AME CET Physics

Sample Paper – 3

Duration: 20 Minutes **Maximum Marks: 80**

Instructions

- This paper contains **20** Multiple Choice Questions (Single Correct Answer), modelled on the Physics section of **AME CET** entrance.
- Each correct answer carries **+4 marks**. Each wrong answer carries -1 **mark**. Unattempted questions carry **0 marks**.
- Only **one** option is correct per question. Choose carefully.
- Syllabus level: **Class 11 and 12 NCERT Physics** (Units & Measurement to Communication Systems).
- Use of mobile phones, calculators, or any electronic gadget is strictly prohibited.

Q1. At a junction in a circuit, currents of 3 A and 5 A flow **into** the junction through two separate branches. The current flowing **out** of the junction must be:

(A) 2 A

(B) 5 A

(C) 8 A

(D) 15 A

Q2. In a Wheatstone bridge, the arms have resistances $P = 2\ \Omega$, $Q = 4\ \Omega$, and $R = 3\ \Omega$. For the bridge to be balanced (no current through the galvanometer), the value of S must be:

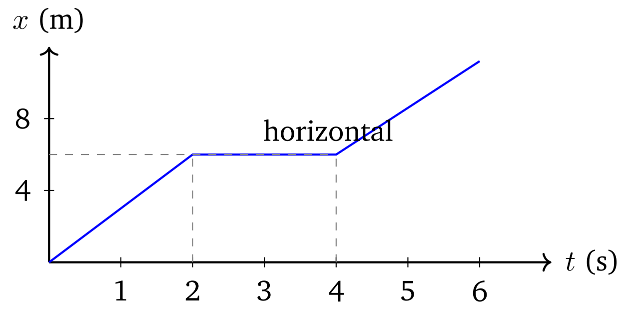
(A) 6 Ω

(B) 3 Ω

(C) 12 Ω

(D) 1.5 Ω

Q3. The displacement–time (x–t) graph of a particle is shown below. During which time interval is the particle **at rest**?



(A) 0 to 2 s

(B) 2 to 4 s

(C) 4 to 6 s

(D) All the time

Q4. Car A moves due east at 60 km/h and Car B moves due west at 40 km/h along the same straight road. The velocity of Car A relative to Car B is:

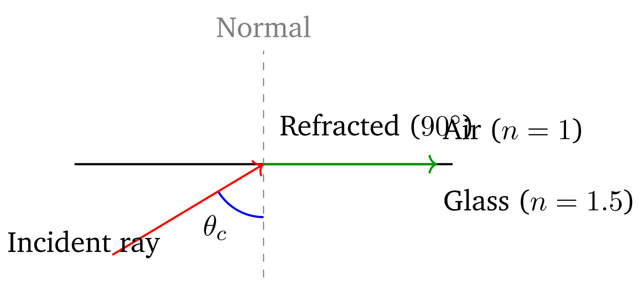
(A) 20 km/h (east)

(B) 40 km/h (east)

(C) 60 km/h (east)

(D) 100 km/h (east)

Q5. A ray of light travels from glass (refractive index $n = 1.5$) to air, as shown in the diagram. The critical angle θ_c for total internal reflection at the glass–air interface is:



(A) 41.8°

(B) 48.6°

(C) 33.6°

(D) 60.0°

Q6. An object is placed 5 cm in front of a concave mirror whose focal length is 10 cm (object is inside the focal length). The nature of the image formed is:

(A) Real, inverted and magnified

(B) Real, inverted and diminished

(C) Real, erect and magnified

(D) Virtual, erect and magnified

Q7. A coil has a self-inductance of $L = 2$ H. If the current through the coil changes at a rate of $\frac{dI}{dt} = 5$ A/s, the magnitude of the self-induced EMF in the coil is:

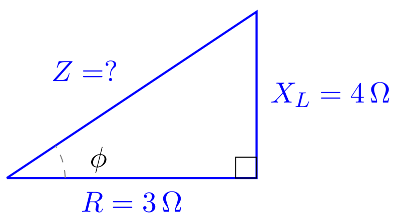
(A) 2.5 V

(B) 10 V

(C) 0.4 V

(D) 20 V

Q8. A series LR circuit has resistance $R = 3\ \Omega$ and inductive reactance $X_L = 4\ \Omega$. The impedance triangle for the circuit is shown below. The impedance Z of the circuit is:



(A) $1\ \Omega$

(B) 7 Ω

(C) 5 Ω

(D) 25 Ω

Q9. A rocket engine ejects exhaust gases at a speed of 40 m/s relative to the rocket. The rate at which mass is burned and ejected is 50 g/s. The thrust force on the rocket is:

(A) 20 N

(B) 0.5 N

(C) 4 N

(D) 2 N

Q10. A block of mass 5 kg is lifted vertically through a height of 3 m. Taking $g = 10$ m/s^2, the gain in gravitational potential energy of the block is:

(A) 15 J

(B) 50 J

(C) 150 J

(D) 30 J

Q11. A point charge $q = 2$ μC is located in free space. The electric potential at a distance of $r = 0.3$ m from the charge is: ($k = 9 \times 10^9$ N·m^2/C^2)

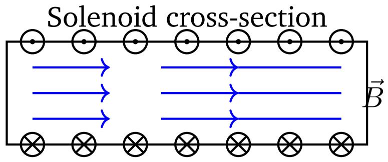
(A) 6×10^4 V

(B) 3×10^4 V

(C) 12×10^4 V

(D) 1×10^4 V

Q12. A solenoid has $N = 1000$ turns, length $L = 0.5$ m, and carries a current $I = 2$ A. The cross-sectional view showing the magnetic field lines inside the solenoid is sketched below. The magnitude of the magnetic field inside the solenoid is: ($\mu_0 = 4\pi \times 10^{-7}$ T·m/A)



(A) $\pi \times 10^{-3}$ T

(B) $16\pi \times 10^{-4}$ T

(C) $8\pi \times 10^{-3}$ T

(D) $4\pi \times 10^{-4}$ T

Q13. The work function of sodium is $\phi = 2.3$ eV. The threshold frequency f_0 below which no photoelectric emission occurs from sodium is: ($h = 6.6 \times 10^{-34}$ J·s, 1 eV $= 1.6 \times 10^{-19}$ J)

(A) 2.3×10^{14} Hz

(B) 3.5×10^{14} Hz

(C) 5.6×10^{14} Hz

(D) 8.0×10^{14} Hz

Q14. The mass defect of a nucleus is found to be $\Delta m = 0.03$ u. The binding energy of the nucleus is: (1 u $= 931.5$ MeV/c^2)

(A) 0.03 MeV

(B) 9.3 MeV

(C) 93.15 MeV

(D) 27.9 MeV

Q15. A sample of 100 g of water is heated and its temperature rises by $60°$C. The specific heat capacity of water is $c = 4.2$ J/(g·°C). The heat energy absorbed by the water is:

(A) 420 J

(B) 25200 J

(C) 4200 J

(D) 2520 J

Q16. A simple pendulum has a time period of $T = 2$ s. Taking $g = 10$ m/s^2 and $\pi^2 \approx 10$, the length of the pendulum is:

(A) 1 m

(B) 0.5 m

(C) 2 m

(D) 0.25 m

Q17. A solid sphere of mass $M = 2$ kg rolls without slipping on a flat surface with a centre-of-mass speed $v = 4$ m/s. The total kinetic energy (translational + rotational) of the sphere is: (For a solid sphere: $I = \frac{2}{5}MR^2$)

(A) 16 J

(B) 22.4 J

(C) 19.2 J

(D) 28.8 J

Q18. When a p–n junction diode is forward biased (positive terminal of the battery connected to the p-side), what happens to the width of the depletion layer?

(A) It increases

(B) It remains unchanged

(C) It becomes a perfect conductor

(D) It decreases

Q19. A small sphere of radius $r_1 = 1$ mm falls through a viscous liquid and reaches a terminal velocity $v_1 = 0.1$ m/s. By Stokes' law, terminal velocity is proportional to r^2. A second sphere made of the same material has terminal velocity $v_2 = 0.4$ m/s in the same liquid. The radius r_2 of the second sphere is:

(A) 0.25 mm

(B) 0.5 mm

(C) 2 mm

(D) 4 mm

Q20. A planet orbits the Sun with a time period of $T = 8$ years. Using Kepler's third law ($T^2 \propto r^3$), the ratio of the orbital radius of this planet to that of the Earth ($T_E = 1$ year, r_E) is:

(A) 4

(B) 8

(C) 2

(D) 16

Detailed Solutions

Q1.

Solution

Concept — Kirchhoff's Current Law (KCL): KCL states that the algebraic sum of all currents at a junction equals zero. In other words, the total current flowing into a junction must equal the total current flowing out.

Step 1 — Identify currents entering the junction:

$$I_{in,1} = 3 \text{ A}, \qquad I_{in,2} = 5 \text{ A}$$

Step 2 — Apply KCL:

$$\sum I_{in} = \sum I_{out}$$
$$3 + 5 = I_{out}$$

Step 3 — Solve for I_{out}:

$$I_{out} = 8 \text{ A}$$

Why other options are wrong:

- Option A (2 A): This is the *difference* of the two currents, not their sum — misapplies KCL.
- Option B (5 A): Equals only the larger incoming current; the 3 A branch is ignored.
- Option D (15 A): This is the product $3 \times 5 = 15$; KCL involves sum, not product.

Final Answer: Current flowing out $= 8$ A $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q1

Q2.

Solution

Concept — Wheatstone Bridge Balance Condition: A Wheatstone bridge is balanced (galvanometer reads zero) when $P/Q = R/S$. Rearranging gives $S = QR/P$.

Step 1 — Write the balance condition:

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

Step 2 — Substitute $P = 2\ \Omega$, $Q = 4\ \Omega$, $R = 3\ \Omega$:

$$S = \frac{4 \times 3}{2}$$

Step 3 — Compute:

$$S = \frac{12}{2} = 6\ \Omega$$

Why other options are wrong:

- Option B (3 Ω): Uses $S = R$ (ignores the ratio Q/P).
- Option C (12 Ω): Uses $S = QR$ without dividing by P — omits the denominator.
- Option D (1.5 Ω): Uses $S = PR/Q = 2 \times 3/4 = 1.5$ — inverts the ratio.

Final Answer: $S = 6\ \Omega \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q2

Q3.

Solution

Concept — Displacement–Time Graph and Velocity: The instantaneous velocity of a particle equals the slope of its x–t graph. A horizontal segment (zero slope) means zero velocity, i.e., the particle is at rest.

Step 1 — Examine the graph from $t = 0$ to $t = 2$ s: The x–t graph rises from $x = 0$ to approximately $x = 6$ m (positive slope). The particle is moving.

Step 2 — Examine the graph from $t = 2$ s to $t = 4$ s: The graph is *horizontal* (constant x, zero slope).

$$v = \frac{dx}{dt} = 0 \text{ m/s} \quad \Rightarrow \quad \text{particle is at rest.}$$

Step 3 — Examine the graph from $t = 4$ s to $t = 6$ s: The graph rises again (positive slope). The particle is moving again.

Why other options are wrong:

- Option A (0 to 2 s): The graph has a positive slope in this interval; the particle is moving.
- Option C (4 to 6 s): The graph rises again; the particle has resumed motion.
- Option D (All the time): The particle moves in two intervals; it is at rest only between $t = 2$ s and $t = 4$ s.

Final Answer: Particle is at rest during $t = 2$ s to $t = 4$ s $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q3

Q4.

Solution

Concept — Relative Velocity: The velocity of object A relative to object B is $\vec{v}_{A/B} = \vec{v}_A - \vec{v}_B$. Taking east as positive, a velocity due west is negative.

Step 1 — Define the positive direction as east:

$$v_A = +60 \text{ km/h}, \qquad v_B = -40 \text{ km/h (moving west)}$$

Step 2 — Apply the relative velocity formula:

$$v_{A/B} = v_A - v_B = (+60) - (-40)$$

Step 3 — Compute:

$$v_{A/B} = 60 + 40 = 100 \text{ km/h (east)}$$

Why other options are wrong:

- Option A (20 km/h): This is $v_A - |v_B| = 60 - 40 = 20$; treats both velocities as same direction.
- Option B (40 km/h): Equals only $|v_B|$; confuses relative velocity with Car B's speed.
- Option C (60 km/h): Equals only v_A; that would be the velocity relative to the ground, not to B.

Final Answer: Velocity of A relative to B $= 100$ km/h (east) $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q4

Q5.

Solution

Concept — Critical Angle and Total Internal Reflection: At the critical angle θ_c, the refracted ray grazes the interface ($\theta_r = 90°$). By Snell's law at the glass–air interface: $n \sin\theta_c = 1 \times \sin 90° = 1$, so $\sin\theta_c = 1/n$.

Step 1 — Apply the critical angle formula:

$$\sin\theta_c = \frac{1}{n} = \frac{1}{1.5} = \frac{2}{3}$$

Step 2 — Compute θ_c:

$$\theta_c = \sin^{-1}\left(\frac{2}{3}\right) \approx 41.8°$$

Why other options are wrong:

- Option B $(48.6°)$: Corresponds to $n = 1/\sin(48.6°) \approx 1.33$ (water), not $n = 1.5$.
- Option C $(33.6°)$: Corresponds to $\sin^{-1}(1/1.8) \approx 33.7°$; uses the wrong refractive index.
- Option D $(60.0°)$: Corresponds to $\sin^{-1}(1/\sqrt{3}/1) \approx 60°$ which is for $n \approx 1.155$, far below 1.5.

Final Answer: $\theta_c \approx 41.8° \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q5

Q6.

Solution

Concept — Concave Mirror with Object Inside Focal Length: When an object is placed between the pole and the focus of a concave mirror (i.e., $u < f$), the mirror formula yields a positive image distance, indicating a virtual image formed behind the mirror. Such an image is erect (same orientation as object) and magnified.

Step 1 — Apply mirror formula (sign convention: distances from pole, incident-ray direction is negative):

$$u = -5 \text{ cm (object inside focus)}, \quad f = -10 \text{ cm (concave mirror)}$$

Step 2 — Use mirror formula $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$:

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-10} - \frac{1}{-5} = -\frac{1}{10} + \frac{1}{5} = \frac{1}{10}$$

Step 3 — Solve for v:

$$v = +10 \text{ cm}$$

Positive v means the image is behind the mirror — it is *virtual*. Magnification $m = -v/u = -10/(-5) = +2 > 0$ (erect and magnified).

Why other options are wrong:

- Option A (Real, inverted, magnified): Real images from concave mirrors require object beyond F; not possible here.
- Option B (Real, inverted, diminished): Diminished images form when object is beyond C; again needs object outside F.
- Option C (Real, erect, magnified): Real images formed by mirrors are always inverted — a real erect image is physically impossible with a single mirror.

Final Answer: Image is virtual, erect and magnified $\Rightarrow$ D

Answer: (D) Go Back to Q6

Q7.

Solution

Concept — Self-Induced EMF: When the current through an inductor changes with time, a self-induced EMF is generated given by $|\varepsilon| = L\frac{dI}{dt}$, where L is the self-inductance and dI/dt is the rate of change of current.

Step 1 — Identify given values:

$$L = 2 \text{ H}, \qquad \frac{dI}{dt} = 5 \text{ A/s}$$

Step 2 — Apply the formula:

$$|\varepsilon| = L \cdot \frac{dI}{dt} = 2 \times 5$$

Step 3 — Compute:

$$|\varepsilon| = 10 \text{ V}$$

Why other options are wrong:

- Option A (2.5 V): Uses $\varepsilon = L/(dI/dt) = 2/5 = 0.4$, or takes $dI/dt = 1.25$; incorrect formula.
- Option C (0.4 V): Uses $\varepsilon = (dI/dt)/L = 5/2/5 = 0.4$; divides instead of multiplies.
- Option D (20 V): Uses $\varepsilon = 2L \cdot (dI/dt) = 4 \times 5$; doubles L erroneously.

Final Answer: Self-induced EMF = 10 V $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q7

Q8.

Solution

Concept — Impedance of a Series LR Circuit: In a series LR (resistor–inductor) circuit, the resistance R and inductive reactance X_L are at right angles in the impedance phasor diagram. The impedance is found using the Pythagorean theorem: $Z = \sqrt{R^2 + X_L^2}$.

Step 1 — Identify given values:

$$R = 3\ \Omega, \qquad X_L = 4\ \Omega$$

Step 2 — Apply the impedance formula:

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{3^2 + 4^2}$$

Step 3 — Compute:

$$Z = \sqrt{9 + 16} = \sqrt{25} = 5\ \Omega$$

This is a classic 3–4–5 Pythagorean triple.

Why other options are wrong:

- Option A (1 Ω): Uses $Z = |X_L - R| = |4 - 3| = 1$ — takes the difference, not the hypotenuse.
- Option B (7 Ω): Uses $Z = R + X_L = 3 + 4 = 7$ — adds directly, ignoring the phase difference.
- Option D (25 Ω): Uses $Z = R^2 + X_L^2 = 9 + 16 = 25$ — forgets to take the square root.

Final Answer: $Z = 5\ \Omega \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q8

Q9.

Solution

Concept — Rocket Thrust Force: By Newton's third law applied to variable mass systems, the thrust on a rocket equals the exhaust speed multiplied by the rate of mass ejection: $F_{thrust} = v_e \cdot \left|\frac{dm}{dt}\right|$.

Step 1 — Convert mass ejection rate to SI units:

$$\left|\frac{dm}{dt}\right| = 50\ \text{g/s} = 50 \times 10^{-3}\ \text{kg/s} = 0.05\ \text{kg/s}$$

Step 2 — Apply the thrust formula:

$$F_{thrust} = v_e \cdot \left|\frac{dm}{dt}\right| = 40\ \text{m/s} \times 0.05\ \text{kg/s}$$

Step 3 — Compute:

$$F_{thrust} = 40 \times 0.05 = 2\ \text{N}$$

Why other options are wrong:

- Option A (20 N): Uses $\dot{m} = 0.5$ kg/s (forgets to convert g/s to kg/s); gives $40 \times 0.5 = 20$.
- Option B (0.5 N): Uses $F = \dot{m}/v_e = 0.05/40 \approx 0.00125$; divides instead of multiplying — or uses $\dot{m} = 0.05/0.1 = 0.5/10$.
- Option C (4 N): Uses $\dot{m} = 0.1$ kg/s instead of 0.05 kg/s (doubles the correct value).

Final Answer: Thrust force $= 2$ N $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q9

Q10.

Solution

Concept — Gravitational Potential Energy: When a body of mass m is raised through a height h near the Earth's surface, the gain in gravitational potential energy is $\Delta PE = mgh$.

Step 1 — Identify given values:

$$m = 5 \text{ kg}, \quad h = 3 \text{ m}, \quad g = 10 \text{ m/s}^2$$

Step 2 — Apply the formula:

$$\Delta PE = m \times g \times h = 5 \times 10 \times 3$$

Step 3 — Compute:

$$\Delta PE = 150 \text{ J}$$

Why other options are wrong:

- Option A (15 J): Uses $\Delta PE = m \times h = 5 \times 3$ — omits g entirely.
- Option B (50 J): Uses $\Delta PE = m \times g = 5 \times 10$ — omits h entirely.
- Option D (30 J): Uses $\Delta PE = 2mh = 2 \times 5 \times 3$; appears to replace g with 2, which is incorrect.

Final Answer: $\Delta PE = 150 \text{ J} \Rightarrow \boxed{\text{C}}$

Answer: (C) **Go Back to Q10**

Q11.

Solution

Concept — Electric Potential Due to a Point Charge: The electric potential at a distance r from a point charge q in free space is $V = k\,q/r$, where $k = 9 \times 10^9$ N·m^2/C^2.

Step 1 — Convert the charge to SI units:

$$q = 2\ \mu\text{C} = 2 \times 10^{-6} \text{ C}$$

Step 2 — Apply the formula:

$$V = \frac{kq}{r} = \frac{9 \times 10^9 \times 2 \times 10^{-6}}{0.3}$$

Step 3 — Compute the numerator:

$$kq = 9 \times 10^9 \times 2 \times 10^{-6} = 18 \times 10^3 = 1.8 \times 10^4 \text{ V·m}$$

Step 4 — Divide by $r = 0.3$ m:

$$V = \frac{1.8 \times 10^4}{0.3} = 6 \times 10^4 \text{ V}$$

Why other options are wrong:

- Option B (3×10^4 V): Divides kq by 0.6 instead of 0.3, or halves the charge.
- Option C (12×10^4 V): Multiplies by r instead of dividing; $1.8 \times 10^4 \times 0.3 \times 20$ or uses $r = 0.15$ m.
- Option D (1×10^4 V): Uses $q = 1/3\ \mu$C or otherwise divides by an additional factor of 6.

Final Answer: $V = 6 \times 10^4$ V $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q11

Q12.

Solution

Concept — Magnetic Field Inside a Solenoid: For an ideal solenoid of N turns and length L carrying current I, the magnetic field inside is uniform and given by $B = \mu_0 nI$, where $n = N/L$ is the number of turns per unit length.

Step 1 — Find n (turns per unit length):

$$n = \frac{N}{L} = \frac{1000}{0.5} = 2000 \text{ turns/m}$$

Step 2 — Apply the solenoid field formula:

$$B = \mu_0 nI = 4\pi \times 10^{-7} \times 2000 \times 2$$

Step 3 — Compute step by step:

$$B = 4\pi \times 10^{-7} \times 4000 = 4\pi \times 4 \times 10^{-4} = 16\pi \times 10^{-4}\ \text{T}$$

Why other options are wrong:

- Option A ($\pi \times 10^{-3}$ T): Uses $n = 1000$ turns/m (ignores the $L = 0.5$ m division) but then $B = 4\pi \times 10^{-7} \times 1000 \times 2 = 8\pi \times 10^{-4}$; off by factor 2.
- Option C ($8\pi \times 10^{-3}$ T): Off by a factor of 20; likely forgets the 10^{-7} or misplaces a decimal.
- Option D ($4\pi \times 10^{-4}$ T): Uses $nI = 1000 \times 1 = 1000$, taking $I = 1$ A instead of 2 A or $n = 500$.

Final Answer: $B = 16\pi \times 10^{-4}$ T $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q12

Q13.

Solution

Concept — Threshold Frequency in Photoelectric Effect: The threshold frequency f_0 is the minimum frequency of light needed to eject electrons from a metal surface. It is related to the work function by $\phi = hf_0$, hence $f_0 = \phi/h$.

Step 1 — Convert work function to Joules:

$$\phi = 2.3\ \text{eV} \times 1.6 \times 10^{-19}\ \text{J/eV} = 3.68 \times 10^{-19}\ \text{J}$$

Step 2 — Apply the threshold frequency formula:

$$f_0 = \frac{\phi}{h} = \frac{3.68 \times 10^{-19}}{6.6 \times 10^{-34}}$$

Step 3 — Compute:

$$f_0 = \frac{3.68}{6.6} \times 10^{-19+34} = 0.5576 \times 10^{15} \approx 5.6 \times 10^{14}\ \text{Hz}$$

Why other options are wrong:

- Option A (2.3×10^{14} Hz): Numerically equals the work function in eV times 10^{14}; misses the conversion and h.

- Option B (3.5×10^{14} Hz): Arises from incorrect partial calculation; perhaps uses $h = 6.6 \times 10^{-33}$ (wrong power).
- Option D (8.0×10^{14} Hz): Would correspond to a work function of ≈ 3.3 eV, not 2.3 eV.

Final Answer: $f_0 \approx 5.6 \times 10^{14}$ Hz $\Rightarrow \boxed{\text{C}}$

Answer: (C) **Go Back to Q13**

Q14.

Solution

Concept — Binding Energy from Mass Defect: The binding energy of a nucleus is the energy equivalent of its mass defect. Using the mass-energy equivalence: $E_B = \Delta m \times 931.5$ MeV, where Δm is in atomic mass units (u).

Step 1 — Identify given values:

$$\Delta m = 0.03 \text{ u}, \qquad 1 \text{ u} \equiv 931.5 \text{ MeV}$$

Step 2 — Apply the formula:

$$E_B = \Delta m \times 931.5 \text{ MeV/u} = 0.03 \times 931.5$$

Step 3 — Compute:

$$E_B = 0.03 \times 931.5 = 27.945 \approx 27.9 \text{ MeV}$$

Why other options are wrong:

- Option A (0.03 MeV): Quotes Δm in eV directly, forgetting the 931.5 MeV/u conversion factor.
- Option B (9.3 MeV): Uses $E_B = 0.03 \times 931.5/3 = 9.3$; divides by an extra factor of 3 with no basis.
- Option C (93.15 MeV): Uses $\Delta m = 0.1$ u (ten times the given value) instead of 0.03 u.

Final Answer: $E_B = 27.9$ MeV $\Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q14**

Q15.

Solution

Concept — Calorimetry (Heat Absorbed): The heat energy absorbed by a substance is $Q = mc\Delta T$, where m is the mass, c is the specific heat capacity, and ΔT is the temperature rise.

Step 1 — Identify given values:

$$m = 100 \text{ g}, \qquad c = 4.2 \text{ J/(g}\cdot{}^\circ\text{C)}, \qquad \Delta T = 60^\circ\text{C}$$

Step 2 — Apply the formula:

$$Q = m \times c \times \Delta T = 100 \times 4.2 \times 60$$

Step 3 — Compute step by step:

$$Q = 100 \times 4.2 = 420$$

$$Q = 420 \times 60 = 25200 \text{ J}$$

Why other options are wrong:

- Option A (420 J): Uses $Q = m \times c = 100 \times 4.2$ — omits the temperature change ΔT.
- Option C (4200 J): Uses $Q = c \times \Delta T = 4.2 \times 60 \times (some factor)$, or omits the mass factor of 100 and multiplies by something else; could arise from using $m = 10$ g.
- Option D (2520 J): Uses $\Delta T = 6^\circ$C (one-tenth of actual) or $m = 10$ g with correct formula.

Final Answer: $Q = 25200 \text{ J} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q15

Q16.

Solution

Concept — Simple Pendulum Period: The time period of a simple pendulum is $T = 2\pi\sqrt{L/g}$. Squaring both sides and rearranging gives $L = g\left(\frac{T}{2\pi}\right)^2$.

Step 1 — Square the period formula:

$$T^2 = 4\pi^2 \cdot \frac{L}{g} \implies L = \frac{gT^2}{4\pi^2}$$

Step 2 — Substitute $T = 2$ s, $g = 10$ m/s^2, $\pi^2 = 10$:

$$L = \frac{10 \times 2^2}{4 \times 10} = \frac{10 \times 4}{40}$$

Step 3 — Compute:

$$L = \frac{40}{40} = 1 \text{ m}$$

Why other options are wrong:

- Option B (0.5 m): Uses $T = 1$ s (half the given period), so $L = g/(4\pi^2) = 10/40 = 0.25$ m; or uses $L = gT^2/(8\pi^2)$ incorrectly.
- Option C (2 m): Doubles the answer, perhaps from $L = gT^2/(2\pi^2)$ (missing a factor of 2 in the denominator).
- Option D (0.25 m): Uses $T = 1$ s (squares 1 instead of 2).

Final Answer: $L = 1$ m $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q16

Q17.

Solution

Concept — Total KE of a Rolling Sphere: For a solid sphere rolling without slipping, total KE = translational KE + rotational KE. Using $I = \frac{2}{5}MR^2$ and the rolling condition $\omega = v/R$:

$$KE_{total} = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2 = \frac{1}{2}Mv^2 + \frac{1}{2}\cdot\frac{2}{5}MR^2\cdot\frac{v^2}{R^2} = \frac{1}{2}Mv^2\left(1 + \frac{2}{5}\right) = \frac{7}{10}Mv^2$$

Step 1 — Identify given values:

$$M = 2 \text{ kg}, \qquad v = 4 \text{ m/s}$$

Step 2 — Compute translational KE:

$$KE_{trans} = \frac{1}{2}Mv^2 = \frac{1}{2} \times 2 \times 16 = 16 \text{ J}$$

Step 3 — Compute rotational KE:

$$KE_{rot} = \frac{1}{2} \times \frac{2}{5}Mv^2 = \frac{1}{5}Mv^2 = \frac{1}{5} \times 2 \times 16 = 6.4 \text{ J}$$

Step 4 — Total KE:

$$KE_{total} = 16 + 6.4 = 22.4 \text{ J}$$

Alternatively: $KE_{total} = \frac{7}{10}Mv^2 = 0.7 \times 2 \times 16 = 22.4$ J.

Why other options are wrong:

- Option A (16 J): Only the translational KE — ignores the rotational contribution.
- Option C (19.2 J): Uses $I = \frac{2}{3}MR^2$ (formula for a hollow sphere), giving $KE_{rot} = \frac{1}{3}Mv^2 = 10.67$ J; total would be ≈ 26.7 J; or arises from $KE = \frac{6}{5} \times \frac{1}{2}Mv^2 \times$ some wrong factor.
- Option D (28.8 J): Uses $KE = \frac{9}{10}Mv^2$, possibly from $I = MR^2$ (ring formula).

Final Answer: $KE_{total} = 22.4 \text{ J} \Rightarrow \boxed{\text{B}}$

Answer: (B) **Go Back to Q17**

Q18.

Solution

Concept — p–n Junction Under Forward Bias: In a p–n junction at equilibrium, the depletion layer forms due to diffusion of majority carriers. When a forward bias is applied (positive terminal to p-side, negative to n-side), the external electric field opposes the built-in field, reducing the barrier and *narrowing* the depletion layer.

Step 1 — Recall the depletion layer at equilibrium: The depletion layer forms because holes from the p-side and electrons from the n-side diffuse across the junction and recombine, creating a space-charge region.

Step 2 — Effect of forward bias: Forward bias reduces the potential barrier at the junction. The external voltage pushes majority carriers towards the junction, shrinking the depletion region.

$$\text{Width of depletion layer} \propto \sqrt{V_{barrier}} \quad \Rightarrow \quad \text{decreases under forward bias.}$$

Step 3 — Conclusion: The depletion layer decreases in width; at a sufficient forward voltage (≈ 0.7 V for Si), it narrows enough that significant current flows.

Why other options are wrong:

- Option A (Increases): Depletion layer increases under *reverse* bias, not forward bias.
- Option B (Unchanged): The layer always changes with applied voltage; unchanged only at exact zero bias.
- Option C (Becomes a perfect conductor): Even in forward bias the depletion layer is never perfectly conducting; the diode conducts through minority and majority carriers.

Final Answer: Depletion layer decreases in width $\Rightarrow$ D

Answer: (D) Go Back to Q18

Q19.

Solution

Concept — Stokes' Law and Terminal Velocity: By Stokes' law, the drag force on a sphere of radius r moving at velocity v through a viscous fluid is $F = 6\pi\eta rv$. At terminal velocity, drag equals net gravitational force (weight minus buoyancy), which is proportional to r^3. This gives terminal velocity $v_t \propto r^2$.

Step 1 — Write the proportionality:

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

Step 2 — Substitute $v_1 = 0.1$ m/s, $v_2 = 0.4$ m/s, $r_1 = 1$ mm:

$$\frac{0.4}{0.1} = \left(\frac{r_2}{1}\right)^2$$

$$4 = r_2^2 \quad (\text{with } r_2 \text{ in mm})$$

Step 3 — Solve for r_2:

$$r_2 = \sqrt{4} = 2 \text{ mm}$$

Why other options are wrong:

- Option A (0.25 mm): Uses $r_2 = r_1 \times (v_1/v_2) = 1 \times 0.25$; inverts the ratio and takes first power.
- Option B (0.5 mm): Uses $r_2 = r_1 \times \sqrt{v_1/v_2} = \sqrt{0.25} = 0.5$; inverts v-ratio under the square root.
- Option D (4 mm): Computes $r_2 = r_1 \times (v_2/v_1) = 1 \times 4$ — uses first power, not square root.

Final Answer: $r_2 = 2 \text{ mm} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q19

Q20.

Solution

Concept — Kepler's Third Law: Kepler's third law states that the square of the orbital period is proportional to the cube of the semi-major axis (orbital radius for circular orbits): $T^2 \propto r^3$.

Step 1 — Write the ratio form of Kepler's third law:

$$\left(\frac{T_p}{T_E}\right)^2 = \left(\frac{r_p}{r_E}\right)^3$$

Step 2 — Substitute $T_p = 8$ yr, $T_E = 1$ yr:

$$\left(\frac{8}{1}\right)^2 = \left(\frac{r_p}{r_E}\right)^3$$

$$64 = \left(\frac{r_p}{r_E}\right)^3$$

Step 3 — Solve for r_p/r_E:

$$\frac{r_p}{r_E} = \sqrt[3]{64} = \sqrt[3]{4^3} = 4$$

Why other options are wrong:

- Option B (8): Uses $r_p/r_E = T_p/T_E = 8$ (first power, not cube root); confuses $T \propto r$.
- Option C (2): Uses $r_p/r_E = \sqrt{T_p/T_E} = \sqrt{8} \approx 2.83$, and rounds down to 2; applies square root instead of cube root.
- Option D (16): Uses $r_p/r_E = (T_p/T_E)^{2/3} \times$ something; perhaps takes $64^{2/3} = 16$ (squares the answer erroneously).

Final Answer: $r_p/r_E = 4 \Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q20**

Answer Key

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