# JEE Main

## Sample Paper – 8

**Duration: 3 Hours (180 Minutes)** | **Maximum Marks: 300**

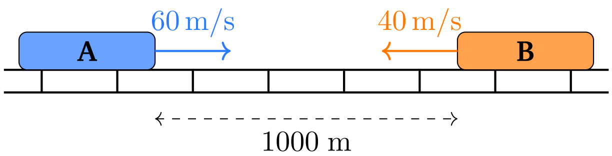
### Instructions

- Full-length mock test modelled on **JEE Main** B.E./B.Tech. Paper 1 — **90 questions** (30 each: Physics, Chemistry, Mathematics).
- **Section A** (20 MCQs per subject): $+4$ for correct; $-1$ for incorrect; 0 for unattempted.
- **Section B** (10 Numerical per subject): attempt **any 5**; $+4$ for correct; no negative marking.
- Total to attempt: **75** (25 per subject). Total available: 90.
- Personal calculators, log tables, and mobile phones are strictly prohibited. A simple on-screen virtual calculator is provided in the CBT interface. Rough sheets will be supplied at the centre.

## PHYSICS

### Section A — Single Correct MCQ (Q1–Q20) [+4 / −1]

**Q1.** Two trains approach each other on parallel tracks. Train A moves at $60\ \mathrm{m/s}$ and Train B moves at $40\ \mathrm{m/s}$ in the opposite direction. The initial separation between the trains is $1\ \mathrm{km}$. How long does it take for the trains to meet?




(A) $5\ \mathrm{s}$

(B) $8\ \mathrm{s}$

(C) 12 s

(D) 10 s

**Q2.** A pendulum is suspended from the roof of a car that is accelerating horizontally at $a = 3\ \mathrm{m/s^2}$ (take $g = 10\ \mathrm{m/s^2}$). Which of the following correctly gives the angle $\theta$ made by the pendulum with the vertical?

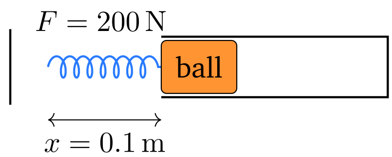
(A) $\tan\theta = g/a$

(B) $\tan\theta = a/g$

(C) $\tan\theta = a^2/g$

(D) $\tan\theta = g/a^2$

**Q3.** A spring gun has its spring compressed by $x = 0.1\ \mathrm{m}$ when a force of $200\ \mathrm{N}$ is applied. What is the elastic potential energy stored in the spring?




(A) 5 J

(B) 20 J

(C) 10 J

(D) 1 J

**Q4.** A ball of mass $m$ moving at velocity $u$ undergoes a perfectly elastic head-on collision with an identical stationary ball of mass $m$. What is the outcome?

(A) The first ball stops completely; the second moves with velocity $u$.

(B) Both balls move with velocity $u/2$.

(C) Both balls rebound with velocity $u$ in opposite directions.

(D) The first ball continues at $u/2$; the second moves at $u/2$.

**Q5.** A thin rectangular plate of mass $M$ has sides of length $a$ and $b$. What is its moment of inertia about an axis through its centre *perpendicular* to the plate?

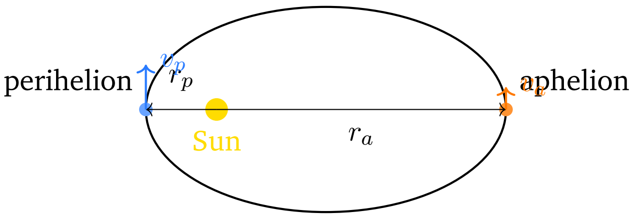
(A) $\dfrac{Ma^2}{12}$

(B) $\dfrac{Mb^2}{12}$

(C) $\dfrac{M(a^2 - b^2)}{12}$

(D) $\dfrac{M(a^2 + b^2)}{12}$

**Q6.** A planet moves in an elliptical orbit around the Sun. At perihelion (closest approach) the orbital speed is $v_p$ and the distance from the Sun is $r_p$; at aphelion (farthest point) the speed is $v_a$ and the distance is $r_a$. Which relation follows from conservation of angular momentum?




(A) $v_p + v_a = \text{const}$

(B) $v_p r_p = v_a r_a$

(C) $v_p^2 r_p = v_a^2 r_a$

(D) $v_p / r_p = v_a / r_a$

**Q7.** The surface tension of a soap solution is $T$. What is the work done in blowing a soap bubble of radius $r$ from negligible initial size?

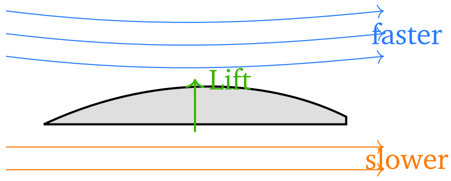
(A) $2\pi r^2 T$

(B) $4\pi r^2 T$

(C) $8\pi r^2 T$

(D) $16\pi r^2 T$

**Q8.** The cross-section of an aircraft wing is shown below. Air flows faster over the curved upper surface than the flat lower surface. How does this explain lift?




(A) Higher speed above $\Rightarrow$ lower pressure above $\Rightarrow$ net upward force (lift).

(B) Higher speed above $\Rightarrow$ higher pressure above $\Rightarrow$ net upward force.

(C) Lower speed below $\Rightarrow$ lower pressure below $\Rightarrow$ net downward force.

(D) Pressure is equal above and below; lift arises from wing inclination only.

**Q9.** In a damped harmonic oscillator with damping constant $\gamma$, the amplitude at time $t$ is $A(t)$ and the initial amplitude is $A_0$. Which expression correctly describes the amplitude decay?

(A) $A(t) = A_0(1 - \gamma t)$

(B) $A(t) = A_0 \cos(\gamma t)$

(C) $A(t) = A_0/(1 + \gamma t)$

(D) $A(t) = A_0\, e^{-\gamma t}$

**Q10.** The speed of sound in an ideal gas at temperature $T$ is $v$. If the temperature is increased to $4T$ (keeping all other parameters constant), the new speed of sound is:

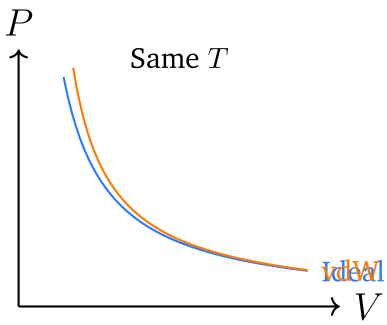
(A) $v$

(B) $2v$

(C) $4v$

(D) $v/2$

**Q11.** The van der Waals equation for a real gas is $\left(P + \frac{a}{V^2}\right)(V - b) = nRT$.




(A) $a$ accounts for finite volume of molecules; $b$ accounts for intermolecular attraction.

(B) Both $a$ and $b$ account for intermolecular forces only.

(C) $a$ accounts for intermolecular attractive forces; $b$ accounts for finite molecular volume.

(D) The equation reduces exactly to ideal gas law at high pressures.

**Q12.** For any spontaneous (irreversible) process in an isolated system, the entropy change $\Delta S_{\text{univ}}$ satisfies:

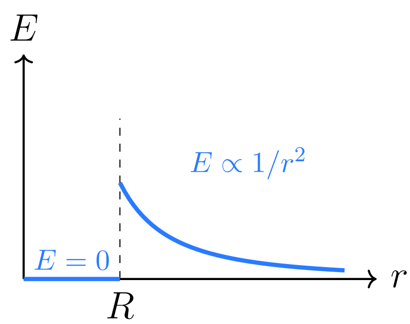
(A) $\Delta S_{\text{univ}} > 0$

(B) $\Delta S_{\text{univ}} = 0$

(C) $\Delta S_{\text{univ}} < 0$

(D) $\Delta S_{\text{univ}}$ may be positive or negative depending on temperature.

**Q13.** A solid conducting sphere of radius $R$ carries charge $Q$. Which statement about the electric field $E$ and potential $V$ is correct?



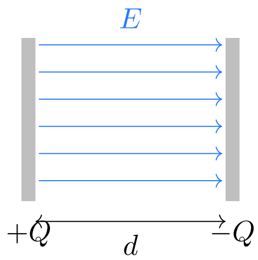
(A) $E = kQ/R^2$ inside; $V = kQ/r$ outside.

(B) $E = kQ/r^2$ everywhere; $V$ is constant inside.

(C) $E = 0$ inside; $V = 0$ inside.

(D) $E = 0$ inside; $V = kQ/R$ (constant) inside, equal to surface potential.

**Q14.** The electric field between the plates of a parallel-plate capacitor is $E$. Which expression gives the energy density (energy per unit volume) stored in this field?




(A) $u_E = \varepsilon_0 E^2$

(B) $u_E = \frac{1}{2}\varepsilon_0 E^2$

(C) $u_E = \frac{E^2}{2\mu_0}$

(D) $u_E = \frac{Q^2}{2C}$

**Q15.** In a potentiometer experiment, two cells of EMF $E_1$ and $E_2$ balance at lengths $l_1$ and $l_2$ respectively on the wire. Which relation correctly gives the ratio of EMFs?

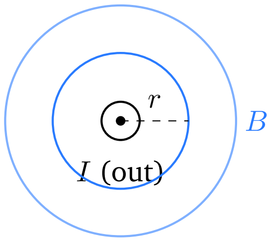
(A) $E_1/E_2 = l_2/l_1$

(B) $E_1/E_2 = l_1^2/l_2^2$

(C) $E_1/E_2 = l_1/l_2$

(D) $E_1 \cdot E_2 = l_1 \cdot l_2$

**Q16.** A long straight wire carries current $I = 10$ A. The magnetic field at a perpendicular distance $r = 0.1$ m from the wire is (use $\mu_0 = 4\pi \times 10^{-7}$ T $\cdot$ m/A):




(A) $B = \mu_0 I/(2\pi r) = 2 \times 10^{-5}$ T

(B) $B = \mu_0 I/(4\pi r^2) = 1 \times 10^{-6}$ T

(C) $B = \mu_0 I r/(2\pi) = 6.3 \times 10^{-8}$ T

(D) $B = 2\mu_0 I/(\pi r) = 8 \times 10^{-5}$ T

**Q17.** Eddy currents are induced in a metal disc moving through a non-uniform magnetic field. Which of the following best describes their primary effect?

(A) They cause the disc to accelerate in the direction of the field gradient.

(B) They have no net mechanical effect on the disc.

(C) They cause the disc to vibrate perpendicular to its motion.

(D) They produce a retarding (braking) force that opposes the motion of the disc.

**Q18.** An object is placed $20$ cm in front of a concave mirror of focal length $10$ cm. Using the mirror formula $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ (sign convention: distances in front of mirror are negative), the image distance $v$ is:

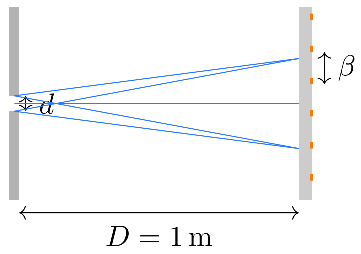
(A) $v = -10$ cm (image at focus)

(B) $v = -20$ cm (real image at centre of curvature)

(C) $v = +20$ cm (virtual image)

(D) $v = -40$ cm (enlarged real image)

**Q19.** In Young's double slit experiment, the wavelength of light is $600$ nm, the slit separation is $d = 0.3$ mm, and the screen is $D = 1$ m from the slits. What is the fringe width?




(A) 0.5 mm

(B) 1 mm

(C) 2 mm

(D) 3 mm

**Q20.** A radioactive sample of $N_0$ atoms has decay constant $\lambda$. The number of undecayed atoms at time $t$ is:

(A) $N = N_0\, e^{-\lambda t}$

(B) $N = N_0(1 - \lambda t)$

(C) $N = N_0 e^{+\lambda t}$

(D) $N = N_0/\lambda t$

**Section B — Numerical Answer Type (Q21–Q30) [+4 / 0]**

**Q21.** The position of a particle is given by $x = 5t^2 - 3t + 2$ (in metres, $t$ in seconds). Find the velocity (in m/s) of the particle at $t = 3$ s. *(Enter numerical value)*

**Q22.** A ball of mass $1$ kg moving at $10$ m/s hits a wall and rebounds at $8$ m/s in the opposite direction. Find the magnitude of the impulse (in N·s) exerted by the wall on the ball. *(Enter numerical value)*

**Q23.** A solid cylinder of mass $M = 4$ kg and radius $R = 0.5$ m rolls without slipping with speed $v = 4$ m/s. Find the total kinetic energy (in J). [Use $KE_{\text{rolling}} = \frac{3}{4}Mv^2$ for a solid cylinder.] *(Enter numerical value)*

**Q24.** A black body radiates power $P = 10$ W at temperature $T$. If its temperature is doubled to $2T$, what is the new power radiated (in W)? *(Enter numerical value)*

**Q25.** Resistors $R_1 = 3\ \Omega$ and $R_2 = 6\ \Omega$ are connected in parallel and the combination is connected to a $12$ V source of negligible internal resistance. Find the total current (in A) drawn from the source. *(Enter numerical value)*

**Q26.** A capacitor of capacitance $C = 100\ \mu$F is charged to a potential difference of $V = 50$ V. Find the energy stored (in mJ). *(Enter numerical value)*

**Q27.** A solenoid has $n = 1000$ turns per metre and carries a current of $I = 1$ A. Find the magnetic field inside the solenoid in units of $4\pi \times 10^{-4}$ T. (i.e., express $B/(4\pi \times 10^{-4}\ \text{T})$ as a whole number.) *(Enter numerical value)*

**Q28.** A coil of self-inductance $L = 2$ H has its current increasing uniformly from $0$ to $10$ A in $5$ s. Find the magnitude of the induced EMF (in V). *(Enter numerical value)*

**Q29.** An object is placed $45$ cm from a convex lens of focal length $f = 15$ cm. Using the lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, find the image distance $v$ (in cm). *(Enter numerical value)*

**Q30.** The total binding energy of a ${}^{4}_{2}$He nucleus is approximately $28.3$ MeV. Find the binding energy per nucleon (in MeV/nucleon), rounded to the nearest whole number. *(Enter numerical value)*

## CHEMISTRY

### Section A — Single Correct MCQ (Q31–Q50) [+4 / −1]

**Q31.** A mixture contains $28$ g of CO (molar mass $= 28$ g/mol) and $44$ g of

$CO_2$ (molar mass $= 44$ g/mol). What is the average molar mass of the mixture?

**Mixture**
CO: 28 g  $CO_2$: 44 g
Total: 72 g, 2 mol
$\longrightarrow \bar{M} = ?$

(A) 32 g/mol

(B) 36 g/mol

(C) 40 g/mol

(D) 44 g/mol

**Q32.** Which of the following best describes the shape of the $d_{z^2}$ orbital?

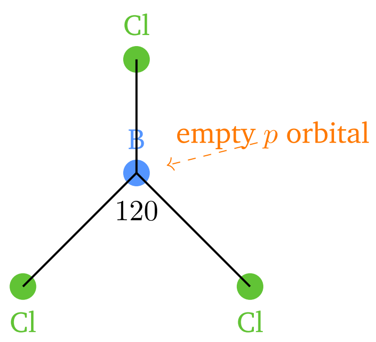
(A) Two lobes along the $x$-axis with a nodal plane in $yz$.

(B) Four lobes, one in each quadrant of the $xy$-plane.

(C) Two lobes along the $z$-axis with a toroidal (doughnut-shaped) ring in the $xy$-plane.

(D) Spherically symmetric with no directional preference.

**Q33.** Boron trichloride ($BCl_3$) is a well-known Lewis acid. Which set of properties correctly describes $BCl_3$?




(A) $sp^3$ hybridised, pyramidal, Lewis base.

(B) $sp$ hybridised, linear, Lewis acid.

(C) $sp^2$ hybridised, trigonal planar, Lewis base.

(D) $sp^2$ hybridised, trigonal planar, Lewis acid.

**Q34.** Among the hydrogen halides HF, HCl, HBr, and HI, which has an anomalously *high* boiling point relative to the trend in the group, and why?

(A) HF; because it forms strong intermolecular hydrogen bonds due to the high electronegativity of F.

(B) HI; because it has the highest molar mass and largest London dispersion forces.

(C) HCl; because Cl forms stronger hydrogen bonds than other halogens.

(D) HBr; because Br has the highest polarisability in the group.

**Q35.** Which pair of elements shows a *diagonal relationship* in the periodic table?

(A) Na and Mg

(B) Be and Al

(C) Li and Ca

(D) B and Si

**Q36.** Lanthanide contraction refers to the gradual decrease in atomic (and ionic) radius across the lanthanide series. What is the primary reason?

(A) Increase in the number of $d$-electrons that shield the nucleus effectively.

(B) Decrease in nuclear charge across the series.

(C) Poor shielding of the nucleus by $4f$-electrons, so effective nuclear charge increases steadily.

(D) Repulsion between $4f$ and $5d$ electrons that contracts the $4f$ shell.

**Q37.** Which of the following statements about ambidentate ligands is correct?

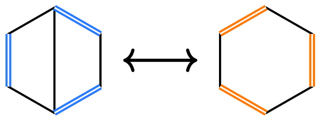
(A) They can bind to two different metal centres simultaneously.

(B) They always form chelate rings with the metal.

(C) They have no lone pairs of electrons.

(D) They can donate electron pairs through two different donor atoms, giving rise to linkage isomerism.

**Q38.** Benzene is stabilised by resonance. The two Kekulé structures are shown.



Which statement about benzene's resonance is correct?

(A) Resonance energy $\approx 150\ \mathrm{kJ/mol}$; all six C–C bonds have equal length ($\approx 1.40$ Å).

(B) Resonance energy $\approx 50\ \mathrm{kJ/mol}$; bond lengths alternate between 1.34 and 1.54 Å.

(C) Benzene has no resonance energy because both Kekulé structures are identical.

(D) Resonance energy $\approx 300\ \mathrm{kJ/mol}$; there are three genuine double bonds.

**Q39.** When HBr is added to propene in the presence of peroxides (ROOR), the product is:

(A) 2-Bromopropane (Markovnikov product)

(B) 1-Bromopropane (anti-Markovnikov product)

(C) 1,2-Dibromopropane

(D) Allyl bromide (3-bromopropene)

**Q40.** In a polar protic solvent (e.g. water or ethanol), the correct order of nucleophilicity of halide ions is:

(A) $F^- > Cl^- > Br^- > I^-$

(B) $Cl^- > Br^- > I^- > F^-$

(C) $I^- > Br^- > Cl^- > F^-$

(D) $Br^- > I^- > Cl^- > F^-$

**Q41.** When phenol ($C_6H_5OH$) reacts with phosphorus pentachloride ($PCl_5$), the organic product formed is:

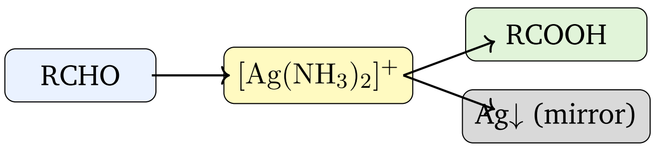
(A) Phenyl phosphate

(B) Diphenyl ether

(C) Phenol remains unchanged

(D) Chlorobenzene

**Q42.** Tollens' reagent $[Ag(NH_3)_2]^+$ reacts with an aldehyde RCHO. What is observed and what is the organic product?




(A) Silver mirror is formed; organic product is carboxylic acid RCOOH.

(B) Silver mirror is formed; organic product is alcohol $RCH_2OH$.

(C) No reaction; Tollens' reagent is specific to ketones.

(D) Black precipitate of $Ag_2O$ forms; organic product is RCOOH.

**Q43.** An ester RCOOR′ is treated with excess lithium aluminium hydride ($LiAlH_4$) followed by aqueous workup. What are the products?

(A) One primary alcohol $RCH_2OH$ and one carboxylic acid R′COOH.

(B) Two primary alcohols: $RCH_2OH$ and R′OH.

(C) One aldehyde RCHO and one alcohol R′OH.

(D) One ketone RCOR′ and water.

**Q44.** Cyclohexanone oxime undergoes Beckmann rearrangement in acidic conditions to give:

(A) Cyclohexanamine

(B) Cyclohexanol

(C) $\varepsilon$-Caprolactam (the monomer of nylon-6)

(D) Adipic acid

**Q45.** A binary liquid solution shows negative deviation from Raoult's law. This means:

(A) A–B interactions are weaker than A–A and B–B interactions.

(B) The solution is always ideal at high temperatures.

(C) The vapour pressure of the mixture is higher than predicted by Raoult's law.

(D) A–B interactions are stronger than A–A and B–B interactions.

**Q46.** A saturated solution of AgCl ($K_{sp} = 1.8 \times 10^{-10}$) is prepared in pure water. If excess $AgNO_3$ is added to make $[\mathrm{Ag^+}] = 0.1$ M, the new solubility of AgCl is approximately:

(A) $1.8 \times 10^{-9}$ M (suppressed by common ion)

(B) $1.8 \times 10^{-10}$ M

(C) $1.34 \times 10^{-5}$ M (unchanged)

(D) $0.1$ M (increased dissolution)

**Q47.** A reactant A undergoes two parallel first-order reactions: $A \xrightarrow{k_1} B$ and $A \xrightarrow{k_2} C$. What is the ratio of products $[B]/[C]$ at any time?

(A) $k_2/k_1$

(B) $k_1/k_2$

(C) $(k_1 + k_2)/k_1$

(D) $k_1 \cdot k_2$

**Q48.** For the half-cell $\mathrm{Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)}$ with $E^\circ = -0.76$ V, the electrode potential at $[\mathrm{Zn^{2+}}] = 0.1$ M and 25°C is:

(A) $-0.76$ V (unchanged from standard)

(B) $-0.73$ V

(C) $-0.79$ V

(D) $-0.83$ V

**Q49.** Emulsifiers (emulsifying agents) are used to stabilise emulsions (e.g. milk, mayonnaise). Which property is essential for an emulsifier?

(A) It must be completely soluble in both phases.

(B) It must be a polymer with high molar mass.

(C) It must be inorganic and ionic.

(D) It must be amphiphilic, possessing both a hydrophilic head and a hydrophobic tail.

**Q50.** Cellulose is a structural polysaccharide found in plant cell walls. The repeating unit is $\beta$-D-glucose. How are the glucose units linked?

(A) By $\beta$-1,4-glycosidic bonds.

(B) By $\alpha$-1,4-glycosidic bonds.

(C) By $\alpha$-1,6-glycosidic bonds.

(D) By $\beta$-1,6-glycosidic bonds.

## Section B — Numerical Answer Type (Q51–Q60) [+4 / 0]

**Q51.** $98$ g of pure $H_2SO_4$ (molar mass $= 98$ g/mol, $n$-factor $= 2$) is dissolved to make $1$ L of solution. Find the normality (in N) of the solution. *(Enter numerical value)*

**Q52.** $0.4$ g of nitrogen gas ($N_2$, molar mass $= 28$ g/mol) is taken at STP ($1$ atm, $0°$C). Find the volume occupied (in litres). [Molar volume at STP $=$ $22.4$ L/mol] *(Enter numerical value)*

**Q53.** 4 g of NaOH (molar mass $= 40$ g/mol) is dissolved in enough water to make 1 L of solution. Find the pH of the solution (assume complete dissociation and $K_w = 10^{-14}$). *(Enter numerical value)*

**Q54.** Using the following bond energies, calculate the enthalpy of combustion of methane ($CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$, in kJ/mol, magnitude only): Bond energies (kJ/mol): C–H $= 413$; O=O $= 498$; C=O (in $CO_2$) $= 799$; O–H $= 463$. *(Enter numerical value)*

**Q55.** For a zero-order reaction, the initial concentration is $[\mathrm{A}]_0 = 0.5$ M and the rate constant $k = 0.05\ \mathrm{M\,min^{-1}}$. Find the time (in min) at which $[\mathrm{A}] = 0.2$ M. *(Enter numerical value)*

**Q56.** For acetic acid solution, $\Lambda_m = 9.3\,\mathrm{S\,cm^2\,mol^{-1}}$ and $\Lambda_m^\infty = 390.7\,\mathrm{S\,cm^2\,mol^{-1}}$. Find the degree of dissociation $\alpha$ (to 3 decimal places). *(Enter numerical value)*

**Q57.** A current of 2 A is passed through a $CuSO_4$ solution for 1 hour. Find the mass of copper deposited at the cathode (in g). [Atomic mass of Cu $= 63.5$ g/mol; Faraday constant $= 96500$ C/mol; $n$-factor of $Cu^{2+} = 2$] *(Enter numerical value)*

**Q58.** After 30 years, only $\frac{1}{4}$ of a radioactive substance remains. Find the half-life (in years). *(Enter numerical value)*

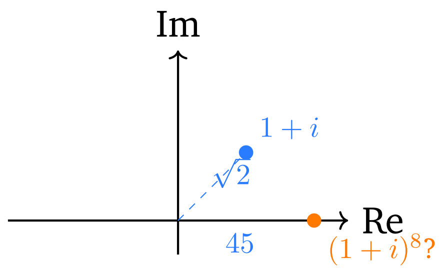
**Q59.** In the complex $[\mathrm{Cr(en)_3}]^{3+}$, where en (ethylenediamine) is a bidentate ligand, what is the coordination number of Cr? *(Enter numerical value)*

**Q60.** 18 g of glucose (molar mass $= 180$ g/mol) is dissolved in 1 L of solution at 27°C. Calculate the osmotic pressure $\pi$ (in atm). [$R = 0.0821\,\mathrm{L\,atm\,mol^{-1}\,K^{-1}}$] *(Enter numerical value)*

## MATHEMATICS

## Section A — Single Correct MCQ (Q61–Q80) [+4 / −1]

**Q61.** Using De Moivre's theorem, find the value of $(1+i)^8$.




(A) $8i$

(B) $16$

(C) $-16$

(D) $8$

**Q62.** A quadratic equation has roots $\alpha = 2$ and $\beta = 3$. Which of the following is the correct quadratic equation?

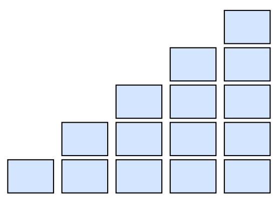
(A) $x^2 + 5x + 6 = 0$

(B) $x^2 + 5x - 6 = 0$

(C) $x^2 - 5x - 6 = 0$

(D) $x^2 - 5x + 6 = 0$

**Q63.** The formula $\sum_{k=1}^{n} k^2 = \frac{n(n+1)(2n+1)}{6}$ gives the sum of the first $n$ perfect squares. Using this, find $\sum_{k=1}^{5} k^2$.



$1^2 + 2^2 + 3^2 + 4^2 + 5^2 = ?$

(A) 35

(B) 45

(C) 55

(D) 65

**Q64.** Find the number of distinct arrangements of the letters of the word **MISSISSIPPI**.

(A) 34650

(B) 69300

(C) 11!

(D) 5040

**Q65.** Find the coefficient of $x^3$ in the expansion of $(1 + x)^8$.

1
1 1
1 2 1
1 3 3 1
1 4 6 4 1
1 5 10 10 5 1
1 6 15 20 15 6 1
1 7 21 35 35 21 7 1
1,8,28,56,70,56,28,8,1 row 8

(A) 28

(B) 56

(C) 70

(D) 84

**Q66.** For the matrix $A = \begin{pmatrix} 2 & 1 \\ 5 & 3 \end{pmatrix}$, find $A^{-1}$.

(A) $\begin{pmatrix} 3 & 1 \\ 5 & 2 \end{pmatrix}$

(B) $\begin{pmatrix} -3 & 1 \\ 5 & -2 \end{pmatrix}$

(C) $\begin{pmatrix} 2 & -1 \\ -5 & 3 \end{pmatrix}$

(D) $\begin{pmatrix} 3 & -1 \\ -5 & 2 \end{pmatrix}$

**Q67.** Which of the following is the correct half-angle formula for $\sin(\theta/2)$ (when $0 < \theta/2 < \pi$)?

(A) $\sin(\theta/2) = \frac{1+\cos\theta}{2}$

(B) $\sin(\theta/2) = \sqrt{\frac{1+\cos\theta}{2}}$

(C) $\sin(\theta/2) = \sqrt{\frac{1-\cos\theta}{2}}$

(D) $\sin(\theta/2) = \frac{1-\cos\theta}{2}$

**Q68.** Find the value of $x$ satisfying $\tan^{-1}(x) = \frac{\pi}{4}$.

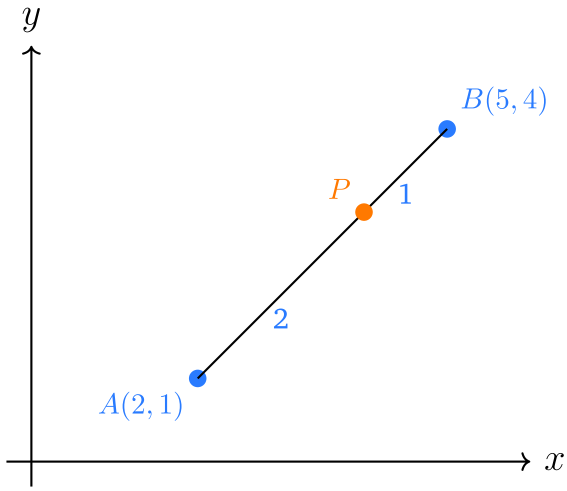
(A) $x = 1$

(B) $x = \sqrt{3}$

(C) $x = 1/\sqrt{3}$

(D) $x = -1$

**Q69.** Point $P$ divides the segment joining $A(2,1)$ and $B(5,4)$ in the ratio $2:1$ internally. Find the coordinates of $P$.



(A) $(3, 2)$

(B) $(4, 3)$

(C) $(3.5, 2.5)$

(D) $(3, 4)$

**Q70.** Two circles are concentric (share the same centre but have different radii). For the circle $x^2 + y^2 - 4x + 6y + k = 0$, which statement is true about a circle concentric with it?

(A) It must have equation $x^2 + y^2 + 4x - 6y + k = 0$.

(B) Concentric circles always intersect.

(C) A circle concentric with it has equation $x^2 + y^2 - 6x + 4y + m = 0$.

(D) A circle concentric with it has equation $x^2 + y^2 - 4x + 6y + m = 0$ (same centre $(2, -3)$, different $m$).

**Q71.** Find the equation of the directrix of the parabola $x^2 = -8y$.

(A) $y = -2$

(B) $x = 2$

(C) $y = 2$

(D) $x = -2$

**Q72.** The equation of the tangent to the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ at the point $(x_1, y_1)$ on the ellipse is:

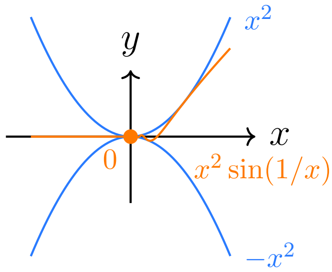
(A) $\frac{x_1 x}{a^2} + \frac{y_1 y}{b^2} = 1$

(B) $\frac{x_1 x}{b^2} + \frac{y_1 y}{a^2} = 1$

(C) $x_1 x + y_1 y = a^2 + b^2$

(D) $\frac{x x_1}{a} + \frac{y y_1}{b} = 1$

**Q73.** Using the Squeeze (Sandwich) theorem, find $\lim_{x\to 0} x^2 \sin\left(\frac{1}{x}\right)$.




(A) 1

(B) 0

(C) Does not exist

(D) $\infty$

**Q74.** For $f(x) = x^2$ on $[1, 3]$, the Mean Value Theorem guarantees a $c \in (1, 3)$ such that $f'(c) = \dfrac{f(3) - f(1)}{3 - 1}$. Find the value of $c$.

(A) $c = 1.5$

(B) $c = 2.5$

(C) $c = 3$

(D) $c = 2$

**Q75.** Find the inflection point of $f(x) = x^3 - 3x^2 + 2$.

(A) $(0, 2)$

(B) $(2, -2)$

(C) $(1, 0)$

(D) $(3, 2)$

**Q76.** Which of the following is the correct antiderivative of $\sin^2 x$?

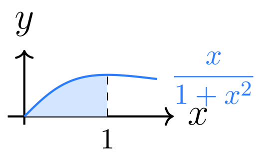
(A) $\dfrac{x}{2} - \dfrac{\sin 2x}{4} + C$

(B) $-\dfrac{\cos 2x}{4} + C$

(C) $\dfrac{x}{2} + \dfrac{\cos 2x}{4} + C$

(D) $\dfrac{\sin 2x}{4} + C$

**Q77.** Evaluate $\displaystyle\int_0^1 \frac{x}{1+x^2}\,dx$.




(A) $\ln 2$

(B) $\dfrac{1}{2}$

(C) $1 - \ln 2$

(D) $\dfrac{\ln 2}{2}$

**Q78.** A point is chosen uniformly at random from the interval $[0, 6]$. What is the probability that the point lies in $[2, 5]$?

(A) $1/3$

(B) $1/4$

(C) $1/2$

(D) $2/3$

**Q79.** Three vectors $\vec{a}$, $\vec{b}$, $\vec{c}$ are coplanar if and only if their scalar triple product satisfies:

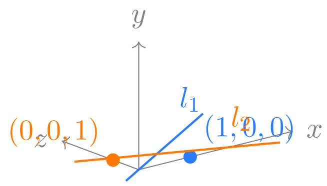
(A) $\vec{a} \cdot (\vec{b} \times \vec{c}) = 1$

(B) $\vec{a} \cdot (\vec{b} \times \vec{c}) = 0$

(C) $\vec{a} \times (\vec{b} \times \vec{c}) = \vec{0}$

(D) $|\vec{a}| + |\vec{b}| + |\vec{c}| = 0$

**Q80.** Find the shortest distance between the skew lines $l_1$: through $(1, 0, 0)$ with direction $(1, 1, 0)$, and $l_2$: through $(0, 0, 1)$ with direction $(1, 0, 1)$.




(A) $\dfrac{2\sqrt{3}}{3}$

(B) $\dfrac{\sqrt{3}}{3}$

(C) $\sqrt{2}$

(D) $1$

## Section B — Numerical Answer Type (Q81–Q90) [+4 / 0]

**Q81.** Find the modulus $|z|$ of the complex number $z = 3 - 4i$. *(Enter numerical value)*

**Q82.** Find the sum of the geometric progression $3 + 9 + 27 + 81 + 243$. *(Enter numerical value)*

**Q83.** Evaluate the determinant $\begin{vmatrix} 4 & 2 \\ 6 & 5 \end{vmatrix}$. *(Enter numerical value)*

**Q84.** In how many ways can 4 people be seated in a row of 4 chairs? *(Enter numerical value)*

**Q85.** Evaluate $\displaystyle\int_0^1 (2x + 3)\, dx$. *(Enter numerical value)*

**Q86.** If $f(x) = x^3 - 2x^2 + 5x - 1$, find $f'(1)$. *(Enter numerical value)*

**Q87.** Find the area under the curve $y = e^x$ from $x = 0$ to $x = \ln 3$. (i.e. evaluate $\displaystyle\int_0^{\ln 3} e^x\, dx$). *(Enter numerical value)*

**Q88.** Find the value of $k$ such that $\vec{a} = k\hat{i} + \hat{j}$ and $\vec{b} = 2\hat{i} - 3\hat{j}$ are perpendicular. *(Enter numerical value)*

**Q89.** Find the standard deviation of the data set $\{2, 4, 4, 4, 5, 5, 7, 9\}$. *(Enter numerical value)*

**Q90.** Two fair dice are rolled simultaneously. What is the denominator of the probability (in lowest terms) that the sum of the numbers is $\geq 10$? [i.e. express $P(\text{sum} \geq 10)$ as a fraction in lowest terms and give the denominator.] *(Enter numerical value)*

# Detailed Solutions

## Q1.

**Solution**

**Concept — Relative Velocity:** When two objects move toward each other, their relative speed of approach is the sum of their individual speeds.

**Step 1 — Relative speed of approach:**

$$v_{\text{rel}} = v_A + v_B = 60 + 40 = 100 \text{ m/s}$$

**Step 2 — Time to meet:**

$$t = \frac{d}{v_{\text{rel}}} = \frac{1000 \text{ m}}{100 \text{ m/s}} = 10 \text{ s}$$

**Why other options are wrong:**

- Option A ($5$ s): uses only $v_A = 60$ and ignores the motion of Train B.
- Option B ($8$ s): incorrect; no standard calculation gives this.
- Option C ($12$ s): uses the relative speed difference $60 - 40 = 20$ with incorrect formula.

**Final Answer:** $\boxed{\text{D}}$

**Answer: (D)** Go Back to Q1

## Q2.

**Solution**

**Concept — Pseudo Force:** In a non-inertial frame (accelerating car), a pseudo force $F_{\text{pseudo}} = ma$ acts backward on the pendulum bob.

**Step 1 — Force balance on bob:**

- Horizontal: $T \sin\theta = ma$ (pseudo force)
- Vertical: $T \cos\theta = mg$

**Step 2 — Dividing the equations:**

$$\tan\theta = \frac{ma}{mg} = \frac{a}{g} = \frac{3}{10} = 0.3$$

**Why other options are wrong:**

- Option A: $\tan\theta = g/a$ would mean a stronger acceleration gives a smaller angle — the reverse of physics.
- Options C, D: involve $a^2$ or $g^2$ terms, which have no dimensional basis in this equilibrium.

**Final Answer:** $\boxed{\text{B}}$

Answer: (B) Go Back to Q2

## Q3.

**Solution**

**Concept — Elastic Potential Energy:** $U = \frac{1}{2}kx^2$, where $k$ is the spring constant.

**Step 1 — Find spring constant:**

$$k = \frac{F}{x} = \frac{200\text{ N}}{0.1\text{ m}} = 2000\text{ N/m}$$

**Step 2 — Compute potential energy:**

$$U = \frac{1}{2}kx^2 = \frac{1}{2} \times 2000 \times (0.1)^2 = \frac{1}{2} \times 2000 \times 0.01 = 10\text{ J}$$

**Why other options are wrong:**

- Option A $(5\text{ J})$: omits the factor $\frac{1}{2}$ in the formula.
- Option B $(20\text{ J})$: uses $U = Fx = 200 \times 0.1$ without the factor $\frac{1}{2}$.
- Option D $(1\text{ J})$: uses an incorrect spring constant.

**Final Answer:** $\boxed{\text{C}}$

Answer: (C) Go Back to Q3

## Q4.

**Solution**

**Concept — Elastic Collision:** For a head-on elastic collision between equal masses $m$:

$$v_1' = \frac{m_1 - m_2}{m_1 + m_2} u_1 = \frac{0}{2m} u = 0$$

$$v_2' = \frac{2m_1}{m_1 + m_2} u_1 = \frac{2m}{2m} u = u$$

**Step 1 — Interpretation:** The first ball comes to rest; the second ball moves forward at the original speed $u$.

**Step 2 — Physical insight:** This is the classic "Newton's cradle" result — momentum and kinetic energy are both conserved, and the only solution for equal masses is a complete velocity exchange.

**Why other options are wrong:**

- Option B: both at $u/2$ satisfies momentum but not kinetic energy conservation.
- Option C: both rebounding violates momentum conservation ($mu \neq -mu + mu$).
- Option D: both at $u/2$ is the inelastic (perfectly inelastic-like) result.

**Final Answer:** $\boxed{\text{A}}$

**Answer: (A)** Go Back to Q4

## Q5.

**Solution**

**Concept — Parallel Axis and Perpendicular Axis Theorems:**

- $I_{a\text{-axis}} = Ma^2/12$ (axis through centre, parallel to side $b$)
- $I_{b\text{-axis}} = Mb^2/12$ (axis through centre, parallel to side $a$)

**Step 1 — Perpendicular axis theorem:** For a lamina in the $xy$-plane, $I_z = I_x + I_y$.

$$I_z = \frac{Ma^2}{12} + \frac{Mb^2}{12} = \frac{M(a^2 + b^2)}{12}$$

**Why other options are wrong:**

- Options A, B: give the moment about one of the in-plane axes, not perpendicular to plate.

- Option C: $M(a^2 - b^2)/12$ is the difference, not sum, and has no physical significance.

**Final Answer:** $\boxed{\text{D}}$

**Answer: (D)** Go Back to Q5

## Q6.

### Solution

**Concept — Angular Momentum Conservation:** No torque acts on the planet about the Sun (gravity is central), so angular momentum $L = mvr$ is conserved.

**Step 1 — At perihelion and aphelion** the velocity is perpendicular to the radius vector, so:

$$L = mv_p r_p = mv_a r_a$$

$$\Rightarrow v_p r_p = v_a r_a$$

**Step 2 — Physical consequence:** Since $r_p < r_a$, it follows that $v_p > v_a$ — the planet moves fastest at perihelion (Kepler's second law).

**Why other options are wrong:**

- Option A: $v_p + v_a =$ const is not a conserved quantity.
- Option C: $v_p^2 r_p = v_a^2 r_a$ would correspond to energy conservation, which gives a different relation.
- Option D: $v_p/r_p = v_a/r_a$ has no conservation law backing it.

**Final Answer:** $\boxed{\text{B}}$

**Answer: (B)** Go Back to Q6

## Q7.

### Solution

**Concept — Two Surfaces of a Soap Bubble:** A soap bubble has two liquid–air interfaces, so the effective surface area is $2 \times 4\pi r^2$.

**Step 1 — Work done against surface tension:**

$$W = T \times \Delta A = T \times (2 \times 4\pi r^2) = 8\pi r^2 T$$

**Why other options are wrong:**

- Option A ($2\pi r^2 T$): factor of 4 is missing; ignores the $4\pi$ solid angle.
- Option B ($4\pi r^2 T$): accounts for only one surface instead of two.
- Option D ($16\pi r^2 T$): off by a factor of 2 from the correct answer.

**Final Answer:** $\boxed{\text{C}}$

**Answer: (C)** Go Back to Q7

## Q8.

### Solution

**Concept — Bernoulli's Principle:** For steady, non-viscous flow along a streamline:

$$P + \frac{1}{2}\rho v^2 + \rho g h = \text{constant}$$

At the same height: higher speed $\Rightarrow$ lower pressure.

**Step 1 — Apply to wing:** Air speed over the curved upper surface $v_{\text{top}} > v_{\text{bottom}}$ (the streamlines are compressed). Therefore:

$$P_{\text{top}} < P_{\text{bottom}}$$

**Step 2 — Net force:** The pressure difference gives a net upward force (lift):

$$F_{\text{lift}} = (P_{\text{bottom}} - P_{\text{top}}) \times A > 0$$

**Why other options are wrong:**

- Option B: incorrectly states higher speed gives higher pressure — the opposite of Bernoulli.
- Options C, D: do not correctly apply Bernoulli's theorem.

**Final Answer:** $\boxed{\text{A}}$

**Answer: (A)** Go Back to Q8

## Q9.

**Solution**

**Concept — Damped Harmonic Oscillator:** The equation of motion gives a solution with exponentially decaying amplitude:

$$x(t) = A_0 e^{-\gamma t} \cos(\omega' t + \phi)$$

**Step 1 — Amplitude envelope:**

$$A(t) = A_0\, e^{-\gamma t}$$

This is an exponential decay, not linear. The energy decays as $E \propto A^2 \propto e^{-2\gamma t}$.

**Why other options are wrong:**

- Option A: linear decay ($A_0(1-\gamma t)$) is only an approximation valid for small $\gamma t$; it gives negative amplitude for large $t$.
- Option B: cosine decay is not the solution to the damped oscillator equation.
- Option C: algebraic decay $A_0/(1+\gamma t)$ is not derived from the standard damping model.

**Final Answer:** $\boxed{\text{D}}$

$\boxed{\textbf{Answer: (D)}}$ Go Back to Q9

## Q10.

**Solution**

**Concept — Speed of Sound in Ideal Gas:**

$$v = \sqrt{\frac{\gamma RT}{M}}$$

$$\Rightarrow v \propto \sqrt{T}$$

**Step 1 — Apply scaling:** If temperature changes from $T$ to $4T$:

$$v_{\text{new}} = v\sqrt{\frac{4T}{T}} = v\sqrt{4} = 2v$$

**Why other options are wrong:**

- Option A ($v$): speed is independent of temperature only for incompressible

media.
- Option C ($4v$): would require $v \propto T$, not $\sqrt{T}$.
- Option D ($v/2$): a decrease occurs for decreasing temperature, not an increase.

**Final Answer:** $\boxed{\text{B}}$

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

## Q11.

**Solution**

**Concept — Van der Waals Corrections:**

$$\left(P + \frac{a}{V^2}\right)(V - b) = nRT$$

**Step 1 — Physical meaning of constants:**

- $a/V^2$: correction to pressure — accounts for the reduction in pressure caused by intermolecular **attractive forces** between molecules (molecules pulling each other back before hitting the wall).
- $b$: excluded volume — accounts for the **finite volume** occupied by gas molecules themselves.

**Why other options are wrong:**

- Option A: reverses the roles of $a$ and $b$.
- Option B: states both constants are for intermolecular forces, ignoring the volume correction.
- Option D: at high pressure, the equation deviates *more* from ideal, not less.

**Final Answer:** $\boxed{\text{C}}$

**Answer: (C)** Go Back to Q11

## Q12.

**Solution**

**Concept — Second Law of Thermodynamics:** The entropy of the universe (system + surroundings) never decreases. For spontaneous irreversible processes:

$$\Delta S_{\text{univ}} > 0$$

**Step 1 — Classify:** A spontaneous process (e.g. heat flow from hot to cold, mixing of gases) is irreversible. The Clausius inequality: $dS \geq \delta Q/T$, with equality only for reversible processes.

**Why other options are wrong:**

- Option B ($= 0$): entropy of universe is constant only for reversible (quasi-static, idealised) processes.
- Option C ($< 0$): would violate the second law.
- Option D: entropy change of the universe does not depend on the sign of temperature.

**Final Answer:** $\boxed{\text{A}}$

Answer: (A) Go Back to Q12

## Q13.

**Solution**

**Concept — Conducting Sphere Electrostatics:**

- Charge resides on surface; $E = 0$ inside (Gauss's law with no enclosed charge).
- Potential is constant inside and on surface: $V = kQ/R$.

**Step 1 — Inside ($r < R$):** $E = 0$; $V = kQ/R =$ const (equal to surface potential).

**Step 2 — Outside ($r > R$):** $E = kQ/r^2$ (radially outward); $V = kQ/r$.

**Why other options are wrong:**

- Option A: incorrectly states $E \neq 0$ inside.
- Option B: $E \neq kQ/r^2$ everywhere (wrong inside the sphere).
- Option C: $V = 0$ inside is wrong; $V$ equals the surface value $kQ/R$ inside.

**Final Answer:** $\boxed{\text{D}}$

Answer: (D) Go Back to Q13

## Q14.

### Solution

**Concept — Electric Field Energy Density:** The energy stored per unit volume in an electric field $E$ is:

$$u_E = \frac{1}{2}\varepsilon_0 E^2$$

**Step 1 — Derivation sketch:** For a parallel-plate capacitor, $U = \frac{1}{2}CV^2$, $C = \varepsilon_0 A/d$, $V = Ed$:

$$u_E = \frac{U}{Ad} = \frac{\frac{1}{2}\varepsilon_0 (Ed)^2/d}{Ad/(Ad)} = \frac{1}{2}\varepsilon_0 E^2$$

**Why other options are wrong:**

- Option A ($\varepsilon_0 E^2$): missing the factor $\frac{1}{2}$.
- Option C ($E^2/(2\mu_0)$): that is the energy density of a *magnetic* field $B$.
- Option D ($Q^2/2C$): gives total energy stored, not energy density.

**Final Answer:** $\boxed{\text{B}}$

Answer: (B) Go Back to Q14

## Q15.

### Solution

**Concept — Potentiometer Principle:** The potential gradient along the wire is uniform. At the null (balance) point, the terminal voltage of the cell equals the potential drop across the balancing length $l$:

$$E = \phi \cdot l$$

where $\phi$ is the potential gradient (V/m).

**Step 1 — Comparing two cells:**

$$E_1 = \phi l_1, \quad E_2 = \phi l_2$$

$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

**Why other options are wrong:**

- Option A: inverts the ratio $(l_2/l_1)$, giving $E_2/E_1$ instead.
- Option B: uses $l^2$ — no physical basis.
- Option D: a product relation is not derived from the principle.

**Final Answer:** $\boxed{\text{C}}$

**Answer: (C)** Go Back to Q15

## Q16.

### Solution

**Concept — Ampere's Circuital Law:** For an infinite straight wire with current $I$, the magnetic field at distance $r$ is:

$$B = \frac{\mu_0 I}{2\pi r}$$

**Step 1 — Substitute values:**

$$B = \frac{4\pi \times 10^{-7} \times 10}{2\pi \times 0.1} = \frac{4\pi \times 10^{-6}}{2\pi \times 10^{-1}} = \frac{4 \times 10^{-6}}{2 \times 10^{-1}} = 2 \times 10^{-5}\ \text{T}$$

**Why other options are wrong:**

- Option B: uses the formula for a magnetic dipole field $(\mu_0 I/4\pi r^2)$, wrong geometry.
- Option C: has an extra factor of $r$ in the numerator.
- Option D: has an extra factor of 4 in the numerator.

**Final Answer:** $\boxed{\text{A}}$

**Answer: (A)** Go Back to Q16

## Q17.

### Solution

**Concept — Eddy Currents (Foucault Currents):** When a conductor moves through a varying magnetic field, induced currents (eddy currents) flow in closed loops within the conductor. By Lenz's law, these currents oppose the change causing them, resulting in a retarding force.

**Step 1 — Energy dissipation:** Eddy currents produce Joule heating $(I^2R)$, converting kinetic energy of the disc into heat. This is the principle behind magnetic brakes and induction cooktops.

**Why other options are wrong:**

- Option A: Lenz's law ensures the force *opposes* motion; acceleration in the field direction would violate energy conservation.
- Option B: eddy currents always have a mechanical effect (braking force) in a non-uniform field.
- Option C: vibration perpendicular to motion is not caused by eddy currents.

**Final Answer:** $\boxed{\text{D}}$

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

## Q18.

### Solution

**Concept — Mirror Formula:** $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$. Sign convention: distances measured from pole; in front of mirror is negative.

**Step 1 — Assign values:** Object in front of mirror: $u = -20$ cm; concave mirror: $f = -10$ cm.

**Step 2 — Solve for $v$:**

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-10} - \frac{1}{-20} = -\frac{1}{10} + \frac{1}{20} = \frac{-2+1}{20} = -\frac{1}{20}$$

$$v = -20 \text{ cm}$$

The negative sign means the image is in front of the mirror (real image). Object is at centre of curvature ($R = 2f = 20$ cm), so the image is also at the centre of curvature — real, inverted, and same size.

**Why other options are wrong:**

- Option A ($-10$ cm): object at infinity gives image at focus, not object at $2f$.
- Option C ($+20$ cm): positive $v$ would be a virtual image, not possible when object is beyond focus.
- Option D ($-40$ cm): would require object between $F$ and $C$ to give enlarged image.

**Final Answer:** $\boxed{\text{B}}$

**Answer: (B)** Go Back to Q18

## Q19.

**Solution**

**Concept — Fringe Width in YDSE:**

$$\beta = \frac{\lambda D}{d}$$

**Step 1 — Substitute values:**

$$\lambda = 600 \times 10^{-9}\ \text{m}, \quad D = 1\ \text{m}, \quad d = 0.3\ \text{mm} = 3 \times 10^{-4}\ \text{m}$$

$$\beta = \frac{600 \times 10^{-9} \times 1}{3 \times 10^{-4}} = \frac{6 \times 10^{-7}}{3 \times 10^{-4}} = 2 \times 10^{-3}\ \text{m} = 2\ \text{mm}$$

**Why other options are wrong:**

- Option A ($0.5$ mm): uses $d = 1.2$ mm (too large).
- Option B ($1$ mm): off by factor 2; would require $d = 0.6$ mm.
- Option D ($3$ mm): off by factor 1.5; would require $d = 0.2$ mm.

**Final Answer:** $\boxed{\text{C}}$

**Answer: (C)** Go Back to Q19

## Q20.

**Solution**

**Concept — Radioactive Decay Law:** The number of undecayed nuclei follows:

$$\frac{dN}{dt} = -\lambda N \quad \Rightarrow \quad N(t) = N_0\, e^{-\lambda t}$$

**Step 1 — Verification:** At $t = 0$: $N = N_0$ (correct). At $t = t_{1/2} = \ln 2/\lambda$: $N = N_0/2$ (correct).

**Step 2 — Activity:** $A = \lambda N = \lambda N_0 e^{-\lambda t} = A_0 e^{-\lambda t}$.

**Why other options are wrong:**

- Option B ($N_0(1 - \lambda t)$): linear — gives negative $N$ for large $t$, physically impossible.
- Option C ($N_0 e^{+\lambda t}$): exponential *growth* — contradicts the nature of radioactive decay.
- Option D ($N_0/\lambda t$): algebraic decay — not the solution to the first-order ODE.

**Final Answer:** $\boxed{\text{A}}$

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

## Q21.

**Solution**

**Velocity from Position:**

$$x = 5t^2 - 3t + 2$$

$$v = \frac{dx}{dt} = 10t - 3$$

At $t = 3$ s:

$$v = 10(3) - 3 = 30 - 3 = 27 \text{ m/s}$$

**Final Answer:** $\boxed{27}$

**Answer: (27)** Go Back to Q21

## Q22.

**Solution**

**Impulse = Change in Momentum:**

Taking the initial direction as positive:

$$J = m\Delta v = m(v_f - v_i) = 1 \times ((-8) - (+10)) = 1 \times (-18) = -18 \text{ N} \cdot \text{s}$$

Magnitude of impulse $= 18 \text{ N} \cdot \text{s}$.

**Final Answer:** $\boxed{18}$

**Answer: (18)** Go Back to Q22

## Q23.

**Solution**

**Rolling Kinetic Energy:** For a solid cylinder rolling without slipping:

$$KE = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2 = \frac{1}{2}Mv^2 + \frac{1}{2} \cdot \frac{MR^2}{2} \cdot \frac{v^2}{R^2} = \frac{3}{4}Mv^2$$

$$KE = \frac{3}{4} \times 4 \times (4)^2 = \frac{3}{4} \times 4 \times 16 = \frac{3}{4} \times 64 = 48 \text{ J}$$

**Final Answer:** $\boxed{48}$

Answer: (48) Go Back to Q23

## Q24.

**Solution**

**Stefan–Boltzmann Law:** $P = \sigma T^4 A$, so $P \propto T^4$.

If temperature doubles ($T \to 2T$):

$$P_{\text{new}} = \sigma(2T)^4 A = 16\sigma T^4 A = 16P$$

$$P_{\text{new}} = 16 \times 10 \text{ W} = 160 \text{ W}$$

**Final Answer:** $\boxed{160}$

Answer: (160) Go Back to Q24

## Q25.

**Solution**

**Parallel Resistance:**

$$\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{3} + \frac{1}{6} = \frac{2+1}{6} = \frac{3}{6} = \frac{1}{2}$$

$$R_{\text{eq}} = 2\ \Omega$$

**Total current:**

$$I = \frac{V}{R_{\text{eq}}} = \frac{12}{2} = 6 \text{ A}$$

**Final Answer:** $\boxed{6}$

Answer: (6) Go Back to Q25

## Q26.

**Solution**

**Energy Stored in Capacitor:**

$$U = \frac{1}{2}CV^2 = \frac{1}{2} \times (100 \times 10^{-6}) \times (50)^2 = \frac{1}{2} \times 10^{-4} \times 2500 = 0.125 \text{ J} = 125 \text{ mJ}$$

**Final Answer:** $\boxed{125}$

Answer: (125) Go Back to Q26

## Q27.

### Solution

**Magnetic Field in Solenoid:**

$$B = \mu_0 n I = (4\pi \times 10^{-7}) \times 1000 \times 1 = 4\pi \times 10^{-4}\ \mathrm{T}$$

Expressing in units of $4\pi \times 10^{-4}$ T:

$$\frac{B}{4\pi \times 10^{-4}} = \frac{4\pi \times 10^{-4}}{4\pi \times 10^{-4}} = 1$$

**Final Answer:** $\boxed{1}$

Answer: (1) Go Back to Q27

## Q28.

### Solution

**Self-Induced EMF:**

$$\mathcal{E} = L\frac{dI}{dt} = 2 \times \frac{10-0}{5} = 2 \times 2 = 4\ \mathrm{V}$$

**Final Answer:** $\boxed{4}$

Answer: (4) Go Back to Q28

## Q29.

### Solution

**Lens Formula:** $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$.

With sign convention: object on left, $u = -45$ cm, $f = +15$ cm (convex lens):

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{15} + \frac{1}{-45} = \frac{3}{45} - \frac{1}{45} = \frac{2}{45}$$

$$v = \frac{45}{2} = 22.5\ \mathrm{cm}$$

**Final Answer:** $\boxed{22.5}$

**Answer: (22.5)** Go Back to Q29

## Q30.

### Solution

**Binding Energy per Nucleon:**

$$BE/A = \frac{28.3\text{ MeV}}{4} = 7.075\text{ MeV/nucleon} \approx 7\text{ MeV/nucleon}$$

**Final Answer:** $\boxed{7}$

**Answer: (7)** Go Back to Q30

## Q31.

### Solution

**Concept — Average Molar Mass:** $\bar{M} = \frac{\text{Total mass}}{\text{Total moles}}$

**Step 1 — Count moles:**

- Moles of CO $= 28/28 = 1$ mol
- Moles of $CO_2 = 44/44 = 1$ mol

**Step 2 — Calculate:**

$$\bar{M} = \frac{28+44}{1+1} = \frac{72}{2} = 36\text{ g/mol}$$

**Why other options are wrong:**

- Option A (32): arithmetic mean of 28 and 44 using mass fractions instead of mole fractions.
- Option C (40): simple arithmetic average of 28 and 44 gives 36, not 40.
- Option D (44): is the molar mass of $CO_2$ alone.

**Final Answer:** $\boxed{\text{B}}$

**Answer: (B)** Go Back to Q31

## Q32.

### Solution

**Concept — $d$-Orbital Shapes:** The five $d$ orbitals have characteristic shapes. The $d_{z^2}$ orbital is unique among the $d$ orbitals.

**Step 1 — $d_{z^2}$ description:** It has two large lobes along the $z$-axis (like a $p_z$ orbital) plus a toroidal (doughnut-shaped) ring of electron density in the $xy$-plane. The angular part of its wave function $Y \propto (3\cos^2\theta - 1)$ gives this shape.

**Why other options are wrong:**

- Option A: describes $d_{x^2-y^2}$ or $p_x$, not $d_{z^2}$.
- Option B: describes $d_{xy}$, $d_{xz}$, or $d_{yz}$ (four-lobe orbitals in a plane).
- Option D: spherically symmetric describes an $s$-orbital.

**Final Answer:** $\boxed{\text{C}}$

**Answer: (C)** Go Back to Q32

## Q33.

### Solution

**Concept — $BCl_3$ Structure and Bonding:**

**Step 1 — Hybridisation:** B has 3 valence electrons; it forms 3 bonds with Cl. No lone pair on B, so hybridisation is $sp^2$ (3 bonding pairs, 0 lone pairs).

**Step 2 — Geometry:** $sp^2 \Rightarrow$ trigonal planar, bond angles $120$.

**Step 3 — Lewis acidity:** B has an empty $2p_z$ orbital perpendicular to the molecular plane. It accepts an electron pair from Lewis bases (like $NH_3$), acting as a Lewis acid.

**Why other options are wrong:**

- Option A ($sp^3$, pyramidal): $sp^3$ requires a lone pair, which B lacks in $BCl_3$.
- Option B ($sp$, linear): $sp$ gives linear geometry (e.g. $BeCl_2$), not the case here.
- Option C (Lewis base): B *accepts* electrons, not donates — it is a Lewis acid.

**Final Answer:** $\boxed{\text{D}}$

**Answer: (D)** Go Back to Q33

## Q34.

**Solution**

**Concept — Hydrogen Bonding in HF:** The boiling points of hydrogen halides normally increase down the group with molar mass (HCl: $-85$C, HBr: $-67$C, HI: $-35$C). HF has an anomalously high boiling point (BP $= +19.5$C).

**Step 1 — Reason:** F is the most electronegative element ($\chi = 4.0$); the H–F bond is highly polar, and F is small enough to form strong intermolecular O$\cdots$H type bonds (F–H$\cdots$F). These hydrogen bonds raise the boiling point far above the trend.

**Why other options are wrong:**

- Option B: HI does have the highest molar mass in the group, but its BP ($-35$C) is below HF.
- Option C: HCl shows only weak hydrogen bonding (Cl is less electronegative and larger than F).
- Option D: HBr's polarisability is high but its BP does not exceed HF.

**Final Answer:** $\boxed{\text{A}}$

Answer: (A) Go Back to Q34

## Q35.

**Solution**

**Concept — Diagonal Relationship:** Elements in the second period show chemical similarity to the element diagonally below-right in the third period due to similar charge/radius ratio.

**Step 1 — Be and Al similarities:**

- Both form amphoteric oxides (BeO and $Al_2O_3$ dissolve in both acid and base).
- Both form covalent chlorides ($BeCl_2$ and $AlCl_3$) that are Lewis acids.
- Both dissolve in NaOH to form tetrahedral anions ($[\mathrm{Be(OH)_4}]^{2-}$ and $[\mathrm{Al(OH)_4}]^{-}$).

**Why other options are wrong:**

- Option A: Na and Mg are in the same period, not diagonal to each other.
- Option C: Li and Ca are 2 periods apart and in different groups.
- Option D: B and Si is a diagonal relationship, but it is less prominent than Be–Al.

**Final Answer:** $\boxed{\text{B}}$

**Answer: (B)** Go Back to Q35

## Q36.

**Solution**

**Concept — Lanthanide Contraction:** Across the lanthanide series (La to Lu), electrons are added to the inner $4f$ subshell. The $4f$ orbitals are diffuse and do not shield outer electrons $(5s^2, 5p^6)$ from the nucleus effectively.

**Step 1 — Mechanism:** As nuclear charge $Z$ increases by 1 at each step, the shielding provided by the added $4f$ electron is poor (shielding constant $\approx 0.35$ for same subshell but effectively much less for $4f$). The effective nuclear charge felt by outer electrons increases across the series, causing a gradual decrease in ionic/atomic radii.

**Consequence:** The $4d$ (2nd transition) and $5d$ (3rd transition) elements in the same group have nearly identical radii (e.g. Zr and Hf are almost the same size).

**Why other options are wrong:**

- Option A: $d$-electrons are not involved in lanthanide contraction.
- Option B: nuclear charge actually *increases* across the series.
- Option D: $4f$–$5d$ repulsion is a secondary effect and not the primary cause.

**Final Answer:** $\boxed{\text{C}}$

**Answer: (C)** Go Back to Q36

## Q37.

**Solution**

**Concept — Ambidentate Ligands:** Ligands that can bond to a metal through two different donor atoms but only one at a time.

**Examples:**

- $SCN^-$: bonds via S (thiocyanato, $M$–SCN) or via N (isothiocyanato, $M$–NCS).
- $NO_2^-$: bonds via N (nitro, $M$–$NO_2$) or via O (nitrito, $M$–ONO).

**Step 1 — Linkage isomerism:** Because the same ligand can coordinate through different atoms, complexes with the same formula but different bonding give linkage isomers (e.g. $[Co(NH_3)_5(NO_2)]^{2+}$ vs. $[Co(NH_3)_5(ONO)]^{2+}$).

**Why other options are wrong:**

- Option A: describes bridging ligands (e.g. $\mu$-bridging), not ambidentate.
- Option B: chelation requires *two* donor atoms bonding simultaneously; ambidentate ligands bond through only one at a time.
- Option C: lone pairs are essential for coordination.

**Final Answer:** $\boxed{\text{D}}$

**Answer: (D)** Go Back to Q37

## Q38.

### Solution

**Concept — Resonance in Benzene:** Benzene cannot be represented by a single Kekulé structure. The real molecule is a resonance hybrid, lower in energy than either Kekulé structure alone.

**Step 1 — Bond length:** All six C–C bonds are equivalent with length $\approx 1.40$ Å (between single bond 1.54 Å and double bond 1.34 Å).

**Step 2 — Resonance energy:** The heat of hydrogenation of benzene is $208\ \text{kJ/mol}$ less than expected for three isolated double bonds ($3 \times 119 = 357\ \text{kJ/mol}$). This stabilisation energy ($\approx 150\ \text{kJ/mol}$) is the resonance energy.

**Why other options are wrong:**

- Option B: resonance energy of $50\ \text{kJ/mol}$ is too low; bond lengths do not alternate.
- Option C: the two Kekulé structures are distinct (single/double bonds interchanged); resonance energy is real.
- Option D: $300\ \text{kJ/mol}$ overestimates the resonance energy.

**Final Answer:** $\boxed{\text{A}}$

**Answer: (A)** Go Back to Q38

## Q39.

**Solution**

**Concept — Kharasch/Peroxide Effect:** In the presence of peroxides, HBr adds via a *radical* mechanism. The bromine radical (less stable than the carbon radical it generates) adds to the less substituted carbon to give the more stable secondary radical at C2, but the Br ends up at C1 in the final product.

**Step 1 — Mechanism:**

(a) $\text{ROOR} \to 2\text{RO}^\bullet$ (initiation)
(b) $\text{RO}^\bullet + \text{HBr} \to \text{ROH} + \text{Br}^\bullet$
(c) $\text{Br}^\bullet + \text{CH}_2\text{=CHCH}_3 \to \text{BrCH}_2\text{–}\dot{\text{C}}\text{H–CH}_3$ (more stable 2° radical at C2)
(d) $\dot{\text{C}}\text{HCH}_3 + \text{HBr} \to \text{BrCH}_2\text{CH}_2\text{CH}_3 + \text{Br}^\bullet$

Product: **1-bromopropane** (anti-Markovnikov).

**Why other options are wrong:**

- Option A: 2-bromopropane is the Markovnikov product from ionic addition of HBr (no peroxide).
- Option C: 1,2-dibromopropane would require two equivalents of $Br_2$, not HBr.
- Option D: allyl bromide requires a different mechanism.

**Final Answer:** $\boxed{\text{B}}$

**Answer: (B)** Go Back to Q39

## Q40.

**Solution**

**Concept — Nucleophilicity in Polar Protic Solvents:** In polar protic solvents (water, alcohols), halide ions are extensively solvated by hydrogen bonding. Smaller ions with higher charge density are more heavily solvated and must shed their solvent shell before nucleophilic attack, making them poorer nucleophiles.

**Step 1 — Order:** $\text{I}^- > \text{Br}^- > \text{Cl}^- > \text{F}^-$

$\text{I}^-$ is largest, least solvated, most polarisable $\Rightarrow$ best nucleophile in polar protic media. $\text{F}^-$ is smallest, most solvated $\Rightarrow$ poorest nucleophile (even though it has the highest base strength in gas phase).

**Why other options are wrong:**

- Option A: this is the order in the gas phase (based purely on electronegativity), reversed from polar protic.
- Options B, D: partial orders that do not reflect the correct trend.

**Final Answer:** $\boxed{\text{C}}$

**Answer: (C)** Go Back to Q40

## Q41.

### Solution

**Concept — Reaction of Phenol with $PCl_5$:** Unlike aliphatic alcohols where R–OH + $PCl_5 \rightarrow$ R–Cl + $POCl_3$ + HCl, phenol has the OH group attached to an aromatic ring. The initial product is a phenyl chlorophosphate intermediate, which then undergoes rearrangement to give **chlorobenzene**.

**Overall reaction:**

$$C_6H_5OH + PCl_5 \rightarrow C_6H_5Cl + POCl_3 + HCl$$

**Why other options are wrong:**

- Option A: phenyl phosphate requires a different phosphate ester reaction; $PCl_5$ is not used.
- Option B: diphenyl ether requires a Williamson synthesis, not $PCl_5$.
- Option C: phenol does react with $PCl_5$ to give chlorobenzene.

**Final Answer:** $\boxed{\text{D}}$

**Answer: (D)** Go Back to Q41

## Q42.

### Solution

**Concept — Tollens' Test (Silver Mirror Reaction):** Tollens' reagent is $[Ag(NH_3)_2]^+$ (ammoniacal silver nitrate). Aldehydes are oxidised; the silver ion is reduced to metallic silver, depositing as a mirror on the inner wall of the flask.

**Balanced equation:**

$$RCHO + 2\,[Ag(NH_3)_2]^+ + 2OH^- \rightarrow RCOOH + 2Ag\downarrow + 4NH_3 + H_2O$$

The organic product is the corresponding **carboxylic acid** RCOOH (or its ammonium salt under basic conditions).

**Why other options are wrong:**

- Option B: alcohol would be the reduction product; Tollens' is an oxidation reaction.
- Option C: Tollens' is specific to *aldehydes*, not ketones (except formic acid and $\alpha$-hydroxy ketones).
- Option D: $Ag_2O$ (black) is not the product; shiny metallic Ag forms a mirror.

**Final Answer:** $\boxed{\text{A}}$

**Answer: (A)** Go Back to Q42

## Q43.

### Solution

**Concept — $LiAlH_4$ Reduction of Esters:** $LiAlH_4$ is a powerful reducing agent that converts esters to two alcohols:

$$\mathrm{RCOOR'} \xrightarrow{1.\,\mathrm{LiAlH_4},\ 2.\,\mathrm{H_2O}} \mathrm{RCH_2OH} + \mathrm{R'OH}$$

**Step 1 — Mechanism:** First, the carbonyl group is reduced to give a hemiacetal equivalent, then the alkoxide leaves to give an aldehyde, which is further reduced to a primary alcohol. R′OH is liberated from the alkoxide $R'O^-$.

**Products:** Both $RCH_2OH$ and R′OH are primary alcohols.

**Why other options are wrong:**

- Option A: a carboxylic acid would not form under these strongly reducing conditions.
- Option C: an aldehyde intermediate would be further reduced by the excess $LiAlH_4$.
- Option D: a ketone cannot be produced — there is no $\alpha$-carbon oxidation.

**Final Answer:** $\boxed{\text{B}}$

**Answer: (B)** Go Back to Q43

## Q44.

**Solution**

**Concept — Beckmann Rearrangement:** Treatment of a ketoxime with acid (e.g. $H_2SO_4$, $PCl_5$, or heat) causes a 1,2-alkyl/aryl migration with loss of nitrogen, giving an amide. For cyclic ketones the product is a cyclic amide (lactam) — ring expansion.

**Step 1 — Cyclohexanone oxime:**

$$\text{Cyclohexanone oxime} \xrightarrow{H^+} \varepsilon\text{-caprolactam (7-membered ring lactam)}$$

$\varepsilon$-Caprolactam is the monomer for **nylon-6** (polycaprolactam), produced industrially by ring-opening polymerisation.

**Why other options are wrong:**

- Option A: cyclohexanamine would require reduction, not rearrangement.
- Option B: cyclohexanol would require hydrolysis under specific conditions.
- Option D: adipic acid is a monomer for nylon-6,6, not nylon-6; it is not a Beckmann product.

**Final Answer:** $\boxed{\text{C}}$

$\boxed{\textbf{Answer: (C)}}$ Go Back to Q44

## Q45.

**Solution**

**Concept — Negative Deviation from Raoult's Law:** Vapour pressure of the mixture is *lower* than predicted by Raoult's law ($P_{\text{mix}} < P_A^* x_A + P_B^* x_B$).

**Step 1 — Molecular explanation:** This occurs when A–B intermolecular interactions are *stronger* than A–A and B–B interactions. Molecules are held more tightly in the mixture, so fewer can escape to the vapour phase.

**Examples:** Acetone + chloroform (dipole-dipole interaction between C=O of acetone and C–H of $CHCl_3$); $HNO_3$–water; HCl–water.

**These solutions:** Form minimum-boiling *negative* azeotropes (actually maximum-boiling azeotropes for negative deviation).

**Why other options are wrong:**

- Option A: describes *positive* deviation (A–B weaker than A–A/B–B).

- Option B: negative deviation persists at high temperature until the azeotrope composition.
- Option C: lower vapour pressure is the hallmark, not higher.

**Final Answer:** $\boxed{\text{D}}$

Answer: (D) Go Back to Q45

## Q46.

### Solution

**Concept — Common Ion Effect:** Addition of excess $Ag^+$ (from $AgNO_3$) suppresses the dissolution of AgCl.

**Step 1 — Solubility in presence of common ion:**

$$K_{sp} = [\mathrm{Ag^+}][\mathrm{Cl^-}] = 1.8 \times 10^{-10}$$

With $[\mathrm{Ag^+}] = 0.1\ \mathrm{M}$ (from $AgNO_3$, dominates):

$$s = [\mathrm{Cl^-}] = \frac{K_{sp}}{[\mathrm{Ag^+}]} = \frac{1.8 \times 10^{-10}}{0.1} = 1.8 \times 10^{-9}\ \mathrm{M}$$

This is much less than solubility in pure water $(1.34 \times 10^{-5}\ \mathrm{M})$.

**Why other options are wrong:**

- Option B $(1.8 \times 10^{-10})$: that is $K_{sp}$, not solubility.
- Option C $(1.34 \times 10^{-5})$: is the solubility in *pure water*, without added $Ag^+$.
- Option D $(0.1\ \mathrm{M})$: would far exceed the $K_{sp}$ limit.

**Final Answer:** $\boxed{\text{A}}$

Answer: (A) Go Back to Q46

## Q47.

**Solution**

**Concept — Parallel (Competing) Reactions:** For $A \xrightarrow{k_1} B$ and $A \xrightarrow{k_2} C$:

$$\frac{d[\mathrm{B}]}{dt} = k_1[\mathrm{A}], \quad \frac{d[\mathrm{C}]}{dt} = k_2[\mathrm{A}]$$

**Step 1 — Divide:**

$$\frac{d[\mathrm{B}]}{d[\mathrm{C}]} = \frac{k_1}{k_2}$$

Integrating: $[\mathrm{B}]/[\mathrm{C}] = k_1/k_2$ (constant at all times, assuming $[\mathrm{B}]_0 = [\mathrm{C}]_0 = 0$).

**Why other options are wrong:**

- Option A ($k_2/k_1$): inverted ratio would give $[\mathrm{C}]/[\mathrm{B}]$.
- Option C ($(k_1 + k_2)/k_1$): total rate constant ratio is not the product ratio.
- Option D ($k_1 \cdot k_2$): a product of constants has no physical significance here.

**Final Answer:** $\boxed{\mathrm{B}}$

**Answer: (B)** Go Back to Q47

## Q48.

**Solution**

**Concept — Nernst Equation:** At 25°C:

$$E = E^\circ - \frac{0.0592}{n} \log Q$$

**Step 1 — Half-cell:** $\mathrm{Zn}^{2+} + 2\mathrm{e}^- \rightarrow \mathrm{Zn}$; $n = 2$; $Q = 1/[\mathrm{Zn}^{2+}] = 1/0.1 = 10$.

**Step 2 — Calculate:**

$$E = -0.76 - \frac{0.0592}{2} \log(10) = -0.76 - 0.0296 \times 1 = -0.76 - 0.0296 \approx -0.79 \text{ V}$$

**Why other options are wrong:**

- Option A ($-0.76$ V): standard electrode potential applies only at $[\mathrm{Zn}^{2+}] = 1$ M.
- Option B ($-0.73$ V): $E$ should decrease (more negative) for lower $[\mathrm{Zn}^{2+}]$, not increase.
- Option D ($-0.83$ V): too negative; that would require $[\mathrm{Zn}^{2+}] = 0.01$ M.

**Final Answer:** $\boxed{C}$

Answer: (C) Go Back to Q48

## Q49.

**Solution**

**Concept — Emulsifiers:** An emulsifier (surfactant) stabilises an emulsion by positioning itself at the interface between the two immiscible phases.

**Step 1 — Amphiphilic structure:** Emulsifiers must have:

- A **hydrophilic (polar/ionic) head** that interacts with the aqueous phase.
- A **hydrophobic (non-polar) tail** that interacts with the oil phase.

This allows them to coat oil droplets (in O/W emulsions) or water droplets (in W/O emulsions) and prevent coalescence.

**Examples:** Soaps (long-chain carboxylates), proteins (in milk), lecithin (in egg yolk).

**Why other options are wrong:**

- Option A: if the emulsifier dissolved equally in both phases, it would not concentrate at the interface.
- Option B: emulsifiers are typically small molecules, not high-molecular-mass polymers.
- Option C: many effective emulsifiers are organic and non-ionic (e.g. polysorbates).

**Final Answer:** $\boxed{D}$

Answer: (D) Go Back to Q49

## Q50.

**Solution**

**Concept — Cellulose:** Cellulose is a structural polysaccharide that gives rigidity to plant cell walls.

**Step 1 — Linkage:** The repeating unit is $\beta$-D-glucopyranose. Adjacent units are joined by $\beta$-1,4-glycosidic bonds (O bridges between C1 of one unit and C4 of the next, in the $\beta$-configuration).

**Step 2 — Consequence:** The $\beta$-linkage causes the chains to be linear and allows extensive intermolecular hydrogen bonding, giving cellulose its high tensile strength. Humans lack $\beta$-glucosidase (cellulase) and therefore cannot digest cellulose.

**Why other options are wrong:**

- Option B ($\alpha$-1,4): describes starch (amylose), which *is* digestible.
- Option C ($\alpha$-1,6): describes the branch points in amylopectin and glycogen.
- Option D ($\beta$-1,6): describes the linkage in some yeast cell wall polysaccharides, not cellulose.

**Final Answer:** $\boxed{\text{A}}$

**Answer: (A)** Go Back to Q50

## Q51.

### Solution

**Normality = Molarity $\times$ $n$-factor:**

$$\text{Molarity} = \frac{98\ \text{g}}{98\ \text{g/mol} \times 1\ \text{L}} = 1\ \text{M}$$

$$\text{Normality} = 1 \times 2 = 2\ \text{N}$$

($H_2SO_4$ provides 2 $H^+$ per formula unit, so $n$-factor $= 2$.)

**Final Answer:** $\boxed{2}$

**Answer: (2)** Go Back to Q51

## Q52.

### Solution

**Molar Volume at STP:**

$$\text{Moles of } N_2 = \frac{0.4\ \text{g}}{28\ \text{g/mol}} = \frac{1}{70}\ \text{mol}$$

$$V = \frac{1}{70} \times 22.4 = \frac{22.4}{70} = 0.32\ \text{L}$$

**Final Answer:** $\boxed{0.32}$

**Answer: (0.32)** Go Back to Q52

## Q53.

**Solution**

**Strong Base pH:**

$$\text{Moles of NaOH} = \frac{4}{40} = 0.1 \text{ mol}$$

$$[\text{OH}^-] = 0.1 \text{ M}, \quad \text{pOH} = -\log(0.1) = 1$$

$$\text{pH} = 14 - \text{pOH} = 14 - 1 = 13$$

**Final Answer:** $\boxed{13}$

**Answer: (13)** Go Back to Q53

## Q54.

**Solution**

**Bond Energy Method:**

$$\Delta H = \Sigma(\text{bonds broken}) - \Sigma(\text{bonds formed})$$

**Bonds broken** (reactants: $CH_4$ + $2O_2$):

$$4 \times C\text{–}H + 2 \times O{=}O = 4(413) + 2(498) = 1652 + 996 = 2648 \text{ kJ}$$

**Bonds formed** (products: $CO_2$ + $2H_2O$):

$$2 \times C{=}O + 4 \times O\text{–}H = 2(799) + 4(463) = 1598 + 1852 = 3450 \text{ kJ}$$

$$\Delta H = 2648 - 3450 = -802 \text{ kJ/mol}$$

Magnitude $= 802$ kJ/mol.

**Final Answer:** $\boxed{802}$

**Answer: (802)** Go Back to Q54

## Q55.

**Solution**

**Zero-Order Kinetics:**

$$[\text{A}] = [\text{A}]_0 - kt$$

$$0.2 = 0.5 - 0.05t$$

$$0.05t = 0.5 - 0.2 = 0.3$$

$$t = \frac{0.3}{0.05} = 6 \text{ min}$$

**Final Answer:** $\boxed{6}$

**Answer: (6)** Go Back to Q55

## Q56.

**Solution**

**Kohlrausch's Law:**

$$\alpha = \frac{\Lambda_m}{\Lambda_m^\infty} = \frac{9.3}{390.7} = 0.0238 \approx 0.024$$

**Final Answer:** $\boxed{0.024}$

**Answer: (0.024)** Go Back to Q56

## Q57.

**Solution**

**Faraday's First Law of Electrolysis:**

$$Q = It = 2 \times 3600 = 7200 \text{ C}$$

$$m = \frac{Q \times M}{n \times F} = \frac{7200 \times 63.5}{2 \times 96500} = \frac{457200}{193000} \approx 2.37 \text{ g}$$

**Final Answer:** $\boxed{2.37}$

**Answer: (2.37)** Go Back to Q57

## Q58.

**Solution**

**Radioactive Decay:**

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/t_{1/2}}$$

$$\frac{1}{4} = \left(\frac{1}{2}\right)^{30/t_{1/2}}$$

$$\left(\frac{1}{2}\right)^2 = \left(\frac{1}{2}\right)^{30/t_{1/2}}$$

$$\frac{30}{t_{1/2}} = 2 \quad \Rightarrow \quad t_{1/2} = 15 \text{ years}$$

**Final Answer:** $\boxed{15}$

**Answer: (15)** Go Back to Q58

## Q59.

### Solution

**Coordination Number:** Ethylenediamine (en) is a bidentate ligand — it binds to the metal through 2 donor atoms (both N atoms).

$$[\mathrm{Cr(en)_3}]^{3+} : \text{ 3 bidentate en ligands} \times 2 \text{ donor atoms each} = 6$$

Coordination number of Cr $= 6$.

**Final Answer:** $\boxed{6}$

**Answer: (6)** Go Back to Q59

## Q60.

### Solution

**van't Hoff Equation:**

$$\pi = MRT$$

$$M = \frac{18}{180 \times 1} = 0.1 \text{ mol/L}, \quad T = 27 + 273 = 300 \text{ K}$$

$$\pi = 0.1 \times 0.0821 \times 300 = 2.463 \approx 2.46 \text{ atm}$$

**Final Answer:** $\boxed{2.46}$

**Answer: (2.46)** Go Back to Q60

## Q61.

### Solution

**Concept — De Moivre's Theorem:** $(\cos\theta + i\sin\theta)^n = \cos(n\theta) + i\sin(n\theta)$.

**Step 1 — Convert** $1 + i$ **to polar form:**

$$|1 + i| = \sqrt{1^2 + 1^2} = \sqrt{2}, \quad \arg(1 + i) = \frac{\pi}{4}$$

$$1 + i = \sqrt{2}\left(\cos\frac{\pi}{4} + i\sin\frac{\pi}{4}\right) = \sqrt{2}\,e^{i\pi/4}$$

**Step 2 — Raise to power 8:**

$$(1+i)^8 = (\sqrt{2})^8\, e^{i\cdot 8\cdot\pi/4} = 2^4\, e^{i2\pi} = 16(\cos 2\pi + i\sin 2\pi) = 16 \times 1 = 16$$

**Why other options are wrong:**

- Option A ($8i$): $(\sqrt{2})^8 = 16$, not 8; and $e^{i2\pi} = 1$ (real), not $i$.
- Option C ($-16$): $e^{i\pi} = -1$, but the exponent here is $2\pi$, giving $+1$.
- Option D ($8$): missing the correct power of $\sqrt{2}$.

**Final Answer:** $\boxed{\text{B}}$

**Answer: (B)** Go Back to Q61

## Q62.

**Solution**

**Concept — Forming Quadratic from Roots:**

$$x^2 - (\alpha+\beta)x + \alpha\beta = 0$$

**Step 1 — Compute:**

$$\alpha+\beta = 2+3 = 5, \quad \alpha\beta = 2\times 3 = 6$$

$$x^2 - 5x + 6 = 0$$

**Verification:** $(x-2)(x-3) = x^2 - 5x + 6$ ✓

**Why other options are wrong:**

- Option A: sum of roots should be $-(-5) = 5$, but option A has $+5x$ (giving sum $-5$).
- Option B: product of roots $= -6$ would mean $\alpha\beta = -6$ (e.g. roots $-2, 3$), incorrect.
- Option C: both signs wrong; roots would be $6, -1$ in this case.

**Final Answer:** $\boxed{\text{D}}$

**Answer: (D)** Go Back to Q62

## Q63.

### Solution

**Concept — Sum of Squares Formula:**

$$\sum_{k=1}^{n} k^2 = \frac{n(n+1)(2n+1)}{6}$$

**Step 1 — Substitute $n = 5$:**

$$\sum_{k=1}^{5} k^2 = \frac{5 \times 6 \times 11}{6} = \frac{330}{6} = 55$$

**Verification:** $1 + 4 + 9 + 16 + 25 = 55$ ✓

**Why other options are wrong:**

- Option A (35): $\sum k$ (not $k^2$) for $n = 7$ gives 28; not matching.
- Option B (45): $\sum_{k=1}^{9} k = 45$, but that is a sum of first 9 integers.
- Option D (65): $\sum_{k=1}^{6} k^2 = 91$, not 65.

**Final Answer:** $\boxed{\text{C}}$

**Answer: (C)** Go Back to Q63

## Q64.

### Solution

**Concept — Multinomial Arrangements:** Number of arrangements of $n$ objects where objects of type 1 occur $n_1$ times, etc.:

$$\frac{n!}{n_1!\, n_2! \cdots}$$

**Step 1 — Count letters in MISSISSIPPI (11 letters):**

- M: 1, I: 4, S: 4, P: 2

**Step 2 — Calculate:**

$$\frac{11!}{1!\,4!\,4!\,2!} = \frac{39916800}{1 \times 24 \times 24 \times 2} = \frac{39916800}{1152} = 34650$$

**Why other options are wrong:**

- Option B $(69300)$: off by a factor of 2.
- Option C $(11!)$: counts all letters as distinct, ignoring repeated letters.
- Option D $(5040)$: $7! = 5040$; wrong denominator.

**Final Answer:** $\boxed{A}$

**Answer: (A)** Go Back to Q64

## Q65.

**Solution**

**Concept — Binomial Theorem:** $(1+x)^n = \sum_{r=0}^{n} \binom{n}{r} x^r$. Coefficient of $x^r$ is $\binom{n}{r}$.

**Step 1 — $n = 8$, $r = 3$:**

$$\binom{8}{3} = \frac{8!}{3!\,5!} = \frac{8 \times 7 \times 6}{3 \times 2 \times 1} = \frac{336}{6} = 56$$

**Why other options are wrong:**

- Option A $(28)$: $\binom{8}{2} = 28$, coefficient of $x^2$, not $x^3$.
- Option C $(70)$: $\binom{8}{4} = 70$, coefficient of $x^4$.
- Option D $(84)$: $\binom{9}{3} = 84$, wrong $n$.

**Final Answer:** $\boxed{B}$

**Answer: (B)** Go Back to Q65

## Q66.

**Solution**

**Concept — Inverse of $2 \times 2$ Matrix:**

$$A = \begin{pmatrix} a & b \\ c & d \end{pmatrix}, \quad A^{-1} = \frac{1}{|A|} \begin{pmatrix} d & -b \\ -c & a \end{pmatrix}$$

**Step 1 — Determinant:**

$$|A| = (2)(3) - (1)(5) = 6 - 5 = 1$$

**Step 2 — Inverse:**

$$A^{-1} = \frac{1}{1}\begin{pmatrix} 3 & -1 \\ -5 & 2 \end{pmatrix} = \begin{pmatrix} 3 & -1 \\ -5 & 2 \end{pmatrix}$$

**Verification:** $AA^{-1} = \begin{pmatrix} 2 & 1 \\ 5 & 3 \end{pmatrix}\begin{pmatrix} 3 & -1 \\ -5 & 2 \end{pmatrix} = \begin{pmatrix} 6-5 & -2+2 \\ 15-15 & -5+6 \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \checkmark$

**Why other options are wrong:**

- Option A: has $+1$ instead of $-1$ in position (1,2).
- Option B: has $-3$ and $+5$, the negatives of the correct entries on the diagonal.
- Option C: swaps $a, d$ and negates $b, c$, but without transposing $b$ and $c$.

**Final Answer:** $\boxed{\text{D}}$

**Answer: (D)** Go Back to Q66

## Q67.

### Solution

**Concept — Half-Angle Formulas:** From $\cos\theta = 1 - 2\sin^2(\theta/2)$:

$$\sin^2\left(\frac{\theta}{2}\right) = \frac{1-\cos\theta}{2}$$

$$\sin\left(\frac{\theta}{2}\right) = \sqrt{\frac{1-\cos\theta}{2}} \quad \text{(positive for } 0 < \theta/2 < \pi)$$

**Verification with** $\theta = 60$:

$$\sin 30 = \sqrt{\frac{1-\cos 60}{2}} = \sqrt{\frac{1-0.5}{2}} = \sqrt{0.25} = 0.5 \checkmark$$

**Why other options are wrong:**

- Option A: $(1+\cos\theta)/2 = \cos^2(\theta/2)$, not $\sin^2(\theta/2)$.
- Option B: $\sqrt{(1+\cos\theta)/2} = |\cos(\theta/2)|$.
- Option D: $(1-\cos\theta)/2$ without the square root gives $\sin^2(\theta/2)$.

**Final Answer:** $\boxed{\text{C}}$

**Answer: (C)** Go Back to Q67

## Q68.

### Solution

**Concept — Inverse Tangent:** $\tan^{-1}(x) = \frac{\pi}{4}$ means $x = \tan\left(\frac{\pi}{4}\right)$.

**Step 1 — Recall:**

$$\tan\left(\frac{\pi}{4}\right) = \tan 45 = 1$$

$$\therefore x = 1$$

**Why other options are wrong:**

- Option B ($\sqrt{3}$): $\tan 60 = \sqrt{3}$, so $\tan^{-1}(\sqrt{3}) = \pi/3$, not $\pi/4$.
- Option C ($1/\sqrt{3}$): $\tan 30 = 1/\sqrt{3}$, so $\tan^{-1}(1/\sqrt{3}) = \pi/6$.
- Option D ($-1$): $\tan(-\pi/4) = -1$, giving $\tan^{-1}(-1) = -\pi/4$.

**Final Answer:** $\boxed{\text{A}}$

**Answer: (A)** Go Back to Q68

## Q69.

### Solution

**Concept — Internal Division (Section Formula):** Point $P$ dividing $AB$ in ratio $m:n$ internally:

$$P = \left(\frac{mx_2 + nx_1}{m+n}, \frac{my_2 + ny_1}{m+n}\right)$$

**Step 1 — Substitute:** $A(2,1)$, $B(5,4)$, ratio $m:n = 2:1$:

$$x_P = \frac{2\times 5 + 1\times 2}{2+1} = \frac{10+2}{3} = \frac{12}{3} = 4$$

$$y_P = \frac{2\times 4 + 1\times 1}{3} = \frac{8+1}{3} = \frac{9}{3} = 3$$

$$P = (4,3)$$

**Why other options are wrong:**

- Option A ($(3,2)$): uses midpoint formula ($1:1$ ratio).
- Option C ($(3.5, 2.5)$): midpoint of $A$ and $B$ is $(3.5, 2.5)$ — uses equal weighting.
- Option D ($(3,4)$): numerators or denominators are incorrectly assigned.

**Final Answer:** $\boxed{\text{B}}$

Answer: (B) Go Back to Q69

## Q70.

**Solution**

**Concept — Concentric Circles:** Two circles are concentric if they have the same centre. The general equation $x^2 + y^2 + 2gx + 2fy + c = 0$ has centre $(-g, -f)$.

**Step 1 — Centre of given circle:** $x^2 + y^2 - 4x + 6y + k = 0 \Rightarrow g = -2$, $f = 3$, centre $= (2, -3)$.

**Step 2 — Concentric circle:** Must have the same $g$ and $f$ (same centre $(2, -3)$) but a different constant $m \neq k$:

$$x^2 + y^2 - 4x + 6y + m = 0$$

**Why other options are wrong:**

- Option A: changes the signs of $g$ and $f$, giving centre $(-2, 3)$ — a different centre.
- Option B: concentric circles never intersect (they have the same centre).
- Option C: coefficients $-6x + 4y$ give centre $(3, -2)$, different from $(2, -3)$.

**Final Answer:** $\boxed{\text{D}}$

Answer: (D) Go Back to Q70

## Q71.

**Solution**

**Concept — Downward Parabola $x^2 = -4py$:** Comparing $x^2 = -8y$ with $x^2 = -4py$:

$$4p = 8 \Rightarrow p = 2$$

- Vertex: $(0, 0)$; opens downward.
- Focus: $(0, -p) = (0, -2)$.
- Directrix: $y = +p = 2$.

**Why other options are wrong:**

- Option A $(y = -2)$: that is the focus, not the directrix.
- Options B, D $(x = \pm 2)$: directrix of a vertical-axis parabola is a horizontal line, not vertical.

**Final Answer:** $\boxed{\text{C}}$

Answer: (C) Go Back to Q71

## Q72.

**Solution**

**Concept — Tangent to Ellipse:** The equation of the tangent to $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ at the point $(x_1, y_1)$ lying on the ellipse is obtained by replacing $x^2 \to xx_1$ and $y^2 \to yy_1$:

$$\frac{x_1 x}{a^2} + \frac{y_1 y}{b^2} = 1$$

**Why other options are wrong:**

- Option B: swaps $a^2$ and $b^2$.
- Option C: $x_1 x + y_1 y = a^2 + b^2$ is not the correct form for an ellipse.
- Option D: uses $a$ and $b$ (not squared) in the denominator.

**Final Answer:** $\boxed{\text{A}}$

Answer: (A) Go Back to Q72

## Q73.

**Solution**

**Concept — Squeeze (Sandwich) Theorem:** If $g(x) \le f(x) \le h(x)$ near $x = a$ and $\lim_{x\to a} g(x) = \lim_{x\to a} h(x) = L$, then $\lim_{x\to a} f(x) = L$.

**Step 1 — Apply:** Since $-1 \le \sin(1/x) \le 1$ for all $x \ne 0$:

$$-x^2 \le x^2 \sin\left(\frac{1}{x}\right) \le x^2$$

**Step 2 — Take the limit:**

$$\lim_{x\to 0}(-x^2) = 0, \quad \lim_{x\to 0}(x^2) = 0$$

By Squeeze Theorem: $\lim_{x\to 0} x^2 \sin\left(\frac{1}{x}\right) = 0.$

**Why other options are wrong:**

- Option A (1): $\lim_{x\to 0} \sin(1/x)$ doesn't exist, but $x^2$ forces the product to 0.

- Option C (does not exist): $x^2 \sin(1/x)$ is bounded by $x^2$, so the limit does exist.
- Option D ($\infty$): $x^2 \to 0$ dominates the oscillation of $\sin(1/x)$.

**Final Answer:** $\boxed{\text{B}}$

**Answer: (B)** Go Back to Q73

## Q74.

### Solution

**Concept — Mean Value Theorem:** $\exists\, c \in (a, b)$ such that $f'(c) = \dfrac{f(b) - f(a)}{b - a}$.

**Step 1 — Compute slope:**

$$f(1) = 1, \quad f(3) = 9$$

$$\frac{f(3) - f(1)}{3 - 1} = \frac{9 - 1}{2} = \frac{8}{2} = 4$$

**Step 2 — Find $c$:**

$$f'(x) = 2x = 4 \Rightarrow x = c = 2$$

$c = 2 \in (1, 3)$ ✓

**Why other options are wrong:**

- Option A ($c = 1.5$): $f'(1.5) = 3 \neq 4$.
- Option B ($c = 2.5$): $f'(2.5) = 5 \neq 4$.
- Option C ($c = 3$): the MVT requires $c$ strictly inside $(a, b)$, and $f'(3) = 6 \neq 4$.

**Final Answer:** $\boxed{\text{D}}$

**Answer: (D)** Go Back to Q74

## Q75.

**Solution**

**Concept — Inflection Point:** Where $f''(x) = 0$ and $f''$ changes sign.

**Step 1:**

$$f(x) = x^3 - 3x^2 + 2, \quad f'(x) = 3x^2 - 6x, \quad f''(x) = 6x - 6$$

**Step 2 — Set $f''(x) = 0$:**

$$6x - 6 = 0 \Rightarrow x = 1$$

$f''$ changes from negative $(x < 1)$ to positive $(x > 1)$ $\Rightarrow$ inflection point.

**Step 3 — Find $y$:**

$$f(1) = 1 - 3 + 2 = 0$$

Inflection point: $(1, 0)$.

**Why other options are wrong:**

- Option A $((0, 2))$: $f(0) = 2$, but $x = 0$ is not an inflection point.
- Option B $((2, -2))$: $f(2) = 8 - 12 + 2 = -2$, but $f''(2) = 6 \neq 0$.
- Option D $((3, 2))$: $f(3) = 27 - 27 + 2 = 2$, not an inflection point.

**Final Answer:** $\boxed{\text{C}}$

**Answer: (C)** Go Back to Q75

## Q76.

**Solution**

**Concept — Half-Angle Identity:**

$$\sin^2 x = \frac{1 - \cos 2x}{2}$$

**Step 1 — Integrate:**

$$\int \sin^2 x \, dx = \int \frac{1 - \cos 2x}{2} \, dx = \frac{x}{2} - \frac{\sin 2x}{4} + C$$

**Why other options are wrong:**

- Option B: $-\cos 2x/4$ is the integral of $\sin 2x/2$, not $\sin^2 x$.
- Option C: has $+\cos 2x/4$ instead of $-\sin 2x/4$.

- Option D: $\sin 2x/4$ alone is not the complete antiderivative.

**Final Answer:** $\boxed{\text{A}}$

**Answer: (A)** Go Back to Q76

## Q77.

### Solution

**Concept — Substitution:** Let $u = 1 + x^2$, $du = 2x\,dx$.

**Step 1:**

$$\int_0^1 \frac{x}{1+x^2}\,dx = \frac{1}{2}\int_0^1 \frac{2x\,dx}{1+x^2} = \frac{1}{2}\Big[\ln(1+x^2)\Big]_0^1$$

$$= \frac{1}{2}[\ln 2 - \ln 1] = \frac{1}{2}\ln 2 = \frac{\ln 2}{2}$$

**Why other options are wrong:**

- Option A ($\ln 2$): missing the factor $\frac{1}{2}$ from the substitution.
- Option B ($\frac{1}{2}$): a constant with no logarithm — approximate but incorrect.
- Option C ($1 - \ln 2$): arises from an incorrect integration.

**Final Answer:** $\boxed{\text{D}}$

**Answer: (D)** Go Back to Q77

## Q78.

### Solution

**Concept — Geometric Probability:** For a uniform distribution on $[a, b]$, the probability that the point lies in a sub-interval $[c, d] \subseteq [a, b]$ is:

$$P = \frac{d-c}{b-a}$$

**Step 1 — Substitute:**

$$P = \frac{5-2}{6-0} = \frac{3}{6} = \frac{1}{2}$$

**Why other options are wrong:**

- Option A ($1/3$): uses $3/9$ or incorrect interval length.
- Option B ($1/4$): would require a sub-interval of length $1.5$ in $[0, 6]$.

- Option D $(2/3)$: $4/6 = 2/3$ would require an interval of length 4.

**Final Answer:** $\boxed{\text{C}}$

**Answer: (C)** Go Back to Q78

## Q79.

**Solution**

**Concept — Coplanarity via Scalar Triple Product:** Three vectors $\vec{a}$, $\vec{b}$, $\vec{c}$ are coplanar if and only if they do not span 3D space, which is equivalent to:

$$[\vec{a}\,\vec{b}\,\vec{c}] = \vec{a} \cdot (\vec{b} \times \vec{c}) = 0$$

**Geometric interpretation:** The scalar triple product equals the volume of the parallelepiped formed by the three vectors. If the volume is 0, the vectors lie in one plane.

**Why other options are wrong:**

- Option A $(= 1)$: there is no reason the scalar triple product should equal 1 for coplanar vectors.
- Option C: the vector triple product $\vec{a} \times (\vec{b} \times \vec{c}) = \vec{0}$ occurs for specific collinear conditions, not general coplanarity.
- Option D: sum of magnitudes cannot be zero unless all vectors are zero.

**Final Answer:** $\boxed{\text{B}}$

**Answer: (B)** Go Back to Q79

## Q80.

**Solution**

**Concept — Shortest Distance between Skew Lines:**

$$d = \frac{|(\vec{r_2} - \vec{r_1}) \cdot (\vec{d_1} \times \vec{d_2})|}{|\vec{d_1} \times \vec{d_2}|}$$

**Step 1 — Identify:**

$$\vec{r_1} = (1, 0, 0), \quad \vec{d_1} = (1, 1, 0)$$
$$\vec{r_2} = (0, 0, 1), \quad \vec{d_2} = (1, 0, 1)$$

**Step 2 — Cross product $\vec{d_1} \times \vec{d_2}$:**

$$\vec{d_1} \times \vec{d_2} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 1 & 0 \\ 1 & 0 & 1 \end{vmatrix} = \hat{i}(1 \cdot 1 - 0 \cdot 0) - \hat{j}(1 \cdot 1 - 0 \cdot 1) + \hat{k}(1 \cdot 0 - 1 \cdot 1)$$

$$= \hat{i}(1) - \hat{j}(1) + \hat{k}(-1) = (1, -1, -1)$$

$$|\vec{d_1} \times \vec{d_2}| = \sqrt{1+1+1} = \sqrt{3}$$

**Step 3 — Numerator:**

$$\vec{r_2} - \vec{r_1} = (0-1,\ 0-0,\ 1-0) = (-1, 0, 1)$$

$$(-1, 0, 1) \cdot (1, -1, -1) = -1 + 0 - 1 = -2$$

$$|-2| = 2$$

**Step 4 — Distance:**

$$d = \frac{2}{\sqrt{3}} = \frac{2\sqrt{3}}{3}$$

**Why other options are wrong:**

- Option B ($\sqrt{3}/3$): off by factor 2.
- Option C ($\sqrt{2}$): incorrect cross-product magnitude.
- Option D ($1$): incorrect numerator or denominator.

**Final Answer:** $\boxed{\text{A}}$

**Answer: (A)** Go Back to Q80

## Q81.

**Solution**

**Modulus of Complex Number:**

$$|z| = |3 - 4i| = \sqrt{3^2 + (-4)^2} = \sqrt{9 + 16} = \sqrt{25} = 5$$

**Final Answer:** $\boxed{5}$

**Answer: (5)** Go Back to Q81

## Q82.

**Solution**

**Sum of Geometric Progression:**

$$S = \frac{a(r^n - 1)}{r - 1} = \frac{3(3^5 - 1)}{3 - 1} = \frac{3(243 - 1)}{2} = \frac{3 \times 242}{2} = \frac{726}{2} = 363$$

**Verification:** $3 + 9 + 27 + 81 + 243 = 363$ ✓

**Final Answer:** $\boxed{363}$

**Answer: (363)** Go Back to Q82

## Q83.

**Solution**

$2 \times 2$ **Determinant:**

$$\begin{vmatrix} 4 & 2 \\ 6 & 5 \end{vmatrix} = (4)(5) - (2)(6) = 20 - 12 = 8$$

**Final Answer:** $\boxed{8}$

**Answer: (8)** Go Back to Q83

## Q84.

**Solution**

**Linear Permutations:** The number of ways to arrange $n$ distinct people in $n$ seats is $n!$

$$4! = 4 \times 3 \times 2 \times 1 = 24$$

**Final Answer:** $\boxed{24}$

**Answer: (24)** Go Back to Q84

## Q85.

**Solution**

**Definite Integral:**

$$\int_0^1 (2x + 3)\, dx = \left[x^2 + 3x\right]_0^1 = (1 + 3) - (0 + 0) = 4$$

**Final Answer:** $\boxed{4}$

Answer: (4) Go Back to Q85

## Q86.

**Solution**

**Differentiation:**

$$f(x) = x^3 - 2x^2 + 5x - 1$$

$$f'(x) = 3x^2 - 4x + 5$$

$$f'(1) = 3(1) - 4(1) + 5 = 3 - 4 + 5 = 4$$

**Final Answer:** $\boxed{4}$

Answer: (4) Go Back to Q86

## Q87.

**Solution**

**Definite Integral of $e^x$:**

$$\int_0^{\ln 3} e^x \, dx = \left[e^x\right]_0^{\ln 3} = e^{\ln 3} - e^0 = 3 - 1 = 2$$

**Final Answer:** $\boxed{2}$

Answer: (2) Go Back to Q87

## Q88.

**Solution**

**Perpendicularity Condition:** $\vec{a} \cdot \vec{b} = 0$

$$\vec{a} \cdot \vec{b} = (k)(2) + (1)(-3) = 2k - 3 = 0$$

$$k = \frac{3}{2} = 1.5$$

**Final Answer:** $\boxed{1.5}$

Answer: (1.5) Go Back to Q88

## Q89.

**Solution**

**Standard Deviation:** Data: $\{2, 4, 4, 4, 5, 5, 7, 9\}$ $(n = 8)$.

**Mean:**

$$\bar{x} = \frac{2+4+4+4+5+5+7+9}{8} = \frac{40}{8} = 5$$

**Sum of squared deviations:**

$$(2-5)^2 + (4-5)^2 + (4-5)^2 + (4-5)^2 + (5-5)^2 + (5-5)^2 + (7-5)^2 + (9-5)^2$$

$$= 9 + 1 + 1 + 1 + 0 + 0 + 4 + 16 = 32$$

**Variance:** $\sigma^2 = 32/8 = 4.$ **SD:** $\sigma = \sqrt{4} = 2.$

**Final Answer:** $\boxed{2}$

Answer: (2) Go Back to Q89

## Q90.

**Solution**

**Probability of Sum $\geq 10$ with two dice:**

Favourable outcomes:

- Sum $= 10$: $(4, 6), (5, 5), (6, 4)$ — 3 outcomes
- Sum $= 11$: $(5, 6), (6, 5)$ — 2 outcomes
- Sum $= 12$: $(6, 6)$ — 1 outcome

Total favourable $= 6$; Total outcomes $= 36$.

$$P(\text{sum} \geq 10) = \frac{6}{36} = \frac{1}{6}$$

The fraction in lowest terms is $\frac{1}{6}$; the denominator is **6**.

**Final Answer:** $\boxed{6}$

Answer: (6) Go Back to Q90

# Answer Key

| Q | Ans | Q | Ans | Q | Ans | Q | Ans | Q | Ans |
|---|---|---|---|---|---|---|---|---|---|
| 1 | D | 2 | B | 3 | C | 4 | A | 5 | D |
| 6 | B | 7 | C | 8 | A | 9 | D | 10 | B |
| 11 | C | 12 | A | 13 | D | 14 | B | 15 | C |
| 16 | A | 17 | D | 18 | B | 19 | C | 20 | A |
| 21 | 27 | 22 | 18 | 23 | 48 | 24 | 160 | 25 | 6 |
| 26 | 125 | 27 | 1 | 28 | 4 | 29 | 22.5 | 30 | 7 |
| 31 | B | 32 | C | 33 | D | 34 | A | 35 | B |
| 36 | C | 37 | D | 38 | A | 39 | B | 40 | C |
| 41 | D | 42 | A | 43 | B | 44 | C | 45 | D |
| 46 | A | 47 | B | 48 | C | 49 | D | 50 | A |
| 51 | 2 | 52 | 0.32 | 53 | 13 | 54 | 802 | 55 | 6 |
| 56 | 0.024 | 57 | 2.37 | 58 | 15 | 59 | 6 | 60 | 2.46 |
| 61 | B | 62 | D | 63 | C | 64 | A | 65 | B |
| 66 | D | 67 | C | 68 | A | 69 | B | 70 | D |
| 71 | C | 72 | A | 73 | B | 74 | D | 75 | C |
| 76 | A | 77 | D | 78 | C | 79 | B | 80 | A |
| 81 | 5 | 82 | 363 | 83 | 8 | 84 | 24 | 85 | 4 |
| 86 | 4 | 87 | 2 | 88 | 1.5 | 89 | 2 | 90 | 6 |