CHEM 9.3.3 ACIDS AND PH

Acids occur in many foods, drinks and even within our stomachs

3.1 Define acids as **proton donors** and describe the **ionisation of acids in water**

- Acids **produce hydrogen ions, H⁺** (protons) – $HNO_{3\,(aq)} \rightarrow H^+_{(aq)} + NO^-_{3\,(aq)}$
  - More accurately, H⁺ reacts with water, so: $HNO_{3\,(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + NO^-_{3\,(aq)}$
- Is an **ionisation reaction** – acid forms hydronium and nitrate ions

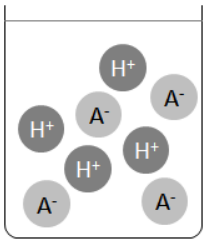
3.2 Identify acids including **acetic** (ethanoic), **citric** (2-hydroxypropane-1,2,3-tricarboxylic), **hydrochloric** and **sulfuric** acid

Acid	Formula	Production and Uses
Acetic (ethanoic)	$CH_3 — COOH$	**Vinegar**, made from oxidation of ethanol (in **wine**)
Citric (2-hydroxypropane-1,2,3-tricarboxylic)	$CH_2(COOH) — C(OH)(COOH) — CH_2(COOH)$	Citrus **fruits**, used as a **food additive** (flavour and preservative)
Hydrochloric	$H — Cl$	**Stomach** for food, commercially for: **cleaning** metals and brickwork, **neutralising** bases, **acidity** of pools
Sulfuric	$H_2 — SO_4$	Most manufactured acid, used for **fertilisers**, synthetic **fibres**, car **batteries**, **detergents**

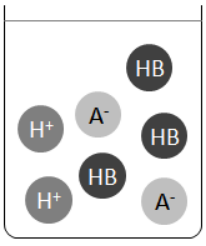
3.3 Describe the use of the **pH scale** in comparing acids and bases

- pH (potential Hydrogen) is used to cover the **wide range** of a solution's **hydrogen ion concentration**
  - **Acidic** – $[H^+] > [OH^-]$ – pH < 7
  - **Neutral** – $[H^+]$ and $[OH^-]$ are equal – pH of 7
  - **Basic** - $[H^+] < [OH^-]$ – pH > 7

3.4 Describe acids and their solutions with the appropriate use of the terms **strong, weak, concentrated** and **dilute**



Strong Acid



Weak Acid

STRONG AND WEAK ACIDS

- Strong acids **ionises completely**, and reaction goes to completion $HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$
  - Examples: **HCl, H_2SO_4, HNO_3, HBr, HI**
- Weak acids **do not ionise completely**, acetic acid is weak
  - Only small amount ionises, the rest stays as acetic acid
  - Examples: **H_2CO_3, CH_3COOH, H_2SO_3**

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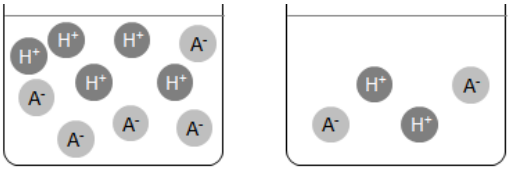
CONCENTRATED AND DILUTE ACIDS

- **Molarity** determines if an acid is concentrated or dilute
  - **Concentrated** > about 5 mol/L
  - **Dilute** < about 2 mol/L



Concentrated Dilute

POLYPROTIC ACIDS

- **Monoprotic** - able to give up one proton (HCl, HNO_3)
- **Diprotic** – two protons (H_2SO_4, H_2CO_3) – can form two salts: $NaHSO_4$ (hydrogen salts), and Na_2SO_4
- **Triprotic** – three protons (H_3PO_4) – can form three salts: K_3PO_4, K_2HPO_4 and KH_2PO_4

3.5 Identify pH as $-\log_{10}[H^+]$ and explain that a change in pH of 1 means a **ten-fold change** in $[H^+]$

- Concentrations range from **10 mol/L to 10^{-13} mol/L** – pH scale is more convenient
  - Example: $[\mathrm{H}^+] = 0.1\ \mathrm{mol/L}\ (\mathrm{i.e.}\ 10^{-1})$, $\therefore pH = -log_{10}0.1 = 1$
- A pH from **7 to 6** goes from **10^{-7} to 10^{-6}** – ten times more $[H^+]$
- Example: Find pH of 0.1 mol/L **weak acid** (e.g. acetic acid) if **1.3% ionises**

$$[\mathrm{H}^+] = 1.3\% \times 0.1 = 1.3 \times 10^{-3}\ \mathrm{mol/L}$$
$$\mathrm{pH} = -\log(1.3 \times 10^{-3})$$
$$\mathrm{pH} = \mathbf{2.9}$$

3.6 Compare the relative **strengths** of equal concentrations of **citric, acetic and hydrochloric acids** and explain in terms of the **degree of ionisation** of their molecules

Acid	**Hydrochloric**	**Citric**	**Acetic**
pH (at 0.1 mol/L)	1	2.1	2.9
Strength	Strong	Weak	Weak
Degree of Ionisation	100%	8%	1.3%

- Degree of ionisation measures **fraction of molecules ionised** into H^+ and A^-
  - Since there is **less ionisation** as you go right, there are **less $[H^+]$**, therefore **higher pH**

3.7 Describe the difference between a **strong and a weak acid** in terms of an **equilibrium** between the **intact molecule and its ions**

For $\boldsymbol{HCl_{(aq)} \rightleftharpoons H^+_{(aq)} + Cl^-_{(aq)}}$ and $\mathbf{CH_3COOH_{(aq)} \rightleftharpoons H^-_{(aq)} + CH_3COO^-_{(aq)}}$

- HCl's equilibrium lies completely to the **right** – **all molecules** become ionised (strong)
- CH_3COOH's equilibrium lies to the **left**, only **1.3% of molecules** are ionised, the rest **remain intact** (weak)

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