International Institute of Information Technology - Hyderabad

Question Paper

Subject: SC1.102: CHEMISTRY TOPICS FOR ENGINEERS

Mid Semester Examination: Monsoon 2025

Max. Time: 1.5 Hr

Max. Marks: 60

Special Instructions about the exam

1. Answer all questions.
2. Make appropriate assumptions where required.
3. Use of nonprogrammable scientific calculators is allowed.

Q1. (a) What is 'chemical shift'? Define in terms of the delta (δ) scale. [2]

(b) Butan-2-one shows a chemical shift around 2.1 on a 300 MHz spectrometer in the H^1 NMR spectrum.

(i) How far upfield or downfield is this peak from TMS in Hz? [2]

(ii) What will be the value of chemical shift when the spectrum is measured with a 400 MHz instrument? [2]

(iii) On this new 400 MHz spectrum, what would be the difference in Hz from the chemical shift to TMS? [2]

(c) The non-toxic, inert substance TMS is used as a standard in recording both ^1H and ^{13}C NMR spectra. Give two other reasons why TMS is used as a standard in recording NMR spectra. [2]

Q2. (a) Compound **P** ($C_4H_8O_2$) was analysed by proton nuclear magnetic resonance spectroscopy. The ^{1}H-NMR spectrum of the compound shows a singlet at ~2.07, a triplet at 1.267, and a quartet at 4.14 ppm. Integration ratio of the peaks is given as: 3:3:2, respectively. Deduce the structure of **P**. Justify your answer. [3]

(b) Assuming the Boltzmann distribution of the spins, show that the intensity is $\propto \frac{N\gamma_N^2 B_0^2}{T}$, where N is the total number of spins, γ_N is the nuclear magnetogyric ratio, B_0 is the strength of the applied magnetic field, and T is the Kelvin temperature. Discuss the physical significance of the expression. [5,1]

(c) Write two differences between NMR and electron paramagnetic (/spin) resonance (EPR/ESR) spectroscopies? [1]

Q3. (a) Maximum how many bonds per atom can Si atom form by electron sharing by satisfying the octet rule? Can we apply the same principle to explain the bonding in Al? Explain. [2]

(b) What is meant by the 'density of states (DOS)'? [1]

(c) Compare the DOS's in a typical 3D metal, semimetal, and semiconductor. [3]

(d) Name a metal oxide that shows copper like electrical conductivity. Use band theory (ligand field theory) to explain its metal-like conduction property. [1,3]

Q4. (a) Which of the following semiconductors, gallium arsenide and silicon, is used for optical devices like LEDs? Why? [1,2]

(b) Describe the working principles of light-emitting diodes (LEDs). [4]

(c) What are 'pigments'? Name an important inorganic black pigment. Explain why black pigments often heat up on exposure to the sunlight. [1,1,1]

Q5. (a) List the criteria for a molecule to exhibit liquid crystalline property. [2]

(b) Briefly describe various major types of thermotropic liquid-crystals. [3]

(c) Mention two applications of thermotropic liquid crystals. Mention the type of thermotropic liquid crystal that is used for the applications you mentioned. [1,1]

(d) Superconductors are often classified as type I or II. Describe the physical characteristic that determines the classification of a superconductor into one or the other of these types. [3]

Q6. (a) Define 'nanomaterials'. Why do nanomaterials show properties that are substantially different from their bulk counterparts? [1,2]

(b) Give one example each of a zero-dimensional (0D) and a two-dimensional (2D) nanomaterial. [2]

(c) Name a conducting polymer and draw the structures of the polymer and its corresponding monomer. [2]

(d) Discuss the electrical conduction mechanisms in conducting polymers. [2]

(e) Mention two advantages of conducting polymers over metallic conductors. [1]