REVISION: ACIDS AND BASES 24 JUNE 2014

Lesson Description

In this lesson we revise:

- Theory of acids and bases
- How to solve acids and bases problems

Summary

Properties of Acids and Bases

Acids have the following properties:

- Have an acidic (sour) taste
- Conducts electricity in solution
- Neutralises a base to produce a metal salt and water
- Increase the concentration of the H^+ ions (H_3O^+ ions) in solution

Bases have the following properties

- Have a bitter taste
- Feel soapy
- Conducts electricity in solution
- Neutralise an acid to produce a metal salt and water
- Alkalis increase the concentration of the OH^- ions in solution (or decreases the H^+ ion concentration)

Definitions of Acids and Bases

- Arrhenius
  - Acid - a substance that releases H^+ ions in an aqueous solution
  - Base – a substance that releases OH^- ions in an aqueous solution

- Brønsted-Lowry
  - An acid is a proton donor
  - A base is a proton acceptor

Conjugate Acid-Base Pairs

During an acid-base reaction there is a transfer of one or more proton (H^+ ion) from the acid to the base and is called a protolytic reaction.

When an acid donates a proton, a conjugate base is formed

Example: $HC\ell \rightleftharpoons H^+ + C\ell^-$

HCl is the acid and Cl^- is the conjugate base

When a base accepts a proton, a conjugate acid is formed

Example: $OH^- + H^+ \rightleftharpoons H_2O$

OH^- is the base and H_2O is the conjugate acid

Brønsted-Lowry acid-base reactions are equilibrium reactions in a system in which two conjugate acid-base pairs are involved.

Example:

Ampholytes

An ampholyte is a substance that either act as an acid or a base. In the presence of a strong acid, the ampholyte is a base. In the presence of a strong base, the ampholyte is an acid.

Example: H_2O

As an acid: $H_2O(\ell) + NH_3(g) \longrightarrow OH^-(aq) + NH_4^+(aq)$

As a base: $HC\ell(g) + H_2O(g) \longrightarrow C\ell^-(aq) + H_3O^+(aq)$

Strength of Acids and Bases

A **strong acid** is an acid that ionises almost completely in water. It has a high percentage of ionisation and a high $[H_3O^+]$

A **weak acid** is an acid that ionises only slightly in water. it has a low percentage of ionisation and a low $[H_3O^+]$

A **strong base** is a base that dissociates (or ionises) almost completely in water. It has a high percentage dissociation.

A **weak base** is a base that dissociates (or ionises) only slightly in water. It has a low percentage dissociation.

Reactions of Acids

In general:

1) Acid + metal → salt + hydrogen
2) Acid + metal oxide → salt + water
3) Acid + metal hydroxide → salt + water
4) Acid + metal carbonate → salt + water + carbon dioxide
5) Neutralisation – acid + base → salt + water

Indicators

An indicator is a weak acid in equilibrium with its conjugate base of which the colour changes if it is added an acid or a base.

Equilibrium constant for water (K_w)

In auto-ionisation of water, a proton is transferred between two molecules of water.

$$H_2O_{(l)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}.$$

The equilibrium constant (K_w) for this reaction is $K_w = [H_3O^+].[OH^-]$

K_w is the ionic product of water. $K_w = 1 \times 10^{-14}$ at 25°C.

In pure water, $[H_3O^+] = 1 \times 10^{-7}$ mol.dm^{-3} and $[OH^-] = 1 \times 10^{-7}$ mol.dm^{-3}

pH and concentration of solutions

- In **acidic** solutions, $[H_3O^+] > [OH^-]$ and pH < 7
- In **neutral** solutions, $[H_3O^+] = [OH^-]$ and pH = 7
- In **alkaline** solutions, $[H_3O^+] < [OH^-]$ and pH > 7

Calculations

Concentration

The unit of concentration is mol.dm^{-3} , which is also written as M (stated as molar)

A concentrated acid or base contains a large quantity of solute (acid or base) per volume of solution.

A dilute acid or base contains a small quantity of solute (acid or base) per volume of solution.

When a solution is diluted, the number of moles of the original solution stays the same even though the volume of the solution changes. The following equation is used.

$c_1V_1 = c_2V_2$	c_1 = concentration of solution 1 (mol.dm^{-3}) c_2 = concentration of solution 2 (mol.dm^{-3}) V_1 = volume of solution 1 (dm^3) V_2 = volume of solution 2 (dm^3)

For a titration reaction the following equation is used.

$\frac{n_a}{n_b} = \frac{c_aV_a}{c_bV_b}$	n_a = number of moles of acid (mol) n_b = number of moles of base (mol) c_a = concentration of acid (mol.dm^{-3}) c_b = concentration of base (mol.dm^{-3}) V_a = volume of acid (dm^3) V_b = volume of base (dm^3)

pH calculations

The pH of a solution is an indication of the acidity or alkalinity of a solution. It is the negative logarithm of the hydronium ion concentration in a solution.

$pH = = \log[H^+]$	$[H^+]$ = concentration of H^+ or H_3O^+ ions
If the pH is known, $[H^+]$ is found by:	$[H^+] = 10^{-pH}$

Improve your skills

Acids and Bases

Question 1

(Adapted from Transvaal Paper 2 HG 1995)

Nitrogen dioxide and sulphur dioxide can be prepared according to the following equations respectively:

(i) $Cu(s) + 4H^+ + 2NO_3^-(aq) \longrightarrow Cu^{2+}(aq) + 2NO_3^-(aq) + 2NO_2(g) + 2H_2O(\ell)$

(ii) $2Na^+(aq) + SO_3^{2-}(aq) + 2HC\ell(aq) \longrightarrow H_2SO_3(aq) + 2Na^+(aq) + 2C\ell^-(aq)$

1.1. What is an acid – base reaction?

1.2. Which of the above reactions represent an acid – base reaction?

1.3. Write down the acid – base conjugate pairs.

1.4. Identify a spectator ion in this reaction.

Question 2

(Adapted from House of Delegates Paper 2 HG 1995)

When HCl(g) is bubbled through distilled water it ionises as a result of proton transfer. The equation for the ionisation process is:

$$HC\ell(g) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + C\ell^-(aq)$$

2.1. Provide a suitable name for the H_3O^+ ion

2.2. What causes the solution to have acidic properties?

2.3. Would the resulting solution be strongly acidic or weakly acidic? Explain your answer.

2.4. What do we call a reaction in which proton transfer occurs?

Acids and Bases Calculations

Question 1

(Taken from Eastern Cape Paper 2 HG November 2000)

In an acid-base reaction, 500 cm^3 of a solution of sodium hydroxide is completely neutralised by 680 cm^3 of a solution of sulphuric acid. The equation for the reaction is

$$H_2SO_4(aq) + 2NaOH(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O(\ell)$$

The pH of the base solution before any acid is added is 13,80 at 25°C.

1.1. Show by calculation that the concentration of the NaOH solution will be 0,631 $mol.dm^{-3}$.

1.2. What is the difference between a strong base and a concentrated base?

1.3. Calculate the mass of salt used to prepare the base solution.

1.4. Calculate the number of moles of $H_3O^+(aq)$ effectively used in the neutralisation process.