BASIC CHEMISTRY

UNIT 1: ATOMS

Learning Outcome:
At the end of this period, you should be able to:
- □ Define atom and learn its structure.
- □ Differentiate atomic number from mass number
- □ Be able to calculate the mass number of an atom
- □ Relate the stability of an atom to the electrons in the valence shell.
- □ Define useful chemical terms and give examples.

CHEMICAL TERMS

1. **Atoms** – are the smallest neutral particle of matter.
- Individual atoms are too small to be seen with the naked eye.
- However, if large group of atoms joined together, we may be able to view it. For example, four billion sodium atoms when put together would cover a full stop at the end of this sentence.

Structure of an Atom
Atoms are made up of 3 small sub-atomic particles.

i) **Protons** – positively charged (+) particle found in the nucleus of an atom.

ii) **Neutrons** – particle without a charge (0), i.e *neutral*. It is found in the nucleus of the atom.

iii) **Electrons** – negatively charged (-) particle that surrounds the nucleus of the atom. They move rapidly in space around the nucleus forming what scientists described as an electron cloud around the nucleus.

2. **Atomic Number** – the number of protons present in the nucleus of an atom. It is also equal to the number of electrons that surrounds the nucleus of an atom.

Atomic number = # of protons = # of electrons

3. **Mass Number** – the number of protons plus neutrons present in the nucleus of the atom. Protons and neutrons present in the nucleus of the atom makes up

4. the mass of the atom. Electrons are very small, and their mass are negligible, sometimes refer to as *zero mass*.

Mass Number = # of protons + # of neutrons

Example A
A sodium atom has 11 protons, 12 neutrons and 11 electrons. Calculate its mass number.

Mass number = No. of protons + No. of neutrons
= 11 + 12
= 23

Therefore, the mass number of the sodium atom is 23.

Example B
Carbon has a mass number of 13. It has 6 protons in its nucleus. How many neutrons are there in this carbon atom.

Mass number = # of protons + # of neutrons
13 = 6 + # of neutrons
Therefore # of neutrons = 13 - 6
No. of neutrons = 7

5. **Elements** – substance that are made up of only one kind of atom. Atoms of an element all contain the same number of protons. There are approximately 110 different elements known.

6. **Periodic Table(Refer to the last page of your note)**
- It is the table that lists the elements in order of their increasing atomic number.
- Elements are arranged into periods (rows) and groups (columns).
- The periodic table is useful because elements with similar properties are in the same part of the table.
  For example, metals are located on the left-hand side of the periodic table whereas non-metals are located on the right hand side of the periodic table.
- Each of the 110 elements has a symbol. The symbol is written with either a capital letter e.g hydrogen (H), Carbon (C) or two letters; helium
- (He), Magnesium (Mg) or sodium (Na).

- A useful ***mnemonic*** for remembering the first 20 elements is shown below:

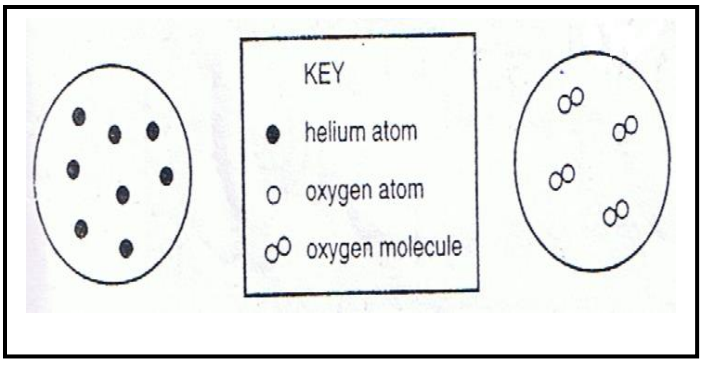
H	-	**H**arry	(Hydrogen)$A = \pi r^2$
He	-	**He**	(Helium)
Li	-	**Li**kes	(Lithium)
Be	-	**Be**er	(Berrylium)
B	-	**B**ottled	(Boron)
C	-	**C**old	(Carbon)
N	-	**N**ot	(Nitrogen)
O	-	**O**ver	(Oxygen)
F	-	**F**rothy	(Fluorine)
Ne	-	**Ne**llies	(Neon)
Na	-	**Na**nny	(Sodium)
Mg	-	**Mg**ht	(Magnesium)
Al	-	**Al**though	(Aluminium)
Si	-	**Si**lly	(Silicon)
P	-	**P**erson	(Phosphorous)
S	-	**S**he	(Sulphur)
Cl	-	**Cl**imbs	(Chlorine)
Ar	-	**Ar**ound	(Argon)
K	-	**K**inky	(Potassium)
Ca	-	**Ca**res	(Calcium)

- There are 8 groups in the Periodic Table. These groups have special names we normally refer to.
- All elements belonging to the same group have similar properties and behave the same way in a chemical reaction.

Group 1 is known as the **alkali metals**
Group 2 is known as the **alkaline metals**
Group 7 is known as the **halogens**
Group 8 is known as the **noble gases (inert gases)**

7. Molecules – group of atoms of the *same* element joined together

Example
Helium is an element made up of individual atoms.
Oxygen gas is an element made up of molecules.
Each molecule contains 2 oxygen atoms bonded together, and has the symbol O_2.



8. Mixtures – substances made up of different elements which can be *easily separated* physically into its elements.

9. Compounds – substances made up of different elements and are usually chemically joined together. They are very difficult to separate.

10. Isotopes – are atoms with the same number of protons but different number of neutrons.

- Isotopes of an element have different masses due to the different numbers of neutrons in their nuclei.
- Isotopes of an element behave the same way in chemical reactions since the number of electrons determines the way an atom reacts.
- An element can be made up of a mixture of isotopes.

Example
For the element oxygen there are three isotopes.

Isotope	$^{16}_{8}O$	$^{17}_{8}O$	$^{18}_{8}O$
Number of electrons	8	8	8
Number of protons	8	8	8
Number of neutrons	8	9	10

- Since all atoms of the same element differ only in their number of neutrons, a particular isotope of an element can be described by writing the symbol and mass number without the atomic number.
- Some isotopes have special name.

Example

(i) The isotope $^{16}_{8}O$ is called Oxygen-16.

(ii) The isotope $^{18}_{8}O$ is called Oxygen–18.

(iii) $^{2}_{1}H$ or Hydrogen–2 is called **deuterium.**

(iv) $^{3}_{1}H$ or Hydrogen–3 is called **tritium**.

11. Electron configuration

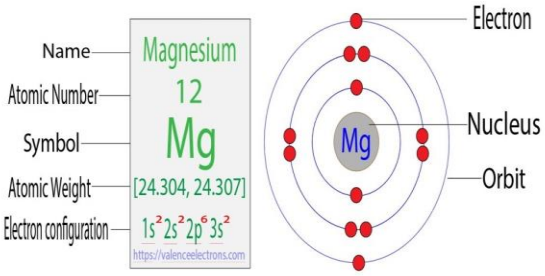
- The way electrons are arranged in an atom.
- There is a limit to the number of electrons which can occupy any one level and the following octet rules apply to the first 20 elements.

Octet Rule

1. The first energy level can hold a maximum of only 2 electrons.
2. The second level holds a maximum of 8 electrons.
3. The third level holds a maximum of 8 electrons.
4. The fourth level holds the remaining electrons.

- The electron configuration can be written as numbers or drawn as a diagram.

Example: The electron configuration for the Magnesium atom is:



From the diagram above, we can write the electron configuration of Magnesium Atom as 2, 8, 2

2, 8, 2

No. of electrons in the first shell.

No. of electrons in the second shell.

No. of electrons in the outermost shell.

- The electrons that occupy the outermost shell (valence shell) of an atom are called **valence electrons**.
- These valence electrons are important as they determine the chemical property of an atom.
- Elements that belong to the same group in the Periodic Table have the same valence electrons, and hence the same chemical property.

For example: Magnesium atom and Calcium atom are both found in the same group of the periodic table (Group 2) and they both have 2 valence electrons.

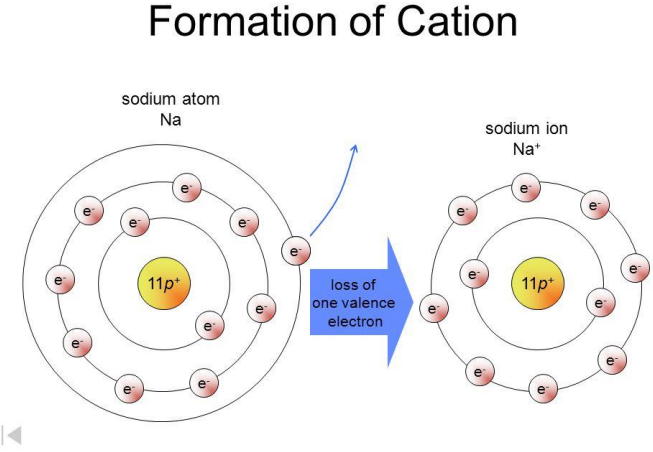
12. Ions and Radicals

Ions – are charged particles formed when an atom either loses or gain an electron.

- Atoms are **unstable(can change)** and tend to be *very reactive* if its outermost shell (valence shell) is incomplete.
- Atoms with a complete valence shell tend to be very **stable**(**cannot change**) and unreactive. **E.g** All elements belonging to Group 8 have complete valence shells and are therefore unreactive.
- Atoms with an **incomplete valence shell** tend to **either lose (or gain)** the electrons in its outermost shell to make it complete in order for the atom to become stable.
- **By losing or gaining an electron, the atom becomes an ion.**

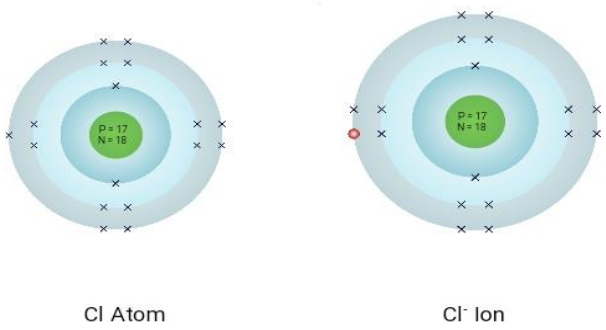
- Ions do not have equal numbers of protons and electrons.
- Each ion is represented by a symbol which shows the charge on the ion and the atom(s) involved in the ion.
- Metals form positively charged ions while non-metals form negatively charged ions.
- If an atom ***loses*** an electron, it becomes **positively charged.** Positively charged ions are called CATIONS.

Example



- If an atom ***gains*** an electron, it becomes **negatively charged.** Negatively charged ions are called ANIONS.

Example



Radical – are group of atoms with a charge e.g NH_4^+, CO_3^{-2}, PO_4^{-3}.

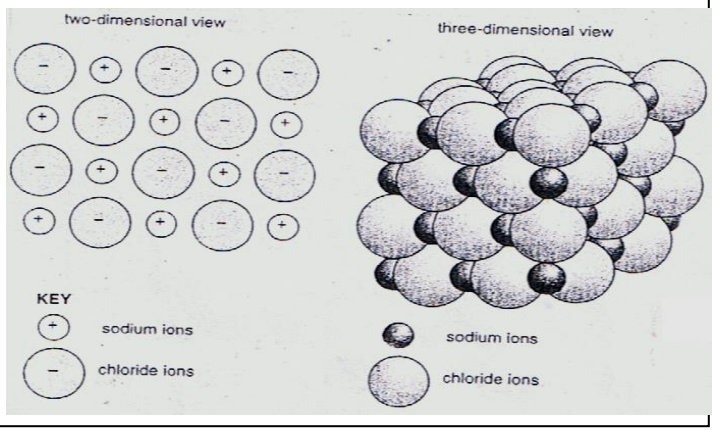
The following table gives the name and symbol of some common ions and radicals.

CATIONS		ANIONS	
Symbol	**Name**	**Symbol**	**Name**
K^+	Potassium ion	Cl^-	Chloride ion
H^+	Hydrogen ion	F^-	Fluoride ion
Na^+	Sodium ion	NO_3^-	Nitrate ion
NH_4^+	Ammonium ion	HCO_3^-	Bicarbonate ion
		OH^-	Hydroxide ion
Fe^{+2}	Iron (Ferrous)	O^{-2}	Oxide ion
Mg^{+2}	Magnesium ion	S^{-2}	Sulphide ion
Ca^{+2}	Calcium ion	SO_4^{-2}	Sulphate ion
Zn^{+2}	Zinc ion	CO_3^{-2}	Carbonate ion
Pb^{+2}	Lead ion		
Cu^{+2}	Copper ion		
Fe^{+3}	Iron (Ferric)	PO_4^{-3}	Phosphate ion
Al^{+3}	Aluminium ion		

13. Ionic compounds

- These are compounds made up of cations and anions.
- The ions are arranged in a three-dimensional (3-D) lattice so that the positive ions are surrounded by negative ions and the negative ions are surrounded by positive ions.

Example:



Self-check #1: Atomic Number & Mass Number

1. A carbon atom has six protons and eight neutrons.
   a) What is the number of electrons in an atom of carbon?
   b) Write down the atomic number of carbon.
   c) Draw a diagram of the carbon atom, labelling each type of sub-atomic particle and showing the region on your diagram that represents the nucleus.
   d) Describe how your diagram shows that the carbon atom is neutral.

2. A magnesium atom has 12 protons and 12 neutrons.
   a) What is the number of electrons in an atom of magnesium?
   b) Write down the atomic number of magnesium.
   c) Draw a diagram of the magnesium atom, labelling each type of sub-atomic particle and showing the region on your diagram that represents the nucleus.
   d) Describe how your diagram shows that the atom is neutral.
   e) Determine from the diagram the charge of Magnesium ion.

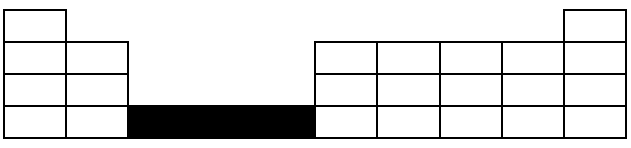
3. a) An atom of chlorine has 17 protons and 18 neutrons. What is:
      (i) The atomic number?
      (ii) The mass number of chlorine?

   b) What is the mass number of an atom containing 16 protons, 18 neutrons and 16 electrons?

4. An atom has atomic number 20 and mass number of 42.
   a) What is the number of protons in the atom?
   b) What is the number of neutrons in the atom?

Self-check #2: Elements and Periodic Table

1. Copy neatly the table below using half a page the outline of the Periodic Table shown below and then label Group 1 – 8. (Draw this into your book)



   a) In the squares on your outline, write the symbol for each of the elements below. Use three different colours to represent which side consist of the metals, the non-metals and the third for the transition metals.
   b) What do you notice about the position of the metals compared to the non-metals?
   c) Find out the state of these elements. What do you notice about the state of the metals compared to the non-metals?
   d) What percentage of the first 20 elements are non-metals?

2. Use the data provided above to complete the table below.

Atomic Number	Name	Symbol
1	Hydrogen	H
2	Helium	He
3	Lithium	Li
.		
.		
.		
.		
.		
.		
20		

Self-check #3: Mixtures, Compounds, Elements & Molecule.

1. a) Which of the following elements exist as molecules:
   (i) sulphur
   (ii) argon
   (iii) gold
   (iv) hydrogen gas, H_2
   (v) phosphorous, P_4
   (vi) iodine, I_2

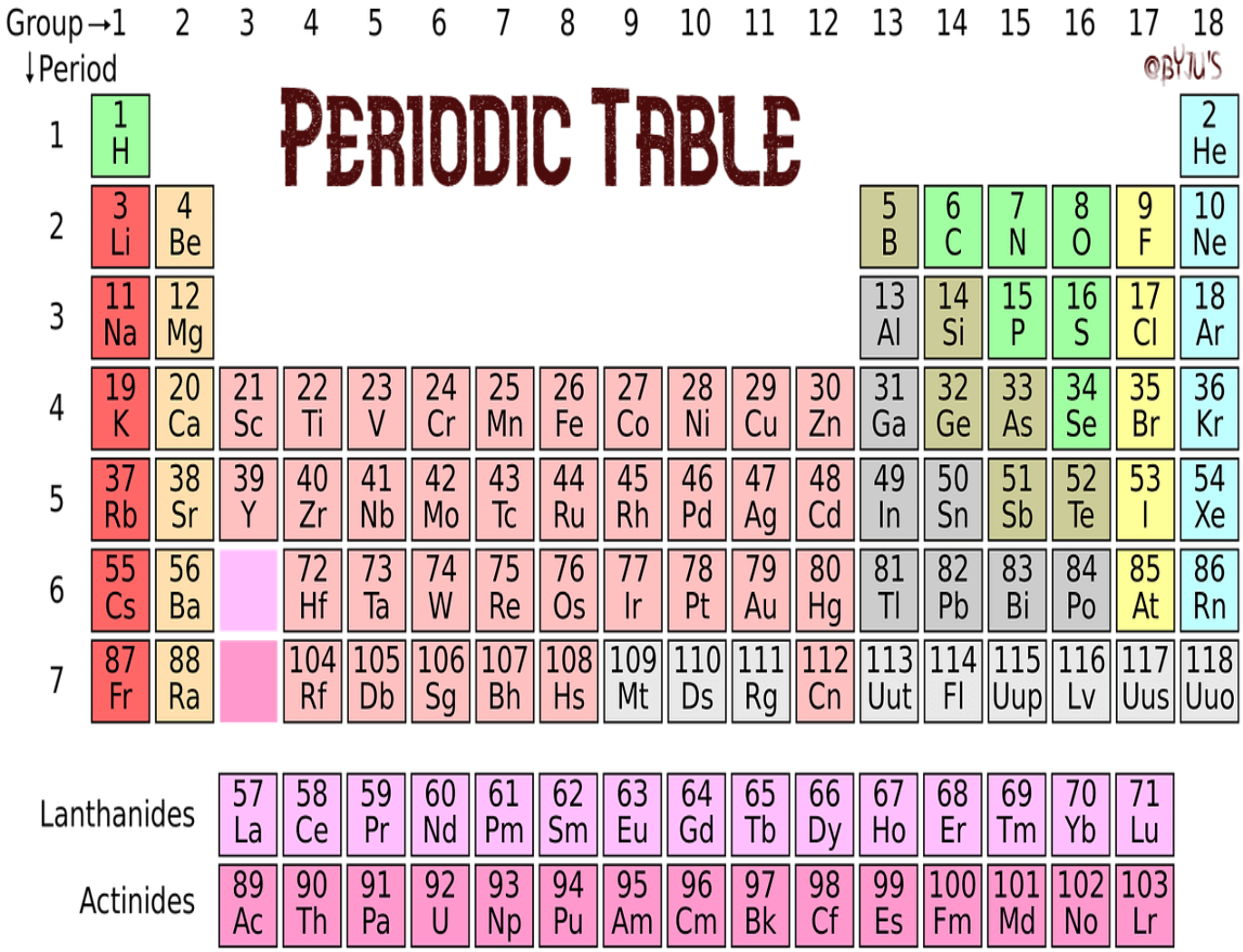
   c) Which element are gases?
   d) Which elements are solid?

2. Classify the following substances into 2 group elements or compounds.

   (i) Water, H_2O
   (ii) Lead, Pb
   (iii) Chlorine gas, Cl_2
   (iv) sugar, $C_6H_{12}O_6$
   (v) ozone, O_3
   (vi) baking soda, $NaHCO_3$

3. If a magnet is placed in a sample of iron sand, fine particles of iron are attracted to the magnet, leaving some sand behind.

   a) Is iron and sand a mixture or a compound?
   b) Give a reason to support your answer.



Note:

Study all your notes, do all the self-check activities and write down all your answers to your book. Make sure to stick all your Science notes to your Science book. If you have any questions, contact me.

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