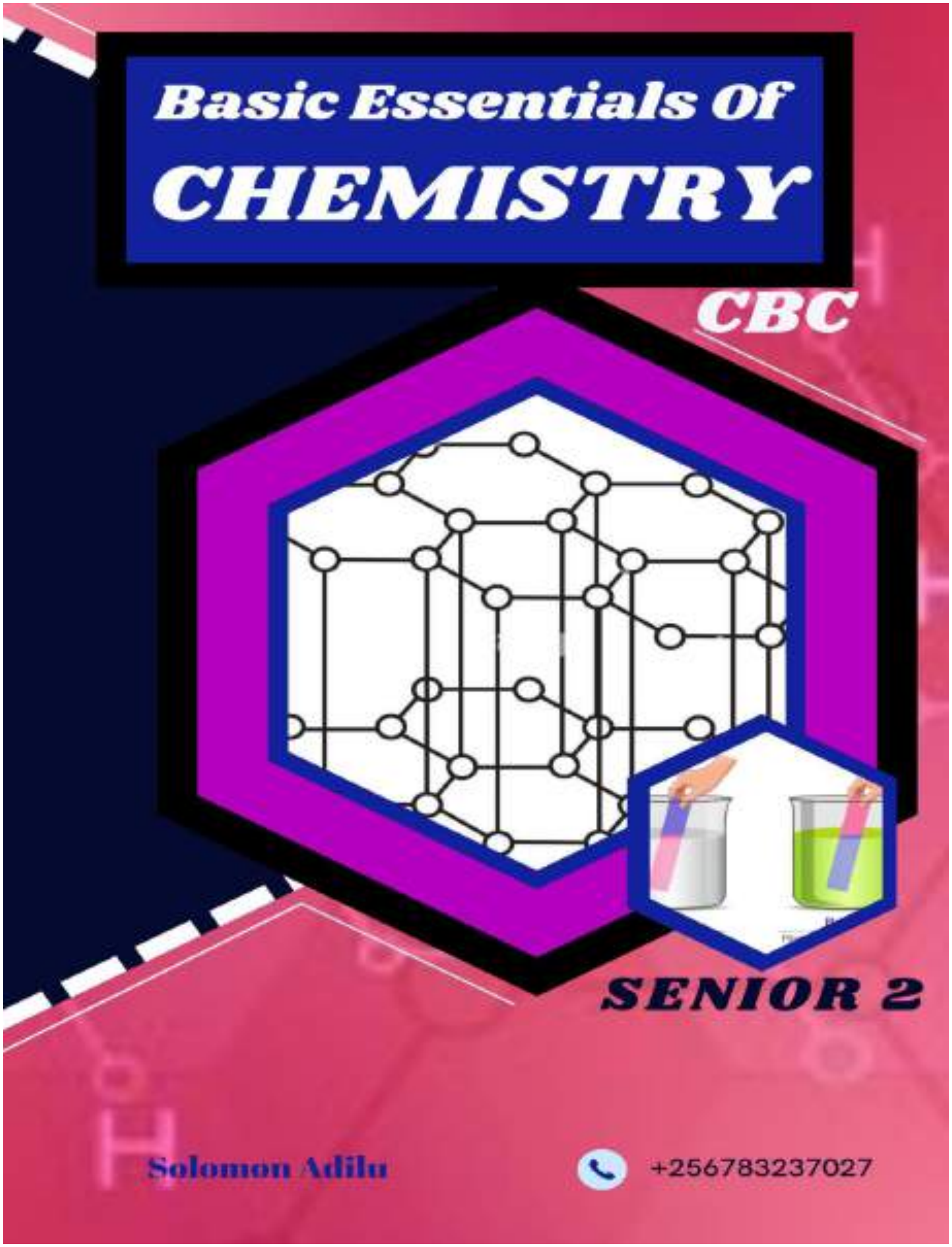
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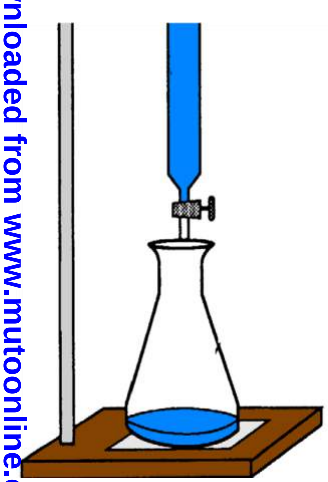

# Competency Based Curriculum

### TOPIC 1:

# ACIDS & BASES


**Competency:** The learner appreciates the properties and importance of acids, alkalis/bases and salts in everyday life.

**Key words**

- Acid
- Base
- Alkali
- pH
- Litmus paper
- Indicator
- Hydrogen ion (H+)
- Hydroxide ion (OH-)
- Neutralization

**By the end of this topic, the learner should be able to;**

- Recognize that locally available materials and substances are either acidic or alkaline(k)
- Understand the concept of pH as a measure of the strength of acids and alkalis(u)
- Understand the reaction between acids and alkalis (u, s)

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# 1.0 Acids & Bases

## Common Acids and Bases

Acids and **bases** are common substances in everyday life, and play crucial roles in our daily lives. They are often identified by their sour taste (acids) or slippery feel (bases), and can be found in some fruits like ***lemons*** and ***oranges*** (*citric* ***acid***) or soap and Aloe Vera (base). Most are ***safe*** to handle but some are definitely not.

**Identifying substances in everyday life that are acidic or alkaline.**

**Note**: The acidity or alkalinity of plant materials can vary depending on factors like species, growth conditions, and part of the plant used. It's always recommended to test specific samples to confirm their pH.

**Materials**

- ✓ Lemon
- ✓ Raw mango
- ✓ Cabbage
- ✓ Tomatoes
- ✓ Baking powder
- ✓ Aloe Vera
- ✓ Moringa leaves
- ✓ Sour milk

**What to do**

- ✓ Wash the materials provided
- ✓ Bite each of them, taste them, feel by touching.
- ✓ Cut the lemons using a knife and taste.
- ✓ Wash your mouth every after tasting a fruit.
- ✓ Record your findings in the table

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**Expected responses**

| Material | Taste | Feel | Acid / Alkaline |
| --- | --- | --- | --- |
| **Lemon** | Sour | Not slippery | Acid |
| **Raw Mango** | Sour | Not slippery | Acid |
| **Cabbage** | Sour | Not slippery | Acid |
| **Tomatoes** | Sour | Not slippery | Acid |
| **Baking powder** | Bitter | Slippery | Alkaline |
| **Aloe Vera** | Bitter | Slippery | Alkaline |
| **Banana peelings** | Bitter | Slippery | Alkaline |
| **Moringa leaves** | Bitter | Slippery | Alkaline |
| **Sour milk** | Sour | Not slippery | Acid |

## Acids

***Acids taste sour*** - the ***Latin*** word for ***sour*** was "***acidus***"


**Definition**: Substances that, when dissolved in water, produce hydrogen ions (H+).

**Characteristics**:

- ✓ Typically sour (e.g., lemon juice, vinegar)
- ✓ React with many metals to produce hydrogen gas.
- ✓ Turn blue litmus paper red.
- ✓ Have a pH value less than 7.

**Common Acids**

***Fizzy*** drinks (*$CO_2$,carbonic **acid***), ***vinegar*** (*ethanoic **acid***), and even many ***vegetables*** (*ascorbic **acid**, vitamin C*) contain ***acids***. These are examples of weak acids. A more unpleasant example is a ***bee*** sting, ***nettle*** sting or ***ant*** bite (*formic acid*).

Stronger acids are found in car ***batteries*** (*sulphuric acid*) while our ***stomachs*** contain acid (*hydrochloric*) to break down our ***food*** into ***smaller*** molecules.

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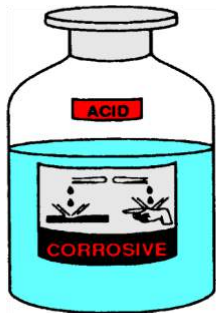


**Note:**

**Acids kill cells.** - the most vulnerable part of you is your eyes, because they have living cells on the surface(ensure you wear Safety Glasses when dealing with acids)

**Some common acids and their sources**

| Acid | Sources |
|---|---|
| **Hydrochloric acid** | Stomach, industrial processes, cleaning products. |
| **Sulphuric acid** | Battery acid, industrial processes, fertilizer |
| **Nitric acid** | Fertilizers, explosive, industrial processes |
| **Acetic acid (ethanoic acid)** | Vinegar, food, cleaning products |
| **Citric acid** | Citrus fruits, soft drinks, food preservatives |
| **Carbonic acid** | Carbonated beverages, respiratory system. |
| **Oxalic acid** | Spinach, cleaning products, Rhubarb. |
| **Phosphoric acid** | Fertilizers, soft drinks, toothpaste. |
| **Tartaric acid** | Grapes, wine, baking powder |
| **Lactic acid** | Milk, yogurt, muscle tissues |
| **Ascorbic acid** | Vitamin C, citrus fruits. |

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# Bases & Alkalis


**A base** is a metal oxide, hydroxide or carbonate that reacts with an acid to form a salt and water.

Our main source of *bases* are the ***Metal Oxides***.

e.g, *lime* (***calcium oxide***), *soda* (***sodium oxide***), *magnesia* (***magnesium oxide***), *pearl ash* (***potassium oxide***), though, we also use many ***Metal Carbonates***.

e.g, limestone (calcium carbonate), marble (calcium carbonate), baking soda (sodium carbonate) or potash (potassium carbonate)

Bases are mainly metal oxides and metal carbonates.

All of these *bases* are ***ionic compounds*** and, therefore, ***solids*** at *room temperature*. As ***solids***, they can be directly added to an acid and will ***neutralise*** the acid.

| | | | | | | |
|---|---|---|---|---|---|---|
| ***base*** | **+** | ***acid*** | → | ***salt*** | **+** | ***water*** |

Sometimes, however, we prefer to use ***solutions*** of *soluble bases* which we then can call ***alkalis***.

**Alkalis** are soluble bases that produce hydroxide ions (OH-) when dissolved in water.

**Examples**

- ✓ Calcium hydroxide ($Ca(OH)_2$)
- ✓ Sodium hydroxide (NaOH)
- ✓ Potassium hydroxide (KOH)
- ✓ Aqueous ammonia ($NH_4OH$) also known as ammonia solution.

Most ***alkalis*** are made by ***dissolving*** a ***metal oxide*** in ***water*** - though only those in ***Group 1*** are very ***soluble***. (*Data Booklet*). These oxides react with water to produce ***hydroxide ions***, $OH^-_{(aq)}$

## Characteristics of Alkalis

- ✓ Typically bitter (e.g., soap solutions)
- ✓ Often feel slippery or soapy to the touch.
- ✓ Turn red litmus paper blue.
- ✓ Have a pH value greater than 7.
- ✓ Some alkalis (Sodium hydroxide and Potassium hydroxide) are deliquescent.

**Some common alkalis/bases with their sources**

| Base | Sources |
|---|---|
| **Sodium hydroxide** | Soap, paper, textile industries, Mineral deposits. |
| **Potassium hydroxide** | Battery manufacturing, cleaning products, Plant ashes |
| **Calcium hydroxide** | Cement, water treatment, Mineral deposits |
| **Magnesium hydroxide** | Antacids, laxatives, fireproofing, Seawater |
| **Ammonia** | Fertilizers, cleaning products, pharmaceuticals. |
| **Sodium carbonate** | Water softening, paper, Glass manufacturing |
| **Sodium bicarbonate** | Baking, cleaning products, pharmaceuticals, toothpaste. |
| **Potassium carbonate** | Glass manufacturing, soap, pharmaceuticals |
| **Barium hydroxide** | Pesticides, oil refining, water treatment. |

Other sources may include Milk of magnesia, Aloe Vera plant extract.

**Note**: All acids contains at least one hydrogen atom. When in aqueous solution, these hydrogen atoms are released as hydrogen ions making the solution behave like an acid.

All alkalis release hydroxide ions when dissolved in water. It is these hydroxide ions that make the substance behave like an alkali in an aqueous solution.

Because alkalis contain hydroxide ions, toothpaste is used for brushing teeth. ***Toothpaste*** contains a ***base*** to help neutralise the ***acid*** on your ***teeth***, produced by ***bacteria*** that remains.

Most ***soaps*** and ***detergents*** contain bases to help cope with ***greasy*** and ***oily*** stains. Our ***liver*** produces ***bile*** (a *base*) to help break down ***fatty*** foods. ***Farmers*** and ***gardeners*** will spread ***lime*** (*calcium hydroxide*) on the ***soil*** if it is too ***acidic***.

***Acidic*** fumes ($SO_2$ and $CO_2$) from ***coal*** burning ***power*** stations are passed through ***lime*** to be neutralised.

The ***human*** stomach produces ***hydrochloric*** acid to help the ***enzyme*** (***catalyst***) *pepsin* to break down ***protein***. Sometimes too much ***acid*** is made and it begins to attack the stomach ***wall*** causing ***pain***. All stomach remedies contain ***bases*** to ***neutralise*** the stomach acid.

**Note:** All alkalis are bases, but Not all bases are alkalis.

| **Activity** | Int2 | SC |
|---|---|---|
| Acids and Bases are found everywhere around us. For each of the substances listed below, decide whether they are acids ***(A)*** or bases ***(B)***.<br>*lemon juice* *toothpaste* *lime*<br>*wasp stings* *vitamin C* *Coca*<br>*Cola tomato ketchup* *nettle* *sting*<br>*bleaches baking soda* *stomach*<br>*juices* *detergents* | Q2. | |
| | S | |

## Indicators

Imagine you have a secret code that changes colour to reveal a message. Acid-base indicators work similarly!

They are special substances that change color with pH when they come into contact with an acid or a base. This color change helps us identify whether a solution is acidic, basic, or neutral (neither acidic nor basic). An indicator has variable colors in acidic and basic media/solutions.

**Did you know that plant extracts can actually act as indicators?**

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You can even make an indicator at home using red cabbage! It changes color depending on the acidity or basicity of the solution.

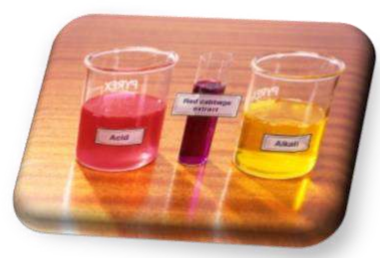
**Experiment: Obtaining an Indicator from Local Plant Extracts**

**Materials**

- ✓ Plant material (e.g., red cabbage, hibiscus flowers, turmeric)
- ✓ Mortar and pestle
- ✓ Beaker
- ✓ Filter paper
- ✓ Test tubes
- ✓ Acidic and alkaline solutions (e.g., vinegar, baking soda)

**Procedure**

- ✓ Grind the plant material into a fine powder using a mortar and pestle.
- ✓ Place the grinded plant material in a beaker and add a small amount of water.
- ✓ Stir the mixture well and let it steep for a few minutes.
- ✓ Filter the mixture through filter paper to obtain a clear extract.

| | | |
|---|---|---|
| <br>Red cabbage | <br>Grinding the leaves | <br>Effect of indicator extract on acids & bases |

**Test the extract**

- ✓ Divide the extract into two test tubes.
- ✓ Add 2-3 drops of an acidic solution (e.g., lemon juice) to one test tube and an alkaline solution (e.g., baking soda) to the other.
- ✓ Observe any color changes in the extract.

**Note:**

Many red fruits and vegetables contain natural pigments called **anthocyanins**. These pigments change color depending on the acidity or alkalinity of the solution.

**Observations**

Acidic Condition (Lemon Juice)

Deep purple color of the red cabbage juice extract shifted to reddish-pink (pH 6-5) and then to deep red when more lemon juice drops are added.

Basic Condition (Baking Soda Solution)

Deep purple color of the red cabbage juice extract shifted to greenish-yellow (pH 8-9)

**Conclusion**

Red cabbage juice serves as a natural pH indicator, exhibiting color changes in response to acidic and basic conditions.

The color change from purple color towards red or orange clearly indicates an increase in acidity. This demonstrates that lemon juice is an acidic substance due to the presence of citric acid.

Anthocyanins are pH-sensitive pigments. In alkaline solutions, they tend to be blue or purple. As the solution becomes more acidic (due to the addition of lemon juice), the anthocyanins change color to red or orange.

**Common commercial acid-base indicators**

- ✓ Litmus paper: This is one of the most well-known indicators. It comes in two colors, Red litmus paper turns blue in alkaline solutions, and blue litmus paper turns red in acidic solutions.
- ✓ Phenolphthalein indicator, Colourless in acidic solutions, pink in alkaline solutions.
- ✓ Methyl orange indicator, Red in acidic solutions, yellow in alkaline solutions.
- ✓ Common Acid-Base Indicators:

## Experiment: Effects of Substances on Litmus Paper

### Safety Precautions

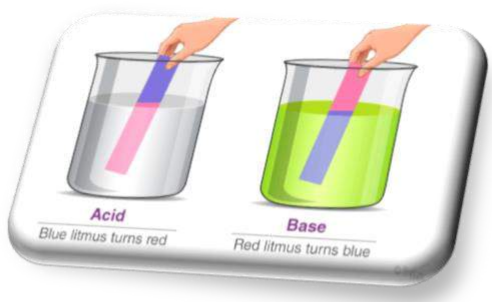
- ✓ Handle acids and bases with care.
- ✓ Avoid contact with your skin and eyes.
- ✓ Work in a well-ventilated area.

### Materials

- ✓ Litmus papers (Red and Blue)
- ✓ Various solutions
  - Lemon juice
  - Vinegar
  - Baking powder
  - Ammonia
  - Diluted liquid soap
  - Tap water

### Procedure

- ✓ Measure $3cm^3$ of baking powder solution in a test-tube.
- ✓ Cut small strips of red and blue litmus paper.
- ✓ Dip a strip of red litmus paper into the solution above and observe any color changes. Repeat with blue litmus paper.
- ✓ Record the color changes in a table.
- ✓ Repeat the procedures above using other substances.




### Table

| Solution | Effect on red litmus paper | Effect on blue litmus paper | Nature of the solution |
|---|---|---|---|
| **Lemon juice** | Red | Red | Acidic |
| **Vinegar** | Red | Red | Acidic |
| **Baking powder** | Blue | Blue | Alkaline |
| **Ammonia** | Blue | Blue | Alkaline |
| **Tap water** | Red | Blue | Neutral |
| **Diluted liquid soap** | Blue | Blue | Alkaline |

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**Discussion**

Litmus paper effectively indicates acidity/alkalinity of solutions. It changes color in response to pH:

- ✓ Acidic (pH < 7): Red
- ✓ Neutral (pH 7): No change
- ✓ Alkaline (pH > 7): Blue

## Strength of Acids and Base

The **strength** of **acids** and **bases** can best be determined by obtaining their pH which can be done using a pH **meter** or using a universal indicator, which displays various colors depending on the nature of the solution, the color is then compared with colors on the **pH scale** and **pH value** read. The pH scale shows the intensity of hydrogen and hydroxide ions in solution, the smaller the pH value, the more acidic the solution is, and the bigger the PH value, the more alkaline the solution is.

PH meter: A pH meter can provide a more accurate measurement of pH.

**Remember:** The acidity or alkalinity of plant materials can affect their taste, nutritional value, and medicinal properties. Understanding their pH can be helpful in various applications, such as food preparation, traditional medicine, and agriculture.

**Universal Indicator**

This is mixture of several indicators that change color over a wide pH range. It's available either in solution form or paper form.

It's used to determine the approximate pH of a solution.

## The pH scale

Measures the concentration of hydrogen ions in a solution. The pH scale ranges from 0 to 14.

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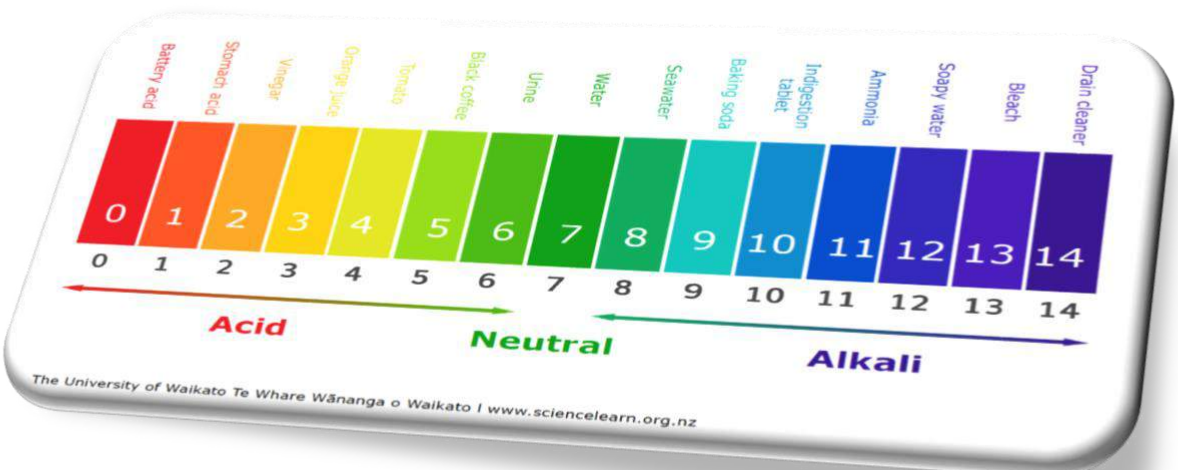
***Neutral solutions*** have a pH which ***equals*** *7*, pH = *7*.
***Neutral*** solutions have ***equal*** amounts of $H^+$ ions and $OH^-$ ions

***Acid solutions*** have a pH which is ***less than*** *7*, pH < *7*.
***Acid solutions*** have ***more*** $H^+$ ions than $OH^-$ ions, $H^+ > OH^-$

If you ***dilute*** an ***acid*** by adding more ***water***, the pH will ***increase*** towards pH = *7*.

***Alkali solutions*** have a pH which is ***more than*** *7*, pH > *7*.
***Alkali solutions*** have ***more*** $OH^-$ ions than $H^+$ ions, $OH^- > H^+$

If you ***dilute*** an ***alkali*** by adding more ***water***, the pH will ***decrease*** towards pH = *7*.


**Note:**

**Strong acids** completely ionize in aqueous solutions, producing a high concentration of hydrogen ions ($H^+$). **Examples**: hydrochloric acid ($HCl$), nitric acid ($HNO_3$), sulphuric acid ($H_2SO_4$). The higher the concentration of hydrogen ions the more acidic the solution is and the smaller the pH value.

**Weak acids** only partially ionize in aqueous solutions, producing a low concentration of hydrogen ions. **Examples**: acetic acid ($CH_3COOH$), carbonic acid ($H_2CO_3$), citric acid and their resulting pH value will be smaller but nearing to 7.

**Strong bases:** Completely ionize in aqueous solutions, producing a high concentration of hydroxide ions ($OH^-$). **Examples**: sodium hydroxide ($NaOH$), potassium hydroxide ($KOH$), calcium hydroxide ($Ca(OH)_2$).Their pH value will be above 7 nearing to 14.

**Weak bases** only partially ionize in aqueous solutions, producing a low concentration of hydroxide ions. **Examples:** ammonia ($NH_3$), carbonate ions ($CO_3^{2-}$), bicarbonate ions ($HCO_3^-$). The greater the concentration of hydroxide ions the greater the alkalinity and the higher the pH value.

**Experiment: Determining the pH of Solutions**

**Materials**

- ✓ Universal indicator solution
- ✓ Test tubes
- ✓ Dropper
- ✓ Various substances to be tested (e.g., lemon juice, vinegar, baking soda, ammonia, water).

**Procedure**

- ✓ Measure 3cm$^3$ of baking powder solution in a test-tube
- ✓ Add a few drops of universal indicator solution to the test tube containing baking powder solution.
- ✓ Observe the color changes in the solutions and record in a table.
- ✓ Repeat the steps above using other substances provided.
- ✓ Use a pH chart or a pH meter to determine the approximate pH based on the color changes.

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Expected Observations

Table

| Substance | Color in universal indicator | Approximate pH value |
|---|---|---|
| **Lemon juice** | Red | 2-3 |
| **Vinegar** | Red-Orange | 2.4-3.4 |
| **Baking soda** | Blue - Green | 8-9 |
| **Ammonia** | Blue | 11-12 |
| **Water** | Green | 7 |

Universal indicator will turn red or orange in acidic solutions, blue or purple in alkaline solutions and green or yellow in neutral solutions.

**Relationship between Acid Strength and Base Strength**

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

Q5. SC

)

pH of some common substances

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# Reactions of Acids

## With Alkalis

One of the most characteristic reactions of acids and bases is their interaction with each other, known as a neutralization reaction and with other substances like metals.

Alkalis are solutions which contains hydroxide ions. Most alkalis are made by dissolving a metal oxide in water- though only those in group 1 are Soluble.

**Neutralization Reaction**

When an acid reacts with a base, they essentially "cancel out" each other's properties. The hydrogen ions (H+) from the acid combine with the hydroxide ions (OH-) from the base to form water ($H_2O$). The remaining ions form a salt.

General Equation:

**Acid + Base → Salt + Water**

**Experiment: Reactions of Acids and Bases (Neutralization reactions)**

**Safety Precautions**

- ✓ Handle acids and bases with care.
- ✓ Avoid contact with your skin and eyes.
- ✓ Work in a well-ventilated area.
- ✓ Dispose of waste materials properly.

**Materials**

- ✓ Test tubes
- ✓ Droppers
- ✓ Universal indicator
- ✓ Acidic and alkaline solutions (e.g., hydrochloric acid, lemon juice, sodium hydroxide)
- ✓ Other substances (e.g., baking powder solution)

**Procedure**

- ✓ Measure 3cm$^3$ of lemon juice and baking powder solutions into separate test tubes.
- ✓ Add a few drops of universal indicator to each acidic and alkaline solution separately. Observe the color changes to confirm their pH.
- ✓ Measure fresh equal amounts of lemon juice and baking powder solution in a test tube and mix. Add few drops of universal indicator and observe any color changes.
- ✓ Repeat the procedures above using dilute hydrochloric acid and sodium hydroxide.

**Expected Observations**

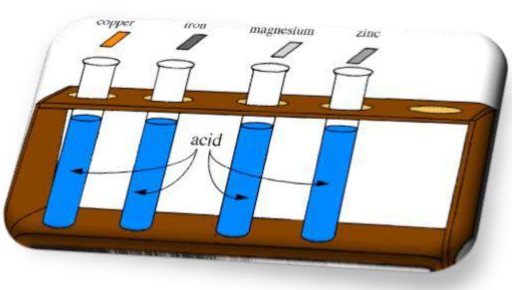
When an acid and a base are combined in equal amounts, they neutralize each other, forming a salt and water. The universal indicator will change color to indicate a neutral pH.

Acids and bases react with each other in neutralization reactions to form salts and water. Lemon juice contains a weak acid (citric acid) which has a pH of about 3. On adding baking powder solution, the resultant solution is neutral in pH and it will have a pH of around 7.

Hydrochloric acid (HCl) reacts with sodium hydroxide (NaOH) to produce a neutral solution of sodium chloride (NaCl) in water.

**$HCl$ (acid) + $NaOH$ (base) → $NaCl$ (salt) + $H_2O$ (water)**

## With Metals




When acids react with metals, they undergo a chemical reaction that typically produces two main products:

- Salt: A salt is an ionic compound formed when a metal cation (positively charged ion) combines with a non-metal anion (negatively charged ion).
- Hydrogen Gas ($H_2$): This is a colorless, odourless, and flammable gas that is released during the reaction.

The gas produced ***burns*** with a ***squeaky*** -***pop***. This shows that the gas is ***hydrogen***.

***Reactive metals*** are able to force ***hydrogen ions*** to change back to ***hydrogen atoms***. This allows the ***metal*** to take the place of the ***hydrogen*** and form a new ***substance*** called a ***Salt***.

For example, when hydrochloric acid is reacted with sodium metal, The ***sodium ion*** takes the place of the ***hydrogen ion*** to form the salt called ***sodium chloride***.


Each acid has its own salts:-

Hydro***chloric*** acid, HCl → ***chlorides*** e.g. ***sodium chloride***, NaCl, ***Sulphuric*** acid, $H_2SO_4$ → ***sulphat***es e.g. ***copper sulphate***, $CuSO_4$, ***nitri***c acid, $HNO_3$ → ***nitrates,*** e.g. ***potassium nitrate***, $KNO_3$

**General Reaction:**

The general equation for the reaction of an acid with a metal can be represented as:

Acid + Metal → Salt + Hydrogen gas

**Experiment: Reaction of Dilute Acids with Metals**