(01) Physics

Structure of the Question Paper

Paper I - **Time : 02 hours**
50 multiple choice questions with **5** options. **All** questions should be answered. Each question carries **02** marks. Total **100** marks.

Paper II - **Time : 03 hours.** (In addition, 10 minutes for reading.)
This paper consists of **two** parts as **Structured Essay** and **Essay**.

Part A - **Four** structured essay type questions. **All** questions should be answered. 10 marks for each question - altogether 40 marks.

Part B - **Six** essay type questions. **Four** questions should be answered. Each question carries 15 marks - altogether 60 marks.

Total marks for Paper II = 100

Calculation of the final mark : Paper I = 100
Paper II = 100
Final mark = 200 ÷ 2 = $\underline{\underline{100}}$

Paper I

Important :

* Answer **all** the questions.
* Select the **correct or the most appropriate** answer.
(A separate multiple choice paper will be provided to mark the answers)

(g = 10 N kg^{-1})

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1. The ways that three students have written the units for linear momentum are given below.
(A) kgm/s (B) kg m s^{-1} (C) kg m/s
The correct form/s of the unit according to SI system is/are,
(1) (A) only. (2) (B) only. (3) (A) and (B) only.
(4) (A) and (C) only (5) (B) and (C) only.

2. Quark content of a proton is,
(1) uud (2) udd (3) uuu (4) uu (5) ud

3. If E is the electric field intensity and B is the magnetic flux density, the ratio E/B has the dimensions equal to the dimensions of,
(1) force (2) mass (3) momentum (4) speed (5) impulse

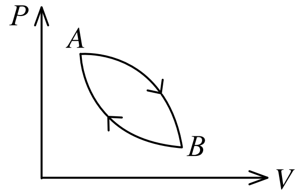
4. Specifications given for a filament bulb are 24 W and 12 V direct current (d.c.). If the bulb is lit for a period of 1 minute, the amount of charge passes through the filament is,
(1) 2 C (2) 20 C (3) 120 C (4) 2400 C (5) 3600 C

5. The amount of heat required to raise the temperature from 20 °C to 50 °C of a metal of mass 2 kg is 7.2×10^4 J. The specific heat capacity of the metal is,
(1) 100 J kg^{-1} K^{-1} (2) 120 J kg^{-1} K^{-1} (3) 600 J kg^{-1} K^{-1}
(4) 1200 J kg^{-1} K^{-1} (5) 6000 J kg^{-1} K^{-1}

6. The work function for gold is 4.1 eV. The minimum frequency of a photon required to remove an electron from a gold surface is (Planck constant = 4.1×10^{-15} eV s)

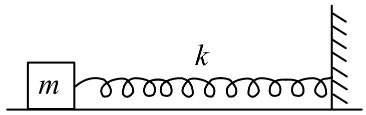
(1) 7.2×10^{13} Hz (2) 1.1×10^{14} Hz (3) 3.8×10^{14} Hz
(4) 0.8×10^{15} Hz (5) 1.0×10^{15} Hz

7. Figure shows a cyclic process of an ideal gas. When the gas expands from A to B it absorbs 50 J of heat. The path B to A is adiabatic and the work done on the gas is 60 J. The change in the internal energy of the gas in the path A to B is



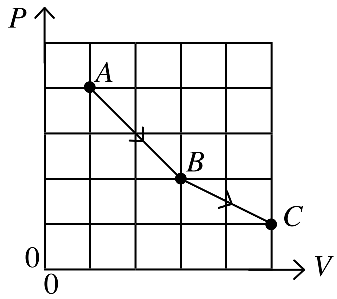
(1) −60 J (2) −30 J (3) −10 J
(4) 60 J (5) 110 J

8. The frequency of oscillation of a spring - mass system kept on a smooth surface is f. If the spring constant is increased by 4 times and the mass m is increased by 2 times, the new frequency of oscillation is



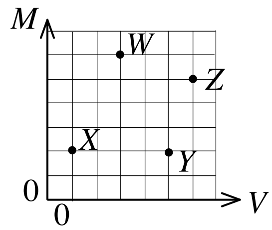
(1) $\frac{1}{\sqrt{2}}f$ (2) $\sqrt{2}\,f$ (3) $2f$ (4) $4f$ (5) $8f$

9. An ideal gas of volume V and pressure P undergoes a change from state A to state C via state B along the path as shown in the P-V graph. If the absolute temperatures of the gas corresponding to the states A, B and C are T_A, T_B and T_C respectively, the correct statement regarding temperature is



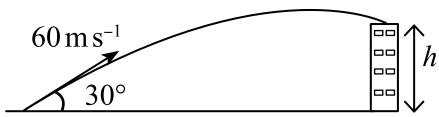
(1) $T_A < T_B < T_C$ (2) $T_A < T_C < T_B$
(3) $T_B < T_A < T_C$ (4) $T_B < T_C < T_A$
(5) $T_C < T_A < T_B$

10. The mass M and volume V of four solid blocks namely W, X, Y and Z are measured and the values are marked on the graph as shown. Which could be made out of the same material?



(1) W and X (2) W and Y
(3) W and Z (4) X and Z
(5) Y and Z

11. A cricket ball leaves a bat after striking at an upward angle of 30° to the horizontal with a velocity of 60 m s^{-1}. The ball lands on a roof of a building as shown in the figure. If the flight time taken to land on the roof is 5 s, the height (h) of the building is

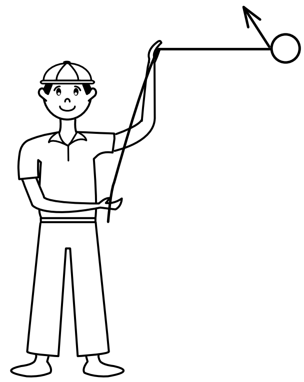


(1) 20 m (2) 24 m (3) 25 m (4) 26 m (5) 28 m

12. A box of mass 5 kg is kept on a horizontal surface. The coefficient of static friction between the surface and box is 0.3. If a horizontal force of 10 N is applied on the box, the frictional force acting on the box is

(1) 1.5 N (2) 3 N (3) 4.5 N (4) 10 N (5) 15 N

13. As shown in the figure, a fire ball displayer of a procession twirls a fire ball on a horizontal circular path of radius r_1 with a uniform angular velocity ω_1. If he shortens the radius of the path to r_2 without applying an external torque, the new angular velocity ω_2 of the fire ball is given by

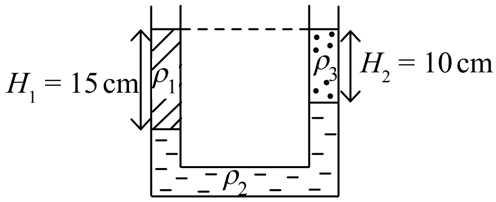


(1) $\omega_2 = \frac{r_1}{r_2}\omega_1$ (2) $\omega_2 = \left(\frac{r_1}{r_2}\right)^2 \omega_1$

(3) $\omega_2 = \left(\frac{r_2}{r_1}\right)^2 \omega_1$ (4) $\omega_2 = \frac{r_2}{r_1}\omega_1$

(5) $\omega_2 = \omega_1$

14. Three different liquids, with densities ρ_1, ρ_2 and ρ_3, are poured into a U-shaped container as shown in the diagram. Which of the following equations gives the correct relation between the densities of the liquids in the container?



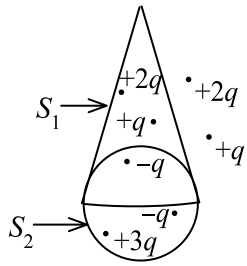
(1) $3\rho_1 = 2\rho_3 + \rho_2$ (2) $\rho_3 = 2\rho_1 + 3\rho_2$

(3) $2\rho_3 = 3\rho_1 + \rho_2$ (4) $\rho_3 = 3\rho_1 + 2\rho_2$

(5) $\rho_3 = \rho_1 + \rho_2$

15. S_1 is a surface of a cone with a base radius r and height $3r$ and S_2 is a spherical surface of radius r.

The ratio, $\dfrac{\text{Net electric flux through } S_1}{\text{Net electric flux through } S_2}$ is

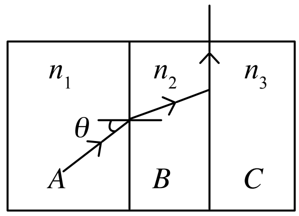


(1) 1 (2) 2 (3) 4 (4) 15 (5) 16

16. A wire of length 2 m and cross sectional area $0.1\,\text{cm}^2$ is made out of a material of Young's modulus $12 \times 10^{10}\,\text{N m}^{-2}$. When the wire is stretched by 0.01 mm, the energy stored in the wire is

(1) 6×10^{-4} J (2) 3×10^{-4} J (3) 10^{-4} J (4) 6×10^{-5} J (5) 3×10^{-5} J

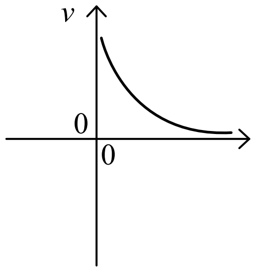
17. As shown in the figure, three parallel sided transparent media A, B and C of refractive indices n_1, n_2 and n_3 respectively are placed in contact with each other. The incident angle on the interface of the media A and B is θ. If the ray grazes the interface of the media B and C, $\sin\theta$ is given by,



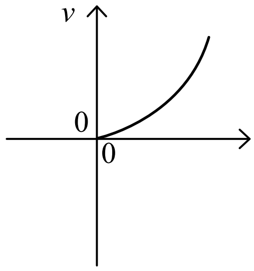
(1) n_1/n_3 (2) n_2/n_1 (3) n_2/n_3

(4) n_3/n_1 (5) n_3/n_2

18. The graph of image distance (v) against object distance (u) for real images produced by a convex lens is best represented by



(1)



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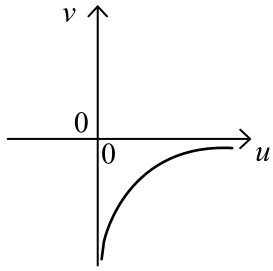

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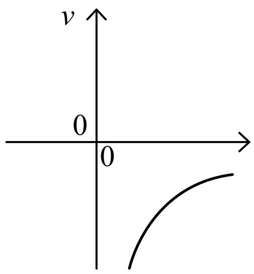

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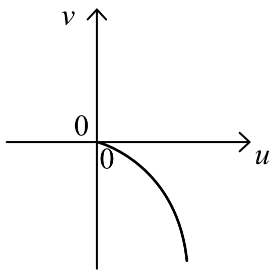
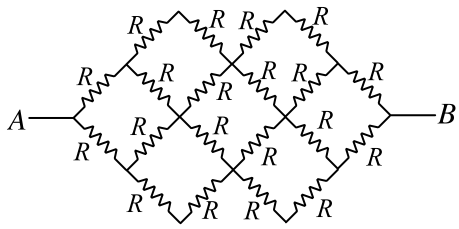


(5)

19. Each resistor in the resistor network shown has a resistance of R. The equivalent resistance of the network between the points A and B is



(1) R (2) $2R$ (3) $4R$
(4) $8R$ (5) $12R$

20. Consider the following statements made about longitudinal waves and transverse waves.
(A) Transverse waves cannot propagate along the surface of a solid medium.
(B) Mechanical transverse waves cannot propagate through a liquid or a gas.
(C) Sound waves are longitudinal where as Electro Magnetic (EM) waves are transverse.
Of the above statements,
(1) only (A) is true. (2) only (B) is true. (3) only (C) is true.
(4) only (A) and (B) are true. (5) only (B) and (C) are true.

21. Consider the following statements made about forces.
(A) A force is needed to keep an object moving.
(B) When a ball has been thrown, the force exerted by the hand on the ball remains with the ball.
(C) The product of mass × acceleration is not considered as a force.
Of the above statements,
(1) only (A) is true. (2) only (B) is true. (3) only (C) is true.
(4) only (A) and (B) are true. (5) only (B) and (C) are true.

22. A current of 10 A flows in opposite directions in each of two long straight parallel wires separated by a distance 1 m. The magnitude and the nature of the forces acting per one metre of each wire are,
($\mu_0 = 4\pi \times 10^{-7}\,\mathrm{T\,m\,A^{-1}}$)
(1) $2 \times 10^{-7}\,\mathrm{N\,m^{-1}}$, and attract each other (2) $2 \times 10^{-7}\,\mathrm{N\,m^{-1}}$, and repel each other
(3) $2 \times 10^{-5}\,\mathrm{N\,m^{-1}}$, and attract each other (4) $2 \times 10^{-5}\,\mathrm{N\,m^{-1}}$, and repel each other
(5) $2 \times 10^{-4}\,\mathrm{N\,m^{-1}}$, and repel each other

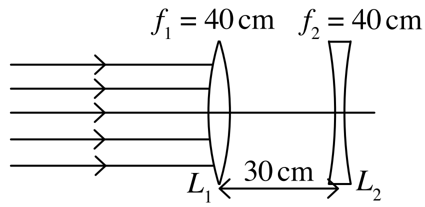
23. A narrow tube of adjustable length opened at both ends is kept in air. A sound source of frequency 680 Hz is placed near one end of the tube. The length of the tube was adjusted as follows (A, B, C). (speed of sound in air = 340 m s^{-1})

(A) 125 mm (B) 250 mm (C) 500 mm

Of the above lengths resonance may occur,

(1) only with (A).
(2) only with (B).
(3) only with (C).
(4) only with (A) and (B).
(5) only with (B) and (C).

24. The diagram shows two thin lenses L_1 and L_2 placed coaxially 30 cm apart. Focal lengths of lenses are 40 cm each. A beam of parallel light is incident on L_1. The final image formed by refraction though both lenses is

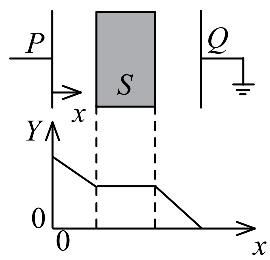


(1) real, between L_1 and L_2.
(2) real, on the right of L_2.
(3) virtual, on the left of L_1.
(4) virtual, on the right of L_1.
(5) at infinity.

25. Which of the following statements is **not true** about electric field lines?

(1) Electric field lines always point from high electric potential to low electric potential.
(2) Electric field lines are closer to each other where the electric field is stronger.
(3) Work has to be done externally in moving an electron along the direction of an electric field line.
(4) Electric field lines tend to attract one another.
(5) Electric field lines are always perpendicular to equipotential surfaces.

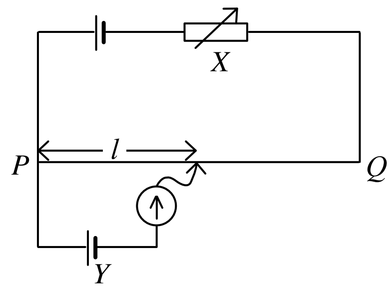
26. The plates P, Q of a capacitor are connected to a direct current (d.c.) power supply and a slab of material S is introduced between the plates. The value of a quantity Y is found to vary with distance x measured from plate P as shown.



Which of the following statements is true?

(1) S is a metal and Y is electric field intensity.
(2) S is an insulator and Y is electric field intensity.
(3) S is an insulator and Y is electric potential gradient.
(4) S is a metal and Y is electric potential.
(5) S is an insulator and Y is electric potential.

27. Figure shows a balanced potentiometer circuit.



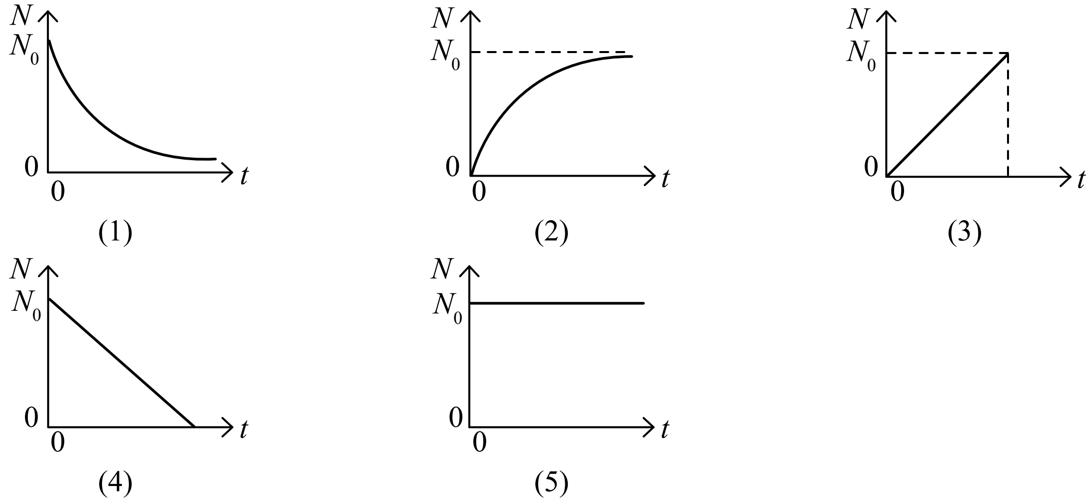
Consider the following statements.

(A) The currents through the potentiometer wire PQ and the cell Y are equal.
(B) An increase in the internal resistance of cell Y would require an increase in l to restore balance.
(C) An increase in the resistance of X would require an increase in l to restore balance.

Of the above statements,

(1) only (A) is true.
(2) only (B) is true.
(3) only (C) is true.
(4) only (A) and (B) are true.
(5) only (B) and (C) are true.

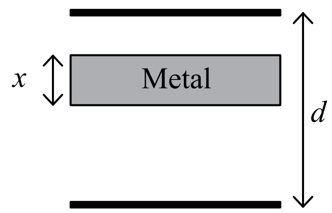
28. A sample of certain radioactive nuclei contains N_0 number of nuclei at time $t = 0$. The variation of the number of nuclei (N) decayed with time t is best represented by,

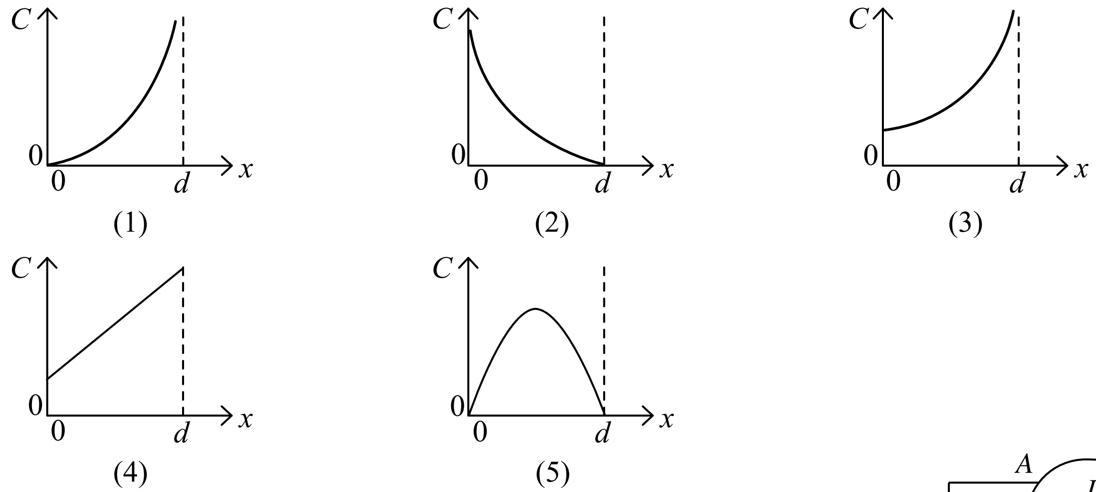


29. Silicon is doped with arsenic so that one in every million Si atoms is replaced by an arsenic atom. The density of free electrons due to arsenic is
(take the Avogadro's number = $6.0 \times 10^{23}\,\text{mol}^{-1}$; Molar mass of Si = $28.0\,\text{g mol}^{-1}$; density of Si = $2.0\,\text{g cm}^{-3}$)

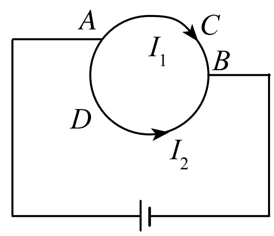
(1) $\frac{1}{28} \times 10^{16}\,\text{cm}^{-3}$ (2) $\frac{3}{28} \times 10^{16}\,\text{cm}^{-3}$ (3) $\frac{1}{7} \times 10^{17}\,\text{cm}^{-3}$ (4) $\frac{2}{7} \times 10^{17}\,\text{cm}^{-3}$ (5) $\frac{3}{7} \times 10^{17}\,\text{cm}^{-3}$

30. A metal block of thickness x is inserted into a parallel plate capacitor as shown in the figure. The separation between the two plates is d. The variation of the effective capacitance (C) of the above combination with the thickness (x) of the metal block inserted is best represented by,





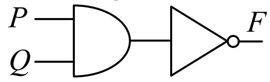
31. A uniform circular wire of radius r is connected to a battery at points A and B, as shown in the figure. The current through path ACB of length l_1 is I_1 and the current through path ADB of length l_2 is I_2. The magnitude of the magnetic flux density at the center of the circular wire is,



(1) zero (2) $\frac{\mu_0}{4\pi r^2}(I_1 l_2 - I_1 l_1)$ (3) $\frac{\mu_0}{4\pi r^2}(I_1 l_1 + I_2 l_2)$

(4) $\frac{\mu_0}{2\pi r^2}(I_1 l_1 + I_2 l_2)$ (5) $\frac{\mu_0}{2\pi r^2}(I_1 l_2 - I_2 l_1)$

32. Consider the following statements made about the logic circuit shown in the figure.

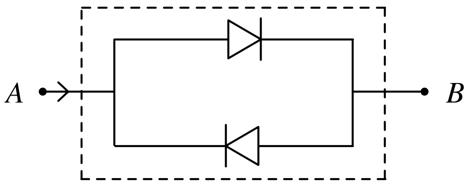


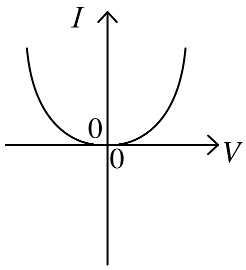
(A) When $P = 1$ and $Q = 1$ the output $F = 1$.
(B) When $P = 1$ and $Q = 0$ the output $F = 1$.
(C) When $P = 0$ and $Q = 1$ the output $F = 0$.

Of the above statements,

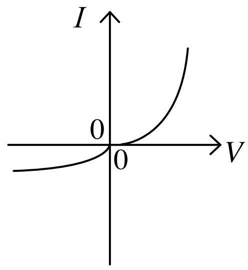
(1) only (A) is true. (2) only (B) is true. (3) only (C) is true.
(4) only (A) and (B) are true. (5) only (B) and (C) are true.

33. Figure shows an arrangement made out of two identical diodes. The most suitable I - V characteristic curve for the arrangement is given by, (Here V is the voltage across A and B, and I is the current through AB.)





(1)



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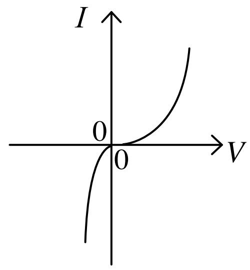

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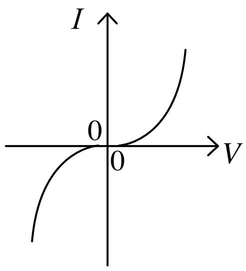

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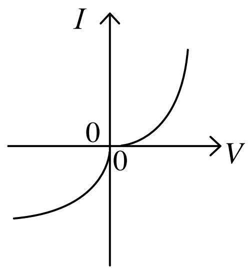

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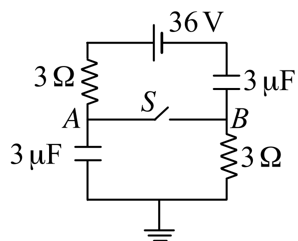
34. In the circuit shown, the potential difference $(V_A - V_B)$ between the points A and B when the switch S is opened and closed are respectively given by, (The internal resistance of the cell is negligible.)



(1) 18 V, 9 V (2) 9 V, 9 V (3) 18 V, 0 V
(4) 0 V, 18 V (5) 36 V, 18 V

35. A charged particle enters perpendicular to a uniform magnetic field. Consider the following statements.

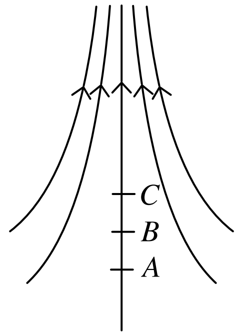
(A) Linear momentum of the particle changes.
(B) Kinetic energy of the particle remains constant.
(C) Work done by the magnetic field on the particle is zero.

Of the above statements,

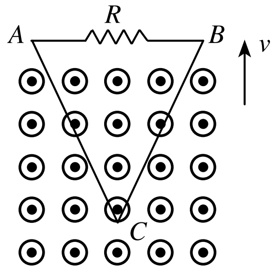
(1) only (B) is true. (2) only (A) and (B) are true.
(3) only (B) and (C) are true. (4) only (A) and (C) are true.
(5) All (A), (B) and (C) are true.

36. The diagram represents an electric field and points *A, B* and *C* are marked along an electric field line. Here $AB = BC$. If the electric potential at B is zero, which of the following gives the possible potentials at A and at C respectively?

(1) −20 V and +20 V
(2) −20 V and −35 V
(3) −30 V and −70 V
(4) +20 V and −20 V
(5) +25 V and −40 V



37. In the figure shown, a triangular coil is being pulled at a constant speed (v) out of a region of a uniform magnetic field pointing out of the paper. Consider the following statements.



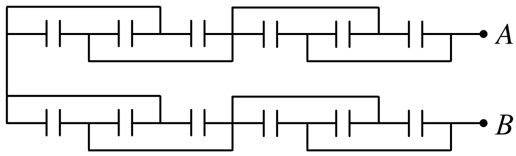
(A) The magnitude of the induced e.m.f. in the coil *ABC* is decreasing with time at a uniform rate.
(B) An induced current flows from *B* to *A* through resistor *R*.
(C) The magnetic flux passing through the coil *ABC* is decreasing with time at a uniform rate.

Of the above statements,

(1) only (A) is true.
(2) only (B) is true.
(3) only (C) is true.
(4) only (A) and (B) are true.
(5) only (A) and (C) are true.

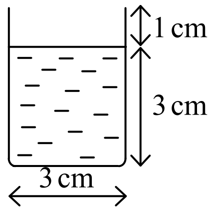
38. The diagram shows a combination of 12 identical capacitors of capacitance C each. The equivalent capacitance between the points A and B is,

(1) $0.5C$
(2) $0.75C$
(3) $1.0C$
(4) $1.5C$
(5) $3.0C$



39. A person travelling in a car is holding a cylindrical cup of tea vertically as shown in the figure. Neglecting the vibration of the car, what is the maximum acceleration that the car can go without spilling any tea?

(1) $\frac{g}{3}$
(2) $\frac{g}{2}$
(3) $\frac{g}{1.5}$
(4) g
(5) $1.5g$

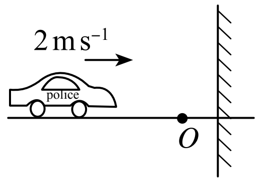


40. The drag force experienced by an object falling in air with velocity v is given by $\frac{1}{2}d_aCAv^2$, where d_a is the density of air, A is the cross-sectional area of the falling object perpendicular to the direction of fall and C is a constant. The terminal velocity v_t acquired by a raindrop of radius r falling through air is given by (d_w = density of water; Neglect the upthrust acting on the drop.)

(1) $v_t = \left[\frac{4}{3}\left(\frac{d_w}{d_a}\right)\left(\frac{rg}{C}\right)\right]^{\frac{1}{2}}$
(2) $v_t = \left[\frac{1}{3}\left(\frac{d_a}{d_w}\right)\left(\frac{rg}{C}\right)\right]^{\frac{1}{2}}$
(3) $v_t = \left[\frac{1}{2}\left(\frac{d_w}{d_a}\right)\left(\frac{C}{rg}\right)\right]^{\frac{1}{2}}$
(4) $v_t = \left[\frac{8}{3}\left(\frac{d_w}{d_a}\right)\left(\frac{rg}{C}\right)\right]^{\frac{1}{2}}$
(5) $v_t = \left[\frac{1}{2}\left(\frac{d_a}{d_w}\right)\left(\frac{C}{rg}\right)\right]^{\frac{1}{2}}$

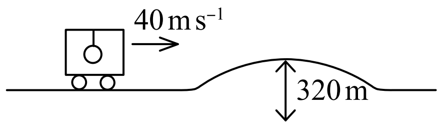
41. It is observed that water vapour has condensed on inner sides of glass walls of a closed room. Which of the following processes might remove water vapour condensed on glass walls?
(1) Switching off a computer located inside the room.
(2) Keeping a vessel inside the room containing boiling water.
(3) Switching on an air conditioner located inside the room.
(4) Switching off a refrigerator kept inside the room.
(5) Keeping a vessel containing ice inside the room.

42. A police car sounding a siren of frequency 338 Hz is moving with a uniform velocity of $2\,\mathrm{m\,s^{-1}}$ towards a vertical barrier which reflects sound. The beat frequency heard by an observer standing at O in between the car and the barrier is (velocity of sound in air = $340\,\mathrm{m\,s^{-1}}$)



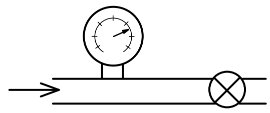
(1) 0 Hz (2) 2 Hz (3) 4 Hz (4) 6 Hz (5) 8 Hz

43. The period of a simple pendulum hung on the roof of a vehicle is T when it is moving with a uniform velocity of $40\,\mathrm{m\,s^{-1}}$. As shown in the diagram the vehicle then enters a bridge with a curved surface of radius 320 m with the same speed. When the vehicle reaches the highest position of the bridge the new period of the pendulum is given by, (Diagram is not drawn to the scale)



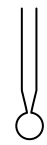
(1) $\frac{1}{\sqrt{2}}T$ (2) $\sqrt{\frac{2}{3}}\,T$ (3) T (4) $\sqrt{\frac{3}{2}}\,T$ (5) $\sqrt{3}\,T$

44. A pressure gauge connected near to a closed valve of a water pipe line reads $3.5 \times 10^5\,\mathrm{N\,m^{-2}}$. When the valve is opened, the reading of the gauge falls to $3.0 \times 10^5\,\mathrm{N\,m^{-2}}$. The speed of water flow in the pipe is, (density of water = $10^3\,\mathrm{kg\,m^{-3}}$)



(1) $1\,\mathrm{m\,s^{-1}}$ (2) $4\,\mathrm{m\,s^{-1}}$ (3) $5\,\mathrm{m\,s^{-1}}$ (4) $8\,\mathrm{m\,s^{-1}}$ (5) $10\,\mathrm{m\,s^{-1}}$

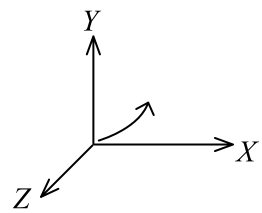
45. If the mass of 25 water droplets of radius R falling through a syringe of internal radius a is m, the surface tension T of water is given by,



(1) $T = \frac{mg}{50\pi R}$ (2) $T = \frac{mg}{25\pi R}$ (3) $T = \frac{mgR}{50\pi a^2}$

(4) $T = \frac{mg}{2\pi a}$ (5) $T = \frac{mg}{50\pi a}$

46. An electron is moving on the X - Y plane and its path is found to be curved, but non-circular. If the electron experiences electric and/or magnetic forces, the allowed condition that E_X, E_Y, E_Z and B_X, B_Y, B_Z should have is (E_X, E_Y and E_Z, and B_X, B_Y and B_Z are X, Y and Z components of the electric field intensity and magnetic flux density respectively. Neglect effect of gravity.)



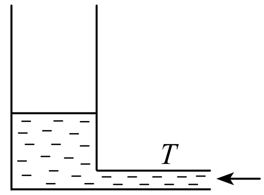
(1) $E_X = E_Y = E_Z = 0, B_X = B_Y = B_Z = 0$
(2) $E_X \neq 0, E_Y \neq 0, E_z = 0, B_X \neq 0, B_Y \neq 0, B_Z \neq 0$
(3) $E_X = 0, E_Y = 0, E_Z = 0, B_X = B_Y = 0, B_Z \neq 0$
(4) $E_X \neq 0, E_Y \neq 0, E_Z \neq 0, B_X = B_Y = B_Z = 0$
(5) $E_X \neq 0, E_Y \neq 0, E_Z = 0, B_X = B_Y = 0, B_Z \neq 0$

47. A satellite of mass m is orbiting the earth of mass M and radius R. The distance from the earth's surface to the satellite is $\frac{R}{2}$. The extra energy needed to increase the distance of the satellite from $\frac{R}{2}$ to R from the earth's surface is given by,

(1) $\frac{GMm}{12R}$ (2) $\frac{GMm}{6R}$ (3) $\frac{GMm}{4R}$

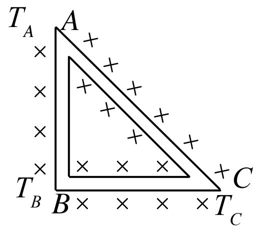
(4) $\frac{GMm}{2R}$ (5) $\frac{GMm}{R}$

48. Figure shows an experimental set-up which could be used to find the speed of sound in air. Water is filled to a tall vertical tube of cross-sectional area $2.0 \times 10^{-3}\,\text{m}^2$ through a narrow tube T. With a low water level in the tube resonance was heard when the air column above the water level was vibrated with a tuning fork of frequency 180 Hz. When an additional amount water $2.0 \times 10^{-3}\,\text{m}^3$ was sent into the tube through T, the next resonance was heard and that was the last resonance that could be heard from the set-up. Wavelength of the vibrating air column and the speed of sound in air are respectively,



(1) 2.0 m, 360 m s^{-1} (2) 1.0 m, 360 m s^{-1} (3) 0.5 m, 360 m s^{-1}
(4) 1.0 m, 180 m s^{-1} (5) 0.5 m, 180 m s^{-1}

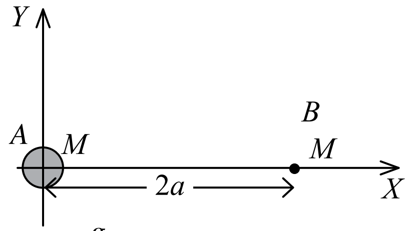
49. Three rods of identical cross-sectional area and made from the same material form the sides of an isosceles triangle ABC as shown in the figure. The rods are fully lagged except at the corners A and B. At the steady state, the temperatures at points A, B and C are T_A, T_B and T_C respectively. If $T_B > T_C > T_A$ then,

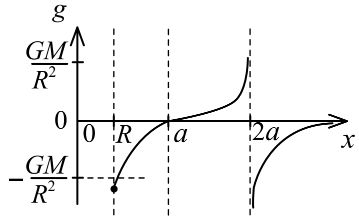


(1) $T_C = \frac{T_B + \sqrt{2}T_A}{\sqrt{2}+1}$ (2) $T_C = \frac{T_B + T_A}{\sqrt{2}+1}$ (3) $T_C = \frac{T_B + T_A}{2}$

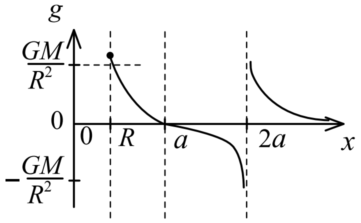
(4) $T_C = \frac{\sqrt{2}(T_B + T_A)}{\sqrt{2}+1}$ (5) $T_C = \frac{\sqrt{2}T_B + T_A}{\sqrt{2}+1}$

50. Two equal masses A and B of mass M are placed on the X-axis as shown in the figure. Radius of A is R, and B is a point mass. The variation of the gravitational field intensity (g) produced due to both masses with x ($x \geq R$) along the positive X direction is best represented by,

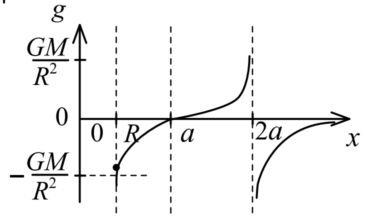




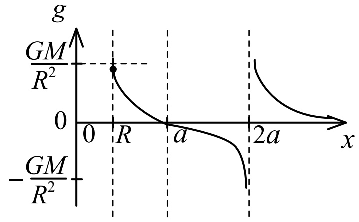
(1)



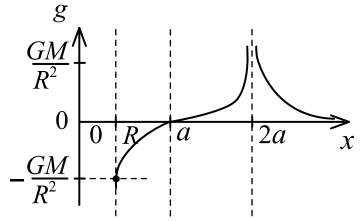
(2)



(3)



(4)



(5)

* * *

(01) Physics

Paper II

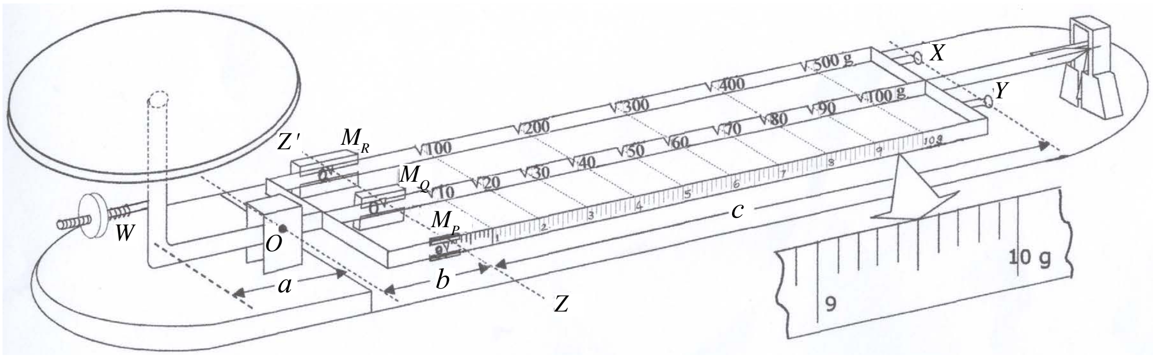
Important :

* Answer **all** the questions in Part **A**.
* Answer only **four** the questions from Part **B**.

Part A - Structured Essay

(g = 10 N kg^{-1})

1. Following figure shows a rough sketch of a triple beam balance. The masses on the beams M_P, M_Q and M_R are at the left hand end (at ZZ^1) when the balance is ready to use. When the system is at balance, the moment of weight of the pan and its attachments, about the horizontal axis passing through O perpendicular to the beams, is equal to sum of the moments of the weights of the masses M_P, M_Q and M_R and the moments of weights of the three beams. (The pan includes a screw weight W.)



(a) Using the enlarged measuring scale given in the diagram find the least count of the balance.

....

(b) When there is no mass on the pan and the masses M_P, M_Q and M_R masses are at the left hand end (at ZZ^1) the system should be balanced. If it is not, how do you obtain the required balance?

....

(c) To get a measurement of a mass on the pan, the masses M_P, M_Q and M_R should be positioned correctly to obtain the balance. Which mass/masses is/are adjusted in the way stated below?

(i) continuously ....

(ii) discretely (in steps) ....

(d) When a mass m is on the pan, the amounts by which M_P, M_Q and M_R masses are displaced from ZZ' along the relevant beams to obtain the balance, are d_1, d_2 and d_3 respectively. Write down an equation relating m, M_P, M_Q and M_R, d_1, d_2, d_3 and a.

....

(e) What is the maximum mass which can be measured using this balance when there is no additional mass hung at X and/or Y at the right hand end of the beams ?

....

(f) When it is required to measure masses larger than the mass mentioned in your answer for (e) above, it can be done by hanging any one or both of the extra masses provided, marked 500 g and 1000 g on them, at X and/or Y.

(i) When only one mass marked 500 g on it is hung at Y, what are the measurable minimum and maximum masses?

Minimum mass ....

Maximum mass ....

(ii) With regard to above, calculate the effective value of the mass marked 500 g on it. (take the values for a, b and c in the diagram as $a = 6$ cm, $b = 3$ cm and $c = 18$ cm)

....

....

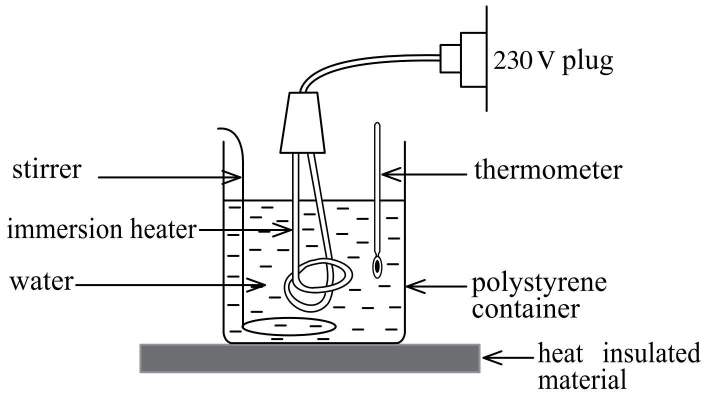
(*g*) State an important step to be taken when placing a mass/masses on the pan to get accurate measurements.

....

(*h*) When the balance is obtained with a mass on the pan, what technique is used in the balance to minimize the oscillation about the axis through O ?

....

2. Figure shows an experimental set-up designed to determine the wattage (P) of an household immersion heater. It is expected to find out the amount of heat absorbed by a certain mass of water.



(*a*) Name the other items that you would need in addition to the items given in the diagram.

(i) ....

(ii) ....

(*b*) What are the measurements that you would take before operating the heater ?

(i) .... (say x_1)

(ii) .... (say x_2)

(iii) .... (say x_3)

(*c*) After operating the heater for a time period t, if the measurement that has to be taken is x_4, write down an expression for the heat absorbed (Q) by water during the time t in terms of x_1, x_2, x_3, x_4 and C_w (specific heat capacity of water). Neglect the mass of water removed due to the evaporation.

....

....

(*d*) Hence obtain an expression for the wattage (P) of the heater.

....

....

(*e*) Mention **two** assumptions that you have made in this experiment.

(i) ....

(ii) ....

(*f*) If the water is heated up to 100 °C explain as to how will it affect the determined value of P ?

....

....

(*g*) If a metal container is used instead of polystyrene container, what other data is needed in order to determine P?

....

....

(*h*) In order to find the specific latent heat of vaporization (L) of water, using the heater, temperature of water is raised to the boiling point and water is allowed to boil.

(i) To find the mass m_0 of water removed due to vaporization during a time period t_0 after boiling what measurement that you have to take?

....

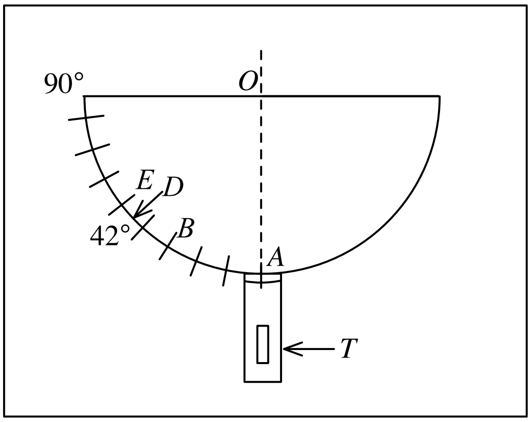
....

(ii) If $t_0 = 100\,\text{s}$, $m_0 = 40.0\,\text{g}$ and $P = 1000\,\text{W}$, obtain a value for L.

....

....

3. A glass block with hemispherical cross - section is placed on a white sheet of paper fixed to a horizontal board. The hemispherical shape of the glass block is traced onto the paper and one half is calibrated in degrees with a least count of 1 degree. Small laser torch (T) is attached to a wooden strip which can rotate in a circular path with O as centre. The laser beam can enter the glass block grazing the surface of the paper. Top view of the set-up is shown in the diagram. This set-up can be used to find the refractive index of glass.



(*a*) When the laser torch is in the position A what is the path of the laser beam?

....

(*b*) Draw the path of the laser beam that you can observe when the laser torch is rotated to the position B, on the Figure (1).

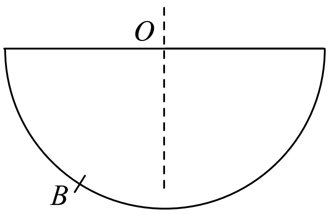


Figure (1)

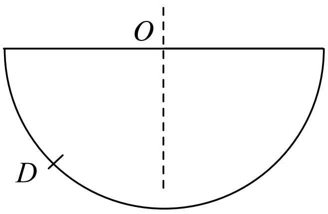


Figure (2)

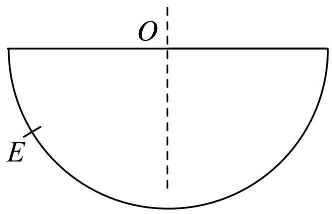


Figure (3)

(*c*) When the laser torch is rotated to the position D (42°) it is observed that the refracted laser beam grazes the plane surface of the glass block. In this situation what is the special name given to the incident angle and draw the path of the laser beam on the Figure (2).

....

(*d*) If the refractive index of glass is n, write down an expression for n using the angle corresponding to the position D.

....

(*e*) If the laser torch is rotated to the position E, draw the new path of the laser beam on the Figure (3).

(*f*) Name the phenomenon related to the above observation (*e*) and state the conditions for such occurrence.

....

....

....

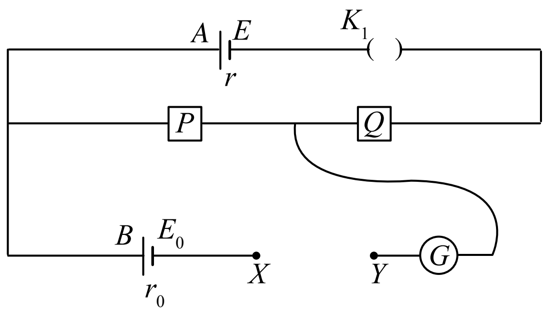
(*g*) A microscope slide is wetted with water and kept in contact with the plane surface of the glass block. When the laser torch is kept in the same position as in (*e*) can you get the same observation as above? Comment on your observation.

....

....

....

4. A circuit that can be used to compare the e.m.fs of two cells A and B, is shown in the figure. E, E_0 and r, r_0 are e.m.fs and the internal resistances of the cells A and B respectively. G is a center zero galvanometer and P and Q are two resistance boxes. The minimum value that can be obtained from both P and Q is 1 Ω each.



(*a*) If a suitable resistor R_0 and a key K_2 are provided, complete the above circuit by connecting R_0 and K_2 in between XY in the above diagram, in order to protect the galvanometer from high currents passing through it.

(*b*) A student sets the resistance value of P to R_1 and varies the resistance value of Q to R_2, so that the reading of G becomes zero.

(i) Write down an expression for the current i in the circuit in terms of E, R_1, R_2 and r in this situation.

....

....

(ii) Write down another expression for the current i in terms of E_0 and R_1.

....

....

....

(iii) Using the above two expressions, derive a suitable expression to plot a graph of (R_1+R_2) vs R_1.

....

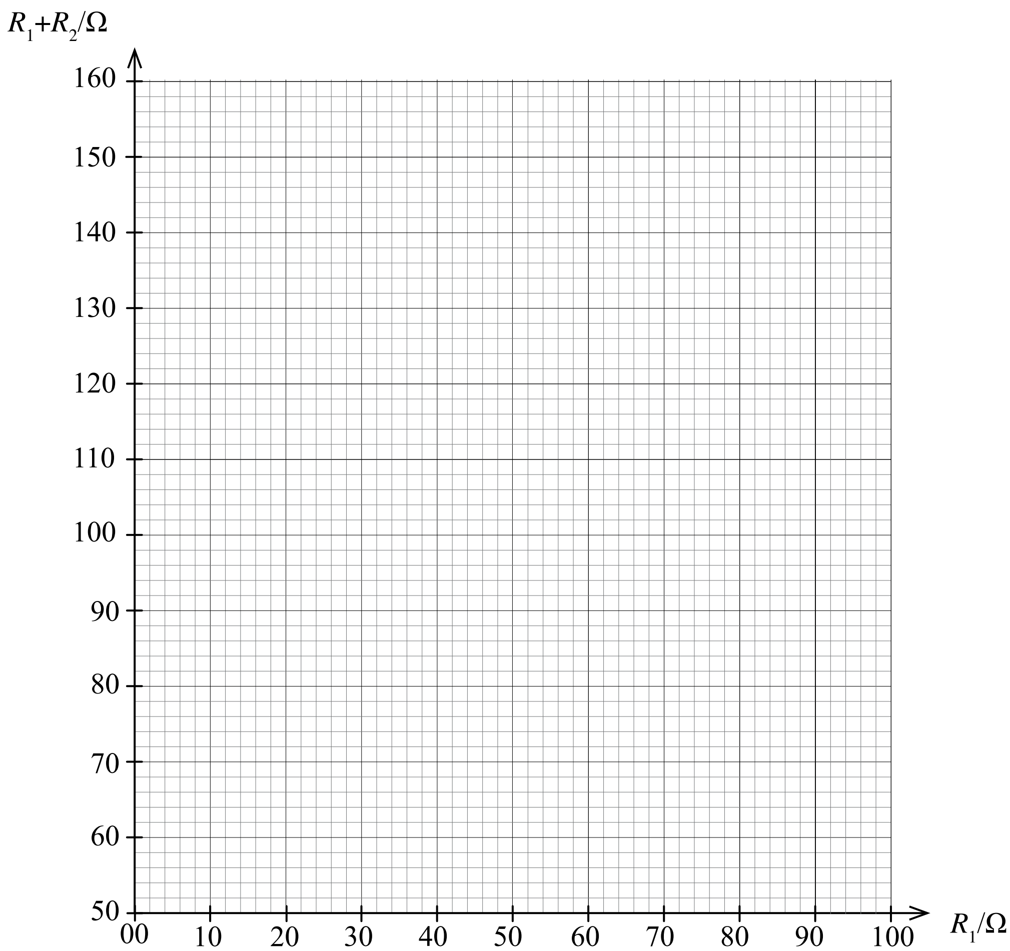
....

....

(*c*) The student doing this experiment obtained the data shown in the following table.

R_1/Ω	R_2/Ω	R_1+R_2 / Ω
30	27	
40	35	
50	42	
60	54	
70	66	
80	72	

Plot the graph (R_1+R_2) vs R_1 on the co-ordinate grid shown below.



(*d*) Obtain the ratio $E/_{E_0}$ using the graph.

(*e*) Explain briefly the practical difficulty arises when achieving the condition of zero reading in the galvanometer.

* *

Part B - Essay

Answer **four** questions only.

($g = 10\,\text{N kg}^{-1}$)

5. Consider a situation where a motor car (A) with an engine trouble is being pulled by a breakdown truck (B) on a flat road as shown in the figure (1). The masses of vehicle A and vehicle B are 1000 kg and 3000 kg respectively. Assume that the resistive force acting on each vehicle against their motion is given by $4\,\text{N kg}^{-1}$.

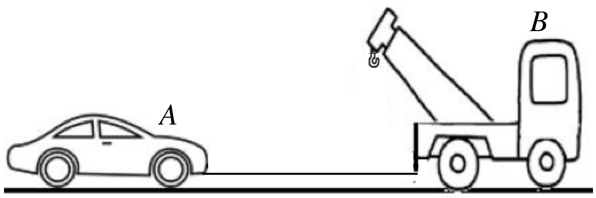


Figure (1)

(*a*) Sketch a diagram of the vehicle A on your answer sheet and draw the forces acting on it.

When the vehicle B is pulling the vehicle A with a constant velocity of $10\,\text{m s}^{-1}$,

(*b*) calculate the forward total force applied by the vehicle B?

(*c*) what is the power of the vehicle B?

(*d*) what is the tension in the cable used to pull the car in this situation?

(*e*) If the force constant of the cable is $40000\,\text{N m}^{-1}$,

  (i) calculate the extension in the cable.

  (ii) calculate the strain energy stored in the cable.

(*f*) If the maximum tension that the cable could withstand is 6000 N, determine the maximum acceleration that the car could be pulled.

Now the front wheels of the vehicle A are raised by attaching one end of the cable to the hook of the crane located in the vehicle B as shown in the figure (2). The vehicle B pulls the vehicle A with a uniform velocity. When the vehicle A is at this new position, the cable makes an angle of 30° to the horizontal, the resistive force acting on it is decreased to 3825 N and the resistive force acting on the vehicle B increases. (Diagrams are not drawn to scale.)

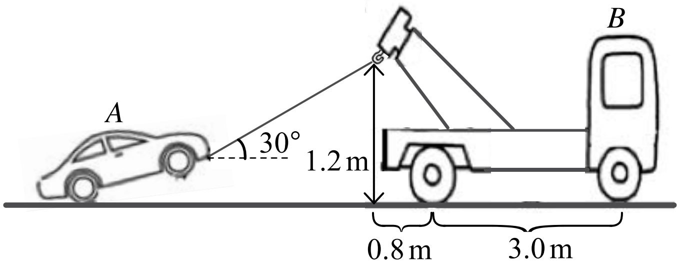


Figure (2)

In this situation,

(*g*) what is the tension in the cable ? (Take $\sqrt{3} = 1.7$)

(*h*) show that the vehicle B does not topple over. All relevant distances are marked in figure (2). Assume that the line of action of weight of the vehicle B act right in between the wheels of the vehicle B.

(*i*) explain giving reasons as to why the resistive force on vehicle A decreases and the resistive force on vehicle B increases.

6. Read the following passage and answer the questions.

The term LASER is an acronym of "Light Amplification by Stimulated Emission of Radiation". It is needed to select a suitable material (laser medium) for the production of a particular laser light and hence it is an essential item in a laser machine. When atoms in a laser medium are excited they may undergo two de-excitation processes to ground level or a lower energy level namely spontaneous emission and stimulated emission where the latter is responsible for the production of laser light. For convenience, consider a laser medium consisting of three energy levels where the ground, intermediate and highest energy levels are E_1, E_2 and E_3 respectively. (Figure 1) The excitation of atoms from E_1 level to E_3 level is carried out by some excitation (pumping) device (e.g. by a flash lamp) which is also an essential part of the laser light production. Some of the excited atoms at E_3 level first decay rapidly to the intermediate energy level (E_2) and they may stay considerably long time (life time is about 1 m s) at E_2 level before it decays to the lower level (E_1). Such a long-lived intermediate level is called a metastable level. When an atom is in the metastable state, a photon of energy (E_2 - E_1) present in the medium can stimulate the de-excitation of the atom from the level E_2 to the level E_1 resulting in an emission of a photon of energy (E_2 - E_1). This process is called stimulated emission which is the laser transition. The most exciting feature of this transition is that the photon used to stimulate the de-excitation and the photon resulted from the de-excitation from level E_2 to level E_1 are in phase. This property is known as coherence.

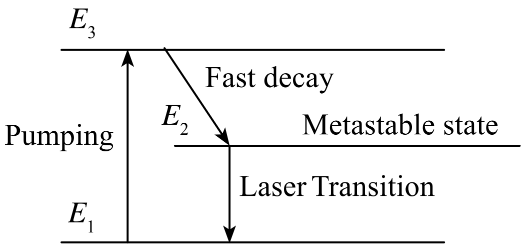


Figure (1) 3-level system

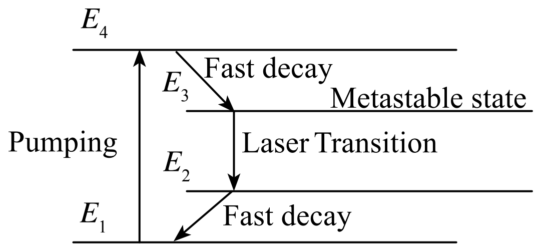


Figure (2) 4 – level system

For the stimulated emission to be efficient, the population of atoms at the metastable state (E_2) should be much higher than the population of atoms at the lowest level (E_1). This condition is known as population inversion which must be achieved for the production of laser photons from a given medium. Population inversion can also be achieved by a four-level laser medium too. (Figure 2) Here E_3 is the metastable state and the laser transition occurs from level E_3 to level E_2. In this case, E_2 level is fast depopulated by the rapid decay from E_2 level to E_1 thus reducing the population at level E_2 allowing population inversion to be more efficient between E_3 and E_2 levels.

In order to get a useful laser beam out of a laser machine, laser photons produced in the laser medium should be multiplied rapidly. This is done by using a resonator in which stimulated emission is enhanced by confining the movement of laser photons produced to the laser medium itself. This can be accomplished by the reflection of laser photons by highly reflective mirrors attached to the both ends of the laser medium. In the resonator, the laser light produce standing waves with nodes at both ends of the resonator so that different modes (harmonics) of standing waves occur. Hence, a resonator is also an essential part of a laser machine. There are two types of lasers i.e. pulsed lasers and continuous lasers. High power can be obtained using laser pulses with small pulse time.

(*a*) What is the emission process which is responsible for the production of laser light ?

(*b*) Explain how the existence of a metastable state in a laser medium contributes to laser transition.

(*c*) With regard to the laser action explain why a four energy level system is more efficient compared to a three energy level system.

(*d*) What are the three essential parts needed to produce a laser machine ?

(*e*) State three unique properties of a laser beam compared to a normal light beam.

(*f*) What is the part of a laser machine by which the colour of the laser light is determined ?

(*g*) In a three-level system, $E_2 - E_1 = 2.20$ eV. Calculate the wavelength (λ) of the laser light produced (Planck constant $h = 6.6 \times 10^{-34}$ J s, the speed of light in vacuum is 3.0×10^{8} m s^{-1}, 1 eV = 1.6×10^{-19} J)

(*h*) A laser pulse is focused onto a small circular target of radius 1.5×10^{-5} m so that whole target is illuminated by laser light. The energy delivered by the laser pulse onto the target is 4.0×10^{-3} J and the time duration of the laser pulse is 1.0×10^{-9} s. Calculate the power delivered to the target per unit area (i.e intensity).

(*i*) The length (L) of the resonator in a laser machine is 30.0 cm and the refractive index (n) of the resonator medium is 1.8. This resonator gives out laser light of wave length (λ), 600 nm. In the resonator a standing wave of m^{th} harmonic is produced. Determine m.

7. A solid cylindrical rod of radius 3 cm is passed through along the axis of a hollow cylinder of radius 5 cm and length 10 cm as shown in the figure (1). The rod is passed through the two flat sides of the hollow cylinder using two frictionless oil seals which are placed around the rod. Assume that there is no leakage of fluid through the frictionless oil seals. A cooling fan (F) is attached to one of the flat sides of the hollow cylinder as shown in the figure (2). The empty space between the hollow cylinder and the rod is filled with a viscous fluid. When the rod rotates about its axis in the absence of viscous fluid the rod slides over the seals without rotating the hollow cylinder. (For calculations take $\pi = 3$)

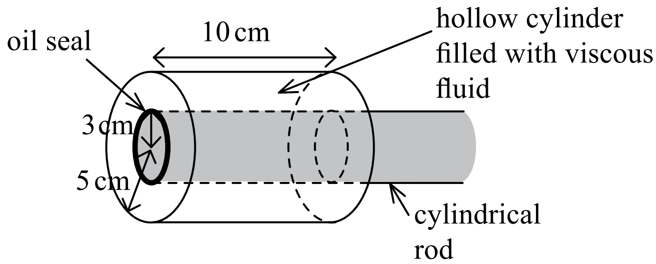


Figure (1)

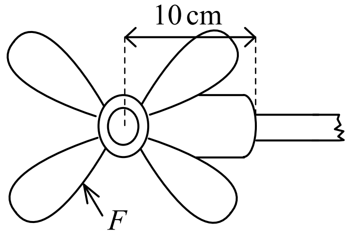


Figure (2)

(*a*) (i) When the rod rotates at a rate of 6000 revolutions per minute, find the tangential velocity of the layer of fluid just touching the curved surface of the rod.

(ii) In this situation the fan rotates at a rate of 3000 revolutions per minute. Explain why the cylinder rotates slower than the rod. Find the minimum tangential velocity that a fluid layer can have.

(iii) Determine the viscous force exerted on the hollow cylinder by the fluid. The coefficient of viscosity of the fluid is $2\,\mathrm{N\,s\,m^{-2}}$.

(*b*) When the coefficient of viscosity of the fluid drops to $1\,\mathrm{N\,s\,m^{-2}}$ the used fluid has to be removed and new fluid should be refilled. What is the reason for this?

(*c*) Determine the volume of the fluid inside the hollow cylinder.

(*d*) The used fluid is removed by pumping it through a hole available on the cylinder surface along a tube of radius of 1 mm and length 10 cm. Determine the pressure difference that has to applied across the tube in order to pump the total volume of fluid in 2 minutes.

8. Removal of microorganisms and other pathogens from a certain area is called sterilization. One of the modern techniques used to sterilize operation theaters is applying a sufficiently large electric field across two conducting plates, which are fixed to the walls situated at opposite sides of the operation theater.

Consider two identical microorganisms separated by a distance of 3 mm located in between the conducting plates. Take the charge of each microorganisms to be equal to 10000 times to that of a charge of an electron ($e = -1.6 \times 10^{-19}\,\mathrm{C}$). For all your calculations microorganisms can be considered as point like particles.

(*a*) Calculate the electrostatic force acting between the two microorganisms.
($\frac{1}{4\pi\varepsilon_0} = 9\times 10^{9}\,\mathrm{N\,m^2\,C^{-2}}$)

(*b*) Now the plates are connected to a 5 kV direct current (d.c.) voltage supply. The separation between the plates is 5 m.

(i) Find the electric field intensity between the two plates.

(ii) Calculate the electrostatic force experienced by a single microorganism due to this electric field.

(iii) Compare the force calculated in (*a*) above with the force calculated in (*b*) (ii) and comment on it.

(iv) Assuming that one of the microorganisms to be at rest at the centre of the operation theater initially, calculate the time taken by the microorganism to reach one of the plates. Take the mass of a microorganism to be equal to 2.0×10^{-14} kg. (Neglect the effect of gravity.)

(v) Find the kinetic energy gained by the microorganism in part (iv).

(*c*) By applying a suitable magnetic field this technique can be modified to separate charged microorganisms according to their masses. Consider three microorganisms with masses m_1, m_2 and m_3 ($m_1 > m_2 > m_3$) located at the vertical mid plane of the two plates. The three microorganisms start their journey at time $t = 0$ with velocities u_1, u_2, u_3 in the direction opposite to the electric field and travel a distance of 1.25 m under the influence of the electric field by spending the same time t. At this moment the electric field is turned off and a uniform magnetic field of flux density B is applied perpendicular to the direction of velocities of the microorganisms . Then these microorganisms travel the rest of the journey under the influence of this magnetic field.

(i) To complete a distance of 1.25 m by the three microorganisms within the same time period t, show that the initial velocities should satisfy the condition $u_1 > u_2 > u_3$.

(ii) Derive an expression for the radius (R_1) of the path of the microorganism of mass m_1 in terms of m_1, u_1, B and t.

9 Answer **either part (A) or part (B)** only.

(A) In order to achieve less environmental pollution there is a tendency of using electric vehicles now. There are three major units in an an electric car as shown in the following block diagram.

The battery unit consists of a low voltage (12 V) battery and a high voltage (about 200 V) battery. 12 V battery is used to supply power for horn, lamps, wipers etc. High voltage battery drives the electric motor which then rotate the wheels.

Making suitable voltage levels and various switching processes are the main functions of the control unit.

(*a*) The 12 V battery is charged by passing a constant current of 5 A through it for 10 hours. What is the amount of charge flown in this process?

(*b*) (i) When the motor is working with a power of 40 kW how much current is drawn from the high voltage battery of 160 V?

(ii) Some electric cars use 300 V battery instead of 160 V battery. State an advantage of using 300 V.

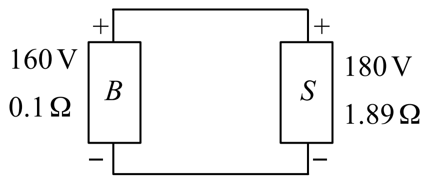
(*c*) The control unit reduces the voltage to charge the 12 V battery from the 160 V battery during the charging process. Is it possible to use a transformer for this reduction of voltage? Give reasons.

(*d*) The battery of e.m.f. 160 V has an internal resistance of 0.1 Ω. When a current of 100 A is drawn from the battery to drive the motor,

(i) what is the potential difference across the terminals of the battery?

(ii) what is the power dissipation in the battery?

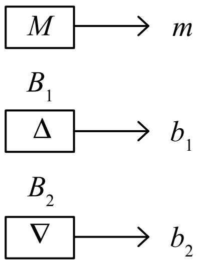
(*e*) The electric car uses a regenerative braking system. The motor turns into the mode of a generator when breaking the car. The voltage produced by this generator is used to recharge the battery (B) of e.m.f. 160 V and internal resistance 0.1 Ω. The control unit supplies the generated voltage to the battery (B) as supply (S) of e.m.f. 180 V direct current (d.c.) with an internal resistance of 1.89 Ω as shown in the diagram.



The total length of the connecting wires is 4 m. Calculate the cross-sectional area of the connecting wires made of copper if the constant charging current is 10 A. (Resistivity of copper is $1.72 \times 10^{-8}\,\Omega\,\text{m}$)

(*f*) A constant resistive force of 750 N acts on the car when it is moving with a constant velocity v. If the constant current drawn from the battery of e.m.f. 160 V and internal resistance 0.1 Ω is 100 A, find the value of the velocity v. Assume that the motor drives the car with an efficiency of 90%.

(B) (*a*) A person waiting in front of a lift of the F^{th} floor of a multi-story building, could push the button Δ (say B_1) or ∇ (say B_2) to select the direction, up or down that he wants to go.
The signal m sent by the motion detector M and the signals b_1 and b_2 sent by the push buttons B_1 and B_2 respectively are as indicated below.



m	=	1	when the lift is moving up
m	=	0	when the lift is moving down
b_1	=	1	when B_1 is pressed
b_1	=	0	when B_1 is not pressed
b_2	=	1	when B_2 is pressed
b_2	=	0	when B_2 is not pressed

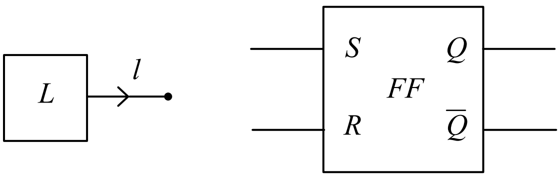
A logic circuit has to be designed to meet the following conditions.

1. When B_1 is pressed the lift stops at the F^{th} floor only if it is in upward motion.
2. When B_2 is pressed the lift stops at the F^{th} floor only if it is in downward motion.

(i) Taking m, b_1 and b_2 as the inputs and Q as the output prepare a truth table to satisfy above conditions.
Consider $Q = 1$ represents the lift stops at the F^{th} floor
$Q = 0$ represents the lift does not stop at the F^{th} floor

(ii) Using the truth table, obtain a Boolean expression for Q and draw the relevant logic circuit. (you may use logic gates with three inputs.)

(*b*) Whenever there is a failure of mains power supply, the lift is automatically driven by a battery backup. For this, another sensor (L) and a flip - flop (FF) are used.



The output (l) of the sensor (L) is as follows.
$l = 1$ when mains power is available.
$l = 0$ when mains power is not available.

The outputs Q and $\overline{Q}$ of the flip-flop (FF) controls the supply of power to the lift as follows.
When $Q = 1$ the lift is powered up by the mains power.
$Q = 0$ the lift is powered up by the battery backup.

(i) Draw a diagram showing how the signal l should be coupled to the inputs S and R of the flip - flop. You are allowed to use only one additional logic gate for this.

(ii) When the mains power is used, a green LED (G) should light to indicate it. When the battery backup is used, a yellow LED (Y) should light to indicate it. In your diagram show how the LEDs should be connected to Q and $\overline{Q}$ terminals.

10 Answer **either part (A) or part (B)** only.

(A) (*a*) Introduce (i) adiabatic and (ii) isothermal processes.

(*b*)

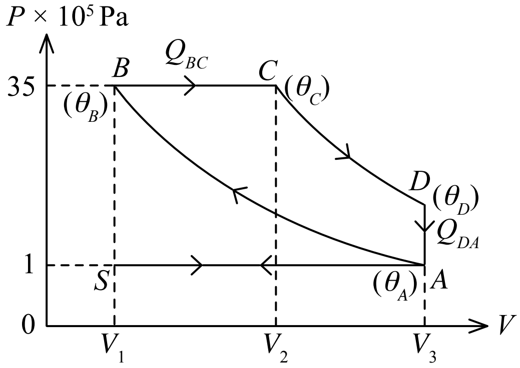


Figure (1)

Figure (1) shows the standard *PV* cycle for a Diesel engine. θ_A, θ_B, θ_C and θ_D are the temperatures of the air mixture at the situations *A*, *B*, *C* and *D* respectively.

Process *S*→*A* (suction stroke);

Air at atmospheric pressure 1.0×10^5 Pa is drawn into the cylinder under constant pressure.

Process *A*→*B* (compression stroke);

In this stroke temperature of air mixture increases from $\theta_A = 50$ °C to $\theta_B = 1000$ °C and the pressure increases from 1.0×10^5 Pa to 35.0×10^5 Pa under **adiabatic compression**.

Process *B*→*C* (fuel injection and combustion);

Diesel droplets sprayed into the cylinder and the air-diesel mixture ignites. Temperature increases from $\theta_B = 1000$ °C to $\theta_C = 2000$ °C under **constant pressure expansion**.

Process *C*→*D* (power stroke);

Temperature of air mixture decreases from $\theta_C = 2000$ °C to $\theta_D = 850$ °C under **adiabatic expansion**.

Process *D*→*A* (exhaust stroke);

Pressure reaches to initial pressure of 1.0×10^5 Pa **under constant volume**. Temperature decreases from $\theta_D = 850$ °C back to $\theta_A = 50$ °C.

(i) During the process *A*→*B* what is the heat exchange (ΔQ_{AB})?

(ii) During the process *B*→*C* find the heat exchange (ΔQ_{BC}) for a air-diesel mixture of 100 g. (C_P for air-diesel mixture = 1000 J kg^{-1} K^{-1}).

(iii) During the process *C*→*D* what is the heat exchange (ΔQ_{CD})?

(iv) During the process *D*→*A* find the heat exchange (ΔQ_{DA}) for a air-diesel mixture of 100 g. (C_V for air-diesel mixture = 750 J kg^{-1} K^{-1}).

(v) For the complete process *ABCDA* find the net heat exchange (ΔQ_{Total}).

(vi) What is the change in the internal energy (ΔU_{Total}) for the complete process *ABCDA*?

(vii) For the complete process *ABCDA* find the net work done (ΔW_{Total})?

(viii) What is the energy liberated by the fuel (i.e. energy input)?

(ix) Calculate the efficiency (*e*) of the engine.

(B) PET (Positron Emission Tomography) scanners are used heavily in clinical oncology, medical imaging of tumors, and for clinical diagnosis of certain brain diseases. The widely used radiopharmaceutical in PET scanners is fluorodeoxy glucose ($C_6H_{11}{}^{18}FO_5$) commonly known as FDG, where positron emitting radionuclide fluorine -18 is substituted for the normal hydroxyl group at one of the C positions in the glucose molecule. The decay scheme of ${}^{18}_{9}F$ is given below.

(*a*) ${}^{18}_{9}F \rightarrow {}^{18}_{8}O + e^{+} + \nu_e$

(i) Name the particle ν_e.

(ii) Rewrite the above decay scheme using nucleons (i.e. using protons and neutrons).

(iii) Rewrite the above decay scheme using quarks and leptons.

(*b*) In a typical scanning application a dose of FDG solution is injected rapidly into a saline drip running into a vein in a patient. Assume that the initial activity of injected ${}^{18}_{9}F$ is 70 MBq and the half-life ($T_{1/2}$) of ${}^{18}_{9}F$ is 2.0 hours.

(i) Give reasons as to why the half -life of a radiopharmaceutical cannot be extremely small or very large.

(ii) The activity A of a radioactive sample with N number of radioactive atoms is given by the formula $A = \frac{0.7N}{T_{1/2}}$. Calculate the mass of FDG sample needed in order to acquire 70 MBq activity. Take the mass of one FDG molecule as 3.0×10^{-25} kg.

(iii) During 2.0 hours after injection if the brain absorbs only 10% of the injected FDG, calculate the activity of ${}^{18}_{9}F$ inside the brain after 2.0 hours.

(*c*) In practice, patients who have been injected with FDG are told to avoid the close vicinity of especially radiation-sensitive persons such as infants, children and pregnant women, for at least 24 hours.

(i) What is the reason for this?

(ii) Due to natural radioactivity (${}^{14}C$, ${}^{40}K$), an activity of about 10^4 Bq is present in the body of a typical person. Justify that 24 hours of waiting time is sufficient for a patient injected with FDG with initial activity of 70 MBq.(Take $\frac{7}{4096} = 1.7 \times 10^{-3}$)

(iii) Positrons emitted by ${}^{18}_{9}F$ annihilate with electrons present in the body and generate two gamma rays. State **two** advantageous of using the PET technique in clinical diagnosis.

(*d*) Since these radiopharmaceuticals have short half-lives one cannot store them for longer periods. Therefore these have to be imported in large quantities or be imported frequently and this process is very expensive. ${}^{18}_{9}F$ is produced by bombarding protons onto ${}^{18}_{8}O$ enriched water and the nuclear reaction that take place is given below.

$$p + {}^{18}_{8}O \rightarrow {}^{18}_{9}F + ?$$

(i) Identify the missing particle in the above reaction.

(ii) The protons need at least 18 Me V to initiate the above reaction. Name the field (electric or magnetic) that scientists are generally using to increase the kinetic energy of charged particles.

(iii) Name a machine that scientists are using to increase the kinetic energy of protons with the help of the field mentioned in (d) (ii) above.

* * *