GCE (AL) GRADES (ශ්‍රේණිය) 12
CHEMISTRY (රසායන විද්‍යාව)

Unit 01: Atomic Structure
(ඒකකය 01 : පරමාණුක ව්‍යුහය)
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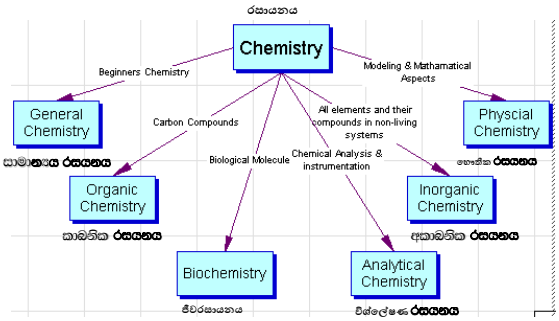
Grade 12 First Term (33 Periods)

Unit 01 Atomic structure	35
Unit 02 Structure and bonding	35
Unit 03 Chemical calculations	37
01 ඒකකය - පරමාණුක ව්‍යුහය	35
02 ඒකකය - ව්‍යුහය සහ බන්ධන	35
03 ඒකකය - රසායනික ගණනය	37

What is Chemistry?
රසායන විද්‍යාව යනු කුමක්ද?

Chemistry: Chemistry is a branch of science(විද්‍යාවේ ශාඛාවයි) dealing with studying composition **(**සංයුතිය**)**, structure(ව්‍යුහය), properties (**ගුණ**) and **non-reversible** (අප්‍රත්‍යාවර්ත**)** changes or transformations of matter.

Branches of Chemistry



General Chemistry (සාමාන්‍යය රසායනය)

Name the branch of chemistry that involves the study of all forms of matter (පදාර්ථය) and the **non-reversible** (අප්‍රත්‍යාවර්ත**) (chemical)** changes it undergoes with the emphasis on individual components of matter: atoms, molecule, ions (පරමාණු, අණු සහ අයන) and chemical reactions (**රසායනික ප්‍රතික්‍රියා**).

Ans. General Chemistry.

Inorganic Chemistry (අකාබනික රසායනය)

Name the branch of science that involves the study of forms of non living matter made up of **all other elements except carbon** and the **non-reversible chemical changes** (අප්‍රත්‍යාවර්ත රසායනික පරිවර්තනයන්) and transformations they undergoes with the emphasis on individual components: atoms, molecule, ions and chemical reactions.

Ans. Inorganic Chemistry.

Organic Chemistry (කාබනික රසායනය)

Name the branch of science that involves the study of forms of **matter containing carbon** and hydrogen compounds and their the **non-reversible chemical changes** (අප්‍රත්‍යාවර්ත රසායනික පරිවර්තනයන්), and transformations they undergoes with the emphasis on individual components of matter: atoms, molecule, ions and chemical reactions. **Ans. Organic Chemistry**.

Biochemistry (ජෛව රසායනය)

Name the branch of science that involves the study of compounds present in all living forms of matter and the the **non-reversible chemical changes** (අප්‍රත්‍යාවර්ත රසායනික පරිවර්තනයන්) and transformations they undergo with the emphasis on individual components of matter: atoms, molecule, ions and chemical reactions. **Ans. Biochemistry**.

(ජීවී පද්ධති වල රසායනය පිළිබඳ අධ්‍යයනය.)

What branch of science?

- Name the branch of science which involves the living matter as distinct from matter which is not living; the study of living tissue with the emphasis on the origin, structure, development, function, and distribution of animals and plants.
- **Ans. Biology (ජීව විද්‍යාව)**.
- Name the branch of science that study of matter and energy in a scale deals with matter on scales ranging from sub-atomic particles (i.e. the particles that make up the atom and the particles that make up *those* particles) to stars and even entire galaxies.
- **Ans. Physics (භෞතික විද්‍යාව)**.

What is the difference between Science & Technology?

The words science and technology can and often are used interchangeably.

But the **goal of science** is the pursuit of knowledge for its own sake

While the **goal of technology** is to create products that solve problems and improve human life. Simply put, technology is the practical application of science.

Which one is Science and Technology?

Physics vs. **Civil Engineering**

Biology vs. **Medicine**

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Which one is Science and Technology?

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Biology vs. **Medicine**

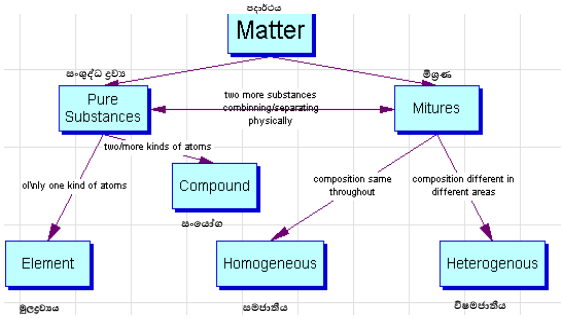
What is Matter & Energy?

- **Matter(**පදාර්ථය**)** : Anything that has mass and volume is matter.
- **Energy(**ශක්ති**):** Matter release or absorb energy during their changes. It comes in different forms - heat (thermal) තාපය (තාපජ), light (radiant), mechanical, electrical, chemical, and nuclear energy- ආලෝකය (විකිරණ), යාන්ත්‍රික, විද්‍යුත්, රසායනික හා න්‍යෂ්ටික බලශක්ති.. Energy is in everything.

What is Matter & Energy?

- 1g of sugar,
- 1g of sugar produces 200 Kcal,
- mole of O_2 gas occupies 22.4 L at STP

Hierarchy of Matter



1.1 Review:. (4 Periods)

- Properties of cathode rays and positive rays
- Introduction to atom and sub atomic particles
- Thomson, Rutherford models
- Atomic number and mass number
- Isotopes
- Nuclides
- Types of nuclides

1.1 models of atomic structure. Learning outcomes (6 periods)

- Compare the properties of cathode rays and positive rays in brief.
- Describe the atom and subatomic particles using previous knowledge.
- Describe the Thomson's and Rutherford's models (gold leaf experiment).
- Review the atomic number and mass number.
- Explain isotopes using examples
- Classify the nuclides according to their nature.
- Appreciate the attempts made by scientists in understanding nature.

Dalton's atomic theory of matter

a) Atoms are small, discrete, indivisible pieces of matter.
b) All elements are made up of particles called atoms.
c) An element's atoms are **identical** in size, mass, and chemical properties.
- Scientists did not know about **isotopes**.
  - **Isotopes are elemental atoms that differ in their mass due to different number of neutrons.**

d) Molecules (compounds) are formed when two or more elements are combined.
e) Molecules are simple whole-number ratio combinations of the combined elements.

Models commonly used to describe atoms, molecules and matter

• **Atom (**පරමාණුව**)** - The smallest unit of an element that has all of the properties of an element.

• **Molecule (**අණුව**)** -The smallest unit of a pure substance that has the properties of that substance. It may contain more that one atom and more than one element.

• **Ions** (අයන)- Charged particles formed by the transfer of electrons between atoms or molecules

• **Nuclide (**නියුක්ලයිඩ**)** (න්‍යෂ්ටිකාව)

a distinct kind of atom or nucleus(න්‍යෂ්ටිය) characterized by a specific number of protons and neutrons.

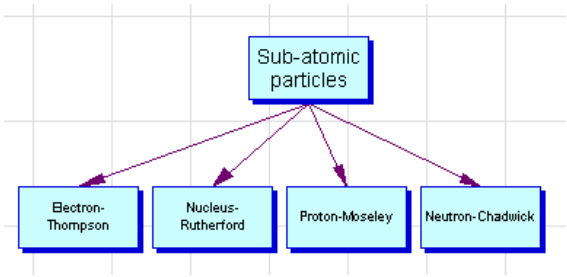
Early Experiments for Sub Atomic Particles

a) J.J. Thomson's cathode ray tube experiments: Discovery of electrons

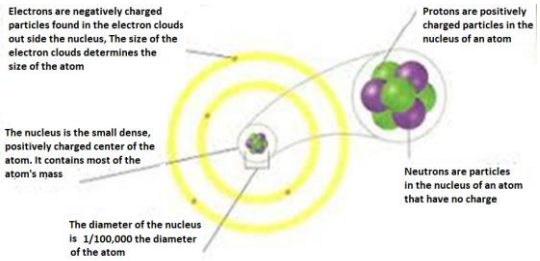
b) Robert Millikan's oil drop experiments: Discovery of electronic charge

c) Rutherford's α -particle experiments: Discovery of nucleus and protons

d) Chadwick's bombardment of ^{9}Be with α-particles: : Discovery of neutrons



Sub Atomic Particles



Discovery of the Electron and Its Properties

- **Discovery of electron and its charge**
  - J.J. Thomson's charge to mass ratio experiment using cathode rays.
    - Thomson believed that these particles were one of the fundamental building blocks of matter.
    - These cathode ray particles became known as **electrons**.
  - Robert Millikan's oil drop experiment
    - showed that the particle had the **same amount of charge as the hydrogen ion but negatively charged** as Thomson observed in his experiments.

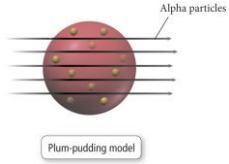
Discovery of Electron

- **J.J. Thomson's charge to mass experiment** investigated the effect on a cathode ray when placing an electric field around a tube.
  1. Charged matter is attracted to an electric field.
  2. Light's path is not deflected by an electric field.
- Cathode rays are made of tiny particles.
  - These particles had a negative charge because the beam always deflected toward the (+) plate.
- The amount of deflection was related to the charge and mass of the particles.
  - The charge–mass (e/m) ratio of these particles was $(-)1.76 \times 10^{8}$ C/g.
  - The electron has a charge of -1.60×10^{-19} C.
  - The electron has a mass of 9.1×10^{-28} g.
  - Electrons are particles found in all atoms. One of the fundamental pieces of matter

J.J. Thomson: The Plum Pudding Model of the Atom

J.J. Thomson (plum pudding model)

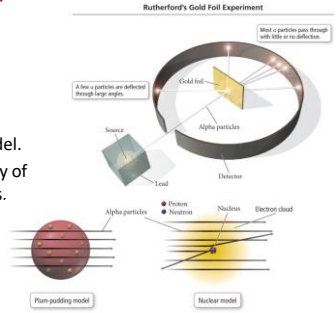
- The atom is composed of a positive cloud of matter in which **electrons** are embedded.
  - Explains the positive (+) and negative (–) charged behavior of matter



Rutherford's Gold Foil Experiment

රදර්ෆර්ඩ් ආකෘතිය :රන්පත් පරීක්ෂාව

- Gold foil experiment
  - could not explain Thomson's plum pudding atom model.
  - led to the discovery of the atom's nucleus.



Rutherford's Gold Foil Experiment- රදර්ෆර්ඩ් ආකෘතිය :රන්පත් පරීක්ෂාව : Discovery of the Nucleus

- From the gold foil experiment the following conclusions were proposed:
  - The atom contains a tiny dense center called the **nucleus**.
  - The nucleus has essentially the entire mass of the atom.
- The electrons weigh so little that they give practically no mass to the atom.
  - The nucleus is positively charged.
- The amount of positive charge balances the negative charge of the electrons.
- The electrons are dispersed in the empty space of the atom surrounding the nucleus.

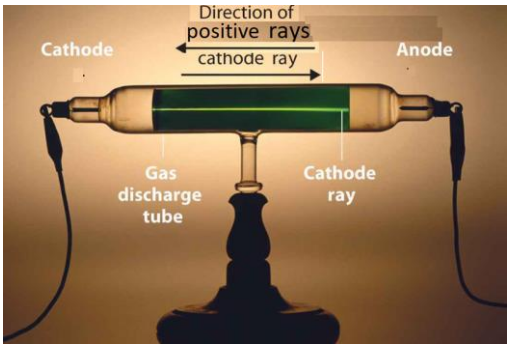
Charge and Mass Characteristics

(පරමාණුක අංශුන් **ගේ** ආරෝපණ හා ස්කන්ධ ගුණ)

	Electron	Proton	Neutron
Charge	−1	+1	0
Actual mass (g)	9.109×10^{-28}	1.673×10^{-24}	1.675×10^{-24}
Relative mass (based on the electron being 1 unit)	1	1837	1839

27

Properties of cathode rays and positive rays



Atomic number (පරමාණුක ක්‍රමාංකය) and mass number (ස්කන්ධ ක්‍රමාංකය).

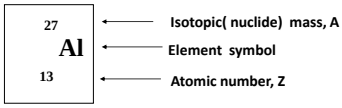
- The **atom number** (symbol Z), also called **atomic number**, is the total **number** of protons in an **atomic** nucleus.
- The **mass number** (symbol A), also called **atomic mass number** or nucleon **number**, is the total **number** of protons and neutrons (either known as nucleons) in forming an **atomic** nucleus. **Mass number** determines the **atomic mass** of an **atom**.

Isotopes (සමස්ථානික)

Two or more atoms of the same element that contain equal numbers of protons but different numbers of neutrons in their nuclei, and hence differ in relative atomic mass but not in chemical properties which is determined by the atomic number

Isotopes: Same Element but with Different Masses

- Isotopes are elements whose atoms differ in mass due to varying numbers of neutrons.
  - They are the same element because they have the same number of protons (atomic number).
  - They are chemically identical.
- Isotopes are identified by their **mass numbers**.
  - Protons + neutrons = mass number
- Isotopic symbol



Nuclide symbol:

$${}^{A}_{Z}E$$

E – Elemental Symbol
Z-- atomic Number
A- Mass Number

E.g: Isotopes

$^{1}_{1}$H (Hydrogen), $^{2}_{1}$H (Duterium), $^{3}_{1}$H (Tritium♂)
$^{12}_{6}$C Carbon-12, $^{13}_{6}$C Carbom-13, $^{14}_{6}$C Carbon-14

How many protons, electrons, and neutrons are in the following atoms?

	Protons	Electrons	Neutrons
1. $^{32}_{16}$S			
2. $^{65}_{29}$Cu			
3. U-240			

How many protons, electrons, and neutrons are in the following atoms?

	Protons	Electrons	Neutrons
1. $^{32}_{16}$S	**16**	**16**	**16**
2. $^{65}_{29}$Cu	**29**	**29**	**36**
3. U – 240	**92**	**92**	**148**

Note: Neutral atoms will have the same number of protons as electrons.

Problem: Complete the following table:

Protons	Neutrons	Electrons	Atomic Number	Mass Number	Isotopic Symbol
6	7				
		42		96	
					$^{27}_{13}$Al
			55	133	

Answer:

Protons	Neutrons	Electrons	Atomic Number	Mass Number	Isotopic Symbol
6	7	**6**	**6**	**13**	$^{13}_{6}$C
42	**54**	42	42	**96**	$^{96}_{42}$Mo
13	**14**	**13**	**13**	**27**	$^{27}_{13}$Al
55	**78**	**55**	55	133	$^{133}_{55}$Cs

Isotopes and Relative Atomic Mass of an Element

- What is the connection between an element's isotopes and its atomic mass?
  - The observed mass of an element is a weighted average of the weights of all the naturally occurring atoms.
    - Average mass = **atomic weight** (amu)
- What information is needed to determine the atomic mass of an element?
  - The natural abundance of each of the element's isotopes
    - The percentage of an element that is one isotope is called the isotope's **natural abundance**.
  - Example problem
    - Boron has two isotopes.
      - Boron is 19.9% ^{10}B and 80.1% ^{11}B.
    - Boron atomic weight
      = 0.199 (10.0 amu) + 0.801 (11.0 amu) = 10.8 amu

Problem:
Calculating an element's Relative atomic mass

The element silver (Ag) has an atomic mass of 107.868 amu. It has two isotopes—Ag-109 (108.905 amu) with an abundance of 48.1600% and Ag-107. Determine the amu for Ag-107.

Answer:
Calculating an element's atomic mass

The element silver (Ag) has an atomic mass of 107.868 amu. It has two isotopes—Ag-109 (108.905 amu) with an abundance of 48.1600% and Ag-107. Determine the amu for Ag-107.

Problem Strategy:
1. Set up an algebraic equation.
2. Solve for *x*, which is the amu for Ag-107.

Answer:
1. Set up an algebraic equation.

(0.481600) 108.905 amu + *x* (0.518400) = 107.868 amu

2. Solve for *x*, which is the amu for Ag-107.

52.4490 amu + 0.518400*x* = 107.868 amu
0.518400 *x* = 55.4180 amu
x = **106.905 amu**

Ions are Charged Atoms

- **IONS** are atoms or groups of atoms with a positive (+) or negative (–) charge.
- **Taking away** an electron from an atom gives a **cation** with a **positive charge**.
  - More protons in nucleus versus electrons surrounding nucleus
  - **Metals** tend to form cations to achieve the "full shell" look.
- **Adding** an electron to an atom gives an **anion** with a **negative charge**.
  - Fewer protons in the nucleus versus electrons surrounding nucleus
  - **Nonmetals** tend to form anions to achieve the "full shell" look.