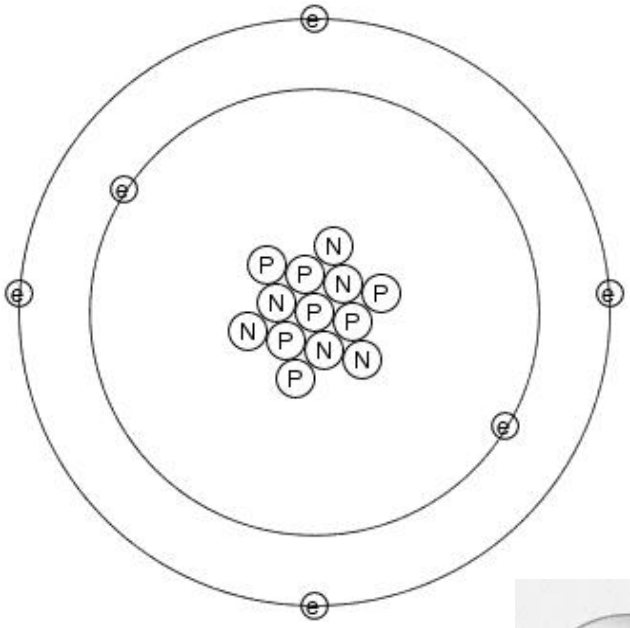
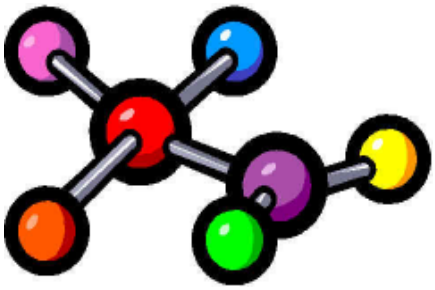
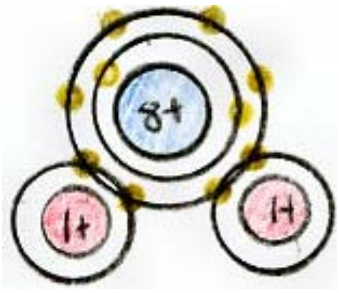
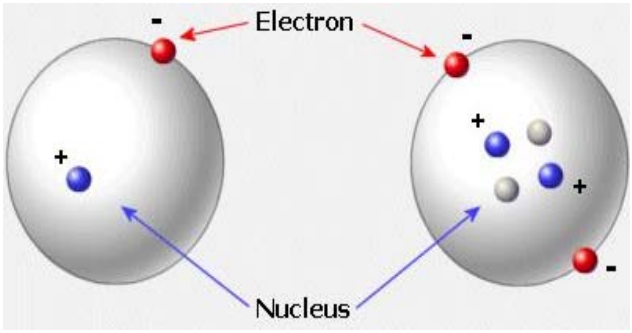
Science Module 2:

Basic Chemistry









Contents

1. Matter

2. Particles in Matter

3. Chemical Reactions

4. Acids, Bases, Salts

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Chapter One: Matter

Everything in the universe is made of matter - (this means some kind of stuff stuff or materials). Anything you can sense (with your 5 senses) is made of matter. Rocks, trees, you, even wind (air) is made of matter.

A. Properties of matter

Activity 1.1

Observing **work in groups**

Step 1 Place an ice cube on your table.

Step 2 Observe the ice cube for about 1 minute.

Think it Over

1. Does the ice cube have mass (is it made of matter)?
2. Does it take up space?
3. Is the (solid) ice cube changing to another form?
4. Does it have weight?

The three properties of matter are:

1. Matter has mass.
2. Matter has volume. That is, it takes up space.
3. Matter can change to another state (solid, liquid or gas).

**** Mass = the amount of matter in an object.***
**** Weight = the force of gravity on an object.***

The properties of matter can be classified as:

- Physical properties: Physical appearance and behavior, etc. Note that these things can be observed using your senses.

e.g. colour, size, shape, weight, mass, temperature, taste, etc…

- Chemical properties: Ability to combine with other substances to make new substances, etc. Note that many chemical properties aren't observable with your senses unless you perform experiments.

e.g. combustible (can burn), decomposible (splitting into 2 or more substances), etc.

Each substance has its own combination of properties that can be used to identify it.

For example, if you are given a cup of clear liquid, what properties would you test to determine if it was water or petrol (gasoline)?

B. Types of Matter

Activity 1.2

Classification **work in groups**

Step 1 Your teacher will give you 10 objects: *magnesium,copper, zinc, water, ethanol, sugar, aluminum, stone,lime juice, salt water*

Step 2 Classify the objects as an: element, compound, or mixture. Put them in the table below.

	elements	compounds	mixtures
matters			

a. Elements

An *element* is matter made of one kind of atom. (An element is the simplest kind of matter. It can't be broken down into other kinds of matter by ordinary physical or chemical means.)

b. Compounds

A *compound* is made up of two or more elements chemically combined in specific ratio. For example; in water molecule (H_2O) the ratio of hydrogen element and oxygen element is 2:1

c. Mixtures

A *mixture* is matter containing two or more substances (element, compound or both) which are not chemically combined.

Activity 1.3

Identify Properties of Matter **Work in Groups**

Step 1 Your teacher will give you a piece of paper, a candle, a piece of magne sium, and a lighter.

Step 2 Observe a piece of paper before, during and after burning it.

Step 3 Observe a candle before, during and after burning it.

Step 4 Observe a piece of magnesium before, during and after burning it. (DO *NOT hold the magnesium in your fingers - use two pencils or sticks.)*

Step 5 Write down your observation in the table below.

C. States of Matter

Activity 1.4

Forming Operational Definitions

Step 1 Put Eno (about 50g) in a 1 litre bottle.
Step 2 Pour about 0.35 liter of water into the bottle. Stretch a balloon over the top of the bottle
Step 3 Observe what happens for about 2 minutes.
Step 4 Remove the balloon and examine its contents.

Think it Over

Identify examples of these different states of matter that you observed in this activity:

solid
liquid
gas

Define each of the three states in your own words.

States of matter are not defined by what they are made of, but mainly by whether or not they hold their volume and shape.

a. Solids

A solid has a definite shape and volume. This is because the particles in a solid are packed tightly together and fixed in one position relative to each other (the matter in a solid doesn't move).

Solids can be classified as:

(1) Crystallized solid

Particles are arranged in a regular and repeated patterns. Has a distinct melting point.

e.g. salt, sugar, ice, etc.

(2) Amorphous solid

Particles are arranged in an irregular patterns. Does not have distinct melting point.

e.g. *plastic, rubber, glass, etc*.

b. Liquids

Particles in a liquid are not packed as tightly together as in a solid. They're more free to move relative to each other. Thus a liquid has no definite shape. However, the particles stay close enough together that they do have a definite volume.

Liquids can be classified by

Viscosity - the resistance of a liquid to moving or flowing

e.g., Water has lower viscosity than honey.

c. Gases

Particles in a gas don't stay close together, instead they spread apart, filling the space available to them. Therefore a gas has neither definite shape nor volume.

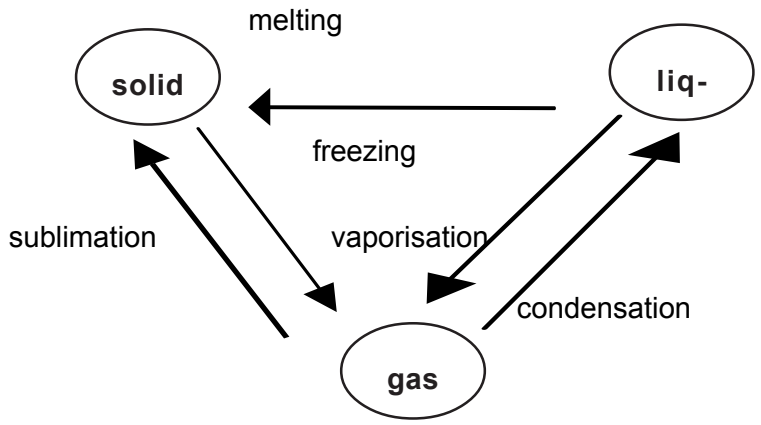
e.g. air (that you breathe), oxygen, carbon dioxide, etc.

Changes in States of Matter: A substance changes state when its thermal energy (heat) increases or decreases by a sufficient amount - (i.e. when the change in heat is big enough).

e.g., When enough heat is added to a solid it changes state and becomes a liquid. When enough heat is removed from a liquid it changes to a solid. Note that thermal energy (heat) is either added or removed; not cold. This is because, the amount of energy can be measured, but cold, the absence of energy isn't measurable.

Activity 1.5

Interpreting a Diagram



Think it Over

Write five sentences about the diagram above.

Melting - the change in state from solid to liquid

Thermal energy increases so particles start moving faster, bumping into each other more and, as a result, push away from each other creating more space between the particles.

e.g., Ice melts to become drinking water.

Freezing - the change in state from liquid to solid

Thermal energy decreases so particles slowe down, stop bumping into each other as much and, as a result, come closer together.

e.g., Water freezes to become ice.

Vaporization- the change in state from liquid to gas

Thermal energy increases and particles start moving so fast, bumping so hard that they fly apart.

Vaporization has two forms:

(a) Evaporation (take places on the surface of liquid)

(b) Boiling (takes place in liquid as well as at the surface)*

e.g., Water vaporizes to become steam (vapor).

Condensation - the change in state from gas to liquid.

Thermal energy decreases and particles slow down and come closer together.

e.g., Steam (vapor) condenses to become water.

Sublimation- The change in state from solid directly to gas.

Thermal energy increases so much that surface particles start moving freely.

e.g., Dry ice sublilmates to become vapor.

*Boiling- Rapid vaporization of a liquid; usually happens when the molecules that make up the liquid gain enough thermal energy (heat) to escape from the liquid and "fly off" into the atmosphere as gas

Boiling Point- Each liquid boils at a specific temperature called a *boiling point.* Boiling point depends on how strongly the particles of the substance are attracted to one another. The boiling point is that temperature at which the thermal energy of the liquid is higher than the force of attraction the particles have for one another.

Activity 1.6

Observing **Work in groups**

Materials *Iodine, spoon, candle*

Heat one crystal of iodine in a spoon over a candle.
What happens?
Can you see any liquid iodine?

D. Changes in Matter

Activity 1.7

Inferring

Step 1 Put about 10g of sugar in glasses A and B
Step 2 Pour about 10cm^3 of water into glass A.
Step 3 Pour about 10cm^3 of concentrated sulphuric acid into glass B.

After 3 minutes... Compare the changes in glass A and glass B.

Think it Over and Discuss in Pairs

1. What happened in glass A after 3 minutes?
2. What happened in glass B after 3 minutes?

Physical Changes

A physical change alters the state or *appearance* of a material but does not make the material into another substance.

Examples of physical changes include:

1. Chopping wood into smaller pieces.
2. Bending copper wire into a new shape
3. Ice melting into water
4. Turning an electric light on and off.

Chemical Changes

A *chemical change* or *chemical reaction* creates a new substance.

Examples of chemical changes include:

1. Burning wood - Wood changes to ash and gases
2. Rusting nail - Iron changes to iron oxide
3. Digestion - Food is broken down into nutrients like starches, sugars, fats, etc.

Chapter Two : Particles in Matter

A. Atoms

A Greek philosopher, Democritus, lived about 440B.C.
He thought that you could cut matter into smaller and smaller pieces until you got to its smallest piece, which couldn't be divided any more. Democritus called this smallest piece *atomos*, which is Greek for "uncuttable". Does that word look familiar? Of course! It's where the word atom comes from. Today scientists use the word atom for the smallest particle or piece of an element.

Yes or No?

1. An atom is the smallest part of matter. *(Y/N)*
2. You are made up of atoms. *(Y/N)*
3. Water (H_2O) is made up of one atom. *(Y/N)*
4. An atoms can be seen with naked eyes. *(Y/N)*
5. There are no atoms in air. *(Y/N)*
6. All matter is made up of one kind of atom. *(Y/N)*
7. Atoms can easlily be broken down into smaller pieces. *(Y/N)*

Dalton's Atomic Theory

- Atoms can't be broken into smaller pieces.
- All the atoms of an element are exactly alike.
- All atoms of an element have a unique mass.
- Atoms of different elements are different.
- Atoms of two or more elements can combine to form compounds.
- The masses of the elements in a compound are always in constant ratio.

Activity 2.1

Group Discussion

Step 1 Read and discuss Dalton's Atomic Theory. If you don't understand something, discuss it with your group.

Step 2 Ask your questions to other groups.

The Structure of Atoms

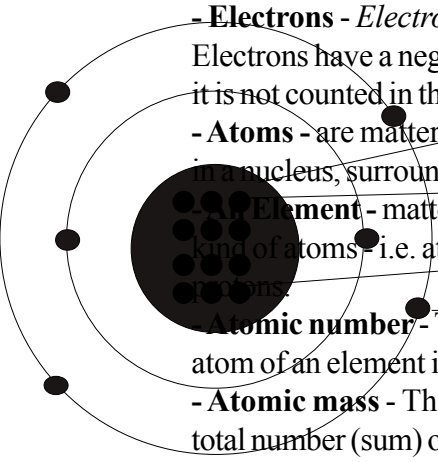
One student will draw a structure of atom on the board. Do you agree with this diagram? Discuss.

The Atom and its Particles

- Protons - P*rotons* are subatomic particles found in the nucleus of an atom. Protons have a positive charge. The charge of one proton is said to be + 1. The mass of one proton is 1 *amu* (atomic mass unit).

- Neutrons - *Neutrons* are subatomic particles that are also found in the nucleus of an atom. Neutrons have no electrical charge. They are neutral. The mass of a neutron is about the same as that of a proton, 1 amu.

- Electrons - *Electrons* are subatomic particles that move in a path, or orbit, around the nucleus. Electrons have a negative charge. Each electron has a charge of -1. The mass of an electron is so small it is not counted in the total mass of the atom.



Carbon Atom

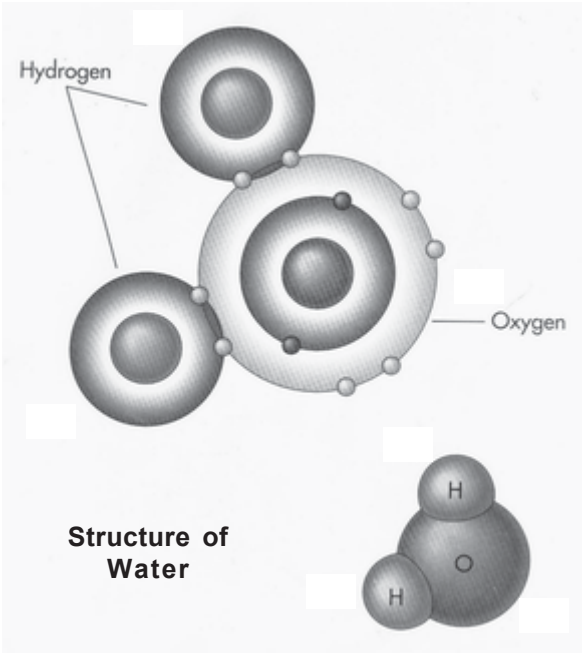
- Atoms - are matter made of protons & neutrons in a nucleus, surrounded by electrons.

- An Element - matter which contains only the same kind of atoms - i.e. atoms with the same number of protons.

- Atomic number - The number of protons in an atom of an element is called its *atomic number*.

- Atomic mass - The *atomic mass* of an atom is the total number (sum) of protons and neutrons in it. Remember that the mass of each of these particles equals one, so the number of particles and their mass is the same.

- Isotopes - *Isotopes* are atoms of the same element
having the same atomic number but a different atomic mass (the same number of protons but a different number of neutrons).



Structure of Water

- Ions - *Ions* are atoms that have become charged by gaining or losing electrons. They have the same number of protons (are the same element) but a different number of electrons.

- Atoms that lose electrons become *positive ions*.
- Atoms that gain electrons become *negative ions*.

Exercises with particles

i. Complete the table below using the Periodic Table of Elements

Element	Number of Protons	Number of Neutrons	Atomic Number	Atomic Mass
Ca	*20*			*41*
Mn	*25*	*30*		
Pd		*60*	*46*	
Pb			*82*	*207*
U		*146*		*237*

ii. Identify the following diagrams: atoms or isotopes?

iii. Answer the questions.

a) An oxygen (O) atom, which has an atomic number of 8, was found to have 10 electrons. Is it an ion or a neutral atom?

b) An aluminum atom, with an atomic number of 13, also was found to have 10 electrons. Is it an ion or a nuetral atom?

c) A magnesium, with an atmoic number of 12, was found to have 12 electons. Is it an ion or a neutral atom?

iv. Identify the following diagrams: - ion(negative ion), + ion(positive ion) or neutral atom?

a) 8p 8n 10e

b) 12p 12n 2e

c) 37p 38n 36e

d) 16p 16n 18e

e) 10p 10n 10e

B. Molecules

Yes or No?

1. Molecules are made up of two or more atoms. *(Y/N)*
2. Molecules are smaller than atoms. *(Y/N)*
3. All molecules have the same structure. *(Y/N)*
4. The same molecules have the same constant ratio of atoms. *(Y/N)*
5. The water molecule (H_2O) has three different kinds of atoms. *(Y/N)*
6. Molecules cannot be broken down. *(Y/N)*
7. (O_2) is a molecule. *(Y/N)*

Molecules are the smallest natural units of all compounds and many elements.
Diatomic Mulecules - two identical atoms bonded (tied) together in a molecule
Diatomic Elements - Some elements don't exist as single atoms in nature, and are only found as diatomic molecules or grouped with other kinds of atoms. The 7 diatomic elements are *Oxygen* (O_2), *Hydrogen* (H_2), *Nitrogen* (N_2), *Fluorine* (F_2), *Chlorine* (Cl_2), *Bromine* (Br_2), and *Iodine* (I_2).

Chemical formula - Scientists use a formula to describe a molecule. A chemical formula tells us the kind and number of atoms of each element found in a compound.

e.g., H_2SO_4 is the formula for a molecule of sulphuric acid. The letters represent the names of the elements, and the numbers show the ratios of the atoms of the different elements in a formula. That means the ratio of hydrogen to sulphur to oxygen in a sulphuric acid molecule is 2:1:4.

<u>Activity 2.2</u> Work in Groups

Your teacher will give you some clay.
Make models of these molecules: *O_2 (oxygen), H_2O (water), CO_2 (carbon dioxide),*
NH_3 (ammonia), and CH_4 (methane).
Draw these models in your book, and write their names beside them.

diatomic	**CO_2**	**H_2SO_4**	**molecule**	**F_2**

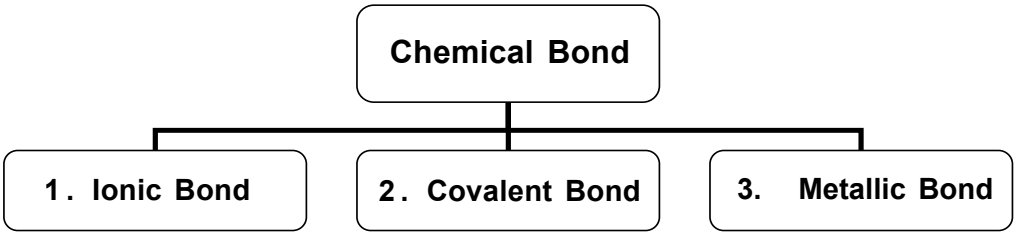
Fill the gaps with words from the box above

A formula describes a _____. Sometimes, a molecule is an element like _____. Fluorine is called a _____ element. An example of a molecule of a compound made of 3 atoms is _____. An Example of a formula showing three different kinds of atoms is _____.

Write the symbols for:

1. An atom of hydrogen
2. A molecule of hydrogen
3. Two molecules of hydrogen
4. Two molecules of water.

C. Chemical Bonds



Chemical Bond - A *chemical bond* is the physical process responsible for the attractive interactions between atoms and molecules. It is the sharing or transfer of electrons between the atoms.

Ionic Bond - *Ionic bonds* form when metal ions bond with non metal ions.
Metal ions have a positive charge (+) and nonmetal ions have a negative charge (-).

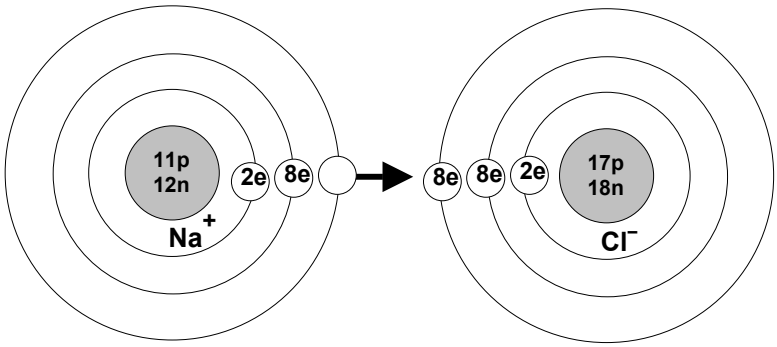
Covalent Bond - A *covalent bond* is formed when atoms share a pair of electrons.

Metallic Bond - If metal atoms lose electrons, they become positive ions. If the lost electrons stay close to the positive ions, the attraction of positive metal ions to the free electrons forms a metallic bond.

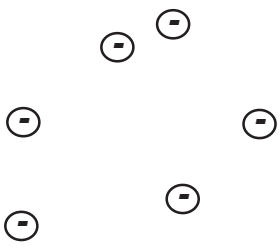
Exercises with Bonds

Identify the following diagrams: ionic, covalent or metallic bonds.

a.)

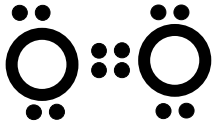


b.)



Sodium metal

c.)



Oxygen molecule

d.)

Chapter Three: Chemical Reactions

A. Understanding Chemical Reactions

Activity 3.1

Observing **Work in Groups**

Step 1 Put two small spoonfuls of baking soda into a small clear plastic cup.

Step 2 Holding the cup over a large bowl, add about 250ml of vinegar. Swirl the cup gently.

Step 3 Observe any changes to the material in the cup. Feel the outside of the cup. What do you notice about the temperature?

Step 4 Carefully, fan some air from over the liquid toward you. What does mixture smell like?

Think it Over

What changes did you detect using your senses of smell and touch?

A **Chemical Reaction** is the production of new materials with properties that are different from those of the starting materials.

For example:

Hydrogen + Oxygen → Water

$2H_2$ + O_2 → $2H_2O$

The materials you have at the beginning (hydrogen and oxygen) are called the *reactants*. When the reaction is complete, you have different materials called the *products* of the reaction (water molecules).

$2H_2$ + O_2 $2H_2O$

(Reactants) ***(Product)***

Activity 3.2

Making Molecular Models

Step 1 Make clay models of two molecules of hydrogen and one molecule of oxygen.

Step 2 Carefully take these models apart and rearrange them as two molecules of water.

Chemical Reactions and Energy

Chemical reactions involve a change in energy. This is because energy may be needed to help the reaction to occur, or because energy many be produced or released by the reaction.

Exothermic reactions *release heat*. Exothermic reactions occur because the energy content of the reactants is greater than the energy content of the products. The excess energy is released as heat during the reaction.

In **endothermic reactions** the energy of product is greater than the energy of the reactants. This means energy must be added to the reactants for the reaction to occur. Thermal energy or heat is absorbed during the reaction, so endothermic reactions *absorb heat*.

B. Types of Chemical Reactions

Many chemical reactions can be classified in one of three categories; **synthesis, decomposition,** or **replacement.**

Synthesis – When two or more substances combine to make a more complex substance, the process is called *synthesis*, e.g

$$\underset{\text{(reactants)}}{C + O_2} \longrightarrow \underset{\text{(products)}}{CO_2}$$

Decomposition – When a single substance breaks down into simpler compounds or elements, the process is called *decomposition*, e.g.

$$\underset{\text{(reactants)}}{2H_2O} \longrightarrow \underset{\text{(products)}}{2H_2 + O_2}$$

Replacement – *Replacement* can be classified as single replacement or double replacement.

- *Single replacement* is when one element replaces another in a compound, e.g.

$$2CuO + C \longrightarrow 2Cu + CO_2$$

- *Double replacement* is when two elements in different compounds exchange places, e.g

$$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2CO_3$$

Activity 3.3

Classifying	**Work in Groups**
Step 1	The teacher will give each group some pieces of paper with equations on them.
Step 2	Classify the type of chemical reaction of each equation.
Step 3	Stick your papers in the correct colums on the board: *synthesis, decomposition, single* or *double replacement.*

C. Rates of Chemical Reactions

Activity 3.4

Drawing Conclusions **Work in Groups**

Materials *sodium bicarbonate, hot* vinegar*, cold* vinegar*, a piece of wood, magnesium*

Procedure - Part A

Step 1 Put about 100 milliliters(ml) of cold vinegar into beaker A and hot vinegar into beaker B.
Step 2 Put a teaspoon of sodium bicarbonate into each beaker.
Step 3 Observe what happens after step 2. Compare the rate of reaction in the two beakers.
Step 4 Record your observations in the data table.

Procedure - Part B

Step 1 Cut a piece of wood into two pieces wood. (About 1-2” thick x 6")
Step 2 Cut one piece into ten smaller pieces.
Step 3 Burn the uncut piece and observe the rate of reaction.
Step 4 Burn the 10 smaller pieces together and observe the rate of reaction.
Step 5 Record your observations in the data table.

Procedure - Part c

Step 1 Put about 5 ml of vinegar into beakers A and B.
Step 2 Pour about 10 ml of water into beaker A.
Step 3 Put the same amount of magnesium into each beaker.
Step 4 Observe what happens after step 3. Compare the rate of reaction in the two beakers.
Step 5 Record your observations in the data table.

Think it Over

Based on your observations, what are the factors that can affect the rates of reactions?
How does each factor affect the rate of reaction?

Data Table	
Reaction	**Observations**
cold water + sodium bicarbonate	
hot water + sodium bicarbonate	
uncut wood + fire	
cut wood (10 pieces) + fire	
concentrated vinegar (no water) + Mg	
dilute vinegar (with water) + Mg	

Chemists can control the rates of reactions by changing factors such as concentration, temperature, and surface area.

Concentration is the amount of one material in a given amount of another material *(e.g. amount of sulphuric acid per amount of water)*.

You can increase the rate of a reaction by increasing the concentration of the reactants.

Temperature is a measure of the thermal energy or heat (i.e. the average energy of motion of the particles) of a substance.

You can increase the rate of a reaction by increasing its temperature.

The **surface area** is the physical part or side of one reactant that contacts with the physical part or side of the other reactant. Only the particles on the surface of the reactants can come in contact.
You can increase the rate of reaction by increasing the surface areas (of the reactants) that are in contact.

Activity 3.5

Drawing Conclusions **Work in Groups**

Materials *rice flour, candle*

Sprinkle rice flour over a lighted candle.

Think it Over

Describe what happens, and give an explanation.

Activity 3.6

Comparing **Work in Groups**

Materials *iron wool, aluminium foil, water*

Step 1 Wet one piece of iron wool.
Step 2 Put both pieces on a sheet of aluminium foil, making sure to keep the dry one dry.
Step 3 After two days, observe the two pices of iron wool.

What has happened? What reaction happened? What is the catalyst in the reaction?

Chemists can also control the rate of reaction by using substances called catalysts and inhibitors.

A **catalyst** is a material that increases the rate of a reaction - (i.e. speed up the reaction).

e.g., steel that is exposed to water and salt rusts more quickly.

An **inhibitor** is a material used to decrease the rate of a reaction - (i.e. slow down the reaction).

e.g., putting paint, grease or oil over steel means it rusts more slowly.

Chapter Four: Acids, Bases and Salts

Activity 4.1

Classifying **Work in Groups**

Step 1 Your teacher will give you some solutions.
Put each solution in a cup.
Step 2 Taste each solution.
Step 3 Classify the solution (acid, base or salt)

Think it Over

How can you classify acids, bases, and salts by using other methods?

An **acid** is a substance which gives hydrogen ions (H^{+}) when placed in water.
A **base** is a substance that gives hydroxide ions (OH^{-}) when placed in water.
A **salt** is a compound formed from the positive ion of a base and the negative ion of an acid.

A. Properties of Acids and Bases

Properties of Acids:

1) Acids are soluble in water.

2) Acids have a sour taste.

3) Acids conduct electricity (electrolytes).

4) Acids can react with certain metals to produce Hydrogen (H_2) gas.

$$e.g \quad Zn + 2HCl \longrightarrow ZnCl_2 + H_2$$

Some metals do not react even with concentrated acids. *(eg. copper, silver and gold)*

5) Acids can react with all metal carbonates to produce carbon dioxide (CO_2) gas.

$$e.g. \quad CaCO_3 + 2HCl \quad CaCl_2 + H_2O + CO_2$$

6) Acids can change the color of indicators:

7) Acids neutralise bases.

Properties of Bases:

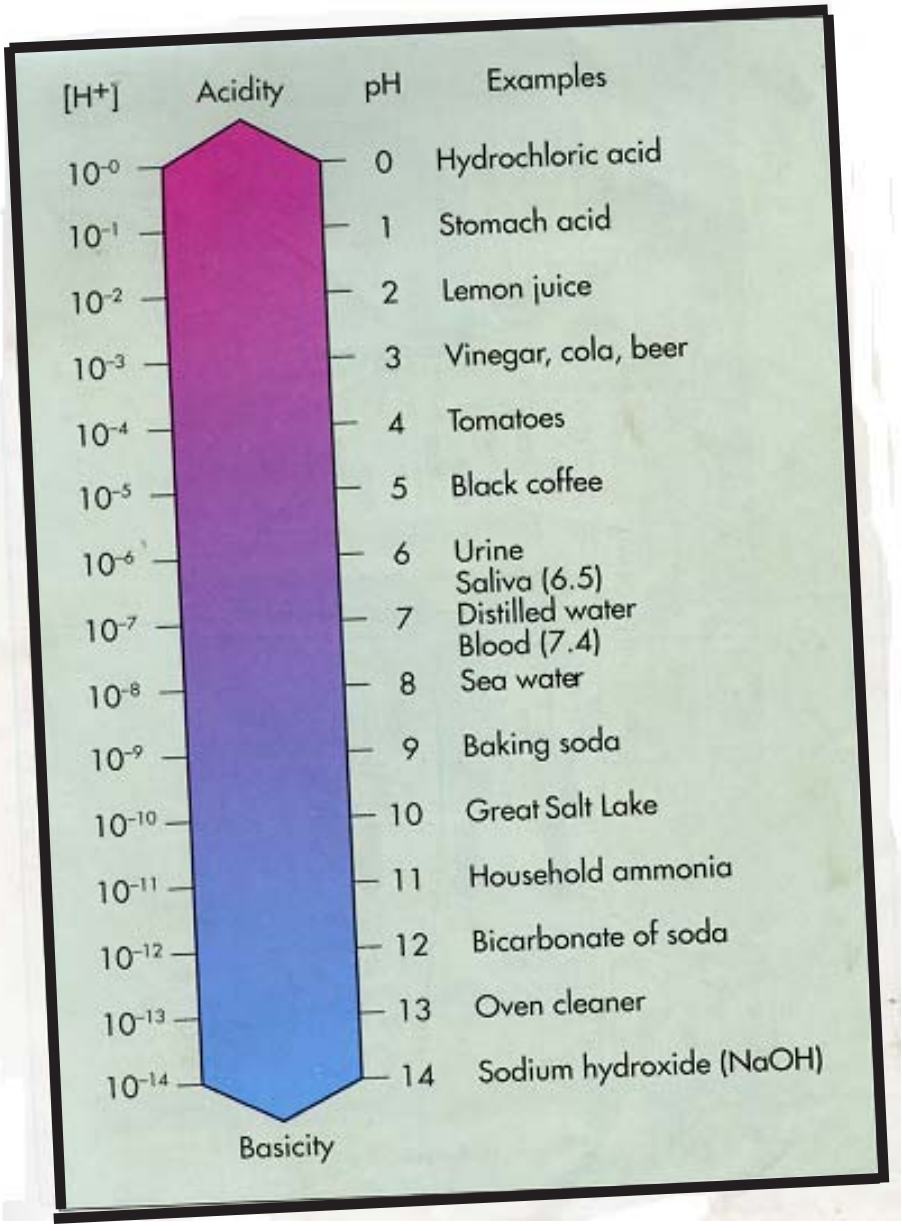
1) Bases that are soluble in water are called alkalis.
2) Bases have a bitter taste.
3) Bases conduct electricity when in solution.
4) Bases feel soapy to the touch.
5) Bases can change the color of indicators:
6) Bases neutralise acids.

B. Strength of Acids and Bases

Chemists use a numeric scale called pH to measure the concentration of acids and bases. The pH scale is a range of values from 0-14. It expresses the concentration of hydrogen ions in a solution. When the pH is low, the concentration of hydrogen ions is high.

The lower the pH number (and the higher the concentration of hydrogen ions), the stronger the acid. An acid with a pH of 1 is much stronger than an acid with pH 6. Pure water has a pH of 7.

A substance which has a pH of greater than 7 is called a base. The higher the pH (and the lower the concentration of hydrogen ions), the more basic the chemical. A base with a pH of 14 is a much stronger base than a base with a pH of 9.



pH Scale

Activity 4.2

Measuring and Ordering **Work in Groups**

Materials *indicator (paper), different kinds of solutions (e.g. lemon, cola, soda, pure water, lye, coffee, soap, milk, etc)*

Step 1 Drop a small amount of each solution on separate pieces of testing paper.
Step 2 Record the change in color and the pH scale of each solution.
Step 3 Decide which solutions have acidic or basic properties.
Step 4 Order the solutions from lowest to highest pH.

Neutralization is a reaction between an acid and a base. An acid-base mixture is not as acidic or basic as the individual starting solutions were. A *neutralization* produces water and a salt.

Why is water a product of the reaction of an acid and a base?

Activity 4.3

Neutralising **Work in Groups**

Materials *lime juice, baking soda, pH scale, paper cups.*

Step 1 Put about 200 ml of lime juice in a cup.
Step 2 Put about 5g of baking soda into the cup.
Step 3 Test the pH scale of the new solution.
Step 4 Add more lime juice if the pH of new solution is more than 7, or add more baking soda if the the pH of the new solution is less than 7.

Repeat step 4 until the solution is neutralized (pH of 7)