The Scientific Endeavour

What is Science?

Science is a study of the natural phenomena in the world.

a) Show an awareness that Science is not confined to the laboratory, but is manifested in all aspects of our lives
b) Show a healthy curiosity about the natural phenomena in the world
c) Show an appreciation of Science being a human endeavour, with scientific knowledge contributed by different civilisations over the centuries

d) Describe and apply the Scientific Method

Science is the study of natural physical phenomena in the world.

We learn science through different behaviours of living thighs through different properties of materials, to explore one part of the body affects the other

Construction of Scientific Knowledge

A scientific breakthrough is not usually achieved by one scientist alone.

It takes the combined efforts of many scientists over many years to build the scientific knowledge we have today.

Scientific knowledge is thus subject to changes as new observations are made and new evidence is found.

What is the Nature of Scientific Knowledge?

Scientific knowledge is reliable, durable, and open to change when new evidence is presented.

a) Recognise that scientific evidence can be quantitative or qualitative, and can be gathered through one's senses or instruments as extensions of one's senses

b) Show an understanding of how scientific knowledge is built from systematic collection, and analyses of evidence and rigorous reasoning based on the evidence

c) Show an awareness that scientific evidence is subject to multiple interpretations

Scientists often carry out experiments in a controlled setting. Scientists use equipment, apparatus and computers to make accurate measurements.

Qualitative Data	Quantitative Data
Usually descriptive and based on language and interpretation. Example: 5 Senses Sight > Colour Hearing > Sound Touch > Texture Smell > Odour Taste > Taste	Usually numerical (countable, measurable) and objective. ● Numerical quantities and units ● Without units the numbers does not have any value in measurements Examples: ● Time in s, min, h ● Length in mm, cm, m, km

Physical Quantity	Measuring Instrument	SI Unit	Other units	Sample Reading
Length	Digital Calipers Ruler Measuring Tape	m	mm cm	3.574 cm 5.0 cm 1.438 m
Time	Digital Stopwatch	s	min	3 min 46.35s
Mass	Electronic Mass Balance	kg	g	34.58 g
Volume of liquid	Measuring Cylinder Pipette Burette	m^3	cm^3	15.5 cm^3
Temperature	Laboratory Thermometer	K	°C	100.0 °C
Weight	Spring Balance / Newton meter	N		14.5 N

The above picture shows the Measurable Physical Quantities.

Deprived Physical Quantities

Physical Quantity	Formula	Unit
Volume of Regular Solids	Cylinder: $\pi r^2 h$ Cube: r^3 Cone: $1/3\pi r^2 h$ Sphere: $4/3\pi r^3$	cm^3
Density	Mass / Volume	g/cm^3 kg/m^3
Average Density	Total Mass / Total Volume	g/cm^3 kg/m^3
Average Speed	Total distance / Total time	m/s km/h
Acceleration	Velocity / Time	m/s^2
Work Done	Force x Distance	J

How do We Practice Science?

The practice of Science is influenced by our values and attitudes.

a) Use scientific inquiry skills such as posing questions, planning, and carrying out investigations, evaluating experimental results and communicating findings (Estimation and measurement skills, knowledge of SI units, and using appropriate units for the respective physical quantities, should be infused into the respective topics)

b) Show an understanding that **accuracy** refers to the closeness of agreement between a measured value and the true value of what is being measured

c) Show an understanding that **precision** of measurement refers to the closeness of agreement between measured values obtained by repeated measurements

d) Identify zero error as the condition where the measuring instrument registers a reading when there should not be any reading

e) Identify parallax error as an error in reading an instrument as a result of not viewing the measurement scale from the correct position

f) Show an understanding that measurement errors may exist due to errors that are either unpredictable (e.g. human reaction time error, non-uniform room temperature) or consistent

Practising science involves demonstrating ways of thinking and doing.

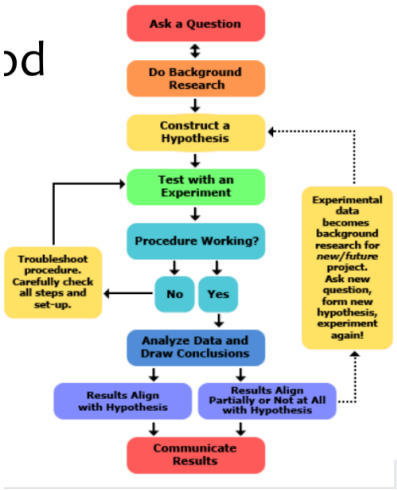
➢ Posing questions and defining problems (Observation – using 5 senses)

➢ Designing scientific investigations (**Hypothesis** and variables)

➢ Conducting **experiments** and testing solutions – **collecting data** with scientific instruments (Measurements – Accuracy, precision and errors; errors that are consistent and unpredictable)

➢ **Developing explanations and solutions**

➢ **Evaluating, reasoning and communicating**



- The Scientific Method is a systematic and iterative process to guide anyone in finding solutions to a problem by validating observations while minimizing observer bias.

- There is a constant feedback loop that reminds the observer to return to a previous step to troubleshoot the procedure and verify the experimental data.

Writing Hypothesis (Important)

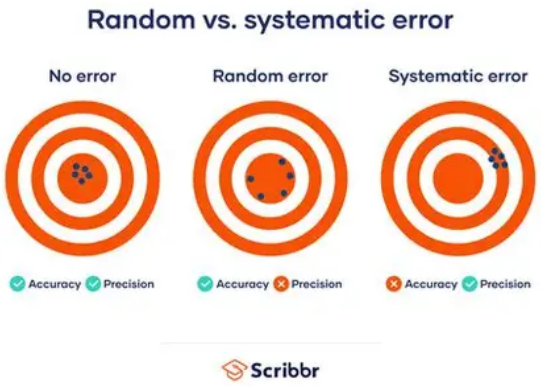
- How to write a Hypothesis?
- Firstly, determine the **independent variable** (cause) and **dependent variable** (effect).
- A hypothesis is an **educated guess** stating how the dependent variable and independent variable are related.
- A hypothesis need not be factually correct.

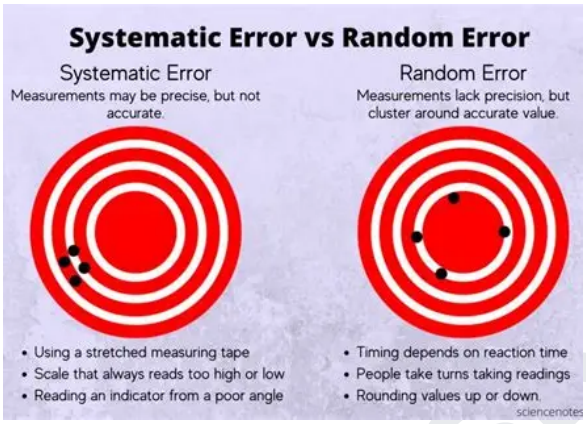
Errors (Important Concept)

Categories of Errors

There are 2 categories of errors: **Systematic Error** and **Random Error**.

- **Systematic error** is consistent, repeated error that can be completely removed.
- **Random error** is fluctuating, unpredictable error that cannot be completely removed.

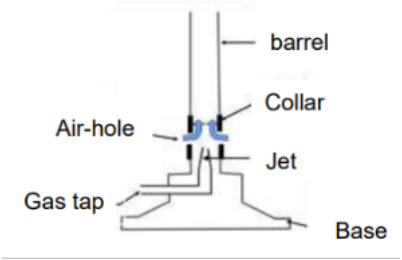




Difference between Random Error and Systematic Error

Systematic Error	Random Error
Error caused by Instrument E.g. Zero Error on an electronic mass balance – to remove this error, just press the TARE or RE-ZERO button.	Error caused by Environment E.g. Inconsistent air temperature in a room/space – to reduce this error, take several readings then find average reading.
Error caused by Observer E.g. Parallax Error when reading the liquid level on a measuring cylinder – to remove this error, place the eye at the same level as the meniscus.	Error caused by Observer E.g. Human Reaction Time Error when someone tries to start and stop the stopwatch – to reduce this error, take several readings then find average reading; or use a sensor to detect
Error caused by Environment E.g. Cell phone near a Geiger Counter which measures radiation will cause it to detect consistently higher than normal readings.	

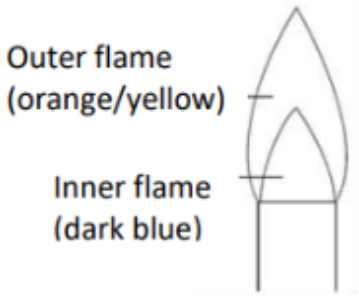
Bunsen Burner



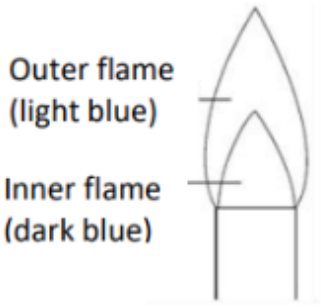
Parts of Bunsen burner	Function
Air-hole	To allow air to mix with the gas
Barrel	To direct the mixture of gas and air to the flame
Collar	To regulate the flow air into the barrel
Jet	To increase the pressure of gas entering the barrel so that air is drawn through the air hole
Gas tap	To provide supply of gas for burning
Base	To hold the barrel upright and in the correct position

Types of Flame (You need to memorise this)

Luminous flame is produced when the **air-hole is completely closed**



Non-luminous flame is produced when the **air-hole is not completely closed**

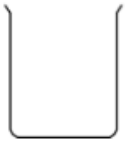
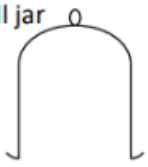


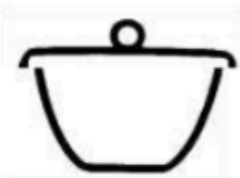
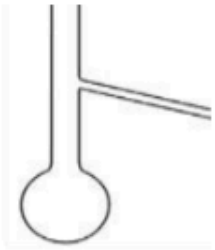
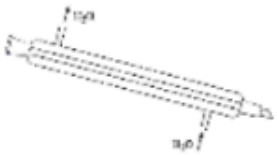
• Visible from afar	• Not visible from afar
• Produces soot (smoke / carbon particles deposit on apparatus)	• Does not produce soot
• Flame is unsteady	• Flame is steady
• Not hot enough for heating experiments	• Very hot – suitable for heating experiments
• Does not burn efficiently because of the incomplete combustion of fuel due to lack of oxygen	• Burns efficiently because of the complete combustion of fuel in excess oxygen
• Safety flame – used when a student wants to leave the place for a short time	• Cannot see the flame clearly so dangerous to leave the naked flame unattended even for a short time

Strike Back

What is a **strike back**? If the air hole is not closed when lighting a Bunsen Burner, striking back will happen.
You may see a flame inside the air hole and hear a strange noise.
If striking back happens, the first thing you should do is to **turn off the gas tap immediately, then inform your teacher.**

Other Laboratory Apparatus

Outline of Apparatus	Use	Outline of Apparatus	Use
(a) Beaker 	For containing chemicals or collecting and holding liquids	(b) Measuring cylinder 	For measuring the volume of liquids (to an accuracy of 0.5 cm^3)
(c) Burette 	For measuring the volume of liquid to an accuracy of 0.05 cm^3	(d) Pipette 	For measuring a specific volume of liquid (eg. 10.0 cm^3, 25.0 cm^3) to an accuracy of 0.1 cm^3
(e) Wire gauze XXXXXXXXXXX (min. 9 x)	**wire gauze** with ceramic centre to support a beaker or flask during heating. The ceramic centre helps to evenly spread the heat under the container	(f) Gas jar 	For collecting gases
(g) Bell jar 	To separate the set-up for an experiment from the surroundings	(h) Evaporating dish 	To evaporate a liquid in a solution over a Bunsen Burner

Outline of Apparatus	Use	Outline of Apparatus	Use
(i) Crucible 	For heating a solid directly over a flame	(j) Water trough 	For containing large amounts of water in the collection of a gas using the gas jar
(k) Filter funnel with filter paper*** 	To filter insoluble solids from a solid-liquid mixture	(l) Glass rod 	A **Glass rod**, stirring **rod** or stir **rod** is a piece of laboratory equipment **used to mix chemicals and liquids for laboratory purposes.**
(m) distilling flask 	The distilling flask is used to separate liquid **mixtures** by distillation. Distillation is the process of separating **mixtures** based on the difference in boiling points of the components of that mixture.	(n) Condenser (Lie-big condenser) 	Liebig condenser is used for condensing of **vapours** that pass through the centre tube. It is cooled with water that passes in the outer tube (shell around the centre tube) in the opposite direction than the one of hot **vapour**.

Safe Practices in Science (Must Know)

 Flammable e.g. benzene, methane	 Oxidising Substance e.g. chlorine, hydrogen peroxide, nitric acid, ozone
 Gases Under Pressure e.g. ammonia, liquid nitrogen, or acetylene.	 Explosives e.g. nitroglycerin, picric acid, azides
 Harmful / Irritant e.g. disinfectants, acids, caustic substances, glues, pesticides	 Corrosives e.g. sodium hydroxide, sulfuric acid, hydrochloric acid
 Acute Toxicity e.g. Bromine, chlorine, mercury compounds, barium chloride, poisons and highly concentrated acids	 Carcinogenicity / Aspiration Hazard e.g. Methanol, lead compounds.
 Environmental Toxicity e.g. arsenic, lead, nitrogen oxides, sulfur oxides, carbon monoxide, carbon dioxide, ozone, pesticides	