Year 11 Additional Science

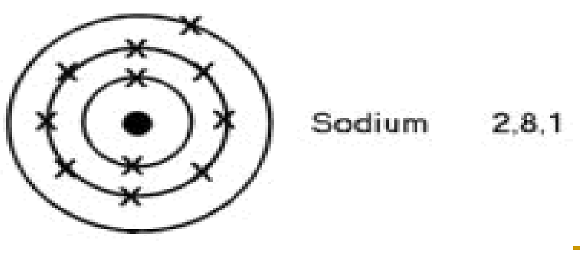
Chemistry 2

Sub-atomic particles

Particle	Charge	Mass
Proton	+1	1
Neutron	0	1
Electron	-1	Almost 0

- Electrons are arranged in energy levels around the nucleus
- The first shell can hold 2, the second 8, the third 8
- electron arrangement can be represented by both diagrams and labels eg

For Sodium;



For Chlorine

2,8,7

The Periodic table and electron arrangement

- Order is by increasing atomic number.
- Elements are grouped by properties – elements in the same group have similar properties.
- Elements in the same group have the same number of electrons in their outer shells (all group 1 elements have 1 electron in their outer shell, all group 7 elements have 7 electrons in their outer shell etc…

Bonding

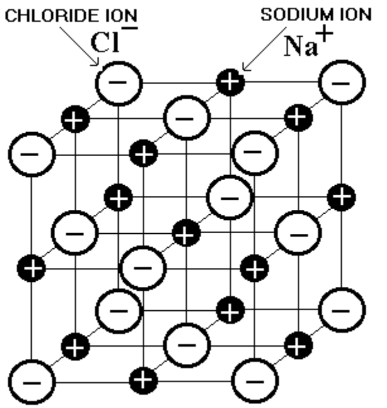
- Chemical bonds are formed by either;
  - Transferring electrons (IONIC – between a metal and a non-metal)
  - Sharing electrons (COVALENT – between two non-metals)

Ions

- Ions are formed by adding or removing electrons
- Non-metals gain electrons (to achieve a complete outer shell) and become negatively charged
- Metals lose electrons (to achieve a full outer shell) and become positively charged

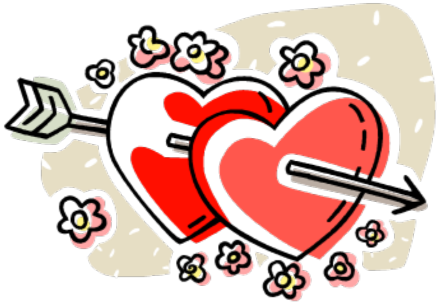
Ionic Bonding

- Occurs between a metal and a non-metal
- Involves transfer of electrons from the metal to the non-metal
- The metal is positively charged.
- The non-metal is negatively charged.
- The opposite charges attract and this holds the compound together in a LATTICE



SODIUM CHLORIDE LATTICE STRUCTURE

Metal
(+)



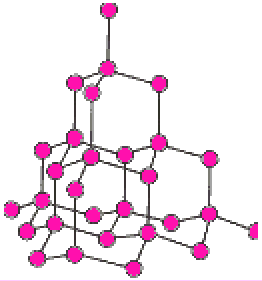
Non-metal
(-)

Properties of Ionic Compounds

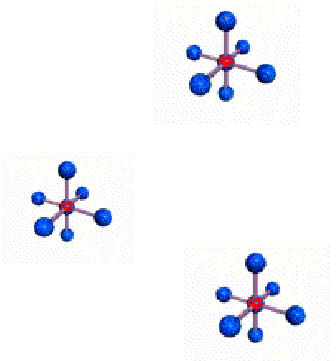
- The have very high melting points
- They are made up of crystals
- When they are dissolved in water or melted, they can conduct electricity.

Covalent bonding

- Occurs only between non-metals
- Involves the sharing of a pair of electrons.
- There are two types of structures; Giant covalent structures and small molecules.



Giant covalent structure



Small molecules

Non-metal

Non-metal

Properties of covalent compounds

- Giant covalent compounds have very high melting points but small molecules do not.
- They do not conduct electricity (except graphite).
- Small molecules are often gases or liquids.
- Giant Covalent molecules do not dissolve in water

Metallic structure

- A giant structure
- Outer electrons are delocalised (“free”)
- Positive ions held together by electrostatic attraction with the “sea of electrons”
- Allows them to conduct electricity
- Layers of atoms in metals allows them to be bent/shaped

Structures and properties

- The type of structure will determine the properties and uses of substances
- Diamond;
  - All four electrons used in bonding
  - Giant covalent structure
  - Very strong/hard + high mpt

- Graphite
  - 3 electrons used for bonding – arranged in layers
  - 1 electron from each carbon is delocalised - and so can conduct electricity
  - Layers make it soft and slippery

- Nanomaterials – VERY Small (1-100nm in size)
  - High surface to vol ratio
  - Many different properties compared with traditional materials

Chemical Symbols

Mass number (the number of protons and neutrons in the nucleus)

$$^{7}_{3}\mathrm{Li}$$

Proton number (the number of protons. This is the same as the number of electrons)

Relative formula mass

- We can work out the relative formula mass of a compound by adding together the relative atomic masses of each atom in the compound.
- E.g. the mass of magnesium oxide (MgO) is 24 + 16 = 40
- The atomic mass of each element is found on the periodic table.

% of an element in a compound

- In the previous example, to work out the % of Mg in MgO;
  - There is 1 Mg in the compound
  - Mg has a mass of 24
  - MgO has a mass of 40
  - % of Mg in MgO = (24/40) x 100
  - 60%

Moles

- 1 mole of an element contains $6x10^{23}$ atoms
- Moles are calculated using;

  moles= mass/relative atomic mass

- Moles of a molecule are calculated using;

  moles=mass/relative formula mass

Moles are used to help calculate the empirical (simplest) formula

Calculations involving moles

- Moles can also be used to calculate the amount of product expected in a reaction

E.g.;

If 4.8g of magnesium are added to excess hydrochloric acid, what mass of magnesium chloride would be made?

- Write out the equation;

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

4.8g → xg

Moles 4.8/24=0.2

As the ratio of moles is 1:1, we have to find out how many grams of $MgCl_2$ there are in 0.2 moles

0.2 x (24+35.5+35.5) = 19g

Mass

19 grams of magnesium chloride will be made from 4.8 grams of magnesium

- **Alternative method;**
- Write out the equation;

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

4.8g →	*x*g
24g	95g *(assumes Mr Cl = 35.5)*
1g	3.95
4.8g	19g

19 grams of magnesium chloride will be made from 4.8 grams of magnesium

Chemical Yield and atom economy

- Yield is the amount of product obtained.
- It is represented as a %
- Atom economy is a measure of how many of the starting material atoms end up in the USEFUL product
- High atom economy = good for economic reasons and good for sustainable development.

Yield calculation example

- One mole of methane was burned in air. The carbon dioxide produced was absorbed by a chemical. This chemical gained 32g in mass – what was the % yield of carbon dioxide?

Answer

- 1 mole of methane = 16g.
- 1 mole of methane makes 1 mole of CO_2
- So 16g of methane should make a maximum of 44g of CO_2 however, only 32g were formed.
- %yield =

(amount of product made/theoretical amount of product) x 100

= (32 / 44) x 100

=73%

Reversible reactions

1. **The Haber process reaction is reversible**
2. **This means that the product (ammonia) can break down again into the reactants (nitrogen and hydrogen)**

Equilibrium

1. **For a reversible reaction in a closed system, an equilibrium is reached where the rate of the forward reaction equals the rate of the reverse reaction**
2. **The amount of reactants and products in the equilibrium depends on the conditions**
3. **The equilibrium will move to reduce any changes in the reaction**

The Haber Process

1. **Ammonia is made in the Haber process**
2. **The raw materials are nitrogen (from the air) and hydrogen (from natural gas)**

The conditions for a reasonable yield are;
high temperatures (about 4500)
high pressures (200 atm).
iron catalyst
The unused reactants are recycled to increase the overall yield.

IDEAL conditions for the Haber process

- A very low temperature as the reaction to make ammonia is EXOTHERMIC, but this would be too slow
- A very high pressure as this would push the equilibrium towards the ammonia as there are less molecules on this side of the equation, but this would be dangerous (risk of explosion) and expensive as special equipment would be needed.

Measuring the rate of reaction

1. **The rate of a reaction can be measured by measuring;**
- **the rate at which the products are produced (e.g. using a syringe if a gas is produced)**
- **the rate at which the reactants are used up (e.g. by monitoring colour changes)**

Rate of reaction

1. **The speed of a reaction can be increased by;**

- **Increasing temperature**
- **Increasing concentration/pressure**
- **Increasing the surface area (breaking up a solid into smaller pieces)**
- ***These will increase the FREQUENCY and/or ENERGY of the collisions, and so there will be more successful collisions***
- **Using a catalyst**

2. **A catalyst increases the rate of a chemical reaction but it is not used up during the reaction**
3. **The total amount of product made is not changed, just how fast it is made.**

Exothermic reactions

1. An exothermic reaction is one which releases heat energy to the surroundings
2. The temperature of the surroundings increases
3. The energy released from forming new bonds is greater than the energy needed to break old bonds

Examples/uses

- **Exothermic**;
  - Combustion
  - Neutralisation
  - Oxidation
  - Self heating coffee cans

- Endothermic;

  -thermal decomposition

  -”ice packs” that cool on twisting

Electrolysis

Electrolysis is the process of splitting up compounds using electricity

- Electrolysis only works if the substance is molten or dissolved (so the ions are free to move)
- Positively charged ions (cations) move to the cathode, negatively charged ions (anions) move to the anode
- Electrolysis is used to extract reactive metals from their ores and to purify copper
- Pure copper is needed for electrical wiring

Electrolysis of Sodium Chloride

1. Sodium Chloride (common salt) is found in the sea and in underground deposits
2. Electrolysis of sodium chloride solution produces chlorine at the anode, hydrogen at the cathode and sodium hydroxide solutions
3. Chlorine bleaches damp litmus paper
4. Each product has important uses

Acids and alkalis

- Acids contain H^+ ions
- Alkalis contain OH^- ions
- pH is a measure of the strength of an acid or alkali
- During neutralisation, the H^+ and OH^- come together to form water. A salt is also formed which can be crystallised.

Neutralisation

1. **Acids react with alkaline solutions to form a salt and water**

- **Hydrochloric acid produces chlorides**
- **Nitric acid produces nitrates**
- **Sulphuric acid produces sulphates**

2. **Ammonia can dissolve in water to produce an alkaline solution. This can be neutralised with acids to produce ammonium salts**
3. **Indicators can monitor neutralisation reactions**

Metal Oxides & Hydroxides

1. Transition metal oxides and hydroxides do not dissolve in water. They are called bases
2. They react with acids to produce salts that are soluble
3. The excess metal oxide can be filtered off

Precipitation reactions

- A precipitation reaction is any reaction that produces an insoluble compound when two aqueous solutions are mixed.
- It is impossible to predict whether or not we will get precipitation reactions unless we know something about the physical states (especially solubility) of the various reactants and products.

Here are the symbols that we use in chemical equations to say what the physical state is:

- (s) solid
- (l) liquid
- (g) gas
- (aq) aqueous (dissolved in water)