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3 (Sem–1/CBCS) CHE HC 1

2020

(Held in 2021)

CHEMISTRY

(Honours)

Paper : CHE–HC–1016

(Inorganic Chemistry–I)

Full Marks : 60

Time : Three hours

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

1. Choose the correct answer from the following : 1×7=7

   (a) The number of unpaired electrons present in the ground state electronic configuration of chromium is —

   (i) 4

   (ii) 5

   (iii) 3

   (iv) 6.

Contd.

(b) Arrange the following in the increasing order of the bond energy :

(i) $O_2 < Cl_2 < N_2 < O_2^+$

(ii) $Cl_2 < O_2^+ < O_2 < N_2$

(iii) $N_2 < O_2 < Cl_2 < O_2^+$

(iv) $Cl_2 < N_2 < O_2^+ < O_2$

(c) Predict the shape of the molecule/ion of ClF_3 and I_3^- :

(i) ClF_3 : Planar triangular,
I_3^- : pyramidal

(ii) ClF_3 : Planar triangular,
I_3^- : linear

(iii) ClF_3 : *T*-shaped, I_3^- : *V*-shaped

(iv) ClF_3 : *T*-shaped, I_3^- : linear.

(d) The four quantum numbers of the unpaired electron of fluorine atom is —

(i) $n = 2, l = 1, m = -1, s = +\frac{1}{2}$

(ii) $n = 2, l = 2, m = -1, s = +\frac{1}{2}$

(iii) $n = 2, l = 1, m = -1, s = 1$

(iv) $n = 2, l = 1, m = -2, s = +\frac{1}{2}$

(e) Which of the following is used as redox indicator during the quantitative analysis of iron by $K_2Cr_2O_7$?

(i) Phenolphthalein

(ii) Methylene blue

(iii) Diphenylamine

(iv) Acid orange.

(f) Effective nuclear charge (Z_{eff}) experienced by an $4d$ electron of Fe atom is —

(i) 3.75

(ii) 6.25

(iii) 5.60

(iv) 7.30.

(g) Radius of Na^+ and Cl^- are 95 pm and $181pm$ respectively. Coordination number of Na^+ ion is —

(i) 4

(ii) 6

(iii) 12

(iv) 8.

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

(a) Wave function must obey certain mathematical conditions to become acceptable. Mention those conditions which are required for a well-behaved function.

(b) State and explain Heisenberg's Uncertainty principle.

(c) Can a nickel rod be used to stir a solution of copper sulphate ? Give reason.

(Given that $E^0_{Ni^{2+}/Ni} = -0.25V$, $E^0_{Cu^{2+}/Cu} = +0.34V$)

(d) 'Electronegativity is not a property of isolated atom rather a property of an atom in molecule' — Explain the statement.

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

(a) What is hydrogen bonding ? What are the different types of hydrogen bond which exist in molecules ? "Ice floats on water" — Explain the statement with the help of hydrogen bonding concept. 1+2+2=5

(b) Quantitative analysis of Fe^{2+} ion can be done by volumetric method using redox reactions. Mention the two types of redox reactions that are mostly used for this purpose. Give the detail redox reactions involved during these two processes. 2+3=5

(c) Draw the Molecular orbital diagram of N_2 molecule. With the help of the Molecular orbital diagram, assign magnetic behaviour to the following molecule/ions :

$N_2, N^{2+}, N_2^-, N_2^{2+}$ 3+2=5

(d) *(i)* Define resonance and resonance energy of molecule. 2

(ii) Explain the following observation in the light of Fajans' rule :

Silver halide	**Solubility product (K_{sp})**
AgF	soluble
AgCl	2×10^{-10}
AgBr	5×10^{-13}
AgI	8×10^{-17}

3

(e) Write briefly about the band theory of metallic bonding. With the help of this theory, define semiconductor and insulators. 2+3=5

4. Answer the following questions : 10×3=30

[Answer ***either*** *(a)* ***or*** *(b)*, ***either*** *(c)* ***or*** *(d)* and ***either*** *(e)* ***or*** *(f)*]

Either

(a) (i) Define lattice energy. Deduce the Born-Landé equation for calculation of lattice energy. 2+4=6

(ii) Explain the use of hydration energy and lattice energy to describe the solubility of alkali halides in water. 4

Or

(b) (i) Van der Waals' radius of *Cl* is more than that of its covalent radius. Explain. 2

(ii) Explain why the absolute size of an atom or ion cannot be defined in an exact manner. 2

(iii) In between Fe^{2+} and Fe^{3+}, select the most electronegative one and give reason. 1

(iv) What is ionization enthalpy ? What are the factors affecting ionization energy ? Define successive ionization energy. 1+2+2=5

Either

(c) (i) Define normalized and orthogonal wave function. Normalize the function $\psi = x^2$ over the interval $0 \leq x \leq k$ (k is a constant). 2+2+3=7

(ii) State Pauli's Exclusion Principle and give its application for arrangement of electron in an orbital. 1+2=3

Or

(d) (i) Explain radial and angular wave function of hydrogen atom. Give the significance of radial and angular distribution function of hydrogen atom. 2+3=5

(ii) What are contour boundary and probability diagrams of atomic orbital ? Explain why *s* orbital is spherical in shape. 3+2=5

Either

(e) (i) Define electron gain enthalpy. Describe various factors on which the electron gain enthalpy of an atom depends. Suggest the trend of the electron gain enthalpy value of halogen atoms. 2+3+2=7

(ii) Explain the shape of the following molecules with the help of hybridization concept.

NH_3, SF_4, $SnCl_2$ 3

Or

(f) Write notes on :

(i) Radius ratio rule and its limitations 3

(ii) Quantum numbers and its significance 4

(iii) Valence bond theory. 3

3 (Sem–1/CBCS) CHE HC 2

2020

(Held in 2021)

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.

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

   (a) Correct representation of the kinetic gas equation is —

   (i) $PV = \frac{1}{2}mN\overline{c^2}$

   (ii) $PV = \frac{1}{3}mN\overline{c^2}$

   (iii) $PV = \frac{1}{2}mN(\overline{c})^2$

   (iv) $PV = \frac{1}{3}mN(\overline{c})^2$

Contd.

(b) Arrange the following liquids in the increasing order of their surface tensions at the same temperature :
water, acetic acid, ethanol, diethyl ether.

(c) Define fluidity of a fluid.

(d) In a bcc lattice, the anion *B* occupies the corner and cation *A* occupies the centre. Find the formula of the compound.

(e) In a tetrahedral void, there are _____ number of spheres around each void and _____ number of voids around each sphere. *(Fill in the blanks)*

(f) In an aqueous solution of H_2S at a given temperature, $\left[H_3O^+\right] = 0.01M$, $K_{a_1} = 1.0 \times 10^{-7}$ and $K_{a_2} = 1.0 \times 10^{-14}$. Molar concentration of S^{2-} in the solution will be —

(i) $1.0 \times 10^{-7} M$

(ii) $1.0 \times 10^{-9} M$

(iii) $1.0 \times 10^{-19} M$

(iv) $1.0 \times 10^{-23} M$

(Choose the correct option)

(g) Define common ion effect.

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

(a) Define the following :

Collision frequency, Collision diameter.

(b) Both *NaCl* and *KCl* have fcc structures. But *KCl* behaves towards X-rays like a simple cubic array. Explain.

(c) Define vapour pressure of a liquid. How vapour pressure of a liquid is related to its boiling point ?

(d) What is meant by ionic product of water ? How does it vary with temperature ?

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

(a) On the basis of Maxwell distribution of molecular speeds, derive an expression for most probable speed of gas molecules. At a given temperature, compare average speed, most probable speed and root mean square speed of a gas.

(b) Define surface tension of a liquid. Give its SI unit. Describe drop number method to measure surface tension of a liquid.

(c) State the law of constancy of interfacial angles and law of rational indices.

Draw the (100), (110) and (111) planes in a simple cubic crystal system.

(d) Derive the Ostwald's dilution law for a weak acid. Give the limitation of the Ostwald's dilution law.

(e) Derive the Henderson-Hasselbalch equation for a buffer solution of a weak acid and its salt.
How the dissociation constant of a weak acid can be determined by measuring the pH of a buffer solution containing equimolar amounts of the acid and its salt ?

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

(i) Obtain a relation between mean free path and co-efficient of viscosity of a gas. 5

(ii) How does co-efficient of viscosity of a gas vary with temperature and pressure ? 2

(iii) The mean free path of N_2 gas at $273K$ and $1\,bar$ pressure is $1.0\times10^{-7}m$. Calculate the mean free path of the gas at $273K$ and $0.01\,bar$ pressure. 3

(iv) From kinetic gas equation, show that average translational kinetic energy of an ideal gas is proportional to its absolute temperature. 3

(v) Calculate the average translational kinetic energy of one molecule and one mole of oxygen gas at $27°C$. 4

(vi) Give the causes of deviation from ideal behaviour by a real gas. 3

(b) Answer ***either*** [*(i)* and *(ii)*] ***or*** [*(iii)*, *(iv)* and *(v)*] :

(i) Explain a method of determination of vapour pressure of a liquid. 4

(ii) What is radial distribution function ? Explain how the radial distribution function is used for elucidation of structure of liquid. 2+4=6

(iii) Explain the cleansing action of detergents. 3

(iv) Explain how surface tension of water is influenced by the addition of sugar and common salt separately. 3

(v) Compare the viscosity of liquid with gas in terms of change of temperature and pressure. 4

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

(i) Explain how temperature and concentration affects the degree of ionisation of weak electrolyte. 3

(ii) What is buffer action ? With the help of a suitable example, explain the mechanism of buffer action. Define buffer capacity. 1+3+1=5

(iii) The pH intercellular fluid and blood of human body is naturally maintained. Name the buffers that helps to maintain the pH of human blood 7·4. 2

(iv) Obtain an expression for hydrolysis constant of CH_3COONa. 3

(v) The degree of hydrolysis of sodium acetate in its 0·01M solution is 0·023%. Calculate the hydrolysis constant, K_h and concentration of OH^- ions in the solution. 3+1=4

(vi) Give the different equilibria stages of H_3PO_4 and compare pKa values in these stages. 3