ATOMIC STRUCTURE AND THE PERIODIC TABLE

1. ATOMIC STRUCTURE

Introduction

What is an atom?

An atom is the smallest particle of an element that is electrically neutral and can take part in a chemical reaction.

An element is a substance which cannot be split into any simpler substance by any chemical means and has the same kind of atoms. Elements are made up of atoms.

The structure of an atom

An atom is made up of two major regions namely;

(a) The nucleus
(b) The energy levels/shells /orbits

(a)The nucleus

The nucleus is located at the centre of the atom and contains two types of particles namely;

(i)Protons

(ii)Neutrons

Protons

The proton carries a positive charge of **plus one** (+1). The mass of a proton is **1g**

Neutrons

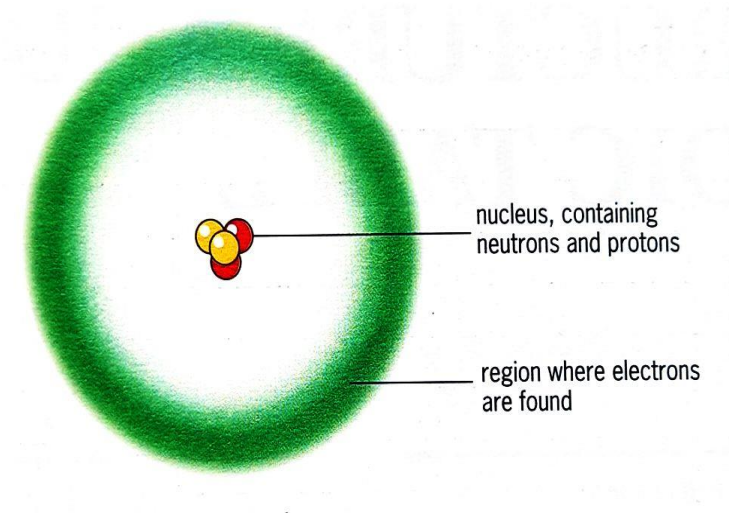
The neutron is neutral ie it has a **zero** charge. The neutron has a mass of **1g.**

(b)The energy levels

This is the region surrounding the nucleus and contains only one type of particles which are called the **electrons.** An atom can have one or more energy levels. These energy levels can be called **shells** or **orbits**. Electrons are not stationary but are mobile within the energy levels. An electron has a charge of negative one (-1). The mass is $\frac{1}{1840}$ g of 1 proton. Because of this, when considering the total mass of an atom, only the mass of protons and neutrons are considered. Mass of electron is considered negligible since it is too small.

NB in an atom the number of protons is equal to the number of electrons. This makes an atom neutral, since the positive charges are equal to the negative charges.

Diagram generalizing the structure of an atom.



Terms Used in atomic structure

1.Atomic number is the number of protons in the nucleus of an atom.

2.Mass number or atomic mass- is the total number of protons and neutrons in the nucleus of an atom.

The symbol of an atom

The symbol of an atom is usually denoted as; $\boldsymbol{^{A}_{Z}X}$. Where;

X= chemical symbol of the atom of an element.

A =the atomic mass

Z= the atomic number

The relationship between the atomic number, mass number and number of neutrons in an atom.

This relationship is represented by the equation;

Mass number (A) = atomic number (Z) + number of neutrons (n)

- ***A = Z + n***

Calculations

1. Calculate the number of neutrons in one atom of; $\boldsymbol{^{24}_{12}Mg}$

Solution

Using the equation; ***A =Z + n***

24 = 12 + n

n= 24 – 12

n = 12.

Where n= number of protons.

2. Work out the number of protons in the atom; $^{207}_{z}\mathbf{Pb}$, the number of neutron is **125.**

3. The atom of an element is represented as; $^{A}_{35}\mathbf{Cl,}$ if its number of neutrons is **18**, calculate its mass number/or atomic number.

4. Work out the number of neutrons in the atoms given below.

a) $^{I6}_{8}\mathbf{O}$

b) $^{106}_{46}\mathbf{Pb}$

c) $^{35}_{17}\mathbf{Cl}$

Isotopes

Isotopes are atoms of the same element with the same number of protons but different number of neutrons. It can also be defined as atoms of the same element with the same atomic number but different mass numbers.

An isotope is one of the atoms of the same element with the same number of protons but different number of neutrons from the rest of the atoms.

Isotopy is the existence of atoms of the same element with the same number of protons but different number of neutrons.

Examples of elements that show isotopy

(a)Chlorine- has two isotopes; Chlorine 35, $^{35}_{17}\mathbf{Cl}$ and chlorine 37, $^{37}_{17}\mathbf{Cl}$

(b)Carbon-has three isotopes; Carbon 12, $^{12}_{6}\mathbf{C}$, Carbon 13, $^{13}_{6}\mathbf{C}$, Carbon 14, $^{14}_{6}\mathbf{C}$.

(c)Hydrogen-has Hydrogen 1; $^{1}_{1}\mathbf{H}$, Hydrogen 2, $^{2}_{1}\mathbf{H}$ and Hydrogen 3, $^{3}_{1}\mathbf{H}$.

Arrangement of electrons in the energy levels of an atom.

This is called the **electronic configuration**. The first shell/energy level/orbit nearest to the nucleus accommodates a maximum of 2 electrons, i.e. a **duplet.** From the second shell to the fourth shell a maximum of only 8 electrons are accommodated i.e. an **octet** arrangement.

The drawing representing such an arrangement is known as an **electronic structure**.

How to write electronic configuration and draw electronic structure of atoms

Electronic structure is only drawn after writing the electronic configuration.

Examples

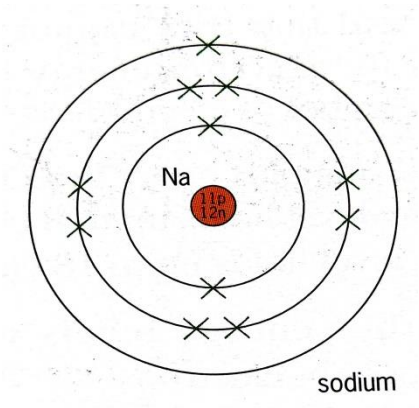
1. Write the electronic configuration and hence draw the electronic structure of the atom of the following elements;

(a)Sodium (sodium has 11 electrons)

Solution.

Electronic configuration; 2:8:1.

The electronic structure is

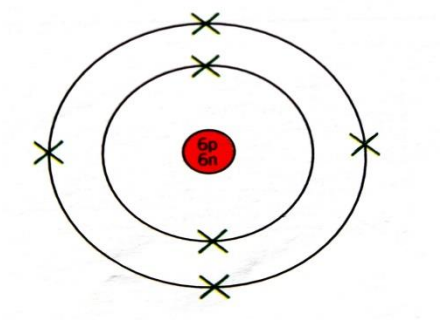


(b)Carbon (the atomic number of carbon is 6)

Solution

Electronic configuration is 2:4.

The electronic structure



(c)Hydrogen (hydrogen has atomic number of 1)

(d)Argon (atomic number is 18)

(e)Lithium (atomic number is 3)

(f)Potassium (atomic number is 19)

The table below is of the first 20 elements. Fill in the chemical symbol of each of the elements and write their electronic configuration in the space provided.

Element	**symbol**	**Atomic number**	**Number of electrons**	**Electronic configuration**
Hydrogen		1		
Helium		2		
Lithium		3		
Beryllium		4		
Boron		5		
Carbon		6		
Nitrogen		7		
Oxygen		8		
Fluorine		9		
Neon		10		
Sodium		11		
Magnesium		12		
Aluminium		13		
Silicon		14		
Phosphorous		15		
Sulphur		16		
Chlorine		17		
Argon		18		
Potassium		19		
Calcium		20		

Application of the knowledge of atomic structure

1 In x-rays. Used for diagnosis of various diseases eg in the establishment of the location of fractures, tumors, etc.

2. Radiations are used to treat diseases like cancer.

3. Nuclear reactors are used to produce electricity and atomic bombs.

4. Carbon dating and potassium dating for estimating the age of fossils and other archeological structures.

2. THE PERIODIC TABLE

Introduction

The periodic table is a table in which all the chemical elements are arranged in **rows** and **columns** according to their increasing atomic number (number of protons) or electrons.

The elements are arranged in **groups** or **periods.** The different columns give the different **groups** while the different rows give the different **periods.**

The elements with similar chemical properties are found in the same group. There are 8 groups of elements. The first column is called **group (I),** the second column is called **group (II)** and so on up to **group (VII).** The final column in the periodic table is called **group (O).**

The **rows** are called **periods** and are numbered **1-7** going down the periodic table. This can be shown in the modern periodic table below.

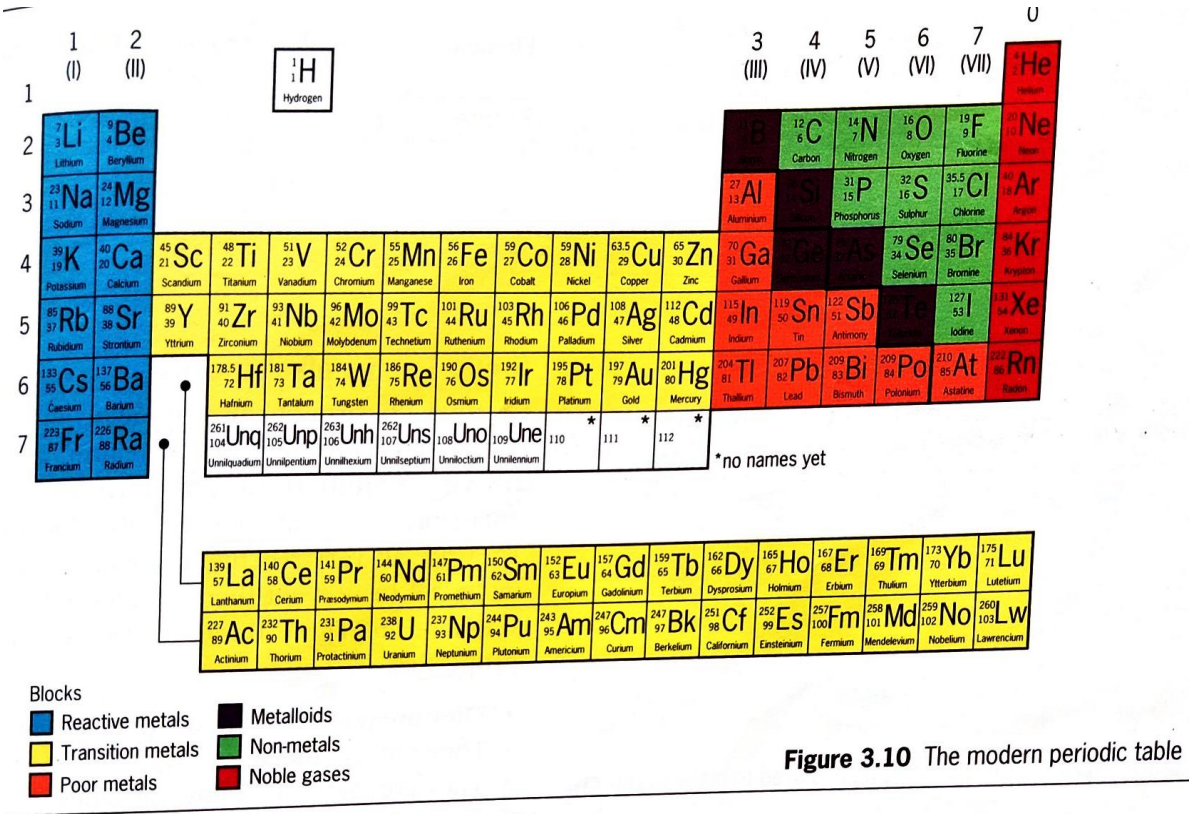


Figure 3.10 The modern periodic table

Determination of groups and periods of elements in the periodic table

Once the atomic number of an element is given(this is equal to the number of electrons),the following is done to determine the **group** and the **period** to which the element belongs in the periodic table;

(i)Write the electronic configuration of the atom of the element

(ii)Determine the group by looking at the number of electrons in the outer energy level. This number gives the group to which the element belongs in the periodic table.

(iii)Determine the period by counting the number of energy levels. The number of energy levels equals the period to which the element belongs.

Examples.

1.Sodium**, Na** has the atomic number 11. Determine the group and the period to which sodium belongs in the periodic table.

Answer

The electronic configuration is; 2:8:1.

It has one electron in the outermost energy level, hence it belongs to group (I).

It has 3 energy levels, hence it belongs to period 3

2.Magnesium is represented as; $^{24}_{12}Mg$. Determine the group and the period to which magnesium belongs in the periodic table.

3.Neon has the atomic number of 10. Determine the group and the period to which neon belongs

4.Calcium is represented as; ${}^{40}_{20}Ca$. What is the group and the period to which calcium belongs.

The unique position of some elements in the periodic table.

(i)**Hydrogen**. Hydrogen has the atomic number of 1. The electronic configuration is also 1. So it has one electron in its only energy level. This makes hydrogen to be placed in group (I), but since to fill up the only energy level, it also needs only one electron just like those elements in group (VII), so it is also placed in group (VII) for that reason. Therefore hydrogen is placed both in group (I) and group (VII) and it shows chemical properties for both groups.

(ii)**Helium,** Helium has the atomic number of 2. The electronic configuration is 2. So it has 2 electrons in the only energy level. It is supposed to be placed in group (II), but it is in group (O). This is because its only energy level is completely filled up with electrons. It cannot accommodate any other electron, a characteristic of group(O) elements. Helium only shows properties of group (O).

Classification of elements in the periodic table

Elements in the periodic table are grouped into;

(a)**Metals** . a metal is an element which is shiny in appearance, a good conductor of electricity and heat. They are in group (I), (II) and (III). Some are in group (IV), (V) and (VI) but at the bottom of the groups. They are found on the left hand side of the periodic table. Metals have the following physical properties;

(i)High melting points.

(ii)Good conductors of electricity

(iii)Good conductors of heat

(iv)High density

(v)High melting point

(vi)Malleable-can be bent or hammered into any shape without breaking or cracking.

(vii)Ductile- able to be drawn out into a thin wire without losing toughness.

(b)**Non-metals-**Are chemical elements in gas, liquid or brittle solid in their most stable form. They are found in group(IV),(V),(VI),(VII) and (O). they are found on the extreme right of the periodic table.

They have the following physical properties;

(i)They are brittle

(ii) They bad conductor of heat and electricity

(iii)They have low melting and boiling points

(iv)Most solid non-metals are soft.

(v)They are non-sonorous.

(c) **Metalloids**-These are Chemical elements which show both metal and non-metal properties. They are located in the middle of the periodic table. Examples includes; Boron B, silicon Si, germanium Ge, Arsenic As, and Tellurium Te. **Transition elements.** These elements form a block of metals between group (II) and group (III) which show much similarity to each other. They have higher boiling points, higher melting **points,** and higher densities than group (I) and group(II) metals. They form colured compounds and the compounds are also coloured in solution form.

Chemical families

A chemical family is a group of elements from the periodic table with similar chemical and physical properties. Some of the families are listed below;

(a)**The alkali metals**- these are group (I) elements.

(b)**The alkaline earth metals-**These are group(II) elements.

(c)**The halogens**-these are group (VII) elements.

(d)**Inert gases/noble gases**-these are group (O) element.