

# SAAT Physics

## Sample Paper – 10

Duration: 40 Minutes

Maximum Marks: 40

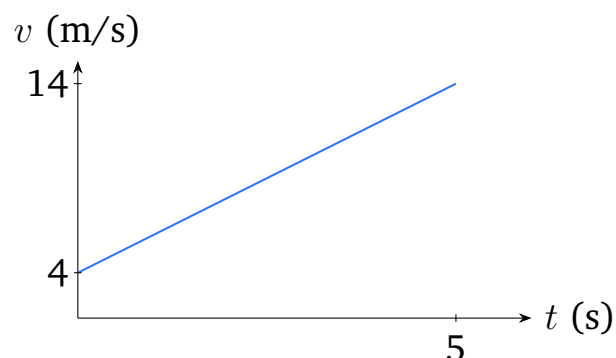
### Instructions

- This paper contains **40** Multiple Choice Questions (Single Correct Answer), modelled on the Physics section of the **SAAT** (Siksha 'O' Anusandhan Admission Test).
- Each correct answer carries **+1 mark**. There is **no negative marking** for incorrect or unattempted answers.
- Only **one** option is correct. Attempt every question, since wrong answers are not penalised.
- Use of mobile phones, calculators, or other electronic gadgets is strictly prohibited.

**Q1.** The dimensional formula of **surface tension** is

- (A)  $MT^{-2}$
- (B)  $ML^{-1}T^{-2}$
- (C)  $MLT^{-2}$
- (D)  $ML^2T^{-2}$

**Q2.** The velocity–time graph of a particle moving along a straight line is shown below. The acceleration of the particle during the interval from 0 to 5 s is

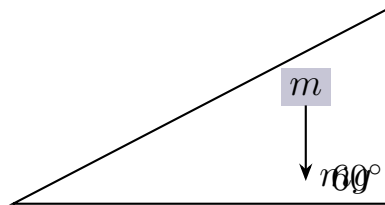


- (A)  $4 \text{ m/s}^2$
- (B)  $2 \text{ m/s}^2$
- (C)  $2.8 \text{ m/s}^2$
- (D)  $10 \text{ m/s}^2$

**Q3.** A projectile is launched with a speed of  $20 \text{ m/s}$  at an angle of  $30^\circ$  above the horizontal. Its horizontal range is ( $g = 10 \text{ m/s}^2$ )

- (A)  $40 \text{ m}$
- (B)  $20 \text{ m}$
- (C)  $20\sqrt{3} \text{ m}$  ( $\approx 34.6 \text{ m}$ )
- (D)  $40\sqrt{3} \text{ m}$

**Q4.** A block of mass  $4 \text{ kg}$  rests on a smooth inclined plane of inclination  $60^\circ$ , as shown. The normal reaction exerted by the surface on the block is ( $g = 10 \text{ m/s}^2$ )



- (A)  $40 \text{ N}$
- (B)  $34.6 \text{ N}$
- (C)  $46 \text{ N}$
- (D)  $20 \text{ N}$

**Q5.** A ball of mass  $0.2 \text{ kg}$  moving at  $15 \text{ m/s}$  strikes a wall normally and rebounds with the same speed. The magnitude of the impulse imparted to the ball is

- (A)  $3 \text{ N s}$
- (B)  $6 \text{ N s}$



(C) 1.5 N s

(D) 0 N s

**Q6.** A constant force of magnitude 10 N acts on a body and displaces it through 4 m, the angle between the force and the displacement being  $60^\circ$ . The work done by the force is

(A) 40 J

(B) 34.6 J

(C) 20 J

(D) 0 J

**Q7.** A body of mass 2 kg is dropped from rest from a height of 20 m. Using energy conservation, its speed just before hitting the ground is ( $g = 10 \text{ m/s}^2$ )

(A) 20 m/s

(B) 10 m/s

(C) 40 m/s

(D) 400 m/s

**Q8.** The moment of inertia of a uniform solid sphere of mass  $M$  and radius  $R$  about an axis passing through its centre is

(A)  $\frac{1}{2}MR^2$

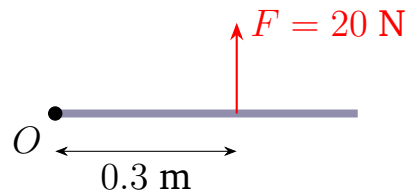
(B)  $MR^2$

(C)  $\frac{2}{3}MR^2$

(D)  $\frac{2}{5}MR^2$

**Q9.** A force of 20 N is applied perpendicular to a rod at a point 0.3 m from the pivot  $O$ , as shown. The torque produced about  $O$  is





- (A)  $2 \text{ N m}$
- (B)  $6 \text{ N m}$
- (C)  $60 \text{ N m}$
- (D)  $0.6 \text{ N m}$

**Q10.** The orbital speed of a satellite revolving very close to the surface of a planet of radius  $R$  and surface gravity  $g$  is

- (A)  $\sqrt{gR}$
- (B)  $\sqrt{2gR}$
- (C)  $\sqrt{gR/2}$
- (D)  $gR$

**Q11.** A steel wire of length  $4 \text{ m}$  and cross-sectional area  $2 \text{ mm}^2$  carries a load of  $200 \text{ N}$ . If the Young's modulus of steel is  $2 \times 10^{11} \text{ N/m}^2$ , the elongation of the wire is

- (A)  $1 \text{ mm}$
- (B)  $4 \text{ mm}$
- (C)  $2 \text{ mm}$
- (D)  $0.5 \text{ mm}$

**Q12.** Water flows out of a small hole in the side of a large tank at a depth of  $5 \text{ m}$  below the free surface. The speed of efflux of the water is ( $g = 10 \text{ m/s}^2$ )

- (A)  $5 \text{ m/s}$
- (B)  $50 \text{ m/s}$
- (C)  $100 \text{ m/s}$



(D) 10 m/s

**Q13.** A gas is supplied with 300 J of heat, and its internal energy increases by 180 J. The work done by the gas on its surroundings is

(A) 480 J

(B) 120 J

(C) 180 J

(D) 300 J

**Q14.** In which one of the following processes is **all** the heat supplied to an ideal gas converted into work done by the gas (so that the internal energy stays constant)?

(A) Isothermal expansion

(B) Adiabatic expansion

(C) Isochoric heating

(D) Isobaric expansion

**Q15.** The average translational kinetic energy of the molecules of an ideal gas at temperature  $T$  is  $E$ . If the absolute temperature is doubled to  $2T$ , the average translational kinetic energy becomes

(A)  $E$

(B)  $4E$

(C)  $2E$

(D)  $E/2$

**Q16.** A Carnot engine works between a source at 400 K and a sink at 300 K. Its efficiency is

(A) 75%

(B) 33%



(C) 50%

(D) 25%

**Q17.** A particle executes simple harmonic motion of amplitude 0.05 m and angular frequency 20 rad/s. The maximum speed of the particle is

(A) 1 m/s

(B) 0.5 m/s

(C) 20 m/s

(D) 400 m/s

**Q18.** A block of mass 2 kg attached to a spring of force constant 200 N/m executes simple harmonic motion on a smooth horizontal surface. The time period of oscillation is

(A)  $\frac{\pi}{20}$  s

(B)  $\frac{\pi}{5}$  s ( $\approx 0.63$  s)

(C)  $\frac{\pi}{10}$  s

(D)  $\pi$  s

**Q19.** Two tuning forks of frequencies 256 Hz and 260 Hz are sounded together. The number of beats heard per second is

(A) 516

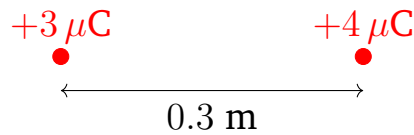
(B) 2

(C) 4

(D) 8

**Q20.** Two point charges of  $+3 \mu\text{C}$  and  $+4 \mu\text{C}$  are separated by a distance of 0.3 m, as shown. The magnitude of the electrostatic force between them is  $\left(\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N m}^2/\text{C}^2\right)$





- (A) 0.36 N
- (B) 3.6 N
- (C) 0.12 N
- (D) 1.2 N

**Q21.** The magnitude of the electric field at a distance of 0.3 m from a point charge of  $5 \mu\text{C}$  is  $\left(\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N m}^2/\text{C}^2\right)$

- (A)  $5 \times 10^5 \text{ N/C}$
- (B)  $1.5 \times 10^5 \text{ N/C}$
- (C)  $1.5 \times 10^6 \text{ N/C}$
- (D)  $5 \times 10^4 \text{ N/C}$

**Q22.** Two capacitors of capacitance  $6 \mu\text{F}$  and  $3 \mu\text{F}$  are connected in series. The equivalent capacitance of the combination is

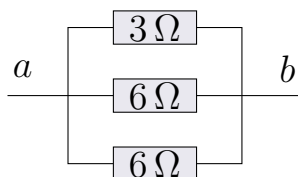
- (A)  $9 \mu\text{F}$
- (B)  $2 \mu\text{F}$
- (C)  $4.5 \mu\text{F}$
- (D)  $18 \mu\text{F}$

**Q23.** The electrostatic potential energy of a system of two point charges  $+2 \mu\text{C}$  and  $-3 \mu\text{C}$  separated by 0.6 m is  $\left(\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N m}^2/\text{C}^2\right)$

- (A) +0.09 J
- (B)  $+9 \times 10^4 \text{ J}$
- (C) -0.18 J
- (D) -0.09 J



**Q24.** In the network shown, three resistors of  $3\ \Omega$ ,  $6\ \Omega$  and  $6\ \Omega$  are connected in parallel across the same two nodes. The equivalent resistance between the nodes is



- (A)  $15\ \Omega$
- (B)  $2\ \Omega$
- (C)  $1.5\ \Omega$
- (D)  $3\ \Omega$

**Q25.** A cell of emf  $6\ \text{V}$  and internal resistance  $0.5\ \Omega$  delivers a current of  $2\ \text{A}$  to an external circuit. The terminal voltage of the cell is

- (A)  $5\ \text{V}$
- (B)  $7\ \text{V}$
- (C)  $6\ \text{V}$
- (D)  $1\ \text{V}$

**Q26.** A current of  $3\ \text{A}$  flows through a  $4\ \Omega$  resistor for  $5\ \text{s}$ . The heat developed in the resistor is

- (A)  $60\ \text{J}$
- (B)  $180\ \text{J}$
- (C)  $36\ \text{J}$
- (D)  $20\ \text{J}$

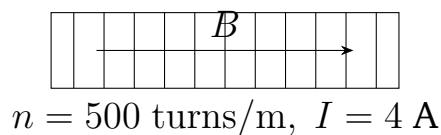
**Q27.** A wire of length  $10\ \text{m}$  and cross-sectional area  $2 \times 10^{-6}\ \text{m}^2$  is made of a material of resistivity  $4 \times 10^{-7}\ \Omega\ \text{m}$ . The resistance of the wire is

- (A)  $0.5\ \Omega$



- (B)  $4 \Omega$
- (C)  $2 \Omega$
- (D)  $20 \Omega$

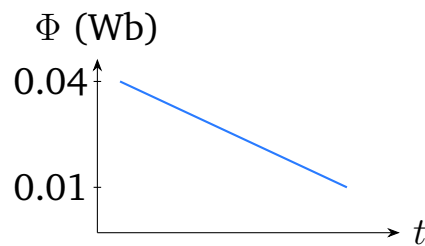
**Q28.** A long solenoid has 500 turns per metre and carries a current of 4 A, as shown. The magnetic field inside the solenoid is ( $\mu_0 = 4\pi \times 10^{-7} \text{ T m/A}$ )



- (A)  $6.28 \times 10^{-3} \text{ T}$
  - (B)  $1.26 \times 10^{-3} \text{ T}$
  - (C)  $4 \times 10^{-3} \text{ T}$
  - (D)  $2.51 \times 10^{-3} \text{ T}$
- Q29.** A straight conductor of length 0.5 m carrying a current of 8 A is placed perpendicular to a uniform magnetic field of 0.4 T. The force experienced by the conductor is
- (A) 3.2 N
  - (B) 1.6 N
  - (C) 0.8 N
  - (D) 6.4 N
- Q30.** A circular coil of 50 turns and radius 0.1 m carries a current of 2 A. The magnetic dipole moment of the coil is
- (A)  $\pi \text{ A m}^2$
  - (B)  $2\pi \text{ A m}^2$
  - (C)  $0.5\pi \text{ A m}^2$
  - (D)  $100\pi \text{ A m}^2$



- Q31.** The magnetic flux through a coil of 200 turns changes uniformly from 0.04 Wb to 0.01 Wb in 0.6 s, as suggested below. The magnitude of the emf induced in the coil is



- (A) 0.05 V  
(B) 1 V  
(C) 5 V  
(D) 10 V
- Q32.** A capacitor of capacitance  $50 \mu\text{F}$  is connected to an AC source of angular frequency  $100 \text{ rad/s}$ . The capacitive reactance is
- (A)  $20 \Omega$   
(B)  $50 \Omega$   
(C)  $200 \Omega$   
(D)  $500 \Omega$
- Q33.** For an electromagnetic wave travelling in free space, the average energy density is shared between the electric and magnetic fields such that
- (A) the electric and magnetic energy densities are equal  
(B) the electric energy density is twice the magnetic energy density  
(C) the magnetic energy density is twice the electric energy density  
(D) the magnetic energy density is zero
- Q34.** Why is a low-frequency audio (message) signal not radiated directly from an antenna and instead superimposed on a high-frequency carrier before transmission?



- (A) Low-frequency signals carry no information
- (B) A practical antenna for low frequencies would be impractically large, and radiated power is very small
- (C) Low-frequency signals travel faster than high-frequency ones
- (D) High-frequency signals cannot be detected at the receiver

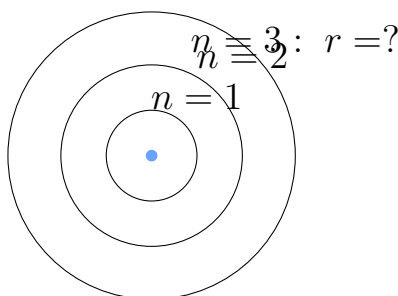
**Q35.** Light of photon energy 6 eV is incident on a metal of work function 2.5 eV. The stopping potential required to halt the most energetic photoelectrons is

- (A) 8.5 V
- (B) 6 V
- (C) 3.5 V
- (D) 2.5 V

**Q36.** The de Broglie wavelength of a moving cricket ball is far too small to be observed in any experiment. The main reason is that

- (A) the ball carries no electric charge
- (B) the ball moves too slowly
- (C) Planck's constant is large for macroscopic bodies
- (D) the ball's momentum is enormous compared with  $h$ , making  $\lambda = h/p$  vanishingly small

**Q37.** In the Bohr model of the hydrogen atom, the radius of the first orbit ( $n = 1$ ) is  $0.53 \text{ \AA}$ . The radius of the orbit  $n = 3$ , indicated in the diagram, is



- (A) 4.77 Å
- (B) 1.59 Å
- (C) 0.53 Å
- (D) 2.12 Å

**Q38.** The mass defect in the formation of a certain nucleus is 0.05 u. Taking  $1 \text{ u} = 931 \text{ MeV}/c^2$ , the binding energy of the nucleus is approximately

- (A) 931 MeV
- (B) 46.6 MeV
- (C) 93.1 MeV
- (D) 18.6 MeV

**Q39.** When silicon is doped with a small amount of a **pentavalent** impurity such as phosphorus, the resulting semiconductor is

- (A) a *p*-type semiconductor with holes as majority carriers
- (B) an intrinsic semiconductor with equal electrons and holes
- (C) an *n*-type semiconductor with electrons as majority carriers
- (D) an insulator with no free carriers

**Q40.** The truth table shown below corresponds to a two-input logic gate whose output *Y* is the complement of  $A + B$  (it is 1 only when both inputs are 0). The gate is

<i>A</i>	<i>B</i>	<i>Y</i>
0	0	1
0	1	0
1	0	0
1	1	0

- (A) AND gate



- (B) OR gate
- (C) NAND gate
- (D) NOR gate



## Detailed Solutions

Q1.

## Solution

**Concept — Dimensional formula of surface tension:** Surface tension is force per unit length,  $T = F/L$ .

**Step 1 — Write the ratio:**  $[T] = \frac{[\text{Force}]}{[\text{Length}]} = \frac{MLT^{-2}}{L}$ .

**Step 2 — Simplify:**  $[T] = MT^{-2}$ .

**Why other options are wrong:**  $ML^{-1}T^{-2}$  is pressure (or energy density);  $MLT^{-2}$  is force;  $ML^2T^{-2}$  is energy.

**Final Answer:** Surface tension has dimensions  $MT^{-2} \Rightarrow$  **A**

**Answer: (A)** [Go Back to Q1](#)

Q2.

## Solution

**Concept — Acceleration from a  $v-t$  graph:** The acceleration is the slope of the velocity–time line.

**Step 1 — Read the endpoints:** Velocity rises from 4 m/s at  $t = 0$  to 14 m/s at  $t = 5$  s.

**Step 2 — Compute the slope:**  $a = \frac{14 - 4}{5 - 0} = \frac{10}{5} = 2 \text{ m/s}^2$ .

**Why other options are wrong:** 4 and 10 read off a single velocity instead of a slope; 2.8 uses a wrong rise.

**Final Answer:**  $a = 2 \text{ m/s}^2 \Rightarrow$  **B**

**Answer: (B)** [Go Back to Q2](#)

Q3.

## Solution

**Concept — Range of a projectile:**  $R = \frac{u^2 \sin 2\theta}{g}$ .

**Step 1 — Substitute:**  $R = \frac{(20)^2 \sin 60^\circ}{10} = \frac{400 \times (\sqrt{3}/2)}{10}$ .



**Step 2 — Compute:**  $R = \frac{200\sqrt{3}}{10} = 20\sqrt{3} \approx 34.6 \text{ m}.$

**Why other options are wrong:** 40 m uses  $\sin 2\theta = 1$  (a  $45^\circ$  launch); 20 m wrongly uses  $\sin \theta$  in place of  $\sin 2\theta$ ;  $40\sqrt{3}$  m doubles the result.

**Final Answer:**  $R = 20\sqrt{3} \approx 34.6 \text{ m} \Rightarrow \boxed{\text{C}}$

**Answer: (C)** [Go Back to Q3](#)

Q4.

### Solution

**Concept — Block on a smooth incline:** The normal reaction balances the component of gravity perpendicular to the surface,  $N = mg \cos \theta.$

**Step 1 — Substitute:**  $N = (4)(10) \cos 60^\circ = 40 \times 0.5.$

**Step 2 — Compute:**  $N = 20 \text{ N}.$

**Why other options are wrong:** 40 N ignores the angle; 34.6 N uses  $\cos 30^\circ$ ; 46 N has no basis.

**Final Answer:**  $N = 20 \text{ N} \Rightarrow \boxed{\text{D}}$

**Answer: (D)** [Go Back to Q4](#)

Q5.

### Solution

**Concept — Impulse equals change in momentum:**  $J = \Delta p = m(v_f - v_i),$  with the rebound velocity reversed.

**Step 1 — Momenta:** Initial  $p_i = 0.2 \times 15 = 3 \text{ kg m/s}$ ; after rebound the velocity reverses, so  $p_f = -3 \text{ kg m/s}.$

**Step 2 — Compute:**  $J = |p_f - p_i| = |-3 - 3| = 6 \text{ N s}.$

**Why other options are wrong:** 3 N s ignores the reversal; 1.5 halves it; 0 assumes no change.

**Final Answer:**  $J = 6 \text{ N s} \Rightarrow \boxed{\text{B}}$

**Answer: (B)** [Go Back to Q5](#)



Q6.

**Solution**

**Concept — Work done by a constant force:**  $W = Fd \cos \theta$ .

**Step 1 — Substitute:**  $W = (10)(4) \cos 60^\circ = 40 \times 0.5$ .

**Step 2 — Compute:**  $W = 20 \text{ J}$ .

**Why other options are wrong:** 40 J takes  $\cos \theta = 1$ ; 34.6 J uses  $\cos 30^\circ$ ; 0 J would need  $\theta = 90^\circ$ .

**Final Answer:**  $W = 20 \text{ J} \Rightarrow$   C

**Answer: (C)** [Go Back to Q6](#)

Q7.

**Solution**

**Concept — Energy conservation in free fall:** The loss in potential energy equals the gain in kinetic energy,  $mgh = \frac{1}{2}mv^2$ , so  $v = \sqrt{2gh}$ .

**Step 1 — Substitute:**  $v = \sqrt{2(10)(20)} = \sqrt{400}$ .

**Step 2 — Compute:**  $v = 20 \text{ m/s}$ .

**Why other options are wrong:** 10 m/s drops a factor of 2; 40 m/s and 400 m/s mis-handle the square root.

**Final Answer:**  $v = 20 \text{ m/s} \Rightarrow$   A

**Answer: (A)** [Go Back to Q7](#)

Q8.

**Solution**

**Concept — Moment of inertia of a solid sphere:** About a diameter through its centre,  $I = \frac{2}{5}MR^2$ .

**Step 1 — Standard result:** Integrating over the solid sphere gives the factor 2/5.

**Why other options are wrong:**  $\frac{1}{2}MR^2$  is a disc;  $MR^2$  is a ring;  $\frac{2}{3}MR^2$  is a thin spherical shell.

**Final Answer:**  $I = \frac{2}{5}MR^2 \Rightarrow$   D

**Answer: (D)** [Go Back to Q8](#)



Q9.

**Solution**

**Concept — Torque of a perpendicular force:**  $\tau = Fr_{\perp}$ , where  $r_{\perp}$  is the perpendicular distance from the pivot.

**Step 1 — Substitute:**  $\tau = 20 \times 0.3$ .

**Step 2 — Compute:**  $\tau = 6 \text{ N m}$ .

**Why other options are wrong:** 2 and 0.6 mis-handle the distance; 60 uses 3 m instead of 0.3 m.

**Final Answer:**  $\tau = 6 \text{ N m} \Rightarrow \boxed{\text{B}}$

**Answer: (B)** [Go Back to Q9](#)

Q10.

**Solution**

**Concept — Orbital speed near a planet's surface:** The gravitational pull supplies the centripetal force,  $\frac{mv^2}{R} = mg$ , so  $v = \sqrt{gR}$ .

**Step 1 — Equate forces:**  $v^2 = gR$ .

**Step 2 — Take the root:**  $v = \sqrt{gR}$ .

**Why other options are wrong:**  $\sqrt{2gR}$  is the escape speed;  $\sqrt{gR/2}$  and  $gR$  have wrong factors or dimensions.

**Final Answer:**  $v = \sqrt{gR} \Rightarrow \boxed{\text{A}}$

**Answer: (A)** [Go Back to Q10](#)

Q11.

**Solution**

**Concept — Elongation from Young's modulus:**  $\Delta L = \frac{FL}{AY}$ .

**Step 1 — Substitute SI values:**  $F = 200 \text{ N}$ ,  $L = 4 \text{ m}$ ,  $A = 2 \times 10^{-6} \text{ m}^2$ ,  $Y = 2 \times 10^{11} \text{ N/m}^2$ .

**Step 2 — Compute:**  $\Delta L = \frac{200 \times 4}{(2 \times 10^{-6})(2 \times 10^{11})} = \frac{800}{4 \times 10^5} = 2 \times 10^{-3} \text{ m} = 2 \text{ mm}$ .

**Why other options are wrong:** 1 mm and 4 mm mis-handle the area or length factor; 0.5 mm uses a wrong  $Y$ .



**Final Answer:**  $\Delta L = 2 \text{ mm} \Rightarrow$   C

**Answer:** (C) [Go Back to Q11](#)

Q12.

### Solution

**Concept — Torricelli's law (speed of efflux):** From Bernoulli's principle,  $v = \sqrt{2gh}$ .

**Step 1 — Substitute:**  $v = \sqrt{2(10)(5)} = \sqrt{100}$ .

**Step 2 — Compute:**  $v = 10 \text{ m/s}$ .

**Why other options are wrong:** 5 m/s drops a factor; 50 and 100 m/s forget the square root.

**Final Answer:**  $v = 10 \text{ m/s} \Rightarrow$   D

**Answer:** (D) [Go Back to Q12](#)

Q13.

### Solution

**Concept — First law of thermodynamics:**  $Q = \Delta U + W$ , so  $W = Q - \Delta U$ .

**Step 1 — Substitute:**  $W = 300 - 180$ .

**Step 2 — Compute:**  $W = 120 \text{ J}$ .

**Why other options are wrong:** 480 J adds instead of subtracting; 180 and 300 J simply restate the data.

**Final Answer:**  $W = 120 \text{ J} \Rightarrow$   B

**Answer:** (B) [Go Back to Q13](#)

Q14.

### Solution

**Concept — Isothermal process:** At constant temperature the internal energy of an ideal gas does not change ( $\Delta U = 0$ ), so the first law gives  $Q = W$ .

**Step 1 — Apply the first law:** With  $\Delta U = 0$ , all the heat supplied appears as work done by the gas.

**Why other options are wrong:** Adiabatic has  $Q = 0$ ; isochoric has  $W = 0$ ;



isobaric expansion raises the internal energy too, so not all heat becomes work.

**Final Answer:** The process is isothermal expansion  $\Rightarrow$

**Answer: (A)** [Go Back to Q14](#)

Q15.

### Solution

**Concept — Average KE of gas molecules:**  $\langle KE \rangle = \frac{3}{2}kT$ , directly proportional to absolute temperature.

**Step 1 — Temperature ratio:** Doubling  $T$  doubles the average kinetic energy.

**Step 2 — New value:**  $E' = 2E$ .

**Why other options are wrong:**  $4E$  uses a  $T^2$  law;  $E$  and  $E/2$  ignore or invert the proportionality.

**Final Answer:**  $E' = 2E \Rightarrow$

**Answer: (C)** [Go Back to Q15](#)

Q16.

### Solution

**Concept — Carnot efficiency:**  $\eta = 1 - \frac{T_{sink}}{T_{source}}$  (kelvin).

**Step 1 — Substitute:**  $\eta = 1 - \frac{300}{400} = 1 - 0.75$ .

**Step 2 — As a percentage:**  $\eta = 0.25 = 25\%$ .

**Why other options are wrong:** 75% uses the ratio the wrong way round; 33% and 50% use wrong temperature pairs.

**Final Answer:**  $\eta = 25\% \Rightarrow$

**Answer: (D)** [Go Back to Q16](#)

Q17.

### Solution

**Concept — Maximum speed in SHM:**  $v_{max} = \omega A$ .

**Step 1 — Substitute:**  $v_{max} = 20 \times 0.05$ .

**Step 2 — Compute:**  $v_{max} = 1$  m/s.



**Why other options are wrong:** 0.5 m/s halves the product; 20 m/s drops the amplitude; 400 m/s mistakenly uses  $\omega^2 A$ .

**Final Answer:**  $v_{max} = 1 \text{ m/s} \Rightarrow \boxed{\text{A}}$

**Answer: (A)** [Go Back to Q17](#)

Q18.

### Solution

**Concept — Period of a spring-mass system:**  $T = 2\pi\sqrt{\frac{m}{k}}$ .

**Step 1 — Substitute:**  $T = 2\pi\sqrt{\frac{2}{200}} = 2\pi\sqrt{0.01}$ .

**Step 2 — Compute:**  $T = 2\pi(0.1) = \frac{\pi}{5} \approx 0.63 \text{ s}$ .

**Why other options are wrong:**  $\pi/20$  squares the factor of 2 wrongly;  $\pi/10$  drops a factor of 2;  $\pi$  uses a wrong ratio.

**Final Answer:**  $T = \frac{\pi}{5} \approx 0.63 \text{ s} \Rightarrow \boxed{\text{B}}$

**Answer: (B)** [Go Back to Q18](#)

Q19.

### Solution

**Concept — Beat frequency:** The number of beats per second equals the difference of the two frequencies,  $f_{beat} = |f_1 - f_2|$ .

**Step 1 — Substitute:**  $f_{beat} = |260 - 256|$ .

**Step 2 — Compute:**  $f_{beat} = 4 \text{ Hz}$ .

**Why other options are wrong:** 516 adds the frequencies; 2 halves the difference; 8 doubles it.

**Final Answer:** 4 beats per second  $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** [Go Back to Q19](#)



Q20.

**Solution**

**Concept — Coulomb's law:**  $F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$ .

**Step 1 — Substitute:**  $F = \frac{9 \times 10^9 \times (3 \times 10^{-6})(4 \times 10^{-6})}{(0.3)^2}$ .

**Step 2 — Compute:**  $F = \frac{9 \times 10^9 \times 12 \times 10^{-12}}{0.09} = \frac{0.108}{0.09} = 1.2 \text{ N}$ .

**Why other options are wrong:** 0.36 N forgets to divide by  $r^2$ ; 3.6 N and 0.12 N mis-place a power of ten.

**Final Answer:**  $F = 1.2 \text{ N} \Rightarrow \boxed{\text{D}}$

**Answer: (D)** [Go Back to Q20](#)

Q21.

**Solution**

**Concept — Field of a point charge:**  $E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$ .

**Step 1 — Substitute:**  $E = \frac{9 \times 10^9 \times 5 \times 10^{-6}}{(0.3)^2}$ .

**Step 2 — Compute:**  $E = \frac{4.5 \times 10^4}{0.09} = 5 \times 10^5 \text{ N/C}$ .

**Why other options are wrong:**  $1.5 \times 10^5$  and  $5 \times 10^4$  mis-handle the  $r^2 = 0.09$  factor;  $1.5 \times 10^6$  over-counts a power of ten.

**Final Answer:**  $E = 5 \times 10^5 \text{ N/C} \Rightarrow \boxed{\text{A}}$

**Answer: (A)** [Go Back to Q21](#)

Q22.

**Solution**

**Concept — Capacitors in series:**  $\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}$ .

**Step 1 — Add reciprocals:**  $\frac{1}{C_s} = \frac{1}{6} + \frac{1}{3} = \frac{1}{6} + \frac{2}{6} = \frac{3}{6} = \frac{1}{2}$ .

**Step 2 — Invert:**  $C_s = 2 \mu\text{F}$ .

**Why other options are wrong:**  $9 \mu\text{F}$  adds them (parallel);  $4.5 \mu\text{F}$  averages them;  $18 \mu\text{F}$  multiplies them.



**Final Answer:**  $C_s = 2 \mu\text{F} \Rightarrow$  **B**

**Answer: (B)** [Go Back to Q22](#)

**Q23.**

### Solution

**Concept — Potential energy of two point charges:**  $U = \frac{1}{4\pi\epsilon_0} \frac{q_1q_2}{r}$ , keeping the signs of the charges.

**Step 1 — Substitute:**  $U = \frac{9 \times 10^9 \times (2 \times 10^{-6})(-3 \times 10^{-6})}{0.6}$ .

**Step 2 — Compute:**  $U = \frac{-5.4 \times 10^{-2}}{0.6} = -9 \times 10^{-2} \text{ J} = -0.09 \text{ J}$ .

**Why other options are wrong:**  $+0.09 \text{ J}$  ignores the negative sign of one charge;  $+9 \times 10^4 \text{ J}$  mis-places the power of ten;  $-0.18 \text{ J}$  uses  $r = 0.3 \text{ m}$  instead of  $0.6 \text{ m}$ .

**Final Answer:**  $U = -0.09 \text{ J} \Rightarrow$  **D**

**Answer: (D)** [Go Back to Q23](#)

**Q24.**

### Solution

**Concept — Resistors in parallel:**  $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ .

**Step 1 — Add reciprocals:**  $\frac{1}{R_p} = \frac{1}{3} + \frac{1}{6} + \frac{1}{6} = \frac{2}{6} + \frac{1}{6} + \frac{1}{6} = \frac{4}{6} = \frac{2}{3}$ .

**Step 2 — Invert:**  $R_p = \frac{3}{2} = 1.5 \Omega$ .

**Why other options are wrong:**  $15 \Omega$  adds them in series;  $2 \Omega$  and  $3 \Omega$  use wrong combinations.

**Final Answer:**  $R_p = 1.5 \Omega \Rightarrow$  **C**

**Answer: (C)** [Go Back to Q24](#)



Q25.

**Solution**

**Concept — Terminal voltage:**  $V = \varepsilon - Ir$ , the emf reduced by the drop across the internal resistance.

**Step 1 — Substitute:**  $V = 6 - (2)(0.5)$ .

**Step 2 — Compute:**  $V = 6 - 1 = 5 \text{ V}$ .

**Why other options are wrong:** 7 V adds the drop instead of subtracting; 6 V ignores internal resistance; 1 V keeps only the drop.

**Final Answer:**  $V = 5 \text{ V} \Rightarrow \boxed{\text{A}}$

**Answer: (A)** [Go Back to Q25](#)

Q26.

**Solution**

**Concept — Joule heating:**  $H = I^2Rt$ .

**Step 1 — Substitute:**  $H = (3)^2 \times 4 \times 5 = 9 \times 4 \times 5$ .

**Step 2 — Compute:**  $H = 180 \text{ J}$ .

**Why other options are wrong:** 60 J uses  $I^2Rt$ ; 36 J drops the time; 20 J has no consistent basis.

**Final Answer:**  $H = 180 \text{ J} \Rightarrow \boxed{\text{B}}$

**Answer: (B)** [Go Back to Q26](#)

Q27.

**Solution**

**Concept — Resistance of a wire:**  $R = \frac{\rho L}{A}$ .

**Step 1 — Substitute:**  $R = \frac{(4 \times 10^{-7})(10)}{2 \times 10^{-6}}$ .

**Step 2 — Compute:**  $R = \frac{4 \times 10^{-6}}{2 \times 10^{-6}} = 2 \Omega$ .

**Why other options are wrong:**  $0.5 \Omega$  inverts the ratio;  $4 \Omega$  and  $20 \Omega$  mis-handle the powers of ten.

**Final Answer:**  $R = 2 \Omega \Rightarrow \boxed{\text{C}}$



Answer: (C) [Go Back to Q27](#)

Q28.

### Solution

**Concept — Field inside a long solenoid:**  $B = \mu_0 n I$ , where  $n$  is the number of turns per metre.

**Step 1 — Substitute:**  $B = (4\pi \times 10^{-7})(500)(4)$ .

**Step 2 — Compute:**  $B = (4\pi \times 10^{-7})(2000) = 8\pi \times 10^{-4} \approx 2.51 \times 10^{-3} \text{ T}$ .

**Why other options are wrong:**  $6.28 \times 10^{-3}$  and  $1.26 \times 10^{-3}$  use wrong numerical factors;  $4 \times 10^{-3}$  drops the  $\pi$ .

**Final Answer:**  $B \approx 2.51 \times 10^{-3} \text{ T} \Rightarrow \boxed{\text{D}}$

Answer: (D) [Go Back to Q28](#)

Q29.

### Solution

**Concept — Force on a current-carrying conductor:**  $F = BIL \sin \theta$ , with  $\theta = 90^\circ$ .

**Step 1 — Substitute:**  $F = (0.4)(8)(0.5)$ .

**Step 2 — Compute:**  $F = 1.6 \text{ N}$ .

**Why other options are wrong:** 3.2 N ignores the length factor; 0.8 N and 6.4 N mis-multiply.

**Final Answer:**  $F = 1.6 \text{ N} \Rightarrow \boxed{\text{B}}$

Answer: (B) [Go Back to Q29](#)

Q30.

### Solution

**Concept — Magnetic moment of a coil:**  $m = NIA = NI\pi r^2$ .

**Step 1 — Substitute:**  $m = 50 \times 2 \times \pi(0.1)^2 = 100 \times \pi \times 0.01$ .

**Step 2 — Compute:**  $m = \pi \text{ A m}^2$ .

**Why other options are wrong:**  $2\pi$  doubles the area;  $0.5\pi$  halves it;  $100\pi$  forgets the  $r^2 = 0.01$  factor.



**Final Answer:**  $m = \pi \text{ A m}^2 \Rightarrow \boxed{\text{A}}$

**Answer:** (A) [Go Back to Q30](#)

Q31.

### Solution

**Concept — Faraday's law:**  $|\varepsilon| = N \frac{|\Delta\Phi|}{\Delta t}$ .

**Step 1 — Change in flux:**  $|\Delta\Phi| = 0.04 - 0.01 = 0.03 \text{ Wb}$ .

**Step 2 — Compute:**  $|\varepsilon| = 200 \times \frac{0.03}{0.6} = 200 \times 0.05 = 10 \text{ V}$ .

**Why other options are wrong:** 0.05 V omits the turns  $N$ ; 1 V and 5 V use a wrong  $\Delta\Phi$  or  $\Delta t$ .

**Final Answer:**  $|\varepsilon| = 10 \text{ V} \Rightarrow \boxed{\text{D}}$

**Answer:** (D) [Go Back to Q31](#)

Q32.

### Solution

**Concept — Capacitive reactance:**  $X_C = \frac{1}{\omega C}$ .

**Step 1 — Substitute:**  $X_C = \frac{1}{(100)(50 \times 10^{-6})}$ .

**Step 2 — Compute:**  $X_C = \frac{1}{5 \times 10^{-3}} = 200 \Omega$ .

**Why other options are wrong:** 20  $\Omega$  and 50  $\Omega$  mis-handle the powers of ten; 500  $\Omega$  uses the wrong product.

**Final Answer:**  $X_C = 200 \Omega \Rightarrow \boxed{\text{C}}$

**Answer:** (C) [Go Back to Q32](#)

Q33.

### Solution

**Concept — Energy density of an EM wave:** In an electromagnetic wave the average electric energy density  $u_E = \frac{1}{2}\varepsilon_0 E^2$  equals the average magnetic energy density  $u_B = \frac{B^2}{2\mu_0}$ .

**Step 1 — Equality of densities:** Because  $E_0 = cB_0$  and  $c = 1/\sqrt{\mu_0\varepsilon_0}$ , the two



expressions are equal at every instant on average.

**Why other options are wrong:** Neither density is twice the other, and the magnetic energy density is certainly not zero in a propagating wave.

**Final Answer:** The electric and magnetic energy densities are equal  $\Rightarrow$  **A**

**Answer: (A)** [Go Back to Q33](#)

Q34.

### Solution

**Concept — Why modulation is needed:** Efficient radiation requires an antenna of size comparable to the wavelength. Audio frequencies have wavelengths of hundreds of kilometres, so a practical antenna is impossibly large and the radiated power is tiny.

**Step 1 — Use a carrier:** Impressing the message on a high-frequency carrier shrinks the required antenna and raises radiated power.

**Why other options are wrong:** Low-frequency signals do carry information and do not travel faster; high-frequency signals can be detected after demodulation.

**Final Answer:** A low-frequency antenna would be impractically large with negligible radiated power  $\Rightarrow$  **B**

**Answer: (B)** [Go Back to Q34](#)

Q35.

### Solution

**Concept — Stopping potential:**  $eV_0 = KE_{max} = E_{photon} - \phi$ , so  $V_0 = \frac{E_{photon} - \phi}{e}$  in volts (energies in eV).

**Step 1 — Maximum kinetic energy:**  $KE_{max} = 6 - 2.5 = 3.5$  eV.

**Step 2 — Stopping potential:**  $V_0 = 3.5$  V.

**Why other options are wrong:** 8.5 V adds the work function; 6 V ignores it; 2.5 V gives only the work function.

**Final Answer:**  $V_0 = 3.5$  V  $\Rightarrow$  **C**

**Answer: (C)** [Go Back to Q35](#)



Q36.

**Solution**

**Concept — de Broglie wavelength:**  $\lambda = \frac{h}{p}$ , with  $h = 6.63 \times 10^{-34}$  J s extremely small.

**Step 1 — Macroscopic momentum:** A cricket ball has a momentum of order 1 kg m/s, enormous compared with  $h$ .

**Step 2 — Resulting wavelength:**  $\lambda = h/p \sim 10^{-34}$  m, far too small to detect.

**Why other options are wrong:** Charge is irrelevant; the ball is not too slow in this sense; Planck's constant is a fixed small number, not large for big bodies.

**Final Answer:** The huge momentum makes  $\lambda = h/p$  vanishingly small  $\Rightarrow$  **D**

**Answer: (D)** [Go Back to Q36](#)

Q37.

**Solution**

**Concept — Bohr orbit radius:**  $r_n = n^2 r_1$ , where  $r_1 = 0.53 \text{ \AA}$ .

**Step 1 — Put  $n = 3$ :**  $r_3 = 3^2 \times 0.53 = 9 \times 0.53$ .

**Step 2 — Compute:**  $r_3 = 4.77 \text{ \AA}$ .

**Why other options are wrong:**  $1.59 \text{ \AA}$  uses  $n$  instead of  $n^2$ ;  $0.53 \text{ \AA}$  is the first orbit;  $2.12 \text{ \AA}$  corresponds to  $n = 2$ .

**Final Answer:**  $r_3 = 4.77 \text{ \AA} \Rightarrow$  **A**

**Answer: (A)** [Go Back to Q37](#)

Q38.

**Solution**

**Concept — Mass–energy of binding:** The binding energy equals the mass defect times 931 MeV per atomic mass unit,  $E_b = \Delta m \times 931 \text{ MeV}$ .

**Step 1 — Substitute:**  $E_b = 0.05 \times 931$ .

**Step 2 — Compute:**  $E_b = 46.55 \approx 46.6 \text{ MeV}$ .

**Why other options are wrong:** 931 MeV uses  $\Delta m = 1 \text{ u}$ ; 93.1 MeV uses 0.1 u; 18.6 MeV uses 0.02 u.

**Final Answer:**  $E_b \approx 46.6 \text{ MeV} \Rightarrow$  **B**



Answer: (B) [Go Back to Q38](#)

Q39.

### Solution

**Concept — Doping with a pentavalent impurity:** A pentavalent atom (e.g. phosphorus) contributes one extra electron after forming four covalent bonds, donating free electrons.

**Step 1 — Identify majority carriers:** The donated electrons make electrons the majority carriers, giving an  $n$ -type semiconductor.

**Why other options are wrong:** Holes are majority carriers only for trivalent ( $p$ -type) doping; doping breaks the intrinsic balance; the crystal remains a good conductor, not an insulator.

**Final Answer:** An  $n$ -type semiconductor with electrons as majority carriers  $\Rightarrow$   C

Answer: (C) [Go Back to Q39](#)

Q40.

### Solution

**Concept — Identifying a gate from its truth table:** An output that is 1 only when both inputs are 0 is the complement of the OR operation,  $Y = \overline{A + B}$ , which defines the NOR gate.

**Step 1 — Match the table:** The given rows  $00 \rightarrow 1$ ,  $01 \rightarrow 0$ ,  $10 \rightarrow 0$ ,  $11 \rightarrow 0$  are exactly the NOR truth table.

**Why other options are wrong:** AND gives 1 only for 11; OR gives 1 whenever any input is 1; NAND gives 0 only for 11.

**Final Answer:** The gate is a NOR gate  $\Rightarrow$   D

Answer: (D) [Go Back to Q40](#)



## Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	B	3	C	4	D	5	B
6	C	7	A	8	D	9	B	10	A
11	C	12	D	13	B	14	A	15	C
16	D	17	A	18	B	19	C	20	D
21	A	22	B	23	D	24	C	25	A
26	B	27	C	28	D	29	B	30	A
31	D	32	C	33	A	34	B	35	C
36	D	37	A	38	B	39	C	40	D

