

## UNIVERSITY EXAMINATION

CHUKA



UNIVERSITY

## RESIT/SPECIAL EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE  
 CHEM 212: COMPARATIVE STUDY OF S AND P BLOCK ELEMENTS

STREAMS:

TIME: 2 HOURS

DAY/DATE: WEDNESDAY 05/05/2021

8.30 A.M – 10.30 A.M

## INSTRUCTIONS:

*Answer ALL Questions*

## QUESTION ONE (30 MARKS)

- a) (i). In a quantum mechanical description of the hydrogen atom. What is the physical significance of the wavefunction  $\psi^2$ ? (2marks)
- ii) What is meant by the expression "electron density"? (2marks)
- b) i) What is a radial distribution function? (2marks)
- ii) Draw this function for 1s and 2s orbitals in a hydrogen atom (2 marks)
- c) What is an orbital? (1 mark)
- d) Draw the shapes and orientation of the 1s; 2s, 2p<sub>x</sub>, 2p<sub>y</sub>, 2p<sub>z</sub> and 3d<sub>z<sup>2</sup></sub> orbitals (6 marks)
- e) Give the names and symbols of the four quantum numbers required to define the energy of electrons in atoms (4marks).
- f) Explain (a) the Pauli exclusion principle, and (b) Hund's rule (2marks)
- g) The first shell may contain up to 2 electrons, the second shell up to 8, the third shell up to 18, and the fourth shell up to 32. Explain this arrangement in terms of quantum numbers. (6 marks).

- h) Give the sequence in which the energy levels in an atom are filled with electrons. Write the condensed electronic configurations for the following elements (using appropriate noble gas core abbreviations) of atomic number 6, 11, 17, 55, 82 and 25, and from this decide to which group in the periodic table each element belongs (3 marks).

**QUESTION TWO (20 MARKS)**

- a) What is meant by the term effective nuclear charge?. How does effective nuclear charge experienced by the valence electrons of an atom vary going from left to right across the period of a periodic table and down the group. Explain. (3 marks)
- b) Which will experience greater effective nuclear charge, the electrons in the  $n = 3$  shell in Argon (Ar) or the  $n = 3$  shell in Kr? Which will be closer to the nucleus? Explain (3 marks)
- c) Use Slater's rule to find the effective nuclear charge felt by an electron in the following orbitals in the respective elements. (i). a 3d electron in titanium (ii) a 5s electron in strontium (iii) a 3d electron in iron (6 marks)
- d) Arrange the following atoms in order of increasing effective nuclear charge experienced by the electrons in the  $n = 3$  electron shell: K, Mg, P, and Ti. Explain the basis of your order (3 marks).
- e) Write the elements in the following groups in order of increasing (smallest to largest) value of the stated property. Give reasons for your answer (5marks).
- (i). Electronegativity: S, Na, Al, Cs
  - (ii) Metallic Character: Ca, Cl, Al
  - (iii) Atomic radius
  - (iv) ionic character:  $\text{H}_2\text{S}$ , KBr,  $\text{F}_2$

**QUESTION THREE (20 MARKS)**

- a) Consider the following elements S, Cl, and K and their most common ions

- (i).List the atoms in order of increasing size (ii).List the ions in order of increasing size (iii) Explain any differences in the orders of the atomic and ionic sizes (3 marks).
- b) Distinguish between ionization energy and electron affinity. Why are the ionization energies always positive quantities and electron affinities negative quantities? Which elements have positive electron affinities Explain (5 marks)
- c) Why does Li have a larger first ionization energy than Na and why does Li have a much larger second ionization energy than Be? (3 marks)
- d) The difference between the third and fourth ionization energies of scandium is much higher than the difference between the third and fourth ionization energy of Titanium. Explain (3 marks)
- e) What is the general relationship between the size of an atom and its first ionization energy? What is the trend in the first ionization energy as one proceeds down the group of the group 17 elements? Explain how this trend relates to the variation in atomic radii (3 marks).
- f) While the electron affinity of bromine is a negative quantity, it is positive for Kr. Similarly, the electron affinity of Lithium is a negative value, whereas the electron affinity is positive for Be. Use electron configuration of the pairs of the two elements to explain their differences (3marks).
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