2025

CHEMISTRY — HONOURS

Paper : DSCC-2

(Fundamentals of Chemistry - II)

Full Marks : 75

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Answer ***question nos.*** **1, 2, 3** and **4** (compulsory) and ***any four*** questions from the rest (***question nos.*** **5** to **10**).

1. Anwer ***any ten*** questions : 2×10

(a) If heavier gas molecules move more slowly than light gas molecules, why is the average kinetic energy independent of mass?

(b) Give name and formula of two interfering acid radicals.

(c) Define *meso* compound with an example.

(d) Draw the one-dimensional velocity distribution curves of the molecules of an ideal gas at two different temperatures and comment on the values of the area under each curve.

(e) What are two different kinds of stoichiometric defects in solids? Give one example in each case.

(f) Draw the structures of $\overset{\oplus}{C}H_3$ and $\overset{\oplus}{C}H_5$ ions, mentioning the state of hybridization of the carbon atom in each case.

(g) Find the numerical value of the compressibility factor of a gas that obeys the equation of state,

$$P(V-nb) = nRT$$

The pressure and temperature are such that $\frac{V}{n} = 10b$.

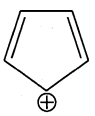
(h) Explain the order of bond angles in NF_3 and PF_3 molecules.

(i) Write down the *meso* and one optically active isomer of 2, 3, 4-trihydroxyglutaric acid.

(j) Give physical arguments explaining why the critical pressure and temperature should increase with increasing van der Waals '*a*' values.

(k) Explain the low dipole moment value ($\mu = 0.11$ D) of CO molecule.

(l) What is the increasing order of stability of the following? Give explanation.



, $Ph\overset{\oplus}{C}H_2$, $\overset{\oplus}{C}H_3$

2. Write a short note on :

(a) Collision between gas molecules (using the following points given below)

(i) Assumptions.

(ii) Frequency of binary collisions between two molecules of different gases (with derivation). 1+4

Or

(b) Intermolecular interactions (using the following points given below)

(i) Three different types of interactions and their temperature dependence with explanation.

(ii) Lennard-Jones 6-12 potential. Potential energy diagram showing Lennard-Jones parameters. (1+1+1)+(1+1)

3. Write a short note on :

(a) Formal charge (using the following points given below)

(i) Definition and expression.

(ii) Lewis structures of $C\overset{\ominus}{N}O$ and $O\overset{\ominus}{C}N$ with assignment of formal charges on each atom.

(iii) Comparative stability between the ions. (½+½)+(1½+1½)+1

Or

(b) Lattice energy (using the following points given below)

(i) Definition.

(ii) Born-Lande equation with derivation. 1+(1+3)

4. Write a short note on :

(a) Racemisation of organic compounds (using the following points given below)

(i) Definition of racemisation.

(ii) Example of racemisation via carbocation formation.

(iii) Example of racemisation via carbanion formation. 1+2+2

Or

(b) Halogenation of isobutane (using the following points given below)

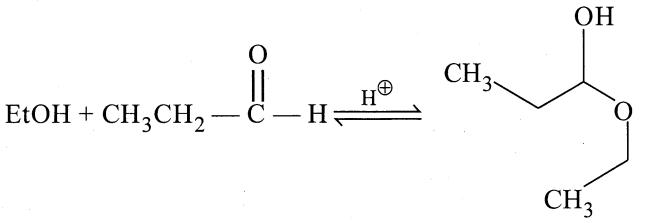
(i) Product composition during chlorination and bromination of isobutane.

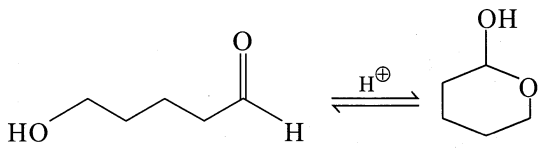
(ii) Explanation on the basis of reactivity-selectivity principle. 2+3

5. (a) The time required for a molecule to travel one mitre is $^1/_C$ in 3D space. Calculate the average time required for the molecule to travel 1 mitre, where C is the speed of gas molecules.

(b) The solubility product of CaF_2 is 4.9×10^{-11}. Calculate the solubility of CaF_2 in a solution of $0.1(M)Ca(NO_3)_2$.

(c) Explain the relative rate of the following reactions with explanation :

(i) 

(ii) 

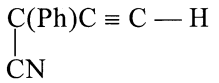
4+3+(1+2)

6. (a) Using VSEPR theory, predict the shapes of $I_3^{\ominus}$ and $I_3^{\oplus}$. Indicate the state of hybridization of the central atom in each case.

(b) What is known as principle of microscopic reversibility? Give one example of a reaction where the principle of microscopic reversibility is obeyed with plausible mechanism.

(c) What will be the ratio of final to initial wall collision frequency of an ideal gas if pressure is halved at constant gas density? (2+2)+(1+2)+3

7. (a) Draw the following as directed :

(i) *R*-isomer of 

(ii) *threo*-3 -Aminobutan-2-ol

(iii) *Z*-Isomer of 1-chloropropane

(iv) (2*S*, 3*R*)-2-Bromo-3-chlorobutane.

(b) The behaviour of two gases *A* and *B* can be approximated by van der Waals equation. The critical constants of these gases are given below :

Gas	P_C/atm	$\bar{V}_C/\text{cm}^3\text{mol}^{-1}$	T_C/K
A	81.5	81.0	324.7
B	2.26	57.76	5.21

Explain :

(i) Which gas has greater intermolecular force of attraction?

(ii) Which gas behaves more ideally at 1 atm pressure and 298K temperature?

Please Turn Over

(c) Compare the thermal stability of $BeCO_3$, $MgCO_3$ and $CaCO_3$ with explanation.
(1+1+1+1)+(1+2)+(1+2)

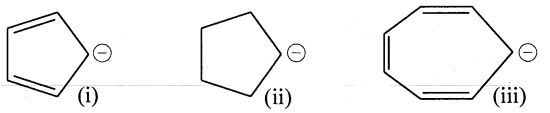
8. (a) At what temperature does the slope of Z versus P curve (at $p = 0$) have a maximum value for the van der Waals gas? What is the value of maximum slope?

(b) Mention the name of the cation present in both Group I and Group II in inorganic qualitative analysis. Give reason behind it.

(c) Draw the diastereoisomers of 1-bromo-1,2-dichloroethene and designate them as *E*/*Z* isomers.
(2+2)+(1+2)+(1½+1½)

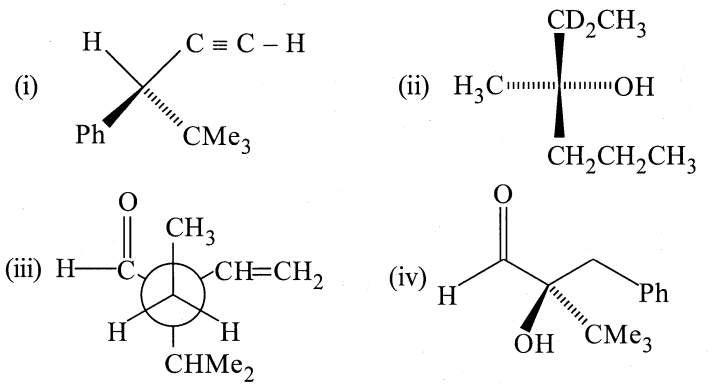
9. (a) What is common ion effect? Why NaCl and NaOH cannot be used in place of NH_4Cl and NH_4OH to precipitate the basic radicals of Group III A in inorganic qualitative analysis?

(b) Discuss the order of stability of the following carbanions with explanation.



(c) Starting with Maxwell's distribution of kinetic energy in three dimension, derive an expression for the fraction of the total number of gas molecules having energy equal to or greater than a given value (say ϵ').
(1+1½+1½)+(1+1+1)+3

10. (a) Assign R/S descriptors for the chiral centre of the following compounds mentioning the priority of ligands attached.



(b) A gas obeys the equation of state :

$$PV = RT\left(1+\frac{b}{V}\right)$$

(i) Would it be possible to liquefy the gas?

(ii) Would it have a critical temperature?

Explain your answer.

(c) In PF_5 molecule, axial P-F bonds are longer than equatorial P-F bonds. Justify.
(1+1+1+1)+(1½+1½)+3