Section A: Q.1 – Q.10 Carry ONE mark each.

Q.1 The reagent required for the following transformation

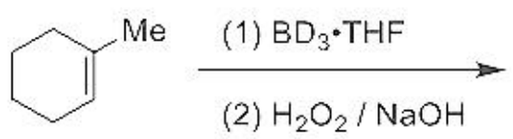
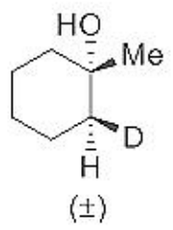
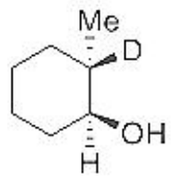
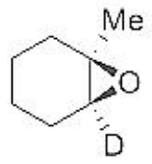
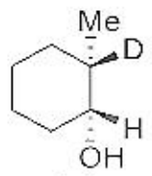
is

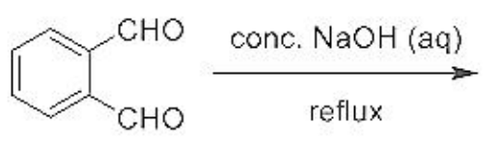
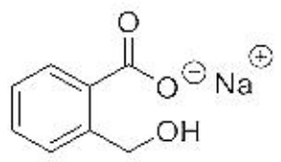
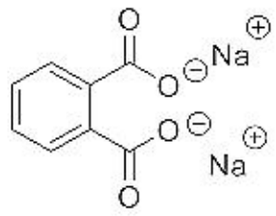
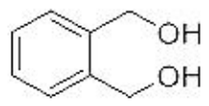
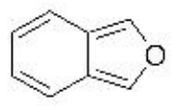
(A) $NaBH_4$

(B) $LiAlH_4$

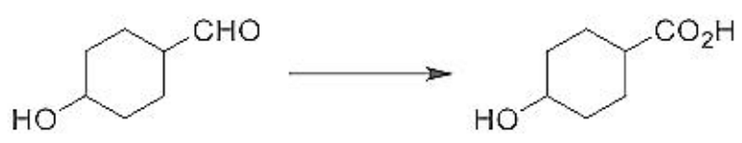
(C) $H_3B{\cdot}THF$

(D) Zn(Hg)/HCl

Q.2	The major product formed in the following reaction  is
(A)	 (±)
(B)	 (±)
(C)	 (±)
(D)	 (±)

Q.3	The major product formed in the following reaction  is
(A)	
(B)	
(C)	
(D)	

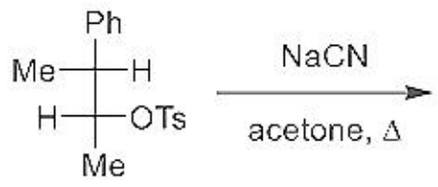
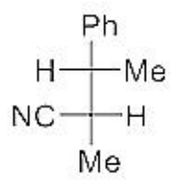
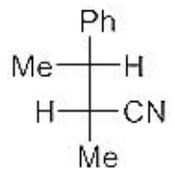
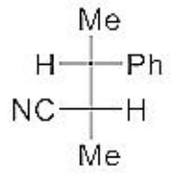
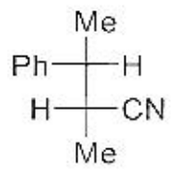
Q.4	The major product formed in the following reaction $K + O_2 \rightarrow$ is
(A)	K_2O
(B)	K_2O_2
(C)	KO_2
(D)	K_2O_3

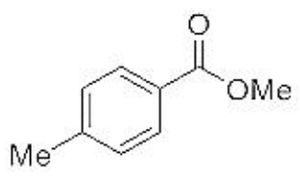
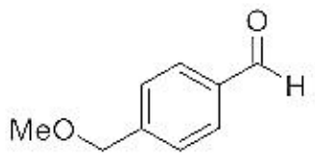
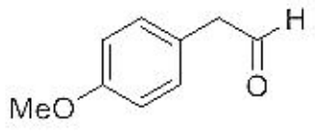
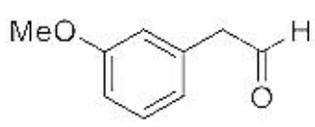
Q.5	Which one of the following options is best suited for effecting the transformation? 
(A)	MnO_2
(B)	DMSO, $(COCl)_2$, Et_3N
(C)	$Al(O\textit{i}\text{-}Pr)_3$
(D)	Ag_2O/NH_4OH

Q.6	The structure of $[XeF_8]^{2-}$ is
(A)	cubic
(B)	hexagonal bipyramid
(C)	square antiprism
(D)	octagonal

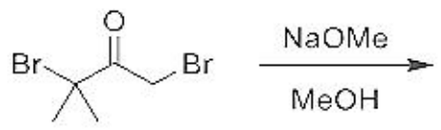
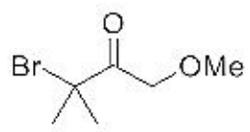
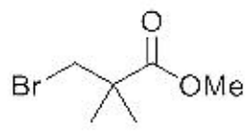
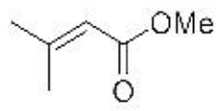
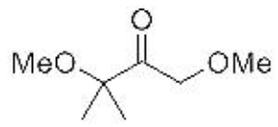
Q.7	Among the following, the compound that forms the strongest hydrogen bond is
(A)	HF
(B)	HCl
(C)	HBr
(D)	HI
Q.8	Among the following, the biomolecule with a direct metal-carbon bond is
(A)	coenzyme B_{12}
(B)	nitrogenase
(C)	chlorophyll
(D)	hemoglobin

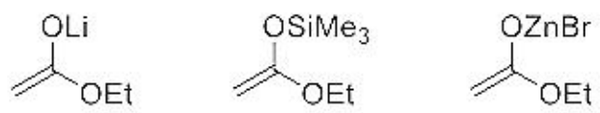
Q.9	For the reaction $H_2PO_2^-(aq) + OH^-(aq) \rightarrow HPO_3^{2-}(aq) + H_2(g)$ the rate expression is $k[H_2PO_2][OH^-]^2$. If the concentration of $H_2PO_2^-$ is doubled, the rate is
(A)	tripled
(B)	halved
(C)	doubled
(D)	unchanged
Q.10	The nature of interaction involved at the gas-solid interface in physisorption is
(A)	ionic
(B)	van der Waals
(C)	hydrogen bonding
(D)	covalent

Section A: Q.11 – Q.30 Carry TWO marks each.	
Q.11	The major product formed in the following reaction  is
(A)	
(B)	
(C)	
(D)	

Q.12	An organic compound having molecular formula $C_9H_{10}O_2$ exhibits the following spectral characteristics: ^1H NMR: δ 9.72 (t, 1H), 7.1 (d, 2H), 6.7 (d, 2H), 3.8 (s, 3H), 3.6 (d, 2H) IR: ~1720 cm^{-1} The most probable structure of the compound is
(A)	
(B)	
(C)	
(D)	

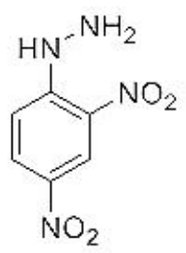
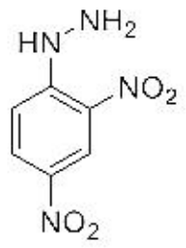
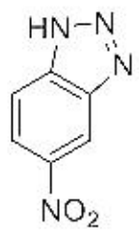
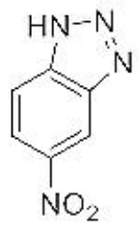
Q.13	The major product formed in the reaction of (2*S*,3*R*)-2-chloro-3-phenylbutane with NaOEt in EtOH is
(A)	(*E*)-2-phenyl-but-2-ene
(B)	(*Z*)-2-phenyl-but-2-ene
(C)	3-phenyl-but-1-ene
(D)	(2*R*,3*R*)-2-ethoxy-3-phenylbutane

Q.14	The major product formed in the following reaction  is
(A)	
(B)	
(C)	
(D)	

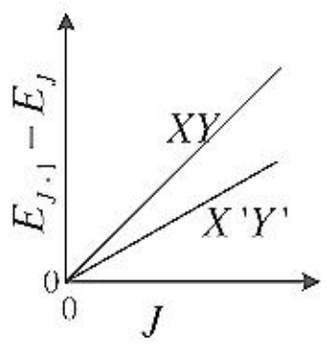
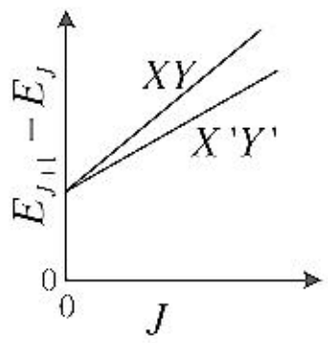
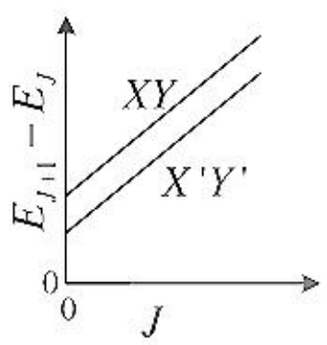
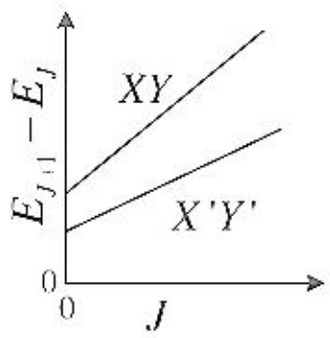
Q.15	The reactivity of the enol derivatives  **I** **II** **III** towards benzaldehyde follows the order
(A)	**I > II > III**
(B)	**III > II > I**
(C)	**II > I > III**
(D)	**I > III > II**
Q.16	All possible lattice types are observed in the
(A)	cubic crystal system
(B)	monoclinic crystal system
(C)	tetragonal crystal system
(D)	orthorhombic crystal system

Q.17	The structure types of $B_{10}H_{10}^{2-}$ and $B_{10}H_{14}$, respectively, are
(A)	*closo* and *nido*
(B)	*nido* and *arachno*
(C)	*nido* and *closo*
(D)	*closo* and *arachno*
Q.18	The ground state and the maximum number of spin-allowed electronic transitions possible in a Co^{2+} tetrahedral complex, respectively, are
(A)	$^4A_2$ and 3
(B)	$^4T_1$ and 2
(C)	$^4A_2$ and 2
(D)	$^4T_1$ and 3

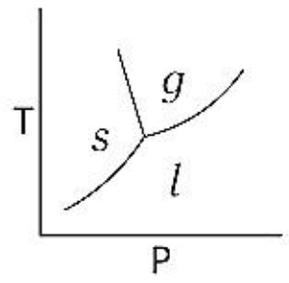
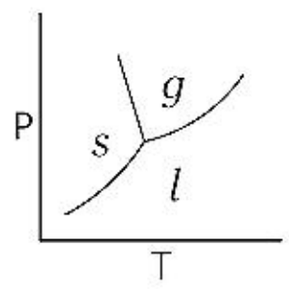
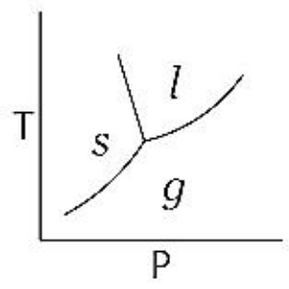
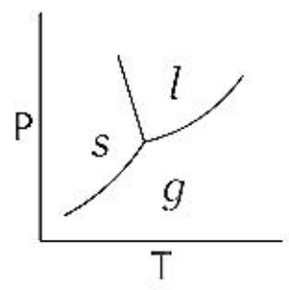
Q.19	The correct statement about the geometries of BH_2^+ and NH_2^+ based on valence shell electron pair repulsion (VSEPR) theory is
(A)	both BH_2^+ and NH_2^+ are trigonal planar
(B)	BH_2^+ is linear and NH_2^+ is trigonal planar
(C)	BH_2^+ is trigonal planar and NH_2^+ is linear
(D)	both BH_2^+ and NH_2^+ are linear
Q.20	The order of increasing CO stretching frequencies in $[Co(CO)_4]^-$, $[Cu(CO)_4]^+$, $[Fe(CO)_4]^{2-}$ and $[Ni(CO)_4]$ is
(A)	$[Cu(CO)_4]^+ < [Ni(CO)_4] < [Co(CO)_4] < [Fe(CO)_4]^{2-}$
(B)	$[Fe(CO)_4]^{2-} < [Co(CO)_4]^- < [Ni(CO)_4] < [Cu(CO)_4]^+$
(C)	$[Co(CO)_4]^- < [Fe(CO)_4]^2 < [Cu(CO)_4]^+ < [Ni(CO)_4]$
(D)	$[Ni(CO)_4] < [Cu(CO)_4]^+ < [Co(CO)_4]^- < [Fe(CO)_4]^{2-}$

Q.21	The reaction of 2,4-dinitrofluorobenzene with hydrazine produces a yellow orange solid **X** used for the identification of an organic functional group **G**. **X** and **G**, respectively, are
(A)	 and carboxylic acid
(B)	 and aldehyde
(C)	 and aldehyde
(D)	 and carboxylic acid

Q.22	The stability of adducts $H_3B{\cdot}PF_3$, $H_3B{\cdot}NMe_3$, $H_3B{\cdot}CO$, $H_3B{\cdot}OMe_2$ follows the order
(A)	$H_3B{\cdot}OMe_2 < H_3B{\cdot}CO < H_3B{\cdot}PF_3 < H_3B{\cdot}NMe_3$
(B)	$H_3B{\cdot}PF_3 < H_3B{\cdot}CO < H_3B{\cdot}NMe_3 < H_3B{\cdot}OMe_2$
(C)	$H_3B{\cdot}CO < H_3B{\cdot}PF_3 < H_3B{\cdot}NMe_3 < H_3B{\cdot}OMe_2$
(D)	$H_3B{\cdot}PF_3 < H_3B{\cdot}CO < H_3B{\cdot}OMe_2 < H_3B{\cdot}NMe_3$

Q.23	The spacing between successive rotational energy levels of a diatomic molecule XY and its heavier isotopic analogue $X'Y'$ varies with the rotational quantum number, J, as
(A)	
(B)	
(C)	
(D)	

Q.24	The ratio of the 2p → 1s transition energy in He^+ to that in the H atom is closest to
(A)	1
(B)	2
(C)	4
(D)	8

Q.25	The phase diagram of water is best represented by
(A)	
(B)	
(C)	
(D)	

Q.26	Capillary W contains water and capillary M contains mercury. The contact angles between the capillary wall and the edge of the meniscus at the air-liquid interface in W and M are θ_W and θ_M , respectively. The contact angles satisfy the conditions
(A)	$\theta_W > 90^\circ$ and $\theta_M > 90^\circ$
(B)	$\theta_W > 90^\circ$ and $\theta_M < 90^\circ$
(C)	$\theta_W < 90^\circ$ and $\theta_M > 90^\circ$
(D)	$\theta_W < 90^\circ$ and $\theta_M < 90^\circ$

Q.27	The Maxwell-Boltzmann distribution $f(v_x)$ of one-dimensional velocities v_x at temperature T is [Given: A is a normalization constant such that $\int_{-\infty}^{\infty} f(v_x)\, dv_x = 1$, and k_B is the Boltzmann constant]
(A)	$A\exp(-mv_x^2 / 2k_BT)$
(B)	$A\exp(-mv_x^2 / k_BT)$
(C)	$Av_x^2\exp(-mv_x^2 / 2k_BT)$
(D)	$Av_x^2\exp(-mv_x^2 / k_BT)$

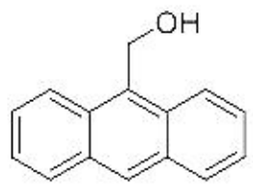
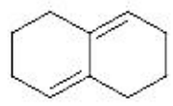
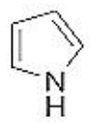
Q.28	The potential for a particle in a one-dimensional box is given as: $V(x)=0$ for $0\le x\le L$, and $V(x)=\infty$ elsewhere. The locations of the internal nodes of the eigenfunctions $\psi_n(x)$, $n\ge 2$, are [Given: m is an integer such that $0<m<n$]
(A)	$x=\frac{m+\frac{1}{2}}{n}L$
(B)	$x=\frac{m}{n}L$
(C)	$x=\frac{m}{n+1}L$
(D)	$x=\frac{m+1}{n+1}L$

Q.29	The number of CO stretching bands in the infrared spectrum of $Fe(CO)_5$ is
(A)	1
(B)	2
(C)	3
(D)	4

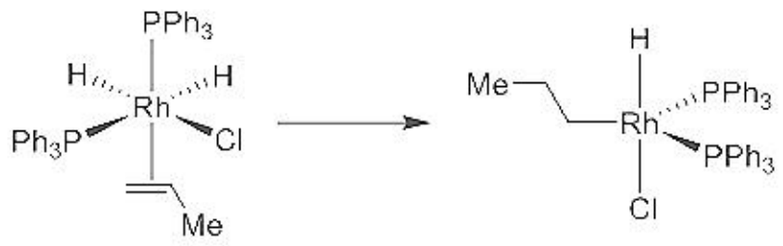
Q.30	The standard Gibbs free energy change for the reaction $H_2O\,(g) \rightarrow H_2\,(g) + \frac{1}{2}O_2\,(g)$ at 2500 K is +118 kJ mol^{-1}. The equilibrium constant for the reaction is [Given: $R = 8.314$ J K^{-1} mol^{-1}]
(A)	0.994
(B)	1.006
(C)	3.42×10^{-3}
(D)	292.12

Section B: Q.31 – Q.40 Carry TWO marks each.	
Q.31	Among the following, the reaction(s) that favor(s) the formation of the products at 25 °C is/are
(A)	
(B)	
(C)	
(D)	

Q.32	Among the following, the correct statement(s) is/are:
(A)	The first pK_a of malonic acid is lower than the pK_a of acetic acid while its second pK_a is higher than the pK_a of acetic acid.
(B)	The first pK_a of malonic acid is higher than the pK_a of acetic acid while its second pK_a is lower than the pK_a of acetic acid.
(C)	Both the first and the second pK_as of malonic acid are lower than the pK_a of acetic acid.
(D)	Both the first and the second pK_as of malonic acid are higher than the pK_a of acetic acid.

Q.33	The compound(s) that participate(s) in Diels-Alder reaction with maleic anhydride is/are
(A)	
(B)	
(C)	
(D)	

Q.34	Among the following, the suitable route(s) for the conversion of benzaldehyde to acetophenone is/are
(A)	CH_3COCl, anhydrous $AlCl_3$
(B)	(i) $HS(CH_2)_3SH$, $F_3B{\cdot}OEt_2$; (ii) n-BuLi; (iii) MeI; (iv) $HgCl_2$, $CdCO_3$, H_2O
(C)	$NaNH_2$, MeI
(D)	(i) MeMgBr; (ii) aq. acid; (iii) pyridinium chlorochromate (PCC)

Q.35	The reaction  involve(s)
(A)	migratory insertion
(B)	change in electron count of Rh from 18 to 16
(C)	oxidative addition
(D)	change in electron count of Rh from 16 to 18

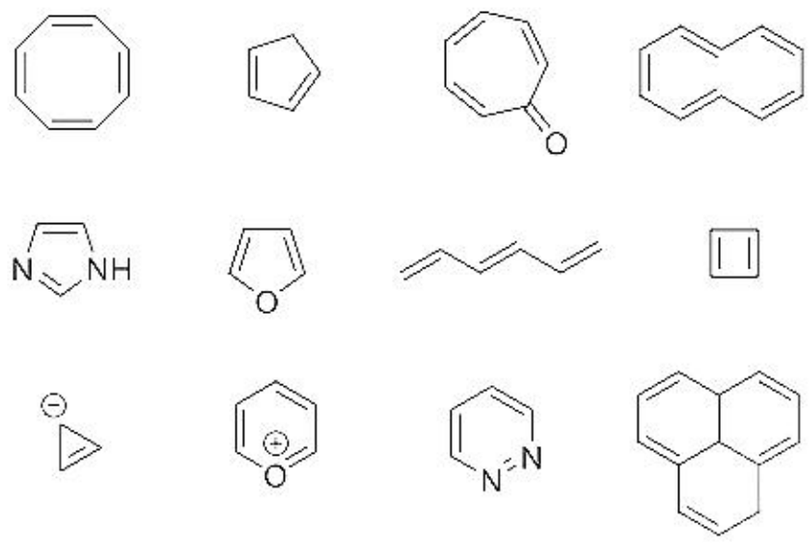
Q.36	The reason(s) for the lower stability of Si_2H_6 compared to C_2H_6 is/are
(A)	silicon is more electronegative than hydrogen
(B)	Si–Si bond is weaker than C–C bond
(C)	Si–H bond is weaker than C–H bond
(D)	the presence of low-lying d-orbitals in silicon

Q.37	For an N-atom nonlinear polyatomic gas, the constant volume molar heat capacity $C_{v,m}$ has the expected value of $3(N-1)R$, based on the principle of equipartition of energy. The correct statement(s) about the measured value of $C_{v,m}$ is/are
(A)	The measured $C_{v,m}$ is independent of temperature.
(B)	The measured $C_{v,m}$ is dependent on temperature.
(C)	The measured $C_{v,m}$ is typically lower than the expected value.
(D)	The measured $C_{v,m}$ is typically higher than the expected value.
Q.38	Zinc containing enzyme(s) is/are
(A)	carboxypeptidase
(B)	hydrogenase
(C)	carbonic anhydrase
(D)	urease

Q.39	The conversion of ICl to ICl^+ involve(s)
(A)	the removal of an electron from a π^* molecular orbital of ICl
(B)	an increase in the bond order from 1 in ICl to 1.5 in ICl^+
(C)	the formation of a paramagnetic species
(D)	the removal of an electron from a molecular orbital localized predominantly on Cl
Q.40	The common point defect(s) in a solid is/are
(A)	Wadsley defect
(B)	Schottky defect
(C)	Suzuki defect
(D)	Frenkel defect

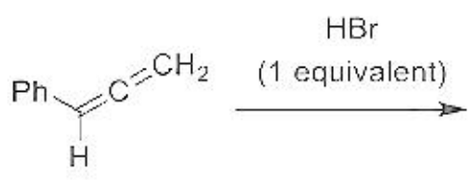
Section C: Q.41 – Q.50 Carry ONE mark each.

Q.41 Among the following

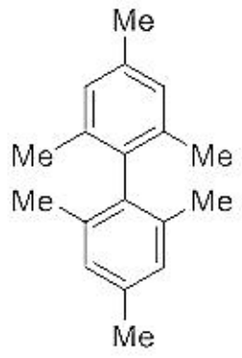
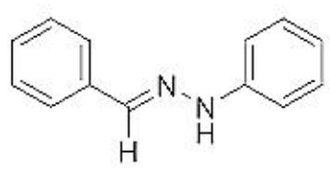


the number of aromatic compounds is _____.

Q.42 The number of stereoisomers possible for the major product formed in the reaction



is _____.

Q.43	The number of signals observed in the ^1H NMR spectrum of the compound  is _____.
Q.44	The reaction of 122 g of benzaldehyde with 108 g of phenylhydrazine gave 157 g of the product  The yield of the product is _____ %. (*round off to the nearest integer*)
Q.45	The B–B bond order in B_2 is _____.
Q.46	The number of unpaired electrons in $[Co(H_2O)_6]^{2+}$ is _____.
Q.47	The number of significant figures in 5.0820×10^2 is _____.

Q.48	The *d* spacing for the first-order X-ray (λ = 1.54 Å) diffraction event of metallic iron (*fcc*) at $2\theta = 20.2°$ is _____ Å. (*round off to three decimal places*)
Q.49	The volume fraction for an element in an *fcc* lattice is _____. (*round off to two decimal places*)
Q.50	A steady current of 1.25 A is passed through an electrochemical cell for 1.5 h using a 12 V battery. The total charge, Q, drawn during this process is _____ Coulombs. (*round off to the nearest integer*)

Section C: Q.51 – Q.60 Carry TWO marks each.	
Q.51	The specific rotation of optically pure (*R*)-1-phenylethylamine is +40 (neat, 20 °C). A synthetic sample of the same compound is shown to contain 4:1 mixture of (*S*)- and (*R*)-enantiomers. The specific rotation of the neat sample at 20 °C is _____. (*round off to the nearest integer*)
Q.52	The number of β particles emitted in the nuclear reaction $^{238}_{92}U \rightarrow {}^{206}_{82}Pb$ is _____.
Q.53	Iron is extracted from its ore via the reaction $Fe_2O_3 + 3\ CO \rightarrow 2\ Fe + 3\ CO_2$ The volume of CO (at STP) required to produce 1 kg of iron is _____ liters. (*round off to the nearest integer*) [Given: Atomic wt. of Fe = 56; assume STP to be 0 °C and 1 atm]

Q.54	Total degeneracy (number of microstates) for a Ti^{3+} ion in spherical symmetry is _____.
Q.55	A galvanic electrochemical cell made of Zn^{2+}/Zn and Cu^{2+}/Cu half-cells produces 1.10 V at 25 °C. The ratio of $[Zn^{2+}]$ to $[Cu^{2+}]$ is maintained at 1.0. The $\Delta G°$ for the reaction when 1.0 mol of Zn gets dissolved is _____ kJ. (*round off to the nearest integer*) [Given: Faraday's constant = 96485 C mol^{-1}]
Q.56	At constant volume, 1.0 kJ of heat is transferred to 2 moles of an ideal gas at 1 atm and 298 K. The final temperature of the ideal gas is _____ K. (*round off to one decimal place*) [Given: R = 8.314 J K^{-1} mol^{-1}]
Q.57	Two close lying bands in a UV spectrum occur at 274 nm and 269 nm. The magnitude of the energy gap between the two bands is _____ cm^{-1}. (*round off to the nearest integer*)

Q.58	The pH of an aqueous buffer prepared using CH_3COOH and $CH_3COO\ Na^+$ is 4.80. The quantity $\frac{[CH_3COO^-] - [CH_3COOH]}{[CH_3COOH]}$ is _____. (*round off to three decimal places*) [Given: pK_a of CH_3COOH in water is 4.75]
Q.59	At constant temperature, 6.40 g of a substance dissolved in 78 g of benzene decreases the vapor pressure of benzene from 0.125 atm to 0.119 atm. The molar mass of the substance is _____ g mol^{-1}. (*round off to one decimal place*) [Given: Mol. wt. of benzene = 78 g mol^{-1}]
Q.60	For a van der Waals gas, the critical temperature is 150 K and the critical pressure is 5×10^6 Pa. The volume occupied by each gas molecule is _____ $Å^3$. (*round off to two decimal places*) [Given: $R = 8.314$ J mol^{-1} K^{-1}, $N_A = 6.023\times10^{23}$]