# Topic V. Characteristics of alkalis

**Reference Reading** Integrated Chemistry Today, L.H.M Chung, Book 1 pg. 363 – 365

**Objectives** 4.4

- recognise that aqueous solutions of potassium hydroxide, sodium hydroxide, calcium hydroxide and ammonia are common alkalis used in the laboratory
- describe the action of alkalis on aqueous solutions of lead(II), copper(II), iron(II) and iron(III)
- understand that the formation of metal hydroxide precipitate in the above-mentioned reactions is an indication of the existence of hydroxide ions in aqueous alkalis
- write equations to show the formation of hydroxide ions from alkalis
- recognise the corrosive nature of concentrated alkalis

**Notes**

## V. Characteristics of alkalis

Some substances can destroy the acidic properties of an acid and form salt and water only. This class of substance is called base.

Many household items contains base.
e.g. window water - ammonia $NH_{3(aq)}$
caustic soda - sodium hydroxide $NaOH_{(s)}$
milk of magnesia - a suspension of magnesium hydroxide $Mg(OH)_{2(s)}$ in water

**Metal oxide and metal hydroxide are the two most common base**.

Generic word equation Base + acid → salt + water
Example 1 $2Fe_2O_{3(s)} + 6HCl_{(aq)} \rightarrow 2FeCl_{3(aq)} + 3H_2O_{(l)}$
Example 2 $CuO_{(s)} + 2HNO_{3(aq)} \rightarrow Cu(NO_3)_{2(aq)} + H_2O_{(l)}$

N.B. A very dilute acid can be used to remove the oxide layer on the surface of a piece of metal.

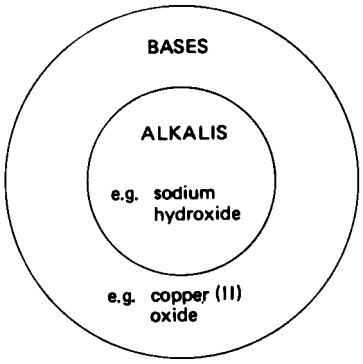
Strictly speaking, carbonate and hydrogencarbonate are not base because they give $CO_{2(g)}$ on top of water and salt.

Generic word equation acid + carbonate → salt + water + carbon dioxide
Generic word equation acid + hydrogencarbonate → salt + water + carbon dioxide

### A. Common alkalis

Most of the base are insoluble only very few are soluble.

Potassium hydroxide $KOH_{(aq)}$ (caustic potash)
Sodium hydroxide $NaOH_{(aq)}$, (caustic soda)
Calcium hydroxide $Ca(OH)_{2(aq)}$, (limewater)
Ammonia solution $NH_{3(aq)}$
are the **only 4 soluble bases** used in the laboratory.




N.B. $Ca(OH)_{2(s)}$ is only slightly soluble in water.

**Soluble base is called alkali, it is only a sub-set of base.**

### 1. Typical alkaline properties

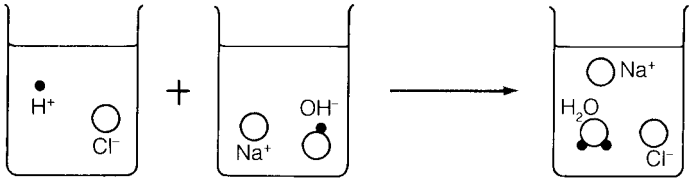
i. Bitter taste
ii. Turns red litmus paper blue
iii. Slippery feel

### 2. Dissociation / Ionization of alkali in water

$KOH_{(aq)}$ $KOH_{(aq)} \rightarrow K^+_{(aq)} + OH^-_{(aq)}$
$NaOH_{(aq)}$ $NaOH_{(aq)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$
$Ca(OH)_{2(aq)}$ $Ca(OH)_{2(aq)} \rightarrow Ca^{2+}_{(aq)} + 2OH^-_{(aq)}$
$NH_{3(aq)}$ $NH_{3(aq)} + H_2O_{(l)}$ d $NH_4^+{}_{(aq)} + OH^-_{(aq)}$

All alkalis produce $OH^-_{(aq)}$ ion in water. $OH^-_{(aq)}$ is the species responsible for the alkaline properties. It is capable to destroy the acidic properties of an acid by neutralization.

$$OH^-_{(aq)} + H^+_{(aq)} \rightarrow H_2O_{(l)}$$




Only the hydrogen ions of the acid react with the hydroxide ion of the alkali.

The ions of salt remain separate. They do not react They are spectator ions.

In neutralization, $H^+_{(aq)}$ of acid is removed by combining with $OH^-_{(aq)}$ to form water molecule. The spectator ions are left behind. If the water is evaporated, the crystal of salt will be obtained.

### B. Precipitation with metal ions

Precipitation means formation of precipitate (solid powder) when two solutions are mixed.

Generic word equation

Solution 1 + Solution 2 → Precipitate (ppt.) + Solution 3

| Ionic equation | Specific example |
|---|---|
| $Pb^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Pb(OH)_{2(s)}$<br>colourless white precipitate | $Pb(NO_3)_{2(aq)} + 2NaOH_{(aq)} \rightarrow Pb(OH)_{2(s)} + 2NaNO_{3(aq)}$ |
| $Cu^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Cu(OH)_{2(s)}$<br>blue blue precipitate | $CuSO_{4(aq)} + 2KOH_{(aq)} \rightarrow Cu(OH)_{2(s)} + K_2SO_{4(aq)}$ |
| $Fe^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Fe(OH)_{2(s)}$<br>green dirty green precipitate | $FeSO_{4(aq)} + 2NH_{3(aq)} + 2H_2O_{(l)} \rightarrow Fe(OH)_{2(s)} + (NH_4)_2SO_{4(aq)}$ |
| $Fe^{3+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Fe(OH)_{3(s)}$<br>yellow reddish brown precipitate | $2FeCl_{3(aq)} + 3Ca(OH)_{2(aq)} \rightarrow 2Fe(OH)_{3(s)} + 3CaCl_{2(aq)}$ |

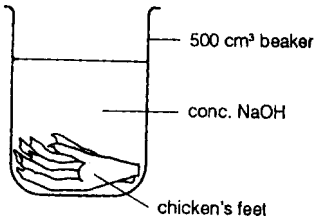
If the concentration of the metal ions is very low, the colour may be too pale to be seen clearly. Formation of coloured precipitate serves as a very **useful test to identify the ion present** in a dilute metal ion solution.

**C. Corrosive nature of conc. alkali**

Protein is made of polypeptide chain which is vulnerable (easily hurt by) to the attack of strong alkali.

e.g. Chicken foot immersed in conc. $NaOH_{(aq)}$

After being immersed in conc. $NaOH_{(aq)}$, the skin and the flesh (the protein) are dissolved by the strong alkali. Therefore, similar to concentrated acid, concentrated alkali should also be handled with care.



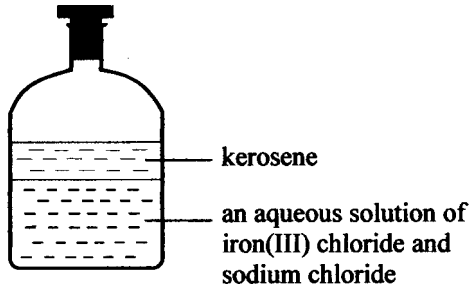

**Glossary** salt base metal oxide metal hydroxide alkali alkaline caustic potash caustic soda limewater sub-set bitter slippery dissociation ionization neutralization spectator ions precipitation precipitate protein polypeptide vulnerable

**Past Paper Questions** 96 I 6 a i
99 I 5

96 I 6 a i

| | | | | | |
|---|---|---|---|---|---|
| 6a | | The table below lists the oxidation number of iron in two compounds : | | | |
| | | Compound | Iron(II) sulphate | Iron(III) sulphate | |
| | | Oxidation number | +2 | +3 | |
| | i | (1) What would be observed when sodium hydroxide solution is added to iron(II) sulphate solution ? Write an ionic equation for the reaction involved.<br>(2) Explain whether this reaction is a redox reaction. | | | 3 |
| | | (1) (dirty) green precipitate / solid is formed. 1 mark<br>$Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$ 1 mark<br>(2) No, because the reaction does not involve any change in oxidation no. / there is no transfer of electron(s). 1 mark | | | |

99 I 5

| | | | |
|---|---|---|---|
| 5 | | The diagram below shows a bottle of chemical waste in a school laboratory.<br>  <br> | |
| | | Describe and explain how you would remove kerosene and iron(III) ions from the chemical waste.<br>(You may use any apparatus and chemicals available in a school laboratory.) | |

91 21

D 21 Iron(II) sulphate solution is mixed with chlorine water. Excess aqueous ammonia is then added to the mixture. What is the colour of the precipitate formed ?

A. white
B. yellow
C. green
D. brown

92 35

D 35 Which of the following reagents can be used to distinguish between $Fe^{2+}_{(aq)}$ and $Fe^{3+}_{(aq)}$ ions ?

(1) ammonia solution
(2) concentrated nitric acid
(3) acidified potassium permanganate solution

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

98 25

D 25 Dilute sodium hydroxide solution is added successively to four different solutions. Which of the following combinations is correct ?

| | Solution | Observation |
|---|---|---|
| A. | ammonium chloride | white precipitate |
| B. | lead(II) nitrate | yellow precipitate |
| C. | potassium dichromate | orange precipitate |
| D. | iron(III) sulphate | brown precipitate |

99 20

A 20 Which of the following solutions would produce a white precipitate with sodium hydroxide solution ?

A. lead(II) nitrate solution
B. iron(III) nitrate solution
C. copper(II) nitrate solution
D. potassium nitrate solution