63 (FY)SEM–3/MAJ/CHMMAJ2024

2024

CHEMISTRY

Paper : CHMMAJ2024

(Physical Chemistry–I)

Full Marks : 50

Pass Marks : 20

Time : Two hours

The figures in the margin indicate full marks for the questions.

1. Choose the correct answer : 1×5=5

   (i) A well-stoppered thermos flask contains some ice cubes. This is an example of

   (a) Isolated system

   (b) Open system

   (c) Closed system

   (d) Non-thermodynamic system

Contd.

(ii) The first law of thermodynamics is the relation between

(a) Heat and work of the system

(b) Heat, work and internal energy of the system

(c) Entropy, enthalpy and surface tension of the system

(d) Heat capacity and entropy of the system

(iii) The heat change at constant pressure q_p is equal to

(a) ΔU

(b) ΔG

(c) ΔH

(d) ΔA

(iv) What is chemical potential ?

(a) Partial molar enthalpy

(b) Partial molar volume

(c) Partial molar free energy

(d) Partial molar internal energy

(v) The p^H of a solution is 4. Its $[H^+]$ is

(a) 10M

(b) 10^{-4}M

(c) 10^{-10}M

(d) 10^{-14}M

2. Answer the following questions : ***(any five)*** 2×5=10

(a) Show that

$$W_{rev} > W_{irr}.$$

(b) Calculate ΔH_f for methane from the following data :

$CH_4(g)+2O_2(g) \rightarrow CO_2(g)+2H_2O(l); \Delta H = -890.3kJ$

$H_2(g)+\frac{1}{2}O_2(g) \rightarrow 2H_2O(l); \Delta H = -285.9kJ$

$C(graphite)+O_2(g) \rightarrow CO_2(g); \Delta H = -393.5kJ$

(c) Define reversible and irreversible processes.

(d) Define entropy. What is its physical significance ?

(e) What is ionic product of water? How does it vary with temperature?

(f) If the molarity of an HCl solution is 10^{-8}M. Calculate the p^H of the acid solution.

(g) Show that at 298K

$pK_a + pK_b = 14$

3. Answer the following questions : ***(any five)*** 5×5=25

(a) Define giving at least one example of each of the following. 1+1+1+1+1=5

(i) an open system

(ii) closed system

(iii) state function

(iv) intensive property

(v) extensive property

(b) Define C_p and C_v. Obtain relation between C_p and C_v for ideal gas. 1+1+3=5

(c) Describe Joule-Thomson experiment. What does it prove? What is the significance of Joule-Thomson coefficient? 3+1+1=5

(d) Show that for the adiabatic process

(i) $\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$ $2\frac{1}{2} + 2\frac{1}{2} = 5$

(ii) PV^{γ} = constant.

(e) Define Gibbs free energy. How is it related to work function? Derive the expression 1+1+3=5

$$\Delta G = \Delta H + T\left[\frac{\partial(\Delta G)}{\partial T}\right]_p.$$

(Terms signify usual meaning)

(f) (i) State and explain the Nernst heat theorem. What is the most important application of the third law of thermodynamics? 2+1=3

(ii) Calculate q, w, ΔU and ΔH for the reversible isothermal expression of one mole of an ideal gas at 27°C from a volume 10 dm^3 to a volume 20 dm^3. 2

(g) (i) For a weak monobasic acid, show that the degree of ionization at a given temperature is inversely proportional to the square root of the initial concentration of the acid. 3

(ii) Calculate the degree of dissociation and the concentration of H_3O^+ ions in a 0.01M solution of methanoic acid at 298K. ($K_a = 2.1 \times 10^{-4}$) 2

(h) What is common ion effect? Explain with an example. Mention one of its application in qualitative analysis of a salt. 1+2+2=5

(i) What is solubility product? The solubility product of AgCl is 1.56×10^{-10} at 298K. Calculate the solubility of AgCl in (i) pure water and (ii) in a solution of 0.1M NaCl. 1+2+2=5

4. Answer ***either*** (A) ***or*** (B) : 10×1=10

(A) (a) State how entropy will change for the following process :

(i) freezing of ethanol

(ii) dissolving glucose in water

(iii) evaporation of bromine from bromine solution at room temperature, and

(iv) cooling nitrogen gas from 373K to 273K

(b) What are the characteristics of a spontaneous process ?

1+1+1+1+1=5

(c) Derive Gibbs-Duhem equation. 5

B. (a) What is buffer solution ? What are the various types of it ? Give an example of each type. 2

(b) What is buffer capacity ? When the buffer capacity will be maximum ?

1+1=2

(c) Explain the mechanism of buffer action with an example. 3

(d) Write the expressions for determination of pH of a buffer solution containing

(i) weak acid and its salt; and

(ii) weak base and its salt.

$$1\frac{1}{2}+1\frac{1}{2}=3$$