

CHEM 211: PHYSICAL INORGANIC CHEMISTRY

Instructions: Answer QUESTION ONE and any OTHER TWO questions.

QUESTION ONE (30 MARKS)

- a) Briefly discuss the two basic principles of classical mechanics (3mks)
- b) Explain the following terms i) Black body (2mks) ii) Quantization of energy (2mks)
- c) Calculate the number of photons emitted by a 200 W yellow lamp in 2.0 seconds. Take the wavelength of yellow light as 560 nm and assume 100 percent efficiency ($h = 6.626 \times 10^{-34}$ JS, $C = 2.998 \times 10^8$ ms⁻¹) (4mks)
- d) Give three properties of the acceptable solutions to the Schrödinger wave equation (3mks)
- e) Define the Heisenberg Uncertainty Principle and give its mathematical expression (3mks)
- f) Draw the particle in a dimensional box and comment on the potential energy (4mks)
- g) i) Define the octet rule (1 mk)
ii) Briefly discuss two exceptions to the octet rule (4mks)
- h) i) Define hybridization (1mk)
ii) Draw the hybridization of Boron Trifluoride (BF₃) molecule and predict its shape of the molecule (4mks)

QUESTION 2 (20 MARKS)

- a) Discuss the photoelectric effect and give three experimental characteristic of the photoelectric effect (4mks)
- b) For a standing wave, such as a vibrating string of wavelength (λ), whose amplitude at any point along x may be described by a function $f(x)$, it can be shown that

$$\frac{d^2f(x)}{dx^2} = -\frac{4\pi^2}{\lambda^2} f(x)$$

Using the equation above, derive the Schrödinger wave equation (5mks)

$$\nabla^2\psi + \frac{8\pi^2m}{h^2} (E - V)\psi = 0$$

- c) Briefly discuss the Valence Shell Electron Pair Repulsion Theory (VSEPR) (4mks)
- d) Using a diagram differentiate between sigma and pi bonds (2mks)
- e) Using the molecular orbital theory draw the atomic and molecular orbitals of He_2^+ molecule and comment on whether it exists (5mks)

QUESTION 3 (20 MARKS)

- a) Explain the Born interpretation of the square of the wave function ψ^2 (2mks)
- b) Show that e^{ax} is an eigen function of the operator d/dx and find the corresponding eigen value (3mks)
- c) Briefly discuss three Fajans rules (6mks)
- d) Explain three rules for linear combination of atomic orbitals (3mks)
- e) Using the molecular orbital theory, draw the energy level diagram of the atomic and molecular orbitals for O_2^- ion and calculate the bond order (6mks)

QUESTION 4 (20 MARKS)

- a) Using diagrams, differentiate between conductors, insulators and semiconductors using the Band Gap Theory (6mks)
- b) Briefly explain the following terms (5mks)
 - i) Electron affinity
 - ii) Aufbau principle
 - iii) Hund's rule
 - iv) Node
 - v) Zero point energy
- c) i) Write the Rayleigh-Jeans law and define the terms (2mks)
 - ii) Explain why the Rayleigh-Jeans law failed in explaining black body radiation (3mks)
- d) Explain the concept of wave function duality (2mks)

e) Write the term symbol arising from the ground-state configurations of Na (2mks)