HSC COLLEGE
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YEAR 11 CHEMISTRY

MODULE 2

THEORY BOOKLET 1

IQ 1: CHEMICAL REACTIONS AND STOICHIOMETRY

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Syllabus Covered

In this section, students will learn to:

★ **identify possible indicators of a chemical change**

1.1 Chemical Change (or Chemical Reaction)

- **Chemical changes** are **chemical reactions in which new substances with different compositions and properties are formed.** In order for this to occur, **chemical bonds are broken and/or formed between atoms.**
- Although new substances are formed in chemical reactions, **no new or extra atoms are created, but rather the atoms from the reactants are just rearranged to form new substances (by breaking and forming chemical bonds between them)**. This is due to the Law of Conservation of Mass which will be studied further on in the theory book.
- Simply stated, **a chemical change (or chemical reaction) is the process where reactants are transformed into products** where reactants and products are entirely different to each other in composition and properties. The chemical equation below is a good example of this phenomenon.

$$A + B \rightarrow C + D$$

- In a chemical reaction the **starting substances are called reactants** or **reagents** and **the substances that are formed are called products**. In the above equation, A & B are the reactants and C & D are the products.
- Chemical changes usually **involve large quantities of energy being absorbed or released**, generally in the form of heat, light or electricity. Significantly more energy is usually required for chemical changes than for physical changes.
- **Chemical changes are mostly irreversible.** Reversal of chemical change may be quite difficult. A burning match is an example of a chemical change that cannot be reversed.
- Chemical reactions are constantly occurring in the world around us; everything from the rusting of an iron fence to the metabolic process of a human biological system are all examples of chemical reactions. Chemistry is an attempt to classify and better understand these reactions.

1.2 Physical Change

- **Physical changes occur without a change in the composition of the particular substance.**
- In a physical change, **no bonds are broken or formed** and hence **no new substance is formed**.
- Physical changes are **often reversible**.
- In physical changes, there should not be any new or entirely different substances produced as compared to the reactants initially involved. The chemical equation below is a good example of this phenomenon.

$$X\ (solid) \rightarrow X(liquid)$$

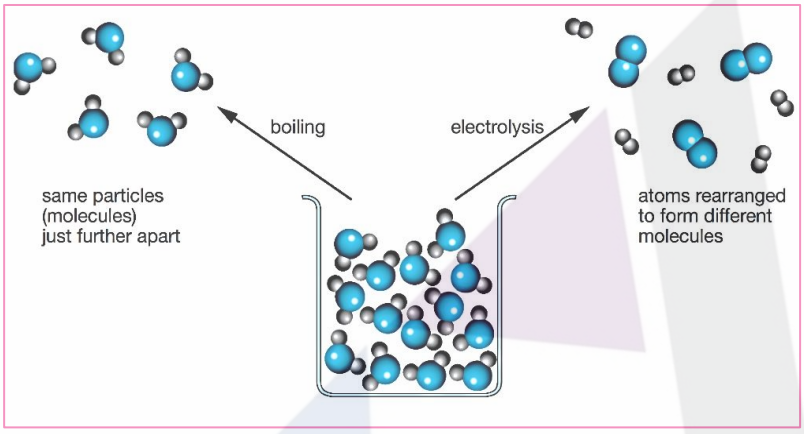
- Ice, for example, can be readily converted to liquid water by heating. Cooling will reverse the process and turn the water back to ice. In each case, no new substances have formed.

1.3 Comparing Physical & Chemical Changes

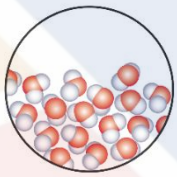
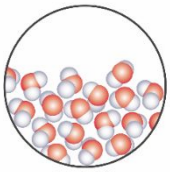
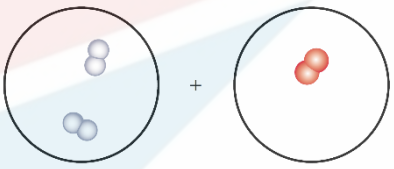
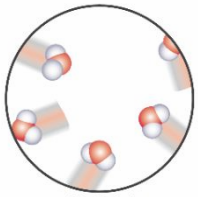
- The following table summarises the differences between chemical and physical changes.

Chemical Change (Reaction)	Physical Change
at least one new substance is formed	no new substance is formed
difficult to reverse (hard to un-boil an egg)	easily reversed (melt a solid: freeze it again)
a large input or output of energy is involved (burning natural gas)	relatively small energy changes involved (evaporate alcohol, dissolve sugar in water)

- The diagram below makes a clear comparison between a physical change (boiling) and chemical change (electrolysis).



- Let's consider the boiling and electrolysis of water in more detail in order to make a clear comparison between a chemical change and a physical change.

	Electrolysis	Boiling
Change	Chemical	Physical
Bonds/Forces broken	Covalent bonds (intramolecular forces) between H and O atoms	Intermolecular forces between individual molecules
Structure before (reactant)	 H_2O (l) liquid water	 H_2O (l) liquid water
Structure after (product)	 $2H_2$ (g) hydrogen gas + O_2 (g) oxygen gas	 H_2O (g) water vapour
Change in composition	Yes	No
Reversibility	Very difficult to reverse	Reversible by condensation
Word equation	Water → Hydrogen gas + Oxygen gas	Water (liquid) → Water (gas)

- Boiling water does not alter the actual particles (molecules): it just separates them from one another: the water vapour contains the same water molecules as the liquid did.

- Electrolysis actually breaks the particles up (water molecules are broken up and hydrogen and oxygen molecules are formed).

☯ The tables below are some examples of physical and chemical changes, with explanations as to why they are so:

Physical Changes	Explanation
Water vapour condensing on a cold window	Water vapour (or steam) which is gas, will condense into a liquid when temperature is low enough. Water is simply changing states from gas to liquid.
Iceberg melting	Water is simply changing states from solid to liquid. No changes in composition within molecules are involved.
Dissolving copper(II) sulfate into water to form a blue solution	Copper(II) sulfate is an ionic compound, which can dissolve in water. The copper and sulfate ions present in water are not 'new' products with changed compositions, as they were already present in the ionic solid.

Chemical Changes	Explanation
Vinegar reacting with baking soda	When vinegar (an acid) reacts with baking soda (a base), a neutralisation reaction occurs. This is a reaction between acid and base, producing a salt and water. The products (salt and water) have entirely new and different chemical compositions to the reactants.
Rusting of nail	Iron of the nail reacts with oxygen when exposed to air. This produces iron oxides as rusts, which are different chemical compounds compared to pure iron.
Burning of wood in a fire	When wood burns in fire, a combustion reaction occurs. The fuel (wood) and oxygen involved in combusting, changes form to carbon dioxide and water.

Common Signs Of Chemical Changes

- In reactions involving chemical changes, bonds in the reactants break and products with different properties are formed. Therefore, there are usually signs which act as evidences that a chemical reaction has occurred. Below are some signs that a chemical change may have occurred. If you observe two or more of these signs during a change, you most likely are observing a chemical change.
  - **if a gas is observed to have formed**, for example when baking soda is added to vinegar a stream of bubbles are created
  - **if a solid (called a precipitate) is formed when two solutions are mixed**; for example when silver nitrate and sodium chloride solutions are mixed, a white solid (silver chloride) forms
  - **if there is a change in colour**; for example when purple potassium permanganate solution is added to hydrogen peroxide, the mixture becomes colourless
  - **if there is a significant change in temperature** of the mixture; for example when magnesium is burnt, the metal becomes very hot
  - **if there is disappearance of a solid which is not merely physical dissolution of the solid in the solvent**; for example white magnesium hydroxide powder added to hydrochloric acid produces a clear solution
  - **if an odour is produced**; for example, when sodium hydroxide is added to a warm solution of ammonium chloride, the sharp smell of ammonia is detected.