TDC (CBCS) Odd Semester Exam., 2021
held in March, 2022

CHEMISTRY

(1st Semester)

Course No. : CHMHCC-101T

(Atomic Structure and Chemical Bonding)

Full Marks : 50
Pass Marks : 20

Time : 3 hours

The figures in the margin indicate full marks for the questions

SECTION—A

Answer *any* **ten** questions from the following : 2×10=20

1. State Heisenberg's uncertainty principle and explain its significance.

2. Show that the de Broglie wavelength of the electron in the first Bohr orbit of hydrogen atom is $2\pi a_0$ (where a_0 = first Bohr radius).

3. State Hund's rule of maximum multiplicity. Calculate the exchange energy of d^6 system.

4. Using Slater's rule, calculate the effective nuclear charge for one $2p$ and one 4s electron in calcium.

5. Comment on the relative ionic radii of F^- and Na^+.

6. Establish a relation between electron affinity of X(g) atom and ionization potential of X(g) ion.

7. Using VSEPR theory, predict the shape of XeO_2F_2 and indicate the hybridization of central atom.

8. Draw the resonating structures of thiocyanate and cyanate showing the necessary formal charge.

9. Find out the limiting value of the radius ratio of cubic coordination.

10. What is meant by 'partial ionic character of a covalent bond'?

11. "HF is liquid but HCl is gas at room temperature." Explain.

12. $AlCl_3$ is largely covalent, whereas, AlF_3 is predominantly ionic. Give reasonable explanation.

13. Define standard electrode potential values of a redox couple. How does it differ from formal potential?

14. Give an example of disproportionation reaction. What is the driving force behind this reaction?

15. Standard electrode potentials of Cu^{2+}/Cu and Cu^+/Cu systems are 0·34 V and 0·522 V respectively. Calculate $E^\circ_{(Cu^{2+},\, Cu^+)}$.

SECTION—B

Answer *any* **five** questions from the following : 6×5=30

16. *(a)* Draw and interpret the radial probability distribution function diagrams of 2s, $3p$ and $3d$ in a hydrogen atom. 3

(b) The energy of an electron in an excited hydrogen atom is –3·4 eV. Calculate the angular momentum of the electron according to Bohr's theory.

Given :

Mass of the electron = $9{\cdot}1\times10^{-31}$ kg

Rydberg's constant = $1{\cdot}09737\times10^{7}$ m^{-1}

Planck's constant = $6{\cdot}6262\times10^{-34}$ J-s

Speed of light = 3×10^{8} $m\,s^{-1}$ 3

17. (a) The wave number of a line in the Lyman series of hydrogen is equal to the wave number of a line in the Balmer series of He^{+}. Assign the transition involved in each case. The small difference between R_H and R_{He^+} may be ignored. 3

(b) Calculate the de Broglie wavelength of the following : 2+1=3

(i) A rifle bullet ($m = 2\times10^{-3}$ kg) moving with a speed of 300 ms^{-1}

(ii) An electron moving with a speed $\frac{1}{10}$th of that of light

18. (a) Define electron affinity of an element. Comment on the negative electron affinity of nitrogen. 2

(b) Calculate the electronegativity of chlorine in Mulliken's scale and hence find out the electronegativity of the same element in Pauling's scale.

Given, electron affinity of chlorine = 4·0 eV per atom and ionization energy of chlorine = 13·0 eV per atom. 4

19. (a) Explain the general trends in ionic radii of the following sets of ions with proper reason : 2

(i) Li^{+}, K^{+}, Na^{+}

(ii) Mg^{2+}, Na^{+}, Al^{3+}

(b) The drop in ionization energy for N to O is larger than for P to S. Explain. 2

(c) Fluorine is more electronegative than chlorine but the electron affinity of chlorine is more than that of fluorine. Explain. 2

20. (a) Using MO theory, explain the observation that the bond length in N_2^{+} is 0·02 Å greater than that in N_2 while the bond length in NO^{+} is 0·09 Å less than that in NO. 4

(b) What is Bent's rule? Explain with an example. 2

21. *(a)* Draw the resonance structures of N_3^- and HN_3 and comment on their relative stabilities. 2

(b) The heat of formation of CaCl is −182 kJ/mole. Calculate the heat of formation of $CaCl_2$ from the given data. Compare the stability of CaCl and $CaCl_2$: 4

Heat of sublimation of Ca = +201 kJ/mole

Heat of dissociation of Cl_2 = +242 kJ/mole

First ionization energy of Ca = +590 kJ/mole

Second ionization energy of Ca = +1146·4 kJ/mole

Electron affinity of Cl = −349 kJ/mole

Lattice energy of $CaCl_2$ = −2280·4 kJ/mole

22. *(a)* Explain ion-dipole interaction mentioning one example. The dipole moment of a gas phase HBr molecule is 0·827D. Determine the charge distribution in this diatomic molecule if the bond distance is 141·5 pm. ($1D = 3{\cdot}336 \times 10^{-30}$ cm) 1+3=4

(b) Why does Schottky defect mainly occur in ionic lattices whereas, Frenkel defect is predominant in covalent lattice system? 2

23. *(a)* Distinguish between extrinsic and intrinsic semiconductors. Give examples. 3

(b) Discuss the effect of polarizing power and polarizability on the properties of ionic compounds. 3

24. *(a)* Use ion-electron method to balance the following equation and then identify the oxidizing and reducing agents : 2

$$Mn^{2+}(aq) + BiO_3^-(aq) \rightarrow MnO_4^-(aq) + Bi^{3+}(aq)$$

(Acidic)

(b) Construct the cell for the reaction and calculate its e.m.f. at 25 °C :

$$Co + Ni^{2+}\ (1\ M) = Co^{2+}\ (0{\cdot}1\ M) + Ni$$

Given :

$$E^\circ_{Co^{2+}/Co} = -0{\cdot}277\ V$$

$$E^\circ_{Ni^{2+}/Ni} = -0{\cdot}25\ V$$ 4

25. *(a)* In the titration of ferrous ion by potassium permanganate in presence of hydrochloric acid, a preventive solution containing excess manganous sulphate has to be added. Explain. 3

(b) In an aqueous solution containing Fe^{2+} and Fe^{3+} ions, the redox potential is 0·70 V at 25 °C. Calculate the $[Fe^{3+}]/[Fe^{2+}]$ in the solution.

[Given, $E^{\circ}_{Fe^{3+}/Fe^{2+}} = 0 \cdot 77$ V] 3

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2021/TDC/CBCS/ODD/
CHMHCC–102T/286

TDC (CBCS) Odd Semester Exam., 2021
held in March, 2022

CHEMISTRY

(1st Semester)

Course No. : CHMHCC–102T

(States of Matter and Ionic Equilibrium)

Full Marks : 50
Pass Marks : 20

Time : 3 hours

The figures in the margin indicate full marks for the questions

SECTION—A

Answer *any* **ten** of the following as directed : 2×10=20

1. Write the two faulty postulates of kinetic theory of gases.

2. Calculate the various degrees of freedom for the following : 1×2=2

(a) H_2

(b) C_2H_2

3. Calculate the most probable velocity of nitrogen molecule at 30 °C.

4. What is Boyle's temperature? State the law of corresponding states. 1+1=2

5. Write the Berthelot equation and explain the terms involved.

6. Define compressibility factor in terms of volume.

7. How does intermolecular force affect vapour pressure and surface tension?

8. Explain the term 'radial distribution function'.

9. The boiling point of liquid increases with increase in pressure. Explain.

10. Frenkel defect is a combination of _____ defect and _____ defect. 1+1=2
(Fill in the blanks)

11. Explain the term 'centre of inversion' with a suitable example.

12. Calculate the (*hkl*) planes for the following intercepts along crystal axes :
(a) $(2a, 3b, c)$
(b) $(2a, -3b, -3c)$

13. Calculate the pH of a 10^{-9} *M* HCl solution.

14. Aqueous solution of NH_4NO_3 is acidic or alkaline. Justify.

15. Write the factors affecting the degree of ionization.

SECTION—B

Answer *any* **five** questions of the following : 6×5=30

16. *(a)* Derive the kinetic gas equation. 3
(b) Explain graphically how Maxwell's distribution of velocities vary with change in temperature. 2
(c) Explain the term 'mean free path'. 1

17. *(a)* Calculate the kinetic energy of *(i)* 4 gm and *(ii)* 4 mol of CH_4 at 27 °C. 1½+1½=3

(b) Calculate the temperature of the gas if it obeys van der Waals' equation from the following data : 3

A flask of 2·5 L contains 10 moles of a gas under 50 atmosphere. (a = 5·46 atm L^2 mol^{-1} and b = 0·031 L mol^{-1})

18. (a) Deduce the relationship between the critical constants and van der Waals' constants. 3

(b) Explain with a proper diagram of the Andrews isotherm of CO_2. 3

19. (a) Calculate the reduced pressure, reduced volume and reduced temperature of one mol of methane gas confined to a volume of 5 dm^3 under a pressure of 5 atm. Also calculate the temperature of the gas. The critical constants of methane are V_c = 0·0988 dm^3 mol L^{-1}, P_c = 54·6 atm, T_c = 190·2 K. 3

(b) Show that for a van der Waals' gas, the Boyle temperature is $T_B = \frac{a}{R_b}$. 3

20. (a) Illustrate the phenomena of cleansing action of detergent with a suitable diagram. 3

(b) Describe the process of determination of viscosity of a liquid by Ostwald's viscometer. 3

21. (a) The time of flow of water through Ostwald viscometer is 1·48 minutes. For the same volume of a liquid of density 0·792 g/mL, it is 2·42 minutes. Find the viscosity of the liquid relative to that of water and also absolute viscosity at 20 °C. Density and viscosity of water at 20 °C are 0·995 g/mL and 10·02 millipoise respectively. 3

(b) Explain the variation of vapour pressure, surface tension and coefficient of viscosity with temperature. 3

22. (a) Mention the differences between symmetry element and symmetry operation. 2

(b) Explain the various non-Stoichiometric defects with a suitable example. 4

23. *(a)* Explain the following with examples : 1½×2=3

(i) *F*-centre

(ii) Plane of symmetry

(b) Write a short note on 'Bravais lattices'. 3

24. *(a)* Explain the factors affecting the degree of ionization. 2

(b) Deduce the Henderson's equation for a basic buffer. 2

(c) Explain the Ostwald's theory of indicator with reference to acid-base titration. 2

25. *(a)* Calculate the hydrolysis constant, degree of hydrolysis and H^+ ion concentration in 0·1 *N* NH_4Cl solution. [K_b for $NH_4OH = 1{\cdot}8\times10^{-5}$ and $K_w = 10^{-14}$]. 3

(b) Explain the following : 1½×2=3

(i) Common ion effect

(ii) Buffer capacity

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