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3 (Sem–1/CBCS) CHE HC 2

2022

CHEMISTRY

(Honours)

Paper : CHE–HC–1026

(Physical Chemistry–I)

Full Marks : 60

Time : Three hours

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

(Symbols used signify their usual meaning)

1. Answer the following as directed : $1 \times 7 = 7$
(any seven)

   (a) Write the kinetic gas equation for an ideal gas.

   (b) Define Boyle temperature of a gas.

   (c) Higher the viscosity, slower is the rate of flow of a liquid at a given temperature. *(State True* ***or*** *False)*

Contd.

(d) State the total number of planes of symmetry in a cubic system.

(e) The planes which are absent in simple cubic crystal system is

(i) (100)

(ii) (200)

(iii) (110)

(iv) (111)

(Choose the correct option)

(f) Explain why Zn^{2+} ion is not precipitated as ZnS, when H_2S gas is passed through a $ZnSO_4$ solution in presence of HCl.

(g) Identify the odd pairs, that will not act as buffer solution, from the following :

(i) NH_4Cl and NH_4OH solution

(ii) $NaCl$ and $NaOH$ solution

(iii) CH_3COONa and CH_3COOH solution

(iv) NaH_2PO_4 and Na_2HPO_4 solution.

(Choose the correct option)

(h) The compression factor for hydrogen gas is always greater than 1. Explain.

(i) How vapour pressure of a liquid is related to its boiling point ?

(j) What is a thermotropic liquid crystal ?

(k) State the law of rational indices in a crystal system.

(l) What is universal indicator in acid-base titration ?

2. Answer the following questions : ***(any four)*** 2×4=8

(a) The mean free path of gas molecules increases and number of collisions per unit time decreases with the decreasing temperature. Explain.

(b) Explain qualitatively the structure of liquid water.

(c) Determine the interplanar spacing between the (221) planes of a cubic lattice of edge length 450 pm.

(d) The degree of hydrolysis of NH_4Cl in 0.02 M aqueous solution at 298 K is 5×10^{-3}. If pK_b for NH_4OH at 298 K is 4.73, calculate pH of the solution.

(e) Value of Van der Waals radius for gaseous A_2 molecule is 2.0 $\mathring{A}$. Calculate Van der Waals constant b for the gas.

(f) Explain why sodium hydroxide solution is not used to precipitate Al^{3+} as $Al(OH)_3$ in Gr 3 of qualitative analysis of salt ?

(g) With the help of a suitable example explain what is impurity defect in crystal.

(h) What is rotating crystal method of observing diffraction in single crystal ?

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

(a) Starting from the Van der Waals equation, find an expression for the Boyle temperature of a gas. Calculate Boyle temperature of CO_2 gas. (Given for CO_2 gas $a = 0.3637\ Nm^4mol^{-2}$ and $b = 42.8\ m^3mol^{-1}$) 3+2=5

(b) Obtain relations to express critical constants in terms of Van der Waals constants *'a'* and *'b'*. Show that critical compressibility constant Z_c of one mole of a Van der Waals gas is 0.375. 4+1=5

(c) Define coefficient of viscosity. Give the *SI* unit of coefficient of viscosity. Give the theory of determination of coefficient of viscosity of a liquid by Ostwald viscometer method. 1+1+3=5

(d) What is meant by symmetry elements and symmetry operations? With the help of suitable examples, explain what are centre of symmetry and axis of symmetry. 2+3=5

(e) Give *one* example each of a strong acid and a weak acid. Explain the role of solvent in the ionization process of these acids. 2+3=5

(f) Using the expression for Maxwell distribution of speed, show that average kinetic energy of a gas molecule is given by $\frac{3}{2}kT$. 5

(g) Explain the following :

(i) Surface tension of water increases on addition of *NaCl*. 2

(ii) Cleansing action of detergent. 3

(h) Discuss the theory of *pH* metric titration between acetic acid solution and sodium hydroxide solution. Show the graphical variation between *pH* change with volume of sodium hydroxide added for the titration. 4+1=5

4. Answer ***any three*** of the following questions : $10 \times 3 = 30$

(a) Define collision frequency. Obtain an expression for bimolecular collision frequency of a pure gas. Explain how collision diameter of a gas can be calculated from the measurement of coefficient of viscosity of the gas. 1+5+4=10

(b) (i) What is the virial equation of state of a gas ? Express the Van der Waals equation of state in the virial form. 2+4=6

(ii) Explain the principle of continuity of states. 4

(c) (i) Show the graphical variations for distribution functions for speeds with speeds of a gas at temperatures T_1, T_2 and $T_3 (T_1 < T_2 < T_3)$. 3

(ii) Define vapour pressure of a liquid at a given temperature. Explain a method of experimental determination of vapour pressure of a liquid. How vapour pressure is related to the boiling point of a liquid ? 1+4+2=7

(d) Explain the powder X-ray diffraction method of determination of a crystal structure. Explain how the lattice planes in sodium chloride are indexed. 5+5=10

(e) (i) What is meant by ionic product of water ? Show that $pH = \frac{1}{2} pK_w$ for pure water. If $K_w = 4.0 \times 10^{-14}$ for pre water at $317K$, calculate pOH. 1+2+2=5

(ii) Define buffer capacity. Explain the role of buffer solution in qualitative analysis of salt. 1+4=5

(f) (i) A bulb of capacity 1 dm^3 contains 3.011×10^{23} gaseous *He* atoms. Pressure exerted by these molecules is $101.325\ kPa$. Calculate the temperature and root mean square speed of the gas, assuming it to behave ideally under the given condition. 4

(ii) Derive an expression for co-efficient of viscosity of a gas relating the mean free path of the gas. How the viscosity of a gas is influenced by the change of pressure ? 5+1=6

(g) (i) Write the Berthelot equation of state for a real gas, explaining the terms involved in it. How this equation is different from the Van der Waals equation of state ? 2+2=4

(ii) Show that at low density, the Van der Waals equation and the Dieterici equation gives the same value of pressure of a gas. 4

(iii) Compare average velocity, root mean square velocity and most probable velocities of a gas at a given temperature. 2

(h) (i) Derive the Henderson equations for acid and basic buffer solutions. 5

(ii) Calculate the change in *pH* when 0.05 cm^3 of 1 *M NaOH* solution is added to one litre of buffer solution containing 0.1 *M* acetic acid and 0.1 *M* sodium acetate at 300 *K*. Given that K_a for acetic acid at 300 *K* is 2.0×10^{-5}. 5
