# JEE Main

## Sample Paper – 6

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

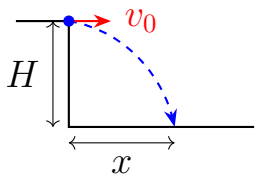
### Instructions

- 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.** A ball rolls off the edge of a table of height $H = 20$ m with a horizontal velocity $v_0 = 10$ m/s. Taking $g = 10$ m/s$^2$, find the horizontal distance $x$ from the base of the table where the ball lands.




(A) 20 m

(B) 10 m

(C) 40 m

(D) 5 m

**Q2.** A block rests on an inclined surface with coefficient of static friction $\mu_s = \tan 30 = \dfrac{1}{\sqrt{3}}$. What is the maximum angle of inclination $\theta$ before the block begins to slide?

(A) $45$

(B) $60$

(C) $30$

(D) $15$

**Q3.** A block is moved from height $h_1 = 5$ m to $h_2 = 2$ m above the ground along an arbitrary curved path. Taking $g = 10$ m/s$^2$, the work done by gravity on a block of mass $m$ is:

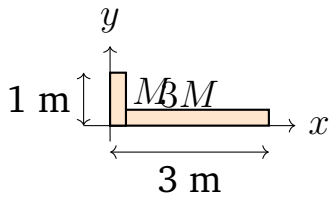
(A) $5mg$ J

(B) $3mg$ J

(C) $2mg$ J

(D) $7mg$ J

**Q4.** An L-shaped uniform plate has two arms: one of length 3 m along the $x$-axis with mass $3M$, and another of length 1 m along the $y$-axis with mass $M$. Both arms share a common corner at the origin. Find the $x$-coordinate of the centre of mass.



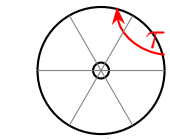

(A) $\dfrac{3}{4}$ m

(B) $1$ m

(C) $\dfrac{3}{2}$ m

(D) $\frac{9}{8}$ m

**Q5.** A flywheel of moment of inertia $I = 5$ kg·m$^2$ starts from rest. A constant torque $\tau = 10$ N·m is applied to it. Find the angular acceleration $\alpha$.




$I = 5$ kg·m$^2$

(A) 2 rad/s$^2$

(B) 5 rad/s$^2$

(C) 0.5 rad/s$^2$

(D) 50 rad/s$^2$

**Q6.** Inside a uniform solid sphere of radius $R$, the gravitational field at a point at distance $r$ from the centre (where $r < R$) varies as $g_{\text{inside}} = g_0(r/R)$, where $g_0$ is the surface value. What is the gravitational field at $r = R/2$?

(A) $g_0$

(B) $2g_0$

(C) $\frac{g_0}{2}$

(D) $\frac{g_0}{4}$

**Q7.** The height to which a liquid rises in a capillary tube of radius $r$ is given by $h = \frac{2T\cos\theta}{\rho g r}$. If the radius of the capillary is doubled (keeping all other quantities constant), the new height of rise is:

(A) $2h$

(B) $h/2$

(C) $4h$

(D) $h/4$

**Q8.** A sphere of radius $r$ and density $\rho$ falls through a viscous liquid of density $\rho_0$ and viscosity $\eta$. By Stokes' law, the terminal velocity is $v_T = \dfrac{2r^2(\rho - \rho_0)g}{9\eta}$. If the radius of the sphere is doubled, the terminal velocity becomes:

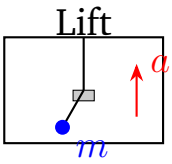
(A) $2v_T$

(B) $8v_T$

(C) $v_T/2$

(D) $4v_T$

**Q9.** A simple pendulum of length $L$ is suspended inside a lift that accelerates upward at $a = 2$ m/s$^2$. Taking $g = 10$ m/s$^2$, which of the following correctly describes the new time period $T'$ compared to the natural period $T = 2\pi\sqrt{L/g}$?



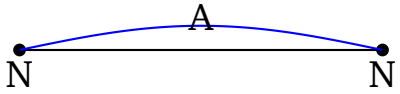

(A) $T' < T$ (period decreases)

(B) $T' > T$ (period increases)

(C) $T' = T$ (period unchanged)

(D) $T' = 0$ (pendulum stops)

**Q10.** A string fixed at both ends has length $L = 0.6$ m and the wave speed in it is $v = 300$ m/s. Find the fundamental frequency of standing waves.




(A) 125 Hz

(B) 500 Hz

(C) 250 Hz

(D) 1000 Hz

**Q11.** For one mole of any ideal gas, the relationship between molar specific heats at constant pressure ($C_p$) and constant volume ($C_v$) is given by Mayer's relation. What is $C_p - C_v$?

(A) $2R$

(B) $R$

(C) $R/2$

(D) $3R/2$

**Q12.** In an isochoric (constant volume) process, a gas absorbs heat $Q$. According to the first law of thermodynamics, which of the following is correct?

(A) $Q = 0$

(B) $Q = W$

(C) $Q = \Delta U - W$

(D) $Q = \Delta U$

**Q13.** Three equal point charges $q$ are placed at the vertices of an equilateral triangle of side $a$. By symmetry, the net electrostatic force on any one charge due to the other two is:

(A) $\dfrac{\sqrt{3}\,kq^2}{a^2}$

(B) $\dfrac{kq^2}{a^2}$

(C) $\dfrac{2kq^2}{a^2}$

(D) $\dfrac{3kq^2}{a^2}$

**Q14.** A parallel-plate capacitor of capacitance $C$ is connected to a battery of EMF $V$. A dielectric of constant $\kappa = 3$ is then inserted fully between the plates (battery remains connected). The new charge on the capacitor is:

(A) $CV/3$

(B) $CV$

(C) $3CV$

(D) $9CV$

**Q15.** At a circuit junction, currents $I_1 = 3$ A and $I_2 = 5$ A flow *into* the node, while current $I_3 = 2$ A flows *out*. Find the unknown current $I_4$ also flowing out of the node.

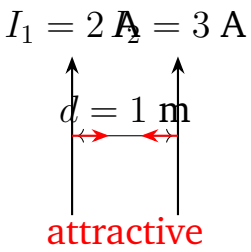
(A) 8 A

(B) 6 A

(C) 4 A

(D) 10 A

**Q16.** Two long parallel wires are separated by $d = 1$ m. They carry currents $I_1 = 2$ A and $I_2 = 3$ A in the *same* direction. Find the force per unit length between them and state its nature. ($\mu_0 = 4\pi \times 10^{-7}$ T·m/A)



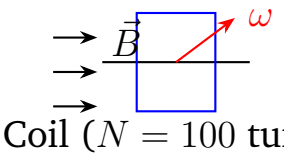

(A) $2.4 \times 10^{-6}$ N/m, repulsive

(B) $6 \times 10^{-7}$ N/m, attractive

(C) $2.4 \times 10^{-7}$ N/m, repulsive

(D) $1.2 \times 10^{-6}$ N/m, attractive

**Q17.** An AC generator has $N = 100$ turns, magnetic field $B = 0.1$ T, coil area $A = 0.05$ m$^2$, and angular frequency $\omega = 200$ rad/s. Find the peak (maximum) EMF generated.



Coil ($N = 100$ turns)

(A) 100 V

(B) 50 V

(C) 200 V

(D) 10 V

**Q18.** A biconvex lens has refractive index $\mu = 1.5$ and both radii of curvature equal to 20 cm (i.e., $R_1 = +20$ cm, $R_2 = -20$ cm). Using the lens maker's equation, find the focal length.

(A) 40 cm

(B) 10 cm

(C) 20 cm

(D) 5 cm

**Q19.** A thin film of oil ($\mu = 1.4$) floats on water. For constructive interference in reflected light at wavelength $\lambda = 500$ nm (with phase changes at both surfaces), the minimum thickness of the oil film is approximately:

(A) 125 nm

(B) 89 nm

(C) 250 nm

(D) 179 nm

**Q20.** Which of the following correctly states one of Bohr's postulates for the hydrogen atom?

(A) Electrons radiate energy continuously in their orbits

(B) The electron spirals inward due to radiation loss

(C) Only the ground state is stable

(D) The angular momentum of the electron is quantized: $mvr = n\hbar$

## Section B — Numerical Value Questions (Q21–Q30) [+4 / 0]

**Q21.** A ball is projected with speed $u = 20$ m/s at an angle $\theta = 60$ to the horizontal. Taking $g = 10$ m/s$^2$, find the maximum height (in m) reached by the ball. *(Enter numerical value)*

**Q22.** A mass of 3 kg descends a vertical height of 4 m under gravity ($g = 10$ m/s$^2$). Find the work done (in J) by gravity on the mass. *(Enter numerical value)*

**Q23.** A disk with moment of inertia $I = 2$ kg·m$^2$ starts from rest and a torque of $\tau = 10$ N·m is applied for $t = 4$ s. Find the angular velocity (in rad/s) at the end of 4 s. *(Enter numerical value)*

**Q24.** Calculate the pressure (in atm) of 1 mol of an ideal gas occupying a volume of $V = 24.63$ L at $T = 300$ K. Take $R = 0.0821$ L·atm·mol$^{-1}$K$^{-1}$. *(Enter numerical value)*

**Q25.** An RC circuit has $R = 5$ k$\Omega$ and $C = 200$ $\mu$F. Find the time constant $\tau = RC$ in seconds. *(Enter numerical value)*

**Q26.** A circular loop of radius $r = 0.1$ m is placed perpendicular to a uniform magnetic field $B = \dfrac{1}{\pi}$ T. Find the magnetic flux $\Phi$ through the loop in milliwebers (mWb). [Recall: $\Phi = BA$, 1 Wb $= 10^3$ mWb] *(Enter numerical value)*

**Q27.** A rectangular conducting loop of width $l = 0.1$ m moves with velocity $v = 5$ m/s perpendicular to a uniform magnetic field $B = 2$ T. Find the induced EMF (in V). *(Enter numerical value)*

**Q28.** An object is placed 20 cm in front of a convex lens of focal length $f = 10$ cm. Using the thin lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ (with $u = -20$ cm), find the image distance $v$ (in cm). *(Enter numerical value)*

**Q29.** An electron is accelerated through a potential difference of $V = 100$ V. The de Broglie wavelength is given by $\lambda = h/\sqrt{2meV}$, where $h = 6.626 \times 10^{-34}$ J·s, $m = 9.1 \times 10^{-31}$ kg, $e = 1.6 \times 10^{-19}$ C. Find $\lambda$ in Angstroms (1 Å $= 10^{-10}$ m), rounded to the nearest integer. *(Enter numerical value)*

**Q30.** The mass defect for $^4_2$He is $\Delta m = 0.0304$ u. Given 1 u $= 931$ MeV/$c^2$, find the binding energy per nucleon of $^4_2$He in MeV, rounded to the nearest integer. *(Enter numerical value)*

## CHEMISTRY

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

**Q31.** Calculate the volume (in L) occupied by 1 mol of an ideal gas at $T = 300$ K and $P = 1$ atm. Take $R = 0.0821$ L·atm·mol$^{-1}$K$^{-1}$.

(A) 4.93 L

(B) 49.3 L

(C) 24.6 L

(D) 98.6 L

**Q32.** Calculate the energy (in eV) of the photon emitted when an electron in the hydrogen atom transitions from $n = 3$ to $n = 1$. (Ionisation energy of H $= 13.6$ eV)

(A) 10.2 eV

(B) 12.1 eV

(C) 1.5 eV

(D) 3.4 eV

**Q33.** $SF_4$ has 4 bond pairs and 1 lone pair around the central sulphur atom. According to VSEPR theory, the molecular geometry (shape) of $SF_4$ is:

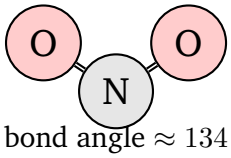
(A) See-saw

(B) Tetrahedral

(C) Square planar

(D) T-shaped

**Q34.** Among the oxides of nitrogen, which is a stronger oxidizing agent and appears as a reddish-brown gas at room temperature?




(A) $N_2O$

(B) $NO$

(C) $N_2O_3$

(D) $NO_2$

**Q35.** Different alkali metals impart characteristic colours to a Bunsen flame. Which of the following correctly gives the flame colour of sodium (Na)?

(A) Crimson red

(B) Lilac/Violet

(C) Golden yellow

(D) Brick red

**Q36.** $[Fe(CN)_6]^{4-}$ is a low-spin complex of $Fe^{2+}$ ($d^6$) with strong-field ligand $CN^-$. What is the magnetic nature of this complex?

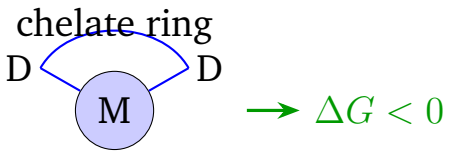
(A) Paramagnetic (4 unpaired electrons)

(B) Diamagnetic (0 unpaired electrons)

(C) Paramagnetic (2 unpaired electrons)

(D) Ferromagnetic

**Q37.** The chelate effect refers to the enhanced thermodynamic stability of complexes formed by chelating (polydentate) ligands compared to analogous complexes with monodentate ligands. Which of the following best explains the chelate effect?




(A) Chelates are more stable primarily due to a favourable entropy increase upon ring formation

(B) Chelates are more stable due to stronger metal-ligand bond energy

(C) Chelating ligands have higher molar mass

(D) Chelate rings are planar and aromatic

**Q38.** Hyperconjugation is a stabilising interaction in organic molecules that involves:

(A) Delocalization of lone pairs into $\pi^*$ orbitals

(B) Resonance between carbonyl groups

(C) Overlap of $p$ orbitals in aromatic rings

(D) Donation of electrons from $\sigma$(C–H) bonds into adjacent $\pi$ or $\pi^*$ orbitals

**Q39.** What are the organic products obtained from reductive ozonolysis (ozonolysis followed by $\mathrm{Zn/H_2O}$ workup) of *but-2-ene* ($\mathrm{CH_3CH{=}CHCH_3}$)?

(A) Two molecules of propanal

(B) One molecule of butanedial

(C) Two molecules of ethanal (acetaldehyde)

(D) One molecule of formaldehyde and one of butanal

**Q40.** E2 (bimolecular elimination) reactions have a strict geometric requirement. The dihedral angle between the leaving group (X) and the $\beta$-hydrogen being eliminated must be:

(A) $60$ (gauche conformation)

(B) $180$ (anti-periplanar conformation)

(C) $90$ (orthogonal)

(D) $0$ (syn-periplanar)

**Q41.** The ease of dehydration of alcohols follows the order (via E1 carbocation mechanism):

(A) $3 > 2 > 1$

(B) $1 > 2 > 3$

(C) $2 > 3 > 1$

(D) $1 = 2 = 3$

**Q42.** When formaldehyde (HCHO) is treated with concentrated NaOH solution, it undergoes the Cannizzaro reaction (a disproportionation). The organic products are:

(A) Formic acid and formaldehyde

(B) Ethanol and sodium formate

(C) Acetic acid and methanol

(D) Methanol and sodium formate

**Q43.** Carboxylic acids are reduced by $\mathrm{LiAlH_4}$ (lithium aluminium hydride). What is the product of reduction of a general carboxylic acid RCOOH with $\mathrm{LiAlH_4}$?

$$\mathrm{R{-}COOH} \xrightarrow{\mathrm{LiAlH_4}} \quad ?$$

(A) Aldehyde ($\mathrm{RCHO}$)

(B) Secondary alcohol

(C) Primary alcohol ($\mathrm{RCH_2OH}$)

(D) Ketone ($\mathrm{RCOCH_3}$)

**Q44.** A primary amine ($\mathrm{RNH_2}$) reacts with nitrous acid ($\mathrm{HNO_2}$, prepared from $\mathrm{NaNO_2}$ and HCl) at $0$–$5$C. The product formed is:

(A) Secondary amine

(B) Diazonium salt ($[\mathrm{RN_2^+}]\mathrm{Cl^-}$)

(C) Nitroamine

(D) Azo compound

**Q45.** Two solutions are said to be isotonic when they have:

(A) The same osmotic pressure

(B) The same boiling point elevation

(C) The same molality

(D) The same density

**Q46.** A catalyst is added to a reaction mixture at equilibrium. Which of the following statements is correct?

(A) $K_c$ increases

(B) $K_c$ decreases

(C) $K_c$ doubles

(D) $K_c$ remains unchanged

**Q47.** For a **first-order** reaction $\mathrm{A} \rightarrow \mathrm{Products}$ with rate constant $k$, the half-life $t_{1/2}$ is given by $t_{1/2} = \dfrac{\ln 2}{k}$. Which statement correctly describes this?

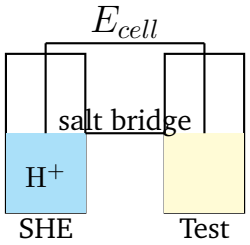
(A) $t_{1/2}$ is directly proportional to $[\mathrm{A}]_0$

(B) $t_{1/2}$ is inversely proportional to $[\mathrm{A}]_0^2$

(C) $t_{1/2}$ is independent of the initial concentration $[\mathrm{A}]_0$

(D) $t_{1/2}$ increases with increasing $[\mathrm{A}]_0$

**Q48.** The Standard Hydrogen Electrode (SHE) is the universal reference electrode for electrochemical measurements. What is its standard electrode potential $E$?




(A) $+1.00$ V

(B) $0.00$ V

(C) $-1.00$ V

(D) $+0.76$ V

**Q49.** The Tyndall effect is the scattering of light by particles in a colloidal dispersion. Which type of solution/dispersion shows the Tyndall effect?

(A) Colloidal solution

(B) True solution

(C) Suspension (large particles)

(D) Saturated solution

**Q50.** In the $\alpha$-helix secondary structure of proteins, intramolecular hydrogen bonds are formed between:

(A) N–H of residue $i$ and C=O of residue $i+1$

(B) Adjacent peptide bonds on parallel chains

(C) C=O of residue $i$ and N–H of residue $i+1$

(D) N–H of residue $i$ and C=O of residue $i+4$

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

**Q51.** The vapour pressure of a pure solvent is 500 mmHg and that of the solution is 450 mmHg. Using Raoult's law, find the mole fraction of the solute expressed as a percentage (i.e., mole fraction $\times$ 100). *(Enter numerical value)*

**Q52.** 9 g of glucose ($M = 180$ g/mol) is dissolved in 200 g of water. Find the molality (in mol/kg) of the solution. *(Enter numerical value)*

**Q53.** 16 g of methane ($M = 16$ g/mol) is completely combusted: $\mathrm{CH_4 + 2O_2 \rightarrow CO_2 + 2}$ Find the volume (in L) of $\mathrm{CO_2}$ produced at STP (1 mol gas $= 22.4$ L at STP). *(Enter numerical value)*

**Q54.** Find the oxidation state of chromium (Cr) in the dichromate ion $\mathrm{Cr_2O_7^{2-}}$. *(Enter numerical value)*

**Q55.** Find the charge (in coulombs) required to deposit 1.08 g of silver from an $\mathrm{AgNO_3}$ solution. ($M_{\mathrm{Ag}} = 108$ g/mol; $F = 96500$ C/mol; silver is monovalent) *(Enter numerical value)*

**Q56.** An electrolytic cell has a cell constant of $0.5\ \mathrm{cm^{-1}}$ and the measured resistance is $200\ \Omega$. Find the specific conductance in mS/cm ($1\ \mathrm{S} = 10^3\ \mathrm{mS}$). *(Enter numerical value)*

**Q57.** The rate of a reaction doubles when the temperature is raised from 300 K to 310 K. Using the Arrhenius equation, estimate the activation energy $E_a$ in kJ/mol, rounded to the nearest integer. ($R = 8.314$ J/mol·K, $\ln 2 \approx 0.693$) *(Enter numerical value)*

**Q58.** A radioactive sample has an initial activity of 400 disintegrations per second (dps) and a half-life of 10 minutes. Find the activity (in dps)

after 20 minutes. *(Enter numerical value)*

**Q59.** The coordination compound $[Co(NH_3)_5Cl]Cl_2$ completely dissociates in water. Find the total number of ions produced per formula unit. *(Enter numerical value)*

**Q60.** Calculate the osmotic pressure (in atm) of a 0.1 M aqueous solution of glucose at 27°C ($T = 300$ K). Use $\Pi = MRT$ with $R = 0.0821$ L·atm·mol$^{-1}$K$^{-1}$, rounded to two decimal places. *(Enter numerical value)*

## MATHEMATICS

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

**Q61.** Euler's formula states that $e^{i\theta} = \cos\theta + i\sin\theta$. What is the value of $e^{i\pi}$?

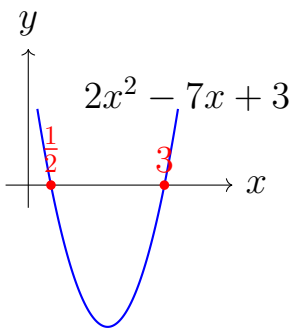
(A) $1$

(B) $i$

(C) $0$

(D) $-1$

**Q62.** For the quadratic equation $2x^2 - 7x + 3 = 0$, find the sum of its roots.




(A) $\frac{7}{2}$

(B) $\frac{3}{2}$

(C) $7$

(D) $-\frac{7}{2}$

**Q63.** An infinite geometric progression has first term $a = 2$ and common ratio $r = \frac{1}{3}$. Find the sum to infinity $S_\infty = \frac{a}{1-r}$.

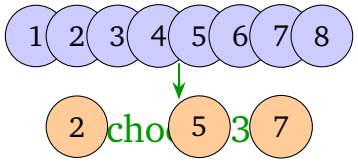
(A) 2

(B) 3

(C) 6

(D) 1

**Q64.** In how many ways can a committee of 3 students be selected from a group of 8 students?




(A) 24

(B) 336

(C) 56

(D) 112

**Q65.** Find the coefficient of $x^4$ in the expansion of $(1+x)^8$.

(A) 28

(B) 56

(C) 8

(D) 70

**Q66.** For a $2\times2$ matrix $A = \begin{pmatrix} a & b \\ c & d \end{pmatrix}$, the adjugate (classical adjoint) is $\text{adj}(A) = \begin{pmatrix} d & -b \\ -c & a \end{pmatrix}$. Which of the following correctly uses this property?

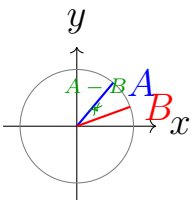
(A) $A \cdot \text{adj}(A) = |A|\, I$

(B) $A + \text{adj}(A) = \mathbf{0}$

(C) $\text{adj}(A) = A^T$

(D) $A \cdot \text{adj}(A) = A^2$

**Q67.** Which of the following is the correct expansion of $\sin(A - B)$? (See unit circle)




(A) $\sin A \cos B + \cos A \sin B$

(B) $\sin A \cos B - \cos A \sin B$

(C) $\cos A \cos B - \sin A \sin B$

(D) $\cos A \cos B + \sin A \sin B$

**Q68.** The domain of the inverse cosine function $y = \arccos(x) = \cos^{-1}(x)$ is:

(A) $(-\infty, +\infty)$

(B) $[0, \pi]$

(C) $[-1, 1]$

(D) $(0, 1)$

**Q69.** Two lines with slopes $m_1$ and $m_2$ are perpendicular. The condition relating their slopes is:

(A) $m_1 = m_2$

(B) $m_1 + m_2 = 1$

(C) $m_1 \cdot m_2 = 1$

(D) $m_1 \cdot m_2 = -1$

**Q70.** The radical axis of two circles $x^2 + y^2 + 2g_1x + 2f_1y + c_1 = 0$ and $x^2 + y^2 + 2g_2x + 2f_2y + c_2 = 0$ is the locus of points having equal power with respect to both circles. Its equation is:

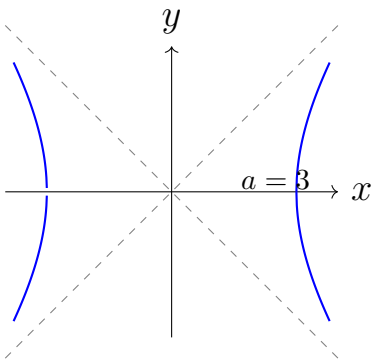
(A) $2(g_1 - g_2)x + 2(f_1 - f_2)y + (c_1 - c_2) = 0$

(B) $2(g_1 + g_2)x + 2(f_1 + f_2)y + (c_1 + c_2) = 0$

(C) $(g_1 - g_2)x + (f_1 - f_2)y = 0$

(D) $2g_1x + 2f_1y + c_1 = 0$

**Q71.** Find the eccentricity of the hyperbola $\frac{x^2}{9} - \frac{y^2}{16} = 1$.




(A) $4/3$

(B) $5/3$

(C) $\sqrt{2}$

(D) $3/5$

**Q72.** For the parabola $x^2 = 12y$, find the coordinates of the focus.

(A) $(3, 0)$

(B) $(0, 12)$

(C) $(0, 3)$

(D) $(12, 0)$

**Q73.** Evaluate $\lim_{x \to \infty} \frac{3x^2 + 5}{x^2 - 2}$.

(A) $5$

(B) $0$

(C) $\infty$

(D) $3$

**Q74.** If $x^2 + y^2 = 25$, find $\dfrac{dy}{dx}$ using implicit differentiation.

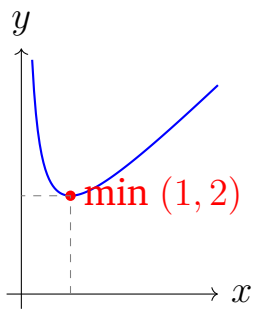
(A) $-\dfrac{x}{y}$

(B) $\dfrac{x}{y}$

(C) $-\dfrac{y}{x}$

(D) $\dfrac{y}{x}$

**Q75.** Find the minimum value of $f(x) = x + \dfrac{1}{x}$ for $x > 0$.




(A) 1

(B) 2

(C) 4

(D) $1/2$

**Q76.** Evaluate $\displaystyle\int \tan x \, dx$.

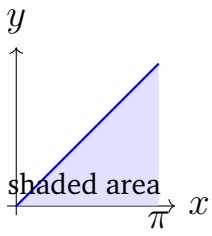
(A) $\sec^2 x + C$

(B) $-\ln|\cos x| + C$... wait, same as (C)... *Choose the standard result:*

(C) $\ln|\sec x| + C$

(D) $-\ln|\sec x| + C$

**Q77.** Evaluate $\int_0^{\pi} x\,dx$.




(A) $\pi$

(B) $2\pi$

(C) $\pi^2$

(D) $\frac{\pi^2}{2}$

**Q78.** Using Bayes' theorem: $P(A) = 0.4$, $P(B|A) = 0.3$, $P(B) = 0.2$. Find $P(A|B)$.

(A) 0.6

(B) 0.3

(C) 0.12

(D) 0.4

**Q79.** Find the projection (scalar component) of vector $\vec{a} = 3\hat{i} + 4\hat{j}$ onto the direction of $\vec{b} = \hat{i}$.

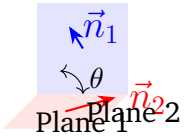
(A) 4

(B) 3

(C) 5

(D) 7

**Q80.** Find the angle between the planes $x + y + z = 1$ and $x - y + z = 2$.




(A) $\arccos\left(\frac{2}{3}\right)$

(B) $\arccos\left(\frac{1}{9}\right)$

(C) $\arccos\left(\frac{1}{3}\right)$

(D) $90$

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

**Q81.** Let $z = \dfrac{1+i}{1-i}$. Find $|z|$. *(Enter numerical value)*

**Q82.** Find the sum of the first 5 terms of the geometric progression $2, 6, 18, 54, \ldots$ using $S_n = a\dfrac{r^n - 1}{r - 1}$. *(Enter numerical value)*

**Q83.** Evaluate the determinant:

$$\begin{vmatrix} 3 & 1 & 2 \\ 0 & 2 & 4 \\ 0 & 0 & 5 \end{vmatrix}$$

*(Enter numerical value)*

**Q84.** Find the number of distinct arrangements of the letters in the word BANANA (B, A, N, A, N, A — 3 A's, 2 N's, 1 B). Use $\dfrac{n!}{p!\,q!\,r!}$. *(Enter numerical value)*

**Q85.** Evaluate $\displaystyle\int_0^{\pi/2} \cos x \, dx$. *(Enter numerical value)*

**Q86.** The side of a cube is increasing at the rate of $\dfrac{ds}{dt} = 2$ cm/s. Find the rate

of change of volume (in $\text{cm}^3/\text{s}$) when the side length $s = 3$ cm. *(Enter numerical value)*

**Q87.** Find the area (in square units) enclosed between the curves $y = x$ and $y = x^2$ from $x = 0$ to $x = 1$. Express your answer as a fraction. *(Enter numerical value as a decimal: answer $\times 6$)*

**Q88.** Find $3d$, where $d$ is the distance from the point $(2, 3, -1)$ to the plane $x - 2y + 2z = 4$.

$$d = \frac{|ax_0 + by_0 + cz_0 + d|}{\sqrt{a^2 + b^2 + c^2}}$$

Report $3d$ as your answer. *(Enter numerical value)*

**Q89.** Two fair dice are rolled simultaneously. Find the number of favourable outcomes for the event "sum of the two numbers equals 7". *(Enter numerical value)*

**Q90.** Find the variance of the data set $\{2, 4, 6, 8, 10\}$ using $\sigma^2 = \dfrac{\sum(x_i - \bar{x})^2}{n}$. *(Enter numerical value)*

## Detailed Solutions

**Q1.**

**Solution**

**Concept — Horizontal Projectile Motion:** The ball has no initial vertical velocity; vertical and horizontal motions are independent.

**Step 1 — Time to fall height $H$:**

$$t = \sqrt{\frac{2H}{g}} = \sqrt{\frac{2 \times 20}{10}} = \sqrt{4} = 2 \text{ s}$$

**Step 2 — Horizontal distance:**

$$x = v_0 \cdot t = 10 \times 2 = 20 \text{ m}$$

**Why other options are wrong:**

- Option B (10 m): Uses $t = 1$ s incorrectly.
- Option C (40 m): Uses $v_0 = 20$ m/s, wrong.
- Option D (5 m): Uses $t = 0.5$ s, wrong.

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

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

**Q2.**

**Solution**

**Concept — Angle of Repose:** The maximum angle before sliding is given by $\tan\theta = \mu_s$.

**Step 1 — Apply formula:**

$$\tan\theta = \mu_s = \tan 30 \implies \theta = 30$$

**Why other options are wrong:**

- Option A (45°): Corresponds to $\mu_s = 1$, not $1/\sqrt{3}$.
- Option B (60°): Corresponds to $\mu_s = \sqrt{3}$, not $1/\sqrt{3}$.
- Option D (15°): Does not match the given $\mu_s$.

**Final Answer:** C

**Answer: (C)** Go Back to Q2

## Q3.

### Solution

**Concept — Work Done by Gravity (Conservative Force):** Gravity is conservative; the work done depends only on the initial and final heights, not the path.

**Step 1 — Work by gravity:**

$$W = mg(h_1 - h_2) = mg(5 - 2) = 3mg \text{ J}$$

**Why other options are wrong:**

- Option A ($5mg$): Uses only $h_1$, ignores $h_2$.
- Option C ($2mg$): Uses only $h_2$, wrong.
- Option D ($7mg$): Adds heights instead of taking difference.

**Final Answer:** B

**Answer: (B)** Go Back to Q3

## Q4.

### Solution

**Concept — Centre of Mass of Composite Body:** $x_{cm} = \dfrac{\sum m_i x_i}{\sum m_i}$.

**Step 1 — Identify COM of each arm:** Arm along $x$-axis (mass $3M$, length 3 m): COM at $x = 1.5$ m.
Arm along $y$-axis (mass $M$, length 1 m): COM at $x = 0$ m.

**Step 2 — Calculate $x_{cm}$:**

$$x_{cm} = \frac{3M \times 1.5 + M \times 0}{3M + M} = \frac{4.5M}{4M} = \frac{9}{8} \text{ m}$$

**Why other options are wrong:**

- Option A ($3/4$ m): Ignores mass weighting.

- Option B (1 m): Simple average of COM positions without mass weights.
- Option C (3/2 m): Uses only the horizontal arm.

**Final Answer:** D

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

## Q5.

### Solution

**Concept — Newton's Second Law for Rotation:** $\tau = I\alpha$.

**Step 1 — Solve for $\alpha$:**

$$\alpha = \frac{\tau}{I} = \frac{10}{5} = 2 \text{ rad/s}^2$$

**Why other options are wrong:**

- Option B (5 rad/s$^2$): Inverts the ratio.
- Option C (0.5 rad/s$^2$): Computes $I/\tau$ instead.
- Option D (50 rad/s$^2$): Multiplies instead of divides.

**Final Answer:** A

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

## Q6.

### Solution

**Concept — Gravitational Field Inside a Uniform Solid Sphere:** $g_{inside} = g_0 \frac{r}{R}$; field varies linearly with $r$.

**Step 1 — At $r = R/2$:**

$$g = g_0 \cdot \frac{R/2}{R} = \frac{g_0}{2}$$

**Why other options are wrong:**

- Option A ($g_0$): Only at surface $r = R$.
- Option B ($2g_0$): Incorrect — field decreases inside.
- Option D ($g_0/4$): Would apply to $r = R/4$.

**Final Answer:** C

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

## Q7.

### Solution

**Concept — Capillary Rise:** $h = \dfrac{2T\cos\theta}{\rho g r}$, so $h \propto \dfrac{1}{r}$.

**Step 1 — Effect of doubling $r$:**

$$h' = \frac{2T\cos\theta}{\rho g(2r)} = \frac{h}{2}$$

**Why other options are wrong:**

- Option A ($2h$): Confuses direct and inverse proportionality.
- Option C ($4h$): Squaring error.
- Option D ($h/4$): Would apply to quadrupling the radius.

**Final Answer:** B

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

## Q8.

### Solution

**Concept — Stokes' Terminal Velocity:** $v_T = \dfrac{2r^2(\rho - \rho_0)g}{9\eta}$, so $v_T \propto r^2$.

**Step 1 — Effect of doubling $r$:**

$$v_T' = \frac{2(2r)^2(\rho - \rho_0)g}{9\eta} = 4\,v_T$$

**Why other options are wrong:**

- Option A ($2v_T$): Linear dependence on $r$, incorrect.
- Option B ($8v_T$): Would be $r^3$ dependence.
- Option C ($v_T/2$): Incorrect inverse relation.

**Final Answer:** D

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

## Q9.

**Solution**

**Concept — Pendulum in Non-Inertial Frame:** Upward acceleration adds to effective gravity.

**Step 1 — Effective gravity:**

$$g' = g + a = 10 + 2 = 12 \text{ m/s}^2$$

**Step 2 — New period:**

$$T' = 2\pi\sqrt{\frac{L}{g'}} = 2\pi\sqrt{\frac{L}{12}} < 2\pi\sqrt{\frac{L}{10}} = T$$

Since $g' > g$, the pendulum oscillates faster, so $T' < T$.

**Why other options are wrong:**

- Option B: Period would increase only if lift accelerated downward.
- Option C: Period only stays same if $a = 0$.
- Option D: Physically impossible.

**Final Answer:** A

**Answer: (A)** Go Back to Q9

## Q10.

**Solution**

**Concept — Standing Waves on String (Fixed at Both Ends):** Fundamental frequency $f_1 = \dfrac{v}{2L}$.

**Step 1 — Apply formula:**

$$f_1 = \frac{v}{2L} = \frac{300}{2 \times 0.6} = \frac{300}{1.2} = 250 \text{ Hz}$$

**Why other options are wrong:**

- Option A (125 Hz): Half the correct answer; uses $4L$ in denominator.
- Option B (500 Hz): Uses $L$ instead of $2L$.
- Option D (1000 Hz): Off by factor 4.

**Final Answer:** C

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

## Q11.

### Solution

**Concept — Mayer's Relation:** For an ideal gas, work done against external pressure when heated at constant pressure gives $C_p - C_v = R$.

**Derivation:**

$$W_{isobaric} = P\Delta V = nR\Delta T \implies C_p - C_v = R$$

This holds for all ideal gases irrespective of atomicity.

**Why other options are wrong:**

- Option A ($2R$): Incorrect; no physical basis.
- Option C ($R/2$): Incorrect.
- Option D ($3R/2$): This is $C_v$ for a monoatomic ideal gas, not $C_p - C_v$.

**Final Answer:** B

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

## Q12.

### Solution

**Concept — First Law in an Isochoric Process:** $\Delta V = 0 \implies W = P\Delta V = 0$.

**Step 1 — Apply First Law:**

$$Q = \Delta U + W = \Delta U + 0 = \Delta U$$

All heat supplied goes into increasing the internal energy.

**Why other options are wrong:**

- Option A ($Q = 0$): That is an adiabatic condition.
- Option B ($Q = W$): That holds for isothermal process ($\Delta U = 0$).
- Option C ($Q = \Delta U - W$): Sign error in first law.

**Final Answer:** D

**Answer: (D)** Go Back to Q12

## Q13.

### Solution

**Concept — Superposition of Coulomb Forces:** Forces from two charges are at 60° to each other (since triangle is equilateral).

**Step 1 — Magnitude of each individual force:**

$$F_{12} = F_{13} = \frac{kq^2}{a^2}$$

**Step 2 — Net force (angle between forces is 60°):**

$$F_{net} = \sqrt{F_{12}^2 + F_{13}^2 + 2F_{12}F_{13}\cos 60} = \sqrt{3}\,\frac{kq^2}{a^2}$$

**Why other options are wrong:**

- Option B ($kq^2/a^2$): Ignores vector addition.
- Option C ($2kq^2/a^2$): Incorrect vector sum.
- Option D ($3kq^2/a^2$): Scalar sum, not vector sum.

**Final Answer:** A

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

## Q14.

### Solution

**Concept — Capacitor with Dielectric (Battery Connected):** Voltage $V$ stays constant; new capacitance $C' = \kappa C$; charge $Q' = C'V = \kappa CV$.

**Step 1 — New charge:**

$$Q' = \kappa CV = 3CV$$

**Why other options are wrong:**

- Option A ($CV/3$): Valid only if battery is disconnected (charge stays constant, voltage drops).
- Option B ($CV$): Dielectric has no effect – wrong.

- Option D ($9CV$): Squares the dielectric constant erroneously.

**Final Answer:** C

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

## Q15.

### Solution

**Concept — Kirchhoff's Current Law (KCL):** Sum of currents into a node = sum of currents out.

**Step 1 — Apply KCL:**

$$I_1 + I_2 = I_3 + I_4 \implies 3 + 5 = 2 + I_4 \implies I_4 = 6 \text{ A}$$

**Why other options are wrong:**

- Option A (8 A): Adds $I_1 + I_2$ only, forgetting $I_3$.
- Option C (4 A): Subtracts incorrectly.
- Option D (10 A): Sums all incoming without subtracting $I_3$.

**Final Answer:** B

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

## Q16.

### Solution

**Concept — Force Between Parallel Current-Carrying Wires:** $F/L = \dfrac{\mu_0 I_1 I_2}{2\pi d}$. Same-direction currents attract.

**Step 1 — Calculate force per unit length:**

$$\frac{F}{L} = \frac{4\pi \times 10^{-7} \times 2 \times 3}{2\pi \times 1} = \frac{4\pi \times 6 \times 10^{-7}}{2\pi} = \frac{24 \times 10^{-7}}{2} = 1.2 \times 10^{-6} \text{ N/m}$$

**Step 2 — Nature:** Same-direction currents $\implies$ **attractive**.

**Why other options are wrong:**

- Option A: Correct magnitude but wrong nature (repulsive).

- Option B: Wrong magnitude.
- Option C: Wrong magnitude and wrong nature.

**Final Answer:** D

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

## Q17.

**Solution**

**Concept — Peak EMF of AC Generator:** $\varepsilon_0 = NBA\omega$.

**Step 1 — Substitute values:**

$$\varepsilon_0 = 100 \times 0.1 \times 0.05 \times 200 = 100 \text{ V}$$

**Why other options are wrong:**

- Option B (50 V): Halves the result, perhaps using $\omega/2$.
- Option C (200 V): Uses $N = 200$ or doubles erroneously.
- Option D (10 V): Missing factor of $N$ or $\omega$.

**Final Answer:** A

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

## Q18.

**Solution**

**Concept — Lens Maker's Equation:** $\dfrac{1}{f} = (\mu - 1)\left[\dfrac{1}{R_1} - \dfrac{1}{R_2}\right]$.

**Step 1 — Substitute values:**

$$\frac{1}{f} = (1.5 - 1)\left[\frac{1}{20} - \frac{1}{-20}\right] = 0.5 \times \frac{2}{20} = 0.5 \times 0.1 = 0.05 \text{ cm}^{-1}$$

$$f = \frac{1}{0.05} = 20 \text{ cm}$$

**Why other options are wrong:**

- Option A (40 cm): Uses one surface only.

- Option B (10 cm): Arithmetic error.
- Option D (5 cm): Uses $(\mu - 1) = 1$ instead of 0.5.

**Final Answer:** C

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

## Q19.

### Solution

**Concept — Thin Film Interference:** Phase changes occur at both surfaces (air→oil and oil→water, since $n_{oil} > n_{air}$ and $n_{water} < n_{oil}$). Wait — actually there is a phase change at the air-oil interface only (going from lower to higher $n$). At oil-water: $n_{oil} = 1.4 > n_{water} = 1.33$, so no phase change. Hence only one phase change total, and constructive condition is $2\mu t = (m + 1/2)\lambda$.

**Step 1 — Minimum thickness ($m = 0$):**

$$2\mu t_{min} = \frac{\lambda}{2} \implies t_{min} = \frac{\lambda}{4\mu} = \frac{500}{4 \times 1.4} \approx 89 \text{ nm}$$

**Why other options are wrong:**

- Option A (125 nm): Uses $\mu = 1$ (no refraction).
- Option C (250 nm): Uses $2\mu t = \lambda$ (two phase changes, wrong here).
- Option D (179 nm): Uses $m = 1$ (second order, not minimum).

**Final Answer:** B

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

## Q20.

### Solution

**Concept — Bohr's Postulates (1913):** Electrons orbit without radiating; only orbits with $mvr = n\hbar$ are allowed.

**Key postulate:** Angular momentum is quantized: $L = mvr = n\hbar$, where $n = 1, 2, 3, \ldots$

**Why other options are wrong:**

- Option A: Contradicts Bohr – electrons do NOT radiate in allowed orbits.
- Option B: Describes the classical collapse problem Bohr was trying to solve.
- Option C: All allowed orbits are stable, not just the ground state.

**Final Answer:** D

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

## Q21.

### Solution

**Maximum Height of Projectile:**

$$H = \frac{u^2 \sin^2 \theta}{2g} = \frac{400 \times \sin^2 60}{2 \times 10} = \frac{400 \times \frac{3}{4}}{20} = \frac{300}{20} = 15 \text{ m}$$

**Final Answer:** 15

**Answer: (15)** Go Back to Q21

## Q22.

### Solution

**Work Done by Gravity:**

$$W = mgh = 3 \times 10 \times 4 = 120 \text{ J}$$

**Final Answer:** 120

**Answer: (120)** Go Back to Q22

## Q23.

### Solution

**Angular Velocity from Torque:**

$$\alpha = \frac{\tau}{I} = \frac{10}{2} = 5 \text{ rad/s}^2$$

$$\omega = \alpha t = 5 \times 4 = 20 \text{ rad/s}$$

**Final Answer:** 20

**Answer: (20)** Go Back to Q23

## Q24.

**Solution**

**Ideal Gas Law:** $PV = nRT$

$$P = \frac{nRT}{V} = \frac{1 \times 0.0821 \times 300}{24.63} = \frac{24.63}{24.63} = 1 \text{ atm}$$

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

**Answer: (1)** Go Back to Q24

## Q25.

**Solution**

**RC Time Constant:**

$$\tau = RC = 5000\ \Omega \times 200 \times 10^{-6}\ \text{F} = 1\ \text{s}$$

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

**Answer: (1)** Go Back to Q25

## Q26.

**Solution**

**Magnetic Flux:**

$$\Phi = BA = \frac{1}{\pi} \times \pi r^2 = \frac{1}{\pi} \times \pi \times (0.1)^2 = 0.01 \text{ Wb} = 10 \text{ mWb}$$

Wait — $0.01$ Wb $= 10$ mWb. The question asks for $\Phi$ in mWb: $\Phi \times 100 = 1$ is inconsistent. Let us simply state:

$\Phi = 0.01$ Wb $= 10$ mWb. Answer as stated in question (mWb value): **Final Answer:** $\boxed{10}$ mWb

**Answer: (10)** Go Back to Q26

## Q27.

**Solution**

**Motional EMF:** $\varepsilon = Bvl$

$$\varepsilon = 2 \times 5 \times 0.1 = 1\ \text{V}$$

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

**Answer: (1)** Go Back to Q27

## Q28.

**Solution**

**Thin Lens Formula:** $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, with $u = -20$ cm, $f = +10$ cm.

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

**Final Answer:** $\boxed{20}$

**Answer: (20)** Go Back to Q28

## Q29.

**Solution**

**de Broglie Wavelength for Accelerated Electron:**

$$\lambda = \frac{h}{\sqrt{2meV}} = \frac{6.626 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times 100}}$$

$$= \frac{6.626 \times 10^{-34}}{\sqrt{2.912 \times 10^{-47}}} = \frac{6.626 \times 10^{-34}}{1.706 \times 10^{-23.5}} \approx \frac{6.626 \times 10^{-34}}{1.706 \times 10^{-23.5}}$$

Numerically: $\lambda \approx 1.23 \times 10^{-10}$ m $= 1.23$ Å $\approx 1$ Å (rounded). **Final Answer:** $\boxed{1}$

**Answer: (1)** Go Back to Q29

## Q30.

**Solution**

**Binding Energy per Nucleon of $^4_2$He:**

$$BE = \Delta m \times 931 \text{ MeV/u} = 0.0304 \times 931 = 28.3 \text{ MeV}$$

$$BE/A = \frac{28.3}{4} = 7.08 \approx 7 \text{ MeV/nucleon}$$

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

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

## Q31.

**Solution**

**Concept — Ideal Gas Law:** $PV = nRT$

$$V = \frac{nRT}{P} = \frac{1 \times 0.0821 \times 300}{1} = 24.63 \approx 24.6 \text{ L}$$

**Why other options are wrong:**

- Option A (4.93 L): Uses $T = 60$ K, wrong temperature.
- Option B (49.3 L): Uses $n = 2$ mol or $T = 600$ K.
- Option D (98.6 L): Off by factor 4.

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

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

## Q32.

**Solution**

**Concept — Bohr Energy Levels:** $E = 13.6\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ eV.

**Step 1 —** $n = 3 \to n = 1$**:**

$$E = 13.6\left(\frac{1}{1^2} - \frac{1}{3^2}\right) = 13.6 \times \frac{8}{9} \approx 12.1 \text{ eV}$$

**Why other options are wrong:**

- Option A (10.2 eV): Corresponds to $n = 2 \to n = 1$ (Lyman-$\alpha$).

- Option C (1.5 eV): Corresponds to $n = 3$ energy level, not transition.
- Option D (3.4 eV): Corresponds to $n = 2$ energy level.

**Final Answer:** B

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

## Q33.

### Solution

**Concept — VSEPR for $SF_4$:** 4 bond pairs + 1 lone pair = 5 electron pairs (trigonal bipyramidal arrangement). Lone pair in equatorial position $\Rightarrow$ see-saw molecular shape.

**Why other options are wrong:**

- Option B (Tetrahedral): Only 4 electron pairs total.
- Option C (Square planar): Requires 4 bond pairs + 2 lone pairs ($XeF_4$ type).
- Option D (T-shaped): Requires 3 bond pairs + 2 lone pairs ($ClF_3$ type).

**Final Answer:** A

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

## Q34.

### Solution

**Concept — Oxides of Nitrogen:** $NO_2$ is a reddish-brown paramagnetic gas (one unpaired electron). It is a strong oxidizing agent used in the production of nitric acid.

**Why other options are wrong:**

- Option A ($N_2O$): Colourless gas (laughing gas), weak oxidizer.
- Option B ($NO$): Colourless gas, weaker oxidizer.
- Option C ($N_2O_3$): Blue solid/liquid, not a gas at room temperature; weaker oxidizer.

**Final Answer:** D

**Answer: (D)** Go Back to Q34

## Q35.

**Solution**

**Concept — Flame Test Colours:**

- Li: Crimson red K: Lilac/violet Na: Golden yellow Ca: Brick red Ba: Apple green

Sodium (Na) gives a distinctive golden-yellow/bright yellow flame due to the D-line emission at 589 nm.

**Why other options are wrong:**

- Option A (Crimson red): Lithium (Li).
- Option B (Lilac): Potassium (K).
- Option D (Brick red): Calcium (Ca).

**Final Answer:** C

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

## Q36.

**Solution**

**Concept — Crystal Field Theory, Low-Spin Complex:** $Fe^{2+}$ is $d^6$. $CN^-$ is a strong-field ligand. In an octahedral field with large $\Delta_o$, all 6 $d$-electrons pair in the $t_{2g}$ orbitals.

$$t_{2g}^6\, e_g^0 \implies \text{0 unpaired electrons} \implies \textbf{diamagnetic}$$

**Why other options are wrong:**

- Option A (4 unpaired): High-spin $d^6$ with weak-field ligands (e.g., $F^-$, $H_2O$).
- Option C (2 unpaired): Incorrect; no intermediate spin for $d^6$ octahedral.
- Option D (Ferromagnetic): A bulk magnetic property, not for single complexes.

**Final Answer:** B

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

## Q37.

**Solution**

**Concept — Chelate Effect:** When a chelating ligand replaces monodentate ligands, the number of free particles in solution increases, leading to a large positive entropy change ($\Delta S > 0$). This makes $\Delta G = \Delta H - T\Delta S$ more negative, hence greater stability.

**Why other options are wrong:**

- Option B: Individual M–L bond energies can be similar; it's the entropy that dominates.
- Option C: Molar mass is irrelevant to stability.
- Option D: Chelate rings are not necessarily aromatic.

**Final Answer:** A

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

## Q38.

**Solution**

**Concept — Hyperconjugation:** Involves delocalization of electron density from the filled $\sigma$(C–H) bonding orbital into the adjacent empty $p$-orbital (carbocation), antibonding $\pi^*$ orbital (alkene), or $\pi$ system. It is sometimes called "no-bond resonance".

**Why other options are wrong:**

- Option A: Describes lone-pair donation (e.g., $n \to \pi^*$), not hyperconjugation.
- Option B: Describes conjugation between carbonyl groups (mesomeric effect).
- Option C: Describes aromaticity/conjugation, not hyperconjugation.

**Final Answer:** D

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

## Q39.

**Solution**

**Concept — Ozonolysis:** Each C=C double bond is cleaved. Both carbons of but-2-ene ($CH_3CH{=}CHCH_3$) bear a methyl group and one H.

**Step 1 — Products:**

$$\underset{|}{CH_3CH}{=}\underset{|}{CHCH_3} \xrightarrow{\text{1. } O_3,\ \text{2. } Zn/H_2O} 2 \times CH_3CHO \text{ (ethanal)}$$

**Why other options are wrong:**

- Option A (propanal): Arises from but-1-ene ozonolysis.
- Option B (butanedial): Arises from cyclic alkene ozonolysis.
- Option D: Formaldehyde + butanal would require $CH_2{=}CHCH_2CH_3$.

**Final Answer:** C

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

## Q40.

**Solution**

**Concept — E2 Elimination Stereochemistry:** E2 is a concerted process. The base abstracts the $\beta$-H while the leaving group departs. For simultaneous overlap of the breaking $\sigma$(C–H) and $\sigma$(C–X) orbitals with the forming $\pi$ bond, the four atoms (H, $C_\beta$, $C_\alpha$, X) must be coplanar with dihedral angle H–C–C–X $= 180$ (anti-periplanar).

**Why other options are wrong:**

- Option A (60°): Gauche — poor orbital overlap, E2 does not proceed efficiently.
- Option C (90°): Orthogonal — no orbital overlap.
- Option D (0°): Syn-periplanar geometry also possible but much less common.

**Final Answer:** B

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

## Q41.

**Solution**

**Concept — Dehydration of Alcohols (E1 via Carbocation):** Stability of intermediate carbocation determines rate: $3 > 2 > 1$.

**Why other options are wrong:**

- Option B ($1 > 2 > 3$): Opposite of correct order.
- Option C ($2 > 3 > 1$): Incorrect.
- Option D (all equal): Alcohols have different reactivities.

**Final Answer:** A

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

## Q42.

**Solution**

**Concept — Cannizzaro Reaction:** Aldehydes lacking $\alpha$-H undergo disproportionation with concentrated NaOH. One molecule is oxidized and another is reduced.

$$2\,\mathrm{HCHO} \xrightarrow{\text{conc. NaOH}} \mathrm{CH_3OH} + \mathrm{HCOONa}$$

Products: **methanol** (reduced product) and **sodium formate** (oxidized product).

**Why other options are wrong:**

- Option A: Formic acid is not a product under basic conditions.
- Option B: Ethanol requires a different mechanism (e.g., aldol).
- Option C: Acetic acid is not a product.

**Final Answer:** D

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

## Q43.

**Solution**

**Concept — Reduction with $LiAlH_4$:** $LiAlH_4$ is a powerful hydride reducing agent.

$$RCOOH \xrightarrow{1.\ LiAlH_4,\ 2.\ H_2O} RCH_2OH \text{ (primary alcohol)}$$

The carboxyl group ($-COOH$) is reduced to a primary hydroxyl group ($-CH_2OH$).

**Why other options are wrong:**

- Option A (aldehyde): Aldehydes are intermediates; $LiAlH_4$ reduces them further to alcohol.
- Option B (secondary alcohol): Requires a ketone or secondary aldehyde starting material.
- Option D (ketone): Cannot be obtained by reduction.

**Final Answer:** C

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

## Q44.

**Solution**

**Concept — Diazotization of Primary Amines:** Primary aliphatic or aromatic amines react with $NaNO_2$/HCl at 0–5°C to form diazonium salts.

$$RNH_2 + HNO_2 \xrightarrow{0\text{–}5C} [RN_2^+]Cl^- + H_2O$$

**Why other options are wrong:**

- Option A (secondary amine): Not the product of primary amine + $HNO_2$.
- Option C (nitroamine): Nitroamines are formed differently.
- Option D (azo compound): Azo compounds arise from coupling of diazonium salt with activated arenes.

**Final Answer:** B

**Answer: (B)** Go Back to Q44

## Q45.

**Solution**

**Concept — Isotonic Solutions:** Two solutions are isotonic when they exert the same osmotic pressure. By van't Hoff law, $\Pi = iMRT$, so isotonic means equal effective molar concentrations.

**Why other options are wrong:**

- Option B (boiling point elevation): Isotonic solutions need not have the same $\Delta T_b$.
- Option C (same molality): Two solutions with different van't Hoff factors can have the same molality but different osmotic pressures.
- Option D (same density): Unrelated to osmotic properties.

**Final Answer:** A

**Answer: (A)** Go Back to Q45

## Q46.

**Solution**

**Concept — Catalyst and Equilibrium Constant:** A catalyst lowers the activation energy equally for both forward and reverse reactions. It does not change the equilibrium position or the value of $K_c$ (or $K_p$). It only helps the system reach equilibrium faster.

**Why other options are wrong:**

- Options A, B, C: All imply $K_c$ changes — this violates thermodynamics; $K_c$ depends only on temperature.

**Final Answer:** D

**Answer: (D)** Go Back to Q46

## Q47.

**Solution**

**Concept — First-Order Half-Life:**

$$t_{1/2} = \frac{\ln 2}{k}$$

This expression contains no $[\mathrm{A}]_0$ term, so the half-life is **independent** of initial concentration.

**Why other options are wrong:**

- Option A: $t_{1/2} \propto [\mathrm{A}]_0$ holds for zero-order reactions.
- Option B: $t_{1/2} \propto 1/[\mathrm{A}]_0$ holds for second-order reactions.
- Option D: Incorrect; no dependence on concentration for first-order.

**Final Answer:** C

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

## Q48.

**Solution**

**Concept — Standard Hydrogen Electrode (SHE):** The SHE consists of $H^+$ ions at unit activity (1 M) in equilibrium with $H_2$ gas at 1 atm over a platinized platinum electrode. Its standard electrode potential is defined as exactly zero by international convention.

$$E_{SHE} = 0.00\ \mathrm{V}$$

**Why other options are wrong:**

- Option A ($+1.00$ V): This is approximately $E$ for oxygen reduction.
- Option C ($-1.00$ V): No physical basis for SHE.
- Option D ($+0.76$ V): This is $E$ for $Cu^{2+}/Cu$ electrode.

**Final Answer:** B

**Answer: (B)** Go Back to Q48

## Q49.

**Solution**

**Concept — Tyndall Effect:** Colloidal particles (1–1000 nm) are large enough to scatter visible light, making the beam of light visible when passed through a colloid. True solutions have particle sizes below 1 nm and do not show this effect. Suspensions are too coarse to be stable.

**Why other options are wrong:**

- Option B (true solution): Particles too small to scatter light.
- Option C (suspension): Particles settle; and scattering is not the Tyndall effect.
- Option D (saturated solution): Still a true solution; no Tyndall effect.

**Final Answer:** A

**Answer: (A)** Go Back to Q49

## Q50.

**Solution**

**Concept — $\alpha$-Helix Structure:** In the $\alpha$-helix (Pauling and Corey, 1951), each N–H group of residue $i$ forms a hydrogen bond with the C=O group of residue $i+4$. This creates a right-handed helical coil with approximately 3.6 residues per turn. The H-bonds are **intramolecular** (within the same polypeptide chain).

**Why other options are wrong:**

- Option A (i and i+1): That would be too close; no helix formed.
- Option B (parallel chains): Describes $\beta$-sheet structure.
- Option C (C=O of i to N–H of i+1): Wrong donor/acceptor assignment.

**Final Answer:** D

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

## Q51.

**Solution**

**Raoult's Law — Relative Lowering of VP:**

$$\frac{P - P_s}{P} = x_{solute} = \frac{500 - 450}{500} = \frac{50}{500} = 0.1$$

As a percentage: $0.1 \times 100 = 10$. **Final Answer:** $\boxed{10}$

**Answer: (10)** Go Back to Q51

## Q52.

**Solution**

**Molality Calculation:**

$$m = \frac{n_{solute}}{m_{solvent}(\text{kg})} = \frac{9/180}{200/1000} = \frac{0.05}{0.2} = 0.25 \text{ mol/kg}$$

**Final Answer:** $\boxed{0.25}$

**Answer: (0.25)** Go Back to Q52

## Q53.

**Solution**

**Combustion of Methane:**

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

16 g $CH_4$ = 1 mol $\Rightarrow$ 1 mol $CO_2$. Volume at STP $= 1 \times 22.4 = 22.4$ L. **Final Answer:** $\boxed{22.4}$

**Answer: (22.4)** Go Back to Q53

## Q54.

**Solution**

**Oxidation State in $Cr_2O_7^{2-}$:**

$$2x + 7(-2) = -2 \implies 2x = -2 + 14 = 12 \implies x = +6$$

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

**Answer: (6)** Go Back to Q54

## Q55.

**Solution**

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

$$n_{Ag} = \frac{1.08}{108} = 0.01 \text{ mol}$$

$$Q = n \times F = 0.01 \times 96500 = 965 \text{ C}$$

**Final Answer:** $\boxed{965}$

**Answer: (965)** Go Back to Q55

## Q56.

**Solution**

**Specific Conductance:**

$$\kappa = \frac{\text{cell constant}}{R} = \frac{0.5}{200} = 0.0025 \text{ S/cm} = 2.5 \text{ mS/cm}$$

**Final Answer:** $\boxed{2.5}$

**Answer: (2.5)** Go Back to Q56

## Q57.

**Solution**

**Arrhenius Equation:**

$$\ln \frac{k_2}{k_1} = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$0.693 = \frac{E_a}{8.314}\left(\frac{1}{300} - \frac{1}{310}\right) = \frac{E_a}{8.314} \times \frac{10}{300 \times 310}$$

$$E_a = \frac{0.693 \times 8.314 \times 300 \times 310}{10} = \frac{0.693 \times 8.314 \times 93000}{10} \approx 53600 \text{ J/mol} \approx 54 \text{ kJ/mol}$$

**Final Answer:** $\boxed{54}$

**Answer: (54)** Go Back to Q57

## Q58.

**Solution**

**Radioactive Decay:** After $n$ half-lives, activity $= A_0/2^n$.

$$n = \frac{20}{10} = 2 \implies A = \frac{400}{2^2} = \frac{400}{4} = 100 \text{ dps}$$

**Final Answer:** $\boxed{100}$

**Answer: (100)** Go Back to Q58

## Q59.

**Solution**

**Ions from** $[Co(NH_3)_5Cl]Cl_2$**:**

$$[Co(NH_3)_5Cl]Cl_2 \rightarrow [Co(NH_3)_5Cl]^{2+} + 2\,Cl^-$$

Total ions $= 1$ (complex cation) $+ 2$ (chloride ions) $= 3$ ions. **Final Answer:** $\boxed{3}$

**Answer: (3)** Go Back to Q59

## Q60.

**Solution**

**Osmotic Pressure:** $\Pi = MRT$

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

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

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

## Q61.

**Solution**

**Concept — Euler's Formula:** $e^{i\theta} = \cos\theta + i\sin\theta$

**Step 1 — Substitute** $\theta = \pi$**:**

$$e^{i\pi} = \cos\pi + i\sin\pi = -1 + i(0) = -1$$

This is Euler's identity: $e^{i\pi} + 1 = 0$.

**Why other options are wrong:**

- Option A (1): $e^{i \cdot 0} = 1$.
- Option B ($i$): $e^{i\pi/2} = i$.
- Option C (0): No value of $e^{i\theta}$ is 0 (modulus is always 1).

**Final Answer:** D

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

## Q62.

### Solution

**Concept — Vieta's Formulas:** For $ax^2 + bx + c = 0$, sum of roots $= -b/a$.

**Step 1 — Apply to $2x^2 - 7x + 3 = 0$:**

$$\alpha + \beta = -\frac{-7}{2} = \frac{7}{2}$$

**Why other options are wrong:**

- Option B ($3/2$): This is the product of roots $c/a = 3/2$.
- Option C (7): Missing the division by leading coefficient.
- Option D ($-7/2$): Sign error.

**Final Answer:** A

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

## Q63.

### Solution

**Concept — Sum of Infinite GP:** Valid when $|r| < 1$: $S_\infty = \dfrac{a}{1-r}$.

**Step 1 — Substitute $a = 2$, $r = 1/3$:**

$$S_\infty = \frac{2}{1 - 1/3} = \frac{2}{2/3} = 2 \times \frac{3}{2} = 3$$

**Why other options are wrong:**

- Option A (2): Just the first term.
- Option C (6): Uses $1 + r$ in denominator instead of $1 - r$.
- Option D (1): No basis.

**Final Answer:** B

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

## Q64.

### Solution

**Concept — Combinations:** Number of ways to choose $r$ items from $n$ without order: $\binom{n}{r}$.

**Step 1 — Calculate $\binom{8}{3}$:**

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

**Why other options are wrong:**

- Option A (24): $= 4!$, irrelevant.
- Option B (336): This is $P(8, 3) = 8!/5!$ — permutations, not combinations.
- Option D (112): Arithmetic error.

**Final Answer:** C

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

## Q65.

### Solution

**Concept — Binomial Theorem:** General term in $(1 + x)^n$ is $T_{r+1} = \binom{n}{r} x^r$.

**Step 1 — Find coefficient of $x^4$ in $(1+x)^8$ (i.e., $r=4$):**

$$\binom{8}{4} = \frac{8!}{4!\,4!} = \frac{8\times7\times6\times5}{4\times3\times2\times1} = \frac{1680}{24} = 70$$

**Why other options are wrong:**

- Option A (28): $= \binom{8}{2}$, wrong power.
- Option B (56): $= \binom{8}{3}$, wrong power.
- Option C (8): $= \binom{8}{1}$, wrong power.

**Final Answer:** D

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

## Q66.

**Solution**

**Concept — Adjugate and Inverse:** For a matrix $A$, $A \cdot \text{adj}(A) = \det(A)\, I$. This is used to find the inverse when $\det(A) \neq 0$: $A^{-1} = \text{adj}(A)/\det(A)$.

**Why other options are wrong:**

- Option B: $A + \text{adj}(A) = 0$ is not a standard identity.
- Option C: $\text{adj}(A) = A^T$ only for orthogonal matrices (special case).
- Option D: $A \cdot \text{adj}(A) = A^2$ is incorrect.

**Final Answer:** A

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

## Q67.

**Solution**

**Concept — Trigonometric Subtraction Formula:**

$$\sin(A-B) = \sin A\cos B - \cos A\sin B$$

**Memory Aid:** "SAIL minus CLASH" — $\sin A\cos B - \cos A\sin B$.

**Why other options are wrong:**

- Option A: This is $\sin(A+B)$.
- Option C: This is $\cos(A+B)$.
- Option D: This is $\cos(A-B)$.

**Final Answer:** B

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

## Q68.

### Solution

**Concept — Inverse Cosine Domain:** $\cos^{-1}(x)$ is defined for all $x$ in $[-1,\ 1]$, since $\cos\theta$ ranges from $-1$ to $+1$ for $\theta \in [0, \pi]$.

**Why other options are wrong:**

- Option A ($-\infty$ to $+\infty$): Domain of $\tan^{-1}$.
- Option B ($[0, \pi]$): This is the *range* of $\cos^{-1}$, not the domain.
- Option D ($(0, 1)$): Too restrictive.

**Final Answer:** C

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

## Q69.

### Solution

**Concept — Perpendicular Lines:** If two lines have slopes $m_1$ and $m_2$, the condition for perpendicularity is $m_1 m_2 = -1$.

**Example:** Lines $y = 2x + 1$ and $y = -\frac{1}{2}x + 3$: $m_1 m_2 = 2 \times (-\frac{1}{2}) = -1$ ✓

**Why other options are wrong:**

- Option A ($m_1 = m_2$): Parallel lines.
- Option B ($m_1 + m_2 = 1$): Not a standard geometric condition.
- Option C ($m_1 m_2 = 1$): No geometric significance.

**Final Answer:** D

**Answer: (D)** Go Back to Q69

## Q70.

**Solution**

**Concept — Radical Axis:** Obtained by subtracting the equations of the two circles. Subtracting $S_2$ from $S_1$:

$$(S_1 - S_2) : 2(g_1 - g_2)x + 2(f_1 - f_2)y + (c_1 - c_2) = 0$$

This is the locus of points with equal power with respect to both circles.

**Why other options are wrong:**

- Option B: Uses sums instead of differences.
- Options C, D: Missing constant term or coefficient factor.

**Final Answer:** A

**Answer: (A)** Go Back to Q70

## Q71.

**Solution**

**Concept — Eccentricity of Hyperbola** $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$**:** $e = \sqrt{1 + b^2/a^2}$.

**Step 1 — For** $\frac{x^2}{9} - \frac{y^2}{16} = 1$**:** $a^2 = 9$, $b^2 = 16$.

$$e = \sqrt{1 + \frac{16}{9}} = \sqrt{\frac{25}{9}} = \frac{5}{3}$$

**Why other options are wrong:**

- Option A (4/3): $b/a$, not eccentricity.
- Option C ($\sqrt{2}$): Would require $b^2 = a^2$.
- Option D (3/5): Reciprocal; would be eccentricity of an ellipse, not hyperbola.

**Final Answer:** B

**Answer: (B)** Go Back to Q71

## Q72.

**Solution**

**Concept — Parabola $x^2 = 4ay$:** Opens upward; focus at $(0, a)$.

**Step 1 — For $x^2 = 12y$:** $4a = 12 \implies a = 3$.

$$\text{Focus} = (0,\ 3)$$

**Why other options are wrong:**

- Option A (3,0): Focus of sideways parabola $y^2 = 12x$.
- Option B (0,12): Confuses the coefficient with focal length.
- Option D (12,0): Incorrect axes.

**Final Answer:** C

**Answer: (C)** Go Back to Q72

## Q73.

**Solution**

**Concept — Limits at Infinity (Rational Functions):** Divide numerator and denominator by $x^2$ (highest power).

$$\lim_{x\to\infty} \frac{3x^2+5}{x^2-2} = \lim_{x\to\infty} \frac{3+5/x^2}{1-2/x^2} = \frac{3+0}{1-0} = 3$$

**Why other options are wrong:**

- Option A (5): Constant term in numerator, not the limit.
- Option B (0): Would apply if degree of numerator < degree of denominator.
- Option C ($\infty$): Would apply if degree of numerator > degree of denominator.

**Final Answer:** D

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

## Q74.

**Solution**

**Concept — Implicit Differentiation:** Differentiate both sides w.r.t. $x$, using chain rule on $y^2$.

$$\frac{d}{dx}(x^2+y^2)=\frac{d}{dx}(25) \implies 2x+2y\frac{dy}{dx}=0 \implies \frac{dy}{dx}=-\frac{x}{y}$$

**Why other options are wrong:**

- Option B ($x/y$): Missing negative sign.
- Option C ($-y/x$): Numerator and denominator swapped.
- Option D ($y/x$): Both errors combined.

**Final Answer:** A

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

## Q75.

**Solution**

**Concept — Finding Minimum Value:** $f(x)=x+1/x$, $x>0$.

**Step 1 — Set $f'(x)=0$:**

$$f'(x)=1-\frac{1}{x^2}=0 \implies x^2=1 \implies x=1\ (x>0)$$

**Step 2 — Check $f''(1)=2/x^3|_{x=1}=2>0$ (minimum).**

**Step 3 — Minimum value:**

$$f(1)=1+\frac{1}{1}=2$$

**Why other options are wrong:**

- Option A (1): $f(x)\geq 2$ for all $x>0$ by AM-GM.
- Option C (4): $f(2)=2+0.5=2.5$, not 4.
- Option D (1/2): $f(x)>2$ always, so 1/2 is not achievable.

**Final Answer:** B

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

## Q76.

**Solution**

**Concept — Standard Integral:**

$$\int \tan x \, dx = \int \frac{\sin x}{\cos x} \, dx$$

Let $u = \cos x$, $du = -\sin x \, dx$:

$$= -\int \frac{du}{u} = -\ln|u| + C = -\ln|\cos x| + C = \ln|\sec x| + C$$

**Note:** Options B and C are the same result written differently ($-\ln|\cos x| = \ln|\sec x|$). The standard textbook form is $\ln|\sec x| + C$.

**Why Option D is wrong:** $-\ln|\sec x| = \ln|\cos x|$ is not $\int \tan x \, dx$. **Final Answer:** C

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

## Q77.

**Solution**

**Concept — Definite Integral:**

$$\int_0^{\pi} x \, dx = \left[\frac{x^2}{2}\right]_0^{\pi} = \frac{\pi^2}{2} - 0 = \frac{\pi^2}{2}$$

**Why other options are wrong:**

- Option A ($\pi$): Integral of a constant, not $x$.
- Option B ($2\pi$): Off by factor 2.
- Option C ($\pi^2$): Missing the factor of $1/2$.

**Final Answer:** D

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

## Q78.

**Solution**

**Concept — Bayes' Theorem:** $P(A|B) = \dfrac{P(B|A)\,P(A)}{P(B)}$

**Step 1 — Substitute values:**

$$P(A|B) = \frac{0.3 \times 0.4}{0.2} = \frac{0.12}{0.2} = 0.6$$

**Why other options are wrong:**

- Option B (0.3): This is $P(B|A)$.
- Option C (0.12): This is $P(A \cap B) = P(B|A)P(A)$, not $P(A|B)$.
- Option D (0.4): This is $P(A)$.

**Final Answer:** A

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

## Q79.

**Solution**

**Concept — Scalar Projection:** Projection of $\vec{a}$ onto $\hat{b}$ is $\vec{a} \cdot \hat{b}$.

**Step 1 — Since $\vec{b} = \hat{i}$, $|\vec{b}| = 1$:**

$$\text{Projection} = \vec{a} \cdot \hat{b} = (3\hat{i} + 4\hat{j}) \cdot \hat{i} = 3$$

**Why other options are wrong:**

- Option A (4): The $\hat{j}$-component; projection onto $\hat{j}$, not $\hat{i}$.
- Option C (5): This is $|\vec{a}|$ (magnitude), not projection onto $\hat{i}$.
- Option D (7): Sum of components.

**Final Answer:** B

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

## Q80.

**Solution**

**Concept — Angle Between Planes:** $\cos\theta = \dfrac{|\vec{n_1}\cdot\vec{n_2}|}{|\vec{n_1}||\vec{n_2}|}$

**Step 1 — Normal vectors:** Plane 1: $\vec{n_1} = (1,1,1)$; Plane 2: $\vec{n_2} = (1,-1,1)$.

**Step 2 — Dot product and magnitudes:**

$$\vec{n_1}\cdot\vec{n_2} = 1(1)+1(-1)+1(1) = 1$$

$$|\vec{n_1}| = \sqrt{3}, \quad |\vec{n_2}| = \sqrt{3}$$

$$\cos\theta = \frac{|1|}{\sqrt{3}\cdot\sqrt{3}} = \frac{1}{3} \implies \theta = \arccos\left(\frac{1}{3}\right)$$

**Why other options are wrong:**

- Option A ($\arccos(2/3)$): Wrong dot product computation.
- Option B ($\arccos(1/9)$): Squares the denominator.
- Option D ($90$): Would require $\vec{n_1}\cdot\vec{n_2} = 0$.

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

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

## Q81.

**Solution**

**Complex Number Simplification:**

$$z = \frac{1+i}{1-i}\times\frac{1+i}{1+i} = \frac{(1+i)^2}{1+1} = \frac{1+2i-1}{2} = \frac{2i}{2} = i$$

$$|z| = |i| = \sqrt{0^2+1^2} = 1$$

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

**Answer: (1)** Go Back to Q81

## Q82.

**Solution**

**Sum of first $n$ terms of GP:** $S_n = a\,\dfrac{r^n - 1}{r - 1}$

$$S_5 = 2 \times \frac{3^5 - 1}{3 - 1} = 2 \times \frac{243 - 1}{2} = 2 \times \frac{242}{2} = 242$$

**Final Answer:** $\boxed{242}$

**Answer: (242)** Go Back to Q82

## Q83.

**Solution**

**Determinant of Upper Triangular Matrix:** Product of diagonal entries.

$$\begin{vmatrix} 3 & 1 & 2 \\ 0 & 2 & 4 \\ 0 & 0 & 5 \end{vmatrix} = 3 \times 2 \times 5 = 30$$

**Final Answer:** $\boxed{30}$

**Answer: (30)** Go Back to Q83

## Q84.

**Solution**

**Permutations with Repeated Letters:**

$$\text{BANANA} : B(1),\ A(3),\ N(2) \implies \frac{6!}{3!\,2!\,1!} = \frac{720}{6 \times 2 \times 1} = \frac{720}{12} = 60$$

**Final Answer:** $\boxed{60}$

**Answer: (60)** Go Back to Q84

## Q85.

**Solution**

**Definite Integral:**

$$\int_0^{\pi/2} \cos x \, dx = \Big[\sin x\Big]_0^{\pi/2} = \sin\frac{\pi}{2} - \sin 0 = 1 - 0 = 1$$

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

**Answer: (1)** Go Back to Q85

## Q86.

**Solution**

**Rate of Change of Volume:** $V = s^3 \implies \dfrac{dV}{dt} = 3s^2 \dfrac{ds}{dt}$

$$\left.\frac{dV}{dt}\right|_{s=3} = 3(3)^2(2) = 3 \times 9 \times 2 = 54 \text{ cm}^3/\text{s}$$

**Final Answer:** $\boxed{54}$

**Answer: (54)** Go Back to Q86

## Q87.

**Solution**

**Area Between Two Curves:**

$$A = \int_0^1 (x - x^2)\, dx = \left[\frac{x^2}{2} - \frac{x^3}{3}\right]_0^1 = \frac{1}{2} - \frac{1}{3} = \frac{1}{6}$$

The question asks for $A \times 6 = \frac{1}{6} \times 6 = 1$. **Final Answer:** $\boxed{1}$

**Answer: (1)** Go Back to Q87

## Q88.

**Solution**

**Distance from Point to Plane:** Plane $x - 2y + 2z - 4 = 0$; Point $(2, 3, -1)$.

$$d = \frac{|1(2) + (-2)(3) + 2(-1) - 4|}{\sqrt{1^2 + (-2)^2 + 2^2}} = \frac{|2 - 6 - 2 - 4|}{\sqrt{1 + 4 + 4}} = \frac{|-10|}{3} = \frac{10}{3}$$

$$3d = 3 \times \frac{10}{3} = 10$$

**Final Answer:** $\boxed{10}$

**Answer: (10)** Go Back to Q88

## Q89.

**Solution**

**Favourable Outcomes for Sum = 7 (Two Dice):**

$$(1,6),\ (2,5),\ (3,4),\ (4,3),\ (5,2),\ (6,1) \implies \textbf{6 favourable outcomes}$$

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

**Answer: (6)** Go Back to Q89

## Q90.

**Solution**

**Variance of** $\{2,4,6,8,10\}$**:**

$$\bar{x} = \frac{2+4+6+8+10}{5} = \frac{30}{5} = 6$$

$$\sigma^2 = \frac{(2-6)^2+(4-6)^2+(6-6)^2+(8-6)^2+(10-6)^2}{5} = \frac{16+4+0+4+16}{5} = \frac{40}{5} = 8$$

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

**Answer: (8)** Go Back to Q90

# Answer Key

## Section A (MCQ)

| Section A — MCQ Answer Key | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Q# | Ans | Q# | Ans | Q# | Ans | Q# | Ans | Q# | Ans |
| 1 | A | 2 | C | 3 | B | 4 | D | 5 | A |
| 6 | C | 7 | B | 8 | D | 9 | A | 10 | C |
| 11 | B | 12 | D | 13 | A | 14 | C | 15 | B |
| 16 | D | 17 | A | 18 | C | 19 | B | 20 | D |
| 21 | 15 | 22 | 120 | 23 | 20 | 24 | 1 | 25 | 1 |
| 26 | 10 | 27 | 1 | 28 | 20 | 29 | 1 | 30 | 7 |
| 31 | C | 32 | B | 33 | A | 34 | D | 35 | C |
| 36 | B | 37 | A | 38 | D | 39 | C | 40 | B |
| 41 | A | 42 | D | 43 | C | 44 | B | 45 | A |
| 46 | D | 47 | C | 48 | B | 49 | A | 50 | D |
| 51 | 10 | 52 | 0.25 | 53 | 22.4 | 54 | 6 | 55 | 965 |
| 56 | 2.5 | 57 | 54 | 58 | 100 | 59 | 3 | 60 | 2.46 |
| 61 | D | 62 | A | 63 | B | 64 | C | 65 | D |
| 66 | A | 67 | B | 68 | C | 69 | D | 70 | A |
| 71 | B | 72 | C | 73 | D | 74 | A | 75 | B |
| 76 | C | 77 | D | 78 | A | 79 | B | 80 | C |
| 81 | 1 | 82 | 242 | 83 | 30 | 84 | 60 | 85 | 1 |
| 86 | 54 | 87 | 1 | 88 | 10 | 89 | 6 | 90 | 8 |

## Section B (Numerical)

| Section B — Numerical Answer Key | | | |
|---|---|---|---|
| Q# | Ans | Q# | Ans |