Five Year Integrated M.Sc. Examination 2024

Semester - I

Course: CH-1-1-1

(Chemistry)

Full Marks: 60

Time: Three Hours

Questions are of value as indicated in the margin

Group-A

Answer ***any four*** questions

1. (a) Discuss about artificial radioactivity with appropriate example. 2
   (b) Find out the effective nuclear charge on a *d* electron having Z = 28. 2
   (c) Distinguish between orbit and orbital. 1

2. (a) An archaeological specimen containing ^{14}C gives 55 counts in 5 minutes per gram of carbon. A specimen of freshly cut wood gives 21.5 counts per gram of carbon per minute. The counter used recorded a back-ground count of 6 counts per minute in absence of any ^{14}C-containing sample. What is the age of the specimen? Given: $t_{½}$ of ^{14}C = 5730 years 2
   (b) Show the distributions of the radial functions for (i) 1s, 2s and 3s and (ii) 3s, 3p and 3d atomic orbitals in hydrogen. 2
   (c) Name two chalcogens and two halogens with their symbols. 1

3. (a) Calculate the de Broglie wavelength of a bullet ($m = 2\times10^{-3}$ kg) moving with a speed of 400 m/s. 2
   (b) Write a note on meson field theory. 2
   (c) State the demerits of the Rutherford Atom Model. 1

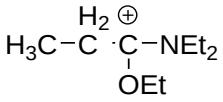
4. (a) Find out the mass defect of helium atom. 2
   Given: Mass spectrometric mass of the helium atom = 4.002603 u; mass of hydrogen = 1.007825 u and mass of neutron = 1.008665 u
   (b) What are the conditions for a wave function to be acceptable? 2
   (c) Distinguish between absorption spectra and emission spectra? 1

5. (a) Derive the expression for the radius and energy of an electron in a Bohr orbit in hydrogen like atom. 3
   (b) Name the different disintegration series (natural and artificial) specifying their starting and end products with mass and atomic numbers. 2

Group-B

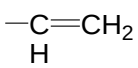
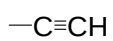
Answer ***any four*** questions

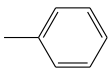
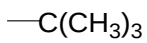
6. (a) Draw the resonating structures for the following compound. Which resonating structure is most stable and why? 2



(b) State Hückel's rule of aromaticity with a suitable example. 1

(c) Which ligand in each of the following pair has higher priority? 2

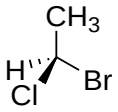
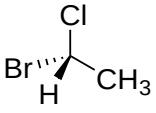
(i)  and 

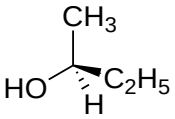
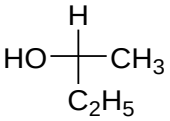
(ii)  and 

7. (a) Although N-F bonds are much polar than N-H bonds, NF_3 (0.26 D) has a smaller dipole moment than NH_3 (1.46 D). Explain. 1.5

(b) 1, 2-Dibromoethane has zero dipole moment in gaseous phase but in solution the dipole moment increases with increase in polarity of the solvent. Explain. 1.5

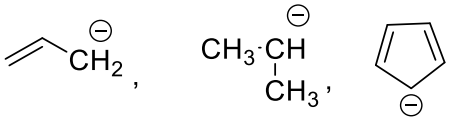
(c) Predict whether the two structures in each pair represent identical or different compounds. 2.0

(i)  and 

(ii)  and 

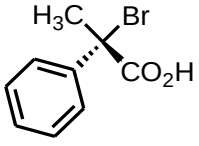
8. (a) Draw the conformational energy diagram of *n*-butane for rotation around the C_2-C_3 bond. Show all the conformers and comment on their relative stabilities. 3.5

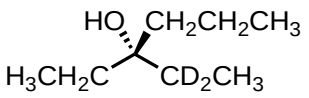
(b) Arrange the following carbanions in order of their increasing stability and explain their stability. 1.5

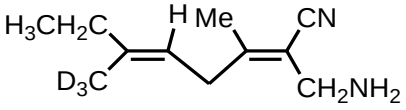


9. (a) Pure (-) enantiomer of an optically active compound **A** has a specific rotation $[\alpha]_D^{20^\circ} = -51.3^\circ$. What is the optical purity of a sample of **A** which shows a rotation -33.95°? How much of each enantiomer is present in the enantiomeric mixture? 2.0

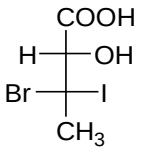
(b) Assign R/S or E/Z descriptor to the following compounds showing priority sequence of ligands. 3.0

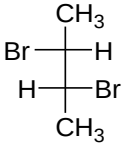
(i) 

(ii) 

(iii) 

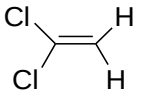
10. (a) Covert the given Fischer projection into Newman and corresponding sawhorse projection formulae. (Only staggered conformations) 2.0

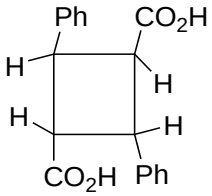
(i) 

(ii) 

(b) Define enantiomers, diastereomers, chiral. 1.5

(c) Indicate the element(s) of symmetry, if any, present in the following molecules. 1.5

(i) $CHCl_3$ (ii) 

(iii) 

Group-C

Answer ***any four*** questions

11. (a) Write the basic assumptions those are used to frame the kinetic model of the ideal gases. 1

(b) In the light of kinetic theory, show that $PV = \frac{2}{3} N \in_{tran}$, where P is the pressure, V is the volume, N is the number of molecules in the gas and $\in_{tran}$ is the average kinetic energy per molecule. 3

(c) Calculate the volume of 10 moles of methane at 100 atm pressure and 0 ^oC. At this temperature and pressure, $z = 0.75$. 1

12. The Maxwell-Boltzmann speed distribution in a gas can be described by the equation:

$$dN_v = 4\pi N \left(\frac{m}{2\pi\kappa T}\right)^{3/2} v^2 \, e^{-mv2/2kT} \partial v$$

where, m is the atomic mass, κ is the Boltzmann constant, T is the absolute temperature, N is the number of molecules and v is the molecular speed.

(a) Explain briefly what does this equation represent. 2

(b) Derive the most probable speed of the gas molecules using this expression. 2

(c) Calculate the partial pressure of 10 moles of methane and 5 moles of oxygen. Given the total pressure of the mixture is 90 atm. 1

13. (a) What is "mean free path (λ)" of a gas molecule? Derive an expression of the mean free path (λ) of a gas molecule having radius (r). Assume that there are N number of gas molecules present in a container of volume V at a pressure (P) and temperature (T). 1+2

(b) What will happen to the mean free path if the temperature of the gas is increased keeping the volume of the container constant? 1

(c) Calculate the mean free path (λ) of the molecules of hydrogen (σ = 2 Å) at 1atm and 298 K. 1

14. (a) Define "bond moment and dipole moment". The dipole moment of CCl_4 is zero, though bond moment of C → Cl is non-zero. Explain why? 1+1

(b) Define the "London Forces". 1.5

(c) Suppose there are two systems, one consisting of molecular hydrogen and the other of molecular nitrogen. If their root mean square (*rms*) speeds are the same, what can you conclude about the temperature of the two gases? 1.5

15. The van der Waals equation of state is written by,

$$\left(P + \frac{a}{V_m^2}\right)(V_m - b) = RT$$

where, 'a' and 'b' are constant, V_m is the volume per mole of the gas and the remaining variables have their usual meaning.

(a) Explain briefly the physical interpretation of the terms which makes this difference from the ideal gas equation of state. 1

(b) Deduce the expression for the reduced equation of state of a van der Waal gas and hence define the laws of corresponding states. 1+2

(c) The critical volume (V_c) = 98.7 cm^3mol^{-1}. Calculate the radius of the van der Waal gas molecules. 1