

### 3 (Sem-1/CBCS) CHE HC 2

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 :  $1 \times 7 = 7$

(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)  $T = T_c; P < P_c$

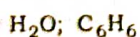
( Choose the correct option )

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- (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  $1 \times 10^{-8}$  mol dm<sup>-3</sup> hydrochloric acid solution is not 8.
- (g) An aqueous solution of  $\text{Na}_2\text{CO}_3$  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 :



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- (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  $30^\circ$ . 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.

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- (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  $K_{sp}(\text{AgCl}) = 1.7 \times 10^{-10}$ .
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  $\text{H}_2$  gas at 300 K, while flask B contains equal mass of  $\text{C}_2\text{H}_6$  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?

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( Continued )

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- (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

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

Cubic; orthorhombic

Give one example each of these two crystal systems.

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

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(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  $0.1 \text{ mol dm}^{-3}$  HCl solution with 50 mL  $0.2 \text{ mol dm}^{-3}$  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.

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

1+1+3=5

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

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NaOH vs.  $\text{CH}_3\text{COOH}$ ;

$\text{Na}_2\text{CO}_3$  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  $1.20 \times 10^{-11}$ .

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