Total No. of Printed Pages—12

1 SEM TDC CHM M 1 (N/O)

2015

(November)

CHEMISTRY

(Major)

Course : 101

(Physical, Inorganic and Organic)

Full Marks : 80

Pass Marks : 32 (Backlog) / 24 (2014 onwards)

Time : 3 hours

The figures in the margin indicate full marks for the questions

Write the answers to the separate Sections in separate books

SECTION—I

(Physical Chemistry)

(*Marks* : 26)

1. Choose the correct answer of the following : 1×3=3

(a) In a face-centred cubic lattice, atom *A* occupies the corner positions and atom *B* occupies the face-centred positions. If one atom of *B* is missing from one of the face-centred points, the formula of the compound is

(i) AB_2 *(ii)* A_2B_3

(iii) A_2B_5 *(iv)* A_2B

(b) The temperature at which root-mean-square velocity of SO_2 molecules is half that of He molecules at 300 K is

(i) 150 K

(ii) 600 K

(iii) 900 K

(iv) 1200 K

(c) Out of the four liquids given below, the one having the highest surface tension, is

(i) CH_3OH

(ii) C_2H_5OH

(iii) C_6H_6

(iv) H_2O

2. Answer any *three* questions from the following : 2×3=6

(a) Explain why the viscosity of gases increases with increase of temperature.

(b) Frenkel defect is not shown by alkali metal halides but silver halides show. Explain.

(c) Calculate the average internal energy of a diatomic molecule at 300 K using law of equipartition of energy.

(d) What is the vapour pressure of a liquid? Explain two factors upon which vapour pressure depends.

(e) Write the differences between nematic and smectic liquid crystals.

UNIT—I

Answer any *two* questions from the following : 3½×2=7

3. (a) With the help of kinetic gas equation, deduce Charles' law. 2

(b) Calculate the volume of 10 moles of methane at 100 atm pressure and 0 °C. At this temperature and pressure the value of Z is 0·75. 1½

4. What is critical phenomenon? Derive the expressions for the critical constants of a gas using van der Waals' equation of states. 1+2½=3½

5. (a) What do you mean by mean free path, collision diameter and collision frequency of a gas molecule? Explain the effect of temperature on mean free path. 1½+1=2½

(b) An ideal gas can never be liquefied. Justify. 1

UNIT—II

Answer any *one* question from the following : 3

6. Describe the laboratory method for determining the coefficient of viscosity of a liquid. 3

7. *(a)* Show that surface tension and surface energy have the same dimension. 1

(b) Equal volume of an organic liquid and water formed 110 drops and 70 drops respectively in the same stalagmometer at 300 K. The densities of water and the organic liquid are $0{\cdot}996\ g\ cm^{-3}$ and $0{\cdot}80\ g\ cm^{-3}$. Surface tension of water at this temperature is $7{\cdot}2\times10^{-2}\ Nm^{-1}$. Calculate the surface tension of the organic liquid. 2

UNIT—III

Answer any *two* questions from the following : $3\frac{1}{2}\times2=7$

8. *(a)* Derive an expression showing the relation between the spacings of the lattice planes and the wavelength of the X-rays used to study the crystal system. $2\frac{1}{2}$

(b) Draw (110) plane in a cubic crystal. 1

9. *(a)* The first-order reflections from the 100, 110 and 111 planes of a given cubic crystal were found to occur at angles 5·9°, 8·4° and 5·2° respectively. Determine the type of cubic lattice to which the crystal belongs. 2

(b) Calculate the number of atoms present in a body-centred cubic unit cell. 1½

10. *(a)* In terms of band theory, explain the difference between a conductor and an insulator. 2

(b) Why does the electrical conductivity of semiconductors increase with increase in temperature? 1½

SECTION—II

(Inorganic Chemistry)

(*Marks* : 27)

11. Choose the correct answer of the following : 1×3=3

(a) The first ionization potential of Na, Mg, Al and Si is in the order

(i) Na < Mg < Al < Si

(ii) Na > Mg > Al < Si

(iii) Na < Mg > Al < Si

(iv) Na > Mg > Al > Si

(b) The low solubility of $BaSO_4$ in water is due to

(i) low dissociation energy

(ii) ionic bonds

(iii) low value of lattice energy

(iv) high value of lattice energy

(c) Which of the following molecular orbitals in N_2 has the least energy?

(i) π_{2p_y}

(ii) $\pi^*_{2p_z}$

(iii) σ_{2p}

(iv) σ^*_{2p}

12. Answer the following : 2×3=6

(a) Electron affinity values of the second period elements are lower in comparison to the values of the third period elements. Explain giving reasons.

(b) What are the conditions for the combination of atomic orbitals?

(c) Bond angle decreases from NH_3 (107·3°) to NF_3 (102·1°) and from H_2O (104·5°) to OF_2 (103·2°). Explain this decrease.

(Continued)

13. Answer any *two* questions from the following : 3×2=6

(a) Explain the following in the light of Slater's rule : 1½×2=3

(i) Iron loses the 4*s* electrons first during ionization.

(ii) Chloride ion is larger in size than chlorine atom.

(b) Define electronegativity of an element. Discuss the observation that ionization potential of oxygen atom is less than that of nitrogen but electronegativity of nitrogen is less than that of oxygen. 1+2=3

(c) Define ionic radii. How are the ionic radii of ions in ionic crystals which have isoelectronic ions determined? 1+2=3

14. Answer any *three* questions from the following : 4×3=12

(a) *(i)* Define lattice energy. Write Born-Landé equation for the lattice energy of ionic solids indicating the various terms involved in it. 2

(ii) Calculate the lattice energy of potassium chloride from the following data : 2

Heat of formation of KCl = −104·2 kcal/mole

Heat of sublimation of K = 21·5 kcal/mole

Ionization energy of K
= 101·6 kcal/mole

Dissociation energy of Cl_2
= 57·8 kcal/mole

Electron affinity of Cl
= –87·3 kcal/mole

(b) (i) How does partial ionic character depend on electronegativity difference? 2

(ii) Draw the molecular orbital energy level diagram for B_2 molecule and predict its magnetic properties. 2

(c) (i) Bond angle decreases from NH_3 (107·5°) to PH_3 (93·2°) to AsH_3 (91·5°). Explain giving reasons. 2

(ii) Using VSEPR theory, predict the structures of IF_5 and PF_5. 2

(d) (i) Arrange the following in the increasing order of bond length : 2

$$O_2,\ O_2^-,\ O_2^+,\ O_2^{2+}$$

(ii) How does Pauling-Slater theory explain the directional characteristics in covalent bond? 2

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SECTION—III

(Organic Chemistry)

(*Marks* : 27)

15. Choose the correct answer of the following : 1×3=3

(a) Which of the following will have hyper-conjugation effect when attached to benzene?

(i) $-CH_3$

(ii) $-CMe_3$

(iii) $-C_6H_5$

(iv) All of the above

(b) Which of the following carbocations is likely to be most stable?

(i) $CH_3CH_2^{\oplus}$

(ii) $Me_2\overset{\oplus}{C}H$

(iii) $Me_3C^{\oplus}$

(iv) $CH_2=CH-CH_2^{\oplus}$

(c) The IUPAC name of  is

(i) 3,7-nonadiene

(ii) 2,6-diethyl-1,6-heptadiene

(iii) 7-ethyl-3-methylene-1-ene

(iv) 2,6-diethyl-1,6-heptene

16. Answer any *four* questions from the following : $1\frac{1}{2} \times 4 = 6$

(a) In aqueous solution, whether acetic acid or acetate ion is more stable? Explain.

(b) NH_3 molecule has high dipole moment value (1·47D) than NF_3 molecule (0·23D). Explain.

(c) Aqueous solution of phenol is acidic in nature. Explain.

(d) Classify the following as hard acid, hard base and soft base :

RSH, $AlCl_3$, H_2O

(e) Define nitrene. How are nitrenes formed? Give one example.

17. Answer any *three* questions from the following : $2 \times 3 = 6$

(a) Draw the energy profile diagram of an exothermic reaction involving two reaction intermediates in which second step is rate determining.

(b) Explain the stability order of alkyl carbocations using the concept of hyper-conjugation.

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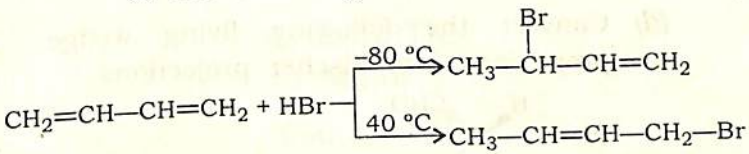
(c) Identify the kinetically controlled and thermodynamically controlled products in the following reaction :

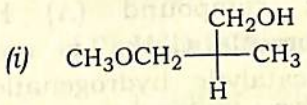


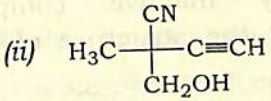
Draw the energy profile diagram for both the reactions.

(d) Draw the orbital diagram of $CH_2=CH-CHO$.

18. Answer any *six* questions from the following : 2×6=12

(a) Label the following with *R*- or *S*- configurations :

(i) 

(ii) 

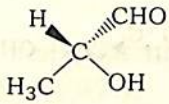
(b) Sketch the following :

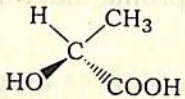
(i) Fischer projection formula for (*R*)-3-methylpentan-1-ol

(ii) Newman projection formula for *erythro*-2-bromo-3-chlorobutane

(c) Write a short note on geometrical isomerism of alicyclic compounds.

(d) Convert the following flying wedge projections into Fischer projections :

(i) 

(ii) 

(e) Write in brief about Walden inversion.

(f) Define alternating axis of symmetry with the help of an example.

(g) An organic compound (*A*) having molecular formula C_6H_{12} is optically active. On catalytic hydrogenation, it gives optically inactive compound C_6H_{14}. Identify the structure of (*A*).

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