FORM 6 CHEMISTRY, WEEK 2 NOTES
Elements and isotopes

Learning Outcomes:
- □ Define element (1)
- □ Name the first 20 elements of the periodic table from Hydrogen to Calcium (1)
- □ Write the symbols for the first 20 elements in the form ${}^{A}_{Z}X$ (2)
- □ Determine the number of sub-atomic particles of an atom from its given symbol (1 or 2)
- □ Determine the atomic and/ or mass number of an atom from its given symbol (1 or 2)

Elements – substance that are made up of only one kind of atom. Atoms of an element all contain the same number of protons.
Over 118 different elements have been 'discovered'. A few have yet to be studied completely. The symbol element is either:
- A single uppercase letter, eg. H, C
- Two letters, eg. He, Cu

The symbol for an element X, can be written together with the mass number, A, and atomic number, Z, as ${}^{A}_{Z}X$.

Example:
${}^{23}_{11}$Na is the symbol for a sodium atom.
The 11 shows there are 11 protons (and 11 electrons)
The number of neutrons is: A – Z = 23 – 11
= 12

Periodic Table
- 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:

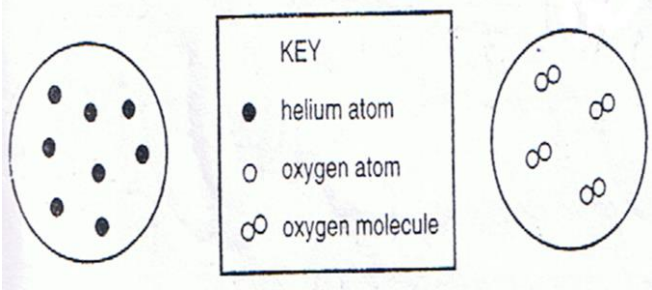
H -	**H**arry	(Hydrogen)
He -	**He**	(Helium)
Li -	**Li**kes	(Lithium)
Be -	**Be**er	(Berrylium)
B -	**B**ottled	(Boron)
C -	**C**old	(Carbon)
N -	**N**ot	(Nitrogen)
O -	**O**ver	(Oxygen)
F -	**F**rothy	(Fluorine)
Ne -	**Ne**llies	(Neon)
Na -	**Na**nny	(Sodium)
Mg -	**Mig**ht	(Magnesium)
Al -	**Al**though	(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)**

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.



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

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

Exercise 2:

1. Define element.

2. Name the following elements:
   a) Ne
   b) K
   c) Be
   d) P

3. Write the symbols for these elements in the form ${}^{A}_{Z}X$.
   a) N
   b) Ar
   c) S
   d) Al

4. Consider atom Y with symbol ${}^{39}_{19}Y$.
   a) Determine the mass number for the atom.
   b) How many neutrons does this atom have?

5. Complete the table below.

Symbol	Mass number	Atomic number	Number of neutrons	Number of protons
${}^{3}_{1}H$	3	1	a	b
${}^{c}_{d}C$	13	e	f	6
${}^{g}_{h}Fe$	*i*	26	30	j
${}^{k}_{17}Cl$	*l*	m	20	n
${}^{16}_{o}O$	p	q	r	8

6. Consider the atom with the symbol ${}^{42}_{20}X$.
   a) What is the mass number for the atom?
   b) Determine the number of neutrons in the atom.

ISOTOPES

Learning Outcomes:

- Define isotopes (1)
- Give example(s) of isotopes (1 or 2)
- Name the two isotopes of Hydrogen (Deuterium & Tritium) (2)
- Write the symbol of either one of the two isotopes of Hydrogen (2)
- Describe the components of the two isotopes of Hydrogen (2)
- Describe the proportion of isotopes of any element as they exist in nature (2)
- Identify isotopes given the atomic symbols or sub-particle components of any number of elements (2)
- Describe the components of isotopes of the same element (2)
- Determine the difference between at least two given atomic symbols in terms of their sub-atomic particles (2)
- Determine the relationship between at least any two atoms given their sub-atomic particles (2)
- Compare the chemical properties of any isotopes of the same element (3)
- Explain why isotopes of the same element show the same chemical properties (3)

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

- Atoms **that** have the same atomic **number** (**number** of protons), but different mass numbers (**number** of protons and neutrons) are called **isotopes**. There are **naturally** occurring **isotopes** and **isotopes that** are artificially produced.
- They **are** the same type of atom, however, because their nuclei have the same number of protons in them.
- Isotopes of an element have different masses due to the different numbers of neutrons in their nuclei.

  Eg. Isotopes of Chlorine: $^{35}_{17}Cl$ $^{37}_{17}Cl$
- 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**.

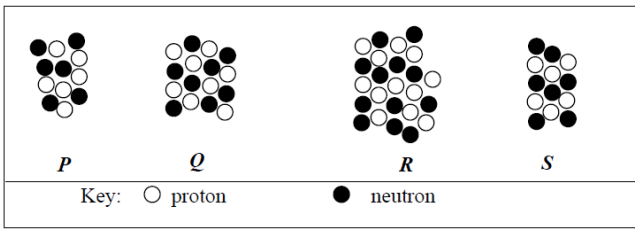
- There are three isotopes of the element hydrogen: hydrogen, deuterium, and tritium. How do we distinguish between them? They each have one single proton (Z = 1), but differ in the number of their **neutrons**. Hydrogen has no neutron, deuterium has one, and tritium has two **neutrons**.
- ***Isotope proportion*** is a number of atoms of each ***isotope*** in a sample of one element.
- **Isotopes** are atoms **that** have the same **number** of protons and electrons, but a different **number** of neutrons. Changing the **number** of neutrons in

an atom does not change the **element**. Atoms of **elements** with different numbers of neutrons are called "**isotopes**" of **that element**.

- **Isotopes** and radioactive decay. As mentioned above, **isotopes** are **different** forms of an **element** that have the **same** number of protons but **different** numbers of neutrons. ... A neutral atom of Carbon-12 contains six protons, six neutrons, and six electrons; therefore, it has a mass number of 12 (six protons plus six neutrons).
- The **chemical properties** of **isotopes** are **identical** because the **chemical properties** of an atom or **element** are determined by the number of valence electrons it has.
- The **different isotopes have different** numbers of neutrons, because they **do** not all weigh the same or **have** the same mass. **Different isotopes** of the same **element have** the same atomic number. They **have** the same number of protons. The atomic number is decided by the number of protons.
- Since isotopes have different numbers of neutrons, this affects the **mass** number. **Mass** number determines the physical properties such as boiling/melting/density etc. They have similar chemical properties because isotopes of an element have the same number of electrons as an atom of that element.
- **Elements** in the same group in the periodic table have **similar chemical properties**. This is because their atoms have the same number of electrons in the highest occupied energy level. Group 1 **elements** are reactive metals called the alkali metals. Group 0 **elements** are unreactive non-metals called the noble gases.

Exercise 3:

1. Define isotopes.
2. Give two examples of isotopes.
3. Name the two isotopes of Hydrogen.
4. Write the symbol of the two isotopes of Hydrogen.
5. Describe the components of the two isotopes of Hydrogen.
6. Potassium exists as ^{39}K, ^{40}K *and* ^{41}K.
   a) Write the name given to the different forms of potassium element shown above.
   b) How many protons are in an atom of ^{41}K?
   c) Write the symbol of an ion of ^{41}K.
7. Describe the proportion of isotopes of any element as they exist in nature.
8. The diagrams below show the nuclei of four atoms.



   a) Which two atoms are isotopes of the same elements?
   b) Which element are they isotopes of?
   c) Write the full symbol of each isotope showing the mass number (A) and atomic number (Z).
9. Compare the chemical properties of any isotopes of the same element.
10. Explain why isotopes of the same element show the same chemical properties.

ELECTRON ARRANGEMENT

Learning Outcomes:

- Identify the first, second, third and fourth main electron energy levels in terms of their distance away from the nucleus (1)
- Describe the importance of their position relative to the atomic nucleus (2)
- Describe how electrons occupy these main energy levels for the first 20 elements only (2)
- Write electron arrangement of any of the first 20 elements with either given name or symbol (2)
- Name the element that has electrons with a given arrangement (1)
- Compare the electron arrangement of at least two of the first 20 elements (3)
- Relate the electron arrangement of atoms in the first 20 elements to the groups and periods in the table (3)

Electron arrangement

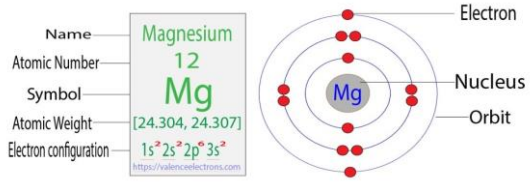
- The way electrons are arranged in an atom.
- There is a limit to the number of electrons which can occupy any one level and the following octet rules apply to the first 20 elements.

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.

Exercise 4:

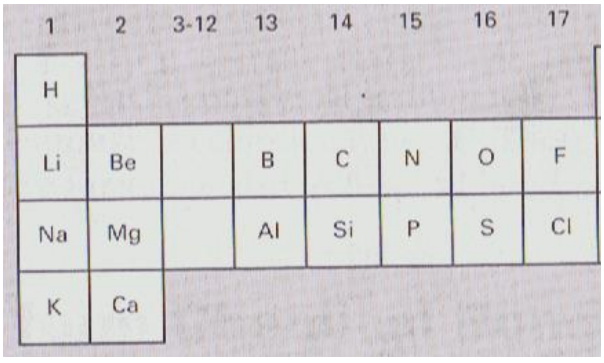
11. Write the electron for the following elements.
    a) Lithium
    b) Nitrogen
    c) Sodium
    d) Argon
    e) Potassium
    f) $^{16}_{8}O$
    g) $^{17}_{8}O$

12. Answer questions (a) to (g) by choosing from the key list A – E:

A. $^{1}_{1}H$	C. $^{12}_{6}C$
	E. $^{37}_{17}Cl$
B. $^{4}_{2}He$	D. $^{23}_{11}Na$

    a) Choose the atom with four valence electrons.
    b) Choose the atoms with one valence electron.
    c) Choose the atom which has the second energy level as its valence level.
    d) Choose the atom with seven valence electrons.
    e) Choose the metal atom.
    f) Choose the atom with a completely filled valence electron level.
    g) Choose the atom which contains one more neutron than protons in its nucleus.

13. Study the periodic table below:



    a) Under each element write the number of valence electrons.
    b) Describe the relationship between the number of valence electrons of the atoms to the groups and periods on the table.
    c) Compare the number of valence electrons of metal elements to non-metal elements.