Chemistry and You

- A **chemical** is any substance used or produced in a chemical process.
- The Earth, and everything in the universe are made of chemicals.

- **Chemistry**: is the study of the composition, structure, and properties of matter and of the reactions by which one form of matter may be produced or converted into other forms.
  - *Physical chemistry*: structure of matter, energy changes from one form to the other.
  - *Analytical chemistry*: Concerned with identification, separation, and determination of different substances.
  - *Organic chemistry*: Synthesis and reactions of the compounds of carbon → Life on Earth is based in carbon compounds.
  - *Inorganic chemistry*: Concerned with elements other than carbon and with their compounds.
  - *Biochemistry*: Study of the molecular basis of life.
  - *Quantum chemistry*: Chemical reactions/changes at the quantum (atomic and subatomic level).

- **Matter**: Anything that occupies space and has mass. All objects in the universe have mass; they are matter.
  - **Mass** is a measurement of the amount of matter that the object contains.
  - **Weight** is a measure of the force of gravity on an object.
  - **Two types of matter → Inorganic & Organic Matter.**

- Matter Conversions & Chemical Changes:
  - Ice → water → gas
  - Burning wood.
  - Nuclear reaction in the Sun.
  - Eating food to access stored energy.
  - Solid → Liquid → Gas

- Matter exists in three different physical states:
  - Solid → rigid, definite shape, & incompressible..
  - Liquid → flows and takes the shape of its container (but levels off at the top). Incompressible.
  - Gas → Takes the shape and volume of a container. Compressible and expandable.

- Evaporation: L → G
- Melting: S → L
- Freezing: L → G
- Condensation: G → L *found on mirror after shower*
- Sublimation 1: G → S *frost*
- Sublimation 2: S → G *air freshener, dry ice*
- S → L → G. Heat is required. (Endothermic)
- G → L → S. Heat is released. (Exothermic)

⇨ The behaviour of matter may also be explained.
- All matter is made up of tiny particles (atoms).
- All the particles in a substance are the same; different substances are made of different particles.
- There are attractive forces among particles.
- The particles are always moving; the more energy the particles gain, the faster they move.
- There are spaces among particles.

⇨ **Energy** → The capacity for doing work, where **work** is the process of causing matter to move against an opposing force.
- Pumping air into a tire → Force of air in tire.
- Pulling a cart → Force of friction.
- Jumping in the air → Force of gravity.

⇨ Energy exists in different forms (like matter does).
- **Potential Energy** → Stored energy in chemical bonds. The *potential* to do work.. An object on a table has the potential to fall down, so it has potential energy.
  - Students have the potential to do very well in Science 9.
- **Kinetic Energy** → Energy an object has because of its motion. Like a moving car, a bullet, or a person.
  - Very important in chemical/nuclear reactions; if atoms do not have enough kinetic energy when they meet, they may bounce off each other and not change form.

⇨ Law of Conservation of Matter
- During a chemical change, there is no detectable increase or decrease in the total quantity of matter from that initially present.

- ⇨ Law of Conservation of Energy
  - During an ordinary chemical change, energy can be neither created nor destroyed, but it can be converted into another form.

- ⇨ **The total quantity of matter and energy available in the universe is fixed.**

Properties of Matter

- ⇨ The characteristics used to distinguish one substance from another are known as **properties**.

- ⇨ **Chemical properties**: The way one kind of matter transforms into another kind.
  - Hydrogen forms with oxygen to make water.
  - Iron reacts with oxygen and water to form iron oxide → rust.
  - Chromium, however, does not rust.

- ⇨ **Physical properties**: Characteristics that do not involve a change in the chemical identity of the matter.
  - Colour, hardness, freezing point, melting temperature, boiling temperature, electrical conductivity, taste, crystal structure, odour, solubility, and density.

- ⇨ Matter can be classified as a mixture or a pure substance.
  - Pure substances have definite properties that are always the same (melting, boiling point; water, hydrogen peroxide; rust, salt). Distilled water is an example.
  - Mixtures consist of two or more pure substances.
    - Mechanical Mixtures → you can see the different parts of the solution (concrete, soil, pizza, and cereal are examples.)
    - Solutions → The mixture appears to be all one substance. (coffee, pop, salt water, and ketchup are examples.)

- ⇨ Worksheet handout.
- ⇨ More on mixtures handout.
- ⇨ Solutions Handout.

Pure Substances

- Made of Elements
  - Particles that cannot be broken down into any simpler substances.

- Compounds
  - Pure substances that contain two or more elements.
  - There are over one hundred elements, so many thousands of compounds can be made.

- Each element has its own set of unique properties.
  - Gases, liquids, metals.
  - Common, rare.
  - Safe, explosive, radioactive, or poisonous.

The Atom

- The smallest amount of an element possible is one atom. There are 109 named element → 109 different kinds of atoms (1 for each element).

- Two main regions in an atom:
  - Nucleus → The centre part which contains 2 types of particles.
    - Protons → Have a positive charge (represented by: p+).
    - Neutrons → Have no charge (represented by: n).

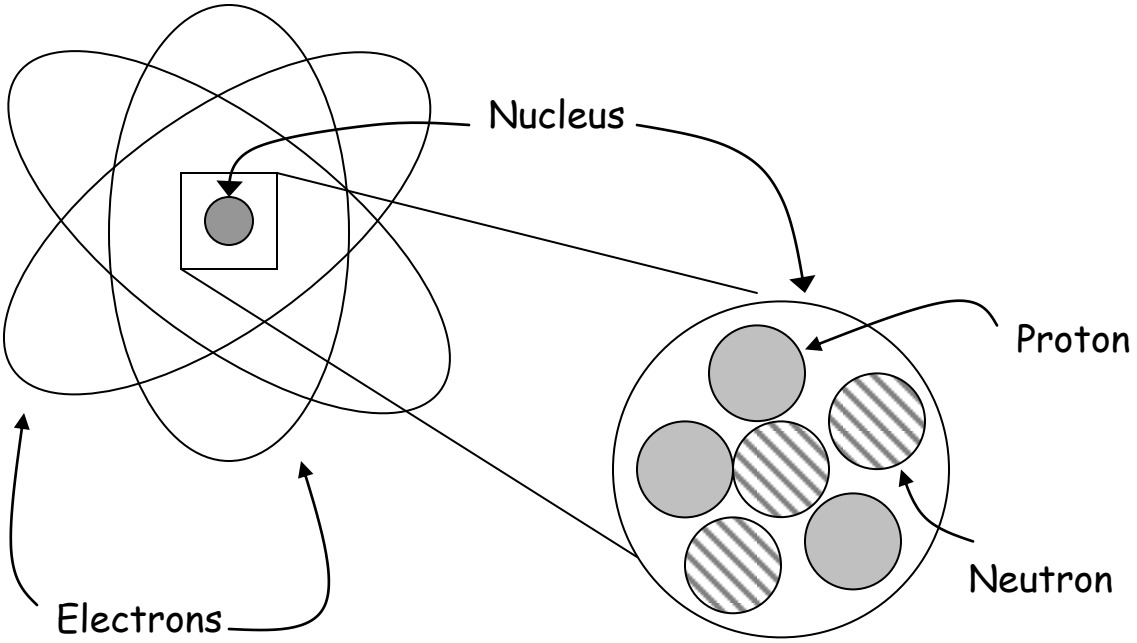
  - The electron cloud.
    - Region of empty space in which the electrons are orbiting the nucleus.
    - An electron has a negative charge (e-)

- Protons and Neutrons are made up of even tinier particles called quarks.
  - Quarks have been discovered only within the last forty years (Compared to hundreds of years of knowing about protons and neutrons).
  - There are 6 types of quarks → suggesting that they may also be made of an even smaller particle! We have yet invented a technology to find them.

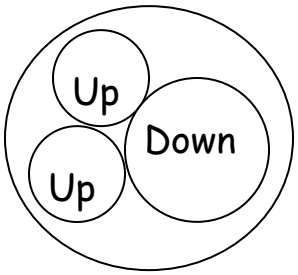
- Protons and Neutrons are made up two quarks called the *Up* and *Down* quarks (which have mass).
- The *Up* quark has a charge of +2/3 of that of a regular proton (or the positive value of the electron charge).
- The *Down* quark has a charge of –1/3 of that of a regular proton.
- The *Down* quark has twice as more mass than the *Up* quark.
- Nature keeps things as simple as possible. The proton is made up of two *Up* quarks and one *Down* quark.
- The neutron is made up of two *Down* quarks and one *Up* quark.

⇨ The entire atom is neutral in charge, therefore the number of protons and electrons are equal.

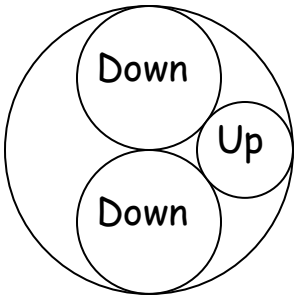
<u>Diagram</u>



Proton → +1 Charge



Neutron → 0 Charge



Up Quark = +2/3 Charge
Down Quark = –1/3 Charge

- The atoms of certain elements always exist with a partner in nature (they are never alone). They are called *diatomic elements*. There are seven of them:
  - N_2, O_2, F_2, Cl_2, H_2, Br_2, & I_2.

- During chemical reactions an atom may gain or lose electrons. The atom is no longer neutral and is now called an *ion*.

Atomic Theory

- All matter is made up of tiny particles called *atoms*.

- Atoms of one element are like one another and are different from atoms of another element.

- Atoms may combine with other atoms to form larger particles called *molecules*.

- Atoms are not created nor destroyed by any ordinary means (but the are created in the centre of the Sun and during Supernovae).

- Some molecules contain only one kind of atom; these are molecules of an **element**.

- ⇨ Other molecules contain different kinds of atoms. **Compounds** are molecules that contain different kinds of atoms.

- ⇨ There are 2 different kinds of pure substances:
  - Compounds – Contain two or more elements combined in a definite fixed proportion.
  - Elements – Cannot be broken down into any simpler substances.

- ⇨ Two or more elements combine during a chemical reaction to form a completely new pure substance that has new properties. (a compound)
  - Na – soft, white metal & Cl – Yellow, poisonous gas combine to form NaCl (sodium chloride) = salt.
  - C – black, brittle, nonmetal + O_2 – odourless, colourless gas + H2 – odourless, colourless gas combine to form:
    - $C_6H_{12}O_6$ = sugar.

- ⇨ Compounds are represented by formulae → CO_2, H_2O,

- ⇨ Elements are represented by symbols → Na, Sn, C.

- ⇨ Element = Atom = Symbol

- ⇨ Compound = molecule = formula

- ⇨ Read up to page 15 then do Activity 1 – 5.

The Periodic Table

- ⇨ Handout Periodic Table

- ⇨ Handout the "A Very Special Table" sheet.

- ⇨ Consists of 7 horizontal rows called periods.
- ⇨ Vertical rows are called groups. The elements in a certain group have similar chemical characteristics.

- ⇨ Noble Gases
  - Most right-hand vertical column.
  - He, Ne, Ar, Kr, Xe, Rn.
  - All these elements are extremely stable which means they rarely *bond* to any other atoms.
  - Make up 6 of the 11 gases found at S.T.P. (standard temperature and pressure → 0°C, 101.3 kpa).
  - Called *inert gases* due to a very stable electron configuration.

- ⇨ Alkali Metals
  - These are the six elements following the Noble gases. They are found in the most left-hand column of the Periodic Table.
  - Li, Na, K, Rb, Cs, Fr.
  - Bright shiny metals.
  - They conduct electricity well.
  - React vigorously with Chlorine, Sulfur, and water.

- ⇨ Halogens
  - All of these are found in the group second from the right.
  - F, Cl, Br, I, At.
  - All of the halogens are non-metals.
  - All form stable diatomic molecules → *Students fill in.*
  - React readily with sodium, calcium, and hydrogen.

Metals vs. Non-Metals

- ⇨ The heavy step-like line on the Periodic table separates the metals from the non-metals.
- ⇨ Based on electrical conductivity and thermal conductivity.
- ⇨ Metals tend to lose electrons easily.
- ⇨ Their metallic character tends to decrease as we move right across the Periodic table and it tends to increase as we move down the periodic table.

Properties	Metals	Non-Metals
State (@ STP)	Solids (except Hg)	Solids, liquids, & gases
Luster	Bright & Shiny	Dull
Conductivity	Good	Poor…Brittle

Hydrogen

- ⇨ A family by itself.
- ⇨ It has similarities to both the halogens and the alkali metals.
- ⇨ Handout Atomic Structure Worksheet
- ⇨ Handout Element word search.
- ⇨ Handout Work-Sheet II
- ⇨ Common Ions & Ion Examples Worksheet

Physical & Chemical Change

- Substances do not always stay as they are but may change as conditions change.
  - A change in which no new substance is made is a physical change.
  - This occurs when atoms or molecules are forced into different positions.
  - Eg → Change of state.
  - Chemical change occurs when one or more new substances are produced. These new substances have different properties than the original substances. This occurs when atoms join (or separate) to form new molecules.
  - "get new partners" = get new molecule or substance.
  - Eg. → Rotting food, burning a canle

- We know a chemical change is taking place if:
  - New colour.
  - Heat/light is given off.
  - Bubbles of gas given off.
  - Solid (precipitate) forms in liquid.

- Are the following chemical or physical changes?
  - Frying an egg.
  - Freezing a banana.
  - Cutting paper.
  - Acid on a jacket.
  - Crushing a rock.
  - Baking a cake.
  - Toasting bread.
  - Firing a gun.
  - Burning wood.
  - Drying clothes.
  - ENO in water.
  - Using a battery.

- Chemical Change Word Search

Reactants & Products

- Another term for chemical change is chemical reaction. In every reaction there is something used up and something produced.
  - Any substance that is used up is a reactant.
  - Any substance that is produced is a product.

- A word equation gives the names of all the reactant, separated by a plus sign, then an arrow which points to the products (which are also separated by plus signs).

- Examples
  - Copper(II) sulphate + iron → iron(II) sulfate + copper
  - Hydrogen + Oxygen → Water

- In many chemical reactions energy (in the form of heat) is absorbed or released.
  - Exothermic → Release of heat. → Nuclear Fusion/Fission.
  - Endothermic → Absorption of heat. → Cooking Food.

Rates of Reactions

- The speed of a chemical reaction is called the reaction rate.

- The rate may be influenced by:

  - *Temperature* → Temperature is a source of energy. Particles are moving around in random motional all the time, called Brownian Motion, and may only react with one another if the temperature is right.
    - Higher temperature usually means more particles have enough energy to react, and the rate will be higher. (cooking meat)
    - Cold temperatures usually hinder chemical reactions. "Cold" atoms have less energy, so the reaction rate is low (dead car batteries)

  - *Surface area* → The closer the contact of substances that react together, the faster the rate of reaction. (grain elevator explosions, acid on an eraser?

  - *Concentration* → The amount of solute in a solution. If the concentration of a certain substance is low, there may not be enough of it to react with another substance. (acids)

Acids & Bases

- ⇨ These are a unique group of compounds with special properties.

- ⇨ Acids
  - All contain the hydrogen ion, H+.
  - HCl → Hydrogen Chloride (Hydrochloric Acid).
  - H_2SO_4 → Hydrogen Sulfate (Sulfuric Acid).
  - HNO_3 → Hydrogen Nitrate (Nitric Acid).
  - $HC_2H_3O_2$ → Hydrogen Acetate (Acetic Acid).
  - Taste sour → Citric Acid.
  - Corrosive, especially on metals.
  - Soluble in water.
  - Neutralize base to form water and salt.
    - $HCl + NaOH \rightarrow H_2O + NaCl$
  - Affect indicators – a substance that tells or indicates the presence of an acid by colour change.
    - Red and blue litmus paper

- ⇨ Bases
  - Most contain hydroxide ion (OH^-) or ammonia (NH_3)
    - $NaOH$, $Ca(OH)_2$
  - Tastes bitter.
  - Corrosive.
  - Soluble in water.
  - Neutralize acids for form salt and water.
  - Affects indicators:
    - Red litmus (acid)red (base)blue
    - Blue litmus (acid)red (base)blue

- ⇨ The strength of acid and bases vary, therefore a measurement is needed. A number scale called the <u>pH scale</u> is used.

- ⇨ The scale is numbered from 0 – 14, zero being the most acidic, and 14 the most basic. The scale is logarithmic → means a pH of 1 is ten times more acidic than a pH of 2. A pH of 2 is ten times more acid than a pH of 3.
  - pH < 7 → acidic.
  - pH > 7→ base.
  - pH = 7 → neutral (pure water)

- ⇨ Example Questions:
  - Which is a stronger acid? pH of 3 or 5? pH of 9 or 12?
  - Which is a stronger base? pH of 2 or 4? pH of 7 or 13?
  - Which is the stronger acid, and by what factor? pH of 4 or 5?
  - Which is the stronger acid, and by what factor? pH of 2 or 5?