

# Five Year Integrated M.Sc. Examination 2021-22

## 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

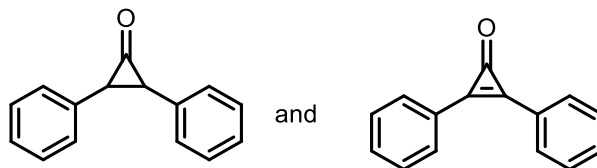
Answer *any two* questions

1. (a) Explain what the probable energy source of the sun is. 2  
(b) A small amount of radioactive material got accidentally spread in an area adjoining a nuclear plant making the level of radiation 50 times the permissible safety level. If  $t_{1/2}$  of the radioactive species be 15 days, after how many days will the place be safe to live? 3  
(c) Show the rough shape of the radial functions for (i) 1s, 2s and 3s and (ii) 3s, 3p and 3d atomic orbitals in hydrogen. 2  
(d) What is ionization energy? Explain the factors which control the ionization energy. 1+2
2. (a) The true mass of an atom (in  $u$ ) is always less than the sum of the masses of its constituents. Justify. 2  
(b) Write a short note on artificial radioactivity. 2  
(c) What new line results from the combination of the first two lines in the Paschen series and what is its wavelength? 3  
(d) Establish that p orbitals cannot have more than 6 electrons. State the underlying principle that guides your answer. 2+1
3. (a) Give two examples of the application of radioactive isotopes in the study of structure and mechanism in Chemistry. 3  
(b) Show that the product of the radius of a Bohr orbit and its energy is a constant. Find the value of this constant for hydrogen. [Given:  $e = 1.602 \times 10^{-19}$ ;  $\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2\text{N}^{-1}\text{m}^{-2}$ ] 2+2  
(c) Name the chalcogens and halogen elements with their symbols. Compare the electronegativity of a chalcogen and halogen element in the same period. 2+1

#### Group-B

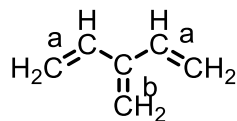
Answer *any two* questions

4. (a) Compare the dipole moments of the following compounds and explain. 2



(b) Compare the marked (a and b) bond length in the following compound.

2

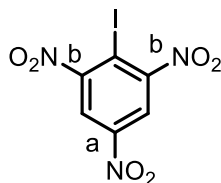


(c) Although N-F bonds are much polar than N-H bonds,  $\text{NF}_3$  (0.26 D) has a smaller dipole moment than  $\text{NH}_3$  (1.46 D). Explain.

2

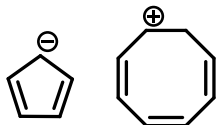
(d) Which C-N bond (a or b) has higher bond length.

2



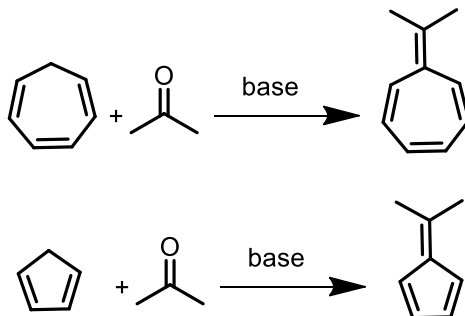
(e) Classify the following molecules as aromatic, anti-aromatic, homoaromatic.

2



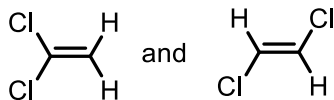
5. (a) Predict the feasibility of the following two reactions.

2



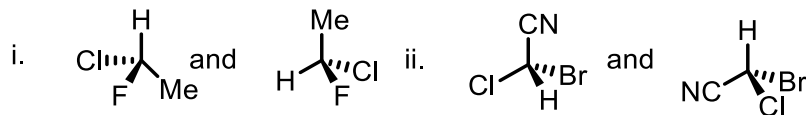
(b) Indicate the element(s) of symmetry, if any, present in the following molecules.

2



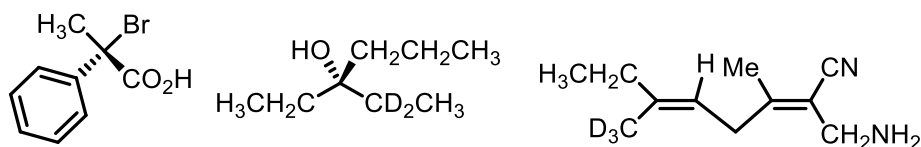
(c) Label the following pairs of molecules as homomers, enantiomers, or, diastereomers as the case may be with justification.

3



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

3



6. (a) 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. 2
- (b) Draw the conformational energy diagram of n-butane for rotation around the C<sub>2</sub>-C<sub>3</sub> bond. Show all the conformers and comment on their relative stabilities. 4
- (c) An optically pure sample of (R)-(-)-2-butanol shows a specific rotation + 13.6°. What relative proportion of (S)-(+)-2-butanol and (R)-(-)-2-butanol would give a specific rotation of +6.8°? What is the optical purity of the above mixture? 2
- (d) Draw the most stable conformation of ethylene glycol giving the explanation in support of your answer. 2

### Group-C

Answer *any two* questions

7. (a) What is “mean free path ( $\lambda$ )” of a gas molecule? Derive the expression of the mean free path at a given temperature (T) and pressure (P). What will happen to the mean free path of the gas molecules, confined in a fixed volume, when the temperature is increased? 1+2+1
- (b) Write down the equation of Maxwell’s distribution of molecular speed of an ideal gas at a temperature T (K) and hence derive the expression for the root mean square speed ( $C_{rms}$ ) of the gas. 1+2
- [Given:  $\int_0^\infty x^4 e^{-ax^2} dx = \frac{3}{8} \sqrt{\frac{\pi}{a^5}}$ ]
- (c) At what pressure does the mean free path of nitrogen at 30°C become comparable to the diameter of the molecules itself? 3
8. (a) What are the Debye forces? Explain with suitable example. 2
- (b) Define the term “equipartition of energy”? Write down the different degrees of freedom a water molecule possesses and hence calculate the total energy of the molecule at the temperature (T). 2+2
- (c) At what temperature the most probable speed ( $C_{mps}$ ) of Kr is equal to that of PF<sub>6</sub> molecule at 300K? 4
- Atomic weight of Krypton (Kr) is 83.789 g and molecular weight of PF<sub>6</sub> is 144.9642 g
9. (a) Why the ideal gas equation needs to be corrected? Derive the equation of state of one mole of a van der Waals gas. Convert this expression in to its reduced form and hence state “the principle of corresponding states”. 1+3+3
- (b) The critical constants of methane are,  $P_c = 45.6$  atm,  $T_c = 190.6$  K and  $V_c = 98.7$  cm<sup>3</sup>.mol<sup>-1</sup>. Calculate the van der Waals parameters of the gas and find the radius of the molecules. 3