AIIMS B.Sc Nursing Physics

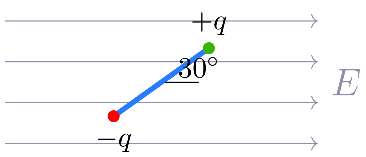
Sample Paper – 5

Duration: 36 Minutes **Maximum Marks: 30**

Instructions

- This paper contains **30 Multiple Choice Questions (single correct answer)**, modelled on the Physics section of the **AIIMS B.Sc Nursing** entrance.
- Each correct answer carries **+1 mark**. $\frac{1}{3}$ **mark is deducted** for every wrong answer, and an unattempted question gets **0 marks**.
- Only **one** option is correct. Choose carefully, since the questions are mostly numerical.
- Personal calculators, log tables, mobile phones, and other electronic gadgets are strictly prohibited.

Q1. An electric dipole of dipole moment 4×10^{-9} C m is placed at 30° to a uniform electric field of 5×10^4 N/C, as shown. The torque acting on the dipole is:



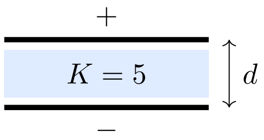
(A) 4×10^{-4} N m

(B) 2×10^{-5} N m

(C) 1×10^{-4} N m

(D) 4×10^{-5} N m

Q2. A parallel plate capacitor has plate area 2×10^{-2} m^2 and plate separation 1 mm. A dielectric slab of dielectric constant $K = 5$ completely fills the gap, as shown. Its capacitance is (take $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m):



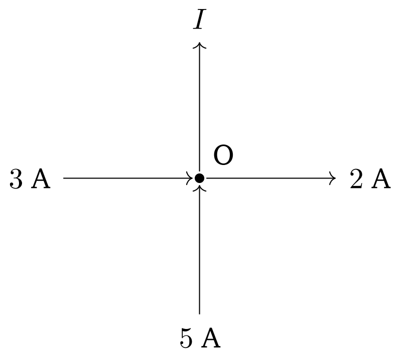
(A) 4.4×10^{-10} F

(B) 8.85×10^{-10} F

(C) 1.77×10^{-10} F

(D) 8.85×10^{-11} F

Q3. Four wires meet at the junction O shown. Currents of 3 A and 5 A flow into the junction, while a current of 2 A flows out through one branch. The current I in the fourth branch (flowing out) is:



(A) 6 A

(B) 10 A

(C) 4 A

(D) 2 A

Q4. Three identical cells, each of emf 1.5 V and internal resistance $0.5\ \Omega$, are connected in series across an external resistance of $7.5\ \Omega$. The current in the circuit is:

(A) 0.6 A

(B) 0.2 A

(C) 0.9 A

(D) 0.5 A

Q5. An electric heater of power 2 kW is used for 3 hours every day. If the cost of electricity is Rs. 5 per unit (kWh), the cost of running it for 10 days is:

(A) Rs. 150

(B) Rs. 300

(C) Rs. 60

(D) Rs. 600

Q6. Which of the following is *not* an SI base (fundamental) unit?

(A) kelvin

(B) mole

(C) newton

(D) ampere

Q7. A car moving at 10 m/s speeds up uniformly to 25 m/s in 5 s. Its acceleration is:

(A) 3 m/s^2

(B) 5 m/s^2

(C) 7 m/s^2

(D) 2 m/s^2

Q8. A ball is projected with a speed of 20 m/s at an angle of 30° to the horizontal. The maximum height it reaches is (take $g = 10$ m/s^2):

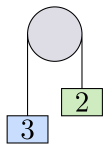
(A) 10 m

(B) 20 m

(C) 2.5 m

(D) 5 m

Q9. Two masses 3 kg and 2 kg hang from the two ends of a light string passing over a frictionless pulley, as shown. The acceleration of the system is (take $g = 10$ m/s^2):



(A) 2 m/s^2

(B) 5 m/s^2

(C) 1 m/s^2

(D) 10 m/s^2

Q10. A stone of mass 0.5 kg is whirled in a horizontal circle of radius 2 m at a constant speed of 4 m/s. The centripetal force on the stone is:

(A) 2 N

(B) 4 N

(C) 8 N

(D) 1 N

Q11. A net force does 40 J of work on a body of mass 2 kg initially at rest. The final speed of the body is:

(A) 20 m/s

(B) 40 m/s

(C) $\sqrt{40}$ m/s

(D) 4 m/s

Q12. A planet's orbital radius around a star is increased to 4 times its original value. By what factor does its time period of revolution change?

(A) 4

(B) 16

(C) 2

(D) 8

Q13. A pressure of 2×10^6 Pa applied to a liquid produces a volumetric strain of 0.001. The bulk modulus of the liquid is:

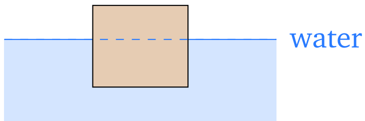
(A) 2×10^9 Pa

(B) 2×10^3 Pa

(C) 2×10^6 Pa

(D) 5×10^{-10} Pa

Q14. A wooden block of density 600 kg/m^3 floats in water (density 1000 kg/m^3), as shown. The fraction of its volume that lies below the water surface is:



(A) 0.4

(B) 0.6

(C) 0.5

(D) 1.0

Q15. If α, β and γ are the coefficients of linear, areal and volume expansion of a solid, then the correct relation is:

(A) $\alpha : \beta : \gamma = 1 : 1 : 1$

(B) $\alpha : \beta : \gamma = 3 : 2 : 1$

(C) $\alpha : \beta : \gamma = 1 : 2 : 3$

(D) $\alpha : \beta : \gamma = 2 : 1 : 3$

Q16. How much heat is needed to convert 50 g of ice at 0 °C into water at 20 °C? (Take $L_{\text{ice}} = 80$ cal/g and $c_{\text{water}} = 1$ cal g^{-1} °C^{-1}.)

(A) 4000 cal

(B) 1000 cal

(C) 4500 cal

(D) 5000 cal

Q17. A Carnot engine operates between a source at 400 K and a sink at 300 K. Its efficiency is:

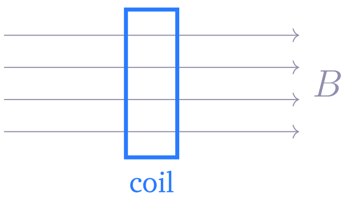
(A) 25%

(B) 75%

(C) 33%

(D) 50%

Q18. A rectangular coil of 50 turns and area 4×10^{-3} m^2 carries a current of 2 A. Its plane is parallel to a uniform magnetic field of 0.1 T, as shown. The torque on the coil is:



(A) 0.02 N m

(B) 0.04 N m

(C) 0.4 N m

(D) 0.08 N m

Q19. Two coils have a mutual inductance of 0.5 H. If the current in the first coil changes at the rate of 4 A/s, the emf induced in the second coil is:

(A) 0.125 V

(B) 4.5 V

(C) 2 V

(D) 8 V

Q20. In an AC circuit the rms voltage is 200 V, the rms current is 5 A and the phase angle between them is $60°$. The average power consumed is (take $\cos 60° = 0.5$):

(A) 1000 W

(B) 866 W

(C) 0 W

(D) 500 W

Q21. A convex lens has a focal length of 25 cm. Its power is:

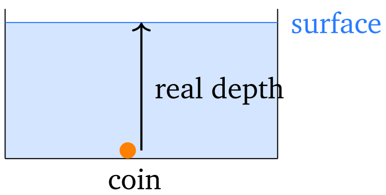
(A) $+4$ D

(B) $+0.25$ D

(C) -4 D

(D) $+2.5$ D

Q22. A coin lies at the bottom of a tank of water (refractive index 1.33) filled to a real depth of 1.33 m, as shown. The apparent depth of the coin as seen from directly above is:



(A) 1.77 m

(B) 1.0 m

(C) 1.33 m

(D) 0.75 m

Q23. Light is incident on a glass surface of refractive index $\sqrt{3}$. The angle of incidence at which the reflected light is completely plane polarised (Brewster's angle) is:

(A) 30°

(B) 45°

(C) 60°

(D) 90°

Q24. The momentum of a photon of wavelength 6.6×10^{-7} m is (take $h = 6.6 \times 10^{-34}$ J s):

(A) 1×10^{-34} kg m/s

(B) 4.4×10^{-27} kg m/s

(C) 1×10^{-41} kg m/s

(D) 1×10^{-27} kg m/s

Q25. Which of the following correctly orders α, β and γ radiations by increasing penetrating power?

(A) $\alpha < \beta < \gamma$

(B) $\gamma < \beta < \alpha$

(C) $\beta < \alpha < \gamma$

(D) $\alpha < \gamma < \beta$

Q26. According to Bohr's model, the angular momentum of an electron in the nth orbit of a hydrogen atom is:

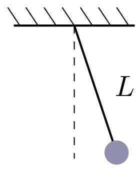
(A) $\frac{nh}{4\pi}$

(B) $\frac{nh}{2\pi}$

(C) $\frac{2\pi}{nh}$

(D) $\frac{nh}{\pi}$

Q27. A simple pendulum has a period of 2 s on the Earth, where $g = 9.8$ m/s^2. On the Moon, where g is one-sixth of its Earth value, its period becomes about:



(A) 2 s

(B) 1.2 s

(C) 4.9 s

(D) 12 s

Q28. A source emitting sound of frequency 400 Hz moves towards a stationary observer at 30 m/s. If the speed of sound is 330 m/s, the frequency heard by the observer is:

(A) 364 Hz

(B) 400 Hz

(C) 330 Hz

(D) 440 Hz

Q29. When pure silicon is doped with a pentavalent impurity such as phosphorus, the impurity atoms behave as:

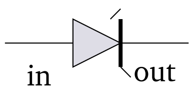
(A) donors, giving an n-type semiconductor

(B) acceptors, giving a p-type semiconductor

(C) donors, giving a p-type semiconductor

(D) acceptors, giving an n-type semiconductor

Q30. A Zener diode is used as a voltage regulator. In this application it is operated in:



(A) forward bias near the knee voltage

(B) unbiased

(C) reverse bias in the breakdown region

(D) forward bias at high current

Detailed Solutions

Q1.

Solution

Concept — Torque on a dipole: When an electric dipole of dipole moment p is placed in a uniform electric field E, the two equal and opposite charges experience equal and opposite forces that form a couple. This couple produces a torque that tends to align the dipole with the field. The torque is given by $\tau = pE\sin\theta$, where p is the dipole moment (in C m), E is the electric field strength (in N/C), and θ is the angle between the dipole axis and the field direction. The torque is maximum when $\theta = 90°$ and zero when the dipole is aligned ($\theta = 0°$).

Given: $p = 4 \times 10^{-9}$ C m, $E = 5 \times 10^{4}$ N/C, $\theta = 30°$.

Step 1 — Write the formula and substitute: $\tau = pE\sin\theta = (4 \times 10^{-9}\ \text{C m})(5 \times 10^{4}\ \text{N/C})(\sin 30°)$.

Step 2 — Compute the product pE: $pE = (4 \times 10^{-9})(5 \times 10^{4}) = 20 \times 10^{-5} = 2 \times 10^{-4}$ N m.

Step 3 — Apply $\sin 30° = 0.5$: $\tau = (2 \times 10^{-4})(0.5) = 1 \times 10^{-4}$ N m.

Why each other option is wrong:

- (A) 4×10^{-4} N m results from forgetting the factor $\sin 30°$ and mis-multiplying the mantissas.
- (B) 2×10^{-5} N m uses a wrong power of ten (an exponent error of one decade).
- (D) 4×10^{-5} N m keeps the wrong mantissa 4 together with a wrong power of ten.

Key point: Always include the $\sin\theta$ factor; the torque is not simply pE unless the dipole is perpendicular to the field.

Final Answer: $\tau = 1 \times 10^{-4}$ N m $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q1

Q2.

Solution

Concept — Capacitor with a dielectric: The capacitance of a parallel plate capacitor measures its ability to store charge per unit potential difference. When the gap is completely filled with a dielectric of dielectric constant K, the capacitance is $C = \dfrac{K\varepsilon_0 A}{d}$, where K is the dielectric constant (dimensionless), $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m is the permittivity of free space, A is the plate area (in m^2) and d is the plate separation (in m). The dielectric increases the capacitance by the factor K compared with vacuum.

Given: $A = 2 \times 10^{-2}$ m^2, $d = 1$ mm $= 1 \times 10^{-3}$ m, $K = 5$, $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m.

Step 1 — Write the formula and substitute: $C = \dfrac{K\varepsilon_0 A}{d} = \dfrac{(5)(8.85 \times 10^{-12}\ \text{F/m})(2 \times 10^{-2}\ \text{m}^2)}{1 \times 10^{-3}\ \text{m}}$.

Step 2 — Evaluate the numerator: $5 \times 8.85 \times 10^{-12} \times 2 \times 10^{-2} = (5 \times 2 \times 8.85) \times 10^{-14} = 88.5 \times 10^{-14} = 8.85 \times 10^{-13}$ F m.

Step 3 — Divide by d: $C = \dfrac{8.85 \times 10^{-13}}{1 \times 10^{-3}} = 8.85 \times 10^{-10}$ F.

Why each other option is wrong:

- (A) 4.4×10^{-10} F is roughly half the correct value, as if $K = 2.5$ were used.
- (C) 1.77×10^{-10} F omits the dielectric constant $K = 5$ entirely (the vacuum value).
- (D) 8.85×10^{-11} F uses a wrong power of ten (one decade too small).

Key point: The dielectric multiplies the vacuum capacitance by K; keep careful track of powers of ten when combining 10^{-12}, 10^{-2} and 10^{-3}.

Final Answer: $C = 8.85 \times 10^{-10}$ F $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q2

Q3.

Solution

Concept — Kirchhoff's current law (KCL): KCL is a statement of conservation of electric charge at a junction: charge cannot accumulate at a point, so the total current flowing into a junction must equal the total current flowing out of it. In symbols, $\sum I_{\text{in}} = \sum I_{\text{out}}$. Here three currents are specified at junction O: 3 A and 5 A flow in, while 2 A and the unknown I flow out.

Given: $I_{\text{in}} = 3$ A and 5 A; $I_{\text{out}} = 2$ A and I.

Step 1 — Total current in: $\sum I_{\text{in}} = 3\text{ A} + 5\text{ A} = 8\text{ A}$.

Step 2 — Total current out: $\sum I_{\text{out}} = 2\text{ A} + I$.

Step 3 — Apply KCL and solve: $8\text{ A} = 2\text{ A} + I \Rightarrow I = 8 - 2 = 6\text{ A}$.

Why each other option is wrong:

- (B) 10 A simply adds all the inflows $3+5+2$, ignoring that 2 A is an outflow.
- (C) 4 A miscounts by subtracting the wrong pair of currents.
- (D) 2 A merely repeats the given outgoing branch and forgets to balance.

Key point: Assign a clear sign convention (in positive, out negative) before summing; currents in must always equal currents out.

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

Answer: (A) Go Back to Q3

Q4.

Solution

Concept — Cells in series: When n identical cells, each of emf $\mathcal{E}$ and internal resistance r, are joined in series, their emfs add and their internal resistances add. The net emf becomes $n\mathcal{E}$ and the total internal resistance becomes nr. Applying Ohm's law to the complete loop (external resistance R in series with the cells), the current is $I = \dfrac{n\mathcal{E}}{R+nr}$, where every quantity is in SI units (volts, ohms, amperes).

Given: $n = 3$, $\mathcal{E} = 1.5$ V, $r = 0.5\ \Omega$, $R = 7.5\ \Omega$.

Step 1 — Net emf: $n\mathcal{E} = 3 \times 1.5\text{ V} = 4.5\text{ V}$.

Step 2 — Total internal resistance: $nr = 3 \times 0.5\ \Omega = 1.5\ \Omega$, so total circuit resistance $= R + nr = 7.5 + 1.5 = 9\ \Omega$.

Step 3 — Apply Ohm's law: $I = \dfrac{n\mathcal{E}}{R+nr} = \dfrac{4.5\text{ V}}{9\ \Omega} = 0.5\text{ A}$.

Why each other option is wrong:

- (A) 0.6 A ignores the internal resistance, dividing 4.5 V by $7.5\ \Omega$ alone.
- (B) 0.2 A uses an incorrect (too small) net emf or too large a resistance.
- (C) 0.9 A drops a factor of two in the resistance, dividing 4.5 V by $5\ \Omega$.

Key point: In a series combination both the emfs and the internal resistances multiply by n; never forget to add nr to the external resistance.

Final Answer: $I = 0.5$ A $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q4

Q5.

Solution

Concept — Electrical energy and cost: The commercial unit of electrical energy is the kilowatt-hour (kWh), defined as the energy consumed by a 1 kW appliance running for 1 hour. The energy used is $E = P(\text{in kW}) \times t(\text{in hours})$, and the cost is cost $= E(\text{in kWh}) \times \text{rate(per unit)}$. One "unit" on an electricity bill is exactly 1 kWh.

Given: $P = 2$ kW, daily use $t = 3$ h, number of days $= 10$, rate $=$ Rs. 5 per kWh.

Step 1 — Daily energy: $E_{\text{day}} = P \times t = 2$ kW $\times\ 3$ h $= 6$ kWh.

Step 2 — Total energy over 10 days: $E_{\text{total}} = 6$ kWh/day $\times\ 10$ days $= 60$ kWh.

Step 3 — Cost: cost $= E_{\text{total}} \times$ rate $= 60$ kWh $\times$ Rs. 5/kWh $=$ Rs. 300.

Why each other option is wrong:

- (A) Rs. 150 uses only 30 kWh, as if the heater ran 1.5 h/day or for 5 days.
- (C) Rs. 60 gives the energy in kWh but forgets to multiply by the Rs. 5 rate.
- (D) Rs. 600 doubles the power (using 4 kW) or doubles the time.

Key point: Keep power in kilowatts and time in hours so that the product is directly in kWh; only then multiply by the per-unit rate.

Final Answer: Rs. $300 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q5

Q6.

Solution

Concept — SI base units: The International System of Units (SI) defines seven base (fundamental) units from which all other units are derived. They are the metre (length), kilogram (mass), second (time), ampere (electric current), kelvin (thermodynamic temperature), mole (amount of substance) and candela (luminous intensity). Any unit not in this list is a derived unit, obtained by combining base units. This question asks which option is NOT a base unit.

Step 1 — Test each option against the list: kelvin is the base unit of temperature; mole is the base unit of amount of substance; ampere is the base unit of electric current. All three appear in the list of seven.

Step 2 — Identify the odd one out: The newton does not appear in the seven base units. It is a derived unit of force, defined through Newton's second law as $1\ \text{N} = 1\ \text{kg} \cdot \text{m} \cdot \text{s}^{-2}$, a combination of the base units kilogram, metre and second.

Why each other option is wrong (i.e. is actually a base unit):

- (A) kelvin is the SI base unit of thermodynamic temperature, so it cannot be the answer.
- (B) mole is the SI base unit for amount of substance, so it cannot be the answer.
- (D) ampere is the SI base unit of electric current, so it cannot be the answer.

Key point: Force, energy, pressure and power are all derived quantities; only the seven listed units are fundamental.

Final Answer: newton $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q6

Q7.

Solution

Concept — Uniform acceleration: Acceleration is the rate of change of velocity with time. For uniform (constant) acceleration, it equals the change in velocity divided by the time taken: $a = \dfrac{v-u}{t}$, where u is the initial velocity, v is the final velocity (both in m/s) and t is the time interval (in s). The result carries units of m/s^2.

Given: $u = 10$ m/s, $v = 25$ m/s, $t = 5$ s.

Step 1 — Write the formula and substitute: $a = \dfrac{v-u}{t} = \dfrac{25\ \text{m/s} - 10\ \text{m/s}}{5\ \text{s}}$.

Step 2 — Evaluate the numerator: $v - u = 25 - 10 = 15$ m/s.

Step 3 — Divide by time: $a = \dfrac{15\ \text{m/s}}{5\ \text{s}} = 3\ \text{m/s}^2$.

Why each other option is wrong:

- (B) $5\ \text{m/s}^2$ comes from dividing only the final speed $v = 25$ by 5, forgetting to subtract u.
- (C) $7\ \text{m/s}^2$ misreads the speed change as 35 m/s.

- (D) $2\ \text{m/s}^2$ misreads the velocity difference as $10\ \text{m/s}$.

Key point: Always take the difference $v - u$, not just the final velocity, before dividing by time.

Final Answer: $a = 3\ \text{m/s}^2 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q7

Q8.

Solution

Concept — Maximum height of a projectile: A projectile launched with speed u at angle θ to the horizontal has an initial vertical velocity component $u \sin\theta$. At the highest point this vertical component becomes zero. Using $v_y^2 = (u\sin\theta)^2 - 2gH$ with $v_y = 0$ gives the maximum height $H = \dfrac{u^2 \sin^2\theta}{2g}$, where u is the launch speed (m/s), θ the angle of projection, and g the acceleration due to gravity (m/s^2).

Given: $u = 20$ m/s, $\theta = 30^\circ$, $g = 10$ m/s^2.

Step 1 — Write the formula and substitute: $H = \dfrac{u^2\sin^2\theta}{2g} = \dfrac{(20)^2(\sin 30^\circ)^2}{2 \times 10}$.

Step 2 — Evaluate u^2 and $\sin^2\theta$: $u^2 = 400\ \text{m}^2/\text{s}^2$ and $\sin 30^\circ = 0.5$, so $\sin^2 30^\circ = 0.25$.

Step 3 — Combine: $H = \dfrac{400 \times 0.25}{20} = \dfrac{100}{20} = 5$ m.

Why each other option is wrong:

- (A) 10 m uses $\sin\theta$ in place of $\sin^2\theta$, doubling the height.
- (B) 20 m drops the $2g$ in the denominator (or uses g instead of $2g$).
- (C) 2.5 m mistakenly halves the correct height.

Key point: It is the square of the vertical velocity component ($u^2\sin^2\theta$) that enters the maximum-height formula, not $u^2 \sin\theta$.

Final Answer: $H = 5\ \text{m} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q8

Q9.

Solution

Concept — Atwood machine: Two masses connected by a light, inextensible string over a frictionless pulley form an Atwood machine. The heavier mass descends and the lighter rises with a common magnitude of acceleration. Applying Newton's second law to each mass and eliminating the tension gives $a = \frac{(m_1 - m_2)g}{m_1 + m_2}$, where m_1 is the heavier mass, m_2 the lighter mass (both in kg) and g the acceleration due to gravity (m/s^2). The net driving force is the weight difference $(m_1 - m_2)g$ acting on the total mass $(m_1 + m_2)$.

Given: $m_1 = 3$ kg, $m_2 = 2$ kg, $g = 10$ m/s^2.

Step 1 — Write the formula and substitute: $a = \frac{(m_1 - m_2)g}{m_1 + m_2} = \frac{(3-2) \times 10}{3+2}$.

Step 2 — Evaluate the numerator and denominator: numerator $= (1)(10) = 10$ N (the net force), denominator $= 5$ kg (the total mass).

Step 3 — Divide: $a = \frac{10}{5} = 2$ m/s^2.

Why each other option is wrong:

- (B) 5 m/s^2 divides by a wrong total mass (e.g. by 2 instead of 5).
- (C) 1 m/s^2 halves the net force or doubles the denominator.
- (D) 10 m/s^2 is free fall, which would only occur if one mass were absent.

Key point: The acceleration depends on the difference of the masses over their sum; it is always less than g for unequal finite masses.

Final Answer: $a = 2$ m/s$^2 \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q9

Q10.

Solution

Concept — Centripetal force: A body moving in a circle at constant speed is continuously accelerating because the direction of its velocity changes. This acceleration points toward the centre and requires a net inward (centripetal) force of magnitude $F = \frac{mv^2}{r}$, where m is the mass (kg), v the constant speed (m/s) and r the radius of the circular path (m). The force does no work since it is perpendicular to the velocity.

Given: $m = 0.5$ kg, $v = 4$ m/s, $r = 2$ m.

Step 1 — Write the formula and substitute: $F = \frac{mv^2}{r} = \frac{(0.5 \text{ kg})(4 \text{ m/s})^2}{2 \text{ m}}$.

Step 2 — Square the speed: $v^2 = (4)^2 = 16 \text{ m}^2/\text{s}^2$, so the numerator is $0.5 \times 16 = 8$ N m.

Step 3 — Divide by the radius: $F = \frac{8}{2} = 4$ N.

Why each other option is wrong:

- (A) 2 N forgets to square the speed (uses v instead of v^2).
- (C) 8 N omits the division by the radius r.
- (D) 1 N divides by an extra factor (e.g. an unnecessary factor of 4).

Key point: Centripetal force grows with the square of the speed, so doubling the speed quadruples the required force.

Final Answer: $F = 4 \text{ N} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q10

Q11.

Solution

Concept — Work-energy theorem: The work-energy theorem states that the net work done on a body equals its change in kinetic energy: $W = \Delta KE = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$. If the body starts from rest ($u = 0$), this reduces to $W = \frac{1}{2}mv^2$, where W is the net work (in joules), m is the mass (kg) and v is the final speed (m/s).

Given: $W = 40$ J, $m = 2$ kg, $u = 0$.

Step 1 — Write the equation and substitute: $W = \frac{1}{2}mv^2 \Rightarrow 40 = \frac{1}{2}(2)v^2$.

Step 2 — Simplify: $\frac{1}{2}(2) = 1$, so $40 = v^2$, giving $v^2 = 40 \text{ m}^2/\text{s}^2$.

Step 3 — Take the square root: $v = \sqrt{40} \approx 6.3$ m/s.

Why each other option is wrong:

- (A) 20 m/s comes from leaving v^2 without taking the square root and then mis-scaling.
- (B) 40 m/s simply quotes $v^2 = 40$ as if it were the speed, skipping the root.
- (D) 4 m/s uses a wrong mass or an incorrect rearrangement of the formula.

Key point: Kinetic energy depends on v^2, so you must take a square root at the end; $\sqrt{40} \approx 6.3$ m/s, not 40.

Final Answer: $v = \sqrt{40}$ m/s $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q11

Q12.

Solution

Concept — Kepler's third law: Kepler's third law of planetary motion states that the square of a planet's orbital period is proportional to the cube of its orbital radius (semi-major axis): $T^2 \propto r^3$. Taking the square root gives $T \propto r^{3/2}$. This means a change in orbital radius by a factor k changes the period by a factor $k^{3/2}$.

Given: new radius $r' = 4r$ (so the scaling factor is $k = 4$).

Step 1 — Set up the ratio: $\dfrac{T'}{T} = \left(\dfrac{r'}{r}\right)^{3/2} = (4)^{3/2}$.

Step 2 — Evaluate $4^{3/2}$: $4^{3/2} = (4^{1/2})^3 = (\sqrt{4})^3 = 2^3$.

Step 3 — Compute: $2^3 = 8$, so the period becomes 8 times the original.

Why each other option is wrong:

- (A) 4 assumes $T \propto r$ (a linear law), ignoring the $3/2$ power.
- (B) 16 assumes $T \propto r^2$, squaring the radius factor wrongly.
- (C) 2 assumes $T \propto r^{1/2}$, using only the square root of the factor.

Key point: The correct exponent is $3/2$; remember $T^2 \propto r^3$ leads to $T \propto r^{3/2}$, so a factor-4 radius gives a factor-8 period.

Final Answer: factor $= 8 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q12

Q13.

Solution

Concept — Bulk modulus: The bulk modulus measures a substance's resistance to uniform compression. It is the ratio of the applied volumetric (normal) stress to the resulting volumetric strain: $B = \dfrac{\Delta P}{(-\Delta V/V)}$, where ΔP is the applied pressure (Pa) and $\Delta V/V$ is the fractional change in volume (volumetric strain, dimensionless). A large bulk modulus means the liquid is hard to compress.

Given: $\Delta P = 2 \times 10^6$ Pa, volumetric strain $= 0.001 = 1 \times 10^{-3}$.

Step 1 — Write the formula and substitute: $B = \dfrac{\Delta P}{\text{strain}} = \dfrac{2 \times 10^6 \text{ Pa}}{1 \times 10^{-3}}$.

Step 2 — Handle the powers of ten: dividing by 10^{-3} is the same as multiplying by 10^3, so $B = 2 \times 10^6 \times 10^3$.

Step 3 — Combine: $B = 2 \times 10^9$ Pa.

Why each other option is wrong:

- (B) 2×10^3 Pa multiplies by the strain instead of dividing by it.
- (C) 2×10^6 Pa ignores the strain altogether and just reports ΔP.
- (D) 5×10^{-10} Pa is actually the compressibility $1/B$, the reciprocal quantity.

Key point: Divide stress by strain (not multiply); a small strain in the denominator makes the bulk modulus very large.

Final Answer: $B = 2 \times 10^9$ Pa $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q13

Q14.

Solution

Concept — Floating bodies and Archimedes' principle: A body floats in equilibrium when its weight is balanced by the buoyant force, which equals the weight of liquid displaced by the submerged part. Setting weight equal to buoyancy, $\rho_{\text{body}} V g = \rho_{\text{liquid}} V_{\text{sub}}\, g$, gives the fraction submerged $\dfrac{V_{\text{sub}}}{V} = \dfrac{\rho_{\text{body}}}{\rho_{\text{liquid}}}$, where ρ_{body} and ρ_{liquid} are the densities of the block and the liquid respectively.

Given: $\rho_{\text{body}} = 600 \text{ kg/m}^3$ (wood), $\rho_{\text{liquid}} = 1000 \text{ kg/m}^3$ (water).

Step 1 — Write the formula and substitute: fraction submerged $= \dfrac{\rho_{\text{body}}}{\rho_{\text{liquid}}} = \dfrac{600 \text{ kg/m}^3}{1000 \text{ kg/m}^3}$.

Step 2 — Simplify: the units cancel, leaving fraction $= \dfrac{600}{1000} = 0.6$.

Step 3 — Interpret: 0.6 (i.e. 60%) of the block's volume lies below the water surface, and the remaining 0.4 floats above.

Why each other option is wrong:

- (A) 0.4 is the fraction floating *above* the water, not the submerged part.

- (C) 0.5 ignores the actual densities and just assumes half-submersion.
- (D) 1.0 would mean the block is fully submerged, which happens only when $\rho_{\text{body}} = \rho_{\text{liquid}}$.

Key point: The submerged fraction is the density ratio (block over liquid); the part above water is one minus that fraction.

Final Answer: $0.6 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept — Coefficients of thermal expansion: When a solid is heated, it expands in length, area and volume. The linear coefficient α governs length expansion, the areal (superficial) coefficient β governs area expansion, and the volume (cubical) coefficient γ governs volume expansion. Because area is two dimensions of length and volume is three, geometry forces the relations $\beta = 2\alpha$ and $\gamma = 3\alpha$ for an isotropic solid.

Step 1 — Express each in terms of α: using $\beta = 2\alpha$ and $\gamma = 3\alpha$, write $\alpha : \beta : \gamma = \alpha : 2\alpha : 3\alpha$.

Step 2 — Cancel the common α: dividing each term by α gives $\alpha : \beta : \gamma = 1 : 2 : 3$.

Why each other option is wrong:

- (A) $1 : 1 : 1$ wrongly treats all three coefficients as equal, ignoring dimensionality.
- (B) $3 : 2 : 1$ reverses the order, putting the largest coefficient with the linear term.
- (D) $2 : 1 : 3$ jumbles the values, mismatching β and α.

Key point: The ratio simply follows the number of dimensions: length 1, area 2, volume 3, so $\alpha : \beta : \gamma = 1 : 2 : 3$.

Final Answer: $1 : 2 : 3 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q15

Q16.

Solution

Concept — Latent heat and specific heat: Converting ice at $0\,°\text{C}$ to warm water happens in two distinct stages. First the ice melts at constant temperature, absorbing latent heat $Q_1 = mL$, where L is the latent heat of fusion. Then the resulting water is warmed, absorbing sensible heat $Q_2 = mc\,\Delta T$, where c is the specific heat of water and ΔT is the temperature rise. The total heat is $Q = mL + mc\,\Delta T$.

Given: $m = 50$ g, $L_{\text{ice}} = 80$ cal/g, $c_{\text{water}} = 1$ cal g^{-1} °C^{-1}, $\Delta T = 20 - 0 = 20\,°\text{C}$.

Step 1 — Melt the ice (latent heat): $Q_1 = mL = (50 \text{ g})(80 \text{ cal/g}) = 4000$ cal.

Step 2 — Warm the water (sensible heat): $Q_2 = mc\,\Delta T = (50 \text{ g})(1 \text{ cal g}^{-1}°\text{C}^{-1})(20\,°\text{C}) = 1000$ cal.

Step 3 — Add the two stages: $Q = Q_1 + Q_2 = 4000 + 1000 = 5000$ cal.

Why each other option is wrong:

- (A) 4000 cal stops after melting and omits the heating of the water.
- (B) 1000 cal counts only the warming and ignores the latent heat of fusion.
- (C) 4500 cal mis-adds the two parts (e.g. uses $\Delta T = 10\,°\text{C}$).

Key point: Melting absorbs heat at constant temperature; you must add both the latent-heat term and the specific-heat term.

Final Answer: $Q = 5000$ cal $\Rightarrow$ D

Answer: (D) Go Back to Q16

Q17.

Solution

Concept — Carnot efficiency: A Carnot engine is the ideal, reversible heat engine operating between a hot source at temperature T_1 and a cold sink at temperature T_2. Its efficiency depends only on these two absolute temperatures: $\eta = 1 - \frac{T_2}{T_1}$, where both temperatures must be in kelvin. This is the maximum possible efficiency any engine working between the same two reservoirs can have.

Given: $T_1 = 400$ K (source), $T_2 = 300$ K (sink).

Step 1 — Write the formula and substitute: $\eta = 1 - \dfrac{T_2}{T_1} = 1 - \dfrac{300 \text{ K}}{400 \text{ K}}$.

Step 2 — Evaluate the ratio: $\dfrac{300}{400} = 0.75$.

Step 3 — Subtract and convert to percent: $\eta = 1 - 0.75 = 0.25 = 25\%$.

Why each other option is wrong:

- (B) 75% quotes the ratio T_2/T_1 itself, forgetting to subtract from 1.
- (C) 33% uses a wrong temperature pair (e.g. treating $T_2/T_1 = 2/3$).
- (D) 50% assumes a sink temperature of 200 K, not the given 300 K.

Key point: Always use absolute (kelvin) temperatures and remember the efficiency is $1 - T_2/T_1$, never just T_2/T_1.

Final Answer: $\eta = 25\% \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q17

Q18.

Solution

Concept — Torque on a current-carrying coil: A coil of N turns, area A, carrying current I in a magnetic field B experiences a torque $\tau = NBIA\sin\theta$, where θ is the angle between the magnetic field and the *normal* to the coil's plane. When the plane of the coil is parallel to B, the normal is perpendicular to B ($\theta = 90°$), so $\sin\theta = 1$ and the torque is maximum: $\tau = NBIA$.

Given: $N = 50$ turns, $A = 4 \times 10^{-3}$ m^2, $I = 2$ A, $B = 0.1$ T, plane parallel to B so $\sin\theta = 1$.

Step 1 — Write the formula and substitute: $\tau = NBIA = (50)(0.1\ \text{T})(2\ \text{A})(4 \times 10^{-3}\ \text{m}^2)$.

Step 2 — Multiply the leading numbers: $50 \times 0.1 \times 2 = 10$, so $\tau = 10 \times (4 \times 10^{-3})$.

Step 3 — Combine: $\tau = 40 \times 10^{-3} = 0.04\ \text{N m}$.

Why each other option is wrong:

- (A) 0.02 N m drops a factor of 2 (e.g. forgets the current $I = 2$ A).
- (C) 0.4 N m uses a wrong power of ten, one decade too large.
- (D) 0.08 N m doubles the result by an extra factor of 2.

Key point: "Plane parallel to the field" means the torque is maximum ($\sin\theta = 1$); do not set $\sin\theta = 0$ here.

Final Answer: $\tau = 0.04\ \text{N m} \Rightarrow \boxed{B}$

Answer: (B) Go Back to Q18

Q19.

Solution

Concept — Mutual inductance: When two coils are placed near each other, a changing current in one (the primary) produces a changing magnetic flux through the other (the secondary), inducing an emf in it. The magnitude of this induced emf is $\varepsilon = M\frac{dI}{dt}$, where M is the mutual inductance (in henry, H) and $\frac{dI}{dt}$ is the rate of change of current in the first coil (in A/s). This is a direct consequence of Faraday's law of electromagnetic induction.

Given: $M = 0.5$ H, $\frac{dI}{dt} = 4$ A/s.

Step 1 — Write the formula and substitute: $\varepsilon = M\frac{dI}{dt} = (0.5\text{ H})(4\text{ A/s})$.

Step 2 — Multiply: $\varepsilon = 0.5 \times 4 = 2$ V (since 1 H · A/s $= 1$ V).

Why each other option is wrong:

- (A) 0.125 V divides M by $\frac{dI}{dt}$ instead of multiplying.
- (B) 4.5 V adds M and $\frac{dI}{dt}$ rather than multiplying them.
- (D) 8 V multiplies by an extra factor of 4 (or uses $M = 2$ H).

Key point: The induced emf is the product of mutual inductance and the rate of change of current; check that the units H·A/s reduce to volts.

Final Answer: $\varepsilon = 2\text{ V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q19

Q20.

Solution

Concept — Average power in an AC circuit: In an AC circuit the voltage and current may be out of phase by an angle ϕ. The average (real) power actually dissipated is $P = V_{rms} I_{rms} \cos\phi$, where V_{rms} and I_{rms} are the root-mean-square voltage and current and $\cos\phi$ is the power factor. The product $V_{rms}I_{rms}$ alone is the apparent power; only the component in phase with the current delivers real power.

Given: $V_{rms} = 200$ V, $I_{rms} = 5$ A, $\phi = 60°$, $\cos 60° = 0.5$.

Step 1 — Write the formula and substitute: $P = V_{rms}I_{rms}\cos\phi = (200\text{ V})(5\text{ A})(\cos 60°)$.

Step 2 — Compute the apparent power: $V_{rms}I_{rms} = 200 \times 5 = 1000$ VA.

Step 3 — Apply the power factor: $P = 1000 \times 0.5 = 500$ W.

Why each other option is wrong:

- (A) 1000 W ignores the power factor $\cos 60°$ and reports the apparent power.
- (B) 866 W uses $\cos 30° \approx 0.866$ instead of $\cos 60°$.
- (C) 0 W would require $\phi = 90°$ (a purely reactive circuit), which is not the case here.

Key point: Real power always includes the power factor $\cos\phi$; only at $\phi = 90°$ does the average power vanish.

Final Answer: $P = 500 \text{ W} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q20

Q21.

Solution

Concept — Power of a lens: The power of a lens measures its ability to converge or diverge light and is defined as the reciprocal of its focal length expressed in metres: $P = \dfrac{1}{f(\text{in m})}$. The unit is the dioptre (D), where $1 \text{ D} = 1 \text{ m}^{-1}$. A converging (convex) lens has a positive focal length and therefore a positive power; a diverging (concave) lens has negative power.

Given: convex lens with focal length $f = 25$ cm.

Step 1 — Convert the focal length to metres: $f = 25 \text{ cm} = \dfrac{25}{100} \text{ m} = 0.25 \text{ m}$.

Step 2 — Apply the formula: $P = \dfrac{1}{f} = \dfrac{1}{0.25 \text{ m}}$.

Step 3 — Evaluate: $P = +4$ D (positive because the lens is convex).

Why each other option is wrong:

- (B) $+0.25$ D quotes the focal length in metres rather than its reciprocal.
- (C) -4 D has the wrong sign; a convex (converging) lens has positive power.
- (D) $+2.5$ D wrongly uses $f = 0.4$ m or mishandles the cm-to-m conversion.

Key point: Convert the focal length to metres before inverting, and keep the sign convention (convex positive, concave negative).

Final Answer: $P = +4\text{ D} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept — Apparent depth: When an object lies under a transparent medium such as water and is viewed from directly above, refraction at the surface makes it appear closer to the surface than it really is. The apparent depth is related to the real depth by apparent depth $= \frac{\text{real depth}}{n}$, where n is the refractive index of the medium relative to air. Because $n > 1$, the apparent depth is always less than the real depth.

Given: real depth $= 1.33$ m, refractive index $n = 1.33$.

Step 1 — Write the formula and substitute: apparent depth $= \frac{\text{real depth}}{n} = \frac{1.33\text{ m}}{1.33}$.

Step 2 — Evaluate: the 1.33 values cancel, giving apparent depth $= 1.0$ m.

Why each other option is wrong:

- (A) 1.77 m multiplies the real depth by n instead of dividing.
- (C) 1.33 m ignores the refraction and simply repeats the real depth.
- (D) 0.75 m divides by a wrong factor (e.g. by n^2 or 1.77).

Key point: Divide the real depth by the refractive index; an object always looks shallower, never deeper, when viewed through water.

Final Answer: apparent depth $= 1.0\text{ m} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q22

Q23.

Solution

Concept — Brewster's angle and polarisation: When unpolarised light strikes a transparent surface, the reflected ray is completely plane polarised at one particular angle of incidence called Brewster's angle θ_B. At this angle the reflected and refracted rays are perpendicular to each other, which leads to Brewster's law: $\tan\theta_B = n$, where n is the refractive index of the surface relative to the incident medium.

Given: refractive index $n = \sqrt{3}$.

Step 1 — Write Brewster's law and substitute: $\tan\theta_B = n = \sqrt{3}$.

Step 2 — Take the inverse tangent: $\theta_B = \tan^{-1}(\sqrt{3})$.

Step 3 — Evaluate the standard angle: since $\tan 60° = \sqrt{3}$, we get $\theta_B = 60°$.

Why each other option is wrong:

- (A) $30°$ gives $\tan 30° = 1/\sqrt{3}$, the reciprocal of the required value.
- (B) $45°$ gives $\tan 45° = 1$, corresponding to $n = 1$ (no refraction).
- (D) $90°$ is grazing incidence, not a physically meaningful polarising angle here.

Key point: Brewster's angle is the inverse tangent of the refractive index; for $n = \sqrt{3}$ this is exactly $60°$.

Final Answer: $\theta_B = 60° \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q23

Q24.

Solution

Concept — Photon momentum: Although a photon has no rest mass, it carries momentum given by the de Broglie relation $p = \frac{h}{\lambda}$, where $h = 6.6 \times 10^{-34}$ J s is Planck's constant and λ is the wavelength of the light (in m). This follows from combining $E = hc/\lambda$ with $E = pc$ for a photon. The momentum has units of kg m/s.

Given: $\lambda = 6.6 \times 10^{-7}$ m, $h = 6.6 \times 10^{-34}$ J s.

Step 1 — Write the formula and substitute: $p = \frac{h}{\lambda} = \frac{6.6 \times 10^{-34}\ \text{J s}}{6.6 \times 10^{-7}\ \text{m}}$.

Step 2 — Divide the mantissas: $\frac{6.6}{6.6} = 1$.

Step 3 — Handle the powers of ten: $\frac{10^{-34}}{10^{-7}} = 10^{-34+7} = 10^{-27}$, so $p = 1 \times 10^{-27}$ kg m/s.

Why each other option is wrong:

- (A) 1×10^{-34} keeps only h and forgets to divide by the wavelength.
- (B) 4.4×10^{-27} uses incorrect mantissas unrelated to the given data.

- (C) 1×10^{-41} multiplies the exponents instead of subtracting them $(-34 - 7)$.

Key point: Subtract exponents when dividing powers of ten: $-34 - (-7) = -27$, giving $p = 1 \times 10^{-27}$ kg m/s.

Final Answer: $p = 1 \times 10^{-27}$ kg m/s $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q24

Q25.

Solution

Concept — Penetrating power of nuclear radiations: The three common radioactive emissions differ greatly in mass, charge and penetrating ability. Alpha (α) particles are helium nuclei: heavy, doubly charged, and strongly ionising, so they lose energy quickly and penetrate least. Beta (β) particles are fast electrons: much lighter and singly charged, so they penetrate further. Gamma (γ) rays are high-energy photons with no charge and no rest mass, so they penetrate the most.

Step 1 — Recall the stopping materials: α is stopped by a sheet of paper, β is stopped by a few millimetres of aluminium, and γ requires thick lead or concrete.

Step 2 — Rank by penetrating power: since paper $<$ aluminium $<$ lead in shielding required, the increasing order of penetration is $\alpha < \beta < \gamma$.

Why each other option is wrong:

- (B) $\gamma < \beta < \alpha$ is exactly reversed; γ is the most penetrating, not the least.
- (C) $\beta < \alpha < \gamma$ wrongly places α above β in penetration.
- (D) $\alpha < \gamma < \beta$ wrongly puts γ below β.

Key point: Penetrating power increases as $\alpha < \beta < \gamma$, exactly opposite to their ionising power, which decreases in the same order.

Final Answer: $\alpha < \beta < \gamma \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q25

Q26.

Solution

Concept — Bohr's quantisation of angular momentum: In Bohr's model of the hydrogen atom, the electron can occupy only certain stable orbits in which its angular momentum is an integer multiple of $\frac{h}{2\pi}$. This quantisation postulate is written $L = mvr = n\frac{h}{2\pi}$, where m is the electron mass, v its speed, r the orbit radius, h Planck's constant, and $n = 1, 2, 3, \ldots$ the principal quantum number. The quantity $\frac{h}{2\pi}$ is often written as $\hbar$ (h-bar).

Step 1 — State the postulate: Bohr assumed $mvr = n\frac{h}{2\pi}$ for allowed orbits.

Step 2 — Identify the angular momentum: the left side mvr is precisely the orbital angular momentum L, so $L = \frac{nh}{2\pi}$.

Why each other option is wrong:

- (A) $\frac{nh}{4\pi}$ uses the wrong denominator (this is half the correct value).
- (C) $\frac{2\pi}{nh}$ inverts the expression, giving the wrong dimensions entirely.
- (D) $\frac{nh}{\pi}$ omits the factor of 2 in the denominator (twice too large).

Key point: The Bohr quantisation condition is $L = n\frac{h}{2\pi} = n\hbar$; the denominator is 2π, not π or 4π.

Final Answer: $L = \frac{nh}{2\pi} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q26

Q27.

Solution

Concept — Simple pendulum and gravity: The period of a simple pendulum of length L is $T = 2\pi\sqrt{\frac{L}{g}}$, where g is the local acceleration due to gravity. For a fixed length, the period depends only on g, with $T \propto \frac{1}{\sqrt{g}}$. So if g decreases, the period increases. On the Moon g is one-sixth of its Earth value, so the pendulum swings more slowly.

Given: $T_{\text{earth}} = 2$ s, $g_{\text{moon}} = \frac{g_{\text{earth}}}{6}$, same length L.

Step 1 — Form the ratio of periods: since $T \propto \frac{1}{\sqrt{g}}$, $\frac{T_{\text{moon}}}{T_{\text{earth}}} = \sqrt{\frac{g_{\text{earth}}}{g_{\text{moon}}}} = \sqrt{6}$.

Step 2 — Solve for T_{moon}: $T_{\text{moon}} = T_{\text{earth}} \times \sqrt{6} = 2 \times \sqrt{6}$ s.

Step 3 — Evaluate numerically: $\sqrt{6} \approx 2.45$, so $T_{\text{moon}} \approx 2 \times 2.45 = 4.9$ s.

Why each other option is wrong:

- (A) 2 s ignores the change in g and keeps the Earth period.
- (B) 1.2 s shortens the period, which would require a *larger* g.
- (D) 12 s uses a factor of 6 instead of $\sqrt{6}$.

Key point: The period scales with $1/\sqrt{g}$, so a sixfold drop in g lengthens the period by $\sqrt{6} \approx 2.45$, not by 6.

Final Answer: $T \approx 4.9$ s $\Rightarrow$ C

Answer: (C) Go Back to Q27

Q28.

Solution

Concept — Doppler effect for sound: When a source of sound moves relative to a stationary observer, the observed frequency differs from the emitted frequency. For a source approaching a stationary observer, the wavefronts bunch up and the observer hears a higher frequency given by $f' = f\frac{v}{v - v_s}$, where f is the source frequency, v is the speed of sound and v_s is the speed of the source. The minus sign in the denominator (for approach) makes the fraction greater than 1, raising the pitch.

Given: $f = 400$ Hz, $v = 330$ m/s, $v_s = 30$ m/s (approaching).

Step 1 — Write the formula and substitute: $f' = f\frac{v}{v - v_s} = 400 \times \frac{330}{330 - 30}$.

Step 2 — Simplify the denominator: $330 - 30 = 300$, so $f' = 400 \times \frac{330}{300}$.

Step 3 — Evaluate: $\frac{330}{300} = 1.1$, so $f' = 400 \times 1.1 = 440$ Hz.

Why each other option is wrong:

- (A) 364 Hz uses $v + v_s$ in the denominator, which applies to a *receding* source.
- (B) 400 Hz ignores the source motion entirely.
- (C) 330 Hz is the speed of sound in m/s, not a frequency at all.

Key point: For an approaching source use $v - v_s$ in the denominator so the heard frequency rises; a receding source uses $v + v_s$.

Final Answer: $f' = 440$ Hz $\Rightarrow$ D

Answer: (D) Go Back to Q28

Q29.

Solution

Concept — Doping of semiconductors: Pure (intrinsic) silicon has four valence electrons per atom, all used in covalent bonds. Doping adds a small amount of impurity to control conductivity. A pentavalent impurity (such as phosphorus, arsenic or antimony) has five valence electrons; four form covalent bonds with neighbouring silicon atoms, leaving a fifth electron loosely bound. This extra electron is easily freed, so the impurity *donates* a free electron and is called a donor.

Step 1 — Count the bonding electrons: four of phosphorus's five valence electrons bond with silicon; one is left over as a nearly free electron.

Step 2 — Identify the majority carrier: the donated free electrons greatly outnumber holes, so electrons are the majority carriers. A material with extra negative carriers is called n-type.

Step 3 — Classify: phosphorus acts as a donor, producing an n-type semiconductor.

Why each other option is wrong:

- (B) acceptors and p-type require a *trivalent* impurity (e.g. boron), not pentavalent.
- (C) donors correctly describe phosphorus, but donors give n-type, not p-type.
- (D) acceptors do not give n-type; this pairs the wrong dopant role with the wrong type.

Key point: Pentavalent $\rightarrow$ donor $\rightarrow$ n-type (extra electrons); trivalent $\rightarrow$ acceptor $\rightarrow$ p-type (extra holes).

Final Answer: donor, n-type $\Rightarrow$ A

Answer: (A) Go Back to Q29

Q30.

Solution

Concept — Zener diode as a voltage regulator: A Zener diode is a heavily doped p-n junction designed to operate safely in the reverse breakdown region. In ordinary diodes reverse breakdown is destructive, but a Zener diode is built to withstand it. The key property is that once breakdown begins, the voltage across the diode stays almost constant at the Zener voltage V_Z even though the current through it changes substantially. This nearly constant voltage is exactly what is needed to regulate (stabilise) an output voltage.

Step 1 — Determine the operating region: for regulation the diode must be connected in *reverse bias* and driven into the breakdown region beyond V_Z.

Step 2 — Explain the regulation mechanism: in breakdown the steep, nearly vertical part of the I–V curve means large current changes produce only tiny voltage changes, so the output voltage is held at V_Z.

Step 3 — Conclude: therefore a Zener voltage regulator works in reverse bias in the breakdown region.

Why each other option is wrong:

- (A) forward bias near the knee gives the ordinary diode drop (≈ 0.7 V), which is not a stable regulating voltage.
- (B) an unbiased diode carries essentially no current and cannot regulate anything.
- (D) forward bias at high current simply behaves like a conducting diode, not a regulator.

Key point: A Zener regulator always operates in reverse breakdown, where the constant V_Z provides the stable reference voltage.

Final Answer: reverse bias in the breakdown region $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q30

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	B	3	A	4	D	5	B
6	C	7	A	8	D	9	A	10	B
11	C	12	D	13	A	14	B	15	C
16	D	17	A	18	B	19	C	20	D
21	A	22	B	23	C	24	D	25	A
26	B	27	C	28	D	29	A	30	C