Total No. of Printed Pages—7

1 SEM TDC CHMH (CBCS) C 2

2019

(December)

CHEMISTRY

(Core)

Paper : C–2

(Physical Chemistry)

Full Marks : 53

Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

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

(a) The critical temperature is that temperature

(i) at which a gas behaves ideally

(ii) above which a gas can be easily liquefied

(iii) below which a gas can be liquefied by pressure alone

(iv) at which a gas cannot be liquefied

(b) The gases which have the same kinetic energy at a given temperature and pressure are

(i) H_2 and N_2

(ii) N_2 and CH_4

(iii) CH_4 and N_2

(iv) All of the above

(c) Water is a liquid at room temperature because it

(i) has high dipole moment of 1·85 *D*

(ii) is a symmetrical molecule

(iii) is extensively H-bonded with other molecules

(iv) has large dispersion forces

2. Answer any *four* questions from the following : 2×4=8

(a) Xe has $P_c = 58{\cdot}0$ atm and $T_c = 289{\cdot}7$ K. Determine its van der Waals' constants a and b.

(b) Out of *n*-pentane and neo-pentane (both are isomers of pentane) which has higher boiling point and why?

(Continued)

(c) Silver crystallizes in a face-centred cubic lattice with all the atoms at the lattice points. The length of the edge of the unit cell as determined by X-ray diffraction studies is found to be $4{\cdot}077\times10^{-8}$ cm. The density of silver is $10{\cdot}5$ g cm^{-3}. Calculate the atomic mass of silver.

(d) Explain ionic product of water. What is the effect of temperature on it?

(e) Derive the relation $P_cV_c = \frac{3}{8}RT_c$.

(f) A buffer solution contains 0·4 mole of NH_4OH and 0·5 mole of NH_4Cl per litre. Calculate the pH of the solution. Dissociation constant of NH_4OH at the room temperature is $1{\cdot}81\times10^{-5}$.

UNIT—I

3. Answer any *two* questions from the following : 7×2=14

(a) (i) Derive van der Waals' equation for n moles of a real gas. 4

(ii) Show that the excluded volume b is four times the actual volume of the molecule. 3

(b) (i) From the kinetic gas equation, derive the expression for root-mean-square velocity. 2

(ii) Derive the relationship between most probable, average and root-mean-square velocity. 2

(iii) Calculate the temperature at which the average velocity of oxygen equals that of hydrogen at 20 K. 3

(c) (i) What are reduced pressure, temperature and volume? Derive the reduced equation of state. Write its significance. 1½+2½+1=5

(ii) The reduced volume and temperature of a gas are 10·2 and 0·7. What will be its pressure if its critical pressure is 4·25 MPa? 2

UNIT—II

4. Answer any *one* question from the following : 5

(a) (i) Explain three different inter-molecular forces present in liquids. Give examples. 3

(ii) What structural part of a liquid makes it flow? Explain briefly how a liquid flows. 2

(b) (i) Describe drop number method for determining the surface tension of a liquid. 3

(ii) In the determination of surface tension of a liquid using stalagmometre, the liquid gave 58 drops while water gave 24 drops, the volume of the liquid and water being the same. The density of water is $0{\cdot}998\ g\ mol^{-1}$ while that of the liquid is $0{\cdot}795\ g\ mol^{-1}$. The surface tension of water at the given temperature is $70{\cdot}8$ dynes cm^{-1}. What is the surface tension of the liquid? 2

UNIT—III

5. Answer any *two* questions form the following : $4\frac{1}{2}\times2=9$

(a) What are liquid crystals? Name the different types and how do they differ in their molecular arrangement. Write any one application of liquid crystal. $1+3+\frac{1}{2}=4\frac{1}{2}$

(b) (i) Derive Bragg's equation for crystal structure determination. 3

(ii) Sodium metal crystallizes in b.c.c. lattice with the cell edge 4·29 Å. What is the radius of sodium atom? 1½

(c) (i) What are Miller indices? Illustrate (111) plane in cubic system. 1+1½=2½

(ii) Electrical conductivity of semi-conductor increases with increase in temperature. Explain from band theory. 2

UNIT—IV

6. Answer any *two* questions from the following : 7×2=14

(a) (i) Define the terms solubility and solubility product of a substance. Explain the use of solubility product in qualitative analysis. 2+3=5

(ii) 0·00094 gm of AgCl is dissolved in 500 ml of water at 25 °C to form a saturated solution. Calculate the solubility product of AgCl. (Ag = 108, Cl = 35·5). 2

(b) (i) What is buffer solution? Derive Henderson's equation for acidic buffer. Write three applications of buffer solution. 1+2½+1½=5

(Continued)

(ii) Calculate the pH value of a solution obtained by mixing 0·083 moles of acetic acid and 0·091 moles of sodium acetate and making the volume 500 ml. K_a for acetic acid is $1{\cdot}75\times10^{-5}$. 2

(c) (i) What is salt hydrolysis? For a salt of weak base and strong acid, prove that $K_h = \frac{K_w}{K_b}$. Deduce an expression for pH of such salt solution. 1+2+2=5

(ii) Explain why phenolphthalein is not a suitable indicator in the titration of ammonium hydroxide and HCl. 2

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Total No. of Printed Pages—7

1 SEM TDC CHMH (CBCS) C 1

2019

(December)

CHEMISTRY

(Core)

Paper : C–1

(Inorganic Chemistry)

Full Marks : 53

Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct answer from the following : 1×6=6

(a) Heisenberg's uncertainty principle is

(i) $\Delta x \cdot \Delta P = \frac{h}{4\pi m}$

(ii) $\Delta x \cdot \Delta P = \frac{h}{mV}$

(iii) $\Delta x \cdot \Delta P \geq \frac{h}{4\pi}$

(iv) $\Delta x \cdot \Delta P \leq \frac{h}{4\pi}$

(e) The geometrical shape of ClF_3 molecule is

(i) pyramidal

(ii) trigonal planar

(iii) T-shape

(iv) tetrahedral

(f) Which of the following is paramagnetic?

(i) O_2^-

(ii) CO

(iii) NO^+

(iv) CN^-

2. Answer the following questions : 2×9=18

(a) What are normalized and orthogonal wave functions? 1+1=2

(b) Write Schrödinger's wave equation and give the meanings of the symbols used there. 1+1=2

(c) Arrange H_2O, H_2S, H_2Se and H_2Te in the increasing order of bond angle, giving the proper explanation for this trend. 2

(Turn Over)

(d) What do you mean by ionization potential? Why is the value of second ionization potential higher than the first ionization potential? 1+1=2

(e) Define electron affinity. Electron affinity value increases from nitrogen to fluorine in the periodic table. Explain giving reason. 2

(f) Which of the following orbitals are not possible and why? 2

$1p$, $2s$, $2p$ and $3f$

(g) Using VSEPR theory, predict the structures of the following : 1×2=2

(i) SF_4

(ii) XeF_2

(h) Using Fazans' rule, explain that "AlF_3 is high-melting solid while $AlCl_3$ is low-melting volatile solid". 2

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

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

3. Answer any *two* of the following questions : 4×2=8

(a) *(i)* State and explain the principles applied to build up the electronic configuration of nitrogen atom. 2

(ii) Determine the values of n, l, m and s for the valence shell electron of potassium. 2

(b) Derive de Broglie equation. Calculate the wavelength associated with a moving electron having kinetic energy $1{\cdot}375\times10^{-25}$ J. ($h = 6{\cdot}626\times10^{-34}$ J-s) 2+2=4

(c) *(i)* Write the radial and angular wave functions for hydrogen atom. 2

(ii) Write a note on contour boundary. 2

4. Answer any *two* of the following questions : 3×2=6

(a) What is effective nuclear charge? Explain on the basis of Slater's rule, why 4*s* orbital is filled earlier than 3*d* orbital taking potassium atom as an example. 1+2=3

(b) What do you mean by electronegativity of an element? Calculate the electronegativity of fluorine using Allred-Rochow equation. (Covalent radius of fluorine = 0·72 Å) 1+2=3

(c) Nitrogen has positive electron gain enthalpy whereas oxygen has negative. However, oxygen has lower ionization enthalpy than nitrogen. Explain. 3

5. Answer any *two* of the following questions : 3×2=6

(a) What do you mean by percentage of ionic character? HBr molecule has H—Br bond length $1{\cdot}41\times10^{-10}$ m and its dipole moment is $0{\cdot}79\times10^{-29}$ cm. Calculate the percentage of ionic character of HBr molecule. (Given, electronic charge = $1{\cdot}602\times10^{-19}$ C) 1+2=3

(b) What do you mean by hydrogen bond? What are the different types of hydrogen bond? Explain why *o*-hydroxybenzaldehyde is a liquid whereas *p*-hydroxybenzaldehyde is a solid. ½+1+1½=3

(Continued)

(c) What do you mean by bond order of a molecule? The bond dissociation energy of C_2 (599 kJ mol^{-1}) decreases slightly on forming C_2^+ (513 kJ mol^{-1}) and increases greatly on forming C_2^- (818 kJ mol^{-1}). Why? 1+2=3

6. Write short notes on any *two* of the following : 2½×2=5

(a) Solvation energy

(b) Defects in solids

(c) Mulliken-Jaffe electronegativity scales

7. What is standard electrode potential? Explain two important applications of its inorganic reaction. 1+1½+1½=4

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Total No. of Printed Pages—15

1 SEM TDC CHM M 1 (N/O)

2019

(November)

CHEMISTRY

(Major)

Course : 101

(Physical, Inorganic and Organic)

The figures in the margin indicate full marks for the questions

Write the answers to the separate Sections in separate books

(New Course)

Full Marks : 80
Pass Marks : 24

Time : 3 hours

SECTION—A

(Physical Chemistry)

(*Marks* : 26)

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

(a) Bravais lattices are of

(i) 8 types

(ii) 10 types

(iii) 14 types

(iv) 16 types

(b) Compressibility factor of an ideal gas is

(i) 0

(ii) 1

(iii) infinity

(iv) 0·9

(c) The shape of a drop of liquid is spherical due to

(i) viscosity

(ii) absorption

(iii) conductivity

(iv) surface tension

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

(a) Write two differences between smectic and nematic liquid crystals.

(b) What are crystalline and amorphous solids? Give one example of each.

(c) Describe any two factors upon which the surface tension of a liquid depends.

(d) Write the physical significances of van der Waals' constants a and b.

(e) Prove that $P_cV_c = \frac{3}{8}RT_c$.

UNIT—I

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

(a) Write kinetic gas equation. From this equation, derive Boyle's law. 1+2½=3½

(b) Derive reduced equation of states. Write its significance. 2½+1=3½

(c) (i) Give the relationship among most probable, average and root mean square velocities. 2

(ii) Calculate Boyle's temperature for carbon dioxide gas assuming it to be a real gas. ($a = 3{\cdot}59\ l^2 atm\ mol^{-2}$, $b = 0{\cdot}0427\ l\ mol^{-1}$) 1½

UNIT—II

4. Answer any *one* question from the following : 3

(a) Describe the method for determining the viscosity of a liquid in the laboratory. 3

(b) What do you mean by vapour pressure of a liquid? Write any two factors upon which the vapour pressure of a liquid depends. Mention the SI unit of surface tension. 1+1+1=3

UNIT—III

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

(a) What is unit cell? Calculate the number of atoms present in face-centered unit lattice and body-centered unit lattice. ½+(1½×2)=3½

(b) *(i)* Derive Bragg's equation. 2½

(ii) Write the names of two methods by which the structure of a solid can be determined. 1

(c) *(i)* At room temperature, sodium crystallizes in a body-centered cubic cell with edge length 4·24 Å. Calculate the density of sodium. (Atomic mass of sodium = 23 a.m.u.) 2½

(ii) What is *F*-centre? 1

SECTION—B

(Inorganic Chemistry)

(*Marks* : 27)

6. Choose the correct answer from the following : 1×3=3

(a) The correct decreasing order of first ionization energy of five elements of second period is

(i) Be > B > C > N > F

(ii) N > F > C > B > Be

(iii) F > N > C > Be > B

(iv) N > F > B > C > Be

(b) The molecular geometry of SF_4 is

(i) T-shaped

(ii) seesaw

(iii) tetrahedral

(iv) square planar

(c) The bond order of C_2 molecule is

(i) 1 (ii) 2

(iii) 0 (iv) 3

7. Answer the following questions : 2×3=6

(a) The first ionization energy of C atom is greater than that of B, whereas the reverse is true for the second ionization energy. Explain.

(b) Discuss the favourable factors for the formation of ionic bond.

(c) NH_3 molecule is pyramidal but NH_4^+ is tetrahedral though molecules involves sp^3 hybridization. Explain.

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

(a) Define effective nuclear charge. Calculate the effective nuclear charge at the periphery of a Cu atom. 1+2=3

(b) Define electronegativity of an element. Calculate the electronegativity of N atom using Allred-Rochow equation. (Covalent radius of N = 0·74 Å) 1+2=3

(c) Define electron affinity. The first electron affinity of oxygen is 141 $kJ\,mol^{-1}$ while that the second electron affinity is −770 $kJ\,mol^{-1}$. Account for this. 3

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

(a) What are the necessary conditions for the combination of atomic orbitals? Draw the molecular orbital energy level diagram for CO molecule and determine its bond order and magnetic behaviour. 2+2=4

(b) Define bond length and bond energy. What are the effects on bond order in the following ionization processes? 2+2=4

(i) $C_2 \longrightarrow C_2^+ + e^-$

(ii) $O_2 \longrightarrow O_2^+ + e^-$

(c) (i) Define lattice energy. Write the Born-Landé equation for the lattice energy of ionic crystal and indicate the each term of the equation. 2

(ii) Calculate the enthalpy of formation of MgF_2 from the following data : 2

Sublimation enthalpy of Mg = 146·4 $kJ\,mol^{-1}$

Dissociation enthalpy of F = 158·8 $kJ\,mol^{-1}$

Ionization enthalpy of Mg = 2186·0 $kJ\,mol^{-1}$

Electron gain enthalpy of F = – 332·6 $kJ\,mol^{-1}$

Lattice energy of MgF_2 = – 2922·5 $kJ\,mol^{-1}$

(d) (i) Bond angles of NH_3, PH_3 and AsH_3 are 107·5°, 93·2° and 91·5° respectively. How would you account for this? 2

(ii) Write a note on partial ionic character in covalent bond. 2

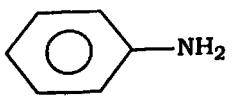
SECTION—C

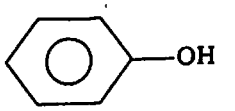
(Organic Chemistry)

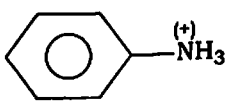
(*Marks* : 27)

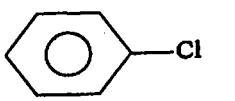
10. Choose the correct answer from the following : 1×3=3

(a) In which of the following molecules resonance effect is not present?

(i) 

(ii) 

(iii) 

(iv) 

(b) Which of the following compounds has the highest acidic strength?

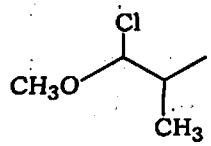
(i) *m*-nitrophenol

(ii) Phenol

(iii) *o*-nitrophenol

(iv) *p*-nitrophenol

(c) The IUPAC name of the compound



is

(i) 3-chloro-3-methoxy-2-methylpropane

(ii) 1-chloro-1-methoxy-2-methylpropane

(iii) 3-chloro-2-methyl-3-methoxypropane

(iv) None of the above

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

(a) Arrange the following compounds in order of increasing acidity with reasoning :

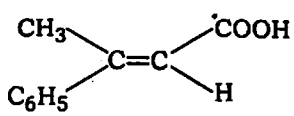
$$CH_3-CH_2-\overset{(+)}{N}H_3,\quad CH_3-CH=\overset{(+)}{N}H_2,\quad CH_3-C\equiv\overset{(+)}{N}H$$

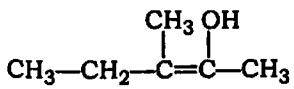
(b) The pK_a value of phenol is 10 and that of cyclohexanol is 16. Explain this observation.

(c) Dipole moment of $CHCl_3$ is less than that of CH_2Cl_2. Explain.

(d) Draw the Fischer projection of mesotartaric acid and convert it into Newman projection.

(e) Write down the *E* and *Z* nomenclature of the following compounds (any *two*) :

(i) 

(ii) 

(iii) $CH_3-CH_2-C(Br)=C(Cl)-COOH$

UNIT—I

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

(a) Draw the energy profile diagram of a three-step exothermic reaction in which the first step is the rate determining step.

(b) What do you understand by the term 'resonance'? Write two conditions necessary for resonance.

(c) What are nitrenes? What happens when an alkylnitrene reacts with a carbon-carbon double bond?

(d) Discuss the structure of a carbocation or a carbanion.

(e) Explain why π-insertion of singlet carbene gives stereospecific addition product.

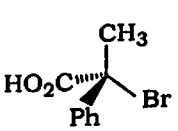
UNIT—II

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

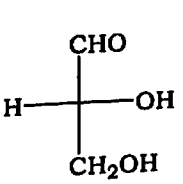
(a) Staggered conformation of *n*-butane is more stable than in eclipsed conformation. Explain with the help of their structures.

(b) Sketch the Newman projection of *meso*-2-3-butanediol.

(c) Assign *R* and *S* designation to the following compounds (any *two*) :

(i) 

(ii) *D*-glyceraldehyde

(iii) 

(d) What is Walden inversion? Give one example.

(e) Draw the Fischer's projection formula of the following :

(i) (*R*)-3-methylpentan-1-ol

(ii) (*S*)-2,3-dimethyl hexane

(f) Draw the three stereoisomers of tartaric acid in Fischer's projection formula. Which of them are enantiomers and which one is the *meso* form?

(g) Sketch the flying wedge and sawhorse projections of *trans*-2-butene.

(h) What do you mean by the term 'racemization'? Active mandelic acid undergoes racemization when treated with NaOH. Give an explanation.