



UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN
CHEMISTRY

CHEM 211: PHYSICAL INORGANIC CHEMISTRY

STREAMS:

TIME: 2 HOURS

DAY/DATE: WEDNESDAY 18/12/2024

11.30 A.M – 1.30 P.M

INSTRUCTIONS:

ANSWER QUESTION ONE AND ANY OTHER TWO QUESTIONS

QUESTION ONE (30 MARKS)

- a) Differentiate between tetrahedral and octahedral holes in close packing. (2marks)
- b) i) Using a suitable equation define the radius ratio. (1 mark)
ii) Explain what happens when radius ratio is less than 0.155 and greater than 0.155. (2marks)
- c) Differentiate between polarizing power and polarizability of an ion. (2marks)
- d) Explain the United Atom Method of chemical bonding briefly. (3marks)
- e) Differentiate between the order of molecular orbitals in simple homonuclear diatomic molecules for nitrogen and heavier elements and for lighter elements boron and carbon. (4marks)
- f) i) Draw the electronic configuration, atomic and molecular orbitals for oxygen. (4marks)
ii) Predict its bond order. (1 mark)
iii) Comment on its magnetic properties. (1mark)
- g) Using a suitable diagram explain the ultraviolet catastrophe. (3marks)
- h) Calculate the number of photons emitted by a 200 W yellow lamp in 10 seconds. Take the wavelength of yellow light as 560 nm and assume 100 percent efficiency. (3marks)
($h = 6.626 \times 10^{-34} \text{ Js}$, $C = 2.998 \times 10^8 \text{ ms}^{-1}$)
- i) Discuss one experiment that proved:

- i. Wave character of particles (2marks)
 ii. Particle character of electromagnetic radiation (2marks)

QUESTION 2 (20 MARKS)

- a) Discuss three Fajans rules (6marks)
 b) i) Using a suitable equation explain the Hess's law and define the terms (4marks)
 ii) Apply Hess's law to obtain the electron affinity of the following NaCl crystal, where
 $\Delta H_f = 381.2 \text{ KJ Mol}^{-1}$; $\Delta H_s = + 108.4 \text{ KJ Mol}^{-1}$, $I = 495.4 \text{ KJ Mol}^{-1}$; $\frac{1}{2} H_d = 120.9 \text{ KJ Mol}^{-1}$; $U = 757.3 \text{ KJ Mol}^{-1}$
 (3marks)
 c) List three rules for linear combination of atomic orbitals. (3marks)
 d) Draw the electronic configuration, atomic and molecular orbitals for C_2 and predict whether it exists ($C=4$). (4marks)

QUESTION THREE (20 MARKS)

- a) Using a mathematical equation, define the Heisenberg Uncertainty principle. (3marks)
 b) For a standing wave (such as a vibrating string) of the wavelength λ , whose amplitude at any point along x may be described by a function $f(x)$, it can be shown that

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

If an electron is considered as a wave which moves in only one dimension, then

$$\frac{d^2}{dx^2} \Psi = -\frac{4\pi^2}{\lambda^2} \Psi$$

- Using this equation and any other, derive the Schrödinger wave equation. (6marks)
 c) Draw a particle in a one dimensional box and explain it briefly. (3marks)
 d) Discuss the hybridization of SF_6 and predict the shape. (4marks)
 e) What should be the range values of the work function of a metal in order to be useful in a photocell for detecting visible light ($h = 6.626 \times 10^{-34} \text{ Js}$, $1 \text{ joule} = 1/1.602 \times 10^{-19} \text{ Ev}$)

QUESTION FOUR (20 MARKS)

- a) Discuss two postulates of quantum mechanics. (4marks)
- b) Find the terms that can arise from the configuration of d^2 (2marks)
- c) Briefly discuss the Valence Bond Theory. (3marks)
- d) Using a suitable diagram, discuss the hybridization of BF_3 atom and predict the shape. (4marks)
- e) The speed of an electron is found to be 1 km. s^{-1} within an accuracy of 0.02 %. Calculate the uncertainty in its position ($m_e = 9.11 \times 10^{-31} \text{ kg}$, $h = 6.626 \times 10^{-34} \text{ Js}$) (4marks)
- f) Calculate the potential difference that must be applied to stop the fastest photo electrons emitted by a surface when irradiated by an electromagnetic radiation of frequency $1.5 \times 10^{15} \text{ Hz}$. The work function is 4 eV . (3marks)
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