



EMBU UNIVERSITY COLLEGE
(A CONSTITUENT COLLEGE OF THE UNIVERSITY OF NAIROBI)

FIRST SEMESTER EXAMINATIONS 2014/2015

THIRD YEAR EXAMINATION FOR THE DEGREE OF BACHELOR OF
SCIENCE

SCH 304: THEORY OF SPECTROSCOPY

DATE: DECEMBER 18, 2014

TIME: 16:00 – 18:00

INSTRUCTIONS:

Answer question ONE and any other TWO questions

CONSTANTS

Avogadro constant, $N_A = 6.023 \times 10^{23} \text{ mol}^{-1}$

Plank's constant, $h = 6.626 \times 10^{-34} \text{ Js}$

Speed of light, $c = 2.9979 \times 10^8 \text{ m/s}$ or $2.9979 \times 10^{10} \text{ cm/s}$

$$E = \left(\nu + \frac{1}{2} \right) \omega_e - \left(\nu + \frac{1}{2} \right)^2 \omega_e X_e$$

QUESTION ONE

- Explain the two factors that affect the width of spectral lines. (4 marks)
- A certain radiation has $\lambda = 2.0 \times 10^{-7} \text{ m}$ determine $E \left(\frac{\text{KJ}}{\text{mol}} \right)$, V and λ for the radiation. (4 marks)
- Identify the various regions of the electromagnetic spectrum and show their respective frequency range. (5 marks)

- d) A compound exhibits a molar extinction coefficient of $245 \text{ m}^2 \text{ mol}^{-1}$ at a radiation of wave length $4.5 \times 10^{-7} \text{ m}$. determine the concentration of the solution that has an absorbance of 0.125 if the cell used is 0.01 m. (4 marks)
- e) Using the principle of moments of inertia identify four classes of molecules and give an example for each. (4 marks)
- f) Explain two advantages of the stark effect. (4 marks)
- g) Using diagram show the three vibrational movements in a molecule of water that are IR active. (3 marks)
- h) Explain the requirements for a molecule to be active within the Raman region. (3 marks)

QUESTION TWO

- a) State the two facets of NMR. (4 marks)
- b) Explain the term 'chemical shift'. Use methanol (CH_3OH) to sketch the two peaks due to OH and CH_3 . (10 marks)
- c) Tetramethylsilane ($\text{Si}(\text{CH}_3)_4$) is normally used as a standard in NMR. Explain three advantages for it as a standard. (6 marks)

QUESTION THREE

- a) Express the Beer-lamber Law. (2 marks)
- b) State what each variable in the law above represents. (5 marks)
- c) Explain the importance of Beer-Lamberts law in quantitative analysis. (3 marks)
- d) Explain how the two factors below affect the intensity of spectral transitions.
 - i) Transition probability (4 marks)
 - ii) Populations of originating states. (4 marks)
- e) State the Heisenberg uncertainty principle. (2 marks)

QUESTION FOUR

- a) Name the three types of molecular spectra. (3 marks)
- b) Explain the three types of molecular spectra named above. (17 marks)

QUESTION FIVE

- a) For a simple harmonic oscillator

$$w = \frac{1}{2\pi} \sqrt{\left(\frac{k}{u}\right)} \text{ show that } E_0 = \frac{1}{2}hw$$

If u is induced mass and k is the force constant. (10 marks)

- b) The spectrum of HCl shows a very intense absorption line at 2886 cm^{-1} , a weaker one at 566 cm^{-1} and a very weak one at 8347 cm^{-1} . Determine the equilibrium frequency of the molecule. (5 marks)
- c) Explain the term “molecular polarizability” as used in the Raman Spectroscopy. (5 marks)

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