MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION TECHNOLOGY)

BACHELOR OF SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

BACHELOR OF EDUCATION (SPECIAL NEEDS EDUCATION)

BACHELOR OF SCIENCE (ANALYTICAL CHEMISTRY)

BACHELOR OF SCIENCE (MATHEMATICS)

BACHELOR OF EDUCATION (SCIENCE)

BACHELOR OF SCIENCE (BIOLOGY)

SCH 100: FUNDAMENTALS OF INORGANIC CHEMISTRY

DATE: 28/1/2022 **TIME: 2.00-4.00 PM**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks)
- Answer any **two** questions from section **B** (each 20 marks)

A table of useful constants

$R_H = 1.09737\times10^{7}\, m^{-1}$	$h = 6.626\times10^{-34}$ Js	$r_n = \dfrac{\varepsilon_0 n_n^2 h^2}{\pi m_e e^2}$
$\varepsilon_O = 8.85418\times10^{-12}\, C^2 J^{-1} m^{-1}$	$m_e = 9.11\times10^{-31}$ kg	
$c = 3.0\times10^{8}$ m/s	$1\ eV = 1.602\times10^{-19}$	

SECTION A

QUESTION ONE (30 MARKS)

a) 50.00 mL of ethylene glycol (ρ = 1.114 g/mL; MW = 62.07 g/mol) is added to 1.000-L water (ρ = 1.00 g/mL) at 20 °C. (Assuming additive volumes, calculate:

i. the density of the mixture (2 marks)

ii. the % mass of the ethylene glycol in the solution (1 mark)

iii. the molarity and molality of ethylene glycol in the solution (2 marks)

b) Write the electron configuration of the following ions using the spdf notation

i. Pb

ii. Pb^{2+}

iii. O^{3-} (3 marks)

c) A photon is emitted as an atom makes a transition from n = 4 to n = 2 level. Calculate:

i. Frequency (2 marks)

ii. Wavelength (2 marks)

iii. Energy of the emitted photon (2 marks)

d) Identify the following as either paramagnetic or diamagnetic molecules stating your reason

i. H_2^+

ii. H_2

iii. He_2^+

iv. He_2 (2 marks)

e) A metal with a threshold frequency of 8.27×10^{14} Hz emits an electron with a velocity of 6.06×10^5 m/s when a radiation of 1.09×10^{15} Hz strikes the metal. Calculate the mass of the electron (3 marks)

f) Balance the following redox reactions using the half-reactions

i. $SO_3^{2-}{}_{(aq)} + MnO_4^-{}_{(aq)} \rightarrow SO_4^{2-}\ (aq) + Mn^{2+}{}_{(aq)}$ (pH = 3) (2 marks)

ii. $MnO_4^-{}_{(aq)} + C_2O_4^{2-}{}_{(aq)} \rightarrow MnO_2 + CO_2$ (pH = 9.5) (2 marks)

g) Show the hybridization in the given molecules and show their electron structure in bonding

i. BF_3

ii. SF_6 (3 marks)

h) State four limitations of Bohr's atomic model (4 marks)

SECTION B

QUESTION TWO (20 MARKS)

a) A piece of metal has a cutoff wavelength of λ cutoff = 450 nm. Consider illuminating this piece of metal with two different wavelengths of light: λ_1 = 500 nm beam and λ_2 = 400 nm beam. For each of the two beams, determine:

i. The maximum kinetic energy of ejected electrons (3 marks)

ii. Their velocity (2 marks)

iii. Their de Broglie wavelength (2 marks)

b) Explain two reasons of Neil Bohr's objection to Rutherford's atomic model. (4 marks)

c) State four postulates of Valency Shell Electron Pair Repulsion (VSEPR) Theory (4 marks)

d) Using VSEPR theory draw and state the geometry and hybridization of the following molecules (5 marks)

i. H_2O

ii. CO_2

iii. CH_4

iv. NH_3

v. SF_4

QUESTION THREE (20 MARKS)

a) Draw the Lewis structure of the following molecules (4 marks)

i. $[Cu(H_2O)_6]^{2+}$

ii. Be_2Cl_6.

iii. C_6H_6

iv. HNO_3

b) If 40.0 mL of 0.10 M phosphoric acid is required to titrate 150.0 mL of NaOH to equivalence point, calculate the molarity of the alkali (3 marks)

c) 50.0 g C_2H_5OH is added to 500.0 g water. Calculate the molality and mole fraction of the solution give the density of ethanol = 0.789 g/cm^3. (3 marks)

d) Determine the pH of the given solutions:

i. $Mg(OH)_2$ with a concentration of 1.65 x 10-4 M (2 marks)

ii. A 25.0 mL sample of 0.10 M lactic acid ($HC_3H_5O_3$, pKa = 3.86) is titrated with 0.10 M NaOH solution. Calculate the pH after addition of 0.00 mL (4 marks)

iii. When 4.0 mL of NaOH solution is added in (ii) (4 marks)

QUESTION FOUR (20 MARKS)

a) i. Define ionization energy (2 marks)

ii. Explain why sulphur's first ionization energy is less than that of phosphorus. (3 marks)

b) Calculate the wavelength (in nanometers) of a H atom (mass = 1.674×10^{-27} kg) moving at 698 cm/s (5 marks)

c) Calculate the velocity of an electron having a de Broglie wavelength of 269.7 pm. (5 marks)

d) Calculate the pH of 0.10 M solution NH_4Cl solution (K_b for $NH_3 = 1.8 \times 10^{-5}$) (5 marks)

QUESTION FIVE (20 MARKS)

a) State the chief characteristic features of the Niels Bohr's Atomic Model (4 marks)

b) Briefly state the information you will obtain from the following quantum numbers

i. The principal quantum number (n)

ii. Azimuthal quantum number (l)

iii. The magnetic quantum number (m)

iv. The spin quantum number (m_s) (8 marks)

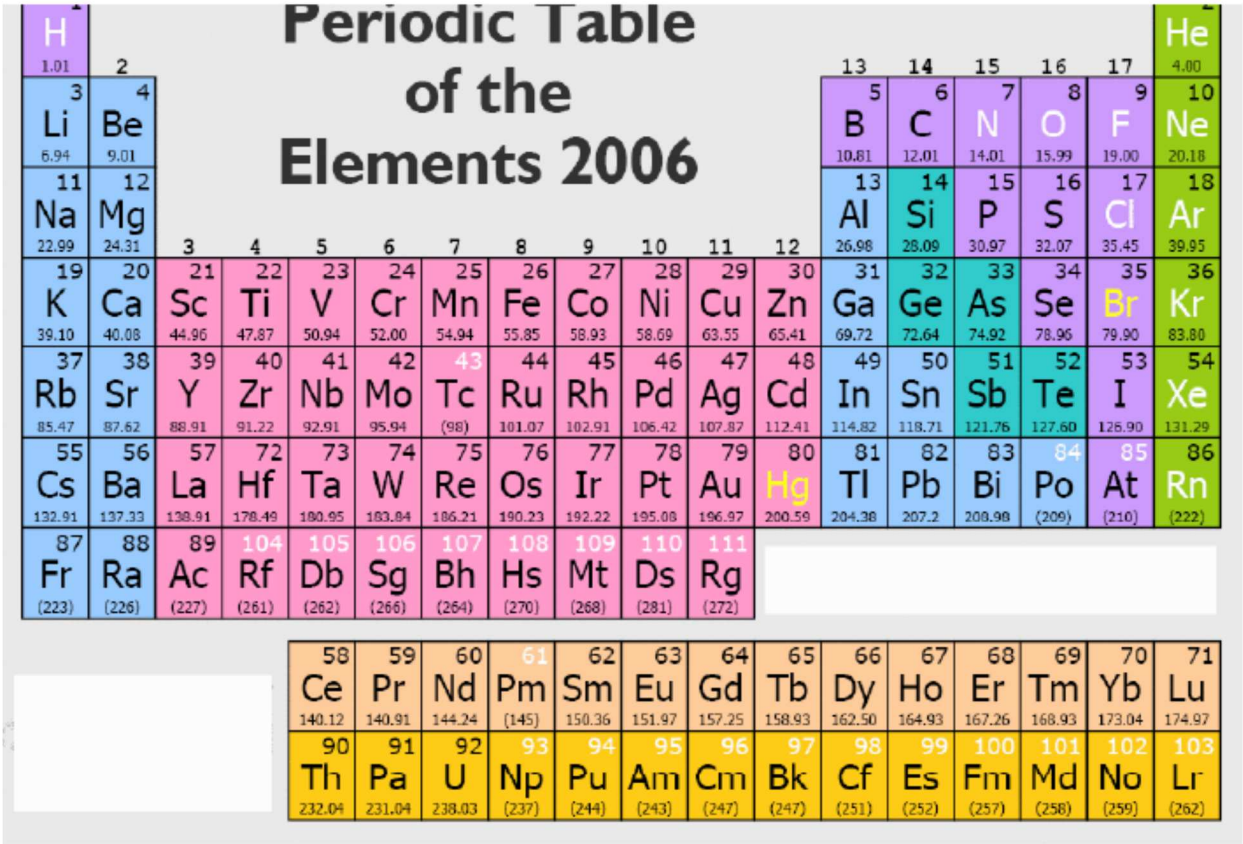
c) Draw the shapes of the following orbitals (2 marks)

i. dz^2

ii. $dx^2\text{-}y^2$

d) Using CH_2CH_2 molecule show how a sigma and pi bonds are formed (2 marks)

e) Calculate the longest and the shortest wavelength of an excited electron in the Balmer series. (4 marks)


Periodic Table of the Elements 2006