}}$ is proportional to

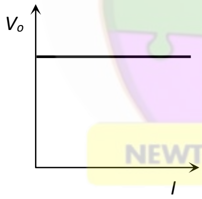
a) $\sqrt{E}$
b) $1/\sqrt{E}$
c) $1/E$
d) Does not depend upon $E$

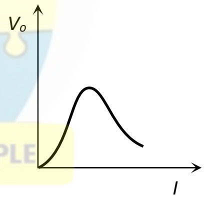
72. In photoelectric effect, the KE of electrons emitted from the metal surface depends upon

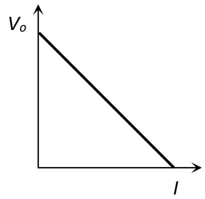
a) Intensity of light
b) Frequency of incident light
c) Velocity of incident light
d) Both intensity and velocity of light

73. The correct curve between the stopping potential ($V$) and intensity of incident light ($I$) is

a) 


b) 

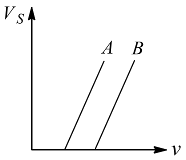

c) 


d) 


74. The velocity of photon is proportional to (where $v$ is frequency)

a) $\frac{v^2}{2}$
b) $\frac{1}{\sqrt{v}}$
c) $\sqrt{v}$
d) $v$

75. When the photons of energy $hv$ fall on a photosensitive metallic surface (work function $hv_0$) electrons are emitted from the metallic surface. The electrons coming out of the surface have some kinetic energy. The most energetic ones have the kinetic energy equal to




a) Less
b) More
c) Equal
d) Nothing can be said

76. A particle with rest mass $m_0$ is moving with speed of light $c$. The de-Broglie wavelength associated with it will be

a) Infinite
b) Zero
c) $m_0 c/h$
d) $hv/m_0 c$

77. A photon and an electron have an equal energy $E$.

a) $\sqrt{E}$
b) $1/\sqrt{E}$
c) $1/E$
d) Does not depend upon $E$

78. Which of the following is not the property of the photons?

a) Momentum
b) Energy
c) Charge
d) Velocity

79. The photoelectric threshold frequency of a metal is $v$. When light of frequency $4v$ is incident on the metal. The maximum kinetic energy of the emitted photoelectrons is

a) 4 $hv$ b) 3 $hv$ c) 5 $hv$ d) $\frac{5}{2}\ hv$

80. In a photoemissive cell with exciting wavelength $\lambda$, the fastest electron has speed $v$. If the exciting wavelength is changed to $3\lambda/4$, the speed of the fastest emitted electron will be

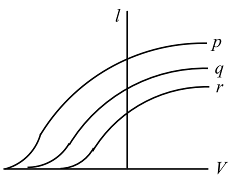
a) $v(3/4)^{1/2}$ b) $v(4/3)^{1/2}$
c) Less than $v(4/3)^{1/2}$ d) Greater than $v(4/3)^{1/2}$

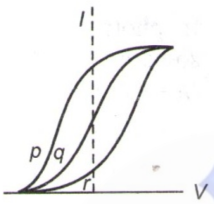
81. The de-Broglie wavelength of an electron in the ground state of the hydrogen atom is

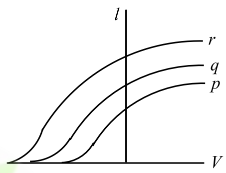
a) $\pi r^2$ b) $2\pi r$ c) $\pi r$ d) $\sqrt{2\pi r}$

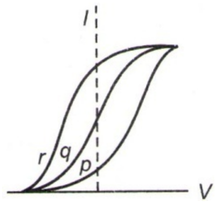
82. Photoelectric effect experiments are performed using three different metal plates $p, q$ and $r$ having work functions $\phi_p = 2.0$ eV, $\phi_q = 2.5$ eV and $\phi_r 3.0$ eV, respectively

A light beam containing wavelengths of 550 nm, 450 nm and 350 nm with equal intensities illuminates each of the plates. The correct $I$-$V$ graph for the experiment is

a) 


b) 


c) 


d) 


83. Photoelectric effect supports quantum nature of light because

III. There is minimum frequency of light below which no photoelectrons are emitted.
IV. Electric charge of photoelectrons is quantized.
V. Maximum kinetic energy of photoelectrons depends only on the frequency of light and not on its intensity.
VI. Even when metal surface is faintly illuminated the photoelectrons leave the surface immediately.

a) 1,2,3 b) 1,2,4 c) 2,3,4 d) 1,3,4

84. Among the following four spectral regions, the photons has the highest energy in

a) Infrared b) Violet c) Red d) Blue

# : HINTS AND SOLUTIONS:

1 **(a)**
When **E**, **v** and **B** are all along same direction, then magnetic force experienced by electron is zero while electric force is acting opposite to velocity of electron, so velocity of electron will decrease.

2 **(a)**
$\frac{1}{2}mv^2 = E \Rightarrow mv = \sqrt{2mE} \therefore \lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mE}}$

3 **(d)**
In Thomson's mass spectrograph $\vec{E}||\vec{B}$

4 **(b)**
Momentum of photon, $p = \frac{h}{\lambda}$
Therefore, wavelength of photon, $\lambda = \frac{h}{p}$

5 **(a)**
The deflection suffered by charged particle in an electric field is
$y = \frac{qELD}{mu^2} = \frac{qELD}{p^2/m} \quad [p = mu]$
$\Rightarrow y \propto \frac{qm}{p^2} \Rightarrow y_p{:}\, y_d{:}\, y_\alpha = \frac{q_p m_p}{p_p^2}{:}\frac{q_d m_d}{p_d^2}{:}\frac{q_\alpha m_\alpha}{p_\alpha^2}$
Since $p_\alpha = p_d = p_p$ [Given]
$m_p{:}\, m_d{:}\, m_\alpha = 1 : 2 : 4$ and $q_p{:}\, q_d{:}\, q_\alpha = 1 : 1 : 2$
$\Rightarrow y_p{:}\, y_d{:}\, y_\alpha = 1 \times 1{:} 1 \times 2 : 2 \times 4 = 1 : 2 : 8$

6 **(c)**
$\lambda = \frac{h}{p} \Rightarrow \lambda - \frac{0.5}{100}\lambda = \frac{h}{p + \Delta p} \Rightarrow \frac{199\lambda}{200} = \frac{h}{p + \Delta p}$
$= \frac{199}{200}\frac{h}{p}$
$\Rightarrow p + \Delta p = \frac{200}{199}p \Rightarrow p = 199\,\Delta p$

7 **(a)**
$$E = \frac{hc}{\lambda} \Rightarrow E \propto \frac{1}{\lambda}$$
$\Rightarrow \quad \frac{E'}{E} = \frac{400}{300} = 1.33$
But $E = eV_s$, $V_s$ being stopping potential. Thus, stopping potential for photoelectrons from a surface becomes approximately 1.0 V greater.

8 **(a)**
De-Broglie wavelength of a particle is given by
$$\lambda = \frac{h}{mv} \text{ ...(i)}$$
Where $h$ is Planck's constant.
If kinetic energy of particle of mass $m$ is $v$, then
$$K = \frac{1}{2}mv^2$$
$\Rightarrow \quad v = \sqrt{\frac{2K}{m}}$ ...(ii)
Combining Eqs. (i) and (ii), we get
$$\lambda = \frac{h}{m\sqrt{\frac{2K}{m}}} = \frac{h}{\sqrt{2mK}} \quad \text{...(iii)}$$
Given $\quad m = 9.1 \times 10^{-31}$ kg
$K = 10\text{keV} = 10 \times 10^3 \times 1.6 \times 10^{-19}$ J
$h = 6.6 \times 10^{-34}$ J-s
Substituting the above values in Eq. (iii), we get
$\lambda = \frac{6.6\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times10\times10^3\times1.6\times10^{-19}}}$
$= 1.22 \times 10^{-11} \approx 0.12$Å

9 **(c)**
$\lambda = \frac{h}{p} \Rightarrow \lambda \propto \frac{1}{p}$

10 **(b)**
$E = W_0 + K_{\max}$
$\Rightarrow hf = W_A + K_A$ ...(i)
and $2hf = W_B + K_B = 2W_A + K_B \left[\because \frac{W_A}{W_B} = \frac{1}{2}\right]$ ...(ii)
Dividing equation (i) by (ii)
$\frac{1}{2} = \frac{W_A + K_A}{2W_A + K_B} \Rightarrow \frac{K_A}{K_B} = \frac{1}{2}$

11 **(a)**
Saturation current is proportional to intensity while stopping potential increases with increase in frequency. Hence,
$$v_a = v_b \text{ while } I_a < I_b$$

12 **(c)**
Let $E_1$ and $E_2$ be the KE of photoelectrons for incident light of frequency $v$ and $2v$ respectively.
Then $hv = E_1 + \phi$ and $h2v = E_2 + \phi_0$
So, $2(E_1 + \phi_0) = E_2 + \phi_0$ or $E_2 = 2E_1 + \phi_0$
It means the KE of photoelectron becomes more than double

13 **(c)**
Linear momntum of an electron in $n$ th orbit $L = \frac{nh}{2\pi'}$
for $n = 2$ then $\quad L = \frac{h}{\pi}$

14 **(c)**
Higher the voltage, higher is the $KE$. Higher the work function, smaller is the $KE$

15 **(c)**

$$\lambda = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2m_\alpha Q_\alpha V}}$$

On putting $Q_\alpha = 2 \times 1.6 \times 10^{-19} C$

$m_\alpha = 4m_p = 4 \times 1.67 \times 10^{-27} kg \Rightarrow \lambda = \frac{0.101}{\sqrt{V}}$ Å

16 **(c)**

$$m = \frac{m_0}{\sqrt{1 - v^2/c^2}} = \frac{m_0}{\sqrt{1 - (0.8c)^2/c^2}} = \frac{5m_0}{3}$$

17 **(d)**

We know that, $\lambda = \frac{h}{\sqrt{2mkT}}$;

So, $\lambda \propto \frac{1}{\sqrt{T}}$

$$\therefore \frac{\lambda_{27}}{\lambda_{927}} = \sqrt{\frac{927 + 273}{27 + 273}} = 2$$

or $\lambda_{27} = 2\lambda_{927} = 2\lambda$

18 **(b)**

$I_1 > I_2$ (given) $\Rightarrow i_1 > i_2$ [$\because i \propto I$]

and stopping potential does not depend upon intensity. So its value will be same $(V_0)$

19 **(a)**

Stopping potential is that negative potential for which photo electric current is zero

20 **(d)**

$$W_0 = h\nu_0 \Rightarrow \nu_0 = \frac{W_0}{h} = \frac{2.51 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}}$$

$= 6.08 \times 10^{14}$ $Cycles/s$

21 **(d)**

de Broglie wavelength

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE}} \Rightarrow \lambda \propto \frac{1}{\sqrt{Em}}$$

Now kinetic energy $E$ gained by a charged particle under potential $V$ is $E = qV$ given $V$ is same for the given three paticles

$\therefore E_e = eV; E_p = eV$

$E_\alpha = 2eV \Rightarrow E_e = E_p < E_\alpha$ and $m_e < m_p < m_\alpha$

$$\Rightarrow \lambda = \frac{h}{\sqrt{2m_e E_e}} > \frac{h}{\sqrt{2m_p E_p}} > \frac{h}{\sqrt{2m_\alpha E_\alpha}}$$

$\lambda_e > \lambda_p > \lambda_\alpha$

22 **(a)**

On increasing wavelength of light of the photoelectric current decreases and at a certain wavelength (cut off) above which photoelectric current stops

23 **(c)**

KE of photoelectrons increases with increase in frequency of the incident light and is independent of the intensity of incident light.

Photoelectrons are emitted if the wavelength of the incident light is less than threshold wavelength, as $\phi_0 = \frac{hc}{\lambda_0}$

Photoelectric emission is an instantaneous process photoelectrons may not be emitted from a gas with ultraviolet light if the work function of that gas is large than the energy UV light

24 **(c)**

From relation

$$eV_s = h(\nu - \nu_0)$$

or $V_s$ = threshold or cut off voltage

$= \frac{h}{e}(\nu - \nu_0)$

$= \frac{6.6 \times 10^{-34}}{1.6 \times 10^{-19}} (8.2 - 3.3) \times 10^{14}$

$= \frac{6.6 \times 4.9 \times 10^{-1}}{1.6} = 2V$

25 **(b)**

From Einstein's photoelectric effect concept the energy of these photons, for light of frequency $\nu$ is

$E = h\nu$

where $h$ is Planck's constant.

Also, frequency $= \frac{\text{velocity}}{\text{wavelength}} = \frac{c}{\lambda}$

$\therefore$ $= \frac{hc}{\lambda}$

Energy of $n$ photons is $E = \frac{nhc}{\lambda}$

Given, $E = 10^{-7} J, \lambda = 5000$ Å

$= 5000 \times 10^{-10}\ m$

$\Rightarrow$ $n = \frac{E\lambda}{hc}$

$= \frac{10^{-7} \times 5000 \times 10^{-10}}{6.6 \times 10^{-34} \times 3 \times 10^8}$

$= 2.5 \times 10^{11}$

26 **(c)**

$$\lambda = \frac{h}{\sqrt{2mQV}} \Rightarrow \lambda \propto \frac{1}{\sqrt{mQ}} \Rightarrow \frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{m_\alpha Q_\alpha}{m_p Q_p}}$$

$$= \sqrt{\frac{4m_p \times 2Q_p}{m_p \times Q_p}} = 2\sqrt{2}$$

27 **(d)**

In photocell, at a particular negative potential (stopping potential $V_0$) of anode, photoelectric current is zero, as the potential difference between cathode and anode increases current through the circuit increases but after some time constant current (saturation current) flows through the circuit even if potential difference still increases

28 **(a)**

$\frac{1}{2}mv^2 = hv - \phi_0 = hv - hv_0$

For minimum kinetic energy of emitted photoelectron,

$v = v_0$

$\therefore \frac{1}{2}mv^2 = 0$

29 **(b)**

$f = \frac{c}{\lambda} = \frac{c}{hc/E} = \frac{E}{h}$

$\therefore \quad f = \frac{1\times1.6\times10^{-13}}{6.6\times10^{-34}} = 2.4\times10^{20}\text{Hz}$

30 **(a)**

If all of the kinetic energy carried by an electron is converted into radiation, the energy of the X-rays photon would be given by

$$E_{\text{max}} = hv_{\text{max}} = eV$$

Where $h$ is Planck's constant, $v_{\text{max}}$ the largest frequency, $e$ charge of an electron and $V$ the applied voltage.

This maximum energy or minimum wavelength is called the Duane-Hunt limit.

$\therefore \quad hv_{\text{max}} = \frac{hc}{\lambda_{\text{min}}} = eV$

$\Rightarrow \quad \lambda_{\text{min}} = \frac{hc}{eV}$

31 **(c)**

de-Broglie wavelength of an electron is given by

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mK}}$$

Or $\quad \lambda \propto \frac{1}{\sqrt{K}}$

$\therefore \quad \frac{\lambda'}{\lambda} = \frac{1}{\sqrt{3K}}\frac{\sqrt{K}}{1} = \frac{1}{\sqrt{3}}$

Or $\quad \lambda' = \frac{\lambda}{\sqrt{3}}$

Hence, de-Broglie wavelength will change by factor $\frac{1}{\sqrt{3}}$.

32 **(a)**

Here, $u = 0; a = \frac{eE}{m}; v = ?; t = t$

$\therefore \ v = u + at = 0 + \frac{eE}{m}t$

de-Broglie wavelength,

$\lambda = \frac{h}{mv} = \frac{h}{m(eEt/m)} = \frac{h}{eEt}$

Rate of change of de-Broglie wavelength

$\frac{d\lambda}{dt} = \frac{h}{eE}\left(-\frac{1}{t^2}\right) = \frac{-h}{eEt^2}$

33 **(c)**

If a charge particle of mass $m$ and charge $q$ is accelerated through a potential difference $V$ and $E$ is the energy acquired by the particle , then

$$E = qV$$

If $v$ is velocity of particle, then

$$E = \frac{1}{2}mv^2$$

Or $\quad v = \sqrt{\left(\frac{2E}{m}\right)}$

Now, de-Broglie wavelength of particle is

$$\lambda = \frac{h}{mv} = \frac{h}{m\sqrt{(2E/m)}}$$

Substituting the value of $E$, we get

$$\lambda = \frac{h}{\sqrt{2mqV}}$$

For electron, $\quad \lambda_e = \frac{h}{\sqrt{2m_e eV}}$

For proton, $\quad \lambda_p = \frac{h}{\sqrt{2m_p eV}}$

$\therefore \quad \frac{\lambda_e}{\lambda_p} = \sqrt{\left(\frac{m_p}{m_e}\right)}$

34 **(d)**

$\left.\begin{cases}\text{Photoelectric effect } \rightarrow \text{Particle nature} \\ \text{Diffraction } \rightarrow \text{Wave nature}\end{cases}\right\}$ Dual nature

35 **(b)**

For ionisation, high energy electrons are required

36 **(a)**

By using $\lambda = \frac{h}{\sqrt{2mE}}$ $E = 10^{-32}J$ = Constant for both particles. Hence $\lambda \propto \frac{1}{\sqrt{m}}$ Since $m_p > m_e$ so $\lambda_p < \lambda_e$

37 **(c)**

In general $X$-rays have larger wavelength than that of gamma rays

38 **(a)**

Refer to threshold frequency

39 **(d)**

From Einstein's photoelectric equation

$$eV_0 = \frac{hc}{\lambda_0} - W_0$$

$$eV' = \frac{hc}{2\lambda_0} - W_0$$

Subtracting $e(V_0 - V') = \frac{hc}{\lambda_0}\left[1 - \frac{1}{2}\right] = \frac{hc}{2\lambda_0}$

or $\quad V' = V_0 - \frac{hc}{2e\lambda_0}$

40 **(b)**

Number of photoelectrons $\propto$ Intensity

Maximum kinetic energy is independent of intensity

41 **(a)**

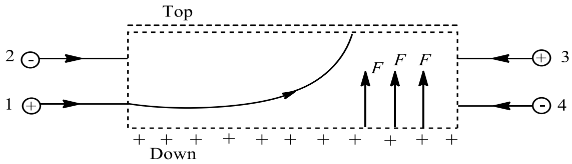
$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2qVm}}$ or $\lambda \propto \frac{1}{\sqrt{qm}}$

$\frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{q_\alpha}{q_p} \cdot \frac{m_\alpha}{m_p}} = \sqrt{\frac{(2)(4)}{(1)(1)}}$ =2.828

The nearest integer is 3.

42 **(a)**

The figure shows the path of a +ve charged particle (1) through a rectangular region of uniform electric field.




Since, +ve charged particle moves as a parabolic path in electric field. It means the direction of electric field is upward. The direction of deflection of particle (2) which is –ve is downward. The direction of deflection of particle (3) which is +ve is upward and direction of deflection of particle (4) is downward.

43 **(c)**

Kinetic energy of a particle at temperature $TK$ is $E=\frac{3}{2}kT$. The de-Broglie wavelength associated with it is

$$\lambda=\frac{h}{\sqrt{2mE}}=\frac{h}{\sqrt{2m\times\frac{3}{2}kT}}$$

$$ie, \lambda\propto\frac{1}{\sqrt{T}}$$

$$\therefore\ \frac{\lambda_{927}}{\lambda_{27}}=\sqrt{\frac{27+373}{927+273}}$$

$$=\sqrt{\frac{300}{1200}}=\frac{1}{2}$$

or $\lambda_{927}=\frac{\lambda_{27}}{2}=\frac{\lambda}{2}$

44 **(b)**

Stopping potential $V_0=\frac{hc}{e}\left[\frac{1}{\lambda}-\frac{1}{\lambda_0}\right]$. As $\lambda$ decreases so $V_0$ increases

45 **(a)**

de-Broglie wavelength, $\lambda=\frac{h}{\sqrt{2mE_k}}$

$$\frac{\lambda_\alpha}{\lambda_p}=\sqrt{\frac{m_p}{m_\alpha}}$$

$$=\sqrt{\frac{1}{4}}=\frac{1}{2}$$

46 **(d)**

From Einstein equation $E=W_0+\frac{1}{2}mv^2$

$$\sqrt{\frac{2(E-W_0)}{m}}=v$$

and a charged particle placed in uniform magnetic field experience a force

$$F=\frac{mv^2}{r}\Rightarrow evB=\frac{mv^2}{r}\Rightarrow r=\frac{mv}{eB}$$

$$\Rightarrow r=\frac{\sqrt{2m(E-W_0)}}{eB}$$

47 **(d)**

By law of conservation of linear momentum

$$m_1v_1=m_2v_2$$

So, $m_1v_1=m_2v_2$

Now, de-Broglie wavelength $\lambda=\frac{h}{mv}$

$$\therefore\ \frac{\lambda_1}{\lambda_2}=\frac{m_2v_2}{m_1v_1}$$

$$\lambda_1:\lambda_2=1:1$$

48 **(b)**

Here the velocity of electron increases, so as per Einstein's equation mass of the electron increases, hence the specific charge $\frac{e}{m}$ decreases

49 **(a)**

According to Einstein's theory of photoelectric effect a single incident photon ejects a single electrons. Therefore, when intensity increases, the number of incident photons increases, so number of ejected electrons increases, hence, photocurrent increases.

50 **(a)**

$$\frac{u_1}{u_2}=\frac{1}{2}$$

Accelerations of cathode rays in electric field, $\vec{a}=\frac{eE}{m}$

It is same for both the cathode rays

As displacement, $s=ut+\frac{1}{2}at^2$

So for a given value of $a$ and $t$, $s\times u$

So, $\frac{s_1}{s_2}=\frac{u_1}{u_2}=\frac{1}{2}$

51 **(c)**

The saturation photocurrent ($i$) depends on intensity ($I$) of light *ie,*

$$i\propto I.$$

So, when intensity changes, the saturation current also changes. Hence the statement I false.

The maximum kinetic energy depends upon the frequency of light. So, the kinetic energy is doubled when frequency is doubled.

So, statement II is true.

52 **(d)**

$K_{\max}$ of photoelectrons doesnot depend upon intensity of incident light.

53 **(c)**

Here, $E_1=E_2$

$$n_1hv_1=n_2hv_2$$

So, $\frac{n_1}{n_2}=\frac{v_2}{v_1}$

54 **(c)**

$$\lambda \propto \frac{1}{p} \Rightarrow \frac{\Delta p}{p} = -\frac{\Delta\lambda}{\lambda} \Rightarrow \left|\frac{\Delta p}{p}\right| = \left|\frac{\Delta\lambda}{\lambda}\right|$$

$$\Rightarrow \frac{p_0}{p} = \frac{0.25}{100} = \frac{1}{400} \Rightarrow p = 400\, p_0$$

55 **(c)**

If the intensity of light incident on photosensitive metal surface is changed it does not affect the maximum kinetic energy of the emitted electrons.

56 **(c)**

Speed obtained by the particle after falling through a potential difference of $V$ volt is

$$v_A = \sqrt{\frac{2Vq}{m}} \quad \ldots (i)$$

And $$v_B = \sqrt{\frac{2V \times 4q}{m}} \quad \ldots\text{(ii)}$$

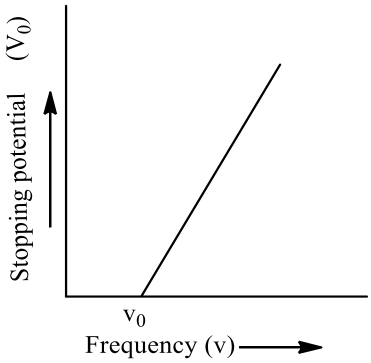
Now dividing Eq. (i) by Eq. (ii), we get

$$\frac{v_A}{v_B} = \sqrt{\frac{1}{4}} = \frac{1}{2}$$

So, $v_A : v_B = 1:2$

57 **(d)**

The emission of photoelectron takes place only, when the frequency of the incident light is above a certain critical value, characteristic of that metal. The critical value of frequency is known as the threshold frequency for the metal of the emitting electrode.




Suppose that when light of certain frequency is incident over a metal surface, the photo-electrons are emitted. To take photoelectric current zero, a particular value of stopping potential will be needed. If we go on reducing the frequency of incident light, the value of stopping potential will also go on decreasing. At certain value of frequency $v_0$, the photoelectric current will become zero, even when no retarding potential is applied. This frequency $v_0$ corresponds to the threshold for the metal surface. The emission of photo-electrons does not take place, till frequency of incident light is below this value.

58 **(c)**

$$E = \frac{hc}{\lambda} - W_0 \text{ and } 2E = \frac{hc}{\lambda'} - W_0$$

$$\Rightarrow \frac{\lambda'}{\lambda} = \frac{E + W_0}{2E + W_0} \Rightarrow \lambda' = \lambda\left(\frac{1 + W_0/E}{2 + W_0/E}\right)$$

Since $\frac{(1+W_0/E)}{(2+W_0/E)} > \frac{1}{2}$ so $\lambda' > \frac{\lambda}{2}$

59 **(a)**

Intensity of light is inversely proportional to square of distance,

*ie,* $$I \propto \frac{1}{r^2}$$

or $$\frac{I_2}{I_1} = \frac{(r_1)^2}{(r_2)^2}$$

Given, $r_1 = 0.5$ m, $r_2 = 1.0$ m

Therefore, $\frac{I_1}{I_2} = \frac{(0.5)^2}{(1)^2} = \frac{1}{4}$

Now, since number of photoelectrons emitted per second is directly proportional to intensity, so number of electrons emitted would decrease by factor of 4.

60 **(a)**

From Planck's quantum theory, the maximum kinetic energy ($E_k$) of photoelectron emitted from the metal is

$$E_k = hv - W$$

Where $W$ is work function of metal and $hv$ is the energy of the photon absorbed by the metal.

Given, $hv = 2\ eV$, $W = 1.4\ eV$

$\therefore \quad E_k = 2 - 1.4 = 0.6\text{eV}$

Hence, stopping potential is , $V_s = \frac{E}{e} = \frac{0.6 \text{ eV}}{e} =$ 0.6 V.

61 **(b)**

Stopping potential

$$v_0 = \frac{hc}{e}\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$$

Where $\lambda_0$= stopping potential

Ist case, $4.8 = \frac{hc}{e}\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right) \quad \ldots$ (i)

IInd case, $1.6 = \frac{hc}{e}\left(\frac{1}{2\lambda} - \frac{1}{\lambda_0}\right) \quad \ldots (ii)$

Dividing Eq. (i) by Eq. (ii)

$$3 = \frac{\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)}{\left(\frac{1}{2\lambda} - \frac{1}{\lambda_0}\right)}$$

$$\frac{3}{2\lambda} - \frac{3}{\lambda_0} = \frac{1}{\lambda} - \frac{1}{\lambda_0}$$

$$\frac{1}{\lambda_0} - \frac{3}{\lambda_0} = \frac{1}{\lambda} - \frac{3}{2\lambda}$$

$$\frac{-2}{\lambda_0} = \frac{2-3}{2\lambda}$$

$$\frac{2}{\lambda_0} = \frac{1}{2\lambda}$$

$$\lambda_0 = 4\lambda$$

62 **(a)**

If an electron and a proton propagating in the form of waves and their wavelength are same, then according to the relation

$$E = \frac{hc}{\lambda}$$

Also, $\lambda_{\text{electron}} = \lambda_{proton}$

$\therefore$ $E_e = E_p$

Hence, their energies are same.

63 **(b)**

$E_k = eV = hv - \phi_0$

or $V = \frac{h}{e} v - \frac{\phi_0}{e}$

Slope of straight line between $V$ and $v$ is $\frac{h}{e}$ $h =$ $e \times$ slope of straight line.

64 **(b)**

$\lambda = \frac{h}{\sqrt{2mE}} \Rightarrow \lambda \propto \frac{1}{\sqrt{m}}$ $[E = \text{same}]$

65 **(b)**

Stopping potential is same for $a$ & $b$, hence their frequencies are same. Also maximum current values are different for $a$ & $b$ so they will have different intensities

66 **(d)**

According to Planck, energy emitted or absorbed from the objects is not continous while it is in small packets of energy which are called photons or quanta. Einstein explained photoelectric effect on the basic of Planck's hypothesis.

67 **(a)**

$$hf = hf_0 + \frac{1}{2}mv^2$$

Hence, $v_1^2 = \frac{2hf_1}{m} - \frac{2hf_0}{m}$

$v_2^2 = \frac{2hf_2}{m} - \frac{2hf_0}{m}$

$\therefore$ $v_1^2 - v_2^2 = \frac{2h}{m}(f_1 - f_2)$

68 **(d)**

$\lambda_{\min} = \frac{hc}{eV}$ or $\lambda_{\min} \propto \frac{1}{V}$ On increasing potential, $\lambda_{\min}$ decreases

69 **(c)**

KE of emitted electron is

$$E_K = hv - W$$
$$= 6.2\,eV - 4.2\,eV = 2.0\,eV$$
$$= 2 \times 1.6 \times 10^{-19} J$$
$$= 3.2 \times 10^{-19} J$$

70 **(b)**

$K_{\text{particle}} = \frac{1}{2}mv^2$ also $\lambda = \frac{h}{mv}$

$\Rightarrow K_{\text{particle}} = \frac{1}{2}\left(\frac{h}{\lambda v}\right).v^2 = \frac{vh}{2\lambda}$ ... (i)

$K_{\text{photon}} = \frac{hc}{\lambda}$ ... (ii)

$\therefore \frac{K_{\text{particle}}}{K_{\text{photon}}} = \frac{v}{2c} = \frac{2.25 \times 10^8}{2 \times 3 \times 10^8} = \frac{3}{8}$

71 **(b)**

$\lambda_{\text{photon}} = \frac{hc}{E}$ and $\lambda_{\text{electron}} = \frac{h}{\sqrt{2mE}}$

$\Rightarrow \frac{\lambda_{\text{photon}}}{\lambda_{\text{electron}}} = c\sqrt{\frac{2m}{E}} \Rightarrow \frac{\lambda_{\text{photon}}}{\lambda_{\text{electron}}} \propto \frac{1}{\sqrt{E}}$

72 **(b)**

From Einstein's photoelectric equation the maximum kinetic energy of photoelectrons emitted from metal surface is $E_K$ and $W$ is work function, then

$E_K = hv - W$

If $v_0$ is threshold frequency, then

$W = hv_0$

$\therefore$ $E_K = hv - hv_0 = h(v - v_0)$

From the above equation, it is clear that maximum kinetic energy of electron will increases almost linearly with increase in the frequency of the incident light.

73 **(b)**

Stopping potential does not depend upon intensity of incident light $(I)$

74 **(d)**

Velocity of photon $c = v\lambda$

75 **(a)**

The value of threshold frequency $v_0$ for $A$ is less than that for $B$, hence $\phi_A < \phi_B$

76 **(b)**

$\lambda = \frac{h}{mv} = \frac{h\sqrt{1 - v^2/c^2}}{m_0 v} = 0$ $(\because v = c)$

77 **(b)**

$\lambda_{\text{photon}} = \frac{hc}{E}$

and $\lambda_{\text{electron}} = \frac{h}{\sqrt{2mE}}$

$\Rightarrow$ $\frac{\lambda_{\text{photon}}}{\lambda_{\text{electron}}} = c\sqrt{\frac{2m}{E}}$

$\Rightarrow$ $\frac{\lambda_{\text{photon}}}{\lambda_{\text{electron}}} \propto \frac{1}{\sqrt{E}}$

78 **(c)**

A photon is a particle which has zero charge and zero mass and is denoted by γ. The energy of photon is

$$E = hv$$

Here, $v$ = frequency and $h$ = Planck's constant.

The momentum of photon is $h/v$ and its velocity is the velocity of light ($c$).
So, the charge is not the property of photons.

79 **(b)**

From Einstein's photoelectric equation the maximum kinetic energy of photoelectrons emitted from metal surface is given by

$$E_k = hv_1 - W$$

Where $W$ is work function of metal.

Given, $W = hv$ and $v_1 = 4v$

$\therefore \quad E_k = 4hv - hv = 3hv$

80 **(d)**

$$hv - W_0 = \frac{1}{2}mv_{\max}^2 \Rightarrow \frac{hc}{\lambda} - \frac{hc}{\lambda_0} = \frac{1}{2}mv_{\max}^2$$

$$\Rightarrow hc\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right) = \frac{1}{2}mv_{\max}^2 \Rightarrow v_{\max}$$

$$= \sqrt{\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right)}$$

When wavelength is $\lambda$ and velocity is $v$, then

$$v = \sqrt{\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right)} \quad \text{... (i)}$$

When wavelength is $\frac{3\lambda}{4}$ and velocity is $v'$ then

$$v' = \sqrt{\frac{2hc}{m}\left[\frac{\lambda_0 - (3\lambda/4)}{(3\lambda/4) \times \lambda_0}\right]} \quad \text{... (ii)}$$

Divide equation (ii) by (i), we get

$$\frac{v'}{v} = \sqrt{\frac{[\lambda_0 - (3\lambda/4)]}{\frac{3}{4}\lambda\lambda_0} \times \frac{\lambda\lambda_0}{\lambda_0 - \lambda}}$$

$$v' = v\left(\frac{4}{3}\right)^{1/2} \sqrt{\frac{[\lambda_0 - (3\lambda/4)]}{\lambda_0 - \lambda}}$$

$$i.e. v' > v\left(\frac{4}{3}\right)^{1/2}$$

81 **(b)**

According to Bohr's theroy

$$mvr = \frac{nh}{2\pi}$$

$$2\pi r = \frac{nh}{mv}$$

$$2\pi r - n\lambda$$

For n=1,$\lambda = 2\pi r$

82 **(a)**

$$K_p = E_p - \phi_p = \frac{1240}{550} - 2.0 = 0.2545 \text{ eV}$$

$$K_q = E_q - \phi_q = \frac{1240}{450} - 2.5 = 0.255 \text{ eV}$$

$$K_r = E_r - \phi_r = \frac{1240}{350} - 3.0 = 0.543\text{eV}$$

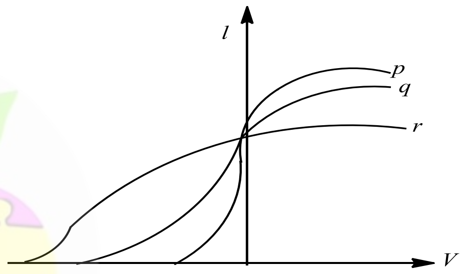
In the above equation $K$ represents maximum kinetic energy of photoelectrons and $E$, the energy of incident right.

From the above values we can see that stopping potential,

$$|V_r| > |V_q| > |V_p|$$

Further, their intensities are equal, but energy of individual photon $r$ is maximum. Hence, number of photons incident (per unit area per unit time) of $r$ can be assumed to be least. Hence, saturation current of $r$ should be minimum.

Keeping these points in mind no option seems to be correct. The correct graph is shown below




$\therefore$ No choice is correct.

83 **(d)**

Photoelectric effect supports quantum nature of light because

1. There is minimum frequency of light below which no photoelectrons are emitted.
2. Maximum kinetic energy of photoelectrons depends only on the frequency of light and not on its intensity.
3. Even when metal surface is fainthy illuminated the photoelectrons leave the surface immediately.

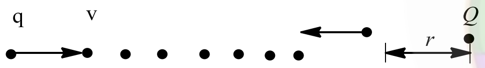
84 **(b)**

Energy of a photon, $E = \frac{hc}{\lambda}$

$\lambda_{\text{infrared}} > \lambda_{\text{red}} > \lambda_{\text{Blue}} > \lambda_{\text{Violet}}$

Therefore, violet has the highest energy


# Atoms

1. First Bohr radius of an atom with $Z = 82$ is $R$. Radius of its third orbit is
   a) $9\ R$ b) $6\ R$ c) $3\ R$ d) $R$
2. In Bohr's model of hydrogen atom, which of the following pairs of quantities are quantized?
   a) Energy and linear momentum b) Linear and angular momentum
   c) Energy and angular momentum d) None of the above
3. A charged particle $q$ is shot towards another charged particle $Q$ which is fixed, with a speed $v$. It approaches $Q$ upto a closest distance $r$ and then returns. If $q$ was given a speed $2v$, the closest distance of approach would be
   
   
   a) $r$ b) $2r$ c) $r/2$ d) $r/4$
4. The ratio of areas of the electron orbits for the first excited state and the ground state for the hydrogen atom is
   a) 4:1 b) 16:1 c) 8:1 d) 2:1
5. The acceleration of electron in the first orbit of hydrogen atom is
   a) $\frac{4\pi^2 m}{h^3}$ b) $\frac{h^2}{4\pi^2 mr}$ c) $\frac{h^2}{4\pi^2 m^2 r^3}$ d) $\frac{m^2 h^2}{4\pi^2 r^3}$
6. An alpha nucleus of energy $\frac{1}{2}mv^2$ bombards a heavy nuclear target of charge $Ze$. Then the distance of closest approach for the alpha nucleus will be proportional to
   a) $v^2$ b) 1/m c) $1/v^4$ d) $1/Ze$
7. In the Bohr model of the hydrogen atom, let $R, V$ and $E$ represent the radius of the orbit, the speed of electron and the total energy of the electron respectively. Which of the following quantities is proportional to quantum number $n$?
   a) $\frac{R}{E}$ b) $\frac{E}{V}$ c) $RE$ d) $VR$
8. The angular momentum of electron in hydrogen atom is proportional to
   a) $\sqrt{r}$ b) $1/r$ c) $r^2$ d) $1/\sqrt{r}$
9. For an electron in the second orbit of Bohr's hydrogen atom, the moment of linear momentum is
   a) $n\pi$ b) $2\pi h$ c) $\frac{2h}{\pi}$ d) $\frac{h}{\pi}$
10. Let the potential energy of hydrogen atom in the ground state be regarded as zero. Then its potential energy in the first excited state will be
    a) 20.4 eV b) 13.6 eV c) 3.4 eV d) 10.2eV

11. Hydrogen atom from excited state comes to the ground state by emitting a photon of wavelength $\lambda$. If $R$ is the Rydberg constant, the principal quantum number $n$ of the excited state is

a) $\sqrt{\frac{\lambda R}{\lambda R-1}}$ b) $\sqrt{\frac{\lambda}{\lambda R-1}}$ c) $\sqrt{\frac{\lambda R^2}{\lambda R-1}}$ d) $\sqrt{\frac{\lambda R}{\lambda-1}}$

12. The angular speed of the electric in the $n$ th orbit of Bohr hydrogen atom is

a) Directly proportional to $n$ b) Inversely proportional to $\sqrt{n}$

c) Inversely proportional to $n^2$ d) Inversely proportional to $n^3$

13. The ratio of kinetic energy and the total energy of the electron in the $n$th quantum state of Bohr's atomic model of hydrogen atom is

a) $-2$ b) $-1$ c) $+2$ d) $+1$

14. White light is passed through a dilutee solution of potassium permanganate. The spectrum produced by the emergent light is

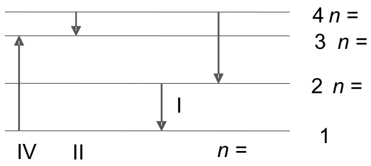
a) Band emission spectrum b) Line emission spectrum

c) Band absorption spectrum d) Line absorption spectrum

15. The product of linear momentum and angular momentum of an electron of the hydrogen atom is proportional to $n^x$, where $x$ is

a) 0 b) 1 c) $-2$ d) 2

16. The diagram shows the energy levels for an electron in a certain atom. Which transition shown represents the emission of a photon with the most energy?




a) III b) IV c) I d) II

17. An electron is moving in an orbit of a hydrogen atom from which there can be a maximum of six transition. An electron is moving in an orbit of another hydrogen atom from which there can be a maximum of three transition. The ratio of the velocities of the electron in these two orbits is

a) $\frac{1}{2}$ b) $\frac{2}{1}$ c) $\frac{5}{4}$ d) $\frac{3}{4}$

18. The ionization energy of hydrogen atom is 13.6eV. Following Bohr's theory, the energy corresponding to a transition between 3rd and 4th orbit is

a) 3.40 eV b) 1.51 eV c) 0.85 eV d) 0.66 eV

19. The wavelength of radiation emitted is $\lambda_0$ when an electron jumps from the third to the second orbit of hydrogen atom. For the electron jump from the fourth to the second orbit of hydrogen atom,the wavelength of radiation emitted will be

a) $\frac{16}{25}\lambda_0$ b) $\frac{20}{27}\lambda_0$ c) $\frac{27}{20}\lambda_0$ d) $\frac{25}{16}\lambda_0$

20. The figure indicates the energy levels of a certain atom. When the system moves from $2E$ level to$E$, a photon of wavelength $\lambda$ is emitted. The wavelength of photon produced during its transition from $\frac{4E}{3}$level to $E$ is

a) $\frac{\lambda}{3}$ b) $\frac{3\lambda}{4}$ c) $\frac{4\lambda}{3}$ d) $3\lambda$

21. In an atom, the two electrons move round the nucleus in circular orbits of radii $R$ and $4R$. The ratio of the times taken by them to complete one revolution is

a) 1/4 b) 4/1 c) 8/1 d) 1/8

22. The orbital frequency of an electron in the hydrogen atom is proportional to

a) $n^3$ b) $n^{-3}$ c) n d) $n^0$

23. If the atom $_{100}\mathrm{Fm}^{257}$ follows the Bohr model and the radius of $_{100}\mathrm{Fm}^{257}$ is $n$ times the Bohr radius, then find $n$.
a) 100 b) 200 c) 4 d) 1/4

24. In Rutherford scattering experiment, what will be the correct angle for $\alpha$ scattering for an impact parameter $b$=0?
a) 90° b) 270° c) 0° d) 180°

25. Consider an electron in the $n$th orbit of a hydrogen atom in the Bohr model. The circumference of the orbit can be expressed in terms of the de-Broglie wavelength $\lambda$ of that electron as
a) $(0.529)\, n\lambda$ b) $\sqrt{n}\,\lambda$ c) $(13.6)\lambda$ d) $n\lambda$

26. The spectral series of the hydrogen atom that lies in the visible region of the electromagnetic spectrum
a) Paschen b) Balmer c) Lyman d) Brackett

27. $V_1$ is the frequency of the series limit of Lyman series, $V_2$ is the frequency of the first line of Lyman series and $V_3$ is the frequency of the series limit of the Balmer series? Then
a) $v_1 - v_2 = v_3$ b) $v_1 = v_2 - v_3$ c) $\frac{1}{v_2} = \frac{1}{v_1} + \frac{1}{v_3}$ d) $\frac{1}{v_1} = \frac{1}{v_2} + \frac{1}{v_3}$

28. If the binding energy of the electron in a hydrogen atom is 13.6 eV, the energy required to remove the electron from the first excited state of $\mathrm{Li}^{2+}$ is
a) 30.6 eV b) 13.6 eV c) 3.4 eV d) 122.4 eV

29. Rutherford's atomic model could account for
a) Concept of stationary orbits
b) The positively charged control core of an atom
c) Origin of spectra
d) Stability of atoms

30. Hydrogen atoms are excited from ground state of the principal quantum number 4. Then the number of spectral lines observed will be
a) 3 b) 6 c) 5 d) 2

31. The nucleus of an atom consists of
a) Electrons and protons
b) Electrons, protons and neutrons
c) Electrons and Neutrons
d) Neutrons and protons

32. Ionization energy of $\mathrm{He}^{+}$ ion at minimum position is
a) 13.6 eV b) 27.2 eV c) 54.4 eV d) 68.0 eV

33. The ratio of minimum wavelengths of Lyman and Balmer series will be
a) 1.25 b) 0.25 c) 5 d) 10

34. According to Bohr's theory of hydrogen atom, for the electron in the $n$th allowed orbit the
(i) Linear momentum is proportional to $1/n$
(ii)Radius is proportional to $n$
(iii)Kinetic energy is proportional to $1/n^2$
(iv) Angular momentum is proportional to $n$
Choose the correct option from the codes given below.
a) (i),(iii),(iv) are correct
b) (i) is correct
c) (i),(ii) are correct
d) (iii) is correct

35. When an electron jumps from the orbit $n = 2$ to $n = 4$,then wavelength of the radiations absorbed will be ($R$ is Rydberg's constant)
a) $\frac{3R}{16}$ b) $\frac{5R}{16}$ c) $\frac{16}{5R}$ d) $\frac{16}{3R}$

36. In a hypothetical bohr hydrogen atom, the mass of the electron is doubled. The energy $E_o$ and energy $r_o$ of the first orbit will be ($a_o$ is the Bohr radius)
a) $E_o = -27.2\mathrm{eV}; r_o = a_o/2$
b) $E_o = -27.2\mathrm{eV}; r_o = a_o$
c) $E_o = -13.6\mathrm{eV}; r_o = a_o/2$
d) $E_o = -13.6\mathrm{eV}; r_o = a_o$

37. Bohr's atom model assumes

a) The nucleus is of infinite mass and is at rest
b) Electrons in a quantized orbit will not radiate energy
c) Mass of electron remains constant
d) All the above conditions.

38. The ratio of minimum to maximum wavelength in Balmer series is

a) 5: 9 b) 5: 36 c) 1: 4 d) 3: 4

39. The ground state energy of hydrogen atom is −13.6 eV. When its electron is in the first excited state, its excitation energy is

a) 3.4 eV b) 6.8 eV c) 10.2 eV d) zero

40. Wavelength of light emitted from second orbit to first orbit in a hydrogen atom is

a) 6563 Å b) 4102 Å c) 4861 Å d) 1215 Å

41. If $\lambda$ is the wavelength of hydrogen atom from the transition $n$ =3 to $n$=1, then what is the wavelength for doubly ionised lithium ion for same transition?

a) $\frac{\lambda}{3}$ b) $3\lambda$ c) $\frac{\lambda}{9}$ d) $9\lambda$

42. If the wavelength of the first line of the Balmer series of hydrogen is 6561Å, the wavelength of the second line of the series should be

a) 13122 Å b) 3280 Å c) 4860 Å d) 2187 Å

43. The ratio of longest wavelength and the shortest wavelength observed in the fifth spectral series of emission spectrum of hydrogen is

a) 4/3 b) 525/376 c) 36/11 d) 960/11

44. Of the following transition in the hydrogen atom, the one which gives an emission line of the highest frequency is

a) $n$ =1 to $n$=2 b) $n$ =2 to $n$=1 c) $n$ =3 to $n$=10 d) $n$ =10 to $n$=3

45. The wave number of the energy emitted when electron comes from fourth orbit to second orbit in hydrogen is 20,397 $cm^{-1}$. The wave number of the energy for the same transition in $He^+$ is

a) 5,099 $cm^{-1}$ b) 20,497 $cm^{-1}$ c) 14400 Å d) 81,588 $cm^{-1}$

1 **(a)**

Radius of Bohr's orbit

$$R_n = \frac{A_0 n^2}{Z}$$

$\Rightarrow \quad R_n \propto n^2 \qquad$ (Z=constant)

$\therefore \quad R_3 = 3^2 R = 9R$

2 **(c)**

According to Bohr's theory of atom electrons can revolve only in those orbits in which their angular momentum is an integral multiple of $\frac{h}{2\pi}$, where $h$ is Planck's constant.

Angular momentum $= mvr = \frac{2h}{2\pi}$

Hence, angular momentum is quantized.

The energy of electron in $n$th orbit of hydrogen atom,

$$E = \frac{Rhc}{n^2} \text{ joule}$$

Thus, it is obvious that the hydrogen atom has some characteristics energy state. In fact this is true for the atom of each element, *ie*, each atom has its energy quantized.

Hence, both energy and angular momentum are quantised.

3 **(d)**

Let a particle of change $q$ having velocity $v$ approaches Q upto a closest distance $r$ and if the velocity becomes $2v$, the closest distance will be $r$.'

The law of conservation of energy yields,

Kinetic energy of particle=electric potential energy between them at closest distance of approach.

Or $\quad \frac{1}{2}mv^2 = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r}$

Or $\quad \frac{1}{2}mv^2 = k\frac{Qq}{r} \qquad$ ...(i)

$$\left(\text{k} = \text{constant} = \frac{1}{4\pi\varepsilon_0}\right)$$

and $\quad \frac{1}{2}m(2v)^2 = k\frac{Qq}{r\prime} \qquad$ ...(ii)

Dividing Eq. (i) by Eq.(ii),

$$\frac{\frac{1}{2}mv^2}{\frac{1}{2}m(2v)^2} = \frac{\frac{kQq}{r}}{\frac{kQq}{r'}}$$

$\Rightarrow \quad \frac{1}{4} = \frac{r'}{r}$

$\Rightarrow \quad \text{r}' = \frac{r}{4}$

4 **(b)**

The radius of the orbit of the electron in the $n$th excited state

$$r_e = \frac{n^2 4\pi\varepsilon_0 h^2}{4\pi^2 mZe^2}$$

For the first excited state

$$n = 2\,, Z = 1$$

$\because \quad r' = \frac{4\varepsilon_0 h^2}{\pi me^2}$

For the ground state of hydrogen atom

$$n = 1\,, Z = 1$$

$\because \quad r'' = \frac{h^2\varepsilon_0}{\pi me^2}$

The ratio of radius

$$\frac{r'}{r''} = \frac{4}{1}$$

The ratio of area of the electron orbit for hydrogen atom

$$\frac{A'}{A''} = \frac{4\pi(r')^2}{4\pi(r'')^2}$$

$$\frac{A'}{A''} = \frac{16}{1}$$

5 **(c)**

From $mvr = \frac{nh}{2\pi}, v = \frac{nh}{2\pi mr}$

Acceleration, $a = \frac{v^2}{r} = \frac{n^2h^2}{4\pi^2m^2r^2(r)} = \frac{h^2}{4\pi^2m^2\mu^3}$

6 **(b)**

At distance of closest approach relative velocity of two particles is $v$. Here target is considered as stationary, so $\alpha$-particle comes to rest instantaneously at distance of closest approach.

Let required distance is $r$, then from work energy-theorem.

$$0 - \frac{mv^2}{2} = -\frac{1}{4\pi\varepsilon_0}\frac{Z_e \times Z_e}{r}$$

$$\text{r} \propto \frac{1}{m}$$

$$\propto \frac{1}{v^2}$$

$$\propto Ze^2$$

7 **(d)**

As $R \propto n^2; V \propto \frac{1}{n}$ and $E \propto \frac{1}{n^2}$

$\therefore VR \propto \left(\frac{1}{n} \times n^2\right) ie, VR \propto n$

8 **(a)**

Angular momentum $= \frac{nh}{2\pi} ie,$

$L \propto n \propto \sqrt{r} \quad (\because r \propto n^2)$

9 **(d)**

The moment of linear momentum is angular momentum

$$L = mvr = \frac{nh}{2\pi}$$

Here, $n$=2

$$\therefore \quad L = \frac{2h}{2\pi} = \frac{h}{\pi}$$

10 **(d)**

11 **(a)**

Here, $n_f = 1, n_i = n$

$$\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$$

$$\Rightarrow \quad \frac{1}{\lambda} = R\left(1 - \frac{1}{n^2}\right) \quad ..(i)$$

or $\frac{1}{\lambda R} = 1 - \frac{1}{n^2}$ or $\frac{1}{n^2} = 1 - \frac{1}{\lambda R}$

or $n = \sqrt{\frac{\lambda R}{\lambda R - 1}}$

12 **(d)**

13 **(b)**

The Kinetic energy of the electron in the $n$th state

$$K = \frac{mZ^2e^4}{8\varepsilon_0^2 h^2 n^2}$$

The total energy of the electron in the $n$th state

$$T = -\frac{mZ^2e^4}{8\varepsilon_0^2 h^2 n^2}$$

$$\therefore \quad \frac{K}{T} = -1$$

14 **(c)**

15 **(a)**

Linear momentum $= mv = \frac{mcZ}{137\,n}$

Angular momentum $= \frac{nh}{2\,\pi}$

Given,

Linear momentum × angular momentum $\propto n^x$

$$\therefore \quad \frac{mcZ}{137\,n} \times \frac{nh}{2\pi} \propto n^x$$

$$n^0 \propto n^x$$

$$\Rightarrow \quad x = 0$$

16 **(a)**

$$E = Rhc\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$$E_{(4\to3)} = Rhc\left[\frac{1}{3^2} - \frac{1}{4^2}\right]$$

$$= Rhc\left[\frac{7}{9 \times 16}\right] = 0.05\ Rhc$$

$$E_{(4\to2)} = Rhc\left[\frac{1}{2^2} - \frac{1}{4^2}\right]$$

$$= Rhc\left[\frac{3}{16}\right] = 0.2\ Rhc$$

$$E_{(2\to1)} = Rhc\left[\frac{1}{(1)^2} - \frac{1}{(2)^2}\right]$$

$$= Rhc\left[\frac{3}{4}\right] = 0.75\ Rhc$$

$$E_{(1\to3)} = Rhc\left[\frac{1}{(3)^2} - \frac{1}{(1)^2}\right]$$

$$= -\frac{8}{9}\ Rhc = -0.9\ Rhc$$

Thus, transition III gives most energy. Transition I represents the absorption of energy.

17 **(d)**

Number of spectral lines obtained due to transition of electrons from $n$th orbit to lower orbit is,

$$N = \frac{n(n-1)}{2}$$

I case $\quad 6 = \frac{n_1(n_1-1)}{2}$

$\Rightarrow \quad n_1 = 4$

II case $\quad 3 = \frac{n_2(n_2-1)}{2}$

$\Rightarrow \quad n_2 = 3$

Velocity of electron in hydrogen atom in $n$th orbit

$$v_n \propto \frac{1}{n}$$

$$\frac{v_n}{v'_n} = \frac{n_2}{n_1}$$

$$\Rightarrow \quad \frac{n_6}{n_3} = \frac{3}{4}$$

18 **(d)**

$E = E_4 - E_3$

$= -\frac{13.6}{4^2} - \left(-\frac{13.6}{3^2}\right) = -0.85 + 1.51$

$= 0.66$ eV

19 **(b)**

Wavelength ($\lambda$) during transition from $n_2$ to $n_1$ is given by

$$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$$\Rightarrow \frac{1}{\lambda_{3\to2}} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right] = \frac{5R}{36}$$

and $\frac{1}{\lambda_{4\to2}} = r\left[\frac{1}{2^2} - \frac{1}{4^2}\right] = \frac{3R}{16}$

$$\therefore \quad \frac{\lambda_{4\to2}}{\lambda_{3\to2}} = \frac{20}{27}$$

$$\Rightarrow \lambda_{4\to 2} = \frac{20}{27}\lambda_0$$

20 **(d)**

In the first case, energy emitted,

$$E_1 = 2E - E = E$$

In the second case, energy emitted

$$E_2 = \frac{4E}{3} - E = \frac{E}{3}$$

As $E_3$ is $\frac{1}{3}$rd, $\lambda_2$must be 3 times, *ie*, $3\lambda$

21 **(d)**

$$\frac{R_1}{R_2} = \frac{n_1^2}{n_2^2} = \frac{1}{4} \therefore \frac{n_1}{n_2} = \frac{1}{2}$$

$$\frac{T_1}{T_2} = \left(\frac{n_1}{n_2}\right)^3 = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$$

22 **(b)**

Time period of electron, $T = \frac{4\varepsilon_0^2 n^3 h^3}{mZ^2 e^4}$

$\therefore \qquad T \propto n^3$

$\therefore \qquad \frac{1}{\text{frequency }(f)} \propto n^3$

or $\qquad f \propto n^{-3}$

23 **(d)**

$$(r_m) = \left(\frac{m^2}{z}\right)(0.53\text{Å}) = (n \times 0.3)\text{Å}$$

$$\therefore \qquad \frac{m^2}{z} = n$$

$m$=5 for $_{100}Fm^{257}$ (the outermost shell) and $z =$ 100

$$\therefore \qquad n = \frac{(5)^2}{100} = \frac{1}{4}$$

24 **(d)**

Impact parameter b $\propto \cot\frac{\theta}{2}$

Here $b$=0, hence, $\theta = 180^0$

25 **(d)**

Circumference of $n$th Bohr orbit = $n\,\lambda$

26 **(b)**

| | |
|---|---|
| Ultraviolet region | Lyman series |
| Visible region | Balmer series |
| Infrared region | Paschen series, Brackett series |
| | Pfund series |

From the above chart it is clear that Balmer series lies in the visible region of the electromagnetic spectrum.

27 **(a)**

Frequency, $\quad v = RC\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$$v_1 = RC\left[1 - \frac{1}{\infty}\right] = RC$$

$$v_2 = RC\left[1 - \frac{1}{4}\right] = \frac{3}{4}RC$$

$$v_3 = RC\left[\frac{1}{4} - \frac{1}{\infty}\right] = \frac{RC}{4}$$

$$\Rightarrow \qquad v_1 - v_2 = v_3$$

28 **(a)**

$$E = -Z^2\frac{13.6}{n^2}\text{eV}$$

For first excited state,

$$E_2 = -3^2 \times \frac{13.6}{4}$$

$$= -30.6 \text{ eV}$$

Ionisation energy for first excited state of $Li^{2+}$ is 30.6 eV.

29 **(b)**

30 **(b)**

Number of spectral lines $= \frac{n(n-1)}{2} = \frac{4(4\ 3)}{2} = 6$

31 **(d)**

Nucleus Contains only the neutrons and protons.

32 **I**

Energy of helium ions.

$$E_n = -\frac{13.6\,Z^2}{n^2}\text{ eV}$$

In minimum position, $n$=1

For $He^+$, $Z = 2$

$$E = \frac{-13.6 \times (2)^2}{1}\text{ eV}$$

$$E = 54.4 \text{ eV}$$

33 **(b)**

The series end of Lyman series corresponds to transition from $n_i = \infty$ to $n_f = 1$, corresponding to the wavelength

$$\frac{1}{(\lambda_{\min})_L} = R\left[\frac{1}{1} - \frac{1}{\infty}\right] = R$$

$$\Rightarrow \quad (\lambda_{\min})_L = \frac{1}{R} = 912\text{ Å} \qquad \text{...(i)}$$

For last line of Balmer series

$$\frac{1}{(\lambda_{\min})_B} = R\left[\frac{1}{(2)^2} - \frac{1}{(\infty)^2}\right] = \frac{R}{4}$$

$$\Rightarrow \quad (\lambda_{\min})_B = \frac{4}{R} = 3636\text{ Å} \qquad \text{...(ii)}$$

Dividing Eq.(i) by Eq. (ii) .we get

$$\frac{(\lambda_{\min})_L}{(\lambda_{\min})_B} = 0.25$$

34 **(a)**

According to Bohr's theory of hydrogen atom , angular momentum is quantized *ie*,

$$L = mv_n r_n = n\left(\frac{h}{2\pi}\right)$$

Or $\quad L \propto n$

Radius of the orbit $r_n \propto \frac{n^2}{Z}$

Kinetic Energy $= \frac{kZ^2e^2}{2n^2}$ *ie*, $k \propto \frac{1}{n^2}$

35 **(d)**

$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$n_1=2, n_2=4$

$\frac{1}{\lambda} = R\left[\frac{1}{4} - \frac{1}{16}\right]$

$= R\left[\frac{4-1}{16}\right] = \frac{3R}{16}$

$\lambda = \frac{16}{3R}$

36 **(a)**

As $r \propto \frac{1}{m}$

$\therefore r_0 = \frac{1}{2}a_0$

As $E \propto m$

$\therefore E_0 = 2(-13.6) = -27.2$ eV

37 **(d)**

38 **(a)**

$$\frac{1}{\lambda_{\text{min}}} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right] = \frac{R \times 5}{36}$$

$$\frac{1}{\lambda_{\text{max}}} = R\left[\frac{1}{2^2} - \frac{1}{\infty}\right] = \frac{R}{4}$$

$$\frac{\lambda_{\text{min}}}{\lambda_{\text{max}}} = \frac{R \times 5}{36} \times \frac{4}{R} = \frac{5}{9}$$

39 **(c)**

Given, ground state energy of hydrogen atom

$E_1 = -13.6$ eV

Energy of electron in first excited state (*ie*, $n$=2)

$E_2 = -\frac{13.6}{(2)^2}$ eV

Therefore ,excitation energy

$\Delta E = E_2 - E_1$

$= -\frac{13.6}{4} - (-13.6) = -3.4 + 13.6 = 10.2$ eV

40 **(d)**

$$\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$$

$$\Rightarrow \frac{1}{\lambda} = 1.097 \times 10^7 \times \frac{3}{4}$$

$\therefore \lambda = 1.215 \times 10^{-7}\text{m} = 1215$ Å

41 **(c)**

For wavelength

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

Here, transition is same

So, $\quad \lambda \propto \frac{1}{Z^2}$

$$\frac{\lambda_{\text{H}}}{\lambda_{\text{Li}}} = \frac{(Z_{\text{Li}})^2}{(Z_{\text{H}})^2} = \frac{(3)^1}{(1)^2} = 9$$

$$\lambda_{\text{Li}} = \frac{\lambda_{\text{H}}}{9} = \frac{\lambda}{9}$$

42 ©

For Balmer series, $n_1 - 2, n_2 = 3$ for 1st line and $n_2 = 4$ for second line

$$\frac{\lambda_1}{\lambda_2} = \left(\frac{\frac{1}{2^2} - \frac{1}{4^2}}{\frac{1}{2^2} - \frac{1}{3^2}}\right) = \frac{3/16}{5/16} = \frac{3}{16} \times \frac{36}{5} = \frac{27}{20}$$

$$\lambda_2 = \frac{20}{27}\lambda_1 = \frac{20}{27} \times 6561 = 4860 \text{ Å}$$

43 ©

For Pfund series, $\frac{1}{\lambda_s} = R\left(\frac{1}{5^2} - \frac{1}{(\infty)^2}\right) = \frac{R}{25}$

$\lambda_s = 25/R$

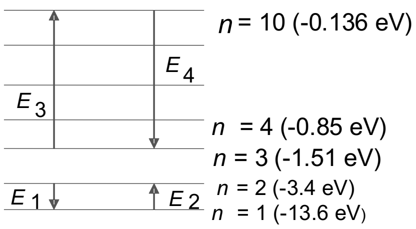
$$\frac{1}{\lambda_l} = R\left(\frac{1}{5^2} - \frac{1}{6^2}\right) = R\left(\frac{36-25}{25 \times 36}\right)$$

$$\lambda_l = \frac{25 \times 36}{11R}$$

$$\therefore \frac{\lambda_l}{\lambda_s} = \frac{25 \times 36}{11R} \times \frac{R}{25}$$

$$= \frac{36}{11}$$

44 **(b)**




$E_1 = -13.6 - (-3.4) = -10.2$ eV

$E_2 = -3.4 - (-13.6) = +10.2$ eV

$E_3 = -0.136 - (-1.51) = -1.374$ eV
$E_4 = -1.51 - (-0.136) = -1.374$ eV
When an electron makes transition from higher energy level having energy $E_2(n_2)$ to lower energy level having energy$E_1(n_1)$, then a photon of frequency $v$ is emitted.
Here, for emission line $E_1$ is maximum hence, it will have the highest frequency emission line.

45 **(d)**

$$\bar{v} = R\left[\frac{1}{2^2} - \frac{1}{4^2}\right] = \frac{3R}{4} = 20397\text{cm}^{-1}$$

For the same transaction in He atom $(Z = 2)$

$$\bar{v} = RZ^2\left[\frac{1}{2^2} - \frac{1}{4^2}\right] = \frac{3R \times 2^2}{4}$$

$= 20397 \times 4 = 81588 \text{ cm}^{-1}$


# Nuclei & Radioactivity

1. A radioactive nucleus can decay simultaneously by two different processes which have decay constant $\lambda_1$ and $\lambda_2$.The effective decay constant of the nuclide is $\lambda$, where
   a) $\lambda = \lambda_1 + \lambda_2$ b) $\lambda = 2(\lambda_1 + \lambda)$ c) $\frac{1}{\lambda} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$ d) $\lambda = \sqrt{\lambda_1 \lambda_2}$
2. The activity of a radioactive sample is measured as $N_0$ counts per minute at $t = 0$ and $N_0/e$ counts per minute at $t = 5$ minutes. The time (in minutes) at which the activity reduces to half its value is
   a) $5 \log_e 2$ b) $\log_e 2/5$ c) $\frac{5}{\log_e 2}$ d) $5 \log_{10} 2$
3. The volume of a nucleus is directly proportional to
   a) $A$ b) $A^3$
   c) $\sqrt{A}$ d) $A^{1/3}$
   (where $A$=mass number of the nucleus)
5. A nucleus disintegrates into two nuclear parts which have their velocities in the ratio 2:1. The ratio of their nuclear sizes will be
   a) $2^{1/3}:1$ b) $1:3^{1/2}$ c) $3^{1/2}:1$ d) $1:2^{1/3}$
6. Decay constant of radium is $\lambda$. By a suitable process its compound radium bromide is obtained. The decay constant of radium bromide will be
   a) $\lambda$ b) More than $\lambda$ c) Less than $\lambda$ d) Zero
7. A radioactive nucleus of mass $M$ emits a photon of frequency $v$ and the nucleus recoils. The recoil energy will be
   a) $hv$ b) $Mc^2 - hv$ c) $\frac{h^2v^2}{2Mc^2}$ d) Zero
8. The S.I. unit of radioactivity is
   a) Roentgen b) Rutherford c) Curie d) Becquerel
9. In the reaction ${}_1^2H + {}_1^3H \rightarrow {}_2^4He + {}_0^1n$ if the binding energies of ${}_1^2H$, ${}_1^3H$ and ${}_2^4He$ are respectively $a, b$ and $c$ (in $MeV$), then the energy (in $MeV$) released in this reaction is
   a) $c + a - b$ b) $c - a - b$ c) $a + b + c$ d) $a + b - c$
10. Half life of a radio-active substance is 20 $minutes$. The time between 20% and 80% decay will be
    a) 20 $minutes$ b) 40 $minutes$ c) 30 $minutes$ d) 25 $minutes$
11. The fussion process is possible at high temperatures, because at higher temperatures
    a) The nucleus disintegrates
    b) The molecules disintegrates
    c) Atom become ionized
    d) The nucleus get sufficient energy to overcome the strong forces of repulsion
12. Two nuclei have their mass numbers in the ratio of 1:3. The ratio of their nuclear densities would be
    a) 1:3 b) 3:1 c) $(3)^{1/3}$:1 d) 1:1

14. Two radioactive samples have decay constant $15x$ and $3x$. If they have the same number of nuclei initially, the ratio of number of nuclei after a time $\frac{1}{6x}$ is

a) $\frac{1}{e}$ b) $\frac{e}{2}$ c) $\frac{1}{e^4}$ d) $\frac{1}{e^2}$

16. Two lithium nuclei in a lithium vapour at room temperature do not combine to form a carbon nucleus because

a) Carbon nucleus is an unstable particle
b) It is not energetically favourable
c) Nuclei do not come very close due to Coulombic repulsion
d) Lithium nucleus is more tightly bound than a carbon nucleus

17. When the number of nucleons in nuclei increase, the binding energy per nucleon

a) Increases continuously with mass number
b) Decreases continuously with mass number
c) Remains constant with mass number
d) First increases and then decreases with increases of mass number

18. In a sample of radioactive material, what fraction of the initial number of active nuclei will remain undisintegrated after half of a half-life of the sample

a) $\frac{1}{4}$ b) $\frac{1}{2\sqrt{2}}$ c) $\frac{1}{\sqrt{2}}$ d) $2\sqrt{2}$

19. The binding energy per nucleon of deuterium and helium atom is 1.1 $MeV$ and 7.0 $MeV$. If two deuterium nuclei fuse to form helium atom, the energy released is

a) 19.2 $MeV$ b) 23.6 $MeV$ c) 26.9 $MeV$ d) 13.9 $MeV$

20. A radioactive sample $S_1$ having the activity $A_1$ has twice the number of nuclei as another sample $S_2$ of activity$A_2$. If $A_2 = 2A_1$, then the ratio of half-life of $S_1$ to the half-life of $S_2$ is

a) 4 b) 2 c) 0.25 d) 0.75

21. The density of uranium is of the order of

a) $10^{20}$ kgm$^{-3}$ b) $10^{17}$ kgm$^{-3}$ c) $10^{14}$ kgm$^{-3}$ d) $10^{11}$ kgm$^{-3}$

22. The control rod in a nuclear reactor is made of

a) Uranium b) Cadmium c) Graphite d) Plutonium

25. The mass of a neutron is the same as that of

a) A proton b) A meson c) An epsilon d) An electron

26. In Rutherford scattering experiment, what will be the correct angle for $\alpha$ scattering for an impact parameter $b = 0$

a) 90° b) 270° c) 0° d) 180°

27. Two radioactive substances $A$ and $B$ have decay constants $5\lambda$ and $\lambda$ respectively. At $t = 0$ they have the same number of nuclei. The ratio of number of nuclei of $A$ to those of $B$ will be $\left(\frac{1}{e}\right)^2$ after a time interval

a) $\frac{1}{4\lambda}$ b) $4\lambda$ c) $2\lambda$ d) $\frac{1}{2\lambda}$

28. During mean life of a radioactive element, the fraction that disintegrates is

a) $e$ b) $\frac{1}{e}$ c) $\frac{e-1}{e}$ d) $\frac{e}{e-1}$

29. The subatomic particles proton and neutron fall under the group of

a) Mesons b) Photons c) Leptons d) Baryons

30. There are two radioactive substances $A$ and $B$. Decay constant of $B$ is two times that of $A$. Initially, both have equal number of nuclei. After $n$ half lives of $A$, rate of disintegration of both are equal. The value of $n$ is

a) 4 b) 2 c) 1 d) 5

31. The average binding energy per nucleon in the nucleus of an atom is approximately

a) 8 $eV$ b) 8 $KeV$ c) 8 $MeV$ d) 8 $J$

32. Consider an initially pure $'M'g$ sample of $^{A}X$, an isotope that has a half life of $T$ hour. What is it's initial decay rate ($N_A$ = Avogrado No.)

a) $\frac{MN_A}{T}$ b) $\frac{0.693MN_A}{T}$ c) $\frac{0.693MN_A}{AT}$ d) $\frac{2.303MN_A}{AT}$

33. Nuclear binding energy is equivalent to

a) Mass of proton b) Mass of neutron
c) Mass of nucleus d) Mass defect of nucleus

35. Heavy water is used in a nuclear reactor to

a) Absorb the neutrons b) Slow down the neutrons
c) Act as coolant d) None of the above

36. Two radioactive materials $X_1$ and $X_2$ have decay constants $10\lambda$ and $\lambda$ repectively. If initially, they have the same number of nuclei, then the ratio of the number of nuclei of $X_1$ to that of $X_2$ will be $1/e$ after a time

a) $\frac{1}{10\lambda}$ b) $\frac{1}{11\lambda}$ c) $\frac{11}{10\lambda}$ d) $\frac{1}{9\lambda}$

38. The half-life of a radioactive substance is 48 hours. How much time will it take to disintegrate to its $\frac{1}{16}th$ part

a) 12 $h$ b) 16 $h$ c) 48 $h$ d) 192 $h$

42. A moderator is used in nuclear reactors in order to

a) Slow down the speed of the neutrons b) Accelerate the neutrons
c) Increase the number of neutrons d) Decrease the number of neutrons

44. For effective nuclear forces, the distance should be

a) $10^{-10}m$ b) $10^{-13}m$ c) $10^{-15}m$ d) $10^{-20}m$

45. The binding energies per nucleon of $\mathrm{Li}^7$ and $\mathrm{He}^4$ are 5.6 MeV and 7.06 MeV respectively, then the energy of the reaction

$\mathrm{Li}^7 + p = 2[\,_2\mathrm{He}^4]$ will be

a) 17.28 MeV b) 39.2 MeV c) 28.24 MeV d) 1.46 MeV

47. Equivalent energy of mass equal to 1 $a.m.u.$ is

a) 931 $KeV$ b) 931 $eV$ c) 931 $MeV$ d) 9.31 $MeV$

48. If $m, m_n$ and $m_p$ are the masses of $_ZX^A$ nucleus, neutron and proton respectively, then

a) $m < (A-Z)m_n + Zm_p$ b) $m = (A-Z)m_n + Zm_p$
c) $m = (A-Z)m_p + Zm_n$ d) $m > (A-Z)m_n + Zm_p$

49. The binding energy per nucleon of deuteron ($^2_1\mathrm{H}$)and helium nucleus ($^4_2\mathrm{He}$)is 1:1MeV and 7MeV respectively. If two deuteron nuclei react to form a single helium nucleus , then the energy released is

a) 13.9MeV b) 26.9MeV c) 23.6MeV d) 19.2MeV

50. The radius of nucleus is

a) Proportional to its mass number
b) Inversely Proportional to its mass number
c) Proportional to the cube root of its mass number
d) Not related to its mass number

[redacted]

1 **(a)**
As disintegration by two different processes is simultaneous, therefore, effective decay constant $\lambda = (\lambda_1 + \lambda_2)$

2 **(a)**

$$N = N_0 e^{-\lambda t} \Rightarrow \frac{N_0}{e} = N_0 e^{-\lambda(5)} \Rightarrow \lambda = \frac{1}{5}$$

Now $\frac{N_0}{2} = N_0 e^{-\lambda(t)} \Rightarrow t = \frac{1}{\lambda} \ln 2 = 5 \ln 2$

3 **(a)**
Radius of nucleus $R = R_0 A^{1/3}$
Where $R_0 = 1.2 \times 10^{-15}$ m
Volume of nucleus $(V) = \frac{4}{3}\pi R^3$

$$= \frac{4}{3}\pi[R_0 A^{1/3}]^3$$

$$= \frac{4}{4}\pi R_0^3 A$$

$\therefore$ $V \propto A$

5 **(d)**
Law of conservation of momentum gives

$$m_1 v_1 = m_2 v_2$$

$\Rightarrow$ $\frac{m_1}{m_2} = \frac{v_2}{v_1}$

But $m = \frac{4}{3}\pi r^3 \rho$

or $m \propto r^3$

$\therefore$ $\frac{m_1}{m_2} = \frac{r_1^3}{r_2^3} = \frac{v_2}{v_1}$

$\Rightarrow$ $\frac{r_1}{r_2} = \left(\frac{1}{2}\right)^{1/3}$

$\therefore$ $r_1 : r_2 = 1 : 2^{1/3}$

6 **(a)**
Decay constant remains unchanged in a chemical reaction

7 **(c)**

$$E = \frac{(\text{momentum})^2}{2M} = \frac{\left(\frac{hv}{c}\right)^2}{2M}$$

8 **(d)**

9 **(b)**
During fusion binding energy of daughter nucleus is always greater than the total energy of the parent nuclei so energy released $= c - (a + b) = c - a - b$

10 **(b)**
Here $T_{1/2} = 20\ minutes$, we know $\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/T_{1/2}}$

For 20% decay $\frac{N}{N_0} = \frac{80}{100} = \left(\frac{1}{2}\right)^{t_1/20}$ ...(i)

For 80% decay $\frac{N}{N_0} = \frac{20}{100} = \left(\frac{1}{2}\right)^{t_2/20}$ ...(ii)

Dividing (ii) by (i)

$$\frac{1}{4} = \left(\frac{1}{2}\right)^{\frac{(t_2 - t_1)}{20}}$$

On solving we get $t_2 - t_1 = 40\ min$

11 **(d)**
In practise, nuclear fusion is very difficult process. This is so when positively charged nuclei come very close for fusion, the force of electrical repulsion between them becomes very strong. For fusion against this force, they require very high energy. To impart, so much energy to them, very high temperature and very high pressure is required.

12 **(d)**
Density of nuclear matter is independent of mass number, so the required ratio is 1:1.



14 **(d)**
Using

$$N = N_0 e^{-\lambda t} \Rightarrow \frac{N_1}{N_2} = \frac{1}{e^2}$$

16 **(c)**
Lithium nucleus and carbon nucleus are positively charge. According to coulomb law same charge repal each other. So, nuclei do not come very close.

17 **(d)**
Average BE/nucleon increase first, and then decreases, as is clear from BE curve.

18 **(c)**

$$\therefore \frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/T_{1/2}} = \left(\frac{1}{2}\right)^{1/2} = \frac{1}{\sqrt{2}}$$

19 **(b)**
${}_1H^2 + {}_1H^2 \rightarrow {}_2He^4$ + energy
Binding energy of a $({}_1H^2)$ deuterium nuclei
$= 2 \times 1.1 = 2.2\ MeV$
Total binding energy of two deuterium nuclei
$= 2.2 \times 2 = 4.4\ MeV$

Binding energy of a ( $_2H^4$) nuclei = $4 \times 7 = 28\ MeV$

So, energy released in fusion = $28 - 4.4 = 23.6\ MeV$

20 **(a)**

Activity, $A = \lambda N = \frac{0.693}{T_{1/2}} N$

Where $T_{1/2}$ is the half-life of a radioactive sample,

$\therefore \quad \frac{A_1}{A_2} = \frac{N_1}{T_1} \times \frac{T_2}{N_2}$

$$\frac{T_1}{T_2} = \frac{A_2}{A_1} \times \frac{N_1}{N_2}$$

$$= \frac{2A_1}{A_1} \times \frac{2N_2}{N_2} = \frac{4}{1}$$

21 **(a)**

Mass of Uranium nucleus = mass of proton + mass of neutron.

$= 92 \times 1.6725 \times 10^{-27} + 143 \times 1.6747 \times 10^{-27})$

$= (153.87 \times 10^{-27} + 239.48 \times 10^{-27})$

$= 3.93.35 \times 10^{-27}$ Kg

since, radius of nucleus is of the order of $10^{-15}$ m, hence, volume is

$$V \propto (10^{-15})^3\ \text{m}^3 \propto 10^{-45}\ \text{m}^3$$

$\therefore$ Density $= \frac{\text{mass}}{\text{volume}} = \frac{393.35 \times 10^{-27}}{10^{-45}} = 10^{20}\ \text{kgm}^{-3}$

22 **(b)**

25 **(a)**

26 **(d)**

Impact parameter $b \propto \cot\frac{\theta}{2}$

Here $b = 0$, hence $\theta = 180°$

27 **(d)**

Number of nuclei remained after time $t$ can be written as

$$N = N_0 e^{-\lambda t}$$

Where $N_0$ is initial number of nuclei of both the substances.

$$N_1 = N_0 e^{-5\lambda t} \quad \ldots..(i)$$

and $\quad N_2 = N_0 e^{-\lambda t} \quad \ldots.(ii)$

Dividing Eq.(i) by Eq.(ii) , we obtain

$$\frac{N_1}{N_2} = e^{(-5\lambda+\lambda)t} = e^{-4\lambda t} = \frac{1}{e^{4\lambda t}}$$

But, we have given

$$\frac{N_1}{N_2} = \left(\frac{1}{e}\right)^2 = \frac{1}{e^2}$$

Hence ,$\frac{1}{e^2} = \frac{1}{e^{4\lambda t}}$

Comparing the powers, we get

$$2 = 4\lambda t$$

or $\quad t = \frac{2}{4\lambda} = \frac{1}{2\lambda}$

28 **(c)**

By using $N = N_0 e^{-\lambda t}$ and average life time $t = \frac{1}{\lambda}$

So $N = N_0 e^{-\lambda \times 1/\lambda} = N_0 e^{-1} \Rightarrow \frac{N}{N_0} = e^{-1} = \frac{1}{e}$

Now disintegrated fraction $= 1 - \frac{N}{N_0} = 1 - \frac{1}{e} = \frac{e-1}{e}$

29 **(d)**

Elementary particles are mainly classified into two parts viz. Bosons & Fermions. Photons and mesons belong to Bosons. Fermions and further divided into leptons and conservation of charge principle. Baryons which are lighter and heavier particles respectively. Electrons belong to leptons. Neutrons and protons belong to Baryons. Baryons and mesons are together known as Hadrons

30 **(c)**

Let $\lambda_A = \lambda \therefore \lambda_B = 2\lambda$

If $N_0$ is total number of atoms in $A$ and $B$ at $t = 0$, then initial rate of disintegration of $A = \lambda N_0$, and initial rate of disintegration of $B = 2\lambda N_0$

As $\lambda_B = 2\lambda_A$

$$\therefore T_B = \frac{1}{2} T_A$$

*ie*, half-life of $B$ is half the half-life of $A$.

After one half-life of $A$

$$\left(-\frac{dN}{dt}\right)_A = \frac{\lambda N_0}{2}$$

Equivalently, after two half lives of $B$

$$\left(-\frac{dN}{dt}\right)_B = \frac{2\lambda N_0}{4} = \frac{\lambda N_0}{2}$$

Clearly, $\left(-\frac{dN}{dt}\right)_A = -\left(\frac{dN}{dt}\right)_B$

after $n = 1$ *ie*, one half-life of $A$

31 **(c)**

32 **(c)**

$$N = N_0 e^{-\lambda t} \Rightarrow \left|\frac{dN}{dt}\right| = N_0 \lambda e^{-\lambda t}$$

Initially at $t = 0, \left|\frac{dN}{dt}\right|_{t=0} = N_0\lambda$

Where $N_0$ = Initial number of undecayed atoms

$= \frac{\text{Mass of the sample}}{\text{Mass of a single atom of } X} = \frac{M}{A/N_A} = \frac{MN_A}{A}$

$\therefore \left|\frac{dN}{dt}\right|_{t=0} = \frac{MN_A\lambda}{A} = \frac{0.693MN_A}{AT}$

33 **(d)**

$B.E. = \Delta m\ amu = \Delta m \times 931\ MeV$

35 **(b)**

Heavy water is used in certain type of nuclear where it acts as a neutron moderator to slow down neutrons so that they can react with uranium in the reactor.

36 **(d)**

Here, $\frac{N_{x_1}(t)}{N_{x_2}(t)} = \frac{1}{e}$

or $\frac{N_0 e^{-10\lambda t}}{N_0 e^{-\lambda t}} = \frac{1}{e}$

(Because initially, both have the same number of nuclei, $N_0$).

or $e = \frac{e^{-\lambda t}}{e^{-10\lambda t}} = e^{9\lambda t}$

$9\lambda t = 1$

$t = \frac{1}{9\lambda}$

38 **(d)**

$\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/T} \Rightarrow \frac{1}{16} = \left(\frac{1}{2}\right)^{t/48}$

$\Rightarrow \left(\frac{1}{2}\right)^4 = \left(\frac{1}{2}\right)^{t/48} \Rightarrow t = 192\ hours$

42 **(a)**

Moderator slows down neutrons

44 **(c)**

45 **(a)**

The reaction is ${}_3\text{Li}^7 + {}_1P^1 \rightarrow 2({}_2\text{He}^4)$

$\therefore\ E_p = 2E({}_2\text{He}^4)E_{(\text{Li})}$

$= 2(4 \times 7.06) - 7 \times 5.6$

$= 56.48 - 39.2 = 17.28$ MeV

47 **(c)**

48 **(a)**

The mass of nucleus formed is always less than the sum of the masses of the constituent protons and neutrons $i.e., m < (A - Z)m_n + Zm_p$

49 **(c)**

As given

${}_1\text{H}^2 + {}_1\text{H}^2 \rightarrow {}_2\text{He}^4$ + energy

The binding energy per nucleon of a deuteron$({}_1\text{H}^2)$

= 1.1MeV

∴ Total binding energy of one deuteron nucleus

= 2 × 1.1 = 2.2MeV

∴ The binding energy per nucleon of Helium$({}_2\text{He}^4)$

=7MeV

∴ Total binding energy

= 4 × 7 = 28MeV

Hence, energy released in the above process

= 28 − 2 × 2.2

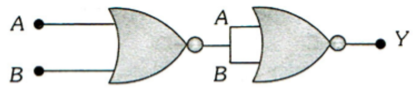
= 28 – 4.4 = 23.6 MeV

50 **(c)**


# Semiconductors and it's devices

## RED ZONE

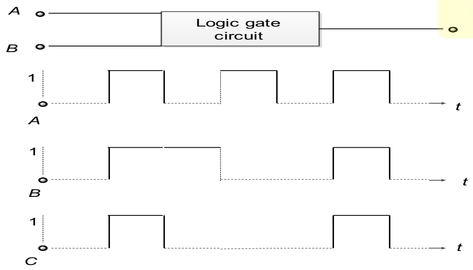
1. In the following circuit, the output $Y$ for all possible inputs $A$ and $B$ is expressed by the truth table




$A \quad B \quad Y$

a) $\begin{vmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \\ 1 & 1 & 1 \end{vmatrix}$ b) $\begin{vmatrix} 0 & 0 & 1 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{vmatrix}$ c) $\begin{vmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \\ 1 & 1 & 0 \end{vmatrix}$ d) $\begin{vmatrix} 0 & 0 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 1 \end{vmatrix}$

2. The following figure shows a logic gate circuit with two inputs $A$ and $B$ and the output $C$. The voltage waveforms of $A$, $B$ and $C$ are as shown below



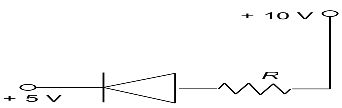

The logic circuit gate is

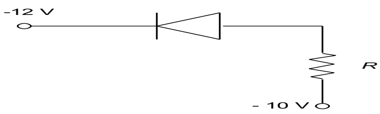
a) AND gate b) NAND gate c) NOR gate d) OR gate

3. When the forward bias voltage of a diode is changed from 0.6 V to 0.7 V, the current changes from 5 mA to 15 mA. Then its forward bias resistance is

a) 0.01 Ω b) 0.1 Ω c) 10 Ω d) 100 Ω

4. In the following, which one of the diodes is reverse biased?

a) 


b) 


5. In Boolean algebra, $\overline{\overline{A} \cdot \overline{B}}$ is equal to

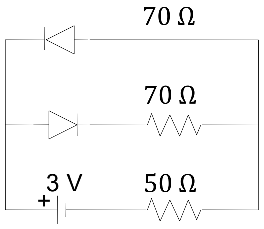
a) $\overline{A} \cdot \overline{B}$ b) $\overline{A} + \overline{B}$ c) $A \cdot B$ d) $A + B$

6. The truth table given below is for ($A$ and $B$ are the inputs, $Y$ is the output)

| **A** | **B** | **Y** |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

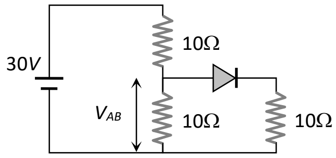
a) NOR b) AND c) XOR d) NAND

7. The circuit shown in the figure contains two diodes each with a forward resistance of 30 Ω and with infinite backward resistance. If the battery is 3V, the current through the 50 Ω resistance (in ampere) is




a) Zero b) 0.01 c) 0.02 d) 0.03

8. Find $V_{AB}$




a) 10 $V$ b) 20 $V$ c) 30 $V$ d) None of these

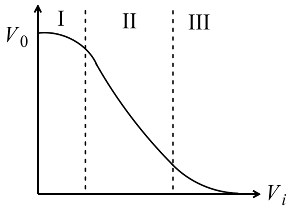
9. Formation of covalent bonds in compounds exhibits
a) Wave nature of electron
b) Particle nature of electron
c) Both wave and particle nature of electron
d) None of the above



10. The temperature coefficient of resistance of a semiconductor
a) Is always positive b) Is always negative
c) Is zero d) May be positive or negative or zero

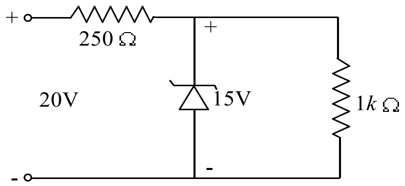
11. The output of a NAND gate is 0
a) If both inputs are 0
b) If one input is 0 and the other input is 1
c) If both inputs are 1
d) Either if both inputs are 1 or if one of the inputs is 1 and the other 0

12. Transfer characteristics [output voltage ($V_0$) vs input voltage ($V_i$)] for a base biased transistor in CE configuration is as shown in the figure. For using transistor as a switch, it is used




a) In region III b) Both in region (I) and (III)
c) In region II d) In region I

13. A zener diode, having breakdown voltage equal to 15 $V$, is used in a voltage regulator circuit shown in figure. The current through the diode is




a) 20 $mA$ b) 5 $mA$ c) 10 $mA$ d) 15 $mA$

14. The current in the circuit shown in the figure, considering ideal diode is


a) 20 A b) $2 \times 10^{-3}$ A c) 200 A d) $2 \times 10^{-4}$ A

15. A $p$-type material is electrically …….
a) Positive
b) Negative
c) Neutral
d) Depends on the concentration of $p$ impurities

16. Which of the following statements is not correct when a junction diode is in forward bias?
a) The width of depletion region decreases.
b) Free electrons on $n$-side will move towards the junction.
c) Holes on $p$-side move towards the junction.
d) Electrons on $n$-side and holes on $p$-side will move away from junction.

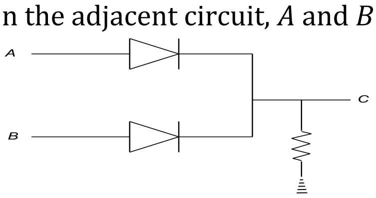
17. In $p - n$ junction, the barrier potential resists
a) Free electrons in $n$-region and holes in –region
b) Free electrons in $p$-region and holes in $n$-region
c) Only free electrons in $n$-region
d) Only holes in $p$-region

18. Within depletion region of $p$-$n$ junction diode
a) $p$-side is positive and $n$-side is negative
b) $p$-side is negative and $n$-side is positive
c) Both sides are positive or both negative
d) Both sides are neutral

19. In an unbiased $p$-$n$ junction
a) Potential at $p$ is more than that at $n$ b) Potential at $p$ is less than that at $n$
c) Potential at $p$ is equal to that at $n$ d) Potential at $p$ is +ve and that at $n$ is −ve

20. Resistance of a semiconductor
a) Increases with increase in temperature
b) Decreases with increase in temperature
c) Is not affected by change in temperature
d) Increase for germanium and decrease for silicon

21. In the adjacent circuit, $A$ and $B$ represent two inputs and $C$ represents the output. The circuit represents




a) NOR gate b) AND gate c) NAND gate d) OR gate

22. If a full wave rectifier circuit is operating from 50Hz mains, the fundamental frequency in the ripple will be
a) 70.7 Hz b) 100 Hz c) 25 Hz d) 59 Hz

23. Which of the following has negative temperature coefficient of resistance

a) Copper b) Aluminum c) Iron d) Germanium

24. In a $p-n$ junction diode

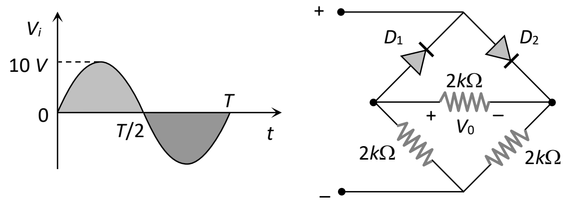
a) The current in the reverse biased condition is generally very small

b) The current in the reverse biased condition is small but the forward biased current is independent of the bias voltage

c) The reverse biased current is strongly dependent on the applied bias voltage

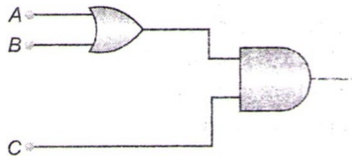
d) The forward biased current is very small in comparison to reverse biased current

25. In the circuit shown in figure the maximum output voltage $V_0$ is



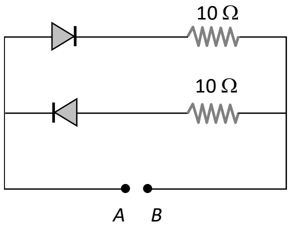

a) 0 $V$ b) 5 $V$ c) 10 $V$ d) $\frac{5}{\sqrt{2}}V$

26. To get an output 1 from the circuit shown in the figure, the input must be



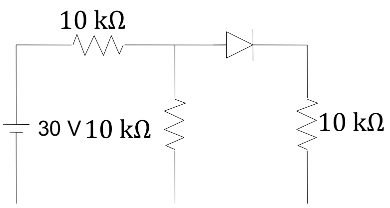

a) $A=0, B=1, C=0$ b) $A=1, B=0, C=0$ c) $A=1, B=0, C=1$ d) $A=1, B=1, C=0$

27. A 2$V$ battery is connected across the points $A$ and $B$ as shown in the figure given below. Assuming that the resistance of each diode is zero in forward bias and infinity in reverse bias, the current supplied by the battery when its positive terminal is connected to $A$ is




a) 0.2 $A$ b) 0.4 $A$ c) Zero d) 0.1 $A$

28. In the figure, potential difference between $A$ and $B$ is

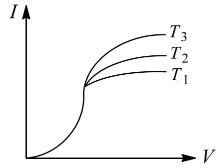



a) Zero b) 5 V c) 10 V d) 15 V

29. On increasing the reverse bias to a large value in a $p$-$n$ junction, diode current

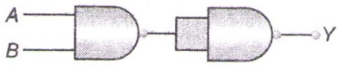
a) Increases slowly b) Remains fixed c) Suddenly increases d) Decreases slowly

30. For the diode, the characteristics curves are given at different temperatures. The relation between the temperatures is



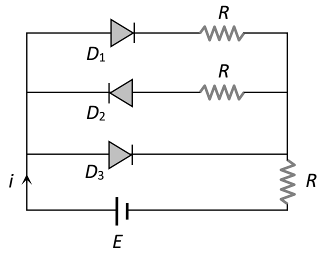

a) $T_1 = T_2 = T_3$ b) $T_1 < T_2 < T_3$ c) $T_1 \geq T_2 \geq T_3$ d) None of these

31. The combination of the following gates produces




a) AND gate b) NAND gate c) NOR gate d) OR gate

32. In the following circuit of $PN$ junction diodes $D_1, D_2$ and $D_3$ are ideal then $i$ is




a) $E/R$ b) $E/2R$ c) $2E/3R$ d) Zero

33. In the middle of the depletion layer of reverse biased $p$-$n$ junction, the

a) Electric field is zero b) Potential is maximum

c) Electric field is maximum d) Potential is zero

34. In breakdown region, a Zener diode behaves as a

a) Constant current source b) Constant voltage source

c) Constant resistance source d) Constant power source

35. The contribution in the total current flowing through a semiconductor due to electrons and holes are $\frac{3}{4}$ and $\frac{1}{4}$ respectively. If the drift velocity of electrons is $\frac{5}{2}$ times that of holes at this temperature, then the radio of concentration of electrons and holes is

a) 6 : 5 b) 5 : 6 c) 3 : 2 d) 2 : 3

36. Why is there sudden increase in current in zener diode?

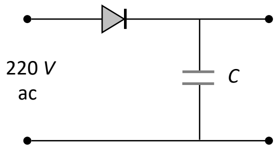
a) Due to rupture of bonds

b) Resistance of depletion layer becomes less

c) Due to high doping

d) None of the above

37. A diode is connected to 220 $V$ $(rms) ac$ in series with a capacitor as shown in figure. The voltage across the capacitor is



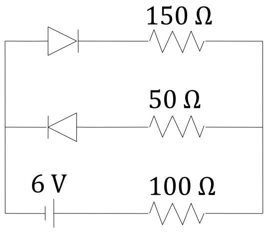

a) 220 $V$ b) 110 $V$ c) 311.1 $V$ d) $\frac{220}{\sqrt{2}} V$

38. When $n$-$p$-$n$ transistor is used as an amplifier

a) Electrons move from emitter to base b) Electrons move from base to emitter

c) Electrons move from collector to base d) Holes move from base to emitter

39. The circuit shown in the figure contains two diodes each with a forward resistance of 50 Ω and with infinite backward resistance. If the battery is 6 V, the current through the 100 Ω resistance (in ampere) is

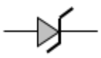
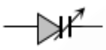
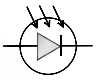
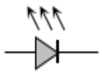



a) Zero b) 0.02 c) 0.03 d) 0.036

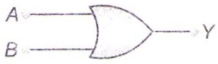
40. $n$-type semiconductor is
a) Positively charged
b) Negatively charged
c) Neutral
d) Positive or negative depending upon doping material

41. A pure semiconductor behaves slightly as a conductor at
a) Room temperature b) Low temperature c) High temperature d) Both (b) and (c)

42. Symbolic representation of photodiode is

a)  b)  c)  d) 

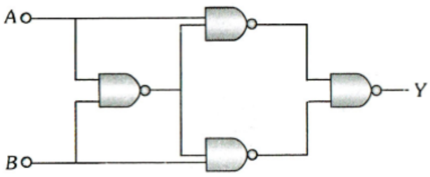
43. A logic gate and its truth table are shown below




| *A* | *B* | *Y* |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

The gate is
a) NOR b) AND c) OR d) NOT

44. Truth table for system of four NAND gates as shown in figure is




a) $\begin{vmatrix} A & B & Y \\ 0 & 0 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{vmatrix}$ b) $\begin{vmatrix} \mathrm{A} & \mathrm{B} & \mathrm{C} \\ 0 & 0 & 0 \\ 0 & 1 & 0 \\ 1 & 0 & 1 \\ 1 & 1 & 1 \end{vmatrix}$ c) $\begin{vmatrix} \mathrm{A} & \mathrm{B} & \mathrm{Y} \\ 0 & 0 & 1 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \\ 1 & 1 & 0 \end{vmatrix}$ d) $\begin{vmatrix} \mathrm{A} & \mathrm{B} & \mathrm{Y} \\ 0 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \\ 1 & 1 & 1 \end{vmatrix}$

45. In $P$-$N$ junction, avalanche current flows in circuit when biasing is
a) Forward b) Reverse c) Zero d) Excess

46. The depletion layer in a silicon diode is 1 $\mu$m wide and its knee potential is 0.6 V, then the electric field in the depletion layer will be
a) 0.6 $\mathrm{Vm^{-1}}$ b) $6 \times 10^4$ $\mathrm{Vm^{-1}}$ c) $6 \times 10^5$ $\mathrm{Vm^{-1}}$ d) Zero

47. $p$-type semiconductor are
a) Positively charged
b) Produced when boron is added as an impurity
c) Produced when phosphorus is added as an impurity to silicon
d) Produced when carbon is added as an impurity to germanium.

# : HINTS AND SOLUTIONS :

1 **(d)**
Boolean expression of the given circuit is $Y = \overline{\overline{A+B}+\overline{A+B}} = A+B$

2 **(a)**
From truth table it is clear that output is high if at least one input is low. The Boolean expression which satisfies the output of this logic gate is $C = A \cdot B$, which is for AND gate.

3 **(c)**
Forward biased resistance $= \frac{\Delta V}{\Delta I} = \frac{0.7-0.6}{(15-5)\times 10^{-3}}$

$= \frac{0.1}{10 \times 10^{-3}} = 10\ \Omega$

4 **(d)**
For reverse biasing of an ideal diode, the potential of $n$-side should be higher than potential of $p$-side. Only option (d) is satisfying the criterion for reverse biasing.

5 **(d)**
According to De-Morgan's theorem

$\bar{A} \cdot \bar{B} = (\overline{A+B})$

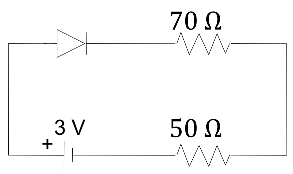
$\therefore \overline{\bar{A} \cdot \bar{B}}) = (\overline{\overline{A+B}})$

$= (A+B) \quad (\because \bar{\bar{A}} = A)$

$\therefore \overline{\bar{A} \cdot \bar{B}} = (A+B)$

6 **(d)**
The output $Y$ is a combination of AND + NOT gate. Hence, the truth table is for NAND gate.

7 **(c)**
In the circuit the upper diode $D_1$ is reverse biased and the lower diode $D_2$ is forward biased. Thus there will be no current across upper diode junction. The effective circuit will be as shown in figure.

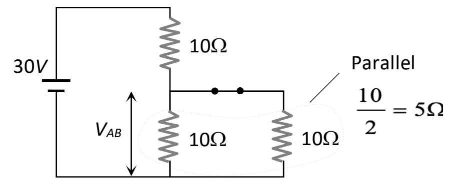



Total resistance of circuit

$R = 50 + 70 + 30 = 150\ \Omega$

Current in circuit, $I = \frac{V}{R} = \frac{3}{150} = 0.02$ A.

8 **(a)**
Diode is in forwards biasing hence the circuit can be redrawn as follows




$V_{AB} = \frac{30}{(10+5)} \times 5 = 10\ V$

9 **(a)**
For motion of covalent bonds in compounds exhibits nature of electron.

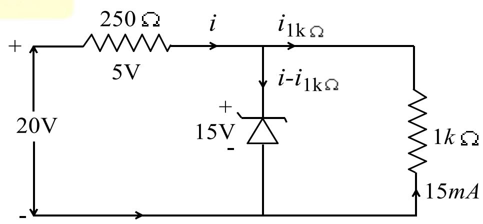
10 **(b)**
The temperature co-efficient of resistance of a semiconductor is always negative

11 **(c)**
If inputs are $A$ and $B$ then output for NAND gate is $Y = \overline{AB}$

$\Rightarrow$ If $A = B = 1, Y = \overline{1.1} = \bar{1} = 0$

12 **(b)**
I → ON
III → OFF
In IInd state it is used as a amplifier it is active region

13 **(b)**
Voltage across zener diode is constant




$i_{1k\Omega} = \frac{15\ volt}{1k\Omega} = 15mA$

$i_{250\Omega} = \frac{(20-15)V}{250\Omega} = \frac{5V}{250\Omega} = \frac{20}{1000}A = 20mA$

$\therefore i_{\text{zener diode}} = (20-15) = 5\ mA$

14 **(b)**
Potential difference across diode

$= 3.2 - 3 = 0.2$ V

∴ Current through diode

$i = \frac{0.2}{100} = 2 \times 10^{-3}$ A

15 **(c)**
A $p$-type material is electrically neutral.

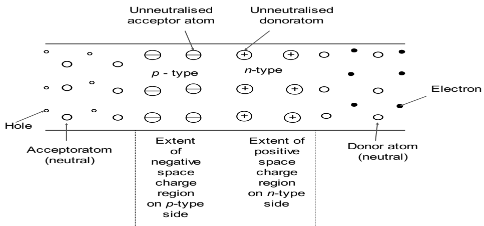
16 **(d)**
In forward biasing both electrons and protons move towards the junction and hence the width of depletion region decreases.

17 **(a)**

In $p - n$ junction, the barrier potential offers resistance to free electrons in n-region and holes in $p$-region.

18 **(b)**

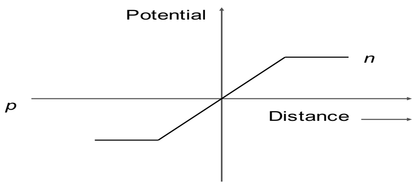
In a $p$-$n$ junction diode, electrons in conduction band on $n$-type side travel across the junction and leave the positively ionized impurity atoms unneutralised. Consequently, there is positively charged region adjacent to the junction in $n$-type material. On $p$-type side the electrons which have traversed the boundary recombine with positive holes in the valence




band and form a layer of unneutralised negatively ionised trivalent impurity atoms making a negatively charged region as shown in figure. The region around the junction is called charge depletion region or space charge region. Hence, within the depletion region, $p$-side is negative and $n$-side is positive.

19 **(b)**

Graph between potential and distance in a $p$-$n$ junction diode is given by




$\therefore$ potential at $p$ is less than that at $n$.

20 **(b)**

The electric resistance of a typical intrinsic (non doped) semiconductor decreases exponentially with temperature

$$R = R_0\, e^{\alpha/T}$$

21 **(d)**

If we give the following inputs to $A$ and $B$, then corresponding output is shown in table.

| $A$ | $B$ | $Y$ |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

The above table is similar to OR gate.

22 **(b)**

For full wave rectifier, ripple frequency

$= 2\times$ input frequency

$= 2 \times 50 = 100$ Hz

23 **(d)**

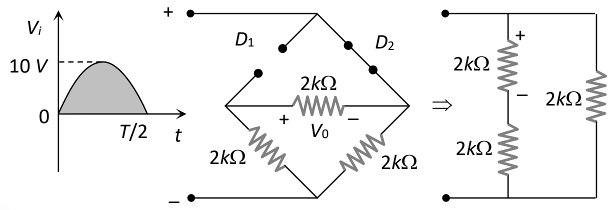
Temperature co-efficient of semiconductor is negative

24 **(a)**

The forward voltage overcomes the barrier voltage. Due to which the forward current is high but depends upon the forward voltage applied. The reverse voltage supports the barrier voltage, due to which the reverse current is low.

25 **(b)**

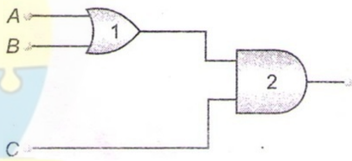
For the positive half cycle of input the resulting network is shown below




$$\Rightarrow (V_0)_{\max} = \frac{1}{2}(V_i)_{\max} = \frac{1}{2} \times 10 = 5\,V$$

26 **(c)**

We can realize the gate circuit as




Output of gate 1, $Y_1 = A + B$

Output of gate 2, $Y_2 = Y_1 \cdot C = (A + B) \cdot C$

(a) If $A = 0, B = 1, C = 0$, then

$$Y_2 = (0 + 1) \cdot 0 = 1 \cdot 0 = 0$$

(b) If $A = 1, B = 0, C = 0$, then

$$Y_2 = (1 + 0) \cdot 0 = 1 \cdot 0 = 0$$

(c) If $A = 1, B = 0, C = 1$, then

$$Y_2 = (1 + 0) \cdot 1 = 1 \cdot 1 = 1$$

(d) If $A = 1, B = 1, C = 0$, then

$$Y_2 = (1 + 1) \cdot 0 = 1 \cdot 0 = 0$$

27 **(a)**

Since diode in upper branch is forward biased and in lower branch is reversed biased. So current through circuit $i = \frac{V}{R + r_d}$; here $r_d =$ diode resistance in forward biasing $= 0$

$$\Rightarrow i = \frac{V}{R} = \frac{2}{10} = 0.2A$$

28 **(c)**

Here $p - n$ junction is forward biased. If $p - n$ junction ideal, its resistance is zero. The effective resistance across $A$ and $B$

$$= \frac{10 \times 10}{10 + 10} = 5\text{k}\Omega.$$

Current in the circuit $I = \frac{V}{R} = \frac{30}{15\times10^3} = \frac{2}{10^3}$ A

Current in arm $AB = I = \frac{2}{10^3}$

Potential difference across $A$ and $B = \frac{2}{10^3} \times 5 \times 10^3 = 10$ V.

29 **(c)**

Under normal reverse voltage, a very little reverse current flows through a $p$-$n$ junction. However, if the reverse voltage attains a high value, the junction may breakdown with sudden rise in reverse current.

If reverse voltage is increased continuously, the kinetic energy of electrons (minority carriers) may become high enough to knock out electrons from the semiconductor atoms. At this stage breakdown of the junction occurs characterised by a sudden rise of reverse current and a sudden fall of the resistance of barrier region. This may destroy the junction permanently.

30 **(b)**

Higher the temperature of cathode, the larger is the value of saturation current.

31 **(a)**

From circuit

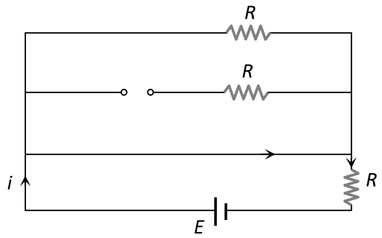
$Y = \overline{\overline{A \cdot B}} = A \cdot B$

This is an output of an AND gate.

32 **(a)**

Diodes $D_1$ and $D_3$ are forward biased and $D_2$ is reverse biased so the circuit can be redrawn as follows

$\Rightarrow i = \frac{E}{R}$

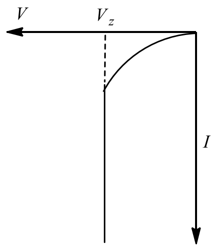



33 **(a)**

Due to the reverse biasing the width of depletion region increases and current flowing through the diode is almost zero. In this case electric field is almost zero at the middle of the depletion region.

34 **(b)**

When the reverse voltage across a zener diode exceeds the breakdown voltage $V_Z$, the current increases very sharply. In this region, the curve is almost vertical. It means voltage across zener diode is constant at $V_Z$ even though the current through it changes. Therefore, a zener diode behaves as a constant voltage source.




Reverse charcteristic of zener diode

35 **(a)**

As we know, current density $J = nqv$

$\Rightarrow \quad j_e = n_e\, qv_e$

and $\quad J_h = n_h\, qv_h$

$$\frac{j_e}{J_h} = \frac{n_e}{n_h} \times \frac{v_e}{v_n}$$

$$\Rightarrow \frac{3/4}{1/4} = \frac{n_e}{n_h} \times \frac{5}{2}$$

$$\Rightarrow \frac{n_e}{n_h} = \frac{6}{5}$$

36 **(a)**

The reverse bias potential that results in this sudden change in characteristics is called the zener potential and is given by the symbol $V_Z$.

When the voltage across diode is increased in the reverse bias region, the minority carriers gain velocity and associated kinetic energy. These minority carriers are responsible for the reverse saturation current. The collisions of these minority carriers with atomic structure will result in an ionisation process and a very high current is established. This current is called avalanche current and the region in which this current is established is called avalanche breakdown region.

The magnitude of zener potential may be decreased by increasing doping levels in the $p$ and $n$-type materials.

When the $V_Z$ decreases to a very low level, there is a strong electric field in the region of the junction that can break the bonds with $C$ in the atom and generate charge carriers. This mechanism is called zener breakdown.

37 **(d)**

The diode $D$ will conduct for positive half cycle of $a.c.$ supply because this is forward biased. For negative half cycle of $a.c.$ supply, this is reverse biased and does not conduct. So out put would be half wave rectified and for half wave rectified out put

$$V_{rms} = \frac{V_0}{2} = \frac{200\sqrt{2}}{2} = \frac{200}{\sqrt{2}}$$

38 **(a)**

When, $n$-$p$-$n$ transistor is used as a common base amplifier, the emitter-base input circuit is forward biased and collector-base output circuit is reverse biased.

When $i_E, i_B, i_C$ are emitter, base and collector current.

The arrow from base to emitter represents the direction of hole current that is the conventional current which is opposite to direction of electron current. Thus, electrons move from emitter to base.

39 **(b)**

In circuit the upper diode junction is forward biased and the lower diode junction is reverse biased. Thus there will be no conduction across lower diode junction. Now the total resistance of circuit= $100 + 150 + 50 = 300\Omega$

Current in $100\Omega = \frac{6}{300} = 0.02$ A.

40 **(c)**

An $n$-type semiconductor is formed by doping pure germanium or silicon crystal with suitable impurity atoms of valence five. As the impurity atoms take the positions of Ge atoms in germanium crystal, its four electrons form covalent bonds by sharing electrons with the neighbouring four atoms of germanium whereas the fifth electron is left free. Since, the atom on the whole is electricall neutral, the $n$-type semiconductor is also neutral.

41 **(a)**

At room temperature some covalent bonds break and semiconductor behaves slightly as a conductor

42 **(c)**

In photodiode, it is illuminated by light radiations, which in turn produces electric current

43 **(c)**

The given truth table express the Boolean expression as

$Y = A + B$

Since, $0 = 0 + 0$

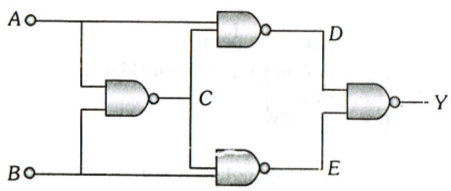
$1 = 0 + 1$

$1 = 1 + 0$

$1 = 1 + 1$

This the Boolean expression of OR gate.

44 **(a)**




| A | B | C | $D = \overline{A.C}$ | $E = \overline{C.B}$ | Y |
|---|---|---|---|---|---|
| 0 | 0 | 1 | 1 | 1 | 0 |
| 0 | 1 | 1 | 1 | 0 | 1 |
| 1 | 0 | 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 1 | 1 | 0 |

45 **(b)**

At a particular reverse voltage in $PN$-junction, a huge current flows in reverse direction known as avalanche current

46 **(c)**

$E = -\frac{dV}{dr} = \frac{0.6}{10^{-6}} = 6 \times 10^5$ Vm$^{-1}$

47 **(b)**

Boron has valency three. When boron is doped in a pure semiconductor, then $p$-type semiconductor is formed.