WJEC Wales Chemistry GCSE

1.6: Limestone

Detailed notes

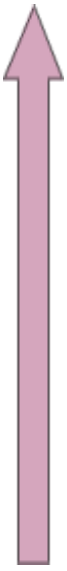
Metal carbonates

Trend in stabilities

Some metal carbonates are more stable than others. The more reactive a metal is, the more stable its metal carbonate is. So, a reactivity series shows the relative stability of the different carbonates:

Most reactive metal, most stable carbonate

K	Potassium
Na	Sodium
Ca	Calcium
Mg	Magnesium
Al	Aluminium
C	Carbon
Zn	Zinc
Fe	Iron
Sn	Tin
Pb	Lead
H	Hydrogen
Cu	Copper
Ag	Silver
Au	Gold
Pt	Platinum



Least reactive metal, least stable carbonate

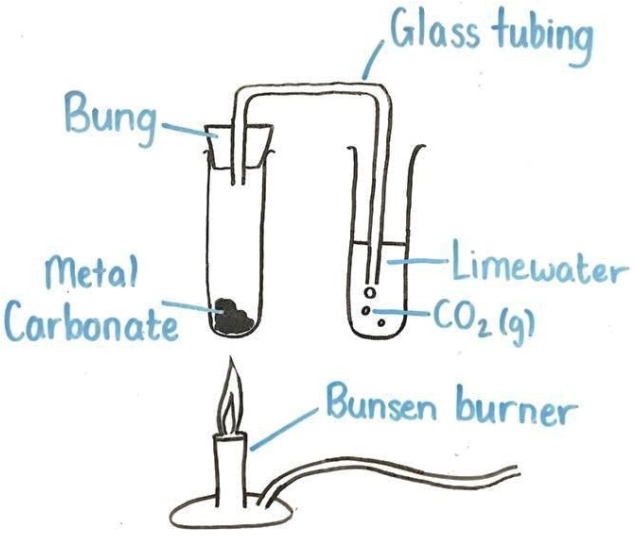
*Carbon and hydrogen are there for comparison

Thermal decomposition

Metal carbonates undergo thermal decomposition when heated to form their metal oxide and carbon dioxide. Some example reactions:

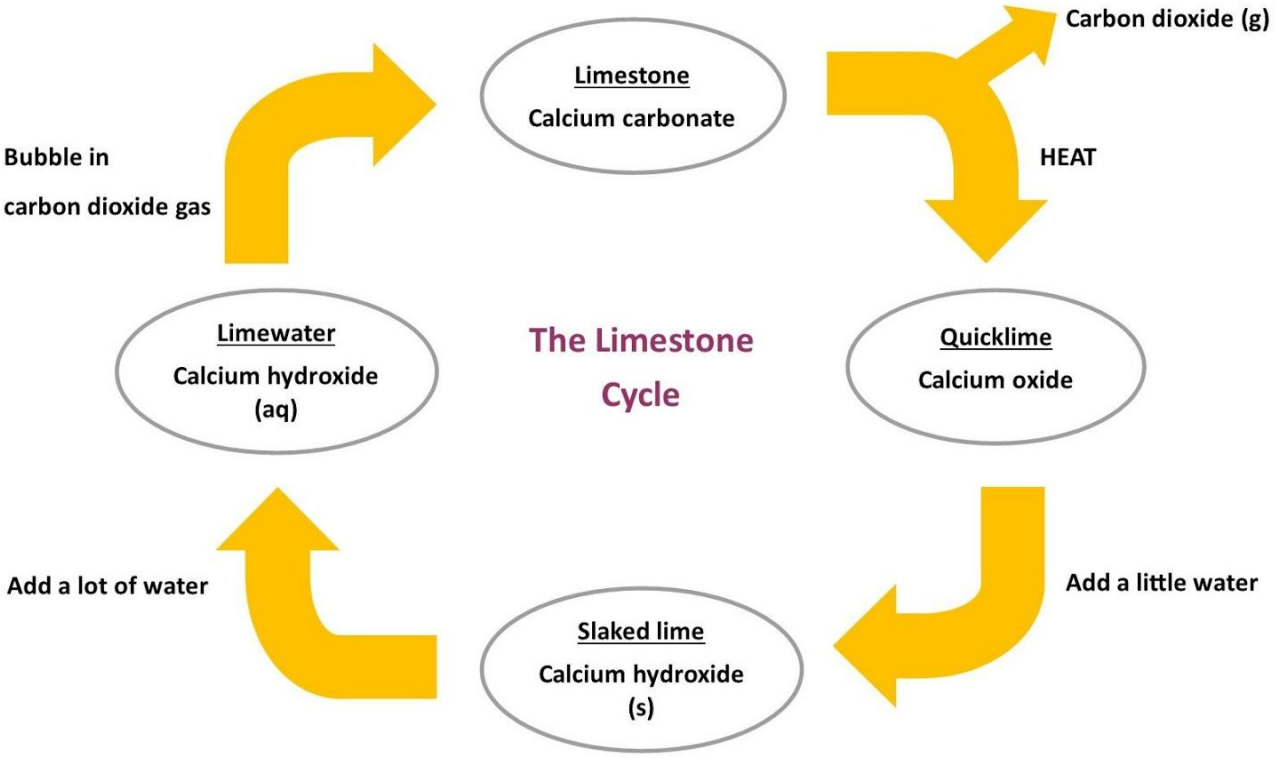
- Sodium carbonate → Sodium oxide + carbon dioxide
  $Na_2CO_3 \rightarrow Na_2O + CO_2$
- Copper carbonate → Copper oxide + carbon dioxide
  $CuCO_3 \rightarrow CuO + CO_2$

Because the reaction produces carbon dioxide gas, the rate of the reaction can be determined practically by using this apparatus:



You can then measure how long it takes for the limewater to go cloudy. The more stable the carbonate is, the longer it will take for the compound to undergo thermal decomposition, so the longer it will take for limewater to go cloudy. This method can therefore be used to find the stability of metal carbonates.

The limestone cycle



Calcium compounds

The following calcium compounds have more common names:

- Calcium carbonate, $CaCO_3$ - limestone

- Calcium hydroxide, $Ca(OH)_2$ - slaked lime
- Calcium hydroxide (aq) - limewater
- Calcium oxide, CaO - quicklime

The reactions of the limestone cycle

The limestone cycle is a series of 4 reactions that links various calcium compounds. It is an important pathway as each of the intermediates has important uses.

- Limestone
- Quicklime - used to make plaster and cement
- Slaked lime - can be added to lakes to neutralises acidity
- Limewater - a chemical test for carbon dioxide

1) Calcium carbonate → calcium oxide + carbon dioxide

- The first reaction is a thermal decomposition reaction of limestone. The limestone takes in heat as it decomposes, making it an endothermic reaction.
  $CaCO_3 \rightarrow CaO + CO_2$

2) Calcium oxide + water → calcium hydroxide

- Calcium oxide reacts with a little water to form calcium hydroxide, an alkali.
- This reaction releases heat into the surroundings, so is exothermic.
  $CaO\ (s) + H_2O\ (l) \rightarrow Ca(OH)_2\ (s)$

3) Calcium hydroxide then dissolves in excess water and forms limewater, $Ca(OH)_2$ (aq)

4) Calcium hydroxide + carbon dioxide → calcium carbonate + water

- When CO_2 gas is bubbled through limewater, solid calcium carbonate forms, completing the cycle.
- As calcium carbonate is a solid precipitate, as the reaction occurs limewater turns cloudy.
  $Ca(OH)_2\ (aq) + CO_2\ (g) \rightarrow CaCO_3\ (s) + H_2O\ (l)$

Uses of limestone

- A building material for statues, buildings and roads
- Can be converted into other compounds in the limestone cycle which have their own uses
- Added to soil to neutralise acidity
  - Helps crops grow better
- Making cement - crushed limestone is heated in a rotary kiln with clay which produces cement. Cement can be used as it is, or made into mortar or concrete:
  - Cement + sand + water → mortar (used to stick bricks together)
  - Cement + sand + water + gravel → concrete (very strong, can be poured on steel bars to create reinforced concrete)
- Making iron
  - Iron is made by heating coal, iron ore and limestone in a blast furnace
  - The main impurity in the mixture is silicon dioxide (sand)
  - Limestone undergoes thermal decomposition into calcium oxide which reacts with silicon dioxide to form solid calcium silicate which can be removed from the furnace
    $CaCO_3\ (s) \rightarrow CaO\ (s) + CO_2\ (g)$

$CaO\ (s) + SiO_2\ (l) \rightarrow CaSiO_3\ (s)$

Quarrying

Most limestone is obtained by quarrying which involves cutting into the ground to obtain the stone. There are advantages and disadvantages to obtaining limestone via quarrying:

Advantages	Disadvantages
• The easiest way to obtain limestone which has many uses and is a valuable material • Quarrying provides jobs • Once the quarry is no longer used it can be turned into something else, such as a new lake • Improves local roads due to the need for large transport vehicles	• Quarrying requires destroying large areas of land, including animal habitats • Creates noise pollution • Creates visual pollution • Dust and pollution from extra vehicles can cause respiratory problems such as asthma