

2019

CHEMISTRY

(Honours)

Paper : CHE-HC-1016

(Inorganic Chemistry—I)

Full Marks : 60

Time : 3 hours

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

1. Choose the correct answer from the following : 1×7=7
 - (a) Maximum number of electron possible in N shell of an atom of an element is

(i) 18	(ii) 8
(iii) 28	(iv) 32
 - (b) Physically meaningful quantity is given by

(i) only ψ	(ii) only ψ^2
(iii) both ψ and ψ^2	(iv) none of ψ and ψ^2

(c) In the long form of modern periodic table, element 49 has the position at

- (i) group 12 of 4th period
- (ii) group 13 of 5th period
- (iii) group 13 of 4th period
- (iv) group 15 of 4th period

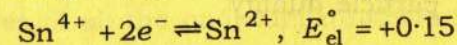
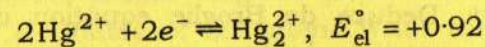
(d) The radii of Mg^{2+} and O^{2-} ions are 0.66 Å and 1.40 Å, and that of B^{3+} and O^{2-} ions are 0.23 Å and 1.40 Å respectively. The crystals formed by MgO and B_2O_3 have shapes respectively

- (i) octahedral and trigonal planar
- (ii) tetrahedral and octahedral
- (iii) octahedral and cubic
- (iv) trigonal planar and octahedral

(e) The van der Waals' forces active in solid I_2 are

- (i) ion-dipole forces
- (ii) dipole-dipole interactions
- (iii) induced dipole interactions
- (iv) zero

(f) The half-cell reaction of two redox systems are as follows :



If the two half cells are linked to give a cell, then

- (i) Hg_2^{2+} will be oxidized and Sn^{4+} will be reduced
- (ii) Hg^{2+} will be reduced and Sn^{2+} will be oxidized
- (iii) both Hg^{2+} and Sn^{2+} will be oxidized
- (iv) both Hg^{2+} and Sn^{2+} will be reduced

(g) When you prepare KMnO_4 and $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ solution by transferring a measured amount of these from chemical balance, then it is necessary to standardize

- (i) both KMnO_4 and $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ solution
- (ii) only $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ solution, but not KMnO_4
- (iii) only KMnO_4 , but not $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ solution
- (iv) none of KMnO_4 and $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ solution

2. Answer the following questions : $2 \times 4 = 8$

- (a) Deduce de Broglie equation of wave-particle duality.
- (b) Write Born-Landé equation with meaning of all the terms involved. From this equation, predict which of CaO and $\text{Al}_2(\text{SO}_4)_3$ has higher lattice energy.
- (c) Define the terms 'bond moment' and 'dipole moment'. Taking an example, explain that bond moment in a molecule does not lead to a non-zero dipole moment in the molecule.
- (d) Isolate the equation in acidic medium $\text{MnO}_4^- + \text{I}^- \rightarrow \text{I}_2 + \text{Mn}^{2+}$ into oxidized half reaction and reduced half reaction and balance the two parts separately and write down the overall balanced reaction.

3. Answer the following questions : $5 \times 3 = 15$

- (a) Find an expression for energy of hydrogen atom. Write the Schrödinger's wave equation for the electron in hydrogen atom. $4 + 1 = 5$

Or

Draw the proper diagram of p -orbitals and d -orbitals of an atom. Write the values of all the quantum numbers for an atom when $n = 3$. $3 + 2 = 5$

- (b) Define electronegativity and deduce the expression for Pauling electronegativity scale. Calculate the electronegativity of carbon atom following Allred-Rochow's approach. (Covalent radius of carbon atom is 0.77 \AA) $1 + 2 + 2 = 5$
- (c) Discuss Heitler-London approach of valence bond theory. 5

Or

- (i) What is solvation energy? Discuss the mechanism of dissolution of an ionic solute in a polar solvent. 3
- (ii) Calculate the formal charge of P and H in PH_3 . 2

4. Answer the following questions (any three) :

$10 \times 3 = 30$

- (a) (i) What are the factors that affect ionization energy? Discuss its periodic trend. Why does successive ionization enthalpy of atom of an element increase immensely? $1 + 2 + 2 = 5$

- (ii) State Slater's rule. Calculate the effective nuclear charge at the periphery of chromium atom. $3+2=5$
- (b) (i) Draw Lewis dot picture for NO and CO_3^{2-} . 2
- (ii) Give a neat molecular orbital diagram of N_2 . Identify HOMO and LUMO in this diagram. Is it possible to obtain an N_2^+ molecular ion? Justify it. $3+1+1=5$
- (iii) What is non-bonding molecular orbital? Explain it with appropriate example. $1+2=3$
- (c) (i) Explain the terms 'radial' and 'angular' wave functions for hydrogen atom. Draw radial probability distribution curve for hydrogen atom when $n=2$. $3+2=5$
- (ii) What are the two basic postulates of VSEPR theory? Is it possible to give suitable explanation for the shape of PCl_3F_2 molecule by VSEPR theory? Elaborate your answer. $2+3=5$
- (d) (i) State and explain Hund's rule of maximum multiplicity. 2

- (ii) How does electronegativity change in sp , sp^2 and sp^3 hybridization? 2
- (iii) Apply molecular orbital theory to CO molecule. 3
- (iv) Describe the theory involved in estimation of Fe^{2+} ion in a given solution of unknown strength. 3

2019

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(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)

(2)

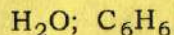
- (c) Define vapour pressure of a liquid.
- (d) In a cubic crystal, there are ____ C_4 axes of symmetry, ____ C_3 axes of symmetry and six C_2 axes of symmetry.

(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 :



(3)

- (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.

2

- (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

- (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
