SECTION 3

THE ELECTRONIC STRUCTURE OF ATOMS OF THE ELEMENTS

Electronic structure of atoms: The arrangement of electrons around the nucleus of the atom.

The properties of atoms can be understood in terms of **Quantum Theory**, which involves the **Heisenberg Uncertainty Principle** and the **Schrödinger Wave Equation**.

Quantum Theory: A theory that states that the energy of an object can only change by discrete steps. A change involves a packet of energy called a **quantum**.

Heisenberg Uncertainty Principle: The position and momentum of a particle cannot both be known simultaneously. This implies that in an atom the position and momentum of an electron cannot both be known simultaneously. (Thus a model of an atom containing electrons in fixed orbits around the nucleus is untenable.)

Schrödinger Wave Equation

Spin of an electron: The intrinsic angular momentum of an electron. Occurs in only two senses denoted ⇒ and .

Electron shells: The electrons in an atom exist in shells, each shell being made up of atomic orbitals or subshells.

Principal quantum number: Symbol *n*, an integer, 1,2 3... which defines the shell. The smaller *n*

Valence electrons: Those electrons in the outermost shell and in unfilled subshells [e.g. Cl has 7 valence electrons ($3s^2p^5$) and Co has 9 valence electrons ($3d^74s^2$)]. Valence electrons are involved in chemical bonds - *section 4*.

The Periodic Table: A table showing the elements in rows and columns in a manner which shows up relationships between the properties of the elements.

Periods: Rows of the periodic table. Elements in the same row are in the same period [e.g. calcium, Ca, and copper, Cu, are both in the 4th period]. The number of the period (row) is equal to the principal quantum number of the outermost valence shell of the atoms.

Groups: Columns of the periodic table. Elements in the same column are in the same group and have the same number of valence electrons (which accounts for their similarities) [e.g. carbon, C, and tin, Sn, are both in group 14 and both have four valence electrons]. This numbering replaces a previous system, shown as Roman numbers on the table, still used by some older chemists.

Blocks: Groups having the same valence orbitals. Groups 1-2 are *s*-block because their elements have only *s* valence electrons; groups 3-12 are *d*-block because their elements have only *s* and *d* valence electrons; groups 13-18 are *p*-block because their elements have *s* and *p* valence electrons.

Alkali metals: The metals (elements) of group 1.

Alkaline earth metals: The metals (elements) of group 2.

Halogens: Elements of group 17 [e.g. chlorine].

Halide: A binary compound of a halogen and another element [e.g. HCl, $CaCl_2$, PCl_3], or with a group [e.g. CH_3Cl, chloromethane but also called methyl chloride; see *section 6-2*].

Halide ion: Monoatomic anion of a halogen [e.g. chloride ion, Cl^-].

Transition metals: The metals (elements) of the *d*-block.

Ionisation energy: The first ionisation energy is the minimum energy required to remove an electron from a neutral atom in the gas phase:

E(g) Eelectrl Tw<006f‡Fj#.26 333.8604 Tm010.0024has80.0009 Tw(

Photon: A particle-like package of electromagnetic radiation. The energy, E, of the photon is related to the frequency, ν, of the radiation by the expression $E = h\nu$ where h is the Planck constant.

EXERCISES

Write the electron configuration of the ground states of the following elements:

1. *Example*: selenium, Se
   Answer: From the periodic table Z = 34; there are 34 electrons to be placed in the orbital energy series.

   $1s^2 2s^2 p^6 3s^2 p^6 4s^2 3d^{10} 4p^4$
   2, 10, 18, 20, 30, 34 accumulative number of electrons
   or $1s^2 2s^2 p^6 3s^2 p^6 d^{10} 4s^2 p^4$

2. carbon 3. fluorine 4. iron 5. arsenic 6. silver

7-12. Give a possible value for the principal quantum number and for the azimuthal quantum number for a valence electron of the elements in questions 1-6 above.

7. *Example*: selenium, Se
   Answer: For Se the valence electrons are 4*s* and 4