

**Section A: Q.1 – Q.10 Carry ONE mark each.**

Q.1 The total number of Na and Cl ions per unit cell of the NaCl crystal is:

- (A) 2
- (B) 4
- (C) 8
- (D) 16

Q.2 The sum of three binary numbers, 10110.10, 11010.01, and 10101.11, in decimal system is:

- (A) 70.75
- (B) 70.25
- (C) 70.50
- (D) 69.50

Q.3 Which of the following matrices is Hermitian as well as unitary?

(A)  $\begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}$

(B)  $\begin{pmatrix} 0 & i \\ i & 0 \end{pmatrix}$

(C)  $\begin{pmatrix} 1 & -i \\ i & 1 \end{pmatrix}$

(D)  $\begin{pmatrix} 0 & 1+i \\ 1-i & 0 \end{pmatrix}$

Q.4 The divergence of a 3-dimensional vector  $\frac{\hat{r}}{r^3}$  ( $\hat{r}$  is the unit radial vector) is:

(A)  $-\frac{1}{r^4}$

(B) Zero

(C)  $\frac{1}{r^3}$

(D)  $-\frac{3}{r^4}$

Q.5 The magnitudes of spin magnetic moments of electron, proton and neutron are  $\mu_e$ ,  $\mu_p$  and  $\mu_n$ , respectively. Then,

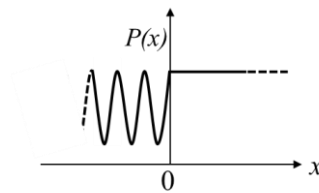
(A)  $\mu_e > \mu_p > \mu_n$

(B)  $\mu_e = \mu_p > \mu_n$

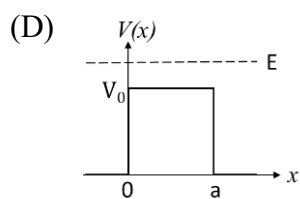
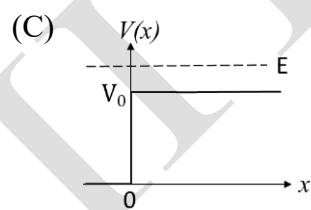
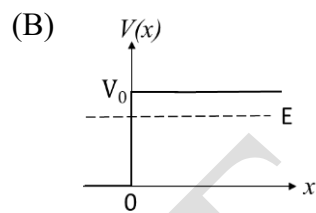
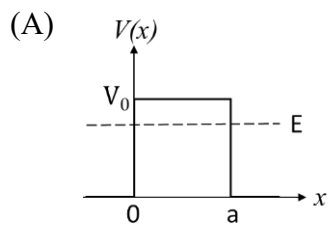
(C)  $\mu_e < \mu_p < \mu_n$

(D)  $\mu_e < \mu_p = \mu_n$

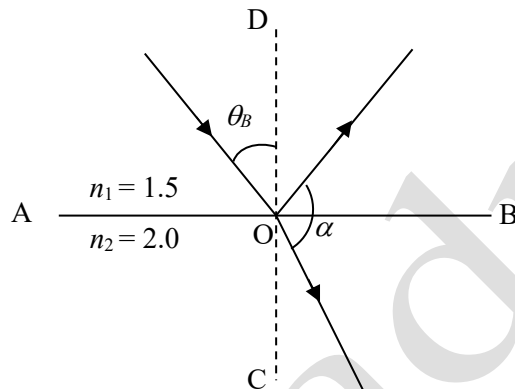
- Q.6 A particle moving along the  $x$ -axis approaches  $x = 0$  from  $x = -\infty$  with a total energy  $E$ . It is subjected to a potential  $V(x)$ . For time  $t \rightarrow \infty$ , the probability density  $P(x)$  of the particle is schematically shown in the figure.



The correct option for the potential  $V(x)$  is:



- Q.7 A plane electromagnetic wave is incident on an interface AB separating two media (refractive indices  $n_1 = 1.5$  and  $n_2 = 2.0$ ) at Brewster angle  $\theta_B$ , as schematically shown in the figure. The angle  $\alpha$  (in degrees) between the reflected wave and the refracted wave is:



- (A) 120  
(B) 116  
(C) 90  
(D) 74

Q.8 If the electric field of an electromagnetic wave is given by,

$$\vec{E} = (4\hat{x} + 3\hat{y})e^{i(\omega t + ax - 600y)},$$

then the value of  $a$  is:

(all values are in the SI units)

- (A) 450
- (B) -450
- (C) 800
- (D) -800

Q.9 A vector field is expressed in the cylindrical coordinate system  $(s, \phi, z)$  as,

$$\vec{F} = \frac{A}{s} \hat{s} + \frac{B}{s} \hat{z}.$$

If this field represents an electrostatic field, then the possible values of  $A$  and  $B$ , respectively, are:

- (A) 1 and 0
- (B) 0 and 1
- (C) -1 and 1
- (D) 1 and -1

Q.10 Which of the following types of motion may be represented by the trajectory,  $y(x) = ax^2 + bx + c$  ?

(Here  $a$ ,  $b$ , and  $c$  are constants;  $x$ ,  $y$  are the position coordinates)

- (A) Projectile motion in a uniform gravitational field
- (B) Simple harmonic motion
- (C) Uniform circular motion
- (D) Motion on an inclined plane in a uniform gravitational field

**Section A: Q.11 – Q.30 Carry TWO marks each.**

Q.11 A crystal plane of a lattice intercepts the principal axes  $\vec{a}_1$ ,  $\vec{a}_2$ , and  $\vec{a}_3$  at  $3a_1$ ,  $4a_2$ , and  $2a_3$ , respectively. The Miller indices of the plane are:

(A) (436)

(B) (342)

(C) (634)

(D) (243)

Q.12 The number of atoms in the *basis* of a primitive cell of hexagonal closed packed structure is:

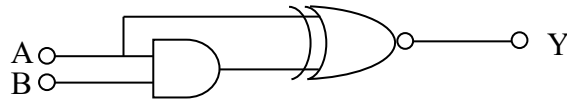
(A) 1

(B) 2

(C) 3

(D) 4

Q.13 Consider the following logic circuit.



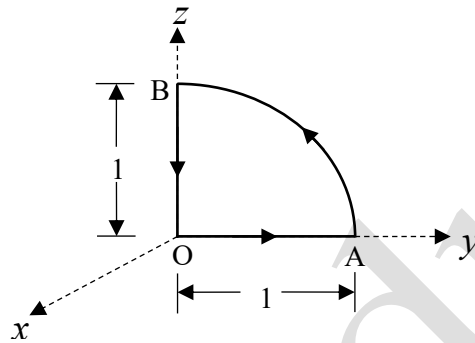
The output Y is LOW when:

- (A)  $A$  is HIGH and  $B$  is LOW
- (B)  $A$  is LOW and  $B$  is HIGH
- (C) Both  $A$  and  $B$  are LOW
- (D) Both  $A$  and  $B$  are HIGH

Q.14 The value of the line integral for the vector,

$$\vec{v} = 2\hat{x} + yz^2\hat{y} + (3y + z^2)\hat{z}$$

along the closed path OABO (as shown in the figure) is:



(Path AB is the arc of a circle of unit radius)

(A)  $\frac{1}{4}(3\pi - 1)$

(B)  $3\pi - \frac{1}{4}$

(C)  $\frac{3\pi}{4} - 1$

(D)  $3\pi - 1$

Q.15 In the  $x$ - $y$  plane, a vector is given by

$$\vec{F}(x, y) = \frac{-y\hat{x} + x\hat{y}}{x^2 + y^2}.$$

The magnitude of the flux of  $\vec{\nabla} \times \vec{F}$ , through a circular loop of radius 2, centered at the origin, is:

- (A)  $\pi$
- (B)  $2\pi$
- (C)  $4\pi$
- (D) 0

Q.16 The roots of the polynomial,  $f(z) = z^4 - 8z^3 + 27z^2 - 38z + 26$ , are  $z_1, z_2, z_3$ , &  $z_4$ , where  $z$  is a complex variable. Which of the following statements is correct?

(A)  $\frac{z_1 + z_2 + z_3 + z_4}{z_1 z_2 z_3 z_4} = -\frac{4}{19}$

(B)  $\frac{z_1 + z_2 + z_3 + z_4}{z_1 z_2 z_3 z_4} = \frac{4}{13}$

(C)  $\frac{z_1 z_2 z_3 z_4}{z_1 + z_2 + z_3 + z_4} = -\frac{26}{27}$

(D)  $\frac{z_1 z_2 z_3 z_4}{z_1 + z_2 + z_3 + z_4} = \frac{13}{19}$

Q.17 The ultraviolet catastrophe in the classical (Rayleigh-Jeans) theory of cavity radiation is attributed to the assumption that

- (A) the standing waves of all allowed frequencies in the cavity have the same average energy
- (B) the density of the standing waves in the cavity is independent of the shape and size of the cavity
- (C) the allowed frequencies of the standing waves inside the cavity have no upper limit
- (D) the number of allowed frequencies for the standing waves in a frequency range  $\nu$  to  $(\nu + d\nu)$  is proportional to  $\nu^2$

Q.18 Given that the rest mass of electron is  $0.511\text{MeV}/c^2$ , the speed (in units of  $c$ ) of an electron with kinetic energy  $5.11\text{MeV}$  is closest to:

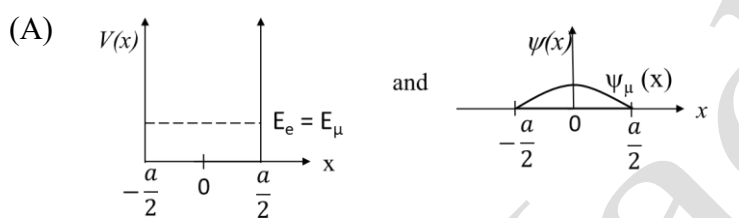
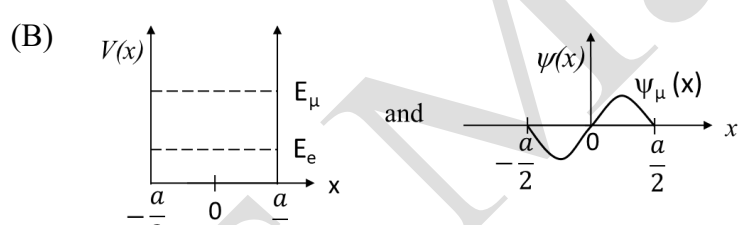
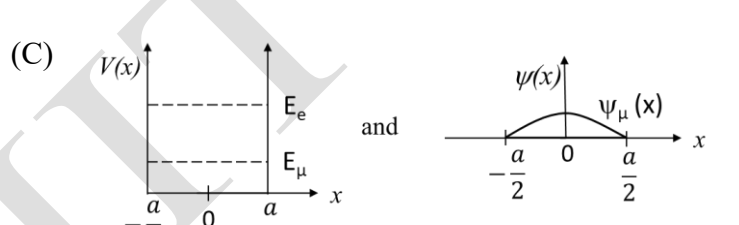
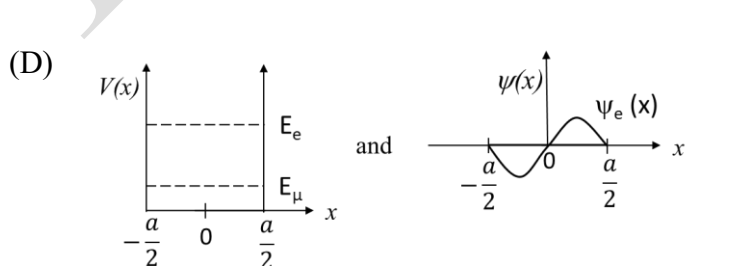
- (A) 0.996
- (B) 0.993
- (C) 0.990
- (D) 0.998

Q.19 A one-dimensional infinite square-well potential is given by:

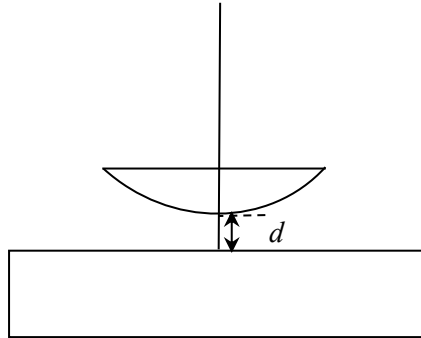
$$V(x) = 0 \quad \text{for } -\frac{a}{2} < x < +\frac{a}{2}$$

$$= \infty \quad \text{elsewhere}$$

Let  $E_e(x)$  and  $\psi_e(x)$  be the ground state energy and the corresponding wave function, respectively, if an electron (e) is trapped in that well. Similarly, let  $E_\mu(x)$  and  $\psi_\mu(x)$  be the corresponding quantities, if a muon ( $\mu$ ) is trapped in the well. Choose the correct option:

- (A) 
- (B) 
- (C) 
- (D) 

- Q.20 In a Newton's rings experiment (using light of free space wavelength  $580\text{nm}$ ), there is an air gap of height  $d$  between the glass plate and a plano-convex lens (see figure). The central fringe is observed to be bright.



The least possible value of  $d$  (in nm) is:

- (A) 145
- (B) 290
- (C) 580
- (D) 72.5

Q.21 Linearly polarized light (free space wavelength  $\lambda_0 = 600\text{nm}$ ) is incident normally on a retarding plate ( $n_e - n_o = 0.05$  at  $\lambda_0 = 600\text{nm}$ ). The emergent light is observed to be linearly polarized, irrespective of the angle between the direction of polarization and the optic axis of the plate. The minimum thickness (in  $\mu\text{m}$ ) of the plate is:

- (A) 6
- (B) 3
- (C) 2
- (D) 1

Q.22 A 15.7mW laser beam has a diameter of 4mm. If the amplitude of the associated magnetic field is expressed as  $\frac{A}{\sqrt{\epsilon_0 c^3}}$ , the value of  $A$  is:

( $\epsilon_0$  is the free space permittivity and  $c$  is the speed of light)

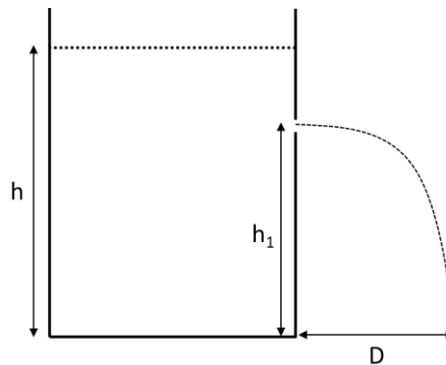
- (A) 50
- (B) 35.4
- (C) 100
- (D) 70.8

- Q.23 The plane  $z = 0$  separates two linear dielectric media with relative permittivities  $\epsilon_{r1} = 4$  and  $\epsilon_{r2} = 3$ , respectively. There is no free charge at the interface. If the electric field in the medium 1 is  $\vec{E}_1 = 3\hat{x} + 2\hat{y} + 4\hat{z}$ , then the displacement vector  $\vec{D}_2$  in medium 2 is:

( $\epsilon_0$  is the permittivity of free space)

- (A)  $(3\hat{x} + 4\hat{y} + 6\hat{z})\epsilon_0$
- (B)  $(3\hat{x} + 6\hat{y} + 8\hat{z})\epsilon_0$
- (C)  $(9\hat{x} + 6\hat{y} + 16\hat{z})\epsilon_0$
- (D)  $(4\hat{x} + 2\hat{y} + 3\hat{z})\epsilon_0$

- Q.24 A tank, placed on the ground, is filled with water up to a height  $h$ . A small hole is made at a height  $h_1$  such that  $h_1 < h$ . The water jet emerging from the hole strikes



the ground at a horizontal distance  $D$ , as shown schematically in the figure. Which of the following statements is correct?

( $g$  is the acceleration due to gravity)

- (A) Velocity at  $h_1$  is  $\sqrt{2gh_1}$
- (B)  $D = 2(h - h_1)$
- (C)  $D$  will be maximum when  $h_1 = \frac{2}{3}h$
- (D) The maximum value of  $D$  is  $h$

- Q.25 An incompressible fluid is flowing through a vertical pipe (height  $h$  and cross-sectional area  $A_o$ ). A thin mesh, having  $n$  circular holes of area  $A_h$ , is fixed at the bottom end of the pipe. The speed of the fluid entering the top-end of the pipe is  $v_o$ . The volume flow rate from an individual hole of the mesh is given by:

( $g$  is the acceleration due to gravity)

(A)  $\frac{A_o}{n} \sqrt{v_o^2 + 2gh}$

(B)  $\frac{A_o}{n} \sqrt{v_o^2 + gh}$

(C)  $n(A_o - A_h) \sqrt{v_o^2 + 2gh}$

(D)  $n(A_o - A_h) \sqrt{v_o^2 + gh_o}$

Q.26 A ball is dropped from a height  $h$  to the ground. If the coefficient of restitution is  $e$ , the time required for the ball to stop bouncing is proportional to:

(A)  $\frac{2+e}{1-e}$

(B)  $\frac{1+e}{1-e}$

(C)  $\frac{1-e}{1+e}$

(D)  $\frac{2-e}{1+e}$

Q.27 A cylinder-piston system contains  $N$  atoms of an ideal gas. If  $t_{avg}$  is the average time between successive collisions of a given atom with other atoms. If the temperature  $T$  of the gas is increased isobarically, then  $t_{avg}$  is proportional to :

(A)  $\sqrt{T}$

(B)  $\frac{1}{\sqrt{T}}$

(C)  $T$

(D)  $\frac{1}{T}$

Q.28 A gas consists of particles, each having three translational and three rotational degrees of freedom. The ratio of specific heats,  $C_p/C_v$ , is:

( $C_p$  and  $C_v$  are the specific heats at constant pressure and constant volume, respectively)

(A)  $5/3$

(B)  $7/5$

(C)  $4/3$

(D)  $3/2$

Q.29 If two traveling waves, given by

$$y_1 = A_0 \sin(kx - \omega t) \text{ and } y_2 = A_0 \sin(\alpha kx - \beta \omega t)$$

are superposed, which of the following statements is correct?

(A) For  $\alpha = \beta = 1$ , the resultant wave is a standing wave

(B) For  $\alpha = \beta = -1$ , the resultant wave is a standing wave

(C) For  $\alpha = \beta = 2$ , the carrier frequency of the resultant wave is  $\frac{3}{2}\omega$

(D) For  $\alpha = \beta = 2$ , the carrier frequency of the resultant wave is  $3\omega$

- Q.30 Suppose that there is a dispersive medium whose refractive index depends on the wavelength as given by  $n(\lambda) = n_0 + \frac{a}{\lambda^2} - \frac{b}{\lambda^4}$ . The value of  $\lambda$  at which the group and phase velocities would be the same, is:

(A)  $\sqrt{\frac{2b}{a}}$

(B)  $\sqrt{\frac{b}{2a}}$

(C)  $\sqrt{\frac{3b}{a}}$

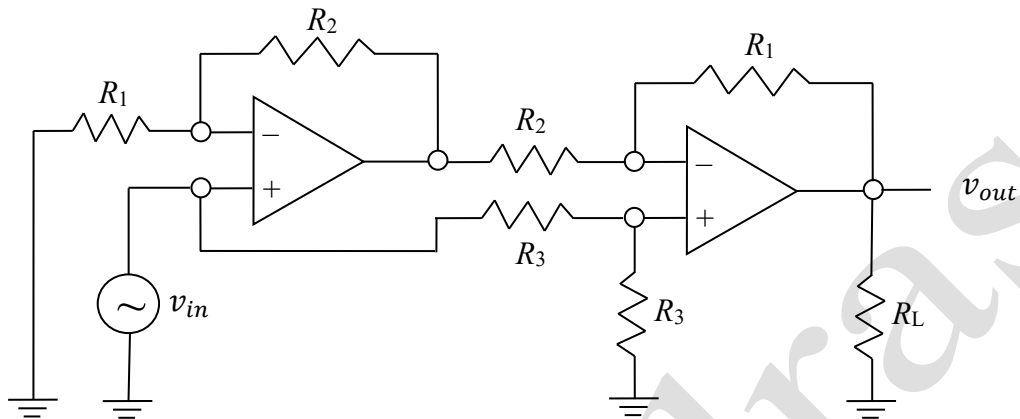
(D)  $\sqrt{\frac{b}{3a}}$

**Section B: Q.31 – Q.40 Carry TWO marks each.**

Q.31 A pure Si crystal can be converted to an  $n$ -type crystal by doping with

- (A) P
- (B) As
- (C) Sb
- (D) In

- Q.32 In the following OP-AMP circuit,  $v_{in}$  and  $v_{out}$  represent the input and output signals, respectively.



Choose the correct statement(s):

- (A)  $v_{out}$  is out-of-phase with  $v_{in}$
- (B) Gain is unity when  $R_1 = R_2$
- (C)  $v_{out}$  is in-phase with  $v_{in}$
- (D)  $v_{out}$  is zero

- Q.33 A spring-mass system (spring constant 80N/m and damping coefficient 40N-s/m), initially at rest, is lying along the y-axis in the horizontal plane. One end of the spring is fixed and the mass (5kg) is attached at its other end. The mass is pulled along the y-axis by 0.5m from its equilibrium position and then released. Choose the correct statement(s).

(Ignore mass of the spring)

- (A) Motion will be under damped
- (B) Trajectory of the mass will be  $y(t) = \frac{1}{2}(1 + t)e^{-4t}$
- (C) Motion will be critically damped
- (D) Trajectory of the mass will be  $y(t) = \frac{1}{2}(1 + 4t)e^{-4t}$

- Q.34 Consider two different Compton scattering experiments, in which X-rays and  $\gamma$ -rays of wavelength ( $\lambda$ )  $1.024\text{\AA}$  and  $0.049\text{\AA}$ , respectively, are scattered from stationary free electrons. The scattered wavelength ( $\lambda'$ ) is measured as a function of the scattering angle ( $\theta$ ). If Compton shift is  $\Delta\lambda = \lambda' - \lambda$ , then which of the following statement(s) is/are true:

$$(h = 6.63 \times 10^{-34} \text{J.s}, m_e = 9.11 \times 10^{-31} \text{kg}, c = 3 \times 10^8 \text{m/s})$$

- (A) For  $\gamma$ -rays,  $\lambda'_{\text{max}} \approx 0.098\text{\AA}$
- (B) For X-rays,  $(\Delta\lambda)_{\text{max}}$  is observed at  $\theta = 180^\circ$
- (C) For X-rays,  $(\Delta\lambda)_{\text{max}} \approx 1.049\text{\AA}$
- (D) For  $\gamma$ -rays, at  $\theta = 90^\circ$ ,  $\lambda' \approx 0.049\text{\AA}$

- Q.35 A particle of mass  $m$ , having an energy  $E$  and angular momentum  $L$ , is in a parabolic trajectory around a planet of mass  $M$ . If the distance of the closest approach to the planet is  $r_m$ , which of the following statement(s) is(are) true?

( $G$  is the Gravitational constant)

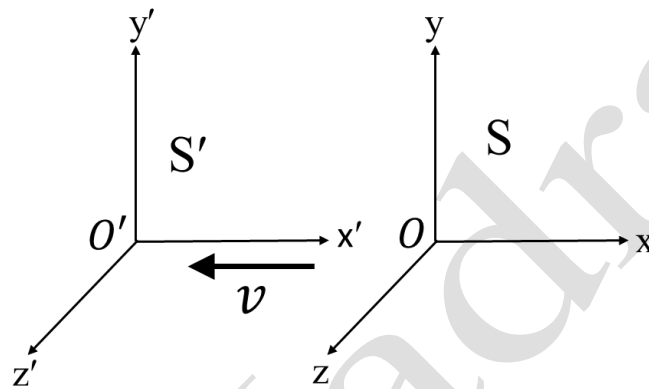
(A)  $E > 0$

(B)  $E = 0$

(C)  $L = \sqrt{2GMm^2r_m}$

(D)  $L = \sqrt{2GM^2mr_m}$

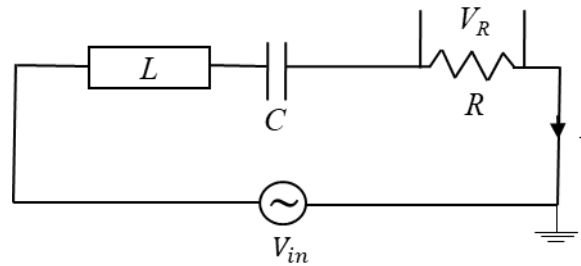
- Q.36 The inertial frame  $S'$  is moving away from the inertial frame  $S$  with a speed  $v = 0.6c$  along the negative  $x$ -direction (see figure). The origins  $O'$  and  $O$  of the frames coincide at  $t = t' = 0$ . As observed in the frame  $S'$ , two events occur simultaneously at two points on the  $x'$ -axis with a separation of  $\Delta x' = 5\text{m}$ . If,  $\Delta t$  and  $\Delta x$  are the magnitudes of the time interval and the space interval, respectively, between the events in  $S$ , then which of the following statements is(are) correct?



$$(c = 3 \times 10^8 \text{ m/s})$$

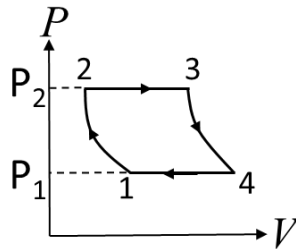
- (A)  $\Delta t = 12.5\text{ns}$
- (B)  $\Delta t = 4.2\text{ns}$
- (C)  $\Delta x = 10.6\text{m}$
- (D)  $\Delta x = 6.25\text{m}$

- Q.37 For the LCR AC-circuit (resonance frequency  $\omega_0$ ) shown in the figure below, choose the correct statement(s).



- (A)  $\omega_0$  depends on the values of  $L$ ,  $C$ , and  $R$
- (B) At  $\omega = \omega_0$ , voltage  $V_R$  and current  $I$  are in-phase
- (C) The amplitude of  $V_R$  at  $\omega = \omega_0/2$  is independent of  $R$
- (D) The amplitude of  $V_R$  at  $\omega = \omega_0$  is independent of  $L$  and  $C$

- Q.38 The  $P$ - $V$  diagram of an engine is shown in the figure below. The temperatures at points 1, 2, 3 and 4 are  $T_1$ ,  $T_2$ ,  $T_3$  and  $T_4$ , respectively.  $1 \rightarrow 2$  and  $3 \rightarrow 4$  are adiabatic processes, and  $2 \rightarrow 3$  and  $4 \rightarrow 1$  are isochoric processes.



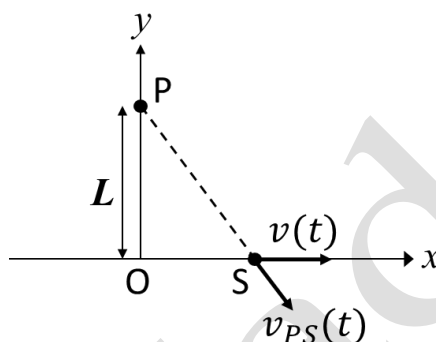
Identify the correct statement(s).

[ $\gamma$  is the ratio of specific heats  $C_p$  (at constant  $P$ ) and  $C_v$  (at constant  $V$ )]

- (A)  $T_1 T_3 = T_2 T_4$
- (B) The efficiency of the engine is  $1 - \left(\frac{P_1}{P_2}\right)^{\frac{\gamma-1}{\gamma}}$
- (C) The change in entropy for the entire cycle is zero
- (D)  $T_1 T_2 = T_3 T_4$

- Q.39 A whistle S of sound frequency  $f$  is oscillating with angular frequency  $\omega$  along the  $x$ -axis. Its instantaneous position and the velocity are given by  $x(t) = a \sin(\omega t)$  and  $v(t) = v_0 \cos(\omega t)$ , respectively. An observer P is located on the  $y$ -axis at a distance  $L$  from the origin (see figure). Let  $v_{PS}(t)$  be the component of  $v(t)$  along the line joining the source and the observer. Choose the correct option(s):

(Here  $a$  and  $v_0$  are constants)



- (A)  $v_{PS}(t) = \frac{1}{2} \frac{av_0}{\sqrt{a^2 \sin^2 \omega t + L^2}} \sin(2\omega t)$
- (B) The observed frequency will be  $f$  when the source is at  $x = 0$  and  $x = \pm a$
- (C) The observed frequency will be  $f$  when the source is at position  $x = \pm \frac{a}{2}$
- (D)  $v_{PS}(t) = \frac{1}{2} \frac{av_0}{\sqrt{a^2 + L^2}} \sin(2\omega t)$

Q.40 One mole of an ideal monoatomic gas, initially at temperature  $T_0$  is expanded from an initial volume  $V_0$  to  $2.5V_0$ . Which of the following statements is(are) correct?

( $R$  is the ideal gas constant)

- (A) When the process is isothermal, the work done is  $RT_0 \ln 2$
- (B) When the process is isothermal, the change in internal energy is zero
- (C) When the process is isobaric, the work done is  $\frac{3}{2}RT_0$
- (D) When the process is isobaric, the change in internal energy is  $\frac{9}{2}RT_0$

**Section C: Q.41 – Q.50 Carry ONE mark each.**

Q.41 Consider a  $p$ - $n$  junction diode which has  $10^{23}$  acceptor-atoms/ $\text{m}^3$  in the  $p$ -side and  $10^{22}$  donor-atoms/ $\text{m}^3$  in the  $n$ -side. If the depletion width in the  $p$ -side is  $0.16\mu\text{m}$ , then the value of depletion width in the  $n$ -side will be \_\_\_\_\_ $\mu\text{m}$ . (Rounded off to one decimal place)

Q.42 The co-ordinate system  $(x,y,z)$  is transformed to the system  $(u,v,w)$ , as given by:

$$u = 2x + 3y - z$$

$$v = x - 4y + z$$

$$w = x + y$$

The Jacobian of the above transformation is \_\_\_\_\_.

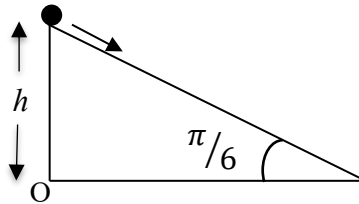
Q.43 Two sides of a triangle OAB are given by:

$$\overrightarrow{OA} = \hat{x} + 2\hat{y} + \hat{z}$$

$$\overrightarrow{OB} = 2\hat{x} - \hat{y} + 3\hat{z}$$

The area of the triangle is \_\_\_\_\_. (Rounded off to one decimal place)

- Q.44 A particle of mass 1kg, initially at rest, starts sliding down from the top of a frictionless inclined plane of angle  $\pi/6$  (as schematically shown in the figure). The magnitude of the torque on the particle about the point O after a time 2seconds is \_\_\_\_\_ N-m. (Rounded off to nearest integer)



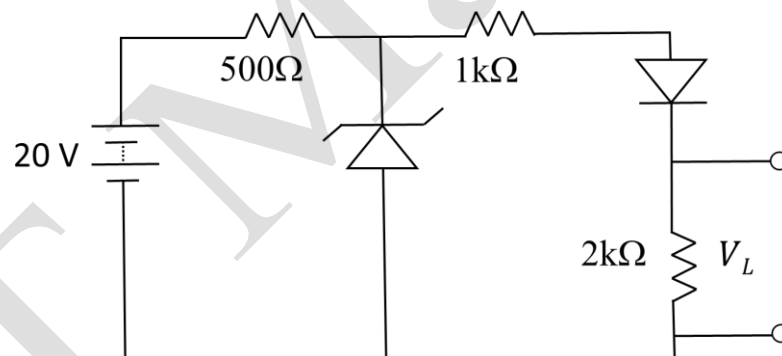
(Take  $g = 10\text{m/s}^2$ )

- Q.45 The moment of inertia of a solid hemisphere (mass  $M$  and radius  $R$ ) about the axis passing through the hemisphere and parallel to its flat surface is  $\frac{2}{5}MR^2$ . The distance of the axis from the center of mass of the hemisphere (in units of  $R$ ) is \_\_\_\_\_. (Rounded off to two decimal places)

- Q.46 A collimated light beam of intensity  $I_0$  is incident normally on an air-dielectric (refractive index 2.0) interface. The intensity of the reflected light is \_\_\_\_\_  $I_0$ . (Rounded off to two decimal places)

- Q.47 A charge of  $-9\text{C}$  is placed at the center of a concentric spherical shell made of a linear dielectric material (relative permittivity 9) and having inner and outer radii of  $0.1\text{m}$  and  $0.2\text{m}$ , respectively. The total charge induced on its inner surface is \_\_\_\_\_ C. (Rounded off to two decimal place)

- Q.48 A Zener diode (rating  $10\text{V}$ ,  $2\text{W}$ ) and a normal diode (turn-on voltage  $0.7\text{V}$ ) are connected in a circuit as shown in the figure. The voltage drop  $V_L$  across the  $2\text{k}\Omega$  resistance is \_\_\_\_\_ V. (Rounded off to one decimal place)



- Q.49 The Fermi energy of a system is  $5.5\text{eV}$ . At  $500\text{K}$ , the energy of a level for which the probability of occupancy is  $0.2$ , is \_\_\_\_\_ eV. (Rounded off to two decimal places)

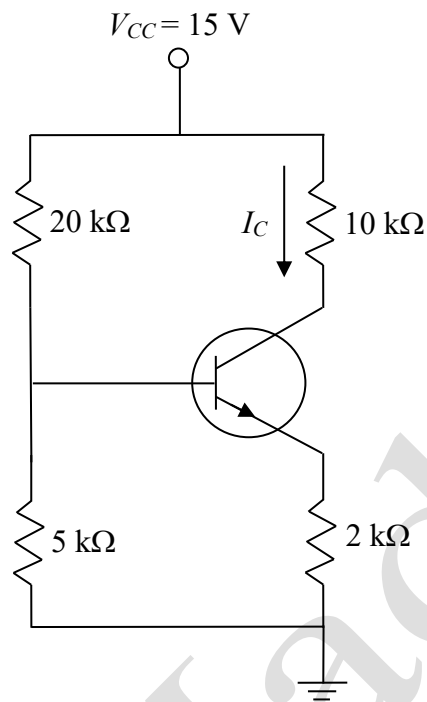
(Boltzmann constant  $k_B = 8.62 \times 10^{-5} \text{ eV/K}$ )

- Q.50 One mole of an ideal monoatomic gas is heated in a closed container, first from 273K to 303K, and then from 303K to 373K. The net change in the entropy is \_\_\_\_\_  $R$ . (Rounded off to two decimal places)
- ( $R$  is the ideal gas constant)

**Section C: Q.51 – Q.60 Carry TWO marks each.**

- Q.51 For a simple cubic crystal, the smallest inter-planar spacing  $d$  that can be determined from its second order of diffraction using monochromatic X-rays of wavelength  $1.32\text{\AA}$  is \_\_\_\_\_  $\text{\AA}$ . (Round off to two decimal places)

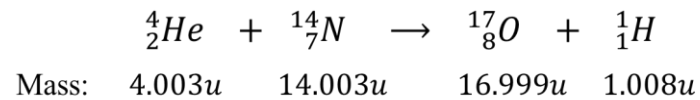
- Q.52 A transistor ( $\beta=100$ ,  $V_{BE} = 0.7V$ ) is connected as shown in the circuit below.



The current  $I_C$  will be \_\_\_\_\_ mA. (Rounded off to two decimal places)

- Q.53 In the Taylor expansion of function,  $F(x) = e^x \sin x$ , around  $x = 0$ , the coefficient of  $x^5$  is \_\_\_\_\_. (Rounded off to three decimal places)

- Q.54 A stationary nitrogen ( $^{14}_7N$ ) nucleus is bombarded with  $\alpha$  - particle ( $^4_2He$ ) and the following nuclear reaction takes place:



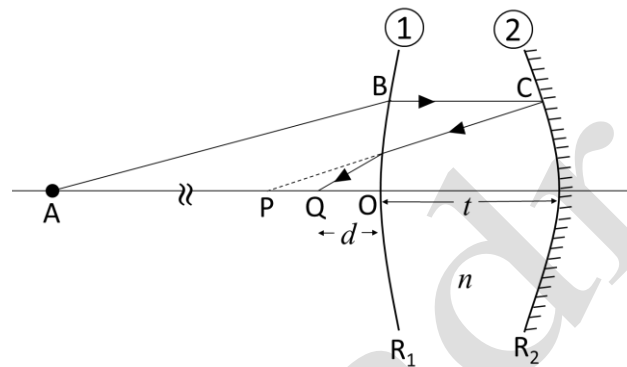
If the kinetic energies of  $^4_2He$  and  $^1_1H$  are 5.314MeV and 4.012MeV, respectively, then the kinetic energy of  $^{17}_8O$  is \_\_\_\_\_ MeV. (Rounded off to one decimal place)

(Masses are given in units of  $u = 931.5\text{MeV}/c^2$ )

- Q.55 A satellite of mass 10kg, in a circular orbit around a planet, is having a speed  $v=200\text{m/s}$ . The total energy of the satellite is \_\_\_\_\_ kJ. (Rounded off to nearest integer)

- Q.56 When a system of multiple long narrow slits (width  $2\mu\text{m}$  and period  $4\mu\text{m}$ ) is illuminated with a laser of wavelength  $600\text{nm}$ . There are 40 minima between the two consecutive principal maxima observed in its diffraction pattern. Then maximum resolving power of the system is \_\_\_\_\_.

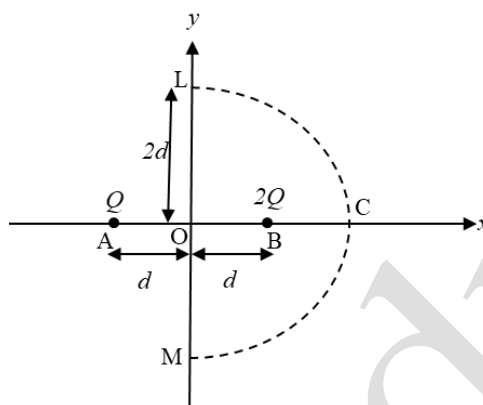
- Q.57 Consider a thick biconvex lens (thickness  $t = 4\text{cm}$  and refractive index  $n = 1.5$ ) whose magnitudes of the radii of curvature  $R_1$  and  $R_2$ , of the first and second surfaces are  $30\text{cm}$  and  $20\text{cm}$ , respectively. Surface 2 is silvered to act as a mirror. A point object is placed at point A on the axis ( $OA = 60\text{cm}$ ) as shown in the figure. If its image is formed at point Q, the distance  $d$  between O and Q is \_\_\_\_\_ cm. (Rounded off to two decimal places)



- Q.58 An unstable particle created at a point P moves with a constant speed of  $0.998c$  until it decays at a point Q. If the lifetime of the particle in its rest frame is  $632\text{ns}$ , the distance between points P and Q is \_\_\_\_\_ m. (Rounded off to the nearest integer)

$$(c = 3 \times 10^8 \text{ m/s})$$

- Q.59 Two positive charges  $Q$  and  $2Q$  are kept at points A and B, separated by a distance  $2d$ , as shown in the figure. MCL is a semicircle of radius  $2d$  centered at the origin O. If  $Q = 2C$  and  $d = 10\text{cm}$ , the value of the line integral  $\int_M^L \vec{E} \cdot d\vec{l}$  (where  $\vec{E}$  represents electric field) along the path MCL will be \_\_\_\_\_ V.



- Q.60 A time dependent magnetic field inside a long solenoid of radius  $0.05\text{m}$  is given by  $\vec{B}(t) = B_0 \sin \omega t \hat{z}$ . If  $\omega = 100\text{rad/s}$  and  $B_0 = 0.98\text{Weber/m}^2$ , then the amplitude of the induced electric field at a distance of  $0.07\text{m}$  from the axis of the solenoid is \_\_\_\_\_ V/m. (Rounded off to two decimal places)