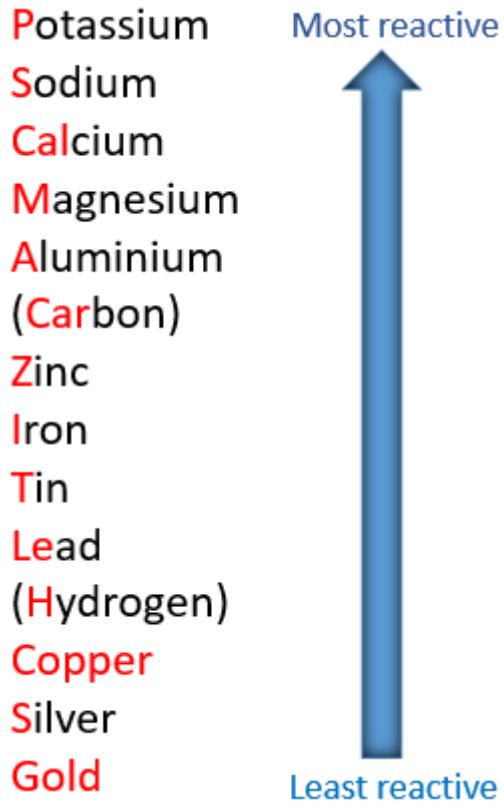
Acids and Bases

Content 

The Reactivity Series



Note:
Use the acronym:
Popular
Scientists
Can
Make
A
Zoo
In
The
Lab
However
Cannot
See
God

Part 1: Acids

Definition of Acids

Physical Properties of Acids

No.	Property	Explanation
1	Have a sour taste	-
2	Dissolve in water to form solutions which conduct electricity (electrodes)	- Presence of free and mobile ions to carry electrical charge
3	Turn moist blue litmus paper red	-

Chemical Properties of an Acid

No.	Property	Observations and test for gases (If any)
1	React with reactive metals to form a salt and hydrogen gas	<u>Observations</u> - Effervescence observed - Colourless, odourless gas produced <u>Test for Gas Produced (Hydrogen)</u> - Place a lighted to the gas - Gas evolved extinguishes the lighted splint with a 'pop' sound - The gas is Hydrogen
2	React with hydrogen carbonates/carbonates to form a salt, carbon dioxide, and water	<u>Observations</u> - Effervescence observed - Colourless, odourless gas produced <u>Test for Gas Produced (Carbon Dioxide)</u> - Bubble the gas through limewater - Gas evolved forms a white precipitate in limewater - The gas is Carbon Dioxide
3	React with Metal Oxides and Hydroxides to form a salt and water only (neutralisation)	-
4	React with Aqueous Ammonia to form an Ammonium salt only	-

Why do acids not react with certain metals?

Case no.	Case
1	<u>Unreactive Metal</u> - When unreactive metals like Copper or Silver are added to dilute acids, there is no reaction
2	<u>Initial Reaction, but stops shortly after</u> - Metals like Lead will react with acids like Hydrochloric acid and Sulfuric acid in its initial reaction - However, the initial reaction forms a layer of insoluble <salt name> that does not dissolve in water - This prevents the metal from further reacting with the acid hence the reaction stops

Role of Water in Acids

- When acids are dissolved in water, they dissociate to form hydrogen ions. The hydrogen ions cause acids to be acidic therefore able to be involved in reactions

- When put in a non-aqueous solution, the acid molecules exist as covalent molecules. No dissociation occurs; therefore, no hydrogen ions are produced, therefore it does not display any acidic properties

Uses of Acids

Acid	Use
Sulfuric Acid	Manufacture of fertilizers
	Manufacture of Detergents
	As battery acid in cars
Hydrochloric Acid	Cleaning impurities by removing rust or scale
Ethanoic Acid	Vinegar, Preservatives, and Flavour Enhancer
Phosphoric Acid	Giving a sour taste to beverages

Basicity of an Acid

- Basicity of an acid is the number of hydrogen ions which can be produced by one molecule of acid.
- Acids like Hydrochloric Acid are monobasic, they dissociate to form 1 hydrogen ion per molecule.
- Acids like Sulfuric Acid are dibasic, they dissociate to form 2 hydrogen ions per molecule
- Acids like Phosphoric Acid are tribasic, they dissociate to form 3 hydrogen ions per molecule

Monoacidic and Diacidic Bases

- Acidity of a base is the number of hydroxide ions which can be produced by one molecule of a base
- Bases like Sodium Hydroxide are monoacidic bases
- Bases like Calcium Hydroxide are diacidic bases

Part 2: Bases and Alkalis

Properties of Alkalis

No.	Property	Observations and Test for gases (If any)
1	Have a bitter taste and feel soapy	-

2	Turn red litmus paper blue	-
3	React with acids to form a salt and water only (neutralization)	-
4	When gently warmed with ammonium salts, produce a salt, ammonia gas and water only	Observations - Colourless, pungent gas produced Test for gas (Ammonia) - Place a piece of moist red litmus paper to the gas - Gas evolved will turn the moist red litmus paper blue - Gas is Ammonia
5	React with a solution containing one metal salt to give another metal salt and metal hydroxide	-

Uses of Bases and Alkalis

Base/Alkali name	Use
Magnesium Oxide	- Making refractory bricks
Sodium Hydroxide and Potassium Hydroxide	- Preparation of detergents
Calcium Hydroxide	- Reduce acidity in soils
Ammonia solution	- Making fertilizers

Why are Ammonia and Calcium Hydroxide not added together to soil?

- Both compounds will react to form ammonia gas, the nitrogen content decreases by ammonia gas, hence the plant will not grow well as nitrogen is lost.

Part 3: Strength and Concentration

Definitions of Strong and Weak Acids/Alkalis

Definition of a Strong Acid/Alkali

- Defined as an acid/alkali that is completely ionized in aqueous solution

Definition of a Weak Acid

- Defined as an acid/alkali that is partially ionized in aqueous solution

Note:
- The strength of an acid is NEVER affected by its concentration
- Dilute Acid does not mean Weak Acid
- A strong acid will always be fully ionised regardless of concentration

Concentration vs Strength of an acid

Strength	Concentration
Extent of ionisation	How much of an acid is dissolved in a solution

Part 4: The pH Scale

Different Methods used to measure the pH of a chemical

1. Using a chemical compound known as an indicator

2. Using a data logger with a pH sensor/probe

Common Indicators and their changes of colour

Indicator	Colour in acidic solution	pH range in which colour change is observed	Colour in alkaline solution
Methyl Orange	Red	3-5	Yellow
Screened Methyl Orange	Violet	3-5	Green
Litmus	Red	5-8	Blue
Bromothymol blue	Yellow	5-8	Blue
Phenolphthalein	Colourless	8-10	Pink

Importance of pH in soil

- It may be unsuitable for plant growth if the soil is too acidic or too alkaline

Part 4: Oxides

Acidic Oxides

- Examples include Carbon Dioxide, Phosphorus Oxide, and Sulfur Trioxide

Basic Oxides

- Defined as an oxide that reacts with an acid to form a salt and water only
- Examples include Copper (II) Oxide, Magnesium Oxide, and Calcium Oxide

Amphoteric Oxides

- Examples include Zinc Oxide, Aluminium Oxide, and Lead (II) Oxide

Neutral Oxides

- Examples are Carbon Monoxide and Nitric Oxide, and Water

Appendix I: Acid Salts and Basic Salts

Acid Salts

- It is called an acidic salt as the hydrogen ions in the acid are not completely replaced by the metal cation or ammonium cation from the base or carbonate it reacts with. The pH of the solution is lower than 7
- Usually formed when a strong acid reacts with a weak base
- Example include Sodium Bicarbonate and Sodium dihydrogen phosphate

Basic Salts

- Is called a basic salt as the hydroxide ions in the base are not completely replaced by the anion of the acid it reacts with. The solution has a pH more than 7
- Usually formed when a weak acid reacts with a strong base
- Examples include Calcium Carbonate

Salts

Part 1: Water of Crystallisation

- Many salts combine with water molecules to form crystals
- Are removed by evaporating the crystals to dryness
- Can always be rehydrated.

Part 2: Solubility of Salts

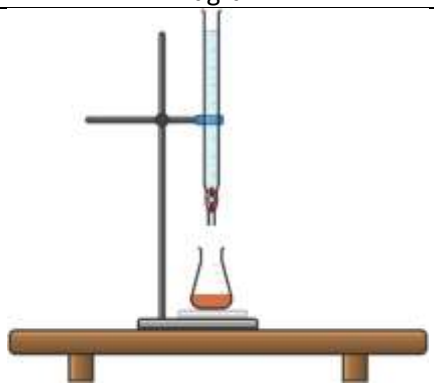
Soluble Salts	Insoluble Salts
All Sodium salts All Potassium Salts All Ammonium salts All nitrates	-
All chlorides/iodides	Lead (II) Chloride/ Iodide Silver Chloride/Iodide
All sulfates	Barium Sulfate Lead (II) Sulfate Calcium Sulfate
Sodium Carbonate/ Sodium Hydroxide Potassium Carbonate/ Potassium Hydroxide Ammonium Carbonate/ Aqueous Ammonia	All Carbonates and Bases

Note:
Use the acronym:
Chinese
Language
Basic,
Lao
Shi,
His name is
Charlie
Brown,
He teaches in
Swiss
Cottage
Institution,
And he decided
to go for a
SPA

Part 3: Making Salts

Section A: Titration (Both starting materials are soluble)

How to carry out Titration?

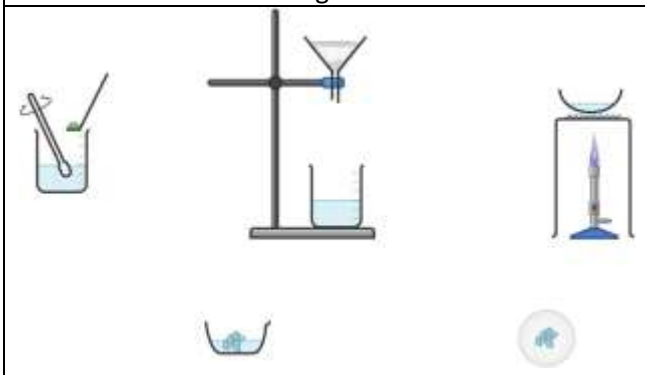
Diagram	Steps
	1. Pipette $25.0cm^3$ of acid into a conical flask 2. Add a few drops of indicator into the conical flask 3. Add the alkali drop by drop slowly until the indicator turns from <initial color> to <final color> permanently 4. Record the volume of alkali needed to completely react with the acid 5. Repeat the experiment using $25.0cm^3$ of acid and the recorded volume of alkali without indicator 6. Heat to evaporate the water until saturated 7. Cool until <salt name> crystals can form 8. Filter and dry <salt name> crystals between sheets of filter paper

Section B: Reacting an Acid with a Metal, Insoluble base, or Insoluble carbonates

When to carry out this method?

- It is carried out when the salt is soluble in water and one of the starting materials is not soluble in water

How to carry out this method?

Diagram	Steps
	1. Fill half a beaker with warm dilute acid 2. With constant stirring, add excess metal/insoluble base/insoluble carbonate into a beaker until no more reaction occurs with the acid 3. Filter to remove excess metal/insoluble base/ insoluble carbonate. Collect the filtrate which is aqueous <salt name> 4. Heat to evaporate water in the filtrate until it is saturated 5. Allow the solution to cool so that the salt can crystallise and <salt name> crystals can form 6. Filter to collect the crystals. Wash crystals with a little cold water to remove impurities. Dry crystals between a few sheets of filter paper

Section B: Ionic Precipitation

When to carry out this method?

- Carried out when the salt is not soluble in water

How to carry out this method?

Diagram	Steps
	1. Add one aqueous solution (containing cation of salt) and add the other aqueous solution (containing anion of salt) in a beaker 2. Filter to collect the precipitate which is <salt name> powder 3. Rinse the precipitate with a little deionised water 4. Allow the precipitate to dry on a piece of filter paper

Test yourself

1. What are acids?
2. What are the physical properties of acids?
3. Why are acids good conductors of electricity?
4. What are some chemical properties of acids?
5. Explain why
    i. Copper in dilute acids has no reaction
    ii. Very vigorous reaction initially but reaction stops between Calcium and Sulfuric Acid
6. Explain why Hydrogen Chloride in water can turn moist blue litmus paper red but Hydrogen Chloride in a non-aqueous solvent (e.g. Dioxane) cannot turn moist blue litmus paper red?
7. What are some uses of acids?
8. What are bases and alkalis?
9. What are the properties of alkalis?
10. What are some uses of bases/alkalis?
11. Why it is common advice for framers to not add slaked lime and ammonium fertiliser together to the soil?
12. What is the meaning of
    i. Strength
    ii. Concentration
13. Explain why
    i. Ethanoic acid has a higher pH than Hydrochloric Acid
    ii. Sulfuric Acid has a lower pH than Nitric Acid
    iii. Phosphine/Ammonia has a lower pH than Sodium Hydroxide
14. What are
    i. Acidic Oxides
    ii. Basic Oxides
    iii. Neutral Oxides
    iv. Amphoteric Oxides
15. State which
    i. Nitrates
    ii. Sulfates
    iii. Metal Halides
    iv. Carbonates
    v. Hydroxides
    Are soluble and insoluble in water
16. Explain how to safely prepare
    i. Potassium Nitrate crystals
    ii. Barium Sulfate powder
    iii. Magnesium Sulfate crystals

Glossary of Terms

Acids	Defined as a substance that ionises into hydrogen ions in water

Bases	Defined as any metal oxide or hydroxide that reacts with an acid to produce a salt and water only
Alkalis	Defined as a substance that ionises to form hydroxide ions in water
Acidic Oxides	Defined as an oxide that reacts with alkalis to form a salt and water only
Basic Oxides	Defined as the strong electrostatic forces of attraction between positive metal ions and the 'sea of delocalized electrons' in a giant metallic lattice structure
Amphoteric oxides	Defined as metallic oxides that react with both acids and alkalis to produce a salt and water
Neutral Oxides	Defined as oxides that do not react with either acids nor alkalis to form a salt and water