Acids and Bases

- The Bronsted - Lowry definition is:
  - an acid is a proton (H^+) donor
  - a base is a proton acceptor.

- Conjugate acid-base pairs always differ by one proton (H^+)

- Amphiprotic refers to the Bronsted - Lowry definition of acids and base and indicates a species that can donate (acting as acid) or accept (acting as a base) a proton.

$NH_3 + \underbrace{H_2O}_{\text{acid}} \rightleftharpoons NH_4^+ + OH^-$ $\qquad HCO_3^-$

$CH_3COOH + \underbrace{H_2O}_{\text{base}} \rightleftharpoons CH_3COO^- + H_3O^+$

- Amphoteric is a more general term and refers to a substance that can act as a acid and a base.

$\overset{\text{acid}}{Al(OH)_{3(s)}} + 3H^+_{(aq)} \longrightarrow Al^{3+}_{(aq)} + 3H_2O_{(l)}$

$\overset{\text{base}}{Al(OH)_{3(s)}} + OH^-_{(aq)} \longrightarrow Al(OH)_4^-{}_{(aq)}$

- Lewis
  - an acid is an electron pair acceptor
  - a base is an electron pair donor.

- A coordinate (dative) covalent bond is always formed in a Lewis acid-base reaction.

- For a substance to act as a Lewis base, it must have a lone pair of electrons. For a substance to act as a Lewis acid, it must have space to accept a pair of electrons in its outer shell.

- metal + acid $\longrightarrow$ salt + hydrogen.

  • Metals lower than hydrogen in the activity series will not react with acids.

- acid + carbonate $\longrightarrow$ salt + water + carbon dioxide.

- base + acid $\longrightarrow$ salt + water.

- Alkalis are solutions obtained when a metal hydroxide dissolves in water or when certain bases react with water.

- Neutralisation reactions are exothermic and produce a salt and water ~~ch~~ only.

- The pH scale can be used to indicate whether a solution is acidic, alkaline or neutral.

- pH is a measure of the concentration of $H^+_{(aq)}$ ions in a solution.
  - pH is the negative log ~~of~~ to the base 10 of the hydrogen ion concentration in an aqueous solution.

$$pH = -\log_{10}[H^+_{(aq)}]$$

$$[H^+_{(aq)}] = 10^{-pH}$$

- $K_w = [H^+_{(aq)}][OH^-_{(aq)}]$

K_w is called the ionic product constant for water
K_w has a value of 1.0×10^{-14} at 298 K.

- A solution is:
  - neutral if $[H^+_{(aq)}] = [OH^-_{(aq)}]$
  - acidic if $[H^+_{(aq)}] > [OH^-_{(aq)}]$
  - base /alkaline if $[OH^-_{(aq)}] > [H^+_{(aq)}]$

- Strong acids such as hydrochloric (HCl), sulfuric (H_2SO_4) and nitric (HNO_3) acid dissociated completely in aqueous solution

Monoprotic - dissociates to form one proton per molecule.
Diprotic - dissociates to form two protons per molecule.

- Weak acids dissociates only partially in aqueous solution.

- Strong bases ionise completely in aqueous solutions.

- Weak bases ionise only partially in aqueous solution.

- The stronger an acid, the weaker its conjugate base.

- The stronger the base, the weaker its conjugate acid.

- Strong acids conduct better electricity than solutions of weak acids. Strong acids are described as strong electrolytes and weak acids are as weak electrolyte.

(equal concentration of acids are being compared)

- pH is a measure of the concentration of H^+ ions in solution - the lower the pH, the higher the concentration of H^+ ions.

- Strong acids have a higher concentration ~~for~~ of free H^+ ions and therefore react more rapidly with a metal to form hydrogen.

- The concentration of acid refers to number of moles of acid in a volume. Titration using an indicator cannot be used to distinguish between a weak and a strong acid - if they have the same concentration they will have the same end point.

- Acid deposition is a more general term than acid rain. It refers to any process in which acidic substances (particles, gases, and precipitation) leave the atmosphere to be deposited on the surface of the Earth. It can be divided into wet deposition (acid rain, fog and snow) and dry deposition.
'Anthropogenic' means produced by human activities.

$$H_2O_{(l)} + CO_{2(g)} \rightleftharpoons H_2CO_{3\,(aq)}$$

$$H_2CO_{3(aq)} \rightleftharpoons H^+_{(aq)} + HCO_3^-{}_{(aq)}$$

$S_{(s)} + O_{2(g)} \longrightarrow SO_2$
$2SO_2 + O_2 \longrightarrow 2SO_3$
$SO_3 + H_2O \longrightarrow H_2SO_4$

or $SO_2 + H_2O \longrightarrow H_2SO_3$

$N_2 + O_2 \longrightarrow 2NO$
$2NO + O_2 \longrightarrow 2NO_2$
$NO_2 + HO\cdot \longrightarrow HNO_3$

or $4NO_2 + O_2 + 2H_2O \longrightarrow 4HNO_3$
$2NO_2 + H_2O \longrightarrow HNO_2 + HNO_3$

- Free radicle is a species with an ~~up~~unpaired electron. highly reactive.

- Problems
• Vegetation - reacts with ions in soil like Mg^{2+} which are needed to produce chlorophyll.

• Lakes and rivers - aquatic life are sensitive to the pH falling

• Buildings - erode due to acid rain. (Limestone and marble)

$$CaCO_{3(s)} + H_2SO_{4(aq)} \longrightarrow CaSO_{4(s)} + H_2O_{(l)} + CO_{2(g)}$$

• Human health

- catalytic converters
- removing sulfer before burning fuels
- using renewable energy sources
- making greater use of public transport
- liming of lakes
- designing efficient power stations.

- desulforisation - before burning
- reacting it with calcium oxide, calcium carbonate

$$CaCO_3 + SO_2 \longrightarrow CaSO_3 + CO_2$$

$$HA_{(aq)} \rightleftharpoons H^+_{(aq)} + A^-_{(aq)}$$

$$K_a = \frac{[A^-][H^+]}{[HA]} \qquad K_a = 10^{-pKa}$$

$$pKa = -\log_{10} K_a$$

- The higher the value of K_a, the stronger the acid. The lower the value of pK_a the stronger the acid.

- K_a and pK_a are better measures of acid strength than pH ~~become~~ because their values do not depend on the concentration of the acid - K_a and pK_a depend only on temperature.

$$B + H_2O \rightleftharpoons BH^+ + OH^-$$

$$K_b = \frac{[BH^+][OH^-]}{[B]}$$

$$pK_b = -\log_{10} K_a$$

$$K_b = 10^{-pK_b}$$

$$pOH = -\log_{10} [OH^-_{(aq)}]$$

$$pK_w = pH + pOH \qquad pH + pOH = 14$$

$$K_a \times K_b = K_w \qquad pK_a + pK_b = pK_w$$

- Strong acid - strong base