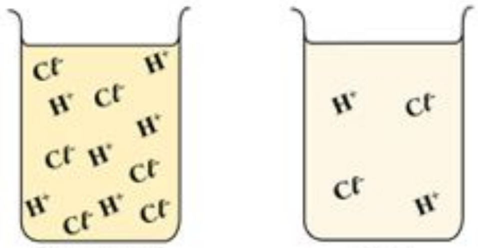
Set 12: Acid and base strength

1. **Concentration** is a description or measure of the proportion of solute in a solution. It can refer to the original form of the solute or to the resulting species formed as a result of the solution process.

If the solubility of an acid or base is high then the resulting solution could be described as concentrated if a relatively large proportion of the solute was dissolved in the solvent. For example $HC\ell$, HF, or NH_3.

However, if the solubility of an acid or base is low then the solution could never be concentrated. For example $Ca(OH)_2$.

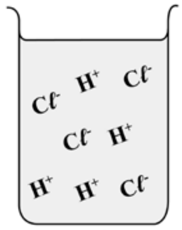

Concentrated solution of $HC\ell$ Dilute solution of $HC\ell$

Strength refers to the degree of ion formation that occurs when an acid or base is dissolved in water as a proportion of the solute actually dissolved. For example:

When hydrogen chloride dissolves in water it ionises completely to form ions as illustrated by the single arrow in the equation:

$$HC\ell_{(aq)} \rightarrow H^+_{(aq)} + C\ell^-_{(aq)}$$

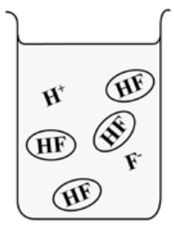
$HC\ell$ is classified as a strong acid as it completely ionises in aqueous solution.


$HC\ell$ is a STRONG acid

When the very soluble hydrogen fluoride dissolves in water there is little ionisation. The double arrows in the equation show partial ionization:

$$HF_{(aq)} \leftrightarrows H^+_{(aq)} + F^-_{(aq)}$$

HF is classified as a weak acid as it only partially ionises in aqueous solution.



HF is a WEAK acid

2. (a) $HC\ell$, HNO_3, H_2SO_4, HBr, HI, $HC\ell O_4$, …….
   (b) CH_3COOH, H_2S, HF, H_3PO_4, $H_2C_2O_4$, HSO_4^-, or any organic acid.
   (c) NaOH, KOH, $Ba(OH)_2$, $Ca(OH)_2$, or any metal hydroxide or oxide.
   (d) NH_3, CO_3^-, CH_3NH_2 or any organic amine.

3. (a) Concentrated and weak
   (b) Dilute and strong
   (c) Concentrated and strong
   (d) Dilute and weak

4. (i) (a) $HBr(g) \rightarrow H^+(aq) + Br^-(aq)$
(b) ionisation
(c) $HBr, OH^-, Br^- \approx H^+$ or H_3O^+, H_2O

(ii) (a) $CH_3COOH(\ell) \leftrightarrows H^+(aq) + CH_3COO^-(aq)$
(b) ionisation
(c) $OH^-, CH_3COO^- \approx H^+$ or H_3O^+, CH_3COOH, H_2O

(iii) (a) $H_2SO_4(\ell) \rightarrow H^+(aq) + HSO_4^-(aq)$ and $HSO_4^-(aq) \leftrightarrows H^+(aq) + SO_4^{2-}(aq)$
(b) ionisation
(c) $H_2SO_4, OH^-, SO_4^{2-}, HSO_4^-, H^+$ or H_3O^+, H_2O

(iv) (a) $NH_3(g) + H_2O(\ell) \leftrightarrows NH_4^+(aq) + OH^-(aq)$
(b) ionisation
(c) H_3O^+ or $H^+, NH_4^+ \approx OH^-, NH_3, H_2O$

(v) (a) $Ba(OH)_2(aq) \rightarrow Ba^{2+}(aq) + 2OH^-(aq)$
(b) dissociation
(c) $Ba(OH)_2, H^+$ or $H_3O^+, Ba^{2+}, OH^-, H_2O$

5. $HC\ell O_4$ is the stronger acid and the weaker base is $C\ell O_4^-$

6. (a) $H_2S(g) + H_2O(\ell) \leftrightarrows H_3O^+(aq) + HS^-(aq)$ and $HS^-(g) + H_2O(\ell) \leftrightarrows H_3O^+(aq) + S^{2-}(aq)$
(b) Strongest acid is H_3O^+ and the strongest base is S^{2-}

7. (a) $H_3PO_4(\ell) \leftrightarrows H^+(aq) + H_2PO_4^-(aq)$
$H_2PO_4^-(aq) \leftrightarrows H^+(aq) + HPO_4^{2-}(aq)$
$HPO_4^{2-}(aq) \leftrightarrows H^+(aq) + PO_4^{3-}(aq)$
(b) H_2O, H_3PO_4, H^+ or $H_3O^+, H_2PO_4^-, HPO_4^{2-}, PO_4^{3-}, OH^-$

8. 99% sulfuric acid consists mostly of H_2SO_4 molecules as there is little water to allow ionisation, so there are very few hydrogen ions too react with the iron. As sulfuric acid is a strong acid there is full ionisation for the release of one hydrogen ion represented by the equation $H_2SO_4(\ell) \rightarrow H^+(aq) + HSO_4^-(aq)$

There is therefore a high concentration of hydrogen ions which is the species that reacts with the iron in a reaction represented by the equation $2H^+(aq) + Fe(s) \rightarrow Fe^{2+}(aq) + H_2(g)$

9. For effective washing, large numbers of OH^- ions are required in the washing powder. To supply these substantial amounts of sodium hydroxide or sodium carbonate need to be present. The sodium hydroxide, being a strong base will produce a high concentration of OH^- ions which can be detrimental to fabrics and certainly to containers made from aluminium, zinc, chromium (a component of stainless steel) and any other amphoteric metal. It is also dangerous to use as concentrated OH^- solutions are corrosive to skin.
Sodium carbonate, however, is a weak base that produces relatively low concentrations of OH^- ions but as these are consumed, more are produced until all of the carbonate ions are used up. The production of the OH^- ions from the carbonate ions is illustrated by the equation
$CO_3^{2-}(aq) + H_2O(\ell) \leftrightharpoons HCO_3^-(aq) + OH^-(aq)$

10. For this use the hydrogen ion concentration produced in the solution must be very low but there must be a process that replaces the hydrogen ions that are used up. It must therefore be a weak acid. As hydrochloric acid is a strong acid the concentration of hydrogen ions, even in dilute solutions is relatively high and would damage human skin particularly sensitive areas such as eyes and areas where fungal infections are likely to occur.