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MAIN EXAMINATION

JANUARY - APRIL 2017 TRIMESTER

FACULTY OF SCIENCE

DEPARTMENT OF CHEMISTRY

SCHOOL FOCUSED PROGRAMME

CHEM 104: CHEMICAL BONDING AND STRUCTURE

Date: APRIL 2017	**Duration: 2 Hours**
INSTRUCTIONS: Answer Question ONE and any other Two Questions	

Q1

a) Scientists have proposed various models of the atom to match experimental evidence available. Describe the following models.
   i. Thomson's plum pudding model **(5 marks)**
   ii. Rutherford's model **(5 marks)**

b)
   i. In order to account for the configuration of multi – electron atoms, quantum numbers l, m and n were introduced. Explain briefly the significance of each of these quantum numbers. **(3 marks)**
   ii. State clearly the values assigned to l and m when n = 3. **(3 marks)**

c)
   i. Derive Broglie wave equation from Einstein equation and Planck's equation. **(4 marks)**

ii. Calculate the wavelength of a wave associated with a water molecule of mass 3 x 10^{-26} kgs, moving at 500 m/s [6.63 x 10m^{-34} Jsec] **(2 marks)**

d)

i. Define an orbital. **(1 mark)**

ii. Using the XYZ plane, sketch the following the orbitals

i. P_z orbital

ii. d_z^2 orbital

iii. $d_x^2–_y^2$ orbital

iv. S–orbital **(4 marks)**

iii.

i. Write the electronic configuration of the following:

i. Cr = 17

ii. Cr = 24

iii. Mo = 42 **(3 marks)**

ii. Calculate the effective nuclear charge on a 3d and 4s electron in Nickel atom [Ni = 25] **(2 marks)**

Q2

a) Describe the following experiments on particulate nature of light

i. The photoelectric effect **(5 marks)**

ii. Compton scattering **(5 marks)**

b)

i. State FIVE assumptions that were based on the Bohr atomic model. **(5 marks)**

ii. State ONE success and THREE failures of the Bohr model. **(3 marks)**

Q3

a) Draw the molecular orbital energy level diagram for the following species:

i. O_2^-

ii. N_2^+

iii. OF

[O = 8; N = 7; F = 9]

For each species determine the bond order magnetic property and write the electronic configuration. **(5 marks)**

b)

i. What is meant by the term resonance? **(5 marks)**

ii. Draw resonance structures of the following ions.

i. NO_3^-

ii. SO_4^{2-} **(3 marks)**

[N = 7; O = 8; S = 16]

Q4

a)

i. Define lattice energy. **(1 mark)**

ii. Using the following data, calculate the lattice energy of potassium bromide using the Born Haber Cycle.

Reaction	**H/KJ mol^{-1}**
K (s) + ½Br_2 (l) ⟶ KBr (s)	–392
K (s) ⟶ K(g)	+90
K (g) ⟶ K^+ (g) + e	+420
½Br_2 (l) ⟶ Br (g)	+112
Br (g) + e ⟶ Br^-	– 342

(5 marks)

b) Describe trends across the periods and down the groups for the following properties of the periodic table.

i. Metallic character

ii. Ionisation energy

iii. Electronegativity

iv. Atomic radius **(12 marks)**

c) Distinguish between electron affinity and electronegativity. **(2 marks)**

Q5

a) The hydrogen emission spectrum arises when electrons move from orbits of high quantum number to orbits of low quantum number. **(2 marks)**

i. Draw an emission spectrum from n = 1 to n = α indicate the Brackets, Paschen and Pfund series. Also indicate the ionization energy of an electron. **(6 marks)**

ii. Calculate the frequency and wavelength of light emitted by a hydrogen atom when an electron falls from orbit n = 4 to orbit n = 2 using the following equation.

$$\frac{1}{\lambda} = R_H\left[\frac{1}{n_{1^2}} - \frac{1}{n_{2^2}}\right] RH = 1.098x10^{-2}\,nm^{-1}$$

(4 marks)

iii. The value of the wavelength at the start of the continuum in the sodium emission spectrum is 242nm. Calculate the 1st ionization energy of sodium [6.626 x 10^{-34} Js; C = 3.0 x 10^{8}m/s; L = 6.02 x 10^{23} mol]. **(4 marks)**

iv. Draw a labeled diagram of the apparatus used to produce the visible spectrum of hydrogen. **(6 marks)**

END