CAIE IGCSE Chemistry

9.4 Reactivity series

Notes

This work by PMT Education is licensed under CC BY-NC-ND 4.0

State the order of the reactivity series as: potassium, sodium, calcium, magnesium, aluminium, carbon, zinc, iron, hydrogen, copper, silver, gold

- Reactivity series arranges metals in order of their reactivity. This can be used to predict products from reactions.
- Non-metals hydrogen and carbon are often included in the reactivity series
- A mnemonic to remember the order of the reactivity series:
    - A Posse of Sly Cats Maliciously Admire Clever Zebras In Hiding Copying Slowly and Gradually

Most reactive
Potassium
Sodium
Calcium
Magnesium
Aluminium
(Carbon)
Zinc
Iron
(Hydrogen)
Copper
Silver
Gold
Least reactive

Describe the reactions, if any, of: (a) potassium, sodium and calcium with cold water (b) magnesium with steam (c) magnesium, zinc, iron, copper, silver and gold with dilute hydrochloric acid and explain these reactions in terms of the position of the metals in the reactivity series

(a) Potassium, sodium and calcium with cold water

- When potassium reacts with cold water, potassium melts and floats, moving rapidly on the surface of the water. A lilac flame will also ignite and sometimes at the end of the reaction a small explosion can occur.
- Potassium will have the most violent/vigorous reaction with cold water since it is at the top of the reactivity series
- Word equation: Potassium + Water → Potassium hydroxide + Hydrogen
- Symbol equation: $2K\,(s) + 2H_2O\,(l) \rightarrow 2KOH\,(aq) + H_2\,(g)$

- When sodium reacts with water, the metal melts to form a ball that moves rapidly around on the surface. The ball fizzes rapidly before it disappears, but the reaction of sodium and water is less vigorous than potassium and water.
- Word equation: Sodium + Water → Sodium hydroxide + Hydrogen
- Symbol equation: $2Na\,(s) + 2H_2O\,(l) \rightarrow 2NaOH\,(aq) + H_2\,(g)$

- When calcium is added to water, the reaction is slower and less violent than the reactions prior. The calcium metal sinks in water and after an hour or so bubbles of hydrogen gas can be seen on the surface of the metal.
- Calcium will have a less vigorous and slower reaction with cold water since it is lower than potassium and sodium in the reactivity series
- Word equation: Calcium + Water → Calcium hydroxide + Hydrogen
- Symbol equation: $Ca\,(s) + 2H_2O\,(g) \rightarrow Ca(OH)_2\,(aq) + H_2\,(g)$

(b) Magnesium with steam

- Magnesium does not react with cold water but it does however react with steam to produce magnesium oxide
    - Very clean magnesium ribbon has a very slight reaction with cold water but the magnesium hydroxide is insoluble so no further reaction occurs.
- The initial reaction between magnesium and steam will form magnesium oxide and hydrogen gas
- Word equation: Magnesium + Steam -> Magnesium oxide + Hydrogen gas
- Symbol equation: $Mg\,(s) + H_2O\,(g) \rightarrow MgO\,(aq) + H_2\,(g)$
- This is because magnesium is further down the reactivity series than potassium, sodium and calcium, so will be more unreactive.

(c) Magnesium, zinc, iron, copper, silver and gold with dilute hydrochloric acid

- Potassium, Sodium and calcium are too reactive that their reactions with hydrochloric acid are too dangerous to be attempted
- The further down the reactivity series, the slower the reaction until no reaction will occur.
- Only metals above hydrogen in the reactivity series will react with dilute acids

Metal	Reaction with dilute hydrochloric acid
Magnesium	Fast reaction
Zinc	Slightly fast reaction
Iron	Slightly fast reaction
Copper	No reaction
Silver	No reaction
Gold	No reaction

CC BY NC ND

Deduce an order of reactivity from a given set of experimental results

- The order of reactivity can be deduced from the results of experiments by determining the speed and observations of each metal
- E.g. A less vigorous and slow reaction will usually mean a lower reactivity whereas lots of effervescence (bubbles/fizzing) and quicker reactions are usually higher in the reactivity series
- In a displacement reaction, the more reactive metal will replace the less reactive metal in a compound

(Extended only) Describe the relative reactivities of metals in terms of their tendency to form positive ions, by displacement reactions, if any, with the aqueous ions of magnesium, zinc, iron, copper and silver

- When metals react with other substances, metal atoms form positive ions
- The reactivity of a metal is determined by their tendency to form positive ions

- In a displacement reaction, the more reactive metal will replace the less reactive metal in a compound
    - If there is no difference in reactivity between the metals, no reaction will take place

- E.g Zinc sulfate + Calcium -> Calcium sulfate + Zinc
  $ZnSO_4(aq) + Ca(s) \longrightarrow Zn(s) + CaSO_4(aq)$
  Calcium is higher in the reactivity series than zinc so will displace zinc ions in zinc sulfate to form calcium sulfate

- The more reactive a metal is, the more easily it will lose its outer shell electrons to form its positive ion.
- E.g. $Ca(s) \rightarrow Ca^{2+}(aq) + 2e^-$ Calcium has been oxidised (lost electrons)
  $Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$ Zinc has been reduced (gained electrons)
- We can see that the more reactive metal, calcium, has lost electrons to form its positive ions and the less reactive metal, zincs, has gained electrons.

(Extended only) Explain the apparent unreactivity of aluminium in terms of its oxide layer

- Aluminium metal reacts with oxygen in the air to form Al_2O_3, aluminium oxide
    - This coats the surface of the aluminium and is very unreactive
- Therefore, it can prevent the aluminium metal from further oxidation

CC BY NC ND