PGIMER BSc Nursing Physics

Sample Paper – 5

Duration: 23 Minutes **Maximum Marks: 25**

Instructions

- This paper contains **25** Multiple Choice Questions (Single Correct Answer), modelled on the Physics portion of the **PGIMER BSc Nursing** entrance exam.
- Each correct answer carries **+1 mark**. **0.25 mark** is deducted for every incorrect answer. Unattempted questions carry **0 marks**.
- Only **one** option is correct. Choose carefully.
- Syllabus level: **Class 11 and 12 (NCERT) Physics**.
- The exam is conducted as a computer-based test. Personal calculators, mobile phones, log tables, and other electronic gadgets are strictly prohibited.

Q1. The density of a certain liquid is measured as 5 g cm^{-3}. Expressed in SI base units (kg m^{-3}), this density is:

(A) 5000 kg m^{-3}

(B) 500 kg m^{-3}

(C) 50 kg m^{-3}

(D) 0.005 kg m^{-3}

Q2. A car covers the first half of a journey at a constant speed of 40 km h^{-1} and the second half at a constant speed of 60 km h^{-1}. The average speed for the whole journey is:

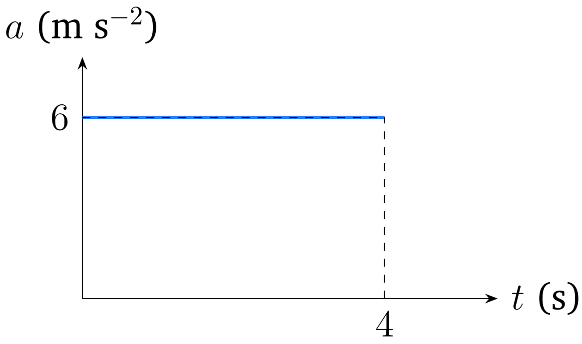
(A) 50 km h^{-1}

(B) 52 km h^{-1}

(C) 45 km h^{-1}

(D) 48 km h^{-1}

Q3. A body starts from rest. Its acceleration–time graph is shown below. The velocity gained by the body during the 4 s interval equals the area under the graph and is:



(A) 12 m s^{-1}

(B) 18 m s^{-1}

(C) 24 m s^{-1}

(D) 30 m s^{-1}

Q4. A car negotiates a circular turn of radius 40 m at a speed of 20 m s^{-1} on a banked road designed so that no friction is needed. Taking $g = 10$ m s^{-2}, the angle of banking θ (where $\tan\theta = v^2/rg$) is:

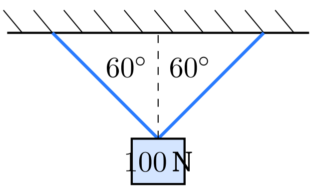
(A) $45°$

(B) $30°$

(C) $60°$

(D) $90°$

Q5. A weight of 100 N hangs in equilibrium from a point that is supported by two light strings fixed to a horizontal ceiling. Each string makes an angle of $60°$ with the vertical, as shown. The tension in each string is:



(A) 50 N

(B) 200 N

(C) 100 N

(D) 173 N

Q6. An engine moves a vehicle at a constant speed of 15 m s^{-1} along a level road against a constant frictional resistance of 800 N. The power developed by the engine is:

(A) 10 kW

(B) 12 kW

(C) 8 kW

(D) 53 kW

Q7. A uniform solid sphere of mass 2 kg rolls without slipping along a horizontal surface with a speed of 3 m s^{-1}. For a solid sphere the total kinetic energy is $\frac{7}{10}mv^2$. The total kinetic energy of the sphere is:

(A) 9 J

(B) 18 J

(C) 12.6 J

(D) 3.6 J

Q8. Two satellites revolve around a planet in circular orbits of radii r and $4r$. If the period of the satellite in the inner orbit is T, then by Kepler's third law ($T^2 \propto r^3$) the period of the satellite in the outer orbit is:

(A) $4T$

(B) $16T$

(C) $2T$

(D) $8T$

Q9. A small sphere falls through a viscous liquid and attains a terminal velocity v. By Stokes' law the terminal velocity is proportional to the square of the radius. A second sphere of the same material but twice the radius, falling through the same liquid, attains a terminal velocity of:

(A) $2v$

(B) $4v$

(C) $v/2$

(D) $8v$

Q10. How much heat is required to raise the temperature of 2 kg of water from $20°$C to $70°$C? (Specific heat capacity of water $c = 4200$ J kg^{-1} °C^{-1}.)

(A) 2.1×10^5 J

(B) 4.2×10^5 J

(C) 4.2×10^4 J

(D) 8.4×10^5 J

Q11. According to the kinetic theory of gases, the pressure of an ideal gas is $P = \dfrac{1}{3}\rho c^2$, where ρ is the density and c is the root-mean-square speed of the molecules. For a gas of density 1.2 kg m^{-3} with $c = 500$ m s^{-1}, the pressure is:

(A) 3×10^5 Pa

(B) 2×10^5 Pa

(C) 0.5×10^5 Pa

(D) 1×10^5 Pa

Q12. A particle executes simple harmonic motion of amplitude 0.1 m on a spring of force constant 200 N m^{-1}. The total mechanical energy of the oscillation ($E = \frac{1}{2}kA^2$) is:

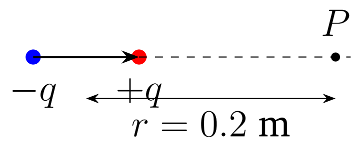
(A) 2 J

(B) 1 J

(C) 0.5 J

(D) 4 J

Q13. An electric dipole has a dipole moment $p = 4 \times 10^{-9}$ C m. The electric field at a point on its axial line, 0.2 m from the centre, is given by $E = \frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}$ with $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}. The field is:



(A) 4500 N C^{-1}

(B) 9000 N C^{-1}

(C) 18000 N C^{-1}

(D) 900 N C^{-1}

Q14. A parallel-plate capacitor has a capacitance of 5 μF with air between its plates. The gap is then completely filled with a dielectric of dielectric constant $K = 4$. The new capacitance is:

(A) 20 μF

(B) 5 μF

(C) 1.25 μF

(D) 9 μF

Q15. In a single-loop circuit, two cells of emf 8 V and 4 V are connected so that they drive current in the same direction around the loop. The loop also contains resistances of 2 Ω and 4 Ω in series, and the cells have negligible internal resistance. Using Kirchhoff's voltage law, the current in the loop is:

(A) 1 A

(B) 0.5 A

(C) 2 A

(D) 5 A

Q16. A wire of length 2 m and uniform cross-sectional area 0.5 mm^2 has a resistance of $0.1\ \Omega$. The resistivity of the material of the wire ($\rho = RA/L$) is:

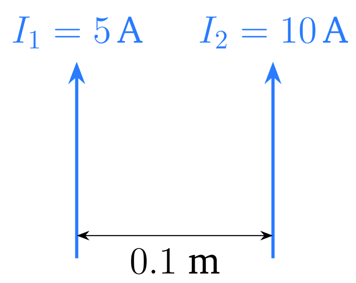
(A) $2.5 \times 10^{-8}\ \Omega\,\text{m}$

(B) $5 \times 10^{-8}\ \Omega\,\text{m}$

(C) $1.25 \times 10^{-8}\ \Omega\,\text{m}$

(D) $2.5 \times 10^{-7}\ \Omega\,\text{m}$

Q17. Two long straight parallel wires, separated by 0.1 m, carry currents of 5 A and 10 A in the same direction, as shown. Taking $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}, the force per unit length between them is:



(A) $1 \times 10^{-4}\ \text{N m}^{-1}$

(B) $2 \times 10^{-4}\ \text{N m}^{-1}$

(C) $0.5 \times 10^{-4}\ \text{N m}^{-1}$

(D) $1 \times 10^{-3}\ \text{N m}^{-1}$

Q18. At a certain place on the Earth's surface, the horizontal component of the Earth's magnetic field is found to be equal in magnitude to its vertical component. The angle of dip ($\tan\delta = B_V/B_H$) at that place is:

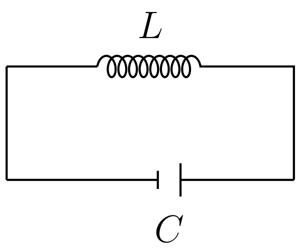
(A) 0°

(B) 30°

(C) 60°

(D) 45°

Q19. An LC circuit consists of an inductor $L = 0.5$ H and a capacitor $C = 2\ \mu$F connected in a loop, as shown. The resonant frequency $f = \dfrac{1}{2\pi\sqrt{LC}}$ of the circuit is approximately:



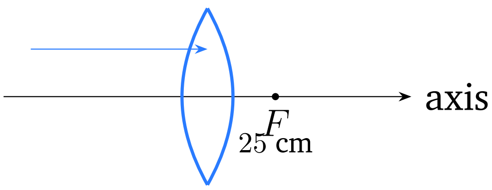
(A) 318 Hz

(B) 1000 Hz

(C) 80 Hz

(D) 159 Hz

Q20. A thin convex lens has a focal length of 25 cm. Its power, measured in dioptres, is:



(A) $+2.5$ D

(B) $+4$ D

(C) -4 D

(D) $+0.25$ D

Q21. Light travelling in air is incident on the surface of a glass slab of refractive index $\sqrt{3}$. The angle of incidence at which the reflected light is completely plane-polarised (Brewster's angle, where $\tan i_B = n$) is:

(A) 30°

(B) 60°

(C) 45°

(D) 90°

Q22. A monochromatic source emits light of wavelength 6600 Å at a power of 10 W. Taking $h = 6.6 \times 10^{-34}$ J s and $c = 3 \times 10^{8}$ m s^{-1}, the number of photons emitted by the source per second is approximately:

(A) 3×10^{18}

(B) 1×10^{20}

(C) 6.6×10^{19}

(D) 3.3×10^{19}

Q23. In the Bohr model of the hydrogen atom, the speed of the electron in the nth orbit is $v_n = \dfrac{2.18 \times 10^{6}}{n}$ m s^{-1}. The speed of the electron in the second orbit ($n = 2$) is:

(A) 1.09×10^{6} m s^{-1}

(B) 2.18×10^{6} m s^{-1}

(C) 0.73×10^{6} m s^{-1}

(D) 4.36×10^{6} m s^{-1}

Q24. The nucleus $^{226}_{88}$Ra undergoes alpha decay. The atomic number (Z) and mass number (A) of the daughter nucleus are, respectively:

(A) $Z = 88,\ A = 222$

(B) $Z = 86,\ A = 226$

(C) $Z = 86,\ A = 222$

(D) $Z = 90,\ A = 222$

Q25. A Zener diode with a breakdown voltage of 6 V is used as a voltage regulator. It is connected in reverse bias across the load, with an unregulated input of 10 V supplied through a series resistor of $200\ \Omega$. When the Zener is regulating, the current through the series resistor is:

(A) 50 mA

(B) 30 mA

(C) 20 mA

(D) 80 mA

Detailed Solutions

Q1.

Solution

Concept — SI unit conversion: To convert from g cm^{-3} to the SI unit kg m^{-3}, convert grams to kilograms and cubic centimetres to cubic metres separately.

Step 1 — Convert the mass unit: $1 \text{ g} = 10^{-3}$ kg.

Step 2 — Convert the volume unit: $1 \text{ cm} = 10^{-2}$ m, so $1 \text{ cm}^3 = (10^{-2})^3 \text{ m}^3 = 10^{-6} \text{ m}^3$.

Step 3 — Combine the conversion factors:

$$1 \frac{\text{g}}{\text{cm}^3} = \frac{10^{-3} \text{ kg}}{10^{-6} \text{ m}^3} = 10^3 \frac{\text{kg}}{\text{m}^3}.$$

Step 4 — Apply to the given value:

$$5 \frac{\text{g}}{\text{cm}^3} = 5 \times 10^3 = 5000 \text{ kg m}^{-3}.$$

Why other options are wrong:

- Option B (500): uses a factor of 10^2 instead of 10^3.
- Option C (50): uses a factor of 10.
- Option D (0.005): divides instead of multiplies by 10^3.

Final Answer: Density $= 5000 \text{ kg m}^{-3} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q1

Q2.

Solution

Concept — Average speed for equal distances: When equal distances are covered at different speeds, the average speed is the harmonic mean, not the arithmetic mean.

Step 1 — Set up the average speed: Let the total distance be $2s$, so each half is s.

$$\text{Average speed} = \frac{\text{total distance}}{\text{total time}} = \frac{2s}{t_1 + t_2}.$$

Step 2 — Find the time for each half:

$$t_1 = \frac{s}{40}, \qquad t_2 = \frac{s}{60}.$$

Step 3 — Substitute the times:

$$\text{Average speed} = \frac{2s}{\frac{s}{40} + \frac{s}{60}} = \frac{2}{\frac{1}{40} + \frac{1}{60}}.$$

Step 4 — Simplify the denominator:

$$\frac{1}{40} + \frac{1}{60} = \frac{3}{120} + \frac{2}{120} = \frac{5}{120} = \frac{1}{24}.$$

Step 5 — Complete the calculation:

$$\text{Average speed} = \frac{2}{1/24} = 2 \times 24 = 48 \text{ km h}^{-1}.$$

Why other options are wrong:

- Option A (50): takes the arithmetic mean $(40 + 60)/2$.
- Option B (52): incorrect averaging.
- Option C (45): arithmetic slip.

Final Answer: Average speed $= 48$ km h^{-1} $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q2

Q3.

Solution

Concept — Area under an acceleration–time graph: The change in velocity of a body equals the area enclosed between the a–t graph and the time axis.

Step 1 — Read the graph: The acceleration is constant at 6 m s^{-2} throughout the interval from $t = 0$ to $t = 4$ s.

Step 2 — Identify the shape: A constant acceleration over time forms a rectangle of height 6 m s^{-2} and width 4 s.

Step 3 — Compute the area:

$$\Delta v = \text{height} \times \text{width} = 6 \times 4 = 24 \text{ m s}^{-1}.$$

Step 4 — Interpret the result: Since the body starts from rest, the velocity gained equals this area, 24 m s^{-1}.

Why other options are wrong:

- Option A (12): treats the area as a triangle ($\frac{1}{2} \times 4 \times 6$).
- Option B (18): uses a width of 3 s.
- Option D (30): uses a height of 7.5.

Final Answer: Velocity gained $= 24 \text{ m s}^{-1} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q3

Q4.

Solution

Concept — Banking of a road: On a frictionless banked road, the horizontal component of the normal reaction supplies the centripetal force, giving $\tan\theta = \frac{v^2}{rg}$.

Step 1 — List the values: Speed $v = 20 \text{ m s}^{-1}$.

Radius $r = 40$ m.

$g = 10 \text{ m s}^{-2}$.

Step 2 — Substitute into the banking formula:

$$\tan\theta = \frac{v^2}{rg} = \frac{(20)^2}{40 \times 10}.$$

Step 3 — Simplify:

$$\tan\theta = \frac{400}{400} = 1.$$

Step 4 — Find the angle:

$$\theta = \tan^{-1}(1) = 45^\circ.$$

Why other options are wrong:

- Option B (30°): would need $\tan\theta = 1/\sqrt{3} \approx 0.58$.
- Option C (60°): would need $\tan\theta = \sqrt{3} \approx 1.73$.

- Option D (90°): would require an infinite ratio.

Final Answer: Angle of banking $= 45^\circ \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q4

Q5.

Solution

Concept — Equilibrium of concurrent forces: For a weight held by two symmetric strings, the vertical components of the two tensions together balance the weight.

Step 1 — Resolve the tensions vertically: Each string makes 60° with the vertical, so the vertical component of each tension is $T \cos 60^\circ$.

Step 2 — Apply the equilibrium condition: The two vertical components support the weight W:

$$2T \cos 60^\circ = W.$$

Step 3 — Substitute the values: With $\cos 60^\circ = 0.5$ and $W = 100$ N:

$$2T \times 0.5 = 100.$$

$$T = 100 \text{ N}.$$

Step 4 — Check the horizontal balance: The horizontal components $T \sin 60^\circ$ of the two strings point in opposite directions and cancel, confirming equilibrium.

Why other options are wrong:

- Option A (50 N): forgets that two strings share the load and miscounts the cosine factor.
- Option B (200 N): inverts the cosine factor.
- Option D (173 N): uses $\sin 60^\circ$ instead of $\cos 60^\circ$.

Final Answer: Tension in each string $= 100$ N $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q5

Q6.

Solution

Concept — Power at constant velocity: When a vehicle moves at constant speed, the engine's driving force equals the opposing resistance, and the power delivered is $P = Fv$.

Step 1 — Identify the driving force: At constant speed there is no acceleration, so the engine force equals the friction: $F = 800$ N.

Step 2 — List the speed: $v = 15 \text{ m s}^{-1}$.

Step 3 — Apply the power relation:

$$P = Fv = 800 \times 15.$$

Step 4 — Simplify:

$$P = 12000 \text{ W} = 12 \text{ kW}.$$

Why other options are wrong:

- Option A (10 kW): uses a speed of 12.5 m s^{-1}.
- Option C (8 kW): uses a speed of 10 m s^{-1}.
- Option D (53 kW): multiplies by an extra factor.

Final Answer: Power $= 12$ kW $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q6

Q7.

Solution

Concept — Kinetic energy of a rolling body: A rolling body has both translational kinetic energy $\frac{1}{2}mv^2$ and rotational kinetic energy $\frac{1}{2}I\omega^2$. For a solid sphere these add to $\frac{7}{10}mv^2$.

Step 1 — Recall the combined formula: For a solid sphere rolling without slipping, total $KE = \dfrac{7}{10}mv^2$.

Step 2 — List the values: Mass $m = 2$ kg.

Speed $v = 3 \text{ m s}^{-1}$, so $v^2 = 9 \text{ m}^2 \text{ s}^{-2}$.

Step 3 — Substitute:

$$KE = \frac{7}{10} \times 2 \times 9.$$

Step 4 — Simplify:

$$KE = \frac{7}{10} \times 18 = \frac{126}{10} = 12.6 \text{ J}.$$

Why other options are wrong:

- Option A (9 J): counts only the translational part $\frac{1}{2}mv^2$.
- Option B (18 J): uses mv^2 without any factor.
- Option D (3.6 J): uses only the rotational part $\frac{1}{5}mv^2$.

Final Answer: Total kinetic energy $= 12.6$ J $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q7

Q8.

Solution

Concept — Kepler's third law: The square of the orbital period is proportional to the cube of the orbital radius: $T^2 \propto r^3$.

Step 1 — Write the ratio for the two orbits:

$$\frac{T_2^2}{T_1^2} = \left(\frac{r_2}{r_1}\right)^3.$$

Step 2 — Substitute the radii ($r_1 = r$, $r_2 = 4r$):

$$\frac{T_2^2}{T^2} = \left(\frac{4r}{r}\right)^3 = 4^3 = 64.$$

Step 3 — Take the square root:

$$\frac{T_2}{T} = \sqrt{64} = 8.$$

$$T_2 = 8T.$$

Why other options are wrong:

- Option A ($4T$): assumes $T \propto r$.
- Option B ($16T$): squares the radius ratio instead of cubing then rooting.

- Option C ($2T$): uses $T \propto \sqrt{r}$.

Final Answer: Period of the outer satellite $= 8T \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q8

Q9.

Solution

Concept — Terminal velocity (Stokes' law): A small sphere falling through a viscous fluid reaches a terminal velocity $v_t = \dfrac{2r^2(\rho - \sigma)g}{9\eta}$, so for the same material and fluid $v_t \propto r^2$.

Step 1 — Write the proportionality:

$$\frac{v_2}{v_1} = \left(\frac{r_2}{r_1}\right)^2.$$

Step 2 — Substitute the radius ratio ($r_2 = 2r_1$):

$$\frac{v_2}{v_1} = \left(\frac{2r_1}{r_1}\right)^2 = 2^2 = 4.$$

Step 3 — Solve for the new terminal velocity:

$$v_2 = 4v_1 = 4v.$$

Why other options are wrong:

- Option A ($2v$): assumes $v_t \propto r$.
- Option C ($v/2$): treats velocity as inversely proportional to radius.
- Option D ($8v$): uses $v_t \propto r^3$.

Final Answer: New terminal velocity $= 4v \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q9

Q10.

Solution

Concept — Heat and temperature change: The heat needed to change the temperature of a body is $Q = mc\,\Delta T$, where m is mass, c is specific heat capacity and ΔT is the temperature rise.

Step 1 — List the values: Mass $m = 2$ kg.

Specific heat $c = 4200$ J kg^{-1} °C^{-1}.

Temperature rise $\Delta T = 70 - 20 = 50\,°$C.

Step 2 — Substitute into the formula:

$$Q = mc\,\Delta T = 2 \times 4200 \times 50.$$

Step 3 — Simplify step by step:

$$2 \times 4200 = 8400.$$

$$Q = 8400 \times 50 = 420000 \text{ J}.$$

$$Q = 4.2 \times 10^5 \text{ J}.$$

Why other options are wrong:

- Option A (2.1×10^5): uses $\Delta T = 25$.
- Option C (4.2×10^4): power-of-ten slip.
- Option D (8.4×10^5): uses $\Delta T = 100$.

Final Answer: Heat required $= 4.2 \times 10^5$ J $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q10

Q11.

Solution

Concept — Pressure from kinetic theory: Kinetic theory gives the gas pressure as $P = \frac{1}{3}\rho c^2$, where ρ is the density and c the rms speed.

Step 1 — List the values: Density $\rho = 1.2$ kg m^{-3}.

Rms speed $c = 500$ m s^{-1}, so $c^2 = 2.5 \times 10^5$ m^2 s^{-2}.

Step 2 — Substitute into the formula:

$$P = \frac{1}{3} \times 1.2 \times 2.5 \times 10^5.$$

Step 3 — Multiply the numerator:

$$1.2 \times 2.5 \times 10^5 = 3.0 \times 10^5.$$

Step 4 — Divide by 3:

$$P = \frac{3.0 \times 10^5}{3} = 1 \times 10^5 \text{ Pa}.$$

Why other options are wrong:

- Option A (3×10^5): forgets to divide by 3.
- Option B (2×10^5): arithmetic error.
- Option C (0.5×10^5): halves the correct value.

Final Answer: Pressure $= 1 \times 10^5$ Pa $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q11

Q12.

Solution

Concept — Total energy in SHM: The total mechanical energy of a simple harmonic oscillator is constant and equals $E = \frac{1}{2}kA^2$, where k is the force constant and A the amplitude.

Step 1 — List the values: Force constant $k = 200$ N m^{-1}.

Amplitude $A = 0.1$ m, so $A^2 = 0.01$ m^2.

Step 2 — Substitute into the energy formula:

$$E = \frac{1}{2} \times 200 \times 0.01.$$

Step 3 — Simplify:

$$E = \frac{1}{2} \times 2 = 1 \text{ J}.$$

Why other options are wrong:

- Option A (2 J): forgets the factor $\frac{1}{2}$.
- Option C (0.5 J): halves the correct value.
- Option D (4 J): uses an amplitude of 0.2 m.

Final Answer: Total energy $= 1$ J $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q12

Q13.

Solution

Concept — Axial field of a dipole: On the axis of a short dipole, the electric field is $E = \dfrac{1}{4\pi\varepsilon_0}\dfrac{2p}{r^3}$.

Step 1 — List the values: Dipole moment $p = 4 \times 10^{-9}$ C m.

Distance $r = 0.2$ m, so $r^3 = (0.2)^3 = 0.008$ m^3.

$\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^9$.

Step 2 — Substitute into the formula:

$$E = 9 \times 10^9 \times \frac{2 \times (4 \times 10^{-9})}{0.008}.$$

Step 3 — Simplify the numerator:

$$9 \times 10^9 \times 2 \times 4 \times 10^{-9} = 9 \times 8 = 72.$$

Step 4 — Divide by r^3:

$$E = \frac{72}{0.008} = 9000 \text{ N C}^{-1}.$$

Why other options are wrong:

- Option A (4500): drops the factor of 2 for the axial field.
- Option C (18000): doubles the correct value.
- Option D (900): power-of-ten slip in r^3.

Final Answer: Axial field $= 9000$ N C^{-1} $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q13

Q14.

Solution

Concept — Dielectric in a capacitor: Filling the gap of a parallel-plate capacitor completely with a dielectric of constant K multiplies its capacitance by K: $C' = KC$.

Step 1 — List the values: Original capacitance $C = 5\ \mu$F.

Dielectric constant $K = 4$.

Step 2 — Apply the relation:

$$C' = KC = 4 \times 5\ \mu\text{F}.$$

Step 3 — Simplify:

$$C' = 20\ \mu\text{F}.$$

Step 4 — Reason physically: The dielectric reduces the field between the plates for the same charge, so more charge can be stored at the same voltage, increasing the capacitance.

Why other options are wrong:

- Option B ($5\ \mu$F): assumes no change.
- Option C ($1.25\ \mu$F): divides by K instead of multiplying.
- Option D ($9\ \mu$F): adds K instead of multiplying.

Final Answer: New capacitance $= 20\ \mu\text{F} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q14

Q15.

Solution

Concept — Kirchhoff's voltage law: Around any closed loop the algebraic sum of the emfs equals the sum of the potential drops across the resistors.

Step 1 — Add the emfs (they aid each other):

$$\sum \varepsilon = 8 + 4 = 12\ \text{V}.$$

Step 2 — Add the resistances (in series):

$$\sum R = 2 + 4 = 6\ \Omega.$$

Step 3 — Apply Kirchhoff's voltage law:

$$\sum \varepsilon = I \sum R.$$

$$12 = I \times 6.$$

Step 4 — Solve for the current:

$$I = \frac{12}{6} = 2\ \text{A}.$$

Why other options are wrong:

- Option A (1 A): uses only one emf of 6 V or doubles the resistance.
- Option B (0.5 A): inverts the calculation.
- Option D (5 A): subtracts the emfs and mishandles the resistance.

Final Answer: Loop current $= 2$ A $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q15

Q16.

Solution

Concept — Resistivity from resistance: The resistance of a wire is $R = \rho\frac{L}{A}$, so the resistivity is $\rho = \frac{RA}{L}$.

Step 1 — Convert the area to SI units:

$$A = 0.5\ \text{mm}^2 = 0.5 \times 10^{-6}\ \text{m}^2 = 5 \times 10^{-7}\ \text{m}^2.$$

Step 2 — List the other values: Resistance $R = 0.1\ \Omega$.

Length $L = 2$ m.

Step 3 — Substitute into the formula:

$$\rho = \frac{RA}{L} = \frac{0.1 \times 5 \times 10^{-7}}{2}.$$

Step 4 — Simplify:

$$\rho = \frac{5 \times 10^{-8}}{2} = 2.5 \times 10^{-8}\ \Omega\,\text{m}.$$

Why other options are wrong:

- Option B (5×10^{-8}): forgets to divide by the length.
- Option C (1.25×10^{-8}): divides by an extra factor of 2.
- Option D (2.5×10^{-7}): power-of-ten error in the area.

Final Answer: Resistivity $= 2.5 \times 10^{-8}\ \Omega\,\text{m} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q16

Q17.

Solution

Concept — Force between parallel currents: Two long parallel wires carrying currents I_1 and I_2 separated by distance d exert a force per unit length $\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi d}$.

Step 1 — List the values: $I_1 = 5$ A, $I_2 = 10$ A.

Separation $d = 0.1$ m.

$\frac{\mu_0}{2\pi} = \frac{4\pi \times 10^{-7}}{2\pi} = 2 \times 10^{-7}$ T m A^{-1}.

Step 2 — Substitute into the formula:

$$\frac{F}{L} = 2 \times 10^{-7} \times \frac{5 \times 10}{0.1}.$$

Step 3 — Simplify the fraction:

$$\frac{5 \times 10}{0.1} = \frac{50}{0.1} = 500.$$

Step 4 — Complete the calculation:

$$\frac{F}{L} = 2 \times 10^{-7} \times 500 = 1 \times 10^{-4}\ \text{N m}^{-1}.$$

Why other options are wrong:

- Option B (2×10^{-4}): doubles the result.
- Option C (0.5×10^{-4}): halves the result.
- Option D (1×10^{-3}): power-of-ten slip in the separation.

Final Answer: Force per unit length $= 1 \times 10^{-4}$ N m^{-1} $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q17

Q18.

Solution

Concept — Angle of dip: The angle of dip δ relates the vertical and horizontal components of the Earth's magnetic field through $\tan\delta = \dfrac{B_V}{B_H}$.

Step 1 — Apply the given condition: The horizontal and vertical components are equal: $B_V = B_H$.

Step 2 — Substitute into the dip relation:

$$\tan\delta = \frac{B_V}{B_H} = \frac{B_H}{B_H} = 1.$$

Step 3 — Solve for the dip:

$$\delta = \tan^{-1}(1) = 45^\circ.$$

Why other options are wrong:

- Option A (0°): would require $B_V = 0$ (the magnetic equator).
- Option B (30°): would need $B_V/B_H = 1/\sqrt{3}$.
- Option C (60°): would need $B_V/B_H = \sqrt{3}$.

Final Answer: Angle of dip $= 45^\circ \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q18

Q19.

Solution

Concept — Resonant frequency of an LC circuit: An LC circuit oscillates at its resonant frequency $f = \dfrac{1}{2\pi\sqrt{LC}}$.

Step 1 — List the values: Inductance $L = 0.5$ H.

Capacitance $C = 2\ \mu\text{F} = 2 \times 10^{-6}$ F.

Step 2 — Compute the product LC:

$$LC = 0.5 \times 2 \times 10^{-6} = 1 \times 10^{-6}\ \text{s}^2.$$

Step 3 — Take the square root:

$$\sqrt{LC} = \sqrt{1 \times 10^{-6}} = 1 \times 10^{-3}\ \text{s}.$$

Step 4 — Substitute into the frequency formula:

$$f = \frac{1}{2\pi \times 10^{-3}} = \frac{1000}{2\pi}.$$

$$f = \frac{1000}{6.28} \approx 159\ \text{Hz}.$$

Why other options are wrong:

- Option A (318 Hz): forgets the factor 2 in 2π.
- Option B (1000 Hz): omits the 2π entirely.
- Option C (80 Hz): halves the correct value.

Final Answer: Resonant frequency ≈ 159 Hz $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q19

Q20.

Solution

Concept — Power of a lens: The power of a lens (in dioptres) is the reciprocal of its focal length expressed in metres: $P = \dfrac{1}{f\ (\text{in m})}$. A converging (convex) lens has positive power.

Step 1 — Convert the focal length to metres:

$$f = 25\ \text{cm} = 0.25\ \text{m}.$$

Step 2 — Apply the power formula:

$$P = \frac{1}{f} = \frac{1}{0.25}.$$

Step 3 — Simplify:

$$P = +4 \text{ D}.$$

The sign is positive because the lens is convex (converging).

Why other options are wrong:

- Option A ($+2.5$ D): uses $f = 0.4$ m.
- Option C (-4 D): wrong sign; that would be a concave lens.
- Option D ($+0.25$ D): uses the focal length in metres directly instead of its reciprocal.

Final Answer: Power of the lens $= +4$ D $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q20

Q21.

Solution

Concept — Brewster's law: When light is incident at the polarising (Brewster) angle, the reflected ray is completely plane-polarised, and $\tan i_B = n$, where n is the refractive index of the second medium.

Step 1 — Write Brewster's law:

$$\tan i_B = n.$$

Step 2 — Substitute the refractive index:

$$\tan i_B = \sqrt{3}.$$

Step 3 — Solve for the angle:

$$i_B = \tan^{-1}(\sqrt{3}) = 60^\circ.$$

Why other options are wrong:

- Option A (30°): would need $\tan i_B = 1/\sqrt{3}$.
- Option C (45°): would need $n = 1$.
- Option D (90°): grazing incidence, not the polarising angle.

Final Answer: Brewster's angle $= 60^\circ \Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q21

Q22.

Solution

Concept — Photons from a source: The number of photons emitted per second equals the total power divided by the energy of a single photon, $E = \dfrac{hc}{\lambda}$.

Step 1 — Convert the wavelength to metres:

$$\lambda = 6600 \text{ Å} = 6600 \times 10^{-10} \text{ m} = 6.6 \times 10^{-7} \text{ m}.$$

Step 2 — Find the energy of one photon:

$$E = \frac{hc}{\lambda} = \frac{(6.6 \times 10^{-34}) \times (3 \times 10^{8})}{6.6 \times 10^{-7}}.$$

Step 3 — Simplify the photon energy:

$$E = \frac{1.98 \times 10^{-25}}{6.6 \times 10^{-7}} = 3 \times 10^{-19} \text{ J}.$$

Step 4 — Divide the power by the photon energy:

$$N = \frac{P}{E} = \frac{10}{3 \times 10^{-19}} = 3.3 \times 10^{19} \text{ per second}.$$

Why other options are wrong:

- Option A (3×10^{18}): power-of-ten slip.
- Option B (1×10^{20}): uses the wrong photon energy.
- Option C (6.6×10^{19}): doubles the result.

Final Answer: Number of photons per second $\approx 3.3 \times 10^{19} \Rightarrow \boxed{D}$

Answer: (D) Go Back to Q22

Q23.

Solution

Concept — Electron speed in a Bohr orbit: In the Bohr model the orbital speed is inversely proportional to n: $v_n = \dfrac{2.18 \times 10^6}{n}$ m s^{-1}.

Step 1 — Substitute $n = 2$:

$$v_2 = \frac{2.18 \times 10^6}{2}.$$

Step 2 — Simplify:

$$v_2 = 1.09 \times 10^6 \text{ m s}^{-1}.$$

Step 3 — Interpret: The electron in the second orbit moves at half the speed of the electron in the first orbit, since $v_n \propto 1/n$.

Why other options are wrong:

- Option B (2.18×10^6): is the speed in the first orbit ($n = 1$).
- Option C (0.73×10^6): is the speed in the third orbit ($n = 3$).
- Option D (4.36×10^6): doubles the first-orbit speed instead of halving it.

Final Answer: Speed in the $n = 2$ orbit $= 1.09 \times 10^6$ m s^{-1} $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q23

Q24.

Solution

Concept — Alpha decay: In alpha decay the nucleus emits an alpha particle ($^4_2$He), so the atomic number Z decreases by 2 and the mass number A decreases by 4.

Step 1 — Note the parent nucleus: $^{226}_{88}$Ra has $Z = 88$ and $A = 226$.

Step 2 — Apply the change in atomic number:

$$Z' = 88 - 2 = 86.$$

Step 3 — Apply the change in mass number:

$$A' = 226 - 4 = 222.$$

Step 4 — Identify the daughter: The daughter nucleus is $^{222}_{86}$Rn, with $Z = 86$ and

$A = 222$.

Why other options are wrong:

- Option A ($Z = 88,\ A = 222$): leaves Z unchanged.
- Option B ($Z = 86,\ A = 226$): changes Z but not A.
- Option D ($Z = 90,\ A = 222$): increases Z (that would be alpha capture, not emission).

Final Answer: Daughter nucleus has $Z = 86,\ A = 222 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q24

Q25.

Solution

Concept — Zener diode as a voltage regulator: A Zener diode in reverse breakdown maintains a constant voltage across the load equal to its breakdown voltage. The series resistor absorbs the difference between the input and the regulated output.

Step 1 — Find the voltage across the series resistor: The output is regulated at the Zener voltage 6 V, so the drop across the series resistor is

$$V_R = V_{\text{in}} - V_Z = 10 - 6 = 4 \text{ V}.$$

Step 2 — Apply Ohm's law to the series resistor:

$$I = \frac{V_R}{R} = \frac{4}{200}.$$

Step 3 — Simplify:

$$I = 0.02 \text{ A} = 20 \text{ mA}.$$

Step 4 — Reason physically: Because the Zener holds the output at 6 V even if the input fluctuates, the regulator delivers a steady voltage to the load.

Why other options are wrong:

- Option A (50 mA): uses the full 10 V across the resistor.
- Option B (30 mA): uses a drop of 6 V instead of 4 V.
- Option D (80 mA): uses a resistance of $50\ \Omega$.

Final Answer: Current through the series resistor $= 20$ mA $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q25

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	D	3	C	4	A	5	C
6	B	7	C	8	D	9	B	10	B
11	D	12	B	13	B	14	A	15	C
16	A	17	A	18	D	19	D	20	B
21	B	22	D	23	A	24	C	25	C