1. A block of mass m is connected to a light spring of force constant k. The system is placed inside a damping medium of damping constant b. The instantaneous values of displacement, acceleration and energy of the block are x, a and E respectively. The initial amplitude of oscillation is A and ω' is the angular frequency of oscillations. The incorrect expression related to the damped oscillations is

(A) $\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$ (B) $m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + kx = 0$ (C) $E = \frac{1}{2}kA^2 e^{-\frac{bt}{m}}$ (D) $x = Ae^{-\frac{b}{m}}\cos(\omega' t + \phi)$

Sol: $x = Ae^{-\frac{bt}{2}}\cos(\omega' t + \phi)$

Ans: (D)

2. The speed of sound in an ideal gas at a given temperature T is v. The rms speed of gas molecules at that temperature is v_{rms}. The ratio of the velocities v and v_{rms} for helium and oxygen gases are X and X' respectively. Then $\frac{X}{X'}$ is equal to

(A) $\frac{5}{\sqrt{21}}$ (B) $\frac{21}{5}$ (C) $\sqrt{\frac{5}{21}}$ (D) $\frac{21}{\sqrt{5}}$

Sol: $\upsilon = \sqrt{\frac{\gamma RT}{M}}$ and $\upsilon_{rms} = \sqrt{\frac{3RT}{M}}$

$\therefore \frac{\upsilon}{\upsilon_{rms}} = \sqrt{\frac{\gamma}{3}}$

For He, $\gamma = \sqrt{\frac{5/3}{3}}$ for $O_2 \gamma = \sqrt{\frac{7/5}{3}}$

$\therefore \frac{x}{x'} = \sqrt{\frac{5/3}{2/5}} = \sqrt{\frac{25}{21}} = \frac{5}{\sqrt{21}}$

Ans: (A)

3. A positively charged glass rod is brought near uncharged metal sphere, which is mounted on an insulated stand. If the glass rod is removed, the net charge on the metal sphere is

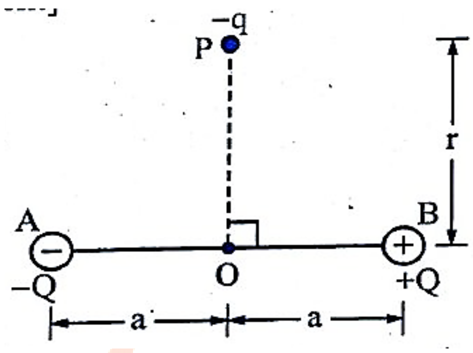
(A) Zero (B) Positive charge (C) 1.6×10^{-19} C (D) Negative charge

Sol: Conceptual

Ans: (A)

4. In the situation shown in the diagram, magnitude of $q << |Q|$ and $r >> a$. The net force on the free charge $-q$ and net torque on it about O at the instant shown respectively

[$p = 2aQ$ is the dipole moment]



(A) $\frac{1}{4\pi\varepsilon_0}\frac{pq}{r^2}\hat{k}, \frac{1}{4\pi\varepsilon_0}\frac{pq}{r^3}\hat{i}$

(B) $\frac{1}{4\pi\varepsilon_0}\frac{pq}{r^3}\hat{i}, +\frac{1}{4\pi\varepsilon_0}\frac{pq}{r^2}\hat{k}$

(C) $-\frac{1}{4\pi\varepsilon_0}\frac{pq}{r^2}\hat{k}, -\frac{1}{4\pi\varepsilon_0}\frac{pq}{r^3}\hat{i}$

(D) $\frac{1}{4\pi\varepsilon_0}\frac{pq}{r^3}\hat{i}, -\frac{1}{4\pi\varepsilon_0}\frac{pq}{r^2}\hat{k}$

Sol: $\vec{F} = -qE\left(-\hat{i}\right) = qE\hat{i} = \frac{1}{4\pi\varepsilon_0}\frac{pq}{r^3}\hat{i}$

$\vec{\tau} = \vec{r}\times\vec{F} = r\hat{j}\times\frac{1}{4\pi\varepsilon_0}\frac{pq}{r^3}\hat{i} = -\frac{1}{4\pi\varepsilon_0}\frac{pq}{r^2}\hat{k}$

Ans: (D)

5. Pressure of ideal gas at constant volume is proportional to

(A) average potential energy of the molecules

(B) average kinetic energy of the molecules

(C) total energy of the gas

(D) force between the molecules

Sol: $P = \frac{2}{3}E$

Ans: (B)

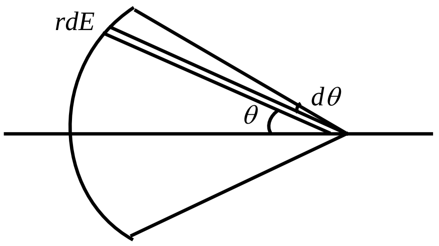
6. Electric field at a distance ′ r ′ from an infinitely long uniformly charged straight conductor, having linear charge density λ is E_1. Another uniformly charged conductor having same linear charge density λ is bent into a semicircle of radius ′ r ′. The electric field at its centre is E_2. Then

(A) $E_2 = \frac{E_1}{r}$ (B) $E_1 = \pi r E_2$ (C) $E_1 = E_2$ (D) $E_2 = \pi r E_1$

Sol: For a long conductor

$E_1 = \frac{\lambda}{2\pi\varepsilon_0 r}$

For semicircular wire



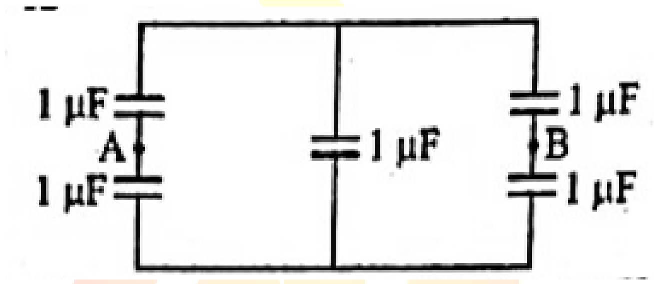
$$dE = \frac{\lambda r d\theta}{4\pi\varepsilon_0 r^2} = \frac{\lambda d\theta}{4\pi\varepsilon_0 r}$$

$$E_2 = \int_{-\pi/2}^{\pi/2} dE\cos\theta = \int_{-\pi/2}^{\pi/2} \frac{\lambda d\theta \cos\theta}{4\pi\varepsilon_0 r}$$

$$E_2 = \frac{\lambda}{2\pi\varepsilon_0 r} \qquad \therefore\ E_1 = E_2$$

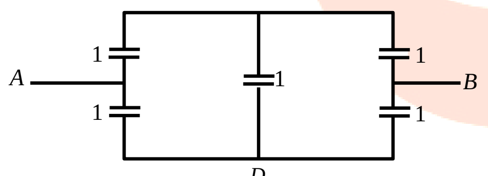
Ans: (C)

7. Five capacitors each of value $1\mu F$ are connected as shown in the figure. The equivalent capacitance between A and B is

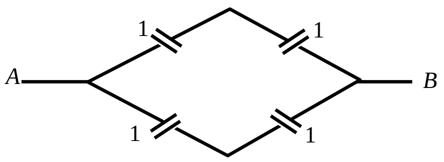


(A) 1 μF (B) 5 μF (C) 2 μF (D) 3 μF

Sol:



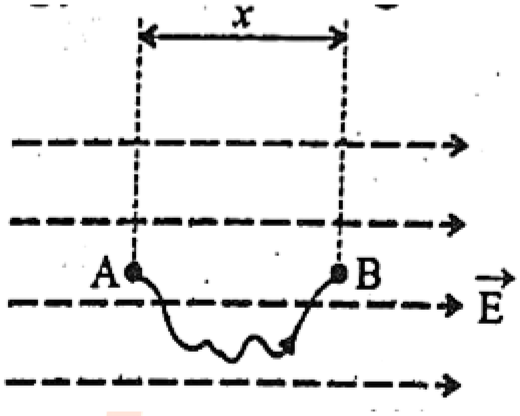
Balanced bridge circuit



$C_{eq} = 1\,\mu F$

Ans: (A)

8. A uniform electric field vector $\vec{E}$ exists along horizontal direction as shown. The electric potential at A is V_A. A small point charge q is slowly taken from A to B along the curved path as shown. The potential energy of the charge when it is at point B is



(A) $q[V_A + Ex]$ (B) qEx (C) $q[Ex - V_A]$ (D) $q[V_A - Ex]$

Sol: P.E. at $B =$ PE at $A +$ Work done in taking to B

$= qV_A + qEx$

$= q(V_A + Ex)$

Ans: (A)

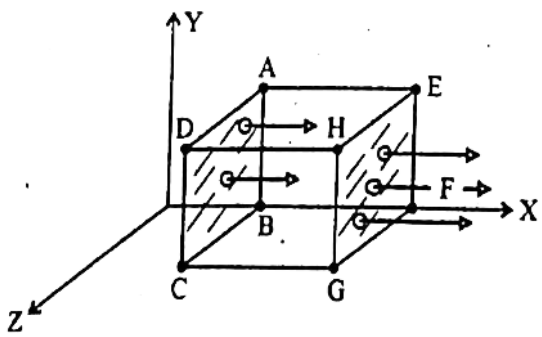
9. A parallel plate capacitor of capacitance C_1 with a dielectric slab in between its plates is connected to a battery. It has a potential difference V_1 across its plates. When the dielectric slab is removed, keeping the capacitor connected to the battery, the new capacitance and potential difference are C_2 and V_2 respectively. Then,

(A) $V_1 > V_2, C_1 > C_2$ (B) $V_1 = V_2, C_1 > C_2$ (C) $V_1 < V_2, C_1 > C_2$ (D) $V_1 = V_2, C_1 < C_2$

Sol: $V_1 = V_2$ as battery remains connected and $C_1 > C_2$ as dielectric removed

Ans: (B)

10. A cubical Gaussian surface has side of length $a = 10\text{cm}$. Electric field lines are parallel to x-axis as shown. The magnitudes of electric fields through surfaces ABCD and EFGH are 6kNC^{-1} and 9kNC^{-1} respectively. Then the total charge enclosed by the cube is $\left[\text{ Take } \varepsilon_0 = 9\times10^{-12}\,\text{Fm}^{-1}\right]$



(A) 1.35nC (B) 0.27nC (C) –1.35nC (D) –0.27nC

Sol: Total flux $=\left(9\times a^2-6\times a^2\right)\times 10^3$

$=3a^2\times 10^3$

$=3\times 10\times 10\times 10^{-4}\times 10^3$

$\phi=3\times 10=30$

$\phi=\frac{q}{\varepsilon_0}$

$q=\varepsilon_0\phi=q\times 10^{-12}\times 30\text{ C}$

$=0.27\text{ nC}$

Ans: (B)

11. The four bands of a colour coded resistor are of the colours gray, red, gold and gold. The value of the resistance of the resistor is

(A) $82\Omega\pm 10\%$ (B) $82\Omega\pm 5\%$ (C) $8.2\Omega\pm 5\%$ (D) $5.2\Omega\pm 5\%$

Sol: $\begin{matrix} B\,B\,ROY\,GBVGW \\ 0\;1\;234\;\;56789 \end{matrix}$

$82\times 10^{-1}\pm 5\%$

Ans: (C)

12. A wire of resistance R is connected across a cell of emf ε and internal resistance r. The current through the circuit is I. In time t, the work done by the battery to establish the current I is

(A) $\frac{\varepsilon^2 t}{R}$ (B) I^2Rt (C) IRt (D) ε It

Sol: I^2Rt - Conceptual

Ans: (B)

13. For a given electric current the drift velocity of conduction electrons in a copper wire is v_d and their mobility is μ. When the current is increased at constant temperature

(A) v_d remains the same, μ increases (B) v_d remains the same, μ decreases

(C) v_d decreases, μ remains the same (D) v_d increases, μ remains the same

Sol: $I=neAv_d$

$\mu=\frac{v_d}{E}$

Ans: (D)

14. Ten identical cells each emf $2V$ and internal resistance 1Ω are connected in series with two cells wrongly connected. A resistor of 10Ω is connected to the combination. What is the current through the resistor?

(A) 2.4A (B) 1.2A (C) 0.6A (D) 1.8A

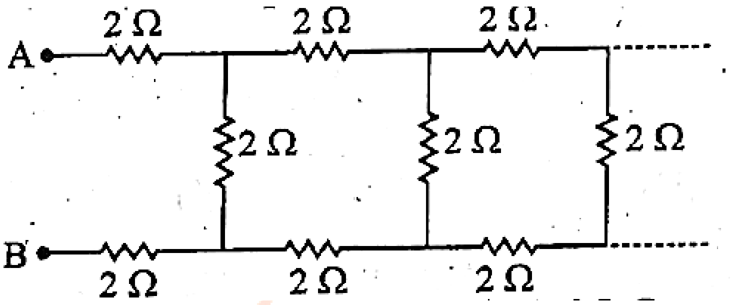
Sol: Total Emf $=6\varepsilon=6\times 2=12$

Total resistance $=10+10\times 1=20$

$\therefore$ Current $= \frac{12}{20} = 0.6\,A$

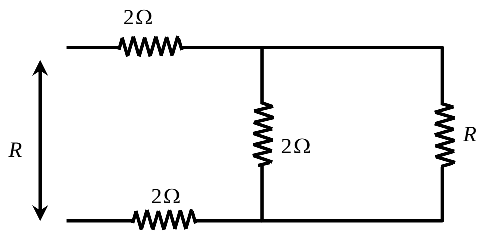
Ans: (C)

15. The equivalent resistance between the points A and B in the following circuit is



(A) 5.5Ω (B) 5Ω (C) 0.05Ω (D) 0.5Ω

Sol: $2\,\text{and}\,R$ are in parallel.



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

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

Total Resistance

$2 + 2 + R' = R$

$4 + \frac{2R}{2+R} = R$

$\frac{8 + 4R + 2R}{2+R} = R$

$8 + 6R = R(2+R)$

$8 + 6R = 2R + R^2$

$R^2 - 4R - 8 = 0$

$\alpha, \beta = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$= \frac{4 \pm \sqrt{16 - 4(1)(-8)}}{2}$

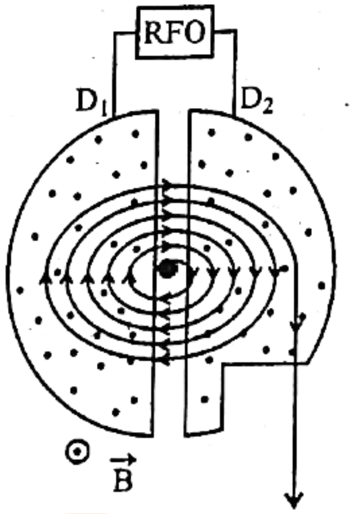
$= \frac{4 \pm \sqrt{48}}{2}$

$= \frac{4 \pm 4\sqrt{3}}{2} = 2 + 2\sqrt{3}$

$= 2 + 2 \times 1.7$

Ans: (A)

16. A charged particle is subjected to acceleration in a cyclotron as shown. The charged particle undergoes increase in its speed



(A) Only inside D_2

(B) Only inside D_1

(C) Inside D_1, D_2 and the gaps

(D) Only in the gap between D_1 and D_2

Sol: Conceptual

Only electric field accelerated.

Ans: (D)

17. The resistance of a carbon resistor is $4.7\text{k}\Omega \pm 5\%$. The colour of the third band is

(A) red (B) orange (C) violet. (D) gold

Sol: Red, $\rightarrow 2 \rightarrow 10^2$

Ans: (A)

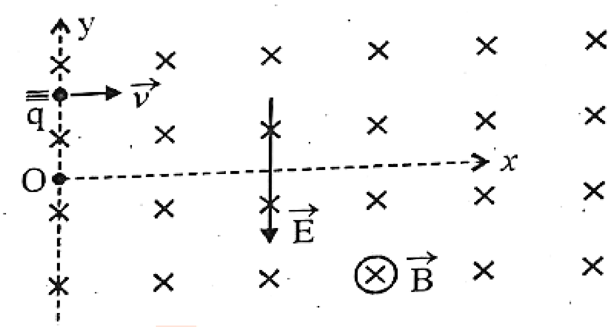
18. A moving coil galvanometer is converted into an ammeter of range 0 to 5mA . The galvanometer resistance is 90Ω and the shunt resistance has a value of 10Ω . If there are 50 divisions in the galvanometer-turned-ammeter on either sides of zero, its current sensitivity is

(A) $1\times10^5\text{ A / div}$ (B) $1\times10^5\text{ div / A}$ (C) $2\times10^4\text{ A / div}$ (D) $2\times10^4\text{ div / A}$

Sol: Current sensitivity $= \frac{100}{5\times10^{-3}} = 2\times10^4 \text{ div / A}$

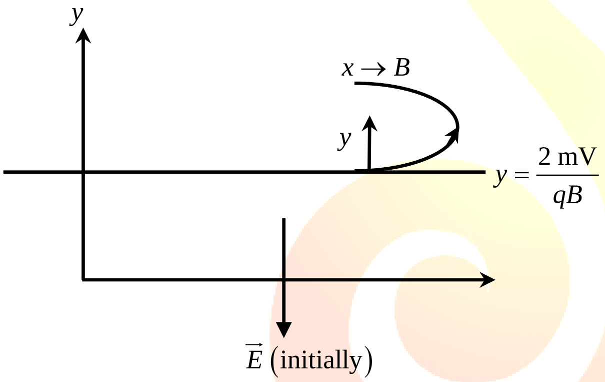
Ans: (D)

19. A positively charged particle of mass m is passed through a velocity selector. It moves horizontally rightward without deviation along the line $y = \frac{2mv}{qB}$ with a speed v. The electric field is vertically downwards and magnetic field is into the plane of the paper. Now, the electric field is switched off at $t = 0$. The angular momentum of the charged particle about origin O at $t = \frac{\pi m}{qB}$ is



(A) $\frac{2mE^2}{qB^3}$ (B) $\frac{mE^3}{qB^2}$ (C) zero (D) $\frac{mE^2}{qB^3}$

Sol:



$\vec{L} = \vec{r} \times \vec{p}$

$|\vec{L}| = r \perp p$

$= \frac{2\text{ mV}}{qB} \times mV$

$q \times B = \frac{mV}{r}$

$r = \frac{mV}{qB}$

$T = \frac{2\pi r}{V} = \frac{2\pi mV}{qB} = \frac{2\pi m}{qB}$

Ans: (Options are not matching)

20. The Curie temperatures of Cobalt and iron are 1400K and 1000K respectively. At $\text{T}=1600\text{K}$, the ratio of magnetic susceptibility of Cobalt to that of iron is

(A) 3 (B) $\frac{5}{7}$ (C) $\frac{7}{5}$ (D) $\frac{1}{3}$

Sol: $\chi \propto \frac{1}{T-T_C}$

For Cobalt:

$\chi_C \propto \frac{1}{1600-1400}$ $\chi_C \propto \frac{1}{200}$

For Iron:

$\chi_I \propto \frac{1}{1600-100} = \frac{1}{600}$

$\frac{\chi_C}{\chi_I} = \frac{\frac{1}{200}}{\frac{1}{600}} = 3$

Ans: (A)

21. The torque acting on a magnetic dipole placed in uniform magnetic field is zero, when the angle between the dipole axis and the magnetic field is _______.

(A) 45° (B) 90° (C) 60° (D) zero

Sol: $\tau = MB\text{Sin}\,\theta = 0$

$\Rightarrow \sin\theta = 0 \quad \Rightarrow \theta = 0$

Ans: (D)

22. The horizontal component of Earth's magnetic field at a place is $3\times10^{-5}\text{T}$. If the dip at that place is 45°, the resultant magnetic field at that place is

(A) $\frac{3}{\sqrt{2}}\times10^{-5}\text{T}$ (B) $3\sqrt{2}\times10^{-5}\text{T}$ (C) $\frac{3}{2}\sqrt{3}\times10^{-5}\text{T}$ (D) $3\times10^{-5}\text{T}$

Sol: $B_H = 3\times10^{-5}T$, $\theta = 45°$

$B_H = B\cos\theta \quad \Rightarrow 3\times10^{-5} = B\cos 45°$

$B = 3\times10^{-5}\sqrt{2} \quad B = 3\sqrt{2}\times10^{-5}T$

Ans: (B)

23. A proton and an alpha-particle moving with the same velocity enter a uniform magnetic field with their velocities perpendicular to the magnetic field. The ratio of radii of their circular paths is

(A) $1:4$ (B) $1:2$ (C) $4:1$ (D) $2:1$

Sol: $\frac{mv^2}{R} = qVB \quad \Rightarrow mV = qBR \Rightarrow R = \frac{mV}{qB} \Rightarrow \frac{R_{proton}}{R_\alpha} = \frac{m_{pr}}{q_{pr}}\times\frac{q_\alpha}{m_\alpha} \Rightarrow Ratio = \frac{2}{4} = \frac{1}{2}$

Ans: (B)

24. A metallic rod of length 1m held along east-west direction is allowed to fall down freely. Given horizontal component of earth's magnetic field $B_H = 3\times10^{-5}$T. The emf induced in the rod at an instant $t = 2$s after it is released is (Take $g = 10\text{ms}^{-2}$)

(A) 3×10^{-3}V (B) 6×10^{-3}V (C) 3×10^{-4}V (D) 6×10^{-4}V

Sol: $|e| = Blv = bl(u+at)$

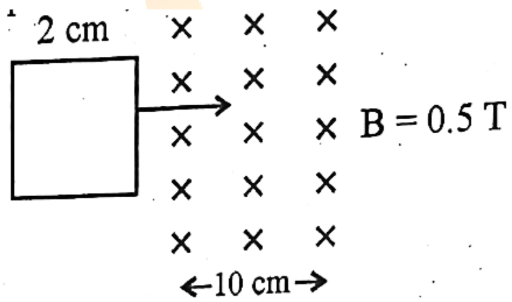
$x = 0, t = 2s, g = 10\text{ ms}^{-2}$

$|e| = Blgt = 3\times10^{-5}\times1\times10\times2 = 60\times10^{-5}$ V

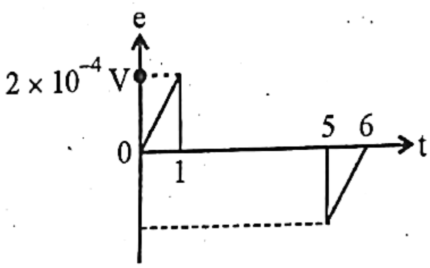
$= 6\times10^{-4}$ V

Ans: (D)

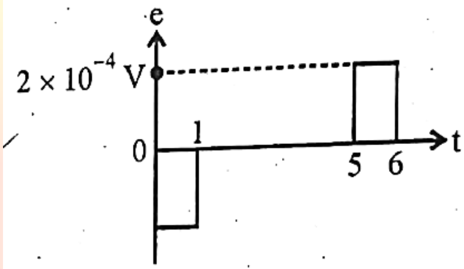
25. A square loop of side 2cm enters a magnetic field with a constant speed of 2cms^{-1} as shown. The front edge enters the field at $t = 0$ s. Which of the following graph correctly depicts the induced emf in the loop? (Take clockwise direction positive)



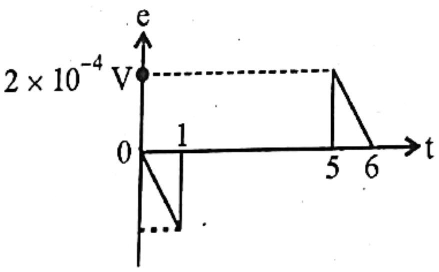
(A)



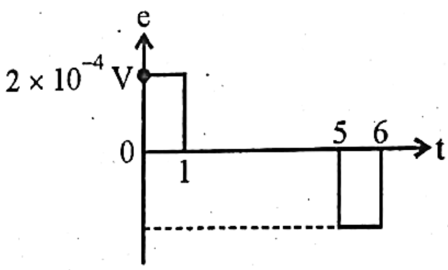
(B)



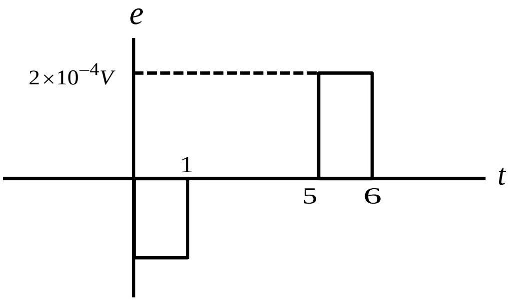
(C)



(D)



Sol: As the square loop enters, flux increases hence emf induced is opposite to flux increases.
When the square loop leaves flux decreases hence emf induced will oppose the change.



Ans: (B)

26. In series LCR circuit at resonance, the phase difference between voltage and current is

(A) π (B) $\frac{\pi}{2}$ (C) $\frac{\pi}{4}$ (D) zero

Sol: At resonance, phase difference between voltage and current is zero.

Ans: (D)

27. An ideal transformer has a turns ratio of 10. When the primary is connected to $220V, 50Hz$ ac source, the power output is

(A) $\frac{1}{10}^{th}$ the power input (B) zero

(C) equal to power input (D) 10 times the power input

Sol: In an ideal transformer,

power output = Power input.

Ans: (C)

28. The current in a coil changes from $2A$ to $5A$ in $0.3s$. The magnitude of emf induced in the coil is $1.0V$. The value of self-inductance of the coil is

(A) 100mH (B) 10mH (C) 0.1mH (D) 1.0mH

Sol: $|e| = L\left|\frac{di}{dt}\right| \Rightarrow L = \frac{|e|}{\left|\frac{di}{dt}\right|} = \frac{1}{\left|\frac{5-2}{0.3}\right|}$

$= 0.1\text{ H} = 100\text{ mH}$

Ans: (A)

29. The ratio of the magnitudes of electric field to the magnetic field of an electromagnetic wave is of the order of

(A) $10^5 ms^{-1}$ (B) $10^8 ms^{-1}$ (C) $10^{-5} ms^{-1}$ (D) $10^{-8} ms^{-1}$

Sol: $c = \frac{E}{B} = 3\times10^8 \text{ m/s}$

Order of magnitude $= 10^8$ m/s

Ans: (B)

30. For a point object, which of the following always produces virtual image in air?

(A) Plano-convex lens (B) Biconvex lens (C) Convex mirror (D) Concave mirror

Sol: Connex mirror always produces virtual image.

Ans: (C)

31. For a given pair of transparent media, the critical angle for which colour is maximum?

(A) Red (B) Violet (C) Blue (D) Green

Sol: $\sin C = \frac{1}{\mu}$

$\frac{\mu_2}{\mu_1} = \frac{\lambda_1}{\lambda_2}$

$\lambda \propto \frac{1}{\mu}$

Ans: (A)

32. An equiconvex lens made of glass of refractive index $\frac{3}{2}$ has focal length f in air. It is completely immersed in water of refractive index $\frac{4}{3}$. The percentage change in the focal length is

(A) 300% decrease (B) 300% increase (C) 400% decrease (D) 400% increase

Sol: $\mu_l = \frac{3}{2}$, $f_{\text{air}} = f$.

$\mu_\omega = \frac{4}{3}$

$$\frac{1}{f_{\text{air}}} = (\mu - 1)(x) = \left(\frac{3}{2} - 1\right)(x)$$

$$\frac{1}{f_{\text{air}}} = \left(\frac{1}{2}\right)x$$

$$\frac{1}{f_{\text{water}}} = \left(\frac{\frac{4}{3}}{\frac{3}{2}} - 1\right)x = \frac{1}{8}x$$

$$\frac{f_{\text{water}}}{f_{\text{air}}} = \frac{\frac{1}{8}x}{\frac{1}{2}} = \frac{1}{4}$$

Decreasing by four times so 400% decrease

Ans: (C)

33. A point object is moving at a constant speed of $1\,\text{ms}^{-1}$ along the principal axis of a convex lens of focal length $10\,\text{cm}$. The speed of the image is also $1\,\text{ms}^{-1}$, when the object is at cm from the optic centre of the lens.

(A) 15 (B) 5 (C) 20 (D) 10

Sol: $\frac{-1}{u}+\frac{1}{v}=\frac{1}{f}$

$\frac{du}{dt}\cdot\frac{1}{u^2}-\frac{dv}{dt}\cdot\frac{1}{v^2}=0$

$\frac{du}{dt}=\frac{u^2}{v^2}\frac{dv}{dt}$

$u=v$

If object placed at $2f$ both velocity must be same.

Ans: (C)

34. When light propagates through a given homogeneous medium, the velocities of

(A) primary wavefronts are lesser than those of secondary wavelets.

(B) primary wavefront and wavelets are equal.

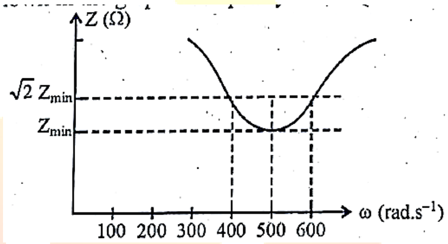
(C) primary wavefronts are greater than or equal to those of secondary wavelets.

(D) primary wavefront are larger than those of secondary wavelets.

Sol: primary wavefront and wavelets are equal

Ans: (B)

35. Total impedance of a series LCR circuit varies with angular frequency of the AC source connected to it as shown in the graph. The quality factor Q of the series LCR circuit is



(A) 2.5 (B) 1 (C) 5 (D) 0.4

Sol: $2\omega_0=2\Delta\omega=600-400=200\,\text{rad s}^{-1}$

$\omega_0=500\,\text{rad s}^{-1}$

Q. factor $=\frac{\omega_0}{2\Delta\omega}$

$=\frac{500}{200}=2.5$

Ans: (A)

36. In the Young's double slit experiment, the intensity of light passing through each of the two double slits is $2\times10^{-2}\,\text{Wm}^{-2}$. The screen-slit distance is very large in comparison with slit-slit distance. The fringe width is β. The distance between the central maximum and a point P on the screen is $x=\frac{\beta}{3}$. Then the total light intensity at that point is

(A) $4\times10^{-2}\,\text{Wm}^{-2}$ (B) $16\times10^{-2}\,\text{Wm}^{-2}$ (C) $2\times10^{-2}\,\text{Wm}^{-2}$ (D) $8\times10^{-2}\,\text{Wm}^{-2}$

Sol: $\Delta x = \frac{yd}{D}$

$\Delta x = \frac{3\beta d}{D} = \frac{3\times\lambda Dd}{dD} = 3\lambda$

$\Delta\phi = \frac{2\pi}{\lambda}\times 3\lambda = 6\pi$

$I = 4I_0\cos^2\left(\frac{6\pi}{2}\right) = 4\times I_0 = 4\times 2\times 10^{-2} = 8\times 10^{-2}$

Ans: (D)

37. A 60W source emits monochromatic light of wavelength 662.5nm. The number of photons emitted per second is

(A) 2×10^{20} (B) 2×10^{29} (C) 5×10^{26} (D) 5×10^{17}

Sol: $P = 60\,\text{W}$, $\lambda = 662.5\times 10^{-9}\,\text{m}$

$E = \frac{nhc}{\lambda}$

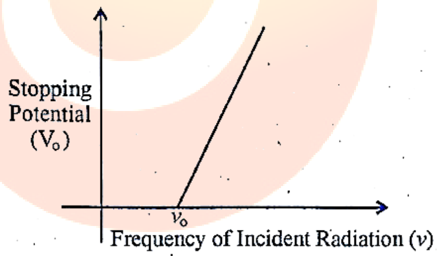
$60\times 1\text{Js} = \frac{n\times 6.63\times 10^{-34}\times 3\times 10^{8}}{662.5\times 10^{-9}\,\text{m}}$

$n = \frac{60\times 1\times 6.63\times 10^{-9}}{6.63\times 10^{-34}\times 3\times 10^{8}}$

$n = 2\times 10^{20}$

Ans: (A)

38. In an experiment to study photo-electric effect the observed variation of stopping potential with frequency of incident radiation is as shown in the figure. The slope and y-intercept are respectively



(A) $\frac{h\nu}{e}, \nu_0$. (B) $h\nu, -h\nu_0$ (C) $\frac{h\nu}{e}, -\frac{h}{e}$ (D) $\frac{h}{e}, -\frac{h\nu_0}{e}$

Sol: $h\nu = h\nu_0 + eV_0$

$V_0 = \frac{h\nu}{e} - \frac{h\nu_0}{e}$

$y = mx + C$

$m = \text{Slope} = \frac{h}{e}$ $\quad$ y intercept will $-\frac{h\nu_0}{e}$

Ans: (D)

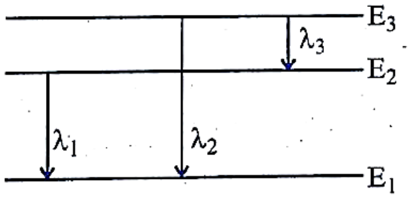
39. In the Rutherford's alpha scattering experiment, as the impact parameter increases, the scattering angle of the alpha particle

(A) is always 90° (B) increases (C) decreases (D) remains the same

Sol: Scattering decreases with increase with impact parameter

Ans: (C)

40. Three energy levels of hydrogen atom and the corresponding wavelength of the emitted radiation due to different electron transition are as shown. Then.



(A) $\lambda_1 = \frac{\lambda_2\lambda_3}{\lambda_2+\lambda_3}$ (B) $\lambda_2 = \frac{\lambda_1\lambda_3}{\lambda_1+\lambda_3}$ (C) $\lambda_2 = \lambda_1 + \lambda_3$ (D) $\lambda_3 = \frac{\lambda_1\lambda_2}{\lambda_1+\lambda_2}$

Sol: $\frac{1}{\lambda_1} + \frac{1}{\lambda_3} = \frac{1}{\lambda_2}$

$\lambda_2 = \frac{\lambda_1\lambda_3}{\lambda_1+\lambda_3}$

Ans: (B)

41. An unpolarised light of intensity I is passed through two polaroids kept one after the other with their planes parallel to each other. The intensity of light emerging from second polaroid is $\frac{I}{4}$. The angle between the pass axes of the polaroids is

(A) 0° (B) 30° (C) 60° (D) 45°

Sol: $I = \frac{I_0}{2}\cos^2\theta$

$\frac{I}{4} = \frac{I}{2}\cos^2\theta$

$\cos^2\theta = \frac{2}{4}$

$\cos^2\theta = \frac{2}{4}$

$\cos\theta = 1/\sqrt{2}$

$\therefore\ \theta = 45^\circ$

Ans: (D)

42. A nucleus with mass number 220 initially at rest emits an alpha particle. If the Q value of reaction is 5.5MeV, calculate the value of kinetic energy of alpha particle.

(A) 5.4MeV (B) 4.5MeV (C) 7.4MeV (D) 6.5MeV

Sol: $KE = \left(\frac{A-4}{A}\right)Q \;= \left(\frac{220-4}{220}\right)5.5 = 5.4\ \text{MeV}$

Ans: (A)

43. A radioactive sample has half-life of 3 years. The time required for the activity of the sample to reduce to $\frac{1}{5}$ th of its initial value is about

(A) 7 years (B) 5 years (C) 15 years (D) 10 years

Sol: $T_{1/2} = 3$ years

$N = A_0 e^{-\lambda t}$

$\frac{A_0}{5} = A_0 e^{-\lambda t}$

$\frac{1}{5} = e^{-\lambda t}$

$e^{\lambda t} = 5$

$\lambda t = \ln 5$

$t = \frac{\ln 5 \times \lambda / 2}{0.693}$

$= \frac{\ln 5 \times 3}{0.693}$

$t = 7$ years

Ans: (A)

44. When a p-n junction diode is in forward bias, which type of charge carriers flows in the connecting wire?

(A) Ions (B) Holes (C) Protons (D) Free electrons

Sol: Free electrons

Ans: (D)

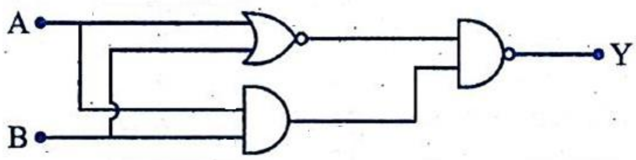
45. A full-wave rectifier with diodes D_1 and D_2 is used to rectify 50Hz alternating voltage. The diode D_1 conducts times in one second.

(A) 25 (B) 50 (C) 75 (D) 100

Sol: The diode D_1 conducts times in one second is 25

Ans: (A)

46. The truth table for the given circuit is



(A)

A	B	Y
1	1	1
1	0	0
0	1	1
0	0	1

(B)

A	B	Y
1	1	1
1	0	1
0	1	1
0	0	0

(C)

A	B	Y
1	1	1
1	0	1
0	1	1
0	0	1

(D)

A	B	Y
1	1	1
1	0	1
0	1	0
0	0	1

Sol:

A	B	Y
1	1	1
1	0	1
0	1	1
0	0	1

Ans: (C)

47. The energy gap of an LED is 2.4eV. When the LED' is switched ' ON ', the momentum of the emitted photons is

(A) $2.56\times10^{-27}\text{kg}\cdot\text{m}\cdot\text{s}^{-1}$
(B) $0.64\times10^{-27}\text{kg}\cdot\text{m.s}^{-1}$
(C) $1.28\times10^{-11}\text{kg}\cdot\text{m.s}^{-1}$
(D) $1.28\times10^{-27}\text{kg}\cdot\text{m}\cdot\text{s}^{-1}$

Sol: $E=\dfrac{hC}{\lambda}$

$E = pC$

$$p=\frac{E}{C}=\frac{2.4\times1.6\times10^{-19}}{3\times10^{8}}=1.28\times10^{-27}\text{ kg ms}^{-1}$$

Ans: (D)

48. In the following equation representing β^{-} decay, the number of neutrons in the nucleus X is

$$^{210}_{83}\text{Bi}\rightarrow\text{X}+\text{e}^{-1}+\overline{\text{v}}$$

(A) 127
(B) 84
(C) 125
(D) 126

Sol: $^{210}Bi\rightarrow\ ^{210}_{84}X+e^{-1}+\vec{v}$

Protons = 84

Neutrons = 210 − 84 = 126

Ans: (D)

49. A body is moving along a straight line with initial velocity v_0, Its acceleration a is constant. Afler 1 seconds, its velocity becomes v. The average velocity of the body over the given time interval is

(A) $\bar{v} = \frac{v^2 + v_0^2}{2at}$ (B) $\bar{v} = \frac{v^2 - v_0^2}{2at}$ (C) $\bar{v} = \frac{v^2 + v_0^2}{at}$ (D) $\bar{v} = \frac{v^2 - v_0^2}{at}$

Sol: $u = v_0$, $a = a$, $v = v$, $t = 1\text{sec}$

$$\text{avg vel} = \frac{\text{T dist}}{\text{T time}} = \frac{\frac{v^2 - u^2}{2a}}{t}$$

$$\bar{v} = \frac{v^2 - v_0^2}{2at}$$

Ans: (B)

50. A particle is in uniform circular motion. Related to one complete revolution or of the particle, which among the statements is incorrect?

(A) Displacement of the particle is zero. (B) Average velocity of the particle is zero.
(C) Average speed of the particle is zero. (D) Average acceleration of the particle is zero.

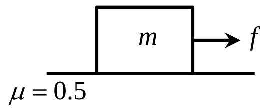
Sol: Average speed of the particle is zero and average speed is not because distance is not zero

Ans: (C)

51. A body of mass 10kg is kept on a horizontal surface. The coefficient of the kinetic friction between the body and the surface is 0.5. A horizontal force of 60N is applied on the body. The resulting acceleration of the body is about

(A) 5ms^{-2} (B) zero (C) 6ms^{-2} (D) 1ms^{-2}

Sol: $F - f = ma$



$60 - 0.5 \times 10 \times 10 = 10 \times a$

$10 = 10a$

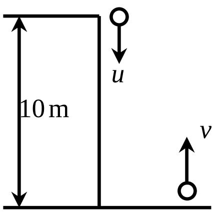
$a = 1\text{m s}^{-2}$

Ans: (D)

52. A ball of mass 0.2kg is thrown vertically down from a height of 10m. It collides with the floor and loses 50% of its energy and then rises back to the same height. The value of its initial velocity is

(A) 14ms^{-1} (B) 20ms^{-1} (C) 196ms^{-1} (D) zero

Sol: $mE_i = \frac{1}{2}mu^2 + mgh$



Before strike: $\frac{1}{2}mu^2 + mgh$

After strike, $\frac{1}{2}\left(\frac{1}{2}mu^2 + mgh\right)$

$\frac{1}{2}\left(\frac{1}{2}mu^2 + mgh\right) = mgh$

$\frac{u^2}{4} = gh - \frac{gh}{2} = \frac{gh}{2}$

$u = \sqrt{2gh}$

$u = \sqrt{2 \times 10 \times 10} = 1.41 \times 10 = 14\,\text{m s}^{-1}$

Ans: (A)

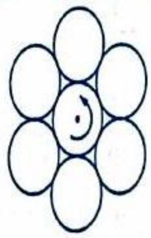
53. The moment of inertia of a rigid body about an axis

(A) does not depend on its shape.
(B) does not depend on its size.
(C) depends on the position of axis of rotation.
(D) does not depend on its mass.

Sol: Depends on the position of axis of rotation

Ans: (C)

54. Seven identical discs are arranged in a planar pattern, so as to touch each other as shown in the figure. Each disc has mass ' m ' radius R. What is the moment of inertia of system of six discs about an axis passing through the centre of central disc and normal to plane of all discs?



(A) 100mR^2
(B) $85\frac{\text{mR}^2}{2}$
(C) $55\frac{\text{mR}^2}{2}$
(D) 27mR^2

Sol: $I = \frac{mR^2}{2} + 6\left[\frac{mR^2}{2} + m(2R)^2\right] = \frac{mR^2}{2} + 3mR^2 + 24mR^2$

$I = \frac{55}{2}mR^2$

Ans: (C)

55. The true length of a wire is 3.678cm. When the length of this wire is measured using instrument A, the length of the wire is 3.5cm. When the length of the wire is measured using instrument B, it is found to have length 3.38cm. Then the

(A) measurement with A is more accurate while measurement with B is more precise.
(B) measurement with A is more precise while measurement with B is more accurate.
(C) measurement with B is more accurate and precise.
(D) measurement with A is more accurate and precise.

Sol: $x = 3.678\,\text{cm}$

$x_A = 3.5\,\text{cm}$ (more accurate)

$x_B = 3.38\,\text{cm}$ (more precise)

Ans: (A)

56. A stretched wire of a material whose Young's modulus $Y = 2\times10^{11}\,\text{Nm}^{-2}$ has Poisson's ratio 0.25. Its lateral strain $\varepsilon_l = 10^{-3}$. The elastic energy density of the wire is

(A) $1\times10^{5}\,\text{Jm}^{-3}$ (B) $8\times10^{5}\,\text{Jm}^{-3}$ (C) $4\times10^{5}\,\text{Jm}^{-3}$ (D) $16\times10^{5}\,\text{Jm}^{-3}$

Sol: $\sigma = \dfrac{\text{lateral strain}}{\text{longitudinal strain}}$

$u = \dfrac{1}{2}\times\text{stress x (strain)}$

$\text{Strain} = \dfrac{10^{-3}}{0.25}$

$\dfrac{\text{Stress}}{\text{Strain}} = y$

Stress = y strain

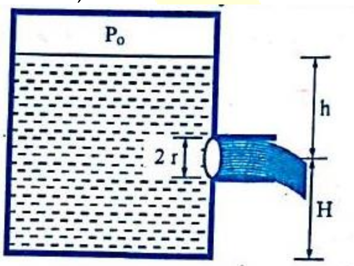
$u = \dfrac{1}{2}\times Y\times\left(\dfrac{10^{-3}}{0.25}\right)^2$

$= \dfrac{1}{2}\times2\times10^{11}\times10^{-6}\times16$

$= 16\times10^{5}\,\text{Jm}^{-3}$

Ans: (D)

57. A closed water tank has cross-sectional area A. It has a small hole at a depth of h from the free surface of water. The radius of the hole is r so that $r \ll \sqrt{\dfrac{A}{\pi}}$. If P_0 is the pressure inside the tank above water level, and P_a is the atmospheric pressure, the rate of flow of the water coming out of the hole is [ρ is the density of water]



(A) $\pi r^2\sqrt{2gh + \dfrac{2(P_o - P_a)}{\rho}}$ (B) $\pi r^2\sqrt{gh + \dfrac{2(P_o - P_a)}{\rho}}$

(C) $\pi r^2\sqrt{2gH}$ (D) $\pi r^2\sqrt{2gh}$

Sol: $P_0 + \dfrac{1}{2}\rho v_1^2 + \rho gh = P_0 + \dfrac{1}{2}\rho v_2^2.$

$Av_1 = \pi r^2 \times v_2$

$v_2 = \dfrac{Av_1}{\pi r^2}$

$P_0 + \dfrac{1}{2}\rho\left(v_2\dfrac{\pi r^2}{A}\right)^2 + \rho gh = P_a + \dfrac{1}{2}\rho v_2^2$

$P_0 - P_a + \rho gh = v_2^2\left[\dfrac{\rho}{2} - \dfrac{\rho}{2}\left(\dfrac{\pi r^2}{A}\right)^2\right]$

$$\sqrt{\frac{P_0 - P_a + \rho g h}{\frac{\rho}{2}\left[1-\left(\frac{\pi r^2}{A}\right)^2\right]}} = v_2^2 \qquad \left(\frac{\pi r^2}{A}\right)^2 \text{ - Neglect due to small value}$$

Volume flow rate $= \pi r^2 \times v_2$

Volume flow rate $= \pi r^2 \times \sqrt{2gh + \frac{2(P_0 - P_a)}{\rho}}$

Ans: (A)

58. 100g of ice at 0°C is mixed with 100g of water at 100°C. The final temperature of the mixture is

[Take $L_f = 3.36\times10^5 \text{Jkg}^{-1}$ and $S_w = 4.2\times10^3 \text{Jkg}^{-1}\text{K}^{-1}$]

(A) 10°C (B) 1°C (C) 50°C (D) 40°C

Sol: $\underset{0^\circ C}{100\,\text{g ice}} + \underset{100^\circ C}{100\,\text{g water}}$

$$0.1\times3.36\times10^5 + 0.1\times4.2\times10^3\times(T) = 0.1\times4.2\times10^3\text{C}\times(100-T)$$

$$336\times10^2 + 420T = 420\times100 - 420T$$

$$840T = 100(420-336)$$

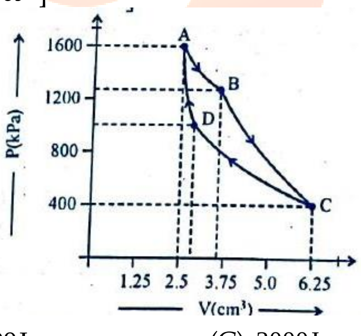
$$840T = 100\times84$$

$$T = 10^\circ\text{C}$$

Ans: (A)

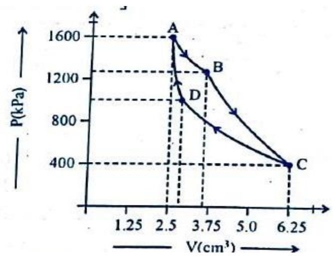
59. The P-V diagram of a Carnot's engine is shown in the graph below. The engine uses 1 mole of an ideal gas as working substance. From the graph, the area enclosed by the $P-V$ diagram is

[The heat supplied to the gas is 8000J]



(A) 2000J (B) 1000J (C) 3000J (D) 1200J

Sol: $\eta = 1 - \frac{T_2}{T_1} = \frac{W}{Q_1}$



$$\frac{10^3\times1600\times2.5}{400\times10^3\times6.25\times\text{cm}^3} = \frac{1\times R\times T_1}{1\times R\times T_2}$$

$$\frac{4}{2.5} = \frac{T_1}{T_2}$$

$P_A V_A = nRT_A$

$P_c V_c = nRT_c$

$\frac{1600 \times 10^3 \times 2.50 \times cm^3}{400 \times 10^3 \times 6.25 \times cm^3} = \frac{T_1}{T_2}$

$\frac{4}{2.5} = \frac{T_1}{T_2}$

$1 - \frac{2.5}{4} = \frac{w}{Q_1}$

$W = 8000\left(\frac{1.5}{4}\right)$

$W = 3000\,J$

Ans: (C)

60. When a planet revolves around the Sun, in general, for the planet

(A) linear momentum and aerial velocity are constant.

(B) angular momentum about the Sun and aerial velocity of the planet are constant.

(C) kinetic and potential energy of the planet are constant.

(D) linear momentum and linear velocity are constant.

Sol: Angular momentum about the Sun and aerial velocity of the planet are constant.

Ans: (B)

Key Answers:

1. D	2. A	3. A	4. D	5. B	6. C	7. A	8. A	9. B	10. B
11. C	12. B	13. D	14. C	15. A	16. D	17. A	18. D	19.	20. A
21. D	22. B	23. B	24. D	25. B	26. D	27. C	28. A	29. B	30. C
31. A	32. C	33. C	34. B	35. A	36. D	37. A	38. D	39. C	40. B
41. D	42. A	43. A	44. D	45. A	46. C	47. D	48. D	49. B	50. C
51. D	52. A	53. C	54. C	55. A	56. D	57. A	58. A	59. C	60. B