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3 (Sem-2/CBCS) CHE HC 2

2022

CHEMISTRY

(Honours)

Paper : CHE-HC-2026

(Physical Chemistry - II)

Full Marks : 60

Time : Three hours

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

1. Answer **any seven** of the following questions : 1×7=7

(a) Give the SI unit of energy.

(b) Define specific heat of a system.

(c) The variation of enthalpy of a reaction with temperature is given by

(i) Hess's law

(ii) Kirchhoff's equation,

(iii) Henry's law,

(iv) Raoult's law

(Choose the correct option)

(d) A process is carried out at constant pressure and temperature. It will be spontaneous if

(i) $\Delta G < 0$

(ii) $\Delta H < 0$

(iii) $\Delta U < 0$

(iv) $\Delta S < 0$

(Choose the correct option)

(e) A solution is a

(i) homogeneous mixture of only two components

Contd.

- (ii) homogeneous mixture of any number of components
 - (iii) heterogeneous mixture
 - (iv) anything mixed with water
- (Choose the correct option)

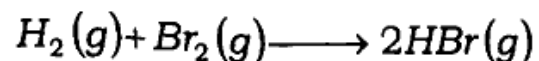
- ~~(f)~~ What is excess thermodynamic function ?
- (g) Name a colligative property that is used to determine the molar mass of a protein.
- (h) Equimolar solutions of glucose and sodium chloride are not isotonic. Justify.
- (i) Find the value of work done when 2 moles of an ideal gas is allowed to expand from 1 L to 10 L against vacuum at 298K.
- (j) Name the thermodynamic property that measures the disorderliness of a system.

2. Answer **any four** of the following questions :

2×4=8

- ~~(a)~~ Define intensive property. Give one example.
- ~~(b)~~ State Zeroth law of thermodynamics.
- ~~(c)~~ Define explosion temperature and adiabatic maximum flame temperature.
- ~~(d)~~ What do you mean by network ? Briefly explain.
- (e) Explain residual entropy.
- (f) Define fugacity function.
- (g) An ideal gas undergoes a single step expansion a constant external pressure P from (P_1, T, V_1) to (P, T, V_2) . What is the magnitude of work done by the system ?

(h) Find ΔH of the reaction :



Given :

$$\Delta H_{H-H} = 435.1, \Delta H_{Br-Br} = 192.5,$$

$$\Delta H_{H-Br} = 368.2 \text{ kJ/mol.}$$

3/ Answer **any three** of the following questions :
5×3=15

(a) (i) State Path function with suitable example. 2

(ii) Show that in an isothermal expansion, the work is done at the expense of the heat absorbed. 3

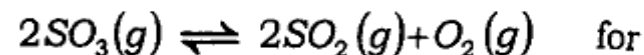
(b) Derive the Gibbs - Helmholtz equation.

(c) (i) Write short note on the third law of thermodynamics. 3

(ii) Explain briefly how absolute entropy of a molecule can be determined from heat capacity measurement. 2

(d) Give the criteria of spontaneity and thermodynamic equilibrium in terms of enthalpy, entropy, Helmholtz free energy and Gibbs free energy. 5

(e) (i) Calculate K_c for the reaction



which $K_p = 3.5 \times 10^{-23} \text{ atm}$ at 27°C . 3

(ii) How molar mass can be determined from freezing point depression ? 2

(f) (i) 0.5g of a non-volatile solute of molar mass 60 g mol^{-1} is dissolved in 100g of ethyl acetate at 20°C . What would be the vapour pressure of this solution at 20°C ? The vapour pressure of ethyl acetate at 20°C is 72.8 Torr . 3

(ii) Explain briefly *any one* method for measurement of vapour pressure lowering. 2

(g) What is osmotic pressure? Give detailed thermodynamic derivation of osmotic pressure of a solution having non-volatile solute.

(h) What are colligative properties? Explain two practical applications of colligative properties.

4. Answer **any three** of the following questions :
10×3=30

(a) (i) State and explain first law of thermodynamics. Show that for isochoric process, $q = \Delta U$. 3+2=5

(ii) Derive the integrated Kirchhoff equation. 5

(b) (i) Define heat capacity of a system. Show that $C_p - C_v = R$ for 1 mole of an ideal gas. 1+3=4

(ii) State and explain Raoult's law for vapour pressure of binary solution of volatile liquid. What is an ideal solution? 5+1=6

(c) (i) Calculate q , w , ΔU and ΔH for the reversible isothermal expansion of one mole of an ideal gas at 27°C from a volume of 10 dm³ to a volume of 20 dm³. 4

(ii) Explain that the entropy of the universe is increasing continuously. 2

(iii) Explain briefly the vapour pressure vs. composition diagram of a binary liquid mixtures having positive deviation. 4

(d) (i) Explain that the thermodynamic isothermal reversible work of expansion is the maximum work. 3

(ii) Give the thermodynamic derivation of the relation between Gibb's free energy of a reaction and its reaction quotient. 5

- (iii) Give two limitations of first law of thermodynamics. 2
- (e) (i) Define enthalpy of neutralization. 1
- (ii) The enthalpy of combustion of glucose $C_6H_{12}O_6(S)$ is $-2816 \text{ kJ mol}^{-1}$ at 25°C . Calculate ΔH_f° of $C_6H_{12}O_6(S)$. The ΔH_f° values for $CO_2(g)$ and $H_2O(l)$ are -393.5 and $-286.2 \text{ kJ mol}^{-1}$ respectively. 3
- (iii) Give a brief account of coupling of exoergic and endoergic reactions. 3
- (iv) State and explain van't Hoff theory of dilute solution as applied to osmotic pressure. 3
- (f) (i) Discuss about the molecular and statistical interpretation of entropy. $2\frac{1}{2} \times 2 = 5$

- (ii) Show that :

$$\Delta G_{mix} = nRT(x_1 \ln x_1 + x_2 \ln x_2)$$
 5

- (g) (i) Prove that : $\left(\frac{\partial V}{\partial T}\right)_P = -\left(\frac{\partial S}{\partial P}\right)_T$ 5

- (ii) Explain the variation of chemical potential with temperature. 3

- (iii) Calculate the pressure of CO_2 gas at 700K in the heterogeneous equilibrium reaction

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$
 if ΔG° for this reaction is $130.2 \text{ kJ mol}^{-1}$. 2

- (h) (i) Show that :

$$K_p = K_x (P)^{\Delta n_g} = K_c (RT)^{\Delta n_g}$$
 under what conditions,

$$K_p = K_x = K_c?$$
 5+1=6

(ii) State and explain *Le Chatelier's* principle taking *any one* example.

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