

Bihar Engineering University, Patna
B.Tech 1st Semester Exam-2022

Course: B.Tech.
Code: 100103

Subject: Chemistry

Time: 03 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.
- (v) Symbols used (if any) have their usual meanings.

Q.1 Answer any seven of the following:

[2 x 7 = 14]

- (a) What is the designation of the orbital having $n = 4$ and $l = 3$?
- (b) Write the ground state electronic configuration of N_2^-
- (c) Which of Cr^+ or Cu^+ is expected to be coloured?
- (d) Arrange molecular species N_2 , N_2^+ , N_2^- and N_2^{2-} in increasing order of stability.
- (e) Out of Cr^{2+} and Cr^{3+} , which one is stable in aqueous solution?
- (f) What is the direction of a reaction when $\Delta G = 0$?
- (g) A gas expands against vacuum. What is the work done on it?
- (h) What is the condition for a reaction to be in equilibrium?
- (i) Which of the following is not a nucleophile?
 H_2O , BF_3 , NH_3 , OH^-
- (j) A reaction has $\Delta H < 0$ and $\Delta S < 0$. At what temperature the forward reaction proceed?

- Q.2**
- (a) At what temperature will water boil when the applied pressure is 528 mm of Hg? (Latent heat of vaporisation of water = 545.5 cal/g) [4]
 - (b) Explain dual nature of light and give one example (property/experiment) in favour of its particle nature and wave nature. [4]
 - (c) The equilibrium constants for the reaction $H_2(g) + S(s) \rightleftharpoons H_2S(g)$ are 18.5 at 925K and 9.25 at 1000 K. Calculate standard enthalpy of the reaction. Also calculate ΔG° and ΔS° at 925 K. [6]

- Q.3**
- (a) Which of the following two molecules has a higher bond length? [6]
 - (i) O_2
 - (ii) O_2^+
 - (iii) O_2^-

Explain using molecular orbital theory.

- (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]

- Q.4**
- (a) Calculate the frequency (in Hz and cm^{-1}) of O — H bond, if the force constant and reduced mass of the atom pair are $770 N m^{-1}$ and $1.563 \times 10^{-27} kg$ respectively. [4]
 - (b) Microwave spectrum of gaseous HCl molecule exhibits a series of equally spaced lines with interspacing of $20.7 cm^{-1}$. Calculate the inter-nuclear distance of HCl molecule. [4]

- (c) Explain geometrical isomerism and optical isomerism for transition metal complex with an example for each. [6]

- Q.5** (a) Calculate the force constant of CO molecule, if its fundamental vibrational frequency is 2140 cm^{-1} . (At. Mass of carbon = $1.99 \times 10^{-26}\text{ kg}$ and O = $2.66 \times 10^{-26}\text{ kg}$.) [4]
- (b) At what frequency shift from TMS, would a group of nuclei with $\delta = 1.00$ resonate in an NMR spectrometer operating at 500 MHz? [4]
- (c) How many ^1H NMR signals are there in the following? [6]
- $\text{CH}_3\text{---CH}_3$
 - $\text{CH}_3\text{---CH}_2\text{---CH}_3$
 - $\text{CH}_3\text{---CH}_2\text{---Cl}$
 - $\text{CH}_3\text{---CHCl---CH}_3$
 - $\text{C}_6\text{H}_5\text{CH}_3$
 - $\text{C}_6\text{H}_5\text{CH}_2\text{CH}_3$

- Q.6** (a) 2 mol of NH_3 at 300 K occupy a volume of $5 \times 10^{-3}\text{ m}^3$. Calculate the pressure using van der Waals equation ($a = 0.417\text{ Nm}^4\text{ mol}^{-2}$ and $b = 0.037 \times 10^{-3}\text{ m}^3\text{ mol}^{-1}$). Compare the above result with the pressure calculated using ideal gas equation. [5]
- (b) Write short notes on the following: [9]
- Magnetic resonance imaging
 - Fingerprint region in infrared spectroscopy
 - Different types of electronic excitations

- Q.7** (a) Write the principle for lime soda process for softening of hard water. [2]
- (b) Calculate the amount of lime and soda required for the softening of a million litres of hard water containing $\text{CaCO}_3 = 25\text{ ppm}$, $\text{MgCO}_3 = 144\text{ ppm}$, $\text{CaCl}_2 = 111\text{ ppm}$, $\text{MgCl}_2 = 95\text{ ppm}$, $\text{Na}_2\text{SO}_4 = 15\text{ ppm}$, $\text{Fe}_2\text{O}_3 = 25\text{ ppm}$. [6]
- (c) The hardness of 50000 litres of water sample was removed by passing it through a zeolite softener. The softener then required 200 L of NaCl solution, containing 125g/L of NaCl for regeneration. Calculate the hardness of the sample of water. [6]

- Q.8** (a) Write notes on the following: [8]
- Optical isomerism of lactic acid
 - Optical isomerism of tartaric acid
- (b) Differentiate between the following: [6]
- Enantiomers and diastereomers
 - Racemic mixture and meso-compounds

- Q.9** (a) Write the product for the following reactions together with reaction mechanism: [7]
- $2\text{CH}_3\text{COCH}_3 + \text{OH}^- \rightarrow$
 - $\text{CH}_3\text{CH}_2\text{OH}$ (heated with H_2SO_4) \rightarrow
- (b) Write short notes on the following: [7]
- Steric effects
 - Diels-Alder reaction

