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University Examinations 2023/2024

FIRST YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF MASTER OF SCIENCE IN CHEMISTRY

SCH 7121: ATOMIC AND MOLECULAR SPECTROSCOPY

DATE: APRIL 2024 **TIME:3 HOURS**

INSTRUCTIONS: *Answer question **one** and any other **two** questions*
Useful constants: $c = 3.0 \times 10^8\ ms^{-1}$, $h = 6.626 \times 10^{-34}\ Js$, Avogadro constant $= 6.022 \times 10^{23}$

QUESTION ONE (30 MARKS)

(a) What does analytical spectrometry involve? (3 marks)

(b) Describe the main parts of a spectrometer. (5 marks)

(c) (i) The light emitted by a sodium hollow cathode lamp has a wavelength of 589 nm. What is the energy in kJ/mol of this radiation? (2 marks)

(ii) Which region of electromagnetic spectrum contain this wavelength? (1 mark)

(d) Explain the following terms.

(i) Chromophore (1 mark)

(ii) Auxochrome (1 mark)

(iii) Zeeman Effect (1 mark)

(e) Explain R:S coupling scheme. (3 marks)

(f) Bohr postulated that to keep the electron in its orbit,

$\underline{Ze^2} = \underline{mv^2}$

r^2 r

Given that the angular momentum mvr is given by the expression,

$$mvr = \frac{nh}{2\pi}$$

Solve for r in a hydrogen atom. (4 marks)

(g) Explain how the secondary fluorescence X-rays are formed. (3 marks)

(h) Explain the quantitative analysis of UV-VIS spectroscopy. (4 marks)

(i) How can you use IR spectroscopy to distinguish between cyclohexane and hex-1-ene? (2 marks)

QUESTION TWO (15 MARKS)

(a) (i) Give the full meaning of LASER. (1 mark)

(ii) Explain three properties of a laser beam. (3 marks)

(b) Describe the following laser processes.

(i) Pumping process (3 marks)

(ii) Spontaneous emission (3 marks)

(c) Explain the application of lasers in analytical chemistry. (5 marks)

QUESTION THREE (15 MARKS)

Explain the mechanism of fluorescence and phosphorescence. (15 marks)

QUESTION FOUR (15 MARKS)

(a) Describe electron magnetic resonance spectroscopy. (3 marks)

(b) (i) State the fundamental nuclear magnetic resonance equation. (1 mark)

(ii) Explain the terms in the equation given in (i) above. (2 marks)

(c) Distinguish the following terms:

(i) Chemical equivalence and magnetic equivalence. (2 marks)

(ii) Vicinal coupling and germinal coupling. (2 marks)

(d) Provide a structure of a compound having a molecular formula of $C_5H_{10}O_2$ that is consistent with the following spectra. SHOW your work and assign all relevant peaks in the IR and ^1H NMR spectra. (5 marks)