Paper Specific Instructions

1. The examination is of 3 hours duration. There are a total of 60 questions carrying 100 marks. The entire paper is divided into three sections, **A**, **B** and **C**. All sections are compulsory. Questions in each section are of different types.

2. **Section – A** contains a total of 30 **Multiple Choice Questions (MCQ).** Each MCQ type question has four choices out of which only **one** choice is the correct answer. Questions Q.1 – Q.30 belong to this section and carry a total of 50 marks. Q.1 – Q.10 carry 1 mark each and Questions Q.11 – Q.30 carry 2 marks each.

3. **Section – B** contains a total of 10 **Multiple Select Questions (MSQ).** Each MSQ type question is similar to MCQ but with a difference that there may be **one or more than one** choice(s) that are correct out of the four given choices. The candidate gets full credit if he/she selects all the correct answers only and no wrong answers. Questions Q.31 – Q.40 belong to this section and carry 2 marks each with a total of 20 marks.

4. **Section – C** contains a total of 20 **Numerical Answer Type (NAT)** questions. For these NAT type questions, the answer is a real number which needs to be entered using the virtual keyboard on the monitor. No choices will be shown for these type of questions. Questions Q.41 – Q.60 belong to this section and carry a total of 30 marks. Q.41 – Q.50 carry 1 mark each and Questions Q.51 – Q.60 carry 2 marks each.

5. In all sections, questions not attempted will result in zero mark. In **Section – A** (MCQ), wrong answer will result in **NEGATIVE** marks. For all 1 mark questions, 1/3 marks will be deducted for each wrong answer. For all 2 marks questions, 2/3 marks will be deducted for each wrong answer. In **Section – B** (MSQ), there is **NO NEGATIVE** and **NO PARTIAL** marking provisions. There is **NO NEGATIVE** marking in **Section – C** (NAT) as well.

6. Only Virtual Scientific Calculator is allowed. Charts, graph sheets, tables, cellular phone or other electronic gadgets are **NOT** allowed in the examination hall.

7. The Scribble Pad will be provided for rough work.

SECTION – A

MULTIPLE CHOICE QUESTIONS (MCQ)

Q. 1 – Q.10 carry one mark each.

Q.1 On hydrolysis, aluminium carbide produces

(A) CH_4 (B) C_2H_6 (C) C_2H_4 (D) C_2H_2

Q.2 Carbonic anhydrase is an example of

(A) Hydrolysis enzyme (B) Redox enzyme
(C) O_2 transport protein (D) Heme protein

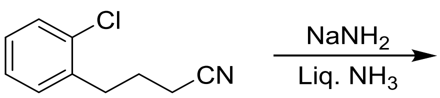
Q.3 The **CORRECT** order of melting points of group 15 trifluorides is

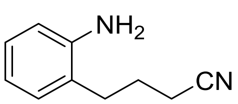
(A) $PF_3 < AsF_3 < SbF_3 < BiF_3$ (B) $BiF_3 < SbF_3 < PF_3 < AsF_3$
(C) $PF_3 < SbF_3 < AsF_3 < BiF_3$ (D) $BiF_3 < AsF_3 < SbF_3 < PF_3$

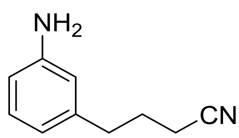
Q.4 NaF, KF, MgO and CaO are crystalline solids. They have NaCl structure. Their lattice energies vary in the order

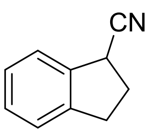
(A) NaF < KF < MgO < CaO
(B) KF < NaF < CaO < MgO
(C) MgO < CaO < NaF < KF
(D) CaO < MgO < KF < NaF

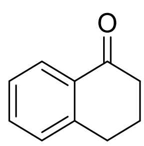
Q.5 The major product formed in the following reaction is



(A) 

(B) 

(C) 

(D) 

Q.6 The compound that contains the most acidic hydrogen is

(A) $H_2C{=}CH_2$ (B) $HC{\equiv}CH$ (C) $H_2C{=}C{=}CH_2$ (D) $H_3C{-}CH_3$

Q.7 The C-2 epimer of D-glucose is

(A) D-Mannose (B) D-Fructose (C) D-Galactose (D) D-Gulose

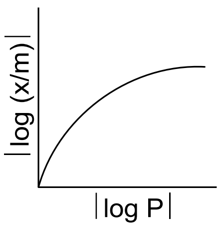
Q.8 The value of integral $\int_{-2}^{+2} x\, e^{-2x^2} dx$ is

(A) 0 (B) $\frac{1}{2}$ (C) 1 (D) 2

Q.9 The number of crystal systems and the number of Bravais lattices are, respectively,

(A) 14 and 7 (B) 7 and 32 (C) 32 and 14 (D) 7 and 14

Q.10 For adsorption of a gas on a solid surface, the plot that represents Freundlich isotherm is
(x = mass of gas, m = mass of adsorbent, P = pressure)

(A)


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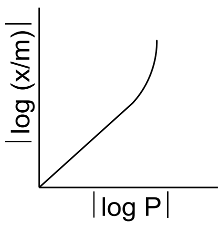

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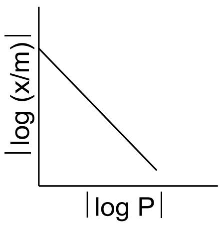

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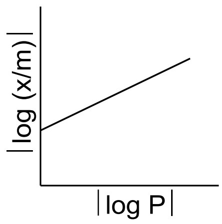


Q. 11 – Q. 30 carry two marks each.

Q.11 With respect to periodic properties, the **CORRECT** statement is

(A) Electron affinity order is F > O > Cl

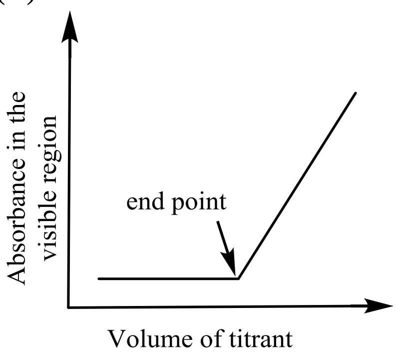
(B) First ionisation energy order is Al > Mg > K

(C) Atomic radius order is N > P > As

(D) Ionic radius order is $K^+ > Ca^{2+} > Mg^{2+}$

Q.12 Which plot represents a spectrophotometric titration, where the titrant alone absorbs light in the visible region?

(A)



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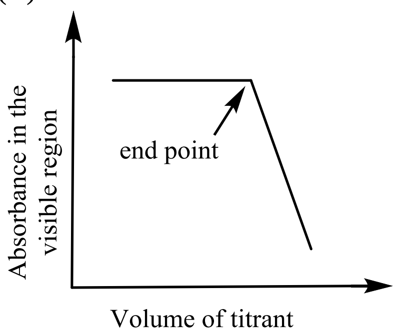
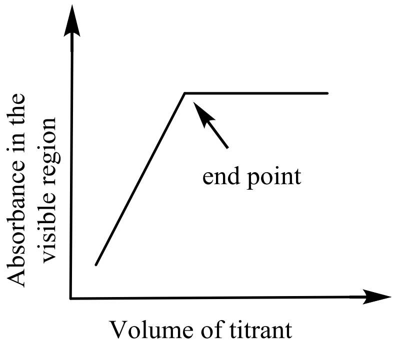
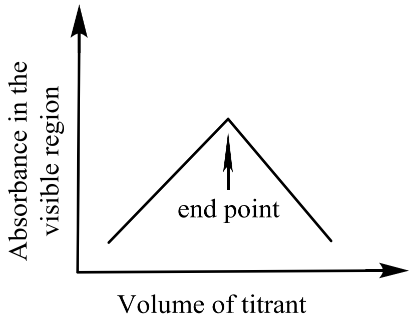


(C)



(D)



Q.13 Among the following metal carbonyl species, the one with the highest metal-carbon back bonding is

(A) $[Ti(CO)_6]^{2-}$ (B) $[V(CO)_6]^{-}$ (C) $Cr(CO)_6$ (D) $[Mn(CO)_6]^{+}$

Q.14 The **CORRECT** order of Δ_o (the octahedral crystal field splitting of d orbitals) values for the following anionic metal complexes is

(A) $[Ir(CN)_6]^{3-} < [Rh(CN)_6]^{3-} < [RhI_6]^{3-} < [CoI_6]^{3-}$

(B) $[CoI_6]^{3-} < [RhI_6]^{3-} < [Rh(CN)_6]^{3-} < [Ir(CN)_6]^{3-}$

(C) $[CoI_6]^{3-} < [Rh(CN)_6]^{3-} < [RhI_6]^{3-} < [Ir(CN)_6]^{3-}$

(D) $[Ir(CN)_6]^{3-} < [CoI_6]^{3-} < [Rh(CN)_6]^{3-} < [RhI_6]^{3-}$

Q.15 The decay modes of ^{14}C and ^{14}O are

(A) β decay

(B) positron emission

(C) β decay and positron emission, respectively

(D) positron emission and β decay, respectively

Q.16 Consider the following four xenon compounds: XeF_2, XeF_4, XeF_6 and XeO_3
The pair of xenon compounds expected to have non-zero dipole moment is

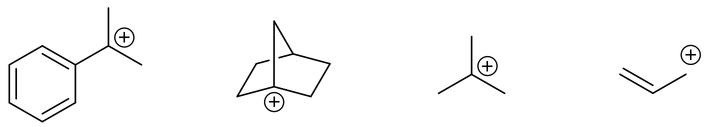
(A) XeF_4 and XeF_6

(B) XeF_2 and XeF_4

(C) XeF_2 and XeO_3

(D) XeF_6 and XeO_3

Q.17 The **CORRECT** order of stability for the following carbocations is



I II III IV

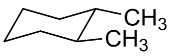
(A) I < III < IV < II

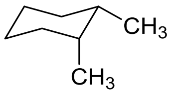
(B) III < II < IV < I

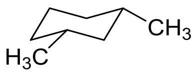
(C) II < IV < III < I

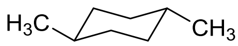
(D) IV < III < I < II

Q.18 Among the dimethylcyclohexanes, which one can be obtained in enantiopure form?

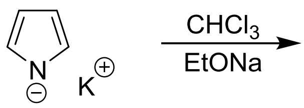
(A) 

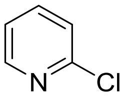
(B) 

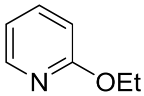
(C) 

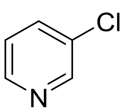
(D) 

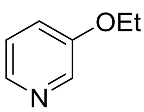
Q.19 The major product formed in the following reaction is



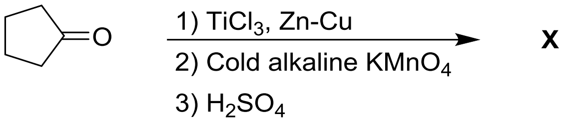
(A) 

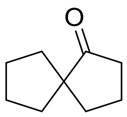
(B) 

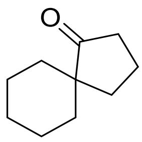
(C) 

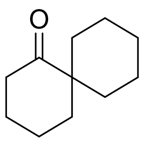
(D) 

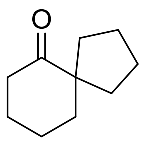
Q.20 The product **X** in the following reaction sequence is



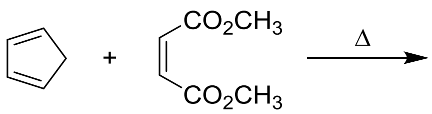
(A)


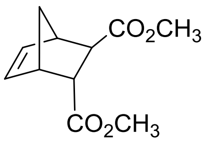
(B)


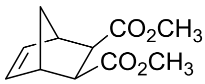
(C)


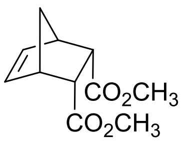
(D)


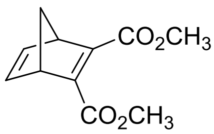
Q.21 The major product formed in the following reaction is



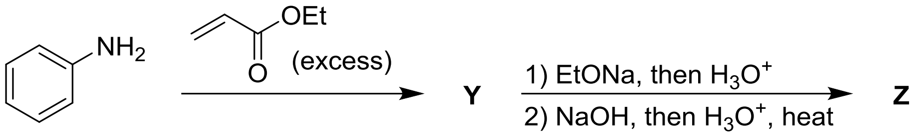
(A)


(B)


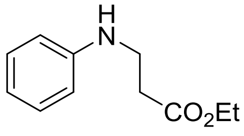
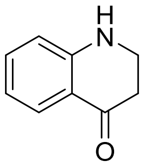
(C)


(D)


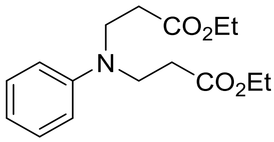
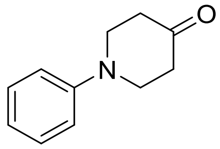
Q.22 The major products **Y** and **Z** in the following reaction sequence are



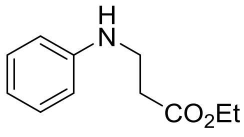
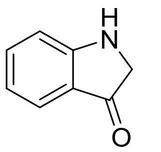
(A)

Y =  **Z** = 

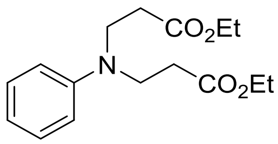
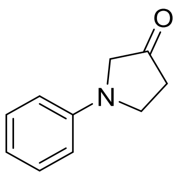
(B)

Y =  **Z** = 

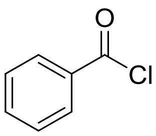
(C)

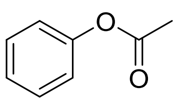
Y =  **Z** = 

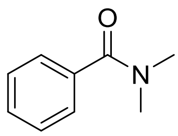
(D)

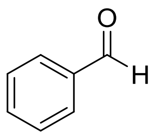
Y =  **Z** = 

Q.23 The **CORRECT** order of carbonyl stretching frequencies for the following compounds is


I


II


III


IV

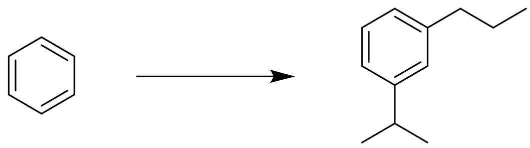
(A) II < I < III < IV

(B) I < III < II < IV

(C) IV < II < III < I

(D) III < IV < II < I

Q.24 The sequence of three steps involved in the following conversion is



(A) (i) Friedel-Crafts alkylation; (ii) Reduction; (iii) Friedel-Crafts acylation

(B) (i) Friedel-Crafts acylation; (ii) Friedel-Crafts alkylation; (iii) Reduction

(C) (i) Friedel-Crafts acylation; (ii) Reduction; (iii) Friedel-Crafts alkylation

(D) (i) Friedel-Crafts alkylation; (ii) Friedel-Crafts acylation; (iii) Reduction

Q.25 The **CORRECT** expression that corresponds to reversible and adiabatic expansion of an ideal gas is

(A) $\Delta U = 0$ (B) $\Delta H = 0$ (C) $\Delta S = 0$ (D) $\Delta G = 0$

Q.26 The electrolyte AB_2 ionises in water as

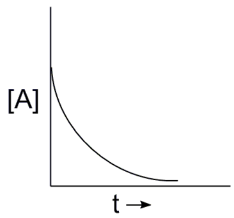
$$AB_2 \rightleftharpoons A^{2+} + 2B^-$$

The mean ionic activity coefficient $(\gamma_\pm)$ is

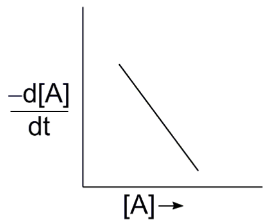
(A) $\gamma_{A^{2+}}^{\frac{1}{2}}\,\gamma_{B^-}$ (B) $\gamma_{A^{2+}}^{\frac{1}{2}}\,\gamma_{B^-}^{\frac{2}{3}}$ (C) $\gamma_{A^{2+}}^{\frac{2}{3}}\,\gamma_{B^-}^{\frac{1}{3}}$ (D) $(\gamma_{A^{2+}} + 2\gamma_{B^-})^{\frac{1}{2}}$

Q.27 The reaction, **A** $\longrightarrow$ **Products**, follows first-order kinetics. If [A] represents the concentration of reactant at time *t*, the **INCORRECT** variation is shown in

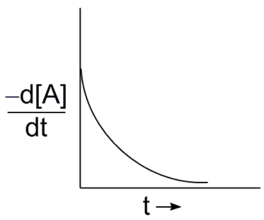
(A)



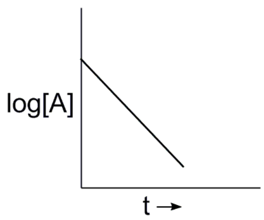
(B)



(C)



(D)



Q.28 The behavior of Cl_2 is closest to ideal gas behavior at

(A) 100 °C and 10.0 atm
(B) 0 ° C and 0.50 atm
(C) 200 °C and 0.50 atm
(D) –100 °C and 10.0 atm

Q.29 A vector $\vec{A} = \vec{\imath} + x\vec{\jmath} + 3\vec{k}$ is rotated through an angle and is also doubled in magnitude resulting in $\vec{B} = 4\vec{\imath} + (4x - 2)\vec{\jmath} + 2\vec{k}$. An acceptable value of x is

(A) 1 (B) 2 (C) 3 (D) $^4/_3$

Q.30 With reference to the variation of molar conductivity (Λ_m) with concentration for a strong electrolyte in an aqueous solution, the **CORRECT** statement is

(A) The asymmetry effect contributes to decrease Λ_m whereas the electrophoretic effect contributes to increase Λ_m
(B) The asymmetry effect contributes to increase Λ_m whereas the electrophoretic effect contributes to decrease Λ_m
(C) Both asymmetry effect and electrophoretic effect contribute to decrease Λ_m
(D) Both asymmetry effect and electrophoretic effect contribute to increase Λ_m

SECTION - B

MULTIPLE SELECT QUESTIONS (MSQ)

Q. 31 – Q. 40 carry two marks each.

Q.31 Which of the following metal(s) is(are) extracted from its(their) sulfide ore(s) by self-reduction/air reduction method?

(A) Cu (B) Al (C) Au (D) Pb

Q.32 In a saturated calomel electrode, the saturation is with respect to

(A) KCl (B) Hg_2Cl_2 (C) $HgCl_2$ (D) AgCl

Q.33 Consider the following six solid binary oxides: CaO, Al_2O_3, PbO, Cs_2O, SiO_2 and Sb_2O_3.
The pair(s) of ionic oxides is(are)

(A) CaO and Al_2O_3 (B) CaO and PbO (C) Cs_2O and Al_2O_3 (D) SiO_2 and Sb_2O_3

Q.34 Choose the **CORRECT** answer(s) with respect to the magnesium-EDTA titration carried out in the pH range 7 – 10.5, using Solochrome black as indicator

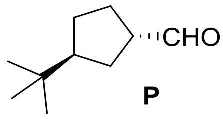
(A) Magnesium–indicator complex is more stable than the magnesium–EDTA complex

(B) At the end point, the colour changes from red to blue

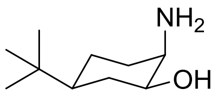
(C) After the end point, the colour of the solution is due to the indicator

(D) pH range of 7 – 10.5 is necessary for observing the specific colour change

Q.35 On reaction with $NaNO_2$ and HCl, which of the following amino alcohol(s) will yield compound **P**?



P

(A)


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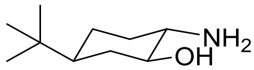
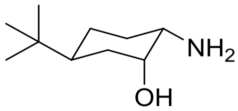
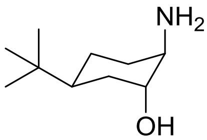


(C)


(D)


Q.36 The **CORRECT** statement(s) about carbene is(are)

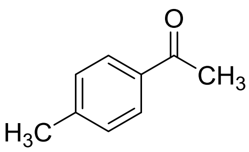
(A) Carbene is a neutral species

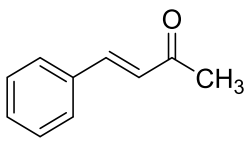
(B) Carbene is an intermediate in the Curtius rearrangement

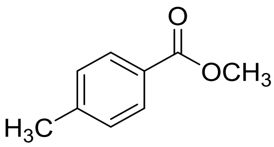
(C) Carbene can insert into both σ and π-bonds

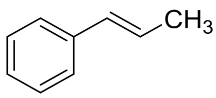
(D) Carbene is generated from amines on reaction with nitrous acid

Q.37 The compound(s) that shows(show) positive haloform test is(are)

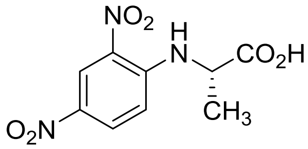
(A)


(B)


(C)


(D)


Q.38 Tetrapeptide(s) that gives(give) the following product on reaction with Sanger's reagent followed by hydrolysis is(are)



(A) Ala-Gly-Leu-Phe (B) Asp-Phe-Leu-Pro

(C) Asp-Gly-Tyr-Phe (D) Ala-Phe-Tyr-Pro

Q.39 Which of the following set(s) of quantum numbers is(are) **NOT** allowed?

(A) n = 3, l = 2, m_l = –1 (B) n = 4, l = 0, m_l = –1

(C) n = 3, l = 3, m_l = –3 (D) n = 5, l = 3, m_l = +2

Q.40 The **CORRECT** expression(s) for isothermal expansion of 1 mol of an ideal gas is(are)

(A) $\Delta A = RT\ ln \frac{V_{initial}}{V_{final}}$ (B) $\Delta G = RT\ ln \frac{V_{initial}}{V_{final}}$

(C) $\Delta H = RT\ ln \frac{V_{final}}{V_{initial}}$ (D) $\Delta S = R\ ln \frac{V_{final}}{V_{initial}}$

SECTION – C

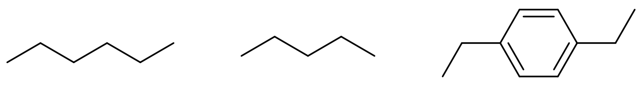
NUMERICAL ANSWER TYPE (NAT)

Q. 41 – Q. 50 carry one mark each.

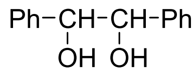
Q.41 The number of possible isomers for [Pt(py)(NH_3)BrCl] is ______. (py is pyridine)

Q.42 The volume of 0.3 M ferrous ammonium sulphate solution required for the completion of redox titration with 20 mL of 0.1 M potassium dichromate solution is ______mL.

Q.43 Among the following hydrocarbon(s), how many of them would give rise to three groups of proton NMR peaks with 2:2:3 integration ratio?



Q.44 The number of stereoisomers possible for the following compound is ______.



Q.45 The number of hydrogen bond(s) present in a guanine-cytosine base pair is ______.

Q.46 The time for 50% completion of a zero order reaction is 30 min. Time for 80% completion of this reaction is ______ min.

Q.47 Consider the reaction $CO(g) + \frac{1}{2}\,O_2(g) \longrightarrow CO_2(g)$.
The value of ΔU for the reaction at 300 K is –281.8 kJ mol^{-1}. The value of ΔH at same temperature is ______ kJ mol^{-1} (rounded up to the first decimal place).
[R = 8.3 J K^{-1} mol^{-1}]

Q.48 The nuclear spin quantum number (I) of a nucleus is $\frac{3}{2}$. When placed in an external magnetic field, the number of possible spin energy states it can occupy is ______.

Q.49 The value of **C_v** for 1 mol of N_2 gas predicted from the principle of equipartition of energy, ignoring vibrational contribution, is ______ J K^{-1} mol^{-1} (rounded up to two decimal places).
[R = 8.3 JK^{-1}mol^{-1}]

Q.50 Assuming ideal gas behavior, the density of O_2 gas at 300 K and 1.0 atm is ______ g L^{-1} (rounded up to two decimal places).
[R = 0.082 L atm mol^{-1} K^{-1}, molar mass of O_2 = 32]

Q. 51 – Q. 60 carry two marks each.

Q.51 How many of the following interhalogen species have 2 lone pairs of electrons on the central atom?

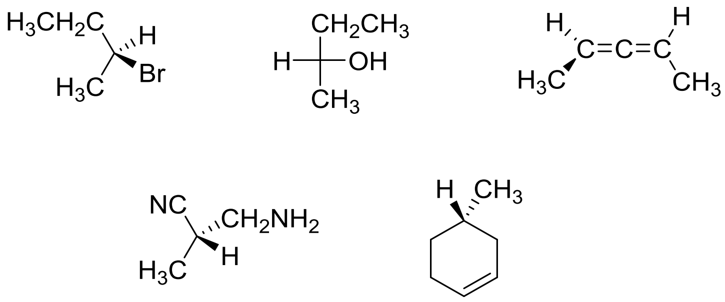
ClF_3, ClF_2^-, ClF_5 and ICl_2^+

Q.52 ^{24}Na decays to one-fourth of its initial amount in 29.8 hours. Its decay constant is_________ hour^{-1} (rounded up to four decimal places).

Q.53 The magnitude of crystal field stabilization energy (CFSE) of octahedral $[Ti(H_2O)_6]^{3+}$ complex is 7680 cm^{-1}. The wavelength at the maximum absorption (λ_{max}) of this complex is __________ nm (rounded up to the nearest integer).

Q.54 Elemental analysis of an organic compound containing C, H and O gives percentage composition: C: 39.9 % and H: 6.7 %. If the molecular weight of the compound is 180, the number of carbon atoms present in the molecule is________.

Q.55 The number of compounds having *S*-configuration among the following is _________.



Q.56 The *emf* of a standard cadmium cell is 1.02 V at 300 K. The temperature coefficient of the cell is -5.0×10^{-5} V K^{-1}. The value of $\Delta H°$ for the cell is _________ kJ mol^{-1} (rounded up to two decimal places).
[1 F = 96500 C mol^{-1}]

Q.57 For the reaction $H_2(g) + \frac{1}{2}\ O_2(g) \longrightarrow H_2O(l)$, the following information is given

T = 300 K

$\Delta\bar{H}° = -285$ kJ mol^{-1} $\qquad$ $\bar{S}^o_{H_2O}(l) = 70$ J K^{-1} mol^{-1}

$\bar{S}^o_{O_2}(g) = 204$ J K^{-1} mol^{-1} $\qquad$ $\bar{S}^o_{H_2}(g) = 130$ J K^{-1} mol^{-1}

$\Delta\bar{S}^o_{universe}$ for the reaction is ______ J K^{-1} mol^{-1}.

Q.58 For H_2 molecule, the fundamental vibrational frequency ($\bar{\upsilon}_e$) can be taken as 4400 cm^{-1}. The zero-point energy of the molecule is ______ kJ mol^{-1} (rounded up to two decimal places).
[$h = 6.6\times10^{-34}$ J s, $c = 3\times10^{8}$ m s^{-1}, $N_A = 6\times10^{23}$ mol^{-1}]

Q.59 The solubility of PbI_2 in 0.10 M KI(aq) is ______ $\times10^{-7}$ M (rounded up to two decimal places).
[The solubility product, $K_{sp} = 7.1\times10^{-9}$]

Q.60 The electron of a hydrogen atom is in its $\boldsymbol{n}^{th}$ Bohr orbit having de Broglie wavelength of 13.4 Å. The value of $\boldsymbol{n}$ is ______ (rounded up to the nearest integer).
[Radius of $\boldsymbol{n}^{th}$ Bohr orbit = $0.53\boldsymbol{n}^2$ Å, $\pi = 3.14$]

END OF THE QUESTION PAPER

Paper Code : CY			
Q. No.	**Question Type (QT)**	**Section**	**Key/Range (KY)**
1	MCQ	A	A
2	MCQ	A	A
3	MCQ	A	A
4	MCQ	A	B
5	MCQ	A	C
6	MCQ	A	B
7	MCQ	A	A
8	MCQ	A	A
9	MCQ	A	D
10	MCQ	A	D
11	MCQ	A	D
12	MCQ	A	A
13	MCQ	A	A
14	MCQ	A	B
15	MCQ	A	C
16	MCQ	A	D
17	MCQ	A	C
18	MCQ	A	A
19	MCQ	A	C
20	MCQ	A	D
21	MCQ	A	C
22	MCQ	A	B
23	MCQ	A	D

Paper Code : CY			
Q. No.	**Question Type (QT)**	**Section**	**Key/Range (KY)**
24	MCQ	A	B
25	MCQ	A	C
26	MCQ	A	Marks To All (MTA)
27	MCQ	A	B
28	MCQ	A	C
29	MCQ	A	B
30	MCQ	A	C
31	MSQ	B	A,D
32	MSQ	B	A,B
33	MSQ	B	A,C
34	MSQ	B	B,C,D
35	MSQ	B	B,C
36	MSQ	B	A,C
37	MSQ	B	A,B
38	MSQ	B	A,D
39	MSQ	B	B,C
40	MSQ	B	A,B,D
41	NAT	C	3 to 3
42	NAT	C	40 to 40
43	NAT	C	2 to 2
44	NAT	C	3 to 3
45	NAT	C	3 to 3
46	NAT	C	48 to 48

Paper Code : CY			
Q. No.	**Question Type (QT)**	**Section**	**Key/Range (KY)**
47	NAT	C	-286.0 to -282.0
48	NAT	C	4 to 4
49	NAT	C	20.00 to 21.00
50	NAT	C	1.29 to 1.31
51	NAT	C	2 to 2
52	NAT	C	0.0460 to 0.0470
53	NAT	C	520 to 521
54	NAT	C	6 to 6
55	NAT	C	4 to 4
56	NAT	C	-201.00 to -198.00
57	NAT	C	786 to 790
58	NAT	C	25.80 to 26.40
59	NAT	C	7.0 to 7.2
60	NAT	C	4 to 4