RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. SECOND SEMESTER EXAMINATION, AUGUST 2021

FIRST YEAR (BATCH 2020-23)

Date : 12/08/2021 **INDUSTRIAL CHEMISTRY (Honours)**

Time : 11.00 am – 1.00 pm **Paper : IV [CC 4]** Full Marks : 50

Unit – I

Answer **any five** questions [5×5]

1. a) Which of the following molecules may show a pure rotational microwave absorption spectrum: (a) H_2O, (b) H_2O_2, (c) NH_3, (d) N_2O

   b) The average spacing between successive rotating lines of CO_2 is 3.826 cm^{-1}. Determine the Temperature which gives most intense spectral line at 3. [1+4]

2. Derive an expression for the value of J corresponding to the most highly populated rotational energy level of a diatomic rotor at a temperature T remembering that the degeneracy of each level is 2J + 1. Evaluate the expression for ICl (for which B = 0.1142 cm^{-1}) at 25°C. Repeat the problem for the most highly populated level of a spherical rotor, taking note of the fact that each level is $(2J + 1)^2$ -fold degenerate. Evaluate the expression for CH4 (for which B = 5.24 cm^{-1}) at 25°C. [5]

3. a) Why rotation along bond axis of a linear molecule is microwave inactive? Mention any two points.

   b) Find the expression of zero point energy for a SHO and Anharmonic oscillator.

   c) Derive the expression of dissociation energy of a molecule. [2+1+2]

4. a) Calculate the frequency of the J = 3 ← 2 transition in the pure rotational spectrum of $^{12}C^{16}O$. The equilibrium bond length is 112.81 pm.

   b) An object of mass 2.0 g suspended from the end of a spring has a vibrational frequency of 3.0 Hz. Calculate the force constant of the spring.

   c) The rotational Raman spectrum of $^{35}Cl_2$ (m(^{35}Cl) = 34.9688 u) shows a series of Stokes lines separated by 0.9752 cm^{-1} and a similar series of anti-Stokes lines. Calculate the bond length of the molecule. [2+1+2]

5. a) Write down the expression of energy level (in cm^{-1}) and from it, derive the general expression of gap between two consecutive energy levels and two consecutive spectral lines for both rotational and vibrational spectra (in cm^{-1}) considering the Rigid Rotor and SHO model.

   b) Suppose we have a sample of HCl. Now, how can we use Infrared spectroscopy to determine the presence and abundance of isotopic Chlorine in the sample? Explain nicely with proper diagram. [3+2]

6. a) The vibrational wavenumbers of the following molecules in their v=0 states are: HCI: 2885 cm^{-1}; DCI: 1990 cm^{-1}; D_2: 2990 cm^{-1}; and HD: 3627 cm^{-1}.

Calculate the energy change, in kJ/mol of the reaction:
$HCl + D_2 \rightarrow DCI + HD$
and determine whether energy is liberated or absorbed.

(Hint: Consider the zero point energies of the four molecules concerned.)

b) The equilibrium vibration frequency of the iodine molecule, is 215 cm^{-1}, and the anharmonicity constant x is 0.003; what, at 300 K, is the intensity of the 'hot band' (v=1to v=2 transition) relative to that of the fundamental (v=0 to v= 1)? [3+2]

7. a) Which of the three vibrations of an AB2 molecule are infrared or Raman active when it is (i) angular, (ii) linear? Explain with reason.

b) Derive the energy gap between the incident radiation and the first stokes line in pure rotational Raman spectra considering the Rigid Rotor model. Also determine the energy-gap between two successive anti-stokes lines. [2+3]

8. a) Draw a perfect Jablonski diagram showing all the possible excitation and de-excitation processes.
b) Fluorescence always occurs from the 1^{st} excited state and never from the other excited states. Explain with reason.
c) Write down the Stokes' Rule in case of Fluorescence. In normal condition, there is always a deviation from the rule, but at very low temperature, the deviation disappears. Elucidate the fact with proper reasoning. [2+1+2]

Unit – II

Answer **any five** questions [5×5]

9. a) What is a metallochromic indicator? Give an example.
b) How will you estimate the amount of Ca^{2+} and Mg^{2+} in a mixture complexometrically? [2+3]

10. a) Explain masking and demasking with suitable example.
b) Distinguish between iodometry and iodimetry. [3+2]

11. a) Outline the principle for the estimation of Ni(II) gravimetrically.
b) Explain the role of buffer in a complexometric titration. [3+2]

12. a) Explain the role of syrupy phosphoric acid in the titration of Fe^{2+} with standard $Cr_2O_7^{2-}$ solution.
b) Name a redox indicator.
c) What is oxine? [3+1+1]

13. a) Distinguish between accuracy and precision.
b) What is meant of Normal (or Gaussian) distribution curve? What is its significance? [2+3]

14. a) The mean of four determinations of the copper content of a sample of an alloy was 8.27 per cent with a standard deviation of 0.17 per cent. Calculate the 95% confidence limit (C.L.) for the true value. [Given: The value of 't' for the 95% C.L. with three degrees of freedom is 3.18]
b) Mention the composition of Zimmermann-Reinhardt (Z.R.) solution. [3+2]

15. a) Briefly enumerate the underlying principle for the estimation of Vitamin C.

    b) Mention the role of ZnO paste in the volumetric estimation of Mn in a pyrolusite ore. [3+2]

16. a) 2.75 gm sample of brass is dissolved in acid and the volume is made upto 250 mL. 25 mL of this stock solution is pipetted out and is titrated iodometrically with 0.1015 N standard $Na_2S_2O_3$ solution to give 16.5 mL titre value. Determine the % of Cu in the sample.
    b) 0.452 gm of $AgNO_3$ gave a precipitate of 0.415 gm AgCl. Calculate the % of Ag in the sample (At. wt. of Ag = 108). [3+2]

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