**STRUCTURE** OF **THE ATOM AND THE PERIODIC TABLE**

**AN ATOM**

* Is the smallest particle of an element which can take part in a chemical reaction.
* An atom is made up of even smaller particles called **sub atomic particles.** They include:
1. **Neutrons**- are neutral particles i.e. have no charge
2. **Protons** – have a positive charge
3. **Electrons** – have a negative charge.

**The structure of the Atom**

* The atom is made up of two regions.
1. **The nucleus (The smaller in part)**
* This is the small central region of the atom consisting of protons and neutrons.
* It is positively charged because of the protons.
* Protons and neutrons are called nucleons because they are found in the nucleus.
* Almost the whole mass of the atom is concentrated in the nucleus.
1. **Energy levels (The larger outer part)**
* **Is** the region around the nucleus and it contains electrons. The electrons move around the nucleus.
* The ele**c**trons are negatively charged and are made to remain in orbit within the atom by the nuclear charge attraction.

 Energy level (Has electrons)

 Nucleus (Has protons and neutrons)

* The hydrogen atom, which is the simplest in composition, has 1 proton, 1 electron and has no neutron. Helium has two protons, two electrons and two neutrons.
* When atoms react in chemical reactions, only electrons in the energy levels take part. An atom can gain or lose an electron. Protons and neutrons remain intact in such chemical reactions.
* In a neutral atom: **Number of protons = Number of electrons.** For any atom the number of protons is equal to the number of electrons making the atom electrically neutral
* Number of neutrons may vary and they contribute to the stability of the nucleus.
* Protons and neutrons usually participate in radioactive reactions. But the neutrons contribute to the stability of the nucleus.

**Nature/Characteristics of sub-atomic particles.**

|  |  |  |
| --- | --- | --- |
| **Sub atomic particle** | **Relative mass** | **Electrical charge** |
| Proton  |  1 | +1 (positive) |
| Neutron |  1 |  0 (neutral) |
| Electron  | $$\frac{1}{1840}$$ |  -1 (negative) |

NB/ Thusan electron is the lightest of the three.

**CHARACTERISTICS OF AN ATOM**

1. **ATOMIC NUMBER**
* Is number of protons in the nucleus of an atom. Hydrogen has 1 proton in its nucleus hence has an atomic number of 1. Sodium atom has 11 protons in its nucleus and thus has atomic number of 11.
1. **MASS NUMBER**
* Is the sum of protons and neutrons in the nucleus of an atom.

**Mass number = protons + Neutrons**

* Mass number is always bigger than the atomic number.
* Mass number tells us the relative mass of the atom.
* The mass of an electron is almost negligible and thus mass of an atom is mainly determined by protons and neutrons.
* Usually atomic number and mass number of an atom of an element can be written alongside the symbol of that element, one as a ***superscript (mass number)*** and the other as a ***subscript (atomic number).*** E.g. sodium is written as:

**11Na** where 11 is the atomic number and **23Na** where 23 is the mass number. Thus an atom of sodium is represented as:

  **23**

 **Na**

 **11**

Magnesium is written as:

  **24**

 **Mg** and so on

 **12**

* The table below shows atoms of first 20 elements

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Element  | symbol | Number of electrons | Number of protons | Number of neutrons | Atomic number | Mass number |
| Hydrogen | H | 1 | 1 | 0 | 1 | 1 |
| Helium | He  | 2 | 2 | 2 | 2 | 4 |
| Lithium | Li | 3 | 3 | 4 | 3 | 7 |
| Beryllium | Be | 4 | 4 | 4 | 4 |  |
| Boron | B | 5 | 5 |  | 5 | 11 |
| Carbon | C | 6 | 6 |  | 6 | 12 |
| Nitrogen | N | 7 | 7 | 7 | 7 |  |
| Oxygen | O | 8 | 8 |  | 8 | 16 |
| Fluorine | F | 9 | 9 |  | 9 | 19 |
| Neon | Ne | 10 | 10 |  | 10 | 20 |
| Sodium | Na | 11 | 11 | 12 | 11 | 23 |
| Magnesium | Mg | 12 | 12 | 12 | 12 |  |
| Aluminium | Al | 13 | 13 | 14 | 13 |  |
| Silicon | Si | 14 | 14 | 14 | 14 | 28 |
| Phosphorus | P | 15 | 15 | 16 | 15 |  |
| Sulphur | S | 16 | 16 |  | 16 | 32 |
| Chlorine | Cl | 17 | 17 | 18 | 17 |  |
| Argon | Ar | 18 | 18 |  | 18 | 40 |
| Potassium | K | 19 | 19 | 20 | 19 |  |
| Calcium | Ca | 20 | 20 | 20 | 20 |  |

**ISOTOPES**

* Are atoms of the same element that have same number of protons but different number of neutrons.

 Or

* Are atoms of the same element with same atomic number but different mass numbers.

For example some atoms of chlorine have 18 neutrons while others have 20 neutrons but they have same number of protons, 17 protons. The two atoms are isotopes of chlorine element.

Cl-35 and Cl-37

* The summary of the elements which exist as isotopes is given in the table below

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Element  | Isotope  | Atomic number  | No of protons | No of neutrons | Mass number | Isotopic representation |
| 1. Hydrogen
 | Hydrogen-1(protium) | 1 | 1 | 0 | 1 | 1 H1 |
| Hydrogen-2(deuterium) | 1 | 1 | 2 | 2 | 2 H1 |
| Hydrogen-3(Tritium) | 1 | 1 | 2 | 2 | 3 H1 |
| 1. Carbon
 | Carbon-12  | 6 | 6 | 6 | 12 | 12 C  6 |
| Carbon-14 | 6 | 6 | 8 | 14 | 14 C 6 |
| 1. Oxygen
 | Oxygen -16 | 8 | 8 | 8 | 16 | 16 O  8 |
| Oxygen -17 | 8 | 8 | 9 | 17 | 17 O  8 |
| Oxygen- 18 | 8 | 8 | 10 | 18 | 18 O  8 |
| 1. Chlorine
 | Chlorine -35 | 17 | 17 | 18 | 35 | 35 Cl  17 |
| Chlorine- 37 | 17 | 17 | 20 | 37 | 37 Cl  17 |

* The number of electrons in an atom determines the way it reacts with other atoms. Thus isotopes of an element all have the same chemical properties, because they all have the same number of electrons.
* Isotopes may have different physical properties like:
1. They may have different masses
2. They may have different densities.
3. They may have different rates of diffusion if gaseous.
4. **RELATIVE ATOMIC MASS**
* Masses of individual atoms are very small and thus difficult to way.
* Thus it is easier to compare one atom with another to get their relative masses.
* ***A standard atom of an element (reference element)*** is chosen and all other atoms compared to it. Hydrogen atom was initially chosen as reference because ***it is the lightest.***
* Oxygen scale was later adopted but dropped because oxygen exists in several isotopes.
* Currently carbon-12 scale is used because:
* Carbon-12 is solid
* Carbon- 12 is stable isotope
* Carbon – 12 is very common element.
* On this scale, an atom of carbon is assigned a value of exactly 12.000atomic mass units (12.000a.m.u).
* Thus **Relative Atomic Mass (R.A.M**);- is the average mass of an atom of an element compared with an atom of carbon-12, the mass of which is 12.000a.m.u
	+ **R.A.M = average mass of one atom of an element.**
		- * $\frac{1}{12}$ **Mass of an atom of carbon-12**
* R.A.M is a ratio and thus has no units.
* **An** instrument called Mass Spectrometer can be used to accurately determine relative atomic masses of elements. It can also be used to determine the relative abundance of isotopes of a given element.
* ***If an element has isotopes, then R.A.M is closest in value to the mass number of the most abundant isotope of the element.***
	+ This is illustrated as follows:

  **Relative abundance**

  **33 34 35 36 37 mass number**

**The** graph above shows mass spectrometer trace for chlorine. It shows that of the two isotopes of chlorine, chlorine -35 is the most abundant.

**EXAMPLES**

1. Chlorine consists of isotopes chlorine-35 and chlorine – 37 with relative abundancies of 75% and 25% respectively. Calculate the relative atomic mass of chlorine.
2. Silicon consists of 3 isotopes, silicon – 28; 92.2%, silicon – 29; 4.7% and silicon – 30; 3.1%. Find the RAM of silicon.
3. Lithium has two isotopes lithium – 6 and lithium – 7. If the RAM of lithium is 6.94, find the relative abundance of each isotope.
4. Calculate the relative atomic mass of an element whose isotopic mass and relative abundances are given below.

|  |  |
| --- | --- |
| **Relative abundance** | **Isotopic mass** |
| 31 | 65 |
| 69 | 63 |

1. An element Y has been discovered to have three isotopes, Y – 48, Y – 49 and Y – 50 (1.5%). If the relative atomic mass of Y is 49.05, calculate the relative abundances of isotope 49 and isotope 48.
2. Study the table below and answer the questions that follow. The letters do not represent the actual symbols of the element.

|  |  |  |  |
| --- | --- | --- | --- |
| **Atom**  | **Protons**  | **Electrons**  | **Neutrons**  |
| A  | 5 | 5 | 6 |
| B  | 9 | 9 | 10 |
| C  | 10 | 10 | 11 |
| D  | 15 | 15 | 16 |
| E  | 10 | 10 | 12 |

1. What is the mass number of atom B?
2. Which of the atoms has a mass number of 11?
3. Which of the atoms represent isotopes of the same element?

Give a reason for your answer

1. What is the atomic number of atom D?
2. Bits Neon gas exists naturally as three isotopes, neon – 20, neon – 21 and neon – 22 with relative abundances of 90.92%, 0.26%, 8.82% respectively. Calculate the relative atomic mass of neon

N/B The existence of isotopes explains why relative atomic masses are in many cases not whole numbers. Mass numbers are whole numbers because they are sum of protons and neutrons

1. **ENERGY LEVEL AND ELECTRONIC CONFIGURATION**
* Energy levels are regions or orbits around the nucleus in which electrons occupy. Electrons occupying same energy levels have approximately same amount of energy.
* The energy levels are numbered 1, 2, 3……..starting with the ones closest to the nucleus.
* Electrons with low energy are located in energy levels closest to the nucleus.
* Electrons with high energy are located in energy levels further away from the nucleus.
* The maximum number of electrons that an energy level can hold at any one time is fixed;
1. The first energy level can only hold a maximum of two electrons.
2. The second energy level holds a maximum of 8electrons.
3. The 3rd energy level holds a maximum of 8 electrons for the first 20 elements.
* When one energy level is full, the remaining electrons occupy the next energy level.

**NB .**For elements beyond 20, the maximum number of electrons are calculated by an expression:

2n2 where n is the number of the energy level.

e.g. for first energy level = 2 x 12 = 2 electrons

 For second energy level = 2 x 22 =8elctrons

 For 3rd energy level = 2 x 32 = 18 electrons and so on.

The arrangement of electrons in energy levels in an atom is called **electronic configuration/electronic arrangement.**

* Hydrogen has one electron in the first energy level. Helium with 2 electrons has the 2 electrons in the first energy level. Thus helium has one energy level which is filled up.
* Lithium has 3 electrons. 2 electrons will occupy the first energy level and become full. The remaining 1 electron will occupy the second energy level. Thus its electronic configuration is written as 2.1. the atom is represented as:

***Lithium atom***

N/B: electrons are represented by crosses (x) or dots (•).

* Magnesium has 12 electrons: 2 electrons will occupy 1st energy level, 8 electrons will occupy the 2nd energy level, the remaining 2 electrons will occupy the 3rd energy level. The electronic configuration is represented as 2.8.2

***Magnesium atom***

***Draw and show the electron arrangement of the following atoms:***

1. ***Boron (5 electrons)***
2. ***Nitrogen (7 electrons)***
3. ***Sulphur (16 electrons)***
4. ***Calcium (20 electrons)***
5. ***Potassium (19 electrons)***

**THE PERIODIC TABLE**

* Is a table or grid in which elements are arranged in groups based on the similarities in their chemical and physical properties.
* Elements were first arranged in a periodic table by a Russian chemist known as Dmitri Mendeleev.
* He arranged the elements in order of increasing atomic mass (mass number) but elements with similar chemical properties occurred periodically.
* However modern periodic table is arranged in order of **increasing atomic numbers.** More elements have been discovered and some artificially made.

**FEATURES OF A PERIODIC TABLE**

1. **GROUPS**
* Are the vertical columns in the periodic table.
* There are 8 main groups in the periodic table: Group 1 (I) to group 8 (VIII)
* Elements in the same group have the following properties:
* They have same number of electrons in their outermost energy levels.

i.e. all elements in group 1 have 1electron in their outer most energy levels, all elements in group 2 have 2electrons in their outer most energy levels, all elements in group 7 have 7electrons in their outermost energy level and so on.

* They have similar chemical and physical properties e.g. all group 1 elements reacts vigorously with water liberating hydrogen gas (chemical property) and they are soft and can be cut easily with a knife.
* Group I elements are called **alkali metals.**
* Group II elements are called **alkaline earth metals.**
* Group VII elements are called **halogens.**
* Group VII elements are called **noble gases.**
* Elements on far left side of periodic table are metallic while those on far right are non-metallic.
* Between group 2 and group 3, there is a class of elements known as **transition metals. (d-block elements).** They do not belong to the 8 main groups and most of them are called **heavy metals** e.g. mercury, lead, copper, zinc, iron, manganese etc.
* Group 4 elements show both properties of metals and non-metals. They are known as **metalloids or semi – metals,** e.g. silicon.
* Hydrogen can be placed in group I or group VII because it can lose the one electron just like group I elements or it can gain one electron from other elements just like group VII elements.
* Helium has 2 electrons in its outermost energy level but it is placed in group 8 instead of group 2 because with the 2 electrons, it is chemically stable and is much unreactive, just like group 8 elements.
* The number of electrons in the outermost energy level shows the group to which the elements belong.
1. **PERIODS**
* These are the horizontal rows in the periodic table.
* There are 7 periods altogether.
* The 1st period contains only two elements, hydrogen and helium.
* The 2nd and 3rd periods have 8 elements each.
* In the 4th period, only 2 elements will be studied, potassium and calcium.
* Elements in the same period have same number of energy levels.
* The number of energy levels equal the period the element belongs to. E.g magnesium has 3 energy levels, it is in period 3 and potassium has 4 energy levels, it is in period 4.

  **ION FORMATION**

* Atoms are electrically neutral because the number of electrons is equal to the number of protons in a neutral atom.
* Atoms lose or gain electrons to attain stability.
* Atoms are most stable if their outermost energy levels are having 8 electrons.
* When electrons are lost or gained, ions are formed.
* **Ions –** are charged particles formed when atoms gain or lose electrons.
* When atoms lose electrons, **cations** are formed. **Cations**- are positively charged ions.
* When atoms gain electrons, **anions** are formed. **Anions** – are negatively charged ions.
* During ion formation, proton number is not changed.

**FORMATION OF CATIONS (POSITIVE IONS)**

* It is observed mostly in metallic elements; those on left hand side of the periodic table.

For example:

**Formation of sodium ion (Na+)**

* Sodium with atomic number 11 has 11 electrons and 11 protons and electronic configuration of 2.8.1
* It can become stable by gaining 7 electrons into its outer energy level, or lose the already present 1 electron.
* Less energy is needed to lose 1 electron than gain 7, so sodium loses 1 electrons. This results to 10 electrons and 11 protons. Therefore there is an extra positively charged proton in the atom. This makes sodium to have a net positive charge of +1
* The particle formed is sodium ion and is represented as Na+1 or Na+
* The loss of the 2 electrons leads to lose of one energy level and thus the ion is smaller than the atom itself.

**Electronic structures of sodium**

**Formation of magnesium ion (Mg2+)**

* Magnesium with atomic number 12 has 12 electrons and 12 protons and electronic configuration 2.8.2
* It can gain 6 electrons or lose 2 electrons to become stable.
* Less energy is needed to lose 2 than gain 6.
* Losing 2 electrons results 10 electrons and 12 protons.
* There are 2 extra positively charged protons. This makes magnesium to have a net positive charge of +2
* The resultant is magnesium ion represented as Mg2+
* The loss of the 1 electrons leads to lose of one energy level and thus the ion is smaller than the atom itself.

**Electronic structure of magnesium ion formation**

1. Formation of lithium ion
2. Formation of calcium ion
3. Formation of beryllium ion

**FORMATION OF ANIONS (NEGATIVE IONS)**

* Mostly observed in non – metals or elements on far right side of the periodic table.

For example:

**Formation of chloride ion**

* A chlorine atom with atomic number of 17 has 17 electrons, 17 protons and electronic configuration of 2.8.7
* It can become stable by losing the 7 electrons or gaining 1 electrons.
* Less energy is needed to gain 1 than lose 7 electrons.
* Gaining 1 electron results to 18 electrons and 17 protons.
* The 1 electron gained goes into the outer most energy level. This results to more repulsion of electrons dilating the ion. Thus the ion become larger than the atom itself.
* Because of the extra 1 negatively charged electron, there is a net negative charge of -1, leading to formation of chloride ion represented as Cl-1 or Cl-

**Diagrams**

1. **Formation of oxide ion (O2-)**
2. **Formation of sulphide ion (S2-)**
3. **Formation of fluoride ion (F-)**

**IONIZATION ENERGY**

* **Ionization** is the removal of an electron from an atom or ion.
* Electrons in the energy levels are attracted to the nucleus by the protons and thus energy is needed to overcome this electrostatic force of attraction before an electron is ejected. This removal only occurs when the atoms are in gaseous states.
* **Ionization energy:- is the minimum energy required to remove an electron from the outermost energy level of an atom in the gaseous state.**
* Ionization energy needed to remove the 1st electron is known as **1st ionization energy**, that needed to remove 2nd electron is **2nd ionization energy** and so on.
* Examples include:
1. **Mg (g) Mg+ (g) + e-  ………………….. 1st ionization energy.**

**Mg (g) Mg2+ (g) + 2e- …………………. 2nd ionization energy.**

1. **Al (g) Al+ (g) + e- ……………………… 1st ionization energy**

**Al+ (g) Al2+ (g) + e- …………………….. 2nd ionization energy**

**Al2+ (g) Al3+ (g) + e- …………………… 3rd ionization energy**

* As the 1st electron is removed, the remaining electrons are held strongly to the nucleus by the excess proton. Thus 2nd ionization energy is higher than 1st ionization energy.
* The energy is measured in Joules (J) which can be converted into kilojoules

1000J = 1kJ

* Elements that readily lose electrons to become stable ions are said to be **electropositive**
* **Electropositivity** is the tendency of an atom to lose electrons to form cations. Group 1, 2 and 3 elements are electropositive. Group 1 elements are more electropositive than group 2 elements.

**ELECTRON AFFINITY**

* Is the energy released or absorbed when an electron is added to an atom.

 When an electron is added to an atom, two forces act on it:

1. Attraction by the positively charged nucleus
2. Repulsion by the other electrons in the energy levels.
* So addition of an electron to the atom needs energy to overcome basically repulsion.
* Elements that readily accepts extra electrons are said to be electronegative. They are normally very reactive non-metals. They have high electron affinity (High ability to gain electrons). Example include fluorine, oxygen and chlorine.

**VALENCY**

* Is the number of electrons an atom loses or gains during a chemical reaction.
* Is the combining power of an element.
* For metals, valence is the number of electrons in the outer most energy level. E.g. valency of sodium is 1, that of magnesium is 2 and that of aluminium is 3.
* For non-metals, valence is the number of electrons an atom needs to gain to become stable. E.g. valence of chlorine is 1, that of oxygen is 2 and that of sulphur is 2.
* Some elements have more than 1 valence, e.g. iron has valence 2 or 3, phosphorous has 3 or 5, lead has 2 or 4 e.t.c.

|  |  |  |
| --- | --- | --- |
| Element  | Symbol  | Valency |
| Hydrogen | H | 1 |
| Lithium | Li | 1 |
| Copper | Cu | 1 or 2 |
| Chlorine | Cl | 1 |
| Lead | Pb | 2 or 4 |
| Sodium | Na | 1 |
| Phosphorous  | P | 3 or 5 |
| Iron | Fe | 2 or 3 |
| Fluorine  | F | 1 |
| Carbon | C | 4 |
| Silicon  | Si | 4 |

* Valency is just a number and has no signs
* Electrons in the outermost energy level of an atom are known as valence electrons because they can be used to determine the valency of an element.

**OXIDATION NUMBER**

* Is the charge on an ion. Is used to describe the positive or negative character of an atom.
* When an atom loses an electron, it acquires a positive oxidation number (state) and negative oxidation number or state when it gains.
* Oxidation number or oxidation state is just valence with a sign (positive for metals and negative for non-metals)

|  |  |
| --- | --- |
| **ION** | **OXIDATION NUMBER** |
| H+ | +1 |
| Na+ | +1 |
| Cu2+ | +2 |
| O2- | -2 |
| Al3+ | +3 |
| Cl- | -1 |
| P3- | -3 |

**RADICALS**

* **A radical** is a group of combined atoms that behaves like a single entity during a chemical reaction.
* Are also known as **polyatomic ions.**
* They have a common oxidation state or number.

|  |  |  |  |
| --- | --- | --- | --- |
| **Radical**  | **Symbol**  | **Valence**  | **Oxidation number** |
| **Ammonium ion** | **NH4+** | **1** | **+1** |
| **Nitrate**  | **NO3-** | **1** | **-1** |
| **Nitrite**  | **NO2-** | **1** | **-1** |
| **Sulphate**  | **SO42-** | **2** | **-2** |
| **Sulphite**  | **SO32-** | **2** | **-2** |
| **Hydrogen sulphate** | **HSO4-** | **1** | **-1** |
| **Carbonate**  | **CO32-** | **2** | **-2** |
| **Hydrogen carbonate** | **HCO3-** | **1** | **-1** |
| **Phosphate**  | **PO43-** | **3** | **-3** |
| **Hydrogen phosphate** | **HPO42-** | **2** | **-2** |
| **Hydroxide**  | **OH-** | **1** | **-1** |

**CHEMICAL FORMULAE**

* Refers to a symbolic representation of the chemical composition of a pure substance.
* It comprises of the symbols of the constituent elements and/or radicals and some cases numbers written as subscripts (below the line). The subscripts are written to the right of the particular element or radical.
* Chemical formulae show the number of atoms in a compound or molecule.
* When a molecule contains one atom of an element, or one unit of a radical, no number is shown.

**WRITING CHEMICAL FORMULAE**

* Identify the symbols of the elements/radicals combining to form the compound
* Identify the valencies of the elements/radicals
* Metallic elements, positive radical or hydrogen, if present, are written first followed by the non-metallic element or negatively charged radicals.
* Interchange the valencies of the elements or radicals combining to get the subscripts.
* Where the value of the subscript is 1, it is not written

**Examples**

1. **Sodium chloride.**

|  |  |  |
| --- | --- | --- |
| **Element present** | **Metallic element** | **Non-metallic element** |
| **Sodium**  | **Chlorine**  |
| Symbols  |  Na |  Cl |
| Valency  |  1 |  1 |
| Interchange valence |  1 |  1 |

Thus the formulae is Na1Cl1 = **NaCl**

1. **Calcium chloride**

|  |  |  |
| --- | --- | --- |
| **Element present** | **Metallic element** | **Non-metallic element** |
| **Calcium**  | **Chlorine**  |
| Symbols  |  Ca |  Cl |
| Valency  |  2 |  1 |
| Interchange valence |  1 |  2 |

Thus the formulae is Ca1Cl2 = **CaCl2**

1. **Magnesium oxide.**

|  |  |  |
| --- | --- | --- |
| **Element present** | **Metallic element** | **Non-metallic element** |
| **Magnesium**  | **Oxygen**  |
| Symbols  |  Mg |  O |
| Valency  |  2 |  2 |
| Interchange valence |  2 |  2 |

Thus the formulae is Mg2O2 which could be simplified to **MgO**

1. **Aluminium sulphate**

|  |  |  |
| --- | --- | --- |
| **Element present** | **Metallic element** | **Radical**  |
| **Aluminium**  | **Sulphate**  |
| Symbols  |  Al | SO4 |
| Valency  |  3 |  2 |
| Interchange valence |  2 |  3 |

Thus the formulae is **Al2(SO4)3**

1. **Ammonium sulphate**

|  |  |  |
| --- | --- | --- |
| **Element present** | **Positive Radical**  | **Negative Radical**  |
| **Ammonium**  | **Sulphate**  |
| Symbols  | NH4 | SO4 |
| Valency  |  1 |  2 |
| Interchange valence |  2 |  1 |

Thus the formulae is **(NH4)2SO4**

1. **Carbon (IV) Oxide**

|  |  |  |
| --- | --- | --- |
| **Element present** | **Metallic element** | **Non-metallic element** |
| **Carbon**  | **Oxygen**  |
| Symbols  |  C |  O |
| Valency  |  4 |  2 |
| Interchange valence |  2 |  4 |

Thus the formulae is C2O4 which is simplified to **CO2**

1. **Water**

|  |  |  |
| --- | --- | --- |
| **Element present** | **Metallic element** | **Non-metallic element** |
| **Hydrogen**  | **Oxygen**  |
| Symbols  |  H |  O |
| Valency  |  1 |  2 |
| Interchange valence |  2 |  1 |

Thus the formulae is H2O1 = **H2O**

**Assignment.**

Write the formulae of the following:

1. lithium carbonate
2. Ammonium nitrate
3. Calcium carbonate
4. Potassium phosphate
5. Sodium hydrogen phosphate
6. Sodium hydroxide
7. Calcium hydroxide
* For compounds that are formed by elements with variable valency, the valency **MUST** be indicated in their names, in brackets and in roman numbers, e.g.

|  |  |
| --- | --- |
| **Formulae of compound** | **Conventional name**  |
| CuO | Copper (II) oxide |
| Cu2O | Copper (I) oxide |
| CO2 | Carbon (IV) oxide |
| CO | Carbon (II) oxide |
| SO2 | Sulphur (IV) oxide |
| SO3 | Sulphur (VI) oxide |
| FeCl2 | Iron (II) chloride |
| FeCl3 | Iron (III) chloride |
| PbO | Lead (II) oxide |
| PbO2 | Lead (IV) oxide |

**CHEMICAL EQUATION**

* Is a summary of the changes that occur during a chemical reaction by use of symbols.
* The formulae of the reactants are placed on the left hand side and those of products on right hand side of the arrow.
* **Reactants Products** (permanent reaction)
* **Reactants Products (**Reversible reaction**)**
* When writing a chemical reaction:
1. Write the word equation of the reaction.

**Copper + oxygen Copper (II) Oxide**

1. Write the correct chemical formulae for both the reactants and products.

 2**Cu (s) + O2 (g) 2CuO(s)**

**Questions**

Write an equation for each of the following cases:

1. When magnesium reacts with steam
2. When calcium reacts with water
3. When hydrochloric acid reacts with calcium carbonate
4. When copper (II) Oxide reacts with dilute sulphuric (VI) acid

**STATE SYMBOLS**

* Are symbols used to indicate the physical states of the reactants and products.
* They are written in brackets after each reactant or product.
* There are 4 main state symbols:

|  |  |  |
| --- | --- | --- |
| **States**  | **Representation**  | **Description**  |
| Solid  | (s) | Solids/precipitates  |
| Liquid  | (l) | Pure liquids like water and Concentrated sulphuric (VI) acid |
| Aqueous  | (aq) | A solute or liquid dissolved in water. |
| Gas  | (g) | Gas or vapour  |

* State symbols MUST always be written.e.g.

Copper + Oxygen gas Copper (II) Oxide

**Cu (s) + O2 (g) CuO(s)**

Magnesium + Steam Magnesium oxide

**Mg(s) + H2O(g) MgO(s)**

Sodium metal + Water Sodium hydroxide + hydrogen gas

**Na (s) + H2O (l) NaOH (aq) + H2 (g)**

**BALANCING CHEMICAL EQUATIONS**

* This is the process of making the number of each kind of atom on both sides of the equation equal.
* An equation is balanced when the number of atoms of each type of reactants is equal to that on the products side. This is because atoms are neither created nor destroyed during a chemical reaction.

The following steps are followed to balance a chemical reaction:

1. Write the word equation

Copper + Oxygen gas Copper (II) Oxide

1. Write the correct chemical equation.

**Cu + O2 CuO (unbalanced)**

1. Check whether the number of atoms of each element on the reactants side is equal to that on the products side. If equal, then the equation is balanced.
2. If not equal, multiply the chemical formula containing the unbalanced atoms with the lowest common multiple. In this case multiply the product by 2 and copper by 2.

**2Cu + O2 2CuO**

1. Check again to ensure that all the atoms are balanced.
2. If balanced, place the correct state symbols after each reactant and products.

**2Cu(s) + O2 (g) 2CuO (s)**

* A chemical equation is only correct if correctly balanced and has correct state symbols

 **Questions**

1. Balance the following equations
2. Mg (s) + HCl (aq) MgCl2 (aq) + H2 (g)
3. Na (s) + H2O (l) NaOH (aq) + H2 (g)
4. CuCO3 (s) + H2SO4 (aq) CuSO4 (aq) + CO2 (g) + H2O (l)
5. C2H6 (g) + O2 (g) CO2 (g) + H2O (l)
6. C4H10 (g) + O2 (g) CO2 (g) + H2O (l)
7. Mg(s) + N2 (g) Mg3N2 (s)
8. Write a balanced equation for the following reactions:
9. Heating sodium metal in oxygen to obtain sodium oxide
10. Reacting zinc metal with dilute sulphuric (VI) acid
11. Burning hydrogen in air to obtain water