RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FIRST SEMESTER EXAMINATION, MARCH 2022

FIRST YEAR [BATCH 2021-24]

Date : 10/03/2022 **CHEMISTRY (HONOURS)**

Time : 11 am – 1 pm **Paper : II [CC2]** Full Marks : 50

Group :A

Unit : I

Answer **any one** question : [1×12]

1. a) $\bar{C}, C_{rms}$ and C_{mp} represent the mean velocity, root mean square velocity and the most probable velocity of a gas at a temperature, T and are represented in the Maxwell speed distribution plot as P, Q and R points, respectively on the x axis. Show P, Q and R in the same speed distribution curve and arrange their values in the increasing order at room temperature. [3]

   b) Derive equation for the law of corresponding states for the van der Waals gas equation and justify that the nature of equation is same for all different gases. [2]

   c) Draw all possible vibrational modes for CO_2 and H_2O molecules and calculate the C_V for both the two molecules at 298K to confirm that their geometries are different. [3]

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

	a	b	V
	$atmL^2mol^{-2}$	$molL^{-1}$	$Lmol^{-1}$
A	0.24	0.026	0.112
B	1.36	0.132	0.111

   i) which gas has higher T_B? How?

   ii) which gas is more compressible? Why? [2+2]

2. a) Derive the equation for 3D speed distribution for gas molecules from the 1D speed (velocity) distribution equation? And find out the root mean square velocity of the gas molecules, when the molecules have only 1D motion. [with appropriate diagram] [3+2]

   b) van der Waals gas equation results nicely to match with the behaviour of real gas molecules. How does the equation explain Amagat's curve towards low and high pressure zone? Comment on the results, in terms of the interactive forces among molecules. [3+1]

   c) A scientist proposed the following equation of state

$$\frac{RT}{V_m} - \frac{B}{V_m^2} + \frac{C}{V_m^3}$$

   Show that the equation leads to critical behaviour and find the constants in terms of B and C. [3]

Unit : II

Answer **any one** question : [1×10]

3. a) The mean free path of the molecule of a certain gas at 300 K is 2.6×10^{-5} m. The collision diameter of the molecule is 0.26 nm. Calculate (i) pressure of the gas, and (ii) number of molecules per unit volume of the gas. (1.5+1.5)

   b) Using kinetic model of gas, prove that $PV=(1/3)mN\langle c^2\rangle$. (3)

c) What do you mean by newtonian fluids? (1)

d) Discuss the effect of temperature on viscosity of liquid. (2)

e) What is fluidity of a liquid? (1)

4. a) For oxygen gas at 25°C, calculate (i) mean free path at 10^{-3} mm Hg of pressure, (ii) number of collision per second per molecule and (iii) number of collision per second per cubic metre. (3)

b) Neon and mercury vapours have very nearly equal van der Waals b parameters, which implies equal atomic volumes and radii. Would you expect any difference in the viscosities of these gases (at the same temperature)? (2)

c) Briefly describe Graham's law of effusion? (1)

d) How viscosity of a liquid can be measured using Ostwald viscometer? (2)

e) Establish relation between kinetic energy and temperature of a gas. (2)

Unit : III

Answer **any one** question : [1×12]

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

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

c) One mole of an ideal gas molar C_v =(3/2)R, initially at 293 K and 1.0 MPa pressure undergoes a two stage transformation.

i) Stage I : Isothermal, reversible expansion to double the initial volume.

ii) Stage II : Beginning at the final state of stage I, keeping the volume constant, the temperature is raised to 353 K.

For each stage I, II and for the over all change 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 $mole^{-1}$.

Calculate heat of formation of cyclopropane. [3]

6. a) A reversible 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) Adiabatic compression of ideal gas from (P_4,V_4, T_2) to (P_1,V_1, T_i).

Calculate W, Q and the ΔU for the whole process. [4×1]

b) One mole of an ideal gas of C_v = 6 $calK^{-1}mole^{-1}$ expands adiabatically from STP to 0.1 atm. (i) Calculate Q, W, ΔU and ΔH if the expansion is reversible. (ii) Calculate the final state if the adiabatic expansion is irreversible and such that the work done is 10% of the value in (i). The final pressure is still 0.1 atm. [3+2]

c) For the following reaction at 298 K

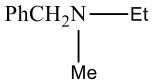
Reaction	ΔH (kJ/mol)
$CaC_2(S) + 2H_2O(l) \rightarrow Ca(OH)_2(s) + C_2H_2(g)$	-127.9
$Ca(s) + 1/2\ O_2\ (g) \rightarrow CaO(s)$	-635.1
$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$	-65.2

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

Answer **any one** question: [1×16]

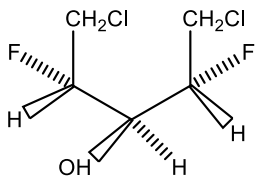
7. a) Write the structure of Threo-butane-2,3-diol in Fischer Projection formula and also represent it in flying wedge form. Draw the most stable conformer of it in Newman projection. [2]

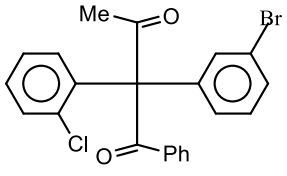
b) Justify or Criticise :  is a chiral molecule. [2]

c) Explain the following observations:

Optically active mandelonitrile(PhCHOHCN) gives optically inactive mandelic acid ($PhCHOHCO_2H$) upon hydrolysis with dilute NaOH followed by acidification with dilute HCL. [2]

d) Assign R/S descriptors of the following molecules. [3]

(i)  ;

(ii) 

e) Label the C-3 centres of the following molecules as stereogenic/non-stereogenic and chirotopic|achirotopic. Justify your answer. [2+2]

(i) Active-2,3,4- trihydroxyglutaric acid.

(ii) Meso – 2,3,4-trihydroxyglutaric acid.

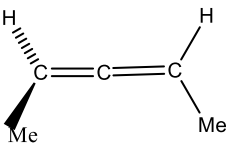
f) Outline the method of resolution of (±)- 2- Octanol. [3]

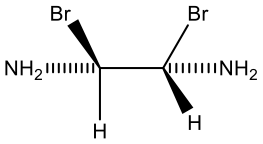
8. a) Draw the energy profile diagram of ethylene glycol for rotation about C-C bond and label the maxima and minima with appropriate conformations. Compare the relative stability of the conformations with explanation. [3]

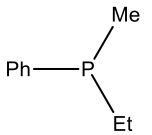
b) Define with an example : Rotamer. [2]

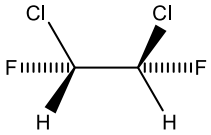
c) Give an example of a molecule having C_3 axis. [1]

d) Explain whether the following molecules are chiral or achiral. [4]

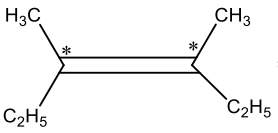
(i) 

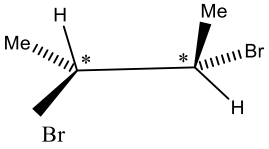
; (ii) 

(iii) 

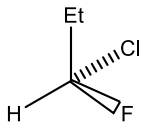
; (iv) 

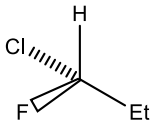
e) Designate the marked (*) centres of the following compounds as stereogenic/Nonstereogenic, Chirotopic/achirotopic. Give reasons. [2]

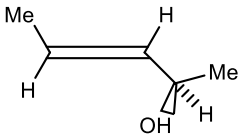
(i) 

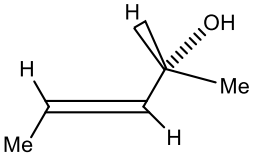
; (ii) 

f) Label the following as homomers, enantiomers or diastereomers: [2]

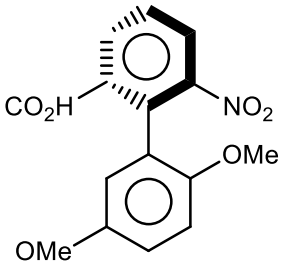
(i) 

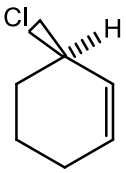
and 

(ii) 

and 

g) Assign R/S configuration to the following molecules: [2]

(i) 

; (ii) 

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