ACIDS & BASES, pH Scale, and Neutralizers

<table>
<thead>
<tr>
<th>pH</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 7</td>
<td>Acids, increasingly acidic</td>
</tr>
<tr>
<td>7</td>
<td>Neutral</td>
</tr>
<tr>
<td>&gt; 7</td>
<td>Alkalis, increasingly alkaline</td>
</tr>
</tbody>
</table>

- Acids: solutions with pH < 7 are acidic, with pH increasing as they become more acidic.
- Bases: solutions with pH > 7 are basic, with pH increasing as they become more basic.
- Neutral: solutions with pH = 7 are neutral.

The pH scale ranges from 0 to 14, with 0 being the most acidic and 14 being the most basic.
Many common pure substances can be classified according to whether they are acids or bases. Some acids and bases are corrosive and poisonous, whereas others add flavour to food or are vitamins. Acid-base indicators are chemicals that change colour in response to acidic or basic conditions. The pH scale is a number scale for measuring how acidic or basic a solution is. A pH value below pH 7 is acidic, pH 7 is neutral, and a pH value above pH 7 is basic. Generally, the chemical formula for an acid starts with H (hydrogen) on the left of the formula. Bases generally have OH on the right of their chemical formulas.
Classifying Substances

- There are other ways you can use to classify compounds. For example, you can classify some compounds as **acids** or **bases**.

- You are very familiar with acids and bases because you see them, use them, and even eat them every day.

- The sour taste of grapefruit, the tart taste of carbonated drinks, and the tangy taste of salad dressings all come from acids.
  
  - For example, lemon juice contains **ascorbic acid**, which is another name for vitamin C, which may help our bodies absorb iron.
  
  - Very strong **acid in your stomach** helps digest what you eat.
  
  - **Acids dissolved in rainwater** can form enormous caverns and destroy valuable buildings and statues over time.
  
  - Because of their corrosive properties, we use some **acids to remove rust** and to purify and process metals.
Properties of Acids

1. Acids have a **sour taste** (lemon juice contains citric acid, vinegar contains acetic acid)

2. They are **corrosive**—they react with solids and “eat” them away (battery acid will burn your skin and hydrochloric acid cleans mortar from bricks)

3. Dissolve in **water** (acids mixed with water are **diluted**. Acids not mixed with water are **concentrated**)

4. **DO conduct electricity**
(acids are made of ions, so in water the ions separate and can conduct an electric charge)
Acids

There are many acids present in our everyday lives.

Lemon juice contains citric acid, and vinegar contains acetic acid.

Some strong acids are hydrochloric acid, sulphuric acid and nitric acid.

Some weak acids are acetic acid, citric acid and carbonic acid.
Acids and Bases

When a substance dissolves in water it makes a solution.

[recall solutions are “aqueous” with a subscript \(aq\)]

Solutions can be sorted by whether they are: acidic, basic or neutral.
When the oxide of some non-metals dissolve in water ... they make an acid.

Acids are compounds that break into hydrogen ($H^+$) ions and another compound when placed in an aqueous solution.
Acids in Solution

For example:
When hydrogen chloride gas is mixed with water, $H^+_{(aq)}$ and $Cl^-_{(aq)}$ ions form in solution.

$$HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$$

Because of the $H^+$ ions, the $HCl_{(aq)}$ is called an **acidic** solution.

A solution can be **weak** or **strong** depending on **how many ions** are present.
Chemical Formulae of Acids

The chemical formula of an acid can often be recognized by starting with **one or more hydrogen ions, $H^+$ (as the cation)** with another negative ion (anion).

**Exception:** acids containing the element carbon, the H may be written on the right side, such as with acetic acid or vinegar, $\text{CH}_3\text{COOH(aq)}$.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Chemical Name</th>
<th>Common Name</th>
<th>Examples of Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{HCl}(aq)$</td>
<td>hydrochloric acid</td>
<td>muriatic acid</td>
<td>• Produced in the stomach to help digest food</td>
</tr>
<tr>
<td>$\text{H}_2\text{SO}_4(aq)$</td>
<td>sulfuric acid</td>
<td>battery acid</td>
<td>• Used in automobile batteries</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Used to clean metals</td>
</tr>
<tr>
<td>$\text{HNO}_3(aq)$</td>
<td>nitric acid</td>
<td>nitric acid</td>
<td>• Used to make fertilizers</td>
</tr>
<tr>
<td>$\text{CH}_3\text{COOH(aq)}$</td>
<td>ethanoic acid</td>
<td>acetic acid</td>
<td>• Present in vinegar</td>
</tr>
</tbody>
</table>
Other common ACIDS

no need to memorize, names/formula will be given
1. How can you recognize an acid by its chemical formula?
2. State which acid is present in:
   (a) your stomach; (b) vinegar; (c) automobile batteries
3. State another name for aqueous hydrogen fluoride, HF(aq).
4. State another name for aqueous hydrogen perchlorate, HClO₄(aq).
5. What does corrosive mean?
Neutralisation

- Acids and bases react with each other.
- The properties of the acid are ‘neutralised’ by a base.
- This is a double-replacement reaction.

\[
\text{Acid} \quad + \quad \text{Base} \quad \rightarrow \quad \text{Salt} \quad + \quad \text{Water}
\]

\[
\text{HCl} \quad + \quad \text{NaOH} \quad \rightarrow \quad \text{NaCl} \quad + \quad \text{H}_2\text{O}
\]

A salt is made.
Applications of Neutralisation

• **Insect Stings**
  Bee stings are acidic and can be neutralised with baking soda (bicarbonate of soda).
  Wasp stings are alkaline and can be neutralised with vinegar.

• **Indigestion**: Our stomach carries around hydrochloric acid.
  Too much of this leads to indigestion.
  To cure indigestion, you can neutralise the excess acid with baking soda or specialised indigestion tablets.
Salts

• The salt made depends on the acid and base used.

• The salt contains the metal atom from the base, and the non-metal of the acid molecule.

• This means the salt is an ionic compound

  The salts of sulphuric acid are known as sulphates. The salts of hydrochloric acid are known as chlorides. The salts of nitric acid are known as nitrates.
Acids react with **metals** and **carbonates**.

**Metal** + Acid $\rightarrow$ Salt + Hydrogen

magnesium + hydrochloric acid $\rightarrow$ magnesium chloride + hydrogen

**Acid** + **Carbonate** $\rightarrow$ Salt + Water + Carbon dioxide

sulphuric acid + copper carbonate $\rightarrow$ copper sulphate + water + carbon dioxide

*The two reactants have rearranged into a larger number of smaller products, this rxn can be described as a **decomposition reaction** as well.*
Properties of Bases

1. Many everyday substances are bases.
2. They feel **soapy & slippery** *(as a result of a chemical reaction between the base and natural oils in the skin)*
3. They are **corrosive** *(some are used as oven and bathroom cleaners)*
4. Usually have a bitter taste *(unpleasant, sharp, or disagreeable)*
5. Do **not** usually dissolve in water *(bases that dissolve in water are called **alkalis**)*
6. DO **conduct electricity** *(bases are made of ions, so in water the ions separate and can conduct an electric charge)*
Bases

When the oxides of some metals dissolve in water they make an alkali solution.

Bases react with acids and neutralise them.

Bases are compounds that break up into hydroxide (OH-) ions and another compound when placed in an aqueous solution.
Bases

Bases are present in many cleaning substances in use in our homes.

Kitchen cleaners are basic because they contain ammonia or sodium hydroxide, which attack grease.

Calcium hydroxide and sodium hydroxide are strong bases. The most recognisable and common weak base is ammonia.
**Common Bases**

**Table 5.5 Some Common Bases**

<table>
<thead>
<tr>
<th>Formula</th>
<th>Chemical Name</th>
<th>Common Name</th>
<th>Examples of Uses</th>
</tr>
</thead>
</table>
| NaOH         | sodium hydroxide  | caustic soda, lye    | • Drain and oven cleaner  
              |                   |                      | • Used to manufacture paper, glass, and soap             |
| Mg(OH)₂      | magnesium hydroxide | milk of magnesia     | • Active ingredient in some antacids                   |
| Ca(OH)₂      | calcium hydroxide | hydrated lime        | • Soil and water treatment                             |
| NH₄OH        | ammonium hydroxide| household ammonia    | • Kitchen cleaner  
              |                   |                      | • Used to make fertilizer                                |

**Bases** are corrosive materials, and will often contain the following safety symbols to represent “corrosive” substances.

*Figure 5.9 Symbols used on Canadian products to indicate corrosive material*
1. How can you recognize a base by its formula?
2. State which base is present in:
   (a) milk of magnesia
   (b) drain cleaner
   (c) household ammonia
3. Give an example of a highly reactive base.
4. What is another term used to describe highly reactive bases?
Production of Ions

- **Acids** produce **hydrogen ions** (H\(^+\)) when dissolved in solution.
- **Bases** produce **hydroxide ions** (OH\(^-\)) when dissolved in solution.
- Testing the pH of a solution is a way of *measuring its concentration of hydrogen ions*, \(H^+_{\text{(aq)}}\).
- **Concentration** of hydrogen ions refers to the number of hydrogen ions in a specific volume of solution. (*i.e.*: *strong or weak concentration*)
- Solutions with a **high concentration of hydrogen ions** are **highly acidic** (low pH).
- Solutions with a **high concentration of hydroxide ions** are **highly basic** (high pH).
Detecting Acids and Bases

1 – 6 Acids

7 Neutral

8 - 14 Alkaline
The pH scale

• Some **acids** are more strongly acidic than others, and some **bases** are more strongly basic than others.

• The **pH scale** of 0**(strongly acidic)**-14**(strongly basic)** indicates how strongly or weakly acidic or basic a substance is.

• Pure water is neither acidic nor basic = neutral= pH 7

• If there are a **lot of** H+ **ions**, the pH is very **low**.

• If there are a **lot of** OH- **ions**, that means the number of H+ ions is very low, so the **pH is high**.
**pH Values of Common Substances**

- **The more acidic** a substance is, the **lower the pH** is.
  - For example, a solution of lemon juice, with a pH of about 2, has a greater acidity than a solution of tomato juice, which has a pH of about 4.

- **Substances that have a pH greater than 7** are said to be **basic**, or alkaline.

- **For solutions containing bases**, the **greater the pH, the more basic** or alkaline the solution is.
  - For example, an oven cleaner with a pH of 13 is more basic than a soap that has a pH of 10.

- **Substances that are neither basic nor acidic** are neutral.
  - For example, pure water is neutral and has a pH of 7.
  - Human saliva is close to neutral, ranging from a pH of 6.5 to a pH of 7.4. Human blood is slightly basic with a pH of 7.3 to 7.5.

![pH Scale](image)

**Figure 5.2** pH values of common substances
• Most of the liquids you find every day have a pH near 7, either a little below or a little above that mark.
• If you ever go into a chemistry lab, you could find solutions with a pH of 1 and others with a pH of 14.
• There are also very strong acids with pH values below one such as battery acid.
• Bases with pH values near 14 include drain cleaner and sodium hydroxide (NaOH).

The pH scale focuses on concentrations of hydrogen ions (H+) and hydroxide ions (OH-).

• Distilled water is 7 (neutral).
• Acids are found between a number very close to 0 and 7.
• Bases are from 7 to 14.
Using the pH Scale

- The pH scale allows chemists to express a wide range of measurements using a small and easily understood range of numbers.
- On the pH scale, one unit of change represents a 10 times change in the degree of acidity or basicity.

What is the increase in acidity if the pH drops from pH 6 to pH 4?

A two unit drop in pH is a $10^2$ or 100 times increase in acidity.

For example, normal precipitation has a pH of about 6 and acid precipitation has a pH of about 4. This means the acidity levels are increased by 100 times or more in acid precipitation as compared with normal precipitation.
That pH scale we talked about is actually a measure of the number of H⁺ ions in a solution.

- If there are a lot of H⁺ ions, the pH is very low. And the solution is highly acidic.
- If there are a lot of OH⁻ ions, that means the number of H⁺ ions is very low, so the pH is high. And the solution is highly basic.
Indicators help you find out whether a solution is acidic or basic.

- A chemical that changes colour depending on the pH of the substance
- They change colour in acid or basic solutions
- Different indicators change to different colours.
**pH Indicators**

- Many common acids and bases form colourless solutions. These solutions look just like water but may be hazardous.

- One safe way to tell whether a solution is acidic or basic is to use a pH indicator.

- pH indicators are chemicals that change colour depending on the pH of the solution they are placed in.

**Litmus:**

- An indicator which contains a compound that is extracted from various lichens.

- Litmus is especially useful when dried onto thin paper strips called **litmus paper**.

- You can use litmus paper to determine whether a solution is acidic or basic.

**Litmus paper comes in two forms, red and blue:**

- Litmus is **red** in an **acid**.

- Litmus is **blue** in a **base**.
LITMUS PAPER

The main use is to test whether the solution is acidic or alkaline.

<table>
<thead>
<tr>
<th>Litmus Paper</th>
<th>Test with acid</th>
<th>Test with alkali</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red litmus paper</td>
<td>No changes</td>
<td>Red $\rightarrow$ blue</td>
</tr>
<tr>
<td>Blue litmus paper</td>
<td>Blue $\rightarrow$ red</td>
<td>No changes</td>
</tr>
</tbody>
</table>
Universal Indicator

- Universal indicator changes colour in acids and bases.

Its colour shows the strength of an acid or base.
Universal Indicator

• Universal indicator contains a number of indicators that turn different colours depending on the pH of the solution.
Other pH Indicators

• Not all pH or acid-base indicators change colour at pH 7 like litmus does.
• For example, *phenolphthalein* is a colourless chemical compound in acidic or slightly basic solutions but **turns pink** in moderately basic to highly **basic solutions**
• Some acid-base indicators, such as **bromothymol blue**, indigo carmine, **methyl orange**, and methyl red are named after their colour changes.

<table>
<thead>
<tr>
<th>Acid-base indicator</th>
<th>pH Range in Which Colour Change Occurs</th>
<th>Colour Change as pH Increases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methyl orange</td>
<td>3.2–4.4</td>
<td>red to yellow</td>
</tr>
<tr>
<td>Methyl red</td>
<td>4.8–6.0</td>
<td>red to yellow</td>
</tr>
<tr>
<td>Bromothymol blue</td>
<td>6.0–7.6</td>
<td>yellow to blue</td>
</tr>
<tr>
<td>Litmus</td>
<td>7.0</td>
<td>red to blue</td>
</tr>
<tr>
<td>Phenolphthalein</td>
<td>8.2–10.0</td>
<td>colourless to pink</td>
</tr>
<tr>
<td>Indigo carmine</td>
<td>11.2–13.0</td>
<td>blue to yellow</td>
</tr>
</tbody>
</table>

**Figure 5.5** Phenolphthalein indicator in an acidic solution (left) and in a highly basic solution (right).

**Figure 5.6** Common acid-base indicators and their pH colour change.
1. What is the pH scale?
2. Above what pH level is a solution said to be basic or alkaline?
3. When the pH rises from 10 to 12, how many times more basic has the solution become?
4. What colour is litmus paper in an acidic solution?
5. What colour is bromothymol blue at the following pH levels?
   (a) pH 5
   (b) pH 7
   (c) pH 9
### Summary of Acid Base Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Acid</th>
<th>Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taste</td>
<td>• Acids taste sour. Lemons, limes, and vinegar are common examples.</td>
<td>• Bases taste bitter. The quinine in tonic water is one example.</td>
</tr>
<tr>
<td>CAUTION: Never taste chemicals in the laboratory.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Touch</td>
<td>• Many acids will burn your skin. Sulfuric acid (battery acid) is one example.</td>
<td>• Bases feel slippery. Many bases will burn your skin. Sodium hydroxide (lye) is one example.</td>
</tr>
<tr>
<td>CAUTION: Never touch chemicals in the laboratory with your bare skin.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indicator tests</td>
<td>• Acids turn blue litmus paper red.</td>
<td>• Bases turn red litmus blue.</td>
</tr>
<tr>
<td></td>
<td>• Phenolphthalein is colourless in an acidic solution.</td>
<td>• Phenolphthalein is colourless in slightly basic solutions and pink in moderate to strongly basic solutions.</td>
</tr>
<tr>
<td>Reaction with some metals, such as magnesium or zinc</td>
<td>• Acids corrode metals.</td>
<td>• No reaction</td>
</tr>
<tr>
<td>Electrical conductivity</td>
<td>• Conductive</td>
<td>• Conductive</td>
</tr>
<tr>
<td>pH</td>
<td>• Less than 7</td>
<td>• More than 7</td>
</tr>
<tr>
<td>Production of ions</td>
<td>• Acids form hydrogen ($H^+$) ions when dissolved in solution.</td>
<td>• Bases form hydroxide ($OH^-$) ions when dissolved in solution.</td>
</tr>
</tbody>
</table>
Assignment #1: Complete the following worksheets on Acids, Bases & Indicators.

1. Compare and contrast acids and bases by completing the following table.

<table>
<thead>
<tr>
<th>Acids</th>
<th>Bases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>definition</strong></td>
<td></td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td></td>
</tr>
<tr>
<td>what to look for in chemical formula</td>
<td></td>
</tr>
<tr>
<td>production of ions</td>
<td></td>
</tr>
<tr>
<td>electrical conductivity</td>
<td></td>
</tr>
<tr>
<td>taste</td>
<td></td>
</tr>
<tr>
<td>touch</td>
<td></td>
</tr>
<tr>
<td>examples</td>
<td></td>
</tr>
</tbody>
</table>

2. Classify each of the following as an acid or a base.

(a) H₃PO₄
(b) NH₃
(c) Mg(OH)₂
(d) has a pH of 4
(e) has a pH of 9
(f) sulphurous acid
(g) hydrogen bromide
(h) potassium hydroxide
(i) causes methyl orange to turn red
(j) causes phenolphthalein to turn pink
(k) causes indigo carmine to turn yellow
(l) causes bromothymol blue to turn yellow

3. Complete the following table by using the two figures shown on the previous page. Identify whether the substance is an acid or a base and indicate what colour the pH indicator will turn.

<table>
<thead>
<tr>
<th>Substance</th>
<th>pH Value</th>
<th>Acid or Base</th>
<th>Methyl Orange</th>
<th>Bromothymol Blue</th>
<th>Litmus</th>
</tr>
</thead>
<tbody>
<tr>
<td>lemon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ammonia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>milk</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) apple

<table>
<thead>
<tr>
<th>Substance</th>
<th>pH Value</th>
<th>Acid or Base</th>
<th>Methyl Orange</th>
<th>Phenolphthalein</th>
<th>Indigo Carmine</th>
</tr>
</thead>
<tbody>
<tr>
<td>tomato</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>oven cleaner</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>egg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Complete the following table. Identify whether the substance is an acid or a base and indicate what colour the pH indicator will turn.

<table>
<thead>
<tr>
<th>Substance</th>
<th>pH Value</th>
<th>Acid or Base</th>
<th>pH Indicator</th>
<th>Colour of pH Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>black coffee</td>
<td>5</td>
<td></td>
<td>Litmus</td>
<td></td>
</tr>
<tr>
<td>milk of magnesia</td>
<td>10</td>
<td></td>
<td>Phenolphthalein</td>
<td></td>
</tr>
<tr>
<td>battery acid</td>
<td>0</td>
<td></td>
<td>Bromothymol blue</td>
<td></td>
</tr>
<tr>
<td>sea water</td>
<td>8</td>
<td></td>
<td>Indigo Carmine</td>
<td></td>
</tr>
<tr>
<td>orange juice</td>
<td>3</td>
<td></td>
<td>Methyl orange</td>
<td></td>
</tr>
<tr>
<td>liquid drain cleaner</td>
<td>14</td>
<td></td>
<td>Methyl red</td>
<td></td>
</tr>
</tbody>
</table>
Additional Activities

https://www.brainpop.com/games/game-finder/?game_keyword=topic:%20pH%20Scale

**Virtual Labs: Acidifying Salsa**
Don’t sell contaminated salsa! Step into the virtual lab and make sure Spicy Salsa Company's product is safe by adjusting its pH to the target level.

**Virtual Labs: pH Scale and Meter Calibration**
Acid or base? Test the pH of common liquids and learn how pH can determine whether food is safe to eat. Then, calibrate your pH meter and use it in a virtual lab!