RAMAKRISHNA MISSION VIDYAMANDIRA
(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FIRST SEMESTER EXAMINATION, MARCH 2021
FIRST YEAR [BATCH 2020-23]
Date : 26/03/2021   **CHEMISTRY [HONOURS]**
Time : 11.00 am – 1.00 pm   **Paper : II [CC 2]**   Full Marks : 50

Group – A

(Physical Chemistry)

Attempt **one** question from **each unit :**

Unit – I   [1×12]

1. a) How does one correlate the 1D velocity distribution of gas molecules to the Gaussian distribution type? Compare the 3D distribution of gas molecular speeds at two different temperatures.   [1+2]

   b) Express the van der Waals equation in the form of virial equation of state and show that 2nd virial coefficient is a function of van der Waals constants, a and b.   [3]

   c) Consider the following data for two van der Waals gases A and B

	a(/atm $L^2 mol^{-2}$)	b(/$Lmol^{-1}$)	V($Lmol^{-1}$)
A	0.24	0.026	0.112
B	1.36	0.132	0.111

   Answer the followings with very short explanation.   [2]

   i) Which gas is more compressible?

   ii) Which gas has higher T_B?

   d) Calculate the ratio of initial to final (i) average velocities and (ii) kinetic energies if the pressure of an ideal gas is doubled at constant gas density.   [4]

2. a) For three gases A, B and C, $m_A = 2m_B = 1/2m_C$ and $T_A = 2T_B = T_C$. (i) Which of the gases have same speed distribution and (ii) same energy distribution?   [4]

   b) A scientist proposed the following equation of state

   $P = RT/V_m – B/V_m^2 + C/V_m^3$

   Find out the critical constants of the gas in terms of B and C. Molar volume is expressed as V_m.   [3]

   c) Apply the law of equipartition of energy to H_2O molecule to find out the theoretical value of C_V (molar).   [2]

   d) In a mixture of N_2 and NO, what are the different types of interactions possible? Which type of interaction is temperature dependent?   [3]

Unit – II   [1×10]

3. a) What does *'mean free path'* mean? How is it related to T and P?   [3]

   b) The proportion of O_2 and SO_2 and SO_3 present in mixture of gases is 0.5:0.3:0.2. They are allowed to effuse through a pinhole at 27°C. Calculate the composition of the mixture leaving initially.   [3]

   c) Two flasks A and B have equal volumes. Flask A containing H_2 gas is maintained at 300 K while B containing an equal mass of C_2H_6 gas is maintained at 900 K. The collision diameter of C_2H_6 gas is four times that of H_2 gas. Assuming ideal behavior for both the gases, answer the following - In which flask, and by how many times, are Z_1 and Z_{11} greater? Z_1 and Z_{11} have the usual meaning.   [4]

4. a) What is the viscosity of a fluid? Discuss how exactly this arises in liquids and gases?   [2]

b) Discuss the effects of temperature and pressure on the viscosity of gases and compare them with those of liquids. [2]

c) Find the molecular formula of hydrocarbon gas (C_nH_{n+2}) that effuses 0.872 times as fast as O_2 through a small hole, the T and P being equal. [3]

d) O_2 gas present in a vessel at 37°C and 1 atm pressure is replaced by N_2 under the same condition. Will there be any change in number of impacts made by each kind of molecules? If yes, calculate the ratio of number of impacts made by N_2 and O_2. If not, explain why. [3]

Unit – III
[1×12]

5. a) Prove mathematically using the properties of differential calculas that work (defined as -PdV) is not a state function. [3]

    b) Under what condition work is independent of path? Explain. [2]

    c) A sample consisting of 1.00 mol Ar is expanded isothermally at 273 K from 22.4 L to 44.8 L (i) reversibly (ii) against a constant external pressure equal to the final pressure of the gas and (iii) freely (against zero external pressure). For all these three processes. Calculate Q, W, ΔU and ΔH. [4]

    d) The heat of combustion of $(CH_2)_3$, carbon and H_2 are -2091, -393 and -285 kJ mole^{-1}.

       i) Calculate heat of formation of cyclopropane.

       ii) Calculate the heat of isomerization of cyclopropane to propylene. [1+2]

6. a) A cyclic engine has the following steps :

       (i) Isothermal expansion of ideal gas from (P_1, V_1, T_1) to (P_2, V_2, T_1)

       (ii) Adiabatic expansion of ideal gas from (P_2, V_2, T_1) to (P_3, V_3, T_2)

       (iii) Isothermal compression of ideal gas from (P_3, V_3, T_2) to (P_4, V_4, T_2)

       (iv) Isothermal compression of ideal gas from (P_4, V_4, T_2) to (P_1, V_1, T_1).

       Calculate W, Q and the change in U for the individual steps as well as the whole process. [(4×1)+2]

    b) When 3.0 mol of O_2 is heated at a constant pressure of 3.35 atm, its temperature increases from 260 K to 285 K. Given that the molar heat capacity of O_2 at constant pressure is 29.4 JK^{-1}, calculate Q, ΔU and ΔH. [3]

    c) For the following reaction at 298 K

Reaction	ΔH (kJ/mol)
$CaC_2(S) + 2H_2O(l) \rightarrow Ca(OH)_2(s) + C_2H_2(g)$	-127.9
$Ca(s) + 1/2 O_2(g) \rightarrow CaO(s)$	-635.1
$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$	-65.2

       The heat of combustion of graphite is -393.51 kJ/mol, and that of $C_2H_2(g)$ is -1299.58 kJ/mol. Calculate the heat of formation of $CaC_2(s)$ at 298K. [3]
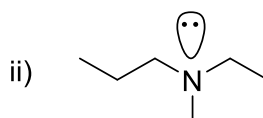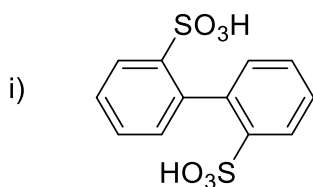
Group – B
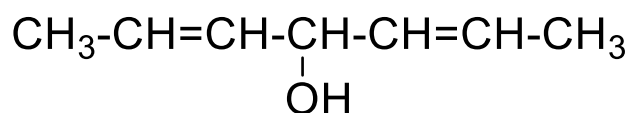
(Organic Chemistry)

Attempt **any one** question : [1×16]

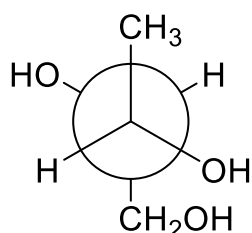7. a) Explain the following compounds are resolvable or not: [2×2]
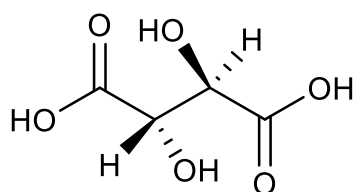
b) Draw all possible stereoisomers of the following molecule and also assign R/S configurational description at the chiral centre(s). [4]

$$CH_3\text{-}CH\text{=}CH\text{-}CH\text{-}CH\text{=}CH\text{-}CH_3$$
$$\underset{\displaystyle OH}{|}$$

c) Convert the following Newman projection formula into flying-wedge: [1]

d) Convert the following 3D representation into Fischer projecting formula: [1]
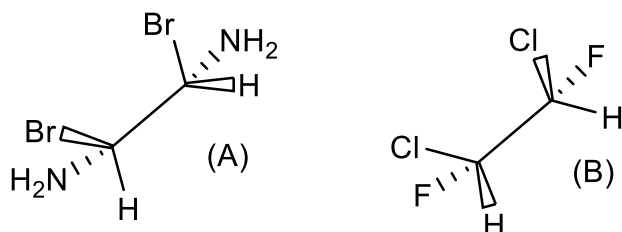

e) Justify or Criticize: [2×2]

i) C-3 of (Z)-butene is a stereogenic centre

ii) Ethylene glycol has higher dipole moment that 1,2-dichloroethane.
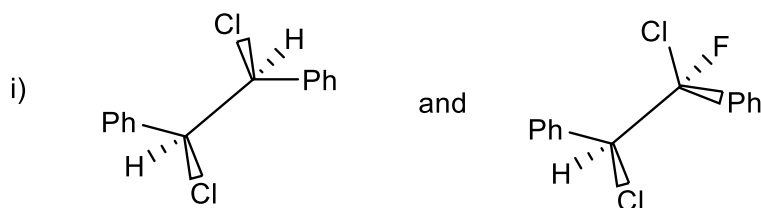
f) Define with an example : Rotamer [2]

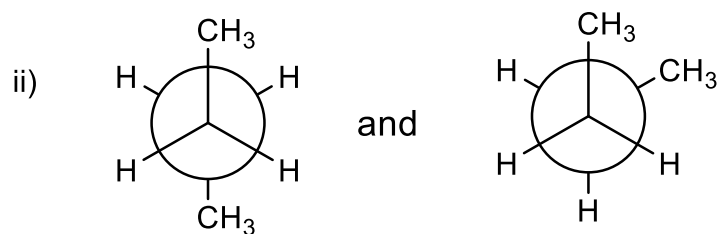8. a) Draw the stable Newman projection formula of the following : [2]

i) meso-butane-2,3-diol

ii) Erythro-3-bromo-2-butanol

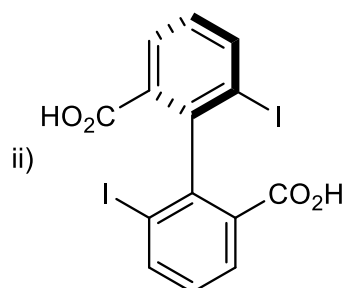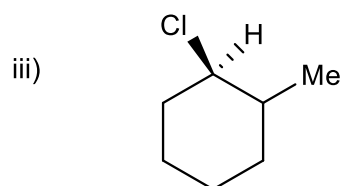b) Determine whether each of the following molecules is chiral or achiral: [2]
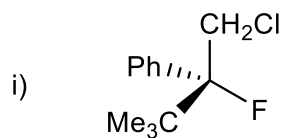

c) Indicate the relationship between the following pair of molecules: [2]

ii)

 and

d) Give R/S designation of the following molecules showing priority order: [1.5×3]

i)

ii)

iii)

e) Indicate the symmetry elements present in Benzene. [2]

f) Draw the conformational energy profile diagram of Ethylene Glycol with proper labeling by conformers. [3.5]

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