

2019

CHEMISTRY

(Honours)

Paper : CHE-HC-1026

(Physical Chemistry—I)

Full Marks : 60

Time : 3 hours

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

1. Answer the following as directed : 1×7=7

(a) From kinetic gas equation, show that $PV = \text{constant}$ for an ideal gas at constant temperature.

(b) A gas can be liquefied, when

(i) $T > T_c$; $P = P_c$

(ii) $T < T_c$; $P < P_c$

(iii) $T < T_c$; $P > P_c$

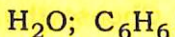
(iv) $T = T_c$; $P < P_c$

(Choose the correct option)

- (c) Define vapour pressure of a liquid.
- (d) In a cubic crystal, there are ____ C_4 axes of symmetry, ____ C_3 axes of symmetry and six C_2 axes of symmetry.
(Fill in the blanks)
- (e) Explain why non-stoichiometric form of NaCl is yellow in colour.
- (f) Explain why pH of 1×10^{-8} mol dm⁻³ hydrochloric acid solution is not 8.
- (g) An aqueous solution of Na_2CO_3 is basic. Explain.

2. Answer the following questions : 2×4=8

- (a) Define mean free path of a gas. How does mean free path of a gas vary with temperature and pressure?
- (b) Give a qualitative idea about the structure of water.
- (c) State the symmetry elements present in the following molecules :



(d) The pH value of a solution containing equimolar concentrations of a weak acid and its salt is 5.0. Calculate the K_a value of the weak acid.

3. Answer any *three* of the following questions :

5×3=15

(a) Derive the van der Waals' equation for a gas. Explain why van der Waals' equation cannot be considered as a generalized equation of state for real gases.

(b) What is critical state of a gas? Derive the expressions for critical constants in terms of the van der Waals' constants.

(c) Derive the Bragg's equation. In an experiment on a crystal using X-rays of wavelength 10^{-10} m, the value of angle of incidence for the first-order reflection was found to be 30° . Calculate the interplanar distance of the crystal.

(d) 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. Give the expressions for dissociation constants of carbonic acid.

(e) Define solubility product of a sparingly soluble salt solution. Give the conditions for precipitation in terms of solubility product. 50 mL of $0.01 \text{ mol dm}^{-3} \text{ AgNO}_3$ solution is mixed with 50 mL of $0.001 \text{ mol dm}^{-3}$ aqueous NaCl solution. Predict whether AgCl will be precipitated or not. Given $K_{\text{sp}}(\text{AgCl}) = 1.7 \times 10^{-10}$.

4. (a) Answer either [(i) and (ii)] or [(iii), (iv) and (v)] :

(i) Give the postulates of kinetic molecular model of a gas. On the basis of these postulates, derive the kinetic gas equation. 3+4=7

(ii) Two flasks A and B have equal volumes. Flask A contain H_2 gas at 300 K, while flask B contains equal mass of C_2H_6 gas at 900 K. If both the gases behave ideally, answer the following : 3

In which flask the molecules will have higher average speed and how many times than the average speed of the other?

- (iii) Derive an expression for root-mean-square speed of gas molecules from the expression for Maxwell distribution of molecular speeds of the gas. 3
- (iv) Show that root-mean-square speed of hydrogen gas is four times that of oxygen gas at the same temperature. 3
- (v) Derive an expression for reduced equation of state for any substance. State the law of corresponding states. $3+1=4$
- (b) Answer either [(i), (ii) and (iii)] or [(iv), (v) and (vi)] :
- (i) How does viscosity of gas differ from that of liquid? 2
- (ii) Describe a method with theory commonly used for the measurement of viscosity of a liquid. 4
- (iii) What are liquid crystals? Give the structural difference between smectic and nematic liquid crystals. Give two applications of liquid crystals. $1+2+1=4$
- (iv) Define the terms—symmetry element, plane of symmetry and centre of symmetry. 3

- (v) What are Bravais lattices? How can the following crystal systems be characterized?

Cubic; orthorhombic

Give one example each of these two crystal systems.

4

- (vi) What are Schottky and Frenkel defects? Give example of each of these two defects.

3

- (c) Answer either [(i), (ii) and (iii)] or [(iv), (v) and (vi)] :

- (i) Define pH of a solution. Give the limitations of pH scale. Calculate pH of a solution obtained by mixing 50 mL 0.1 mol dm^{-3} HCl solution with 50 mL 0.2 mol dm^{-3} NaOH solution at 298 K.

1+1+3=5

- (ii) Discuss briefly about the following : Applications of buffers in qualitative analysis of salt sample.

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- (iii) Obtain an expression for hydrolysis constant for the hydrolysis of $\text{CH}_3\text{COONH}_4$ salt.

3

- (iv) What are acid-base indicators? Give examples. Discuss briefly the Ostwald's theory of acid-base indicators.

1+1+3=5

(7)

(v) State with reasons, what indicators you would choose for the following titrations : 3

NaOH vs. CH_3COOH ;

Na_2CO_3 vs. HCl

(vi) Calculate the solubility of $\text{Mg}(\text{OH})_2$ in pure water at 298 K. Given K_{sp} for $\text{Mg}(\text{OH})_2$ at 298 K is 1.20×10^{-11} . 2

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