**Code : 100203**

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**B.Tech 2nd Semester Exam., 2021**

( 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 any *seven* questions in brief :  2×7=14

   (a) State de Broglie's principle.

   (b) What is an orbital?

   (c) What are the shapes of $BF_3$ and $ClF_3$ molecules?

   (d) Out of $NH_3$, $PH_3$, $AsH_3$ and $SbH_3$, which possesses largest bond angle? Give reason.

   (e) Out of $Cr^{2+}$ and $Cr^{3+}$, which one is stable in aqueous solution?

   (f) $Cu^+$ is colourless but $Cu^{2+}$ 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 $CO_2$ in boiler feed water should be avoided. Why?

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

   $$CaCO_3 = 160 \text{ mg}$$
   $$MgHCO_3 = 150 \text{ mg}$$
   $$CaSO_4 = 136 \text{ mg}$$
   $$MgSO_4 = 120 \text{ mg}$$
   $$NaCl = 10 \text{ mg}$$

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Calculate the quantity of temporary and permanent hardness in the water sample. Calculate the quantity of lime (78% purity) and soda (92% purity) required for softening of 25 million litre of above water sample. 9

(b) In an experiment to determine the hardness of a sample of water, 50 mL of $N/50$ $Na_2CO_3$ solution was added to 200 mL of water sample. After complete precipitation of insoluble carbonate, the unreacted $Na_2CO_3$ was titrated against $N/50$ $H_2SO_4$ solution, when 20 mL of acid was required. Calculate the hardness and comment on the nature of hardness so determined. 5

3. (a) Write short notes on the following : 10

(i) Photoelectric effect

(ii) Heisenberg's uncertainty principle

(b) How many photons of light having a wavelength of 3000 Å are necessary to provide 1 J of energy?

$(h = 6.626 \times 10^{-34}$ J-s) 4

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4. (a) Explain the behaviour of CO as ligand with different metal ions 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

5. (a) Which type of electronic transition(s) is/are observed in UV-visible spectrum of aniline in the range 200 nm to 900 nm? Justify your answer with suitable figure. https://www.akubihar.com 6

(b) 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 $mol^{-1}$ and Na = $23 \times 10^{-3}$ kg $mol^{-1}$) 4

(c) Calculate the force constant for CO, if it absorbs at $2.143 \times 10^5$ $m^{-1}$. (Atomic mass of C = $12 \times 10^{-3}$ kg $mol^{-1}$ and O = $16 \times 10^{-3}$ kg $mol^{-1}$) 4

6. (a) How many types of $^1H$ NMR signals are expected for (i) $CH_3COOCH_2CH_3$ and (ii) $CH_3CHCl_2$? Mention the relative intensity ratio for the signal(s) observed for (i) and (ii). 6

(b) $0.6$ mol of $NH_3$ at $25\,°C$ occupies a volume of $3$ $dm^3$. Calculate the pressure using van der Waals equation $(a = 0.417 \text{ N m}^4 \text{ mol}^{-2}$ and $b = 0.037 \times 10^{-3}$ $m^3$ $mol^{-1})$.

Compare the above result with the pressure calculated using ideal gas equation.    8

7. (a) $7$ mol of a monatomic ideal gas are compressed reversibly and adiabatically. The initial volume is $15\,dm^3$ and the final volume is $9$ $dm^3$. The initial temperature is $27\,°C$. (i) What would be the final temperature in this process? (ii) Calculate $w$, $q$ and $\Delta U$ for the process. Given, $C_v = 20.91$ J K$^{-1}$ mol$^{-1}$ and $\gamma = 1.4$.    7

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

$$E^°_{AgCl/Ag,\, Cl^-} = 0.22 \text{ V}$$

$$E^°_{Ag^+/Ag} = 0.80 \text{ V}$$

Calculate $E^°$ of the cell. Calculate solubility product (or solubility constant) of $AgCl$ and its solubility at $298$ K.    7

8. (a) Write notes on the following :    7

    (i) Optical isomerism of lactic acid

    (ii) Optical isomerism of tartaric acid

(b) Differentiate between the following :    7

    (i) Enantiomers and Diastereomers

    (ii) Racemic mixture and Meso-compounds

9. (a) Explain the following :    6

    (i) Trichloroacetic acid is stronger acid than acetic acid.

    (ii) The amino group in aniline is $o$- and $p$-directing but nitro group is $m$-directing.

(b) Arrange the following carbocations in order of increasing stability with suitable reasons :    4

$$C_6H_5CH_2^+, \quad (CH_3)_3C^+, \quad (C_6H_5)_2CH^+,$$

$$CH_3CH_2^+$$
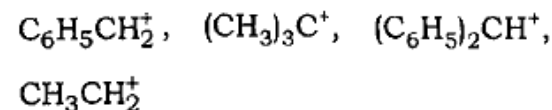
(c) Write short notes on the following :    4

    (i) Markownikoff's rule

    (ii) Kharasch's rule

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