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

Course: B.Tech. | *Time: 03 Hours*
Code: 100103 | *Subject: Chemistry* | *Full Marks: 70*

41049

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 $H_2(g) + S(s) \leftrightharpoons H_2S(g)$ are 18.5 at 925K and 9.25 at 1000 K. Calculate standard enthalpy of the reaction. Also calculate ΔG^o and ΔS^o 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 1.563×10^{-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 = 1.99×10^{-26} kg and O = 2.66×10^{-26} kg.) [4]

(b) At what frequency shift from TMS, would a group of nuclei with δ = 1.00 resonate in an NMR spectrometer operating at 500 MHz? [4]

(c) How many ^1H NMR signals are there in the following? [6]

(i) CH_3-CH_3
(ii) $CH_3-CH_2-CH_3$
(iii) CH_3-CH_2-CL
(iv) $CH_3-CHCL-CH_3$
(v) $C_6H_5CH_3$
(vi) $C_6H_5CH_2CH_3$

Q.6 (a) 2 mol of NH_3 at 300 K occupy a volume of $5x10^{-3}$ m^3. Calculate the pressure using van der Waals equation (a = 0.417 Nm^4 mol^{-2} and b = $0.037x10^{-3}$ m^3 mol^{-1}). Compare the above result with the pressure calculated using ideal gas equation. [5]

(b) Write short notes on the following: [9]

(i) Magnetic resonance imaging
(ii) Fingerprint region in infrared spectroscopy
(iii) 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 $CaCo_3$ = 25 ppm, $MgCO_3$ = 144 ppm, $CaCl_2$ = 111 ppm, $MgCl_2$ = 95 ppm, Na_2SO_4 = 15 ppm , Fe_2O_3 = 25 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]

(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

Q.9 (a) Write the product for the following reactions together with reaction mechanism: [7]

(i) $2CH_3COCH_3 + OH^- \rightarrow$
(ii) CH_3CH_2OH (heated with H_2SO_4) $\rightarrow$

(b) Write short notes on the following: [7]

(i) Steric effects
(ii) Diels-Alder reaction