

Ex/SC/CHEM/UG/CORE/TH/14/2025

B. Sc. CHEMISTRY EXAMINATION, 2025

(5th Semester)

CHEMISTRY (CORE)

PAPER : CORE 14

Time : Two Hours

Full Marks : 40

(20 marks for each Unit)

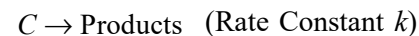
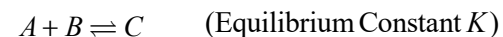
Use a separate answer script for each Unit.

The figures in the margin indicate full marks.

UNIT—5141-I

Answer ***all*** questions.

1. (a) For a mechanistic scheme of a reaction



Here, with the initial condition $[B]_0 \gg [A]_0$, how could you kinetically estimate K and k ? 4

- (b) What is/are the intrinsic difference(s) between D and I_d mechanism for a transition metal octahedral substitution reaction? Discuss. 3

(2)

- (c) KCN is insoluble in benzene but in the presence of 18-Crown-6, a nucleophilic substitution takes place using CN^- as nucleophile. Justify the reaction with appropriate mechanism. 3

2. (a) The $\nu(\text{NO})$ stretching frequency depends on the $\text{M}-\text{N}-\text{O}$ angle in the nitrosyl complexes. Comment. 2

- (b) What happen to $\nu(\text{CO})$ when CO gets coordinated to BH_3 and $\text{Ni}(\text{CO})_3$, respectively? 2

- (c) Determine the number of metal-metal bonds in $(\eta^5\text{-C}_5\text{H}_5)(\text{CO})\text{Fe}(\mu\text{-CO})_2\text{Fe}(\text{CO})(\eta^5\text{-C}_5\text{H}_5)$. 1

- (d) Interpret the $\text{C}-\text{C}$ and $\text{Pt}-\text{C}$ bond distances in $\text{Pt}(\text{C}_2\text{H}_4)\text{Cl}_3$ ($d_{\text{C}-\text{C}}$, 1.37 Å, $d_{\text{Pt}-\text{C}}$, 2.55 Å) and $\text{Pt}(\text{C}_2\text{H}_4)(\text{PPh}_3)_2$ ($d_{\text{C}-\text{C}}$, 1.43 Å, $d_{\text{Pt}-\text{C}}$, 2.11 Å) and $\text{Pt}(\text{C}_2(\text{CN})_4)(\text{PPh}_3)_2$ ($d_{\text{C}-\text{C}}$, 1.49 Å, $d_{\text{Pt}-\text{C}}$, 2.09 Å). 2½

- (e) Match the $\nu(\text{CO})$ frequency with the relevant complex with justification and comment on the nature of bonding on the nature of bonding of CO (ν_{CO} of free CO : 2143 cm^{-1}). 2½

Complex	$\nu(\text{CO})$, cm^{-1}
$[\text{V}(\text{CO})_6]^-$	1858
$[\text{Cr}(\text{CO})_6]$	2000
$[\text{Mn}(\text{CO})_6]^+$	2095

(5)

(OR)

Presence of a dielectric in a parallel plate capacitor decreases its electric field — explain.

- (d) Molar polarization of a certain vapor obeys the relation

$P_m(\text{cm}^3 \text{mol}^{-1}) = 60 + \frac{20.5}{T}(\text{K})$. Assuming ideal behavior, calculate its molar polarization, dipole moment and dielectric constant at STP.

(OR)

Outline in brief the Gouy balance method to determine the magnetic susceptibility of a substance.

$1\frac{1}{2}+1\frac{1}{2}+1\frac{1}{2}+2\frac{1}{2}$

★ ★ ★

(4)

(c) What are spherical harmonics? Verify that

$$\Phi_m(\phi) = \frac{1}{(2\pi)^{\frac{1}{2}}} \exp(im\phi) \text{ constitutes an orthonormal}$$

set for particle in a ring.

(d) Write down the Hamiltonian operator for H₂ molecule.

The Ψ_{2s} atomic orbital of hydrogen atom is given as,

$$\Psi_{2s} = \frac{1}{(32\pi a_0^3)^{\frac{1}{2}}} \left(2 - \frac{r}{a_0} \right) \exp\left(-\frac{r}{2a_0}\right). \text{ Calculate the}$$

radius of nodal surface of H atom in SI unit.

5. (a) What are the various ways by which a molecule can get polarized in the presence of an electrostatic field? How are these related?

(b) Molecules with small HOMO-LUMO gaps can be polarized easily — explain.

(c) Calculate the magnitude of dipole moment of H₂O molecule (in addition to the permanent dipole moment) induced by an applied field strength of $1.0 \times 10^5 \text{ V m}^{-1}$ (given $\alpha'(\text{H}_2\text{O}) = 1.48 \times 10^{-30} \text{ m}^3$ and $\epsilon_0 = 8.854 \times 10^{-12} \text{ J}^{-1} \text{ C}^2 \text{ m}^{-1}$).

(3)

UNIT—5142-P

3. (a) How many spectral lines are expected for 1-D SHO in the IR region? Justify your answer.

(b) Evaluate the expectation value of potential energy of the harmonic oscillator in the ground state. The ground state normalized wave-function of the harmonic

oscillator is $\Psi_0 = \left(\frac{\alpha}{\pi}\right)^{\frac{1}{4}} \exp\left(-\frac{\alpha x^2}{2}\right)$, here α is a constant. 1½+2½

4. Answer any three :

3×3

(a) Verify whether the following function is an eigenfunction

of 1-D SHO, $\Psi = x \exp\left(-\frac{\beta x^2}{2}\right)$, where $\beta = \frac{2\pi(mk)^{\frac{1}{2}}}{h}$,
 k = force constant, m = mass and h = Planck's constant.

(b) Find the probability of getting the electron for H atom in its ground state beyond the Bohr radius (a_0). Given normalized radial part of the ground state wave function,

$$R_{1s} = \frac{2}{a_0^{3/2}} \exp\left(-\frac{r}{a_0}\right).$$