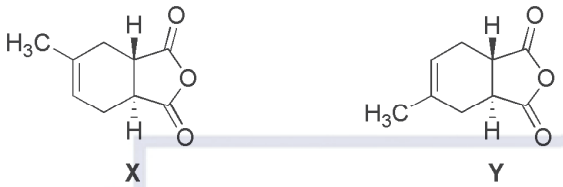
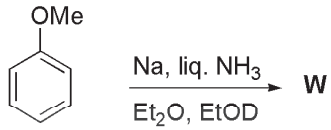
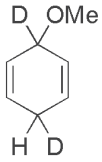
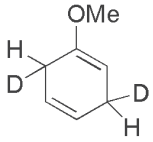
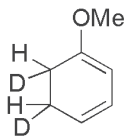
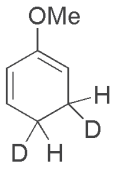
Section A: Q.1 – Q.10 Carry ONE mark each.	
Q.1	The molecule that gets inter-converted into its enantiomer, upon ring flipping in its chair conformation, is _____.
(A)	*cis*-1,2-dimethylcyclohexane
(B)	*cis*-1,3-dimethylcyclohexane
(C)	*cis*-1,4-dimethylcyclohexane
(D)	*trans*-1,2-dimethylcyclohexane
Q.2	In DNA, the number of hydrogen bonds that hold each adenine-thymine base pair and each guanine-cytosine base pair, respectively, are _____.
(A)	3 and 3
(B)	2 and 2
(C)	2 and 3
(D)	3 and 2

Q.3	The correct relationship between the molecules **X** and **Y** is that, they are _____.  **X** **Y**
(A)	regioisomers
(B)	diastereomers
(C)	enantiomers
(D)	identical molecules

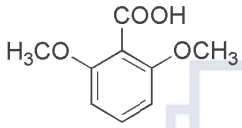
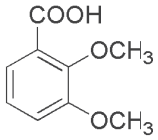
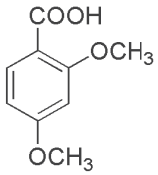
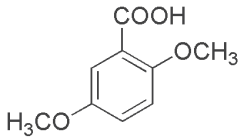
Q.4	The major product **W** formed in the following reaction is 
(A)	
(B)	
(C)	
(D)	

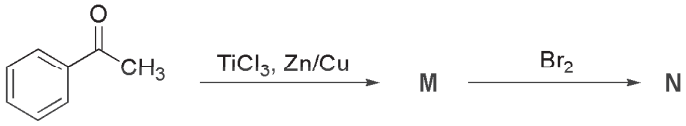
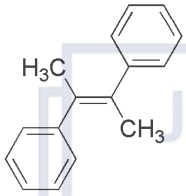
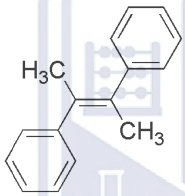
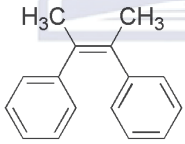
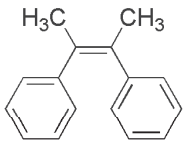
Q.5	Ellingham diagram is a plot of _____.
(A)	$\Delta_f H^o$ *versus* temperature
(B)	$\Delta_f G^o$ *versus* time
(C)	$\Delta_f G^o$ *versus* temperature
(D)	$\Delta_f H^o$ *versus* time
Q.6	The major product formed from the reaction between B_2H_6 and two equivalents of NH_3 at 300 °C is
(A)	$BH_3 \cdot NH_3$
(B)	$[NH_4]^+ [BH_4]^-$
(C)	$[(H_3N)_2BH]^{2+} 2[BH_4]^-$
(D)	$(HBNH)_3$

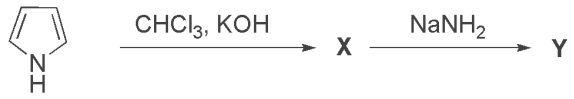
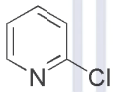
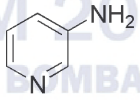
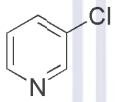
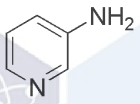
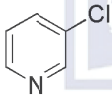
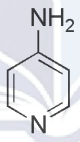
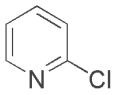
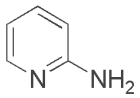
Q.7	The metal that is used as a catalyst in the synthesis of $(CH_3)_2SiCl_2$ in Rochow-Müller process is
(A)	Cu
(B)	Zn
(C)	Sn
(D)	Fe
Q.8	The molecule that has ONLY one lone pair of electrons on xenon is
(A)	XeF_2
(B)	XeF_4
(C)	XeO_2F_2
(D)	XeO_3F_2

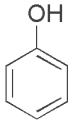
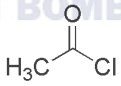
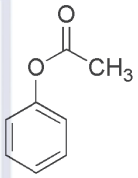
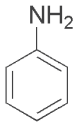
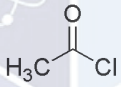
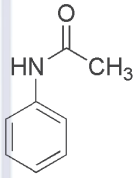
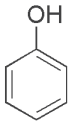
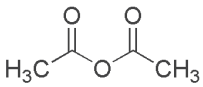
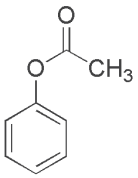
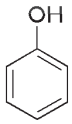
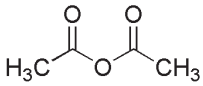
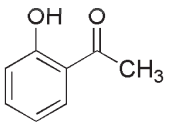
Q.9	For first-order diffraction, the smallest value of d_{hkl} that can be detected with X-ray having a wavelength of 1.54 Å is _____ Å.
(A)	0.38
(B)	0.77
(C)	1.02
(D)	2.05
Q.10	For an ideal gas, the isothermal compressibility $\left[\kappa_T = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T\right]$ is
(A)	$\frac{1}{P}$
(B)	$\frac{1}{T}$
(C)	$\frac{nR}{P}$
(D)	nRT

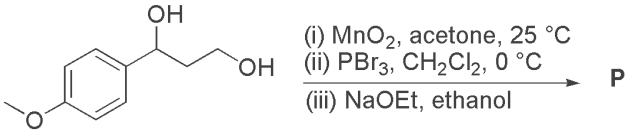
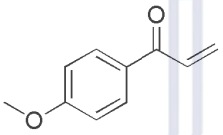
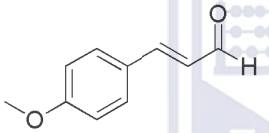
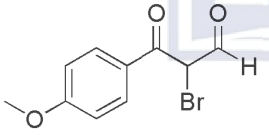
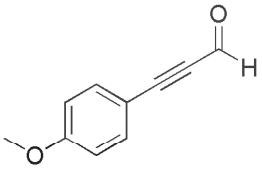
Section A: Q.11 – Q.30 Carry TWO marks each.	
Q.11	The Lennard-Jones (LJ) potential of interaction between two molecules as a function of distance (r), is given by $V_{LJ}(r) = 4\epsilon\left[\left(\frac{\sigma}{r}\right)^{12} - \left(\frac{\sigma}{r}\right)^{6}\right]$, where ϵ and σ are constants. The expression of r at which $V_{LJ}(r)$ reaches minimum is
(A)	$\left(\frac{11}{6}\right)^{1/4}\sigma^{3/2}$
(B)	$2^{1/6}\sigma$
(C)	σ
(D)	$4^{1/5}\epsilon^{1/6}$

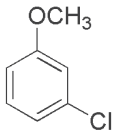
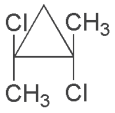
Q.12	The ^{1}H-NMR spectral data of a compound **X** is as follows: δ (ppm): 11.6 (s, 1H, exchangeable with D_2O), 7.60 (d, 1H, J = 7.2 Hz), 7.20 (t, 1H, J = 7.2 Hz), 6.90 (d, 1H, J = 7.2 Hz), 3.70 (s, 3H), 3.58 (s, 3H). Based on the spectral data, choose the appropriate structure for compound **X**.
(A)	
(B)	
(C)	
(D)	

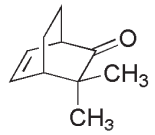
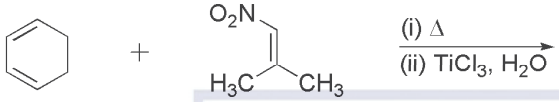
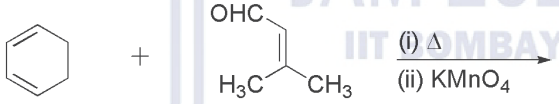
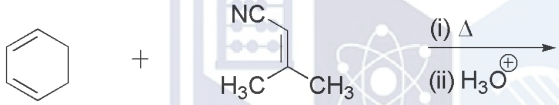
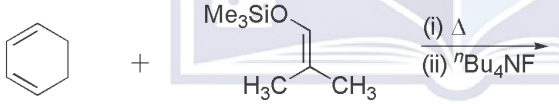
Q.13	The major products **M** and **N** formed in the following reaction sequence are 
(A)	**M** =  **N** = *meso*-2,3-dibromo-2,3-diphenylbutane
(B)	**M** =  **N** = *racemic*-2,3-dibromo-2,3-diphenylbutane
(C)	**M** =  **N** = *racemic*-2,3-dibromo-2,3-diphenylbutane
(D)	**M** =  **N** = *meso*-2,3-dibromo-2,3-diphenylbutane

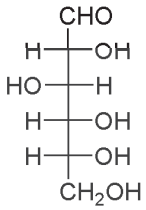
Q.14	The major products **X** and **Y** formed in following reaction sequence are 
(A)	**X** =  **Y** = 
(B)	**X** =  **Y** = 
(C)	**X** =  **Y** = 
(D)	**X** =  **Y** = 

Q.15	A mono-substituted aromatic compound **P** decolourizes bromine water, gives a purple red colour with aqueous $FeCl_3$ and is also soluble in aqueous NaOH. Compound **P** undergoes acetylation with reagent **Q** in the presence of a base to give **R** as the major product. Reagent **Q** displays two characteristic bands at 1830 cm^{-1} and 1750 cm^{-1} in its IR spectrum. **P**, **Q** and **R** are
(A)	**P** =  **Q** =  **R** = 
(B)	**P** =  **Q** =  **R** = 
(C)	**P** =  **Q** =  **R** = 
(D)	**P** =  **Q** =  **R** = 

Q.16	The major product **P** formed in the following transformation is 
(A)	
(B)	
(C)	
(D)	

Q.17	The molecules that possess σ (plane of symmetry) as the ONLY element of symmetry are  (I)  (II) $(CH_3)_2SO$ (III) $(CH_3)_2CO$ (IV)
(A)	**II** and **IV**
(B)	**I** and **IV**
(C)	**III** and **IV**
(D)	**I** and **III**

Q.18	Reaction that yields **P** as the major product is **P** = 
(A)	
(B)	
(C)	
(D)	

Q.19	D-Glucose (structure given below) and its stereoisomers undergo oxidation with conc. HNO_3 to give the corresponding dicarboxylic acids. The number of stereoisomers of glucose that would give *meso*-dicarboxylic acid is  D-Glucose
(A)	2
(B)	4
(C)	6
(D)	8

Q.20	Among the following, the one that has the lowest melting point is
(A)	$LiBr$
(B)	$AlBr_3$
(C)	$NaBr$
(D)	$MgBr_2$
Q.21	The correct order of F—M—F bond angle of compounds given in the options is (where M represents the central element)
(A)	$XeF_2 > BF_3 > OF_2 > [NF_4]^+$
(B)	$XeF_2 > BF_3 > [NF_4]^+ > OF_2$
(C)	$BF_3 > XeF_2 > [NF_4]^+ > OF_2$
(D)	$XeF_2 > OF_2 > BF_3 > [NF_4]^+$

Q.22	The correct order of bond length between carbon and oxygen atoms in the metal carbonyls given in the options is
(A)	$Na_2[Fe(CO)_4] > Na[Co(CO)_4] > [Ni(CO)_4]$
(B)	$[Ni(CO)_4] > Na[Co(CO)_4] > Na_2[Fe(CO)_4]$
(C)	$Na_2[Fe(CO)_4] > [Ni(CO)_4] > Na[Co(CO)_4]$
(D)	$[Ni(CO)_4] > Na_2[Fe(CO)_4] > Na[Co(CO)_4]$
Q.23	The solid having the least packing efficiency is _____.
(A)	caesium chloride
(B)	cadmium iodide
(C)	zinc sulfide (wurtzite form)
(D)	zinc sulfide (zinc blende form)

Q.24	The ligand to metal charge transfer (LMCT) transition energy of the given ions follows the order
(A)	$[WO_4]^{2-} > [MoO_4]^{2-} > [CrO_4]^{2-}$
(B)	$[CrO_4]^{2-} > [MoO_4]^{2-} > [WO_4]^{2-}$
(C)	$[MoO_4]^{2-} > [CrO_4]^{2-} > [WO_4]^{2-}$
(D)	$[MoO_4]^{2-} > [WO_4]^{2-} > [CrO_4]^{2-}$
Q.25	The species that has 'T' shape is
(A)	PCl_3
(B)	$SOCl_2$
(C)	BrF_3
(D)	$[IO_3]^-$

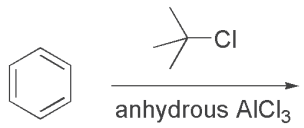
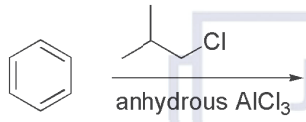
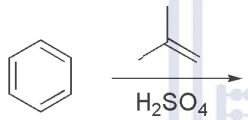
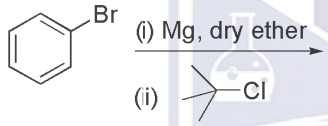
Q.26	The correct pair in which both the complex ions show the ground state electronic degeneracy is
(A)	$[TiF_6]^{2-}$ and $[Ti(H_2O)_6]^{2+}$
(B)	$[Fe(CN)_6]^{4-}$ and $[Mn(CN)_6]^{3-}$
(C)	$[Ti(H_2O)_6]^{2+}$ and $[Mn(CN)_6]^{3-}$
(D)	$[Fe(CN)_6]^{4-}$ and $[TiF_6]^{2-}$
Q.27	The complex having the lowest molar extinction coefficient is
(A)	$Na_2[Ni(Br)_4]$
(B)	$[Cr(NH_3)_6]SO_4$
(C)	$Na_2[Co(Cl)_4]$
(D)	$[Mn(H_2O)_6]SO_4$

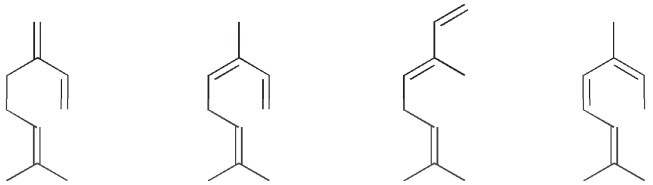
Q.28	For the reaction $NO_2Cl \rightarrow NO_2 + \frac{1}{2}Cl_2$, the proposed mechanism involves the following two elementary steps: $NO_2Cl \overset{k_1}{\rightarrow} NO_2 + Cl$ $NO_2Cl + Cl \overset{k_2}{\rightarrow} NO_2 + Cl_2$ Assuming steady state approximation for Cl, the correct expression for the rate of formation of NO_2 is
(A)	$\frac{d[NO_2]}{dt} = 2k_1[NO_2Cl]$
(B)	$\frac{d[NO_2]}{dt} = \left(\frac{k_1}{k_2}\right)[NO_2Cl]$
(C)	$\frac{d[NO_2]}{dt} = (k_1 + k_2)[NO_2Cl]$
(D)	$\frac{d[NO_2]}{dt} = (k_1k_2)[NO_2Cl]$

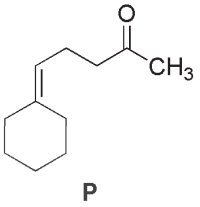
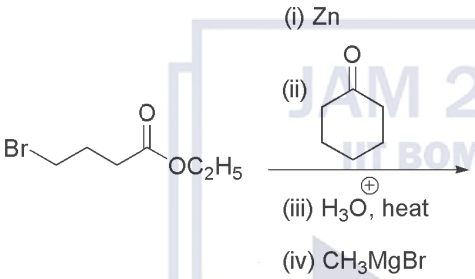
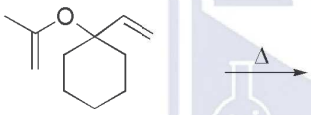
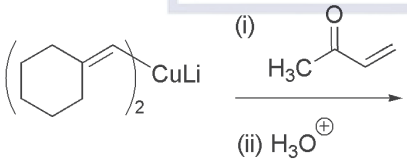
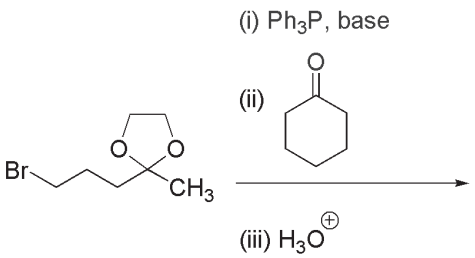
Q.29	In the van der Waals equation of state, the volume correction factor (b) arises from the repulsive interactions between the gas molecules. Considering the molecules to behave as hard spheres of radius r, $b = \mathbf{Y} \times V_{molecule} \times N_A$. The value of **Y** is _____. [Given: N_A is the Avogadro's Number, $V_{molecule}$ is the volume of a gas molecule]
(A)	8
(B)	2
(C)	16
(D)	4

Q.30	For the transformation of 1 mole of an ideal gas from an initial temperature of 27 °C and an initial pressure of 1 atm to a final temperature of 327 °C and a final pressure of 17 atm, the change in enthalpy, ΔH, is _____ kJ. [Given: Molar heat capacity of the gas is $C_p(J\ K^{-1}mol^{-1}) = a + b\ T$, where $a = 20.9\ JK^{-1}mol^{-1}$, $b = 0.042\ JK^{-2}mol^{-1}$, and T is Temperature].
(A)	6.30
(B)	8.50
(C)	11.94
(D)	17.61

Section B: Q.31 – Q.40 Carry TWO marks each.	
Q.31	The possible value(s) of energy (E) obtained from setting the following determinant equal to zero is/are $\begin{vmatrix} \alpha - E & \beta & 0 \\ \beta & \alpha - E & \beta \\ 0 & \beta & \alpha - E \end{vmatrix}$
(A)	$\alpha + \sqrt{2}\,\beta$
(B)	$\alpha + \beta$
(C)	$\alpha - \sqrt{2}\,\beta$
(D)	α

Q.32	The reaction(s) that give(s) *tert*-butylbenzene as the major product is/are
(A)	
(B)	
(C)	
(D)	

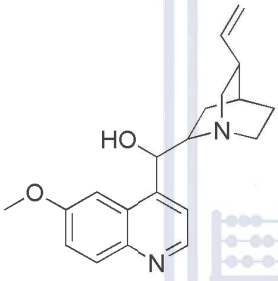
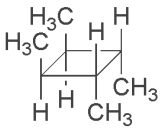
Q.33	Choose the correct statement(s) with regard to the terpenes given below.  M N O P
(A)	Upon ozonolysis, all the terpenes would produce at least one identical carbonyl compound
(B)	Terpenes **N** and **O** are geometrical isomers
(C)	Terpene **O** cannot undergo Diels-Alder reaction with maleic anhydride
(D)	Amongst all, λ_{max} for π-π^* absorption is the lowest for terpene **P**

Q.34	The reaction(s) that yield(s) **P** as the major product is/are  **P**
(A)	
(B)	
(C)	
(D)	

Q.35	Set(s) of reagents that convert(s) benzoyl chloride to aniline is/are
(A)	(i) NH_3; (ii) Br_2, NaOH; (iii) H_2O
(B)	(i) CH_2N_2; (ii) H_2O
(C)	(i) NaN_3; (ii) H_2O
(D)	(i) NH_2OH; (ii) TsCl, Pyridine; (iii) NaOH, Δ; (iv) H_2O
Q.36	The reactions of Li, Na and K with an excess of oxygen results in the formation of **X**, **Y** and **Z** respectively, as major products. The correct option(s) is/are
(A)	**X** is an oxide, **Y** is a peroxide and **Z** is a superoxide
(B)	**X** and **Y** are diamagnetic but **Z** is paramagnetic
(C)	**X** is an oxide, **Y** is a superoxide and **Z** is a peroxide
(D)	aqueous solutions of **X**, **Y** and **Z** are basic in nature

Q.37	Choose the correct option(s) with regard to haemoglobin (Hb)
(A)	Hb binds oxygen in a co-operative process
(B)	The metal ion in oxy-Hb has a larger size than that in deoxy-Hb
(C)	Hb takes up more oxygen at pH 7.4 than at pH 6.8
(D)	The metal ion is paramagnetic in deoxy-Hb
Q.38	Choose the correct statement(s) with regard to the complexometric titration of $[Ni(H_2O)_6]^{2+}$ ion with a complexing agent Na_2H_2EDTA, using a suitable indicator under basic conditions.
(A)	The correct choice of indicator is phenolphthalein
(B)	The stoichiometry of nickel and EDTA ions in the metal complex formed between metal and complexing agent is 1:1
(C)	The binding constant for the complex formed between metal ion and complexing agent is higher than that for the complex formed between metal ion and indicator
(D)	The stoichiometry of nickel and EDTA ions in the metal complex formed between metal and complexing agent is 1:3

Q.39	The correct statement(s) for graphite is/are
(A)	It shows lubricating property
(B)	Each carbon atom of graphite is *sp*-hybridized
(C)	It conducts electricity
(D)	The thermal conductivity of graphite is higher than that of diamond
Q.40	The Langmuir isotherm for the adsorption of a gas on a solid surface can be expressed as $\theta = \frac{K\,p}{1 + K\,p}$. The correct statement(s) about this isotherm is/are [Given: θ is the fractional coverage; p is the pressure of the gas; K is a constant]
(A)	At very low pressures, plot of θ against p is a straight line passing through the origin with slope equal to K
(B)	At very high pressures, plot of θ against p is a straight line parallel to the x-axis with the value of the y-intercept equal to 1
(C)	The Langmuir isotherm can also be expressed as $\frac{1}{\theta} = 1 + \frac{1}{K\,p}$
(D)	The Langmuir isotherm is applicable for multilayer adsorption

Section C: Q.41 – Q.50 Carry ONE mark each.	
Q.41	For the equation $y = 3x^5 + 4x^4 - 3x^3 + x^2 - 2x + 1$, the value of $\frac{d^5y}{dx^5}$ is _____. (*answer in integer*)
Q.42	The number of stereogenic centre(s) present in the given alkaloid is_____. (*answer in integer*) 
Q.43	The type(s) of chemically non-equivalent protons present in the following molecule is_____. (*answer in integer*) 
Q.44	The number of unpaired electron(s) of chromium in $[(\eta^6\text{-}C_6H_6)Cr(CO)_3]$ is _____. (*answer in integer*)

Q.45	Consider the following radioactive decay process $^{238}_{92}U \longrightarrow {}^{210}_{82}Pb + 7\,\alpha + \mathbf{m}\,\beta$ The value of **m** is_____. (*answer in integer*)
Q.46	The Debye temperatures (θ_D) of diamond and copper are 2230 K and 343 K, respectively. The maximum value of the frequency of the atomic oscillations of diamond is Y times the maximum value of the frequency of the atomic oscillations of copper. The value of Y is ____. (*rounded off to two decimal places*)
Q.47	A system consists of 110 (one hundred and ten) particles. Each particle can have only two non-degenerate energy states ϵ_1 and ϵ_2 (with $\epsilon_2 > \epsilon_1$). The energy difference between these two states is 0.10 eV. The temperature at which only 10 particles of the system will be present in the energy state ϵ_2 is ____ K. (*rounded off to two decimal places*) [Given: The value of Boltzmann's constant = 1.38×10^{-23} J K^{-1} 1 eV = 1.6×10^{-19} J]
Q.48	When 3.00 g of a substance of molar mass 250 g mol^{-1} is dissolved in 100 g of CCl_4, the boiling point of the solvent (CCl_4) will be elevated by _____ K. (*rounded off to two decimal places*) [Given: Boiling point constant, K_b, for CCl_4 = 5.00 K kg mol^{-1}]
Q.49	The number of normal modes of vibration in benzene is _____. (*answer in integer*)

Q.50	At 30 °C, the half-life for the decomposition of a compound is 100 seconds and the value of the half-life is independent of the initial concentration of the reactant. The time required for 30% of the reactant to be consumed is _____ seconds. *(rounded off to one decimal place)*
Section C: Q.51 – Q.60 Carry TWO marks each.	
Q.51	The specific rotation $[\alpha]_D^{25}$ of (*S*)-2-pentanol is +13.0 degrees. A one molar solution of (*S*)-2-pentanol is mixed with an equal volume of one molar solution of *racemic* 2-pentanol. The observed rotation, α, of the resulting solution, when measured in a polarimeter tube of path length 10 cm is_____degrees. (*rounded off to three decimal places*) (Given: Molar mass of 2-pentanol is 88 g mol^{-1})
Q.52	The number of iron atom(s) in Fe_3O_4 with an oxidation state of III along with a coordination number of six is _____. (*answer in integer*)
Q.53	The total number of P–O–P bridge(s) in the solid state structure of P_4O_8 is_____. (*answer in integer*)

Q.54	At pH 7, the reaction for the oxidation of NADH at 298 K and a pressure of 1 atm is given below: $$\mathrm{NADH} + \mathrm{H^+} + \frac{1}{2}\mathrm{O_2} \rightarrow \mathrm{NAD^+} + \mathrm{H_2O}$$ At 298 K, $E^o(\mathrm{NAD^+/NADH}) = -0.320\ V$ and $E^o(\mathrm{O_2/H_2O}) = 0.816\ V$ The standard Gibbs free energy change (ΔG^o) for this reaction is _____ kJ. (*rounded off to two decimal places*) [Given: Faraday's constant = 96500 C mol^{-1}]
Q.55	The mobility of $\mathrm{Na^+}$ ions in water at 298 K is $5.19 \times 10^{-8}\ \mathrm{m^2\ s^{-1}\ V^{-1}}$. If the effective radius of a $\mathrm{Na^+}$ ion is Y × 10^{-12} m, the value of Y is _____. (*rounded off to two decimal places*) [Given: Elementary charge = $1.6 \times 10^{-19}\ \mathrm{C}$ Viscosity of water at 298 K is 1 mPa s]
Q.56	For the dissociation reaction, $$\mathrm{N_2O_3\,(g)} \leftrightharpoons \mathrm{NO_2\,(g)} + \mathrm{NO\,(g)}$$ when 1 mole of $\mathrm{N_2O_3\,(g)}$ is allowed to reach equilibrium at 27 °C and at a total pressure of 1 bar, its degree of dissociation is found to be 0.20. The value of equilibrium constant, K_P, is _____. (*rounded off to three decimal places*)

Q.57	A free particle of mass m confined within the walls of a one-dimensional box of length a (with the potential outside the box being infinity), is in the eigenstate having quantum number $n = 4$. The magnitude of uncertainty in the measurement of momentum of the particle is $\mathrm{Y} \times \frac{h}{a}$. The value of Y is_____. (*answer in integer*) [Given: The potential V inside the box is equal to zero and h is the Planck's constant]
Q.58	The rotational spectrum of HF has equally spaced lines that are 40.9 cm^{-1} apart. The moment of inertia of HF is $\mathrm{Y} \times 10^{-47}$ kg m^2. The value of Y is _____. (*rounded off to three decimal places*) [Given: Speed of light, $c = 3 \times 10^8$ m s^{-1} Planck's constant, $h = 6.63 \times 10^{-34}$ J s]
Q.59	At a constant pressure, the entropy of mixing of 1 mole of oxygen with 3 moles of nitrogen at 25 °C is _____ J K^{-1}. (*rounded off to two decimal places*) [Given: Universal gas constant, $R = 8.314$ J mol^{-1} K^{-1} Assume that the gases behave ideally]

Q.60	If the radial wavefunction of the 3p orbital of a hydrogen-like atom is $$R_{31}(r) = \frac{1}{\sqrt{486}} \left(\frac{Z}{a_0}\right)^{3/2} (4 - \rho)e^{-\rho/2}$$ then, the radial node of the orbital is located at $Y \times \frac{a_0}{Z}$, where Y is equal to ____. (*answer in integer*) [Given: Z is the atomic number of the hydrogen-like atom a_0 is the Bohr radius $\rho = \left(\frac{2\,Z}{na_0}\right) r$, n is the principal quantum number]