St Ninian's High School

Chemistry Department

National 5 Chemistry

Unit 1: Chemical Changes & Structure

Section 1.2

Atoms and the Periodic Table

Summary Notes

Name _____

Learning Outcomes

After completing this section you should be able to :

1 state that elements are arranged in the Periodic Table
2 state that a group is a column in the Periodic Table
3 state that elements in one group of the Periodic Table show similar chemical properties
4 identify the alkali metals, halogens, noble gases and transition metals as families of elements
5 state that the noble gases are a family of very unreactive elements
6 state that every element is made up of very small particles called atoms
7 describe the atom as having a very small positively charged nucleus with negatively charged electrons moving around outside the nucleus
8 describe the locations and charge of the proton, neutron and electron
9 state the relative masses of the proton, neutron and electron
10 state that an atom is electrically neutral because the number of positive charges in the nucleus (protons) is equal to the number of negative charges surrounding the nucleus (electrons)
11 state that atoms of different elements are different and have a different number on the Periodic Table called the atomic number
12 the atomic number of an element is equal to the number of protons in an atom of that particular element
13 state that electrons are arranged in energy levels
14 state that elements with the same number of outer electrons have similar chemical properties
15 state that the mass number is equal to the sum of the protons and neutrons in an atom
16 describe the formation of ions
17 calculate the number of protons, neutrons and electrons in an atom or ion from nuclide notation
18 state what is meant by isotopes
19 state what is meant by relative atomic mass and why the average atomic mass of an element is rarely a whole number.

The Periodic Table

Everything in the world is made up from just over 110 chemical elements. An **element** is defined as a substance made up of only one type of atom and all the known elements are listed in the Periodic Table. In the Periodic Table a row is referred to as a period and a column referred to as a group.

All the elements in the one group show similar chemical properties which means they take part in similar chemical reactions. Some of the groups are named as families of elements: Group 1 the **alkalis metals**, group 7 the **halogens** and group 0 the **noble gases**. The transition metals are found between groups 2 and 3. The noble gases are a family of unreactive elements and do not take part in chemical reactions.

Atoms & Atomic Structure

Everything that exists is made up of very small particles called atoms. An element is a substance that is made up of atoms of only one kind. Each different atom has a number called the **atomic number**. Elements are arranged in the Periodic Table in order of increasing atomic numbers.

Atomic Structure

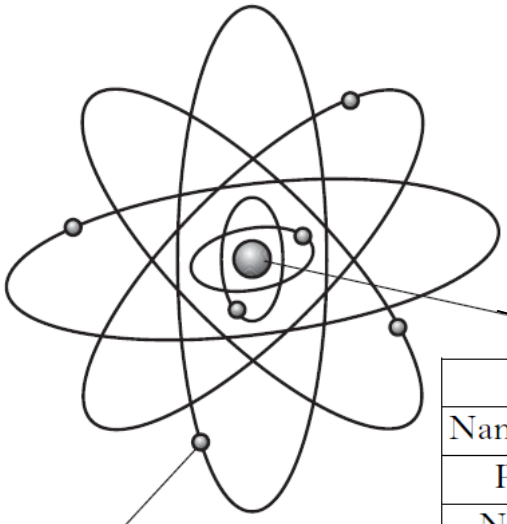
Atoms themselves consist of small particles (sub-atomic particles) called protons, neutrons and electrons.

Protons are found in the very small core at the centre of the atom. This core is called the nucleus and is very small compared to the rest of the atom. Protons have a positive charge and a mass of 1 atomic mass unit (amu).

Electrons move around outside the nucleus and have a negative charge which is opposite to that of the protons. Electrons have virtually no mass. Atoms are overall neutral since they will contain the same number of electrons as protons. This means that the total positive charge of the protons is equal to the total negative charge of the electrons, i.e. the positive and negative charges cancel out and so no overall charge.

Neutrons are also found inside the nucleus and have an atomic mass of 1 amu. Neutrons do not have a charge, i.e. they are neutral.

The Structure of an Atom



THE NUCLEUS	
Name of Particle	Relative mass
PROTON	1
NEUTRON	1

OUTSIDE THE NUCLEUS	
Name of Particle	Relative mass
Electron	0

Atoms & Atomic Structure

Nuclide Notation

Nuclide notation is used to give the chemical symbol, atomic number and mass number of an atom. It is a shorthand way to list and show information about the nucleus of an atom.

The atomic number gives the number of protons in the nucleus of an atom and the mass number gives the number of protons plus the number of neutrons in the nucleus.

Example 1: A chlorine atom with 18 neutrons.

$$\text{Mass number - } {}^{35}\text{Cl} \leftarrow \text{17 protons + 18 neutrons = 35}$$
$$\text{Atomic number - } {}_{17} \leftarrow \text{Atomic number = number of protons = 17}$$

Example 2: A nitrogen atom with 6 neutrons.

$${}^{13}_{7}\text{N}$$

13 ← 7 protons + 6 neutrons = 13

7 ← Atomic number = number of protons = 7

Electron Arrangement

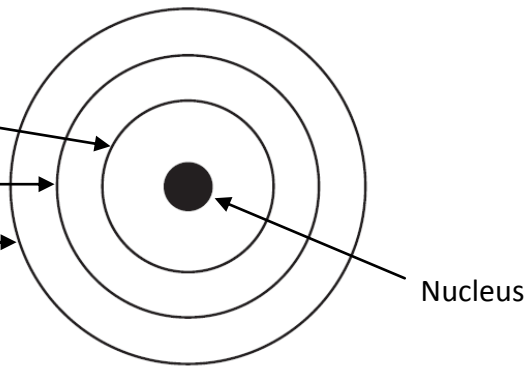
Most of an atom is empty space which electrons move through. The electrons are arranged within this empty space in a particular way.

Electrons are arranged in shells (energy levels) and there is a limit to the number of electrons each shell can hold.

The **first** shell (nearest the nucleus) can hold 2 electrons.

The **second** shell can hold up to 8 electrons.

The **third** shell can hold up to 8 electrons.



Electrons will occupy the shell which is nearest the nucleus before occupying the outer shells. In other words you don't start a new shell until the inner one is full.

Ions

In some chemical reactions, such as those in activity 4, atoms lose electrons to gain a "**stable electron arrangement**". This means that the electrons in the outer shell can be lost to leave the outer shell full or stable. In general metal atoms will lose electrons to gain a stable electron arrangement while non-metal atoms will gain electrons to become stable.

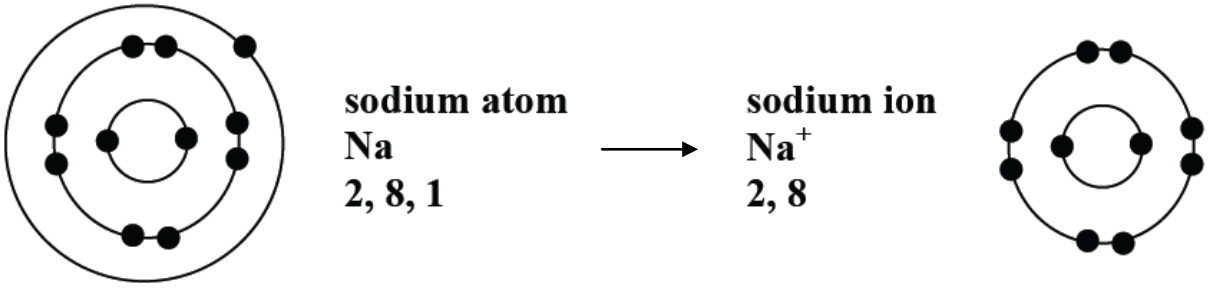
With the loss or gain of electrons atoms will no longer be electrically neutral and they have a charge, this means that an **ion** has been formed. An ion is a charged atom.

An atom which has lost electrons becomes an ion with a positive charge. (Metals)

An atom which has gained electrons becomes an ion with a negative charge. (Non-metals)

Example 1: The formation of a sodium ion.

Sodium atoms have the electron arrangement 2, 8, 1. Sodium atoms lose 1 electron giving a stable electron arrangement of 2, 8. Since an electron (negative charge) has been lost the ion has an overall positive charge.



It is seen that the sodium ion is smaller but it is stable as the outer shell is full.

Sodium ion can be represented as: $^{23}_{11}Na^{+}$

The + sign shows the ion has an overall positive charge.

Example 2: The formation of an oxide ion.

Oxygen atoms will gain 2 electrons to form an oxide ion with a 2 -ve charge.

Oxide ions will have electron arrangement 2, 8, (stable) and represented as: $^{16}_{8}O^{2-}$

Note: Use the data booklet to work out the electron arrangement and charge on an ion.

Isotopes

Atoms of the same element always have the same number of protons (same atomic number). However, atoms of the same element can be different; they can have different numbers of neutrons. This means the mass number will be different.

Atoms which have the same atomic number but a different mass number are called **isotopes**. In other words isotopes have the same number of protons but a different number of neutrons.

Example: Isotopes of chlorine.

Chlorine exists as a mixture of 2 different chlorine atoms. One type of chlorine atom has 18 neutrons which another type of chlorine atom has 20 neutrons.

Chlorine 35: $^{35}_{17}Cl$

Chlorine 37: $^{37}_{17}Cl$

Both isotopes have the **same atomic number** but a **different mass number** since they both have 17 protons and a different number of neutrons.

Relative Atomic Mass

Most elements exist as a mixture of isotopes, each with atoms of different mass. The relative proportions of each isotope will affect the relative atomic mass of that particular element. The relative atomic mass of an element has a value between the mass numbers of the lightest and heaviest isotopes of the element. Its value is always closer to the most abundant (most common) isotope. The relative atomic mass is often not a whole number since it is an average mass of one atom of the element.

Example 1: Chlorine

The relative proportions of isotopes in chlorine is: ^{35}Cl 75%

^{37}Cl 25%

Chlorine has a relative atomic mass of 35·5 since this is closer to the most common mass number i.e. 35 rather than 37.

Example 2: Oxygen

The relative proportions of isotopes in oxygen is: ^{16}O 99.76%

^{17}O 0.037%

^{18}O 0.204%

Oxygen has a relative atomic mass of 16 since this isotope is the most abundant.

Section 1. 2 Summary Statements

- ☐ Elements are arranged in the Periodic Table.
- ☐ A group is a column in the Periodic Table.
- ☐ Elements in one group of the Periodic Table show similar chemical properties.
- ☐ Group 1 are the alkali metals, group 7 the halogens, group 0 the noble gases and transition metals are found between groups 2 & 3 on the Periodic Table.
- ☐ The noble gases are a family of very unreactive elements.
- ☐ Every element is made up of very small particles called atoms.
- ☐ Atoms as having a very small positively charged nucleus with negatively charged electrons moving around outside the nucleus.
- ☐ Protons are positively charged, found in the nucleus and have a mass of 1 amu.
- ☐ Neutrons have no charge, found in the nucleus and have a mass of 1 amu.
- ☐ Electrons are negatively charged, found arranged in energy levels around the nucleus and have a mass of almost 0.
- ☐ An atom is electrically neutral because the number of positive charges in the nucleus (protons) is equal to the number of negative charges surrounding the nucleus (electrons).
- ☐ Atoms of different elements are different and have a different number on the Periodic Table called the atomic number.
- ☐ The atomic number of an element is equal to the number of protons in an atom of that particular element.
- ☐ Electrons are arranged in energy levels, the 1st level holds 2 electrons, the 2nd and 3rd levels each hold up to 8 electrons.
- ☐ Elements with the same number of outer electrons have similar chemical properties.
- ☐ The mass number is equal to the sum of the protons and neutrons in an atom.
- ☐ Ions are formed when atoms lose or gain electrons.
- ☐ Isotopes are atoms with the same number of protons and a different numbers of neutrons.
- ☐ The relative atomic mass of an element is an average mass of all the isotopes taking account of the relative proportions of each isotope. Since it is an average it is rarely a whole number.