



**2021/TDC/CBCS/ODD/
CHMHCC-101T/285**

**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 :

$2 \times 10 = 20$

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).



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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'?

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(3)

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

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(Turn Over)



(4)

- (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 :

$$\text{Mass of the electron} = 9.1 \times 10^{-31} \text{ kg}$$

$$\text{Rydberg's constant} = 1.09737 \times 10^7 \text{ m}^{-1}$$

$$\text{Planck's constant} = 6.6262 \times 10^{-34} \text{ J-s}$$

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

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.

- (b) Calculate the de Broglie wavelength of the following :

(i) A rifle bullet ($m = 2 \times 10^{-3}$ 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.

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(5)

- (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.

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

(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.

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

20. (a) Using MO theory, explain the observation that the bond length in N_2^+ is 0.02 \AA greater than that in N_2 while the bond length in NO^+ is 0.09 \AA less than that in NO.

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

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(6)

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

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(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 $CaCl_2$:

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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. ($1D = 3.336 \times 10^{-30}$ cm) 1+3=4

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(7)

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

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

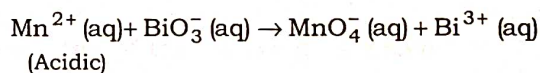
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(b) Discuss the effect of polarizing power and polarizability on the properties of ionic compounds.

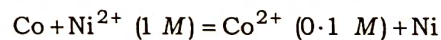
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24. (a) Use ion-electron method to balance the following equation and then identify the oxidizing and reducing agents :

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(b) Construct the cell for the reaction and calculate its e.m.f. at $25^\circ C$:



Given :

$$E^\circ_{Co^{2+}/Co} = -0.277 V$$

$$E^\circ_{Ni^{2+}/Ni} = -0.25 V$$

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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.

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(b) In an aqueous solution containing Fe^{2+} and Fe^{3+} ions, the redox potential is 0.70 V at 25 °C. Calculate the $[\text{Fe}^{3+}]/[\text{Fe}^{2+}]$ in the solution.

[Given, $E^\circ_{\text{Fe}^{3+}/\text{Fe}^{2+}} = 0.77 \text{ V}$]

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An

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