

Code : 100203

## B.Tech 2nd Semester Exam., 2022

( New Course )

## CHEMISTRY

Time : 3 hours

Full Marks : 70

## Instructions :

- (i) The marks are indicated in the right-hand margin.
- (ii) There are **NINE** questions in this paper.
- (iii) Attempt **FIVE** questions in all.
- (iv) Question No. 1 is compulsory.

1. Answer in brief any seven of the following :

2×7=14

- (a) State de Broglie's principle.
- (b) What is an orbital?
- (c) Arrange the covalent bonds C—F, C—Br, C—Cl and C—I in increasing order of strength.

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( Turn Over )

- (d) Which of  $\text{NH}_3$ ,  $\text{PH}_3$ ,  $\text{AsH}_3$  and  $\text{SbH}_3$  possesses largest bond angle? Give reason.
- (e) Out of  $\text{Cr}^{2+}$  and  $\text{Cr}^{3+}$ , which one is stable in aqueous solution?
- (f)  $\text{Cu}^+$  is colourless, but  $\text{Cu}^{2+}$  is coloured. Why?
- (g) What is selection rule?
- (h) A gas expands against vacuum. What is the work done on it?
- (i) What is the condition for a reaction to be in equilibrium?
- (j) The presence of  $\text{CO}_2$  in boiler, feedwater should be avoided. Why?

2. (a) Write short notes on the following : 5

- (i) Wave-particle duality
- (ii) Heisenberg's uncertainty principle
- (b) Discuss photoelectric effect (with mathematical equations) for explaining the particle nature of light. 5

- (c) How many photons of light having a wavelength of 4000 Å are necessary to provide 1 J of energy? ( $h = 6.626 \times 10^{-34}$  J s).

4

3. (a) Which of the following two molecules has a higher bond length?

(i)  $O_2$

(ii)  $O_2^+$

(iii)  $O_2^-$

Explain using molecular orbital theory. 6

- (b) Draw the MO energy level diagram for NO molecule. Using this diagram, calculate and explain bond order and magnetic behaviour of (i) NO, (ii)  $NO^+$  and (iii)  $NO^-$ . 8

4. (a) The internuclear distance of NaCl is  $2.36 \times 10^{-10}$  m. Calculate the reduced mass and moment of inertia of NaCl. (Atomic mass of Cl =  $35 \times 10^{-3}$  kg mol<sup>-1</sup> and Na =  $23 \times 10^{-3}$  kg mol<sup>-1</sup>) 5

- (b) Calculate the force constant for CO, if it absorbs at  $2.143 \times 10^5$  m<sup>-1</sup>. (Atomic mass of C =  $12 \times 10^{-3}$  kg mol<sup>-1</sup> and O =  $16 \times 10^{-3}$  kg mol<sup>-1</sup>) 5

- (c) Which type of electronic transition(s) is/are observed in UV-visible spectrum of phenol in the range 200 nm to 900 nm? Justify your answer. 4

5. (a) How many types of <sup>1</sup>H NMR signals are expected for (i)  $CH_2BrCH_2Cl$  and (ii)  $CH_3OCH_3$ ? Mention relative intensity ratio for the signal(s) observed for (i) and (ii). <https://www.akubihar.com> 5

- (b) At what frequency shift from TMS, would a group of nuclei with  $\delta = 1.5$  resonate in NMR spectrometers operating at 60 MHz and 400 MHz? 4

- (c) 2 mol of  $NH_3$  at 300 K occupy a volume of  $5 \times 10^{-3}$  m<sup>3</sup>. Calculate the pressure using van der Waals equation ( $a = 0.417$  Nm<sup>4</sup> mol<sup>-2</sup> and  $b = 0.037 \times 10^{-3}$  m<sup>3</sup> mol<sup>-1</sup>). Compare the above result with the pressure calculated using ideal gas equation. 5

6. (a) 7 mol of a monatomic ideal gas are compressed reversibly and adiabatically. The initial volume is  $16 \text{ dm}^3$  and the final volume is  $7 \text{ dm}^3$ . The initial temperature is  $27^\circ\text{C}$ .

(i) What would be the final temperature in this process?

(ii) Calculate  $w$ ,  $q$  and  $\Delta U$  for the process.

Given,  $C_v = 20.91 \text{ JK}^{-1} \text{ mol}^{-1}$ ,  $\gamma = 1.4$ . 7

- (b) Write a cell (in proper cell representation) whose cell reaction is  $\text{AgCl} \rightarrow \text{Ag}^+ + \text{Cl}^-$ , using the following standard electrode potentials at  $298 \text{ K}$ :

$$E^\circ_{\text{AgCl}/\text{Ag, Cl}^-} = 0.22 \text{ V}, E^\circ_{\text{Ag}^+/\text{Ag}} = 0.80 \text{ V}$$

Calculate  $E^\circ$  of the cell. Calculate solubility product (or solubility constant) of  $\text{AgCl}$  and its solubility at  $298 \text{ K}$ . 7

7. (a) A water sample had the following constituents per litre :

$\text{CaCO}_3 = 65 \text{ mg}$ ,  $\text{MgHCO}_3 = 80 \text{ mg}$

$\text{CaSO}_4 = 155 \text{ mg}$ ,  $\text{MgSO}_4 = 135 \text{ mg}$

$\text{NaCl} = 8 \text{ mg}$

Calculate the quantity of temporary and permanent hardness in the water sample. Calculate the quantity of lime (80% purity) and soda (90% purity) required for softening of 1 million litre of above water sample. 10

- (b) In an experiment to determine the hardness of a sample of water,  $25 \text{ ml}$  of  $N/50 \text{ Na}_2\text{CO}_3$  solution was added to  $100 \text{ ml}$  of water sample. After complete precipitation of insoluble carbonate, the unreacted  $\text{Na}_2\text{CO}_3$  was titrated against  $N/50 \text{ H}_2\text{SO}_4$  solution, when  $10 \text{ ml}$  of acid was required. Calculate the hardness and comment on the nature of hardness so determined. 4

8. (a) Write notes on the following : 8

(i) Optical isomerism of lactic acid

(ii) Optical isomerism of tartaric acid

- (b) Differentiate between the following : 6

(i) Enantiomers and diastereomers

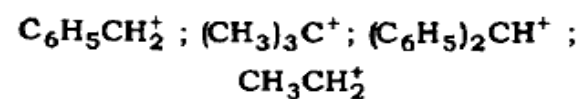
(ii) Racemic mixture and meso-compounds

9. (a) Explain the following : 8

(i) Acetic acid is stronger acid than phenol.

(ii) The amino group in aniline is *o*- and *p*-directing but amide group is meta-directing.

(b) Arrange the following carbocations in order of increasing stability with suitable reasons : 6



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