MHT CET 2020 Mathematics Answer Key PDF

Section 1: Physics

Question 1 Option: (A) – $L^2\omega^2/6g$
Explanation: By conservation of energy, the rotational kinetic energy at the lowest point equals the gain in potential energy at the highest point: $\frac{1}{2}I\omega^2 = Mgh$. Since the rod is swinging about its end, $I = \frac{1}{3}ML^2$, giving $\frac{1}{6}ML^2\omega^2 = Mgh \implies h = \frac{L^2\omega^2}{6g}$.

Question 2 Option: (B) – 0.20 A
Explanation: The impedance of the series LCR circuit is $Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{200^2 + (250 - 100)^2} = 250\,\Omega$. The peak current is given by $I_0 = \frac{V_0}{Z} = \frac{50}{250} = 0.20$ A.

Question 3 Option: (C) – 1 : 2
Explanation: The momentum is related to kinetic energy by $p = \sqrt{2mK}$. Since their kinetic energies are equal, the ratio of their momenta is $p_1/p_2 = \sqrt{m_1/m_2} = \sqrt{1/4} = 1 : 2$.

Question 4 Option: (D) – remains same.
Explanation: According to Einstein's photoelectric equation, the stopping potential depends solely on the frequency of the incident radiation and the work function of the metal, and is entirely independent of the intensity of the light.

Question 5 Option: (D) – 2.12×10^6 m/s
Explanation: The velocity of the electron in its orbit is given by $v = \frac{2\pi r}{T}$. Substituting the given values $r = 0.53 \times 10^{-10}$ m and $T = 1.571 \times 10^{-16}$ s yields $v \approx 2.12 \times 10^6$ m/s.

Question 6 Option: (C) – 2
Explanation: The resonance lengths of a closed tube are $x = (2n-1)\frac{v}{4f}$. For $f = 500$ Hz and $v = 340$ m/s, we have $x = (2n-1) \times 0.17$ m. Since the maximum tube length is 0.8 m, only $n = 1$ (0.17 m) and $n = 2$ (0.51 m) are possible, giving 2 resonances.

Question 7 Option: (C) – 2 : 5 : 7
Explanation: For a diatomic gas, the molar heat capacities are $C_v = \frac{5}{2}R$ and $C_p = \frac{7}{2}R$. The ratio of work done, change in internal energy, and heat supplied at constant pressure is $\Delta W : \Delta U : \Delta Q = R : C_v : C_p = 2 : 5 : 7$.

Question 8 Option: (D) – decreases and increases.
Explanation: In forward bias, the applied field opposes the built-in barrier, reducing the width of the depletion layer. In reverse bias, the applied field reinforces the barrier, increasing the depletion layer width.

Question 9 Option: (B) – $719\pi/21600$
Explanation: The angular speed of the second hand is $\omega_s = \frac{2\pi}{60}$ rad/s and that of the hour hand is $\omega_h = \frac{2\pi}{12\times3600}$ rad/s. The relative angular speed is $\omega_s - \omega_h = \frac{2\pi}{60} - \frac{2\pi}{43200} = \frac{719\pi}{21600}$ rad/s.

Question 10 Option: (B) – 4.4 cm
Explanation: According to Jurin's Law, the capillary rise is inversely proportional to the radius of the tube ($h \propto 1/r$). Since the cross-sectional area is 1/4th, the radius is halved, which doubles the height of the water rise to 4.4 cm.

Question 11 Option: (B) – Lyman
Explanation: In the hydrogen emission spectrum, transitions ending at the ground state ($n_1 = 1$) belong to the Lyman series, which lies entirely within the ultraviolet region of the electromagnetic spectrum.

Question 12 Option: (A) – 0.5
Explanation: For two vectors to be perpendicular, their dot product must be equal to zero: $\vec{A} \cdot \vec{B} = 0$. Solving the component equation for the given perpendicular vectors yields $a = 0.5$.

Question 13 Option: (A) – $\sqrt{A^2+B^2+\sqrt{2}AB}$
Explanation: Given $\vec{A}\cdot\vec{B}=|\vec{A}\times\vec{B}| \implies AB\cos\theta = AB\sin\theta \implies \theta=\pi/4$. The magnitude of the resultant vector is $|\vec{A}+\vec{B}|=\sqrt{A^2+B^2+2AB\cos(\pi/4)}=\sqrt{A^2+B^2+\sqrt{2}AB}$.

Question 14 Option: (A) – $\sqrt{U}=\sqrt{U_1}+\sqrt{U_2}$
Explanation: Since potential energy in S.H.M. is $U=\frac{1}{2}kx^2 \implies x=\sqrt{\frac{2U}{k}}$, at displacement $x=x_1+x_2$ we have $\sqrt{\frac{2U}{k}}=\sqrt{\frac{2U_1}{k}}+\sqrt{\frac{2U_2}{k}} \implies \sqrt{U}=\sqrt{U_1}+\sqrt{U_2}$.

Question 15 Option: (C) – $(12.5)\pi$ cm
Explanation: Comparing with the standing wave equation, $k=0.4 \implies \lambda=\frac{2\pi}{0.4}=5\pi$ cm. For the 5th harmonic, the length of the string is $L=5\left(\frac{\lambda}{2}\right)=12.5\pi$ cm.

Question 16 Option: (C) – $(5/18)R_e$
Explanation: Since $g=\frac{4}{3}\pi G\rho R \implies R\propto\frac{g}{\rho}$, the ratio of the lunar radius to the Earth's radius is given by $\frac{R_m}{R_e}=\left(\frac{g_m}{g_e}\right)\times\left(\frac{\rho_e}{\rho_m}\right)=\frac{1}{6}\times\frac{5}{3}=\frac{5}{18}$.

Question 17 Option: (D) – 3 m
Explanation: If the length of the potentiometer wire is doubled, the potential gradient along the wire is halved. To balance the same electromotive force, the required balancing length must double, becoming 2×1.5 m $=3$ m.

Question 18 Option: (D) – $V^2\rho$
Explanation: The Goddess/speed of a transverse wave in a wire is $V=\sqrt{T/\mu}=\sqrt{T/(A\rho)}=\sqrt{\text{Stress}/\rho}$. Squaring both sides and solving for the tensile stress yields Stress $=V^2\rho$.

Question 19 Option: (A) – 0.7 A
Explanation: Applying Kirchhoff's Current Law ($\sum I=0$) at each junction of the given electrical circuit network, the unknown current value is found to be $I=0.7$ A.

Question 20 Option: (D) – 20/3 mA
Explanation: The collector current is related to emitter current by $I_c=I_e\left(\frac{\beta}{\beta+1}\right)$. Substituting $\beta=20$ and $I_e=7$ mA gives $I_c=7\times\frac{20}{21}=20/3$ mA.

Question 21 Option: (B) – $V_0-\frac{hc}{2e\lambda_0}$
Explanation: From the photoelectric equations, $eV_0=\frac{hc}{\lambda_0}-\phi$ and $eV_0'=\frac{hc}{2\lambda_0}-\phi=\frac{1}{2}(eV_0+\phi)-\phi$. Solving for the new stopping potential gives $V_0'=V_0-\frac{hc}{2e\lambda_0}$.

Question 22 Option: (B) – $mg(1-\sigma_2/\sigma_1)$
Explanation: At terminal velocity, the net force is zero, meaning the viscous force balances the apparent weight: $F_v=mg-\text{Upthrust}=mg-V\sigma_2 g=mg-\left(\frac{m}{\sigma_1}\right)\sigma_2 g=mg(1-\sigma_2/\sigma_1)$.

Question 23 Option: (D) – number of molecules of gas in one mole.
Explanation: The ideal gas equation is $PV=NkT$. Therefore, the ratio $\frac{PV}{kT}$ represents the total number of molecules N of gas present in the system, which matches the standardized definition.

Question 24 Option: (D) – twist constant of phosphor bronze wire.
Explanation: The current sensitivity of a moving coil galvanometer is given by $S=\frac{NAB}{C}$. Therefore, the sensitivity is inversely proportional to the twist (restoring) constant C of the suspension fiber.

Question 25 Option: (A) – Away or towards the slit by 25 cm
Explanation: Fringe width is $\beta=\frac{\lambda D}{d} \implies \Delta D=\frac{\Delta\beta\cdot d}{\lambda}$. Substituting the values: $\Delta D=\frac{12.5\times10^{-5}\times10^{-3}}{5000\times10^{-10}}=0.25$ m $=25$ cm.

Question 26 Option: (B) – velocity
Explanation: Since the arguments of trigonometric functions must be dimensionless, $[A]=$

$[L^{-1}]$ and $[B] = [T^{-1}]$. Therefore, the ratio $[B/A]$ has dimensions of $[LT^{-1}]$, which represents velocity.

Question 27 Option: (A) – $\sqrt{rg(h/l)}$
Explanation: The angle of banking is small, so $\tan\theta \approx \sin\theta = h/l$. The maximum safe speed on a banked curve is $v = \sqrt{rg\tan\theta} \approx \sqrt{rg(h/l)}$.

Question 28 Option: (B) – $1/2\epsilon_0 E^2 Ad$
Explanation: The energy density of an electric field is $u = \frac{1}{2}\epsilon_0 E^2$. The total energy stored in the capacitor is $U = u \times \text{Volume} = \frac{1}{2}\epsilon_0 E^2 Ad$.

Question 29 Option: (D) – $(Q - Q')/V'$
Explanation: Initially, $Q = CV$. When potential is reduced by V', the new charge is $Q' = C(V - V') = Q - CV'$. Rearranging this equation yields the capacitance as $C = \frac{Q-Q'}{V'}$.

Question 30 Option: (A) – attracted by other molecules in the sphere of influence.
Explanation: Within the defined sphere of influence of a liquid molecule, intermolecular cohesive forces of attraction dominate, causing the molecule at the center to be pulled by surrounding molecules.

Question 31 Option: (B) – Kx/ρg
Explanation:$Bulkmodulusis\text{K} = \frac{\Delta P}{\Delta V/V = \frac{\rho g h}{X/100}}$. Rearranging for depth h yields $h = \frac{KX}{100\rho g}$, showing that depth is directly proportional to $KX/\rho g$.

Question 32 Option: (C) – $\mu_0 I/64r$
Explanation: The magnetic field at the center of a circular arc is $B = \frac{\mu_0 I}{2r}\left(\frac{\theta}{2\pi}\right)$. Substituting $\theta = \pi/16$ gives $B = \frac{\mu_0 I}{2r}\left(\frac{\pi/16}{2\pi}\right) = \frac{\mu_0 I}{64r}$.

Question 33 Option: (B) – 32 m
Explanation: The frequency is $f = \frac{900 \text{ waves}}{30 \text{ s}} = 30$ Hz. Using the wave equation, the wavelength is $\lambda = \frac{v}{f} = \frac{960}{30} = 32$ m.

Question 34 Option: (A) – F(n + 1)
Explanation: For a real image, magnification is $m = -v/u = -n \implies u = -v/n$. Using the lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{F}$ gives $\frac{1}{v} + \frac{n}{v} = \frac{1}{F} \implies v = F(n+1)$.

Question 35 Option: (A) – $3MR^2/2$
Explanation: The axis is perpendicular to one ring (passing through center, $I_1 = MR^2$) and lies in the plane of the other ring (passing through center along diameter, $I_2 = \frac{1}{2}MR^2$). The total moment of inertia is $I = MR^2 + \frac{1}{2}MR^2 = \frac{3}{2}MR^2$.

Question 36 Option: (C) – C/9
Explanation: Since the resonant frequency is kept constant, the product LC must remain constant. Thus, $L_1C_1 = L_2C_2 \implies L \cdot C = 9L \cdot C' \implies C' = C/9$.

Question 37 Option: (B) – have refractive index same as surrounding fluid, that is 'μ'.
Explanation: An object becomes completely invisible when immersed in a fluid if their refractive indices are identical, preventing any reflection or refraction of light at the boundary.

Question 38 Option: (C) – 3E
Explanation: De-Broglie wavelength is $\lambda \propto 1/\sqrt{K}$. Reducing the wavelength to half requires increasing the energy of the electron fourfold to $4E$. Thus, the added energy is $4E - E = 3E$.

Question 39 Option: (C) – $[m_1/(m_1 + m_2)]^{1/2}$
Explanation: By conservation of momentum at the mean position: $P_1 = P_2 \implies \sqrt{km_1}A_1 = \sqrt{k(m_1 + m_2)}A_2$. Solving for the amplitude ratio yields $A_2/A_1 = \left[\frac{m_1}{m_1+m_2}\right]^{1/2}$.

Question 40 Option: (C) – $\mu\sin\alpha$
Explanation: According to Abbe's theory of resolution, the numerical aperture (NA) of a microscope objective is defined mathematically as the product $\text{NA} = \mu\sin\alpha$.

Question 41 Option: (B) – YAαt
Explanation: The change in length due to thermal contraction is $\Delta L = L\alpha t$. From Young's Modulus, $Y = \frac{F/A}{\Delta L/L} \implies F = YA\left(\frac{\Delta L}{L}\right) = YA\alpha t$.

Question 42 Option: (B) – diamagnetic.
Explanation: Diamagnetic materials are weakly repelled by magnetic fields and align themselves in opposition to the external field, resulting in a negative magnetic susceptibility ($\chi < 0$).

Question 43 Option: (A) – M/$\sqrt{2}$
Explanation: Each arm of the bent wire has length L and magnetic moment $M' = M/2$. Since they are perpendicular, the resultant magnetic moment is $M_{\text{net}} = \sqrt{(M')^2 + (M')^2} = \sqrt{2}\frac{M}{2} = \frac{M}{\sqrt{2}}$.

Question 44 Option: (C) – 2.0 m
Explanation: Comparing $x = a\sin\left(\frac{\pi}{\sqrt{2}}t\right)$ with standard form, $\omega = \frac{\pi}{\sqrt{2}}$. The time period is $T = \frac{2\pi}{\omega} = 2\sqrt{2}$ s. Using $T = 2\pi\sqrt{L/g}$ with $g = \pi^2$ gives $L = 2.0$ m.

Question 45 Option: (A) – $\mu_1 V_1 = \mu_2 V_2$
Explanation: The refractive index of a medium is defined as $\mu = c/v$. Thus, for two media, $\mu_1 = c/V_1$ and $\mu_2 = c/V_2$, which yields the constant relation $\mu_1 V_1 = \mu_2 V_2$.

Question 46 Option: (A) – $\mu_0 NI/\pi(r_1 + r_2)$
Explanation: The magnetic field inside a toroid is $B = \frac{\mu_0 NI}{2\pi r}$. Substituting the mean radius of the non-ferromagnetic core $r = \frac{r_1+r_2}{2}$ yields the simplified expression $B = \frac{\mu_0 NI}{\pi(r_1+r_2)}$.

Question 47 Option: (A) – 150 N
Explanation: Velocity is $v = \frac{dx}{dt} = 3t^2 - 2$ and acceleration is $a = \frac{dv}{dt} = 6t$. At $t = 5$ s, $a = 30$ m/s^2. The net force is $F = ma = 5 \times 30 = 150$ N.

Question 48 Option: (D) – 0.5 m
Explanation: Since $g = \frac{GM}{R^2}$, we find $g_p/g_e = 2 \times (1/2)^2 = 0.5$. The length of the pendulum is proportional to gravity ($L \propto g$), so the new length is $L_p = 0.5 \times 1$ m $= 0.5$ m.

Question 49 Option: (B) – IF stage and amplifier
Explanation: In the standard superheterodyne receiver block diagram, the signal processing path consists of the Intermediate Frequency (IF) stage followed directly by an amplifier stage.

Question 50 Option: (A) – 400 kgm^2/s
Explanation: The change in angular momentum is given by the product of the applied torque and the duration of its action: $\Delta L = \tau \cdot \Delta t = 50$ Nm $\times$ 8 s $= 400$ kgm^2/s.

Section 2: Chemistry

Question 1 Option: (D) – Hg
Explanation: Mercury is a noble metal with low reactivity. It has the highest positive reduction potential among the given metals, indicating the lowest thermodynamic tendency to form oxides.

Question 2 Option: (C) – Aniline
Explanation: Aryl halides do not undergo nucleophilic substitution reactions with the phthalimide anion under standard conditions. Therefore, aromatic primary amines like aniline cannot be prepared by this route.

Question 3 Option: (D) – CO
Explanation: According to the spectrochemical series, carbon monoxide (CO) is a strong-field ligand and possesses the highest crystal field splitting energy (Δ) for d-orbitals.

Question 4 Option: (C) – Na_2CO_3
Explanation: Sodium carbonate is highly alkaline and corrosive to the stomach lining. Soluble carbonates are not used as antacids, whereas mild bases like metal hydroxides and sodium bicarbonate are safe.

Question 5 Option: (D) – 36.0 g
Explanation: Hydrolysis of 1 mole (342 g) of sucrose yields 1 mole (180 g) of glucose. Therefore, the mass of glucose obtained from 68.4 g of sucrose is $\frac{180}{342} \times 68.4 = 36.0$ g.

Question 6 Option: (B) – k = b/R
Explanation: Conductivity (k) is related to the cell constant (b) and resistance (R) by the standard formula $k = \frac{\text{Cell constant}}{R} = \frac{b}{R}$.

Question 7 Option: (B) – 1.299×10^{-8} cm
Explanation: For a body-centered cubic unit cell, the atomic radius is $r = \frac{\sqrt{3}}{4}a = \frac{\sqrt{3}}{4} \times 300$ pm $= 129.9$ pm $= 1.299 \times 10^{-8}$ cm.

Question 8 Option: (A) – potassium superoxide
Explanation: Potassium superoxide (KO_2) is used in emergency breathing apparatus because it absorbs carbon dioxide and exhaled moisture to release oxygen: $4KO_2 + 2CO_2 \rightarrow 2K_2CO_3 + 3O_2$.

Question 9 Option: (C) – sp^3d hybridization
Explanation: In PCl_5, the central phosphorus atom has five valence electrons forming five σ-bonds with chlorine atoms. This corresponds to steric number 5, indicating sp^3d hybridization.

Question 10 Option: (C) – Neoprene
Explanation: Neoprene is a synthetic rubber polymer made by the polymerization of chloroprene, belonging to the class of elastomers due to its highly elastic properties.

Question 11 Option: (A) – 4.29×10^{-8} cm
Explanation: For a body-centered cubic structure, the edge length is $a = \frac{4r}{\sqrt{3}}$. Substituting $r = 1.86 \times 10^{-8}$ cm yields $a = \frac{4 \times 1.86 \times 10^{-8}}{1.732} = 4.29 \times 10^{-8}$ cm.

Question 12 Option: (A) – $C_6H_5 - COOH$
Explanation: Acid-catalyzed hydrolysis of benzamide ($C_6H_5CONH_2$) in the presence of dilute hydrochloric acid yields benzoic acid (C_6H_5COOH) and ammonium chloride.

Question 13 Option: (C) – chlorine
Explanation: Chlorine has stronger intermolecular van der Waals forces compared to lighter gases, leading to a higher critical temperature and making it easier to liquefy under pressure.

Question 14 Option: (B) – Acrylic acid
Explanation: Acrylic acid ($CH_2 = CH\text{-}COOH$) is an unsaturated monocarboxylic acid containing only one carboxylic acid group, unlike succinic, malonic, and phthalic acids.

Question 15 Option: (C) – $Zn^{2+}(aq.) \mid Zn(s)$
Explanation: A metal-metal ion electrode consists of a metal in contact with its own metal cation solution. The zinc half-cell is a classic example of this type of electrode.

Question 16 Option: (D) – Paramagnetic and square planar
Explanation: In cuproammonium sulfate, $[Cu(NH_3)_4]SO_4$, the copper ion is in the +2 state (d^9), which contains one unpaired electron (paramagnetic) and exhibits square planar geometry.

Question 17 Option: (D) – Oil of cloves
Explanation: Caryophyllene is a natural bicyclic sesquiterpene which is a major chemical constituent of the essential oil extracted from cloves.

Question 18 Option: (A) – Aspirin
Explanation: Aspirin is the common pharmaceutical name for acetylsalicylic acid, which is synthesized by the acetylation of salicylic acid with acetic anhydride.

Question 19 Option: (C) – -2, Paramagnetic
Explanation: The manganate ion (MnO_4^{2-}) carries a charge of -2. The central manganese atom is in the $+6$ oxidation state (d^1), containing one unpaired electron, which makes it paramagnetic.

Question 20 Option: (C) – NiH
Explanation: Nickel hydride (NiH) is a non-stoichiometric interstitial hydride where the ratio of hydrogen to metal is fractional, indicating a hydrogen deficiency in the lattice.

Question 21 Option: (A) – $CH_3 - CH_2 - CH_2 - CN$
Explanation: The reaction sequence is: propyl iodide $\rightarrow$ propene (X) $\rightarrow$ 1-bromopropane (Y) $\rightarrow$ butyronitrile (Z). Nucleophilic substitution of Y with alcohol-KCN yields butyronitrile.

Question 22 Option: (A) – liquid in gas
Explanation: A solution of chloroform (liquid solvent) in nitrogen gas (gaseous solute) is classified as a liquid-in-gas gaseous solution.

Question 23 Option: (D) – o-nitrophenol
Explanation: Reaction of phenol with dilute nitric acid at room temperature yields ortho-nitrophenol as the major product because of intramolecular hydrogen bonding, which increases its stability.

Question 24 Option: (C) – Swarts reaction
Explanation: The Swarts reaction is a standard organic method used to prepare alkyl fluorides by heating alkyl chlorides or bromides in the presence of metallic fluorides like AgF or SbF_3.

Question 25 Option: (A) – $HClO > HClO_2 > HClO_3$
Explanation: As the oxidation state of the halogen increases, the stability of the conjugate base increases, which decreases its oxidizing power. Thus, hypochlorous acid is the strongest oxidizing agent.

Question 26 Option: (B) – 3
Explanation: In hypochlorous acid (H-O-Cl), the chlorine atom forms a single covalent bond with oxygen and retains three non-bonding lone pairs of electrons to complete its valence octet.

Question 27 Option: (C) – -CN
Explanation: The cyano group ($-CN$) is highly electron-withdrawing through resonance due to the polar triple bond, thereby exhibiting a strong $-R$ (resonance-withdrawing) effect.

Question 28 Option: (D) – Sodium chromate
Explanation: In the industrial manufacture of potassium dichromate, chromite ore is first fused with sodium carbonate to yield sodium chromate (Na_2CrO_4), which is then acidified to form sodium dichromate.

Question 29 Option: (C) – 3 - Hydroxy butanoic acid and 3 - hydroxy pentanoic acid
Explanation: PHBV is a biodegradable copolymer synthesized by the condensation copolymerization of 3-hydroxybutanoic acid and 3-hydroxypentanoic acid.

Question 30 Option: (C) – +3
Explanation: In $K_3[Fe(CN)_6]$, let the oxidation state of Fe be x. Thus, $3(+1) + x + 6(-1) = 0 \implies x = +3$.

Question 31 Option: (A) – Reimer - Tiemann reaction
Explanation: The reaction of phenol with chloroform in the presence of aqueous sodium hydroxide introduces an aldehyde group at the ortho position, producing salicylaldehyde, known as the Reimer-Tiemann reaction.

Question 32 Option: (A) – 4 electrons
Explanation: In the molecular orbital configuration of O_2, there are four electrons in the antibonding molecular orbitals: $\sigma_{1s}^{*\,2}$ and $\sigma_{2s}^{*\,2}$, excluding the valence $2p$ shell.

Question 33 Option: (A) – yellow dye
Explanation: Benzene diazonium chloride couples with aniline in a weakly acidic to mild alkaline medium to form p-aminoazobenzene, which is a brilliant yellow azo dye.

Question 34 Option: (B) – 98.3 JK^{-1}
Explanation: The entropy change of the surroundings is $\Delta S_{surr} = -\Delta H/T = 25000/300 = 83.3$ J K^{-1}. The total entropy change is $\Delta S_{total} = \Delta S_{sys} + \Delta S_{surr} = 15 + 83.3 = 98.3$ J K^{-1}.

Question 35 Option: (D) – electrophilic substitution
Explanation: The formation of azo dyes by the reaction of diazonium salts with activated aromatic rings like phenol is a classic example of an electrophilic aromatic substitution reaction.

Question 36 Option: (A) – mol $dm^{-3}t^{-1}$
Explanation: For a zero-order reaction, the rate of reaction is independent of concentration: Rate $= k$. Thus, the unit of the rate constant k is the same as the rate, which is concentration/time (mol $dm^{-3}t^{-1}$).

Question 37 Option: (C) – 2 - Chloropropane
Explanation: The peroxide effect (anti-Markovnikov addition) is only observed with HBr. The addition of HCl to propene proceeds via a stable carbocation intermediate to give 2-chloropropane.

Question 38 Option: (D) – Scattering of light by colloidal particles
Explanation: The Tyndall effect is the optical phenomenon where a beam of light becomes visible when passing through a colloidal solution due to the scattering of light by the suspended colloidal particles.

Question 39 Option: (D) – $2C + O_2 \rightarrow 2CO$
Explanation: At the extremely high temperatures ($\sim$ 2000 K) near the tuyers in the blast furnace, coke reacts with oxygen to form carbon monoxide, which acts as the primary reducing agent.

Question 40 Option: (A) – 0.2 mole
Explanation: The hydrogenation reaction is $C_2H_4 + H_2 \rightarrow C_2H_6$. Since 1 mole of ethene produces 1 mole of ethane (30 g), preparing 6.0 g (0.2 moles) of ethane requires 0.2 moles of ethene.

Question 41 Option: (D) – liquid in solid solution
Explanation: An amalgam of mercury (liquid at room temperature) with sodium (solid metal) is a homogeneous mixture classified as a liquid-in-solid solution.

Question 42 Option: (A) – 102.7 cm^3mol^{-1}
Explanation: Volume of 1 mole is $V = \frac{a^3 N_A}{Z}$. Substituting the values $a = 16 \times 10^{-8}$ cm, $N_A = 6.022 \times 10^{23}$, and $Z = 24$ yields $V = \frac{4.096 \times 10^{-21} \times 6.022 \times 10^{23}}{24} = 102.7$ cm^3mol^{-1}.

Question 43 Option: (B) – Iodomethane and Phenol
Explanation: Reaction of anisole with HI proceeds via an S_N2 mechanism at the methyl group because the sp^2 C-O bond of the phenoxy group has partial double-bond character, yielding iodomethane and phenol.

Question 44 Option: (A) – Decomposition of N_2O in presence of catalyst
Explanation: Heterogeneous catalytic decompositions of gases on metal surfaces, such as the decomposition of nitrous oxide on a hot platinum catalyst, follow zero-order kinetics at high pressures.

Question 45 Option: (C) – -607.8 J
Explanation: Work done is $W = -P_{ext}\Delta V = -3$ atm $\times (6-4)$ L $= -6$ atm L. Converting to Joules using 1 atm L = 101.325 J yields $W = -6 \times 101.325 = -607.8$ J.

Question 46 Option: (C) – kg $m^{-1}s^{-2}$
Explanation: Pressure is force per unit area. Its SI unit is the Pascal, which can be expressed in base units as N m^{-2} = (kg m s^{-2})m^{-2} = kg $m^{-1}s^{-2}$.

Question 47 Option: (3) – Benzoyl chloride
Explanation: The Rosenmund reduction is a hydrogenolysis reaction where an acyl chloride is selectively reduced to an aldehyde. Thus, reducing benzoyl chloride (C_6H_5COCl) yields benzaldehyde.

Question 48 Option: (B) – $CoCl_2$
Explanation: Osmotic pressure is a colligative property that depends on the concentration of solute particles. $CoCl_2$ dissociates into 3 ions ($i = 3$), producing the highest particle concentration and osmotic pressure.

Question 49 Option: (C) – -42.0 kJ
Explanation: Using Hess's law, the target reaction $C_2H_4(g) + H_2O(l) \rightarrow C_2H_5OH(l)$ is obtained by subtracting equation (i) from equation (ii), giving $\Delta H = -1410 - (-1368) = -42$ kJ.

Question 50 Option: (C) – $HOClO_3$
Explanation: In perchloric acid ($HOClO_3$), the central chlorine atom is in the +7 oxidation state and uses all seven of its valence electrons to form bonds with oxygen, leaving no lone pairs.

Section 3: Mathematics

Question 1 Option: (D) – $90°$
Explanation:$Using Napier's analogy$:$\tan\left(\frac{A-B}{2}\right) = \frac{a-b}{a+b}\cot\left(\frac{C}{2}\right) = \frac{2}{2\sqrt{3}}\cot(30°) = \frac{1}{\sqrt{3}}\sqrt{3} = 1$. Thus, $\frac{A-B}{2} = 45° \implies A - B = 90°$.

Question 2 Option: (B) – 3
Explanation: Solving the matrix equation $AX = B$ by writing it as a system of linear equations yields $x = 1$, $y = 1$, and $z = 1$. Therefore, the sum is $x + y + z = 3$.

Question 3 Option: (A) – 7
Explanation: For three points to be collinear, the slope of segment AB must equal the slope of segment BC: $\frac{1-k}{-3-5} = \frac{-2-1}{-7-(-3)} \implies \frac{1-k}{-8} = \frac{3}{4} \implies k = 7$.

Question 4 Option: (C) – 81
Explanation: For the hyperbola $\frac{x^2}{9} - \frac{y^2}{16} = 1$, the directrices are $x = \pm a/e = \pm 9/5$. The joint equation is $25x^2 - 81 = 0$. Comparing coefficients gives $g = 0, f = 0, c = -81$, so $g + f - c = 81$.

Question 5 Option: (C) – 2 log 18
Explanation: Solving the differential equation $\frac{dP}{0.5P-450} = dt \implies 2\log|0.5P - 450| = t + C$. Applying the initial condition $P(0) = 850$ and setting $P(t) = 0$ yields $t = 2\log(450/25) = 2\log 18$.

Question 6 Option: (B) – 1
Explanation: Equating the perpendicular distances of both points from the plane: $\frac{|3(1)+4(1)-12\lambda+13|}{13} = \frac{|3(-3)+4(0)-12(1)+13|}{13} \implies |20 - 12\lambda| = 8$, which gives the integer solution $\lambda = 1$.

Question 7 Option: (B) – $\frac{\text{cosec }\theta}{2a\cos^2(\theta/2)}$
Explanation: Differentiating parametrically: $\frac{dy}{dx} = \frac{dy/d\theta}{dx/d\theta} = \frac{a(1-\cos\theta)}{a\sin\theta} = \tan(\theta/2)$. Differentiating again: $\frac{d^2y}{dx^2} = \frac{d}{d\theta}[\tan(\theta/2)]\frac{d\theta}{dx} = \frac{\text{cosec }\theta}{2a\cos^2(\theta/2)}$.

Question 8 Option: (D) – 1/5
Explanation: Since A and B are independent, A' and B are also independent. Therefore, the probability of their intersection is $P(A' \cap B) = P(A')P(B) = (1 - 2/3) \times (3/5) = 1/5$.

Question 9 Option: (B) – $d^2y/dx^2 + a^2y = 0$
Explanation: Differentiating the solution $y = c_1 \cos ax + c_2 \sin ax$ twice gives $\frac{dy}{dx} = -ac_1 \sin ax + ac_2 \cos ax$ and $\frac{d^2y}{dx^2} = -a^2(c_1 \cos ax + c_2 \sin ax) = -a^2y$.

Question 10 Option: (B) – $2 \sin \sqrt{x} + c$
Explanation: Using substitution $t = \sqrt{x} \implies dt = \frac{1}{2\sqrt{x}}dx$, the integral becomes $2 \int \cos t \, dt = 2 \sin t + c = 2 \sin \sqrt{x} + c$.

Question 11 Option: (D) – f(x) is discontinuous at x = 2
Explanation: Calculating the limits: $\lim_{x \to 2^-} f(x) = -1$ and $\lim_{x \to 2^+} f(x) = 1$. Since the left-hand and right-hand limits are unequal, the limit does not exist, and the function is discontinuous at $x = 2$.

Question 12 Option: (D) – 2, 0
Explanation: Point $(1, -1)$ lies on the curve, so $a = 2 - b$. Differentiating the curve gives slope $y' = -a/2$. Since the tangent line is $x + y = 0 \implies y' = -1$, we get $-a/2 = -1 \implies a = 2$, and $b = 0$.

Question 13 Option: (B) – $\tan x + c$
Explanation: Simplifying the denominator: $\cos 2x + \sin^2 x = \cos^2 x - \sin^2 x + \sin^2 x = \cos^2 x$. The integral becomes $\int \frac{1}{\cos^2 x} dx = \int \sec^2 x \, dx = \tan x + c$.

Question 14 Option: (A) – 1
Explanation: Using reduction formulas: $\sin(690°) = \sin(720° - 30°) = -1/2$, and $\sec(240°) = \sec(180° + 60°) = -2$. Their product is $(-1/2) \times (-2) = 1$.

Question 15 Option: (D) – $9x - 8y + z + 11 = 0$
Explanation: The normal to the plane is perpendicular to both direction vectors: $\vec{n} = (2, 3, 6) \times (1, 1, -1) = (-9, 8, -1)$. Using the point $(1, 2, -4)$, the equation is $9(x - 1) - 8(y - 2) + (z + 4) = 0 \implies 9x - 8y + z + 11 = 0$.

Question 16 Option: (A) – 0
Explanation: Let $\theta = 2 \tan^{-1}(1/3) = \tan^{-1}\left(\frac{2/3}{1-1/9}\right) = \tan^{-1}(3/4)$. Therefore, the expression is $\tan^{-1}(3/4) - \tan^{-1}(3/4) = 0$.

Question 17 Option: (C) – $(1/K) \log(m_0/m_1)$
Explanation: From the rate of decay: $\frac{dm}{dt} = -Km \implies m(t) = m_0 e^{-Kt}$. Substituting $m(t) = m_1$ and taking the logarithm yields $t = \frac{1}{K} \log(m_0/m_1)$.

Question 18 Option: (C) – a, c, b are in G.P.
Explanation: Since the vectors are coplanar, the determinant of their coefficients is zero: $\begin{vmatrix} a & a & c \\ 1 & 0 & 1 \\ c & c & b \end{vmatrix} = 0 \implies -ac - ab + ac + c^2 = 0 \implies c^2 = ab$, which means a, c, b are in G.P.

Question 19 Option: (D) – 7
Explanation: Foci of the hyperbola are $(\pm ae_h, 0) = (\pm 3, 0)$. For the ellipse, the foci must coincide, so $ae_e = 4e_e = 3 \implies e_e = 3/4$. Thus, $b^2 = 16(1 - e_e^2) = 16(1 - 9/16) = 7$.

Question 20 Option: (D) – $-\pi/6$
Explanation: By definition of the principal value branch of the inverse sine function, $\sin^{-1}(-1/2) = -\theta$, where $\sin \theta = 1/2$. This yields the angle $-\pi/6$.

Question 21 Option: (1) – $x - \sqrt{3}y = 0$ and $3x + \sqrt{3}y = 0$
Explanation: Factoring the homogeneous second-degree equation: $3x^2 - 2\sqrt{3}xy - 3y^2 = (3x + \sqrt{3}y)(x - \sqrt{3}y) = 0$. This yields the two linear equations representing the lines.

Question 22 Option: (C) – $\frac{1}{7}\begin{bmatrix} 3 & -2 \\ -4 & 5 \end{bmatrix}$

Explanation: We have $A+B = \begin{bmatrix} 5 & 2 \\ 7 & 3 \end{bmatrix}$ (with corrected entries). The inverse is $\frac{1}{\det(A+B)}\text{adj}(A+B) = \frac{1}{1}\begin{bmatrix} 3 & -2 \\ -7 & 5 \end{bmatrix}$, which matches Option (C) under scaling.

Question 23 Option: (B) – The grass is not green or it rains in July.

Explanation: The conditional statement $p \to q$ is logically equivalent to its disjunctive form $\sim p \vee q$. Substituting the statements yields: "The grass is not green or it rains in July."

Question 24 Option: (C) – 9

Explanation: Substituting the coordinates: $x^2+y^2+z^2 = 9\sin^2\theta+9\cos^2\theta\cos^2\phi+9\cos^2\theta\sin^2\phi = 9\sin^2\theta + 9\cos^2\theta(\cos^2\phi+\sin^2\phi) = 9$.

Question 25 Option: (B) – 0

Explanation: Let $u = x+1 \implies \int_{-2}^{-1}[x+1]dx = \int_{-1}^{0}[u]du = \int_{-1}^{0}(-1)du = -1$. The total integral evaluated piecewise across the boundaries equals exactly 0.

Question 26 Option: (D) – p = 1, q = 3, r = -2

Explanation: The centroid of the triangle is at the origin: $\frac{2+q-5}{3} = 0 \implies q = 3$, $\frac{p-2+1}{3} = 0 \implies p = 1$, and $\frac{-3+5+r}{3} = 0 \implies r = -2$.

Question 27 Option: (B) – $(\sim p \wedge \sim q) \wedge r$

Explanation: "Sandeep neither likes tea nor coffee" is represented by $(\sim p \wedge \sim q)$, and "but enjoys a soft drink" adds the conjunction $\wedge r$, resulting in $(\sim p \wedge \sim q) \wedge r$.

Question 28 Option: (B) – 4/9

Explanation: The probability is $P(|X|<2) = \int_{-2}^{2}\frac{x+2}{18}dx = \frac{1}{18}\left[\frac{x^2}{2}+2x\right]_{-2}^{2} = \frac{1}{18}[(2+4)-(2-4)] = 8/18 = 4/9$.

Question 29 Option: (B) – $\cos^{-1}(2/3)$

Explanation: The direction vectors are $\vec{a} = (4,1,8)$ and $\vec{b} = (2,2,1)$. The angle is $\cos\theta = \frac{\vec{a}\cdot\vec{b}}{|\vec{a}||\vec{b}|} = \frac{8+2+8}{9\times3} = \frac{18}{27} = 2/3 \implies \theta = \cos^{-1}(2/3)$.

Question 30 Option: (C) – $c = \pm\sqrt{3}$

Explanation: Since they are direction cosines, the sum of their squares is equal to 1: $(1/c)^2 + (1/c)^2 + (1/c)^2 = 1 \implies 3/c^2 = 1 \implies c = \pm\sqrt{3}$.

Question 31 Option: (C) – 1/9, 1/14

Explanation: The reciprocals are in A.P.: $4, 1/a, 1/b, 19$. The common difference is $d = \frac{19-4}{3} = 5$. Thus, $1/a = 9 \implies a = 1/9$, and $1/b = 14 \implies b = 1/14$.

Question 32 Option: (B) – 0

Explanation: Using the definite integral property $\int_0^a f(x)dx = \int_0^a f(a-x)dx$ transforms the integral into its negative: $I = -I \implies 2I = 0 \implies I = 0$.

Question 33 Option: (A) – 44

Explanation: The feasible region has corner points $(6,4)$ and $(7.5,1)$. Evaluating the objective function $Z = 6x+2y$ at these points yields $Z(6,4) = 44$ (minimum) and $Z(7.5,1) = 47$.

Question 34 Option: (C) – 2.50

Explanation: The probabilities of getting X heads are $P(0) = 1/4$, $P(1) = 1/2$, $P(2) = 1/4$. The expected gain is $E[X^3] = 0^3(1/4) + 1^3(1/2) + 2^3(1/4) = 0.5 + 2 = 2.50$.

Question 35 Option: (A) – 12

Explanation: We find $\vec{c}-\vec{a} = 3\hat{i}-\hat{j}-3\hat{k}$ and $\vec{b}\times\vec{d} = 3\hat{i}+3\hat{j}-2\hat{k}$. The dot product is $(\vec{c}-\vec{a})\cdot(\vec{b}\times\vec{d}) = 3(3)-1(3)-3(-2) = 12$.

Question 36 Option: (A) – -1, 2/3
Explanation: Equating $f(x) = f(2x+1) \implies x^2 - 3x + 4 = (2x+1)^2 - 3(2x+1) + 4 \implies 3x^2 + x - 2 = 0$. Factoring gives $(3x-2)(x+1) = 0 \implies x = -1, 2/3$.

Question 37 Option: (B) – 64/3 sq. units
Explanation: The latus rectum is $x = 4$. The area in the first quadrant is given by $\int_0^4 y\, dx = \int_0^4 4\sqrt{x}\, dx = 4\left[\frac{2}{3}x^{3/2}\right]_0^4 = \frac{8}{3} \times 8 = 64/3$ sq. units.

Question 38 Option: (C) – 5m
Explanation: Perimeter is $2r + l = 20 \implies l = 20 - 2r$. Area is $A = \frac{1}{2}rl = 10r - r^2$. For maximum area, $\frac{dA}{dr} = 10 - 2r = 0 \implies r = 5$ m.

Question 39 Option: (D) – 12
Explanation: The radius of the circle is $R = \sqrt{g^2 + f^2 - c} = \sqrt{4 + 9 + k}$. Since the radius is 5, we have $13 + k = 25 \implies k = 12$.

Question 40 Option: (D) – 3x - 2y - 1 = 0
Explanation: Differentiating the curve implicitly: $4x + 6yy' = 0 \implies y' = -2/3$ at $(1, 1)$. The slope of the normal is $m = 3/2$, and its equation is $y - 1 = \frac{3}{2}(x-1) \implies 3x - 2y - 1 = 0$.

Question 41 Option: (C) – 2 units
Explanation: By converting the lines to symmetric vector form and applying the shortest distance formula between skew lines, the perpendicular distance is calculated to be exactly 2 units.

Question 42 Option: (C) – $\cos\left(\frac{y-2}{x}\right) = a$
Explanation: Integrating $\frac{dy}{dx} = \cos^{-1} a \implies y = x\cos^{-1} a + C$. Since $y(0) = 2 \implies C = 2$. Thus, $y - 2 = x\cos^{-1} a \implies \cos\left(\frac{y-2}{x}\right) = a$.

Question 43 Option: (D) – -2/25
Explanation: Differentiating the algebraic equation twice implicitly with respect to x and solving for the second derivative yields $\frac{d^2y}{dx^2} = -2/25$.

Question 44 Option: (C) – [4, 5)
Explanation: For $\cos^{-1}(y-5)$, the domain requires $-1 \le y - 5 \le 1 \implies 4 \le y \le 6$. For the denominator, $25 - y^2 > 0 \implies -5 < y < 5$. The intersection is $[4, 5)$.

Question 45 Option: (D) – $(9/10)^{20}$
Explanation: The probability of selecting a non-defective bulb is $q = \frac{90}{100} = 9/10$. The probability that none of the 20 selected bulbs is defective is $q^{20} = (9/10)^{20}$.

Question 46 Option: (B) – $1 - \pi/4$
Explanation: The integral is evaluated as: $\int_0^1 \frac{x^2}{1+x^2}dx = \int_0^1 \left(1 - \frac{1}{1+x^2}\right) dx = [x - \tan^{-1} x]_0^1 = 1 - \pi/4$.

Question 47 Option: (A) – $y = \sqrt{1-x^2} + c(1-x^2)$
Explanation: Writing the differential equation in standard linear form and calculating the integrating factor yields the general solution as $y = \sqrt{1-x^2} + c(1-x^2)$.

Question 48 Option: (D) – sin x
Explanation: Expanding both terms using standard angle sum formulas: $\sin(\pi/3 + x) - \cos(\pi/6 + x) = \left(\frac{\sqrt{3}}{2}\cos x + \frac{1}{2}\sin x\right) - \left(\frac{\sqrt{3}}{2}\cos x - \frac{1}{2}\sin x\right) = \sin x$.

Question 49 Option: (D) – y
Explanation: The infinite series represents the Taylor expansion of e^x, so $y = e^x$. The derivative of e^x is also e^x, which equals the original function y.

Question 50 Option: (C) – A = -3/2, B = 35/36
Explanation: By splitting the numerator into a linear combination of the denominator and its derivative, we determine the integration constants as $A = -3/2$ and $B = 35/36$.