# Lab: To investigate the properties of Acids and Bases

## Introduction

Different substances may be distinguished from each other by the differences in their properties. When a number of different compounds have several common properties they are often classified for convenience as a distinct type of compound.

Two important types of compounds are the **acids** and the **bases**.
The term acid was introduced into chemistry to classify that group of chemical substances which affected certain coloured materials in a distinctive way and which had a sour taste.
Bases were recognized as substances that had an opposite effect on the coloured materials and which 'cured' the sourness of acids.
All acids have common properties and all bases have common properties.

This is merely saying what acids and bases will do, without attempting to say what they are or to explain why they exhibit this type of behaviour.

The observable properties which describe the experimental behaviour of acids or bases constitute an **operational definition** of an acid or base.
By studying the formulas, atomic and molecular structures, and reactions of substances which qualify as acids or bases under our operational definition, we can develop **conceptual definitions** for them.
Conceptual definitions help to explain why certain substances behave in a common manner. These definitions will help you to classify a substance as an acid or base.

*Svante Arrhenius* (1859-1927) developed a conceptual theory in 1887 that provided the first useful theoretical definition of acids and bases based on the experimental reactions of acids and bases.
(Note: Arrhenius's theory is limited to aqueous solutions and cannot explain the properties of many common substances.)

In this lab you will investigate the behaviour of acids and bases, i.e. investigate the operational definitions of acids and bases.

## Purpose

To investigate properties of acids and bases.

### Apparatus

spot plate, scoopula, tweezers

### Materials

Acids: hydrochloric acid, $HCl_{(aq)}$, sulphuric acid, $H_2SO_{4\ (aq)}$, acetic acid, $CH_3COOH_{(aq)}$

Bases: sodium hydroxide, $NaOH_{(aq)}$, potassium hydroxide, $KOH_{(aq)}$, ammonium hydroxide, $NH_4OH_{(aq)}$

Indicators: red litmus paper, blue litmus paper, pH paper, bromothymol blue, (BTB), phenolphthalein

Chemicals: Magnesium ribbon, calcium carbonate

## Procedure

1. Take a clean spot plate and place a few drops of the three acids and a few drops of the three bases into each of the six indents of the spot plate.
2. Place a small piece of red litmus paper into each of the indents containing the acids.
3. Record any change in the colour of the litmus in the Data Table I: Reactions of Acids and Data Table II: Reactions of Bases provided below.
4. Remove the litmus paper using tweezers and discard into the garbage.

5. Repeat steps 2 – 4 using blue litmus paper instead of red litmus paper, with the same six solutions, ( 3 of acids and 3 of bases).

6. Repeat steps 2 – 4 using pH paper instead of red litmus paper, with the same six solutions, ( 3 of acids and 3 of bases). Compare the pH of the solutions with the pH chart provided and record the pH into the Data Table.

7. Repeat steps 2 – 4 using a few drops of bromothymol blue indicator instead of red litmus paper, with the same six solutions, ( 3 of acids and 3 of bases).

8. Repeat steps 2 – 4 using phenolphthalein indicator instead of red litmus paper, with the same six solutions, ( 3 of acids and 3 of bases).

9. Clean the spot plate by washing thoroughly with copious amounts of water.

10. Take the clean spot plate and place a few drops of the three acids and a few drops of the three bases into each of the six indents of the spot plate.
11. Place a piece of magnesium ribbon into each of the indents containing the acids and bases. Record any reactions observed and record the rate of the reaction observed in the Data Table.
12. Remove any unreacted magnesium ribbon using tweezers and discard into the container provided.

13. Repeat steps 9 – 12 using calcium carbonate instead of magnesium ribbon.

**Data Table I: Reactions of Acids**

| Reagent | Hydrochloric acid, $HCl_{(aq)}$ | Sulphuric acid, $H_2SO_{4\ (aq)}$ | Acetic acid, $CH_3COOH_{(aq)}$ |
|---|---|---|---|
| red litmus paper | | | |
| blue litmus paper | | | |
| pH paper (pH #) | | | |
| bromothymol blue | | | |
| phenolphthalein | | | |
| magnesium ribbon | | | |
| calcium carbonate | | | |

**Data Table II: Reactions of Bases**

| Reagent | Sodium hydroxide $NaOH_{(aq)}$ | Potassium hydroxide, $KOH_{(aq)}$ | Ammonium hydroxide, $NH_4OH_{(aq)}$ |
|---|---|---|---|
| red litmus paper | | | |
| blue litmus paper | | | |
| pH paper (pH #) | | | |
| bromothymol blue | | | |
| phenolphthalein | | | |
| magnesium ribbon | | | |
| calcium carbonate | | | |

**Data Processing and Presentation**

Observe Data Table I: Reactions of acids, then answer the following questions:

1. Generally what may be deduced when acids react with:
   a. red litmus paper b. blue litmus paper c. pH paper

3. Compare the pH observed when the pH paper is added to acids such as $HCl_{(aq)}$, $H_2SO_{4\,(aq)}$ to the pH observed to acetic acid, $CH_3COOH_{(aq)}$. Account for this difference.

4. (a) Account for the reaction observed when a metal such as magnesium is added to acids such as $HCl_{(aq)}$, $H_2SO_{4\,(aq)}$. Explain which gas is formed and suggest a test for this gas.
   (b) Compare the rate of the reaction when magnesium metal is added to acids such as $HCl_{(aq)}$, $H_2SO_{4\,(aq)}$ to the rate of the reaction when magnesium metal is added to an acid such as acetic acid, $CH_3COOH_{(aq)}$. Account for this difference.
   (c) Write balanced chemical equations for the observed reactions of magnesium metal with acids.
   (d) Hence, in general what is the equation when an acid reacts with a metal?

5. (a) Account for the reaction observed when a metal carbonate such as calcium carbonate is added to acids such as $HCl_{(aq)}$, $H_2SO_{4\,(aq)}$. Explain which gas is formed and suggest a test for this gas.
   (b) Compare the rate of the reaction when a metal carbonate is added to acids such as $HCl_{(aq)}$, $H_2SO_{4\,(aq)}$ to the rate of the reaction when the metal carbonate is added to an acid such as acetic acid, $CH_3COOH_{(aq)}$. Account for this difference.
   (c) Write balanced chemical equations for the observed reactions of calcium carbonate with acids.
   (d) Hence, in general what is the equation when an acid reacts with a metal carbonate?

Observe Data Table I: Reactions of Bases, then answer the following questions:

1. Generally what may be deduced when bases react with:
   a. red litmus paper b. blue litmus paper c. pH paper
2. Compare the pH observed when the pH paper is added to bases such as $NaOH_{(aq)}$, $KOH_{(aq)}$ to the pH observed to ammonium hydroxide, $NH_4OH_{(aq)}$. Account for this difference.

**Conclusion**

Summarize all the observed reactions of acids and bases in a suitable summary table.