SS1 CHEMISTRY

First Term

Thomas A. Edison

"I believe that the science of chemistry alone almost proves the existence of an intelligent creator."

Compiled By Prosper Nwonu

SS1 FIRST TERM SCHEME OF WORK

WEEK	TOPIC	CONTENTS
1.	**INTRODUCTION TO CHEMISTRY**	- Meaning of chemistry, - Branches of Chemistry - Career prospects tied to chemistry - Applications and ill effects of chemistry - Scientific method - Steps in experimentation
2.	**CHEMICAL INDUSTRIES**	- Definition - Types of chemicals; i) Heavy chemicals ii) and fine chemicals - type/classes of chemical industries careers for chemists in chemical industries - importance - environmental impact and minimizing the environmental impact of chemical industries - raw materials, recycling
3.	**CHEMICAL INDUSTRIES**	Excursion to chemical industries
4.	**MATTER**	- Definition of matter - Properties of matter - Physical and chemical changes - Classes of matter; elements, compounds and mixtures
5.	**SEPARATION TECHNIQUES**	- Sieving, - Magnetic separation, - Sublimation, - Decantation, - Filtration, - Evaporation to dryness, - crystallization,
6.	**SEPARATION TECHNIQUES CONT.**	- Distillation - Separating funnel - Chromatography - Pure and impure substances - Tests for purity
7.	**PARTICULATE NATURE OF MATTER**	- Atoms: Subatomic particles - Molecules: atomicity - Ions: types, radicals

		- Phenomena supporting the particulate nature of matter - Daltons atomic theory and modifications
8.	**PARTICULATE NATURE OF MATTER**	- Atomic structure (I); arrangement of electrons, protons and neutrons in an atom, atomic number and mass number. - Electronic configuration
9.	**PARTICULATE NATURE OF MATTER**	- Elements and symbols, valency chemical formulae, IUPAC naming - Relative atomic mass and isotopy - Relative molecular mass and percentage composition
10.	**PARTICULATE NATURE OF MATTER**	- Mole concept, - Empirical formula
11.	**REVISION**	- Revision
12.	**EXAMINATION**	- Examination
13.	**EXAMINATION**	- Examination

WEEK 1: Introduction to Chemistry
what is chemistry?
This is the study of matter; its properties, composition, uses and changes it undergoes

Branches of Chemistry

The study of modern chemistry has many branches, but it can generally be broken down into five main disciplines, or areas of study:

- Physical chemistry
- Organic chemistry
- Inorganic chemistry
- Analytical Chemistry
- Biochemistry

Physical Chemistry
Physical chemistry is the study of macroscopic properties, atomic properties, and phenomena in chemical systems. A physical chemist may study such things as the rates of chemical reactions, the energy transfers that occur in reactions, or the physical structure of materials at the molecular level.

Organic Chemistry
Organic chemistry is the study of compounds containing carbon. Carbon is one of the most abundant

elements on Earth and is capable of forming a tremendously vast number of chemicals (over twenty million so far). Most of the chemicals found in all living organisms are based on carbon.

Inorganic Chemistry

Inorganic chemistry is the study of chemicals that do not, in general, contain carbon. Inorganic chemicals are commonly found in rocks and minerals. One current important area of inorganic chemistry deals with the design and properties of materials involved in energy and information technology.

Analytical Chemistry

Analytical chemistry is the study of the composition of matter. It focuses on separating, identifying, and quantifying chemicals in samples of matter.

Biochemistry

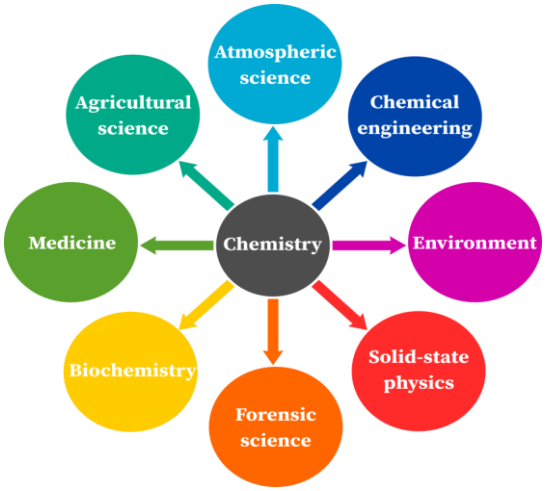
Biochemistry is the study of chemical processes that occur in living things. Research may cover basic cellular processes up to understanding disease states so better treatments can be developed.

Career Prospect Tied To Chemistry

- Analytical Chemist.
- Chemical Engineer.
- Chemistry Teacher.
- Forensic Scientist.
- Geochemist.
- Hazardous Waste Chemist.
- Materials Scientist.
- Pharmacologist. Etc.

Applications and Adverse Effects of Chemistry

Applications



- **Food**: Chemistry is used to increase food production by the use of fertilizer and insecticides, preservation and addition of essential nutrients to improve the quality of food
- **Clothing**: Textile fibers are produced by chemical research
- **Housing**: Cement, concretes, bricks, tiles and roofing sheets are produced by chemical processes
- **Medicine**: Chemical research is employed in the production of drugs and medicines
- **Transportation**: Fuels and structural materials like alloys which are light, strong, and heat resistant are produced by chemical processes

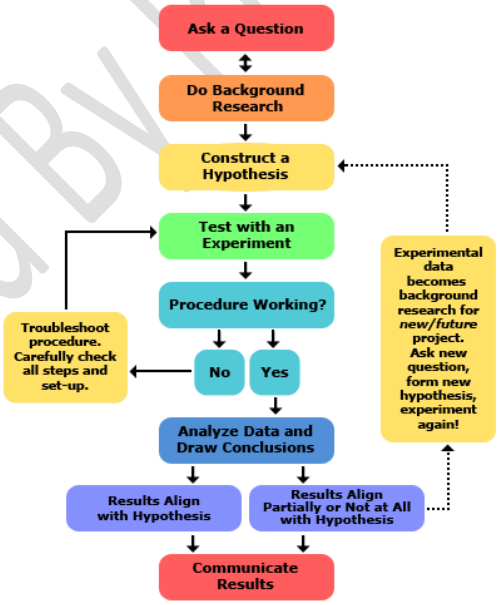
Adverse effects

1. Drug Abuse: Many drugs like cocaine, morphine, heroin, etc.; when abused (wrongly used) can cause damage to the body.
2. Pollution: One of the main adverse effects of chemical industries is the pollution of the environment by:

- Chemical wastes from chemical and petrochemical industries.
- Crude oil spillage, exhaust from motor vehicles.
- Plastic containers - They are not biodegradable (not decomposed by bacteria) thereby causing soil pollution.

The Scientific Method

This is the scientific and systematic way in which scientists do work.



Steps in experimentation

1. Aim
2. Requirements or apparatus
3. Procedure or method
4. Results
5. Conclusion

Assignment 1

Define the following terms

1. Hypothesis
2. Theory
3. Law

WEEK 2: Chemical Industries

A chemical is a distinct compound or substance, especially one which has been artificially prepared or purified.

Distinguish between **heavy** chemicals and **fine chemicals**. Give one example of each chemical
[6 marks] may/june 2012]

1. **Heavy chemical**; a chemical produced and handled in large quantity and often in a more or less crude state. Examples include acids, alkalis, and salts (H_2SO_4, NaOH, Na_2CO_3)
2. **Fine chemical**: a chemical produced and handled in relatively small amounts and usually in a more or less pure state. Examples include; Detergents, perfumes, preservatives, etc.

Chemical industries can be classified according to the products produced;

Chemical industry	Major raw material(s)
Plastics	ethene
Fertilizers	Nitrates, phosphates, and potassium compounds
Glass	Silica (sand), sodium carbonate (Na_2CO_3), limestone ($CaCO_3$), etc.
Pharmaceutical	extracts derived from natural sources such as flowers, fruit, fungus, herbs, leaves, fungi, roots, seeds, stems, etc.
Ceramics	Silica, sand, quartz, flint, silicates, and aluminosilicates (e. g., clays and feldspar).
Paints	Pigments (titanium dioxide, zinc oxide, etc.), solvents (mineral turpentine,) and resins and additives.
Cement	Limestone and Clay

Raw materials should be easily and cheaply obtainable. Fuel supplies are expensive. So the energy requirements of an industrial process have to be taken into consideration. Chemical industries should be located in areas close to their source of raw materials

Factors affecting Location of chemical industries

1. Availability/nearness to raw materials
2. Power
3. Availability of Labour
4. Proximity to Markets
5. Transport Facilities

6. Site and Services
7. Finance
8. Natural and Climatic Considerations etc.

Importance of industries

1. Source of revenue
2. Improve the standard of living by providing many materials for domestic use
3. Provide employment

Minimizing the environmental impact of industries

1. Chemical industries and chemical plants should always be sited in industrial areas on the outskirts of cities to minimize their impact on the lives of the inhabitants
2. The government must provide clear policies and legislation and must be enforced
3. The chemical industry must care for health and safety of its workers and take responsibility for the environmental impact of their products.
4. Consumers must learn to read and understand cautionary labels, use chemicals as directed and dispose of chemicals safely

Recycling

Recycling is the process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products

Benefits of Recycling

- Reduces the amount of waste sent to landfills and incinerators
- Conserves natural resources such as timber, water and minerals
- Increases economic security by tapping a domestic source of materials
- Prevents pollution by reducing the need to collect new raw materials
- Saves energy
- Supports manufacturing and conserves valuable resources
- Helps create jobs in the recycling and manufacturing industries

Assignment 2

Define the term biotechnology and state 3 chemical industries that apply biotechnology to their chemical processes.

Week 3 & 4: Matter

What is matter?
Matter is anything that has mass and occupy space

Properties of matter

1. Physical properties: these are observable and/or measurable properties of matter and are associated with physical changes e.g mass, pH, hardness, boiling point, luster, taste etc.
2. Chemical properties; these are properties associated with chemical changes and are only evident during or after a chemical reaction. E.g rusting, combustion, neutralization e.t.c.

Physical and chemical change

Physical change: this is a change which is easily reversed and in which no new substances are formed. Examples include

1. Melting
2. Boiling
3. Shredding paper
4. Dissolution common salt in water
5. Breaking a substance e.tc

Chemical change: this change is not easily reversed and a new substance is formed. Examples include

1. Slaking of lime i.e dissolution of calcium oxide (quick lime), CaO in water
   $$CaO + H_2O \rightarrow Ca(OH)_2$$
2. Dissolution of metals and limestone in acids
3. Rusting of iron
4. Burning of wood
5. Fermentation and decay
6. Changes in electrochemical cell

Difference between physical and chemical change

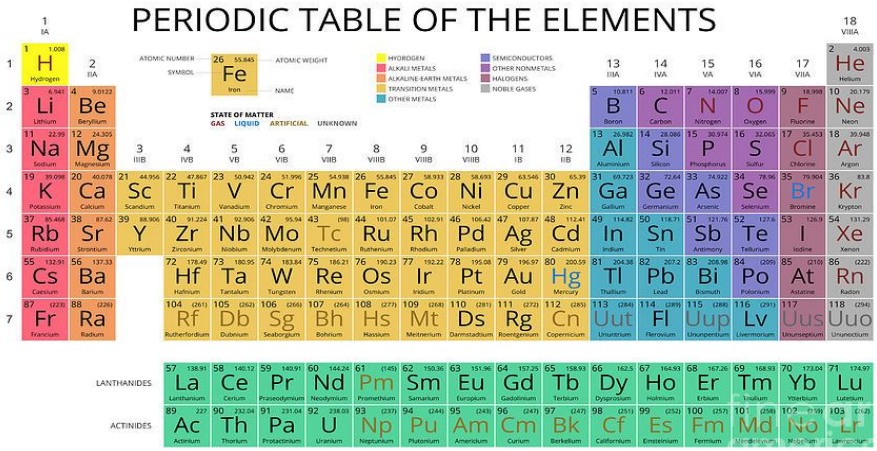
Physical change	Chemical change
1. In a physical change, only physical properties such as colour, physical state, density, volume, etc. change; chemical properties remain unchanged.	1. In a chemical change, the chemical composition and chemical properties undergo a change.
2. No new substance is formed in a physical change.	2. A new substance is formed in a chemical change.
3. Very little or no energy in the form of heat, light or sound is usually absorbed or given out in a physical change.	3. A chemical change is always accompanied by absorption or evolution of energy.
4. A physical change is a temporary change.	4. A chemical change is a permanent change.
5. The original form of substance can be regained by simple physical methods.	5. Original substance cannot be obtained by simple physical methods.
6. A physical change is reversible.	6. A chemical change is irreversible.

Elements, compounds and Mixtures

Example: Copper (Cu) Example: Salt (NaCl) Example: Jelly beans

Elements

An element is a substance which cannot be split into simpler units by an ordinary chemical process. E.g. sodium, calcium, bromine, iodine etc.



Assignment 3

1. With three example for each, classify elements as metals, non-metals and metalloids
2. Using a pie chart show the percentage composition of elements on the earth's crust atmosphere and sea water

Compounds

A compound is a substance that is made up of two or more elements chemically combined together

Some Common Compounds and Their Formulas

Compound	Formula	Elements
ammonia	NH_3	nitrogen, hydrogen
rust	Fe_2O_3	iron, oxygen
sucrose	$C_{12}H_{22}O_{11}$	carbon, hydrogen, oxygen
table salt	NaCl	sodium, chlorine
water	H_2O	hydrogen, oxygen

Mixtures

A mixture is a substance made up of two or more substances which can be separated by physical means. A mixture maybe heterogeneous or homogeneous

Mixture	Constituents
Air	Oxygen, carbon (IV) oxide, nitrogen, rare gases, dust, moisture
Crude oil	Petrol, heavy oil, gas oil, kerosene, naptha, bitumen, etc
Urine	Urea, water, mineral salts
Palm wine	Water, sugar, alkanols, mineral salts, vitamins, yeast, proteins, fats
Sea water	Water, mineral salts, bacterial etc
Milk	Water, sugar, fat, proteins, mineral salts, vitamins
Brass	Copper and zinc

Comparison of mixtures and compounds

Compound	Mixture
1. The composition of elements present in a compound is fixed.	The composition of elements present in a mixture is not fixed.
2 The properties of a compound are different from those of its elements.	It shows the properties of all its constituent elements.
3. Its constituents can be separated by chemical methods only.	Its constituents can be separated by physical methods.
4. A compound is always homogeneous in nature.	The mixtures can be homogeneous or heterogeneous.

WEEK 5 & 6; Separation Techniques

Separation techniques are those **techniques** that can be used to separate the constituent of a mixture.

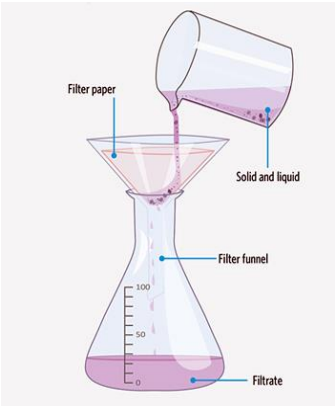
Physical property in which separation depends on

Physical separation techniques are based on the physical properties of the substance. These physical properties can be physical state, magnetic and electrical properties, specific gravity, density, melting point, boiling point, and solubility. Here are some different methods of separating mixtures

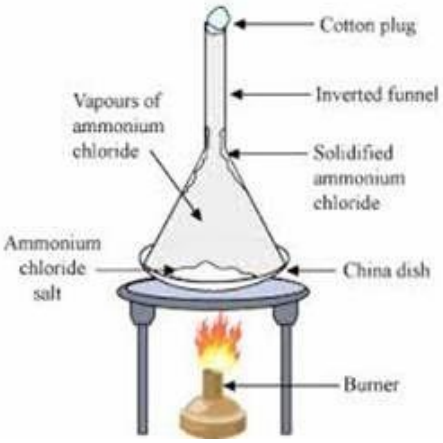
1. Sieving,
2. Magnetic separation,
3. Sublimation
4. Decantation
5. Filtration
6. Evaporation to dryness,
7. Crystallization (simple, fractional, and recrystallization)
8. Distillation (simple and fractional)
9. Separating funnel
10. Chromatography etc.

1. **Sieving**: this is a technique used to separate solid particles of different sizes usually using a mesh.

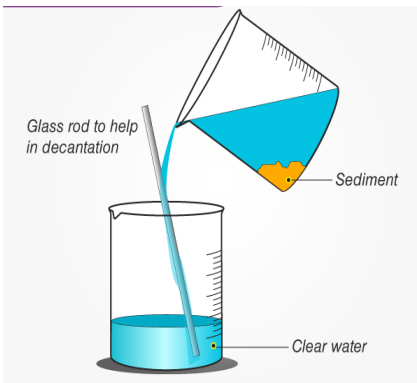
2. **Filtration**: by this technique an in soluble solid can be separated from its liquid medium using a filter paper aided by a funnel. The insoluble solid which is left in the filter paper is called the residue while the liquid medium which goes through the filter paper is the filtrate. For example, we can separate the following mixtures by filtration. A mixture of
   a. Calcium carbonate, $CaCO_3$ and water, H_2O
   b. sand and water
   c. chaff and juice



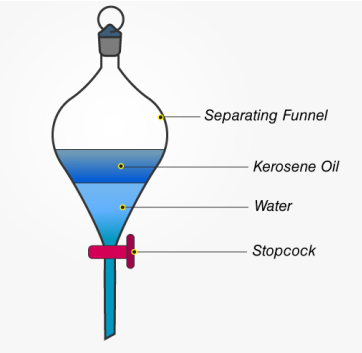
3. **Sublimation**; when a substance changes form solid to gas without going through the liquid state the substance is said to have sublimed. Substances that can sublime include Sulphur, ammonium chloride (NH_4Cl), iodine, and naphthalene (SANI). Substances that can sublime can be separated from those that cannot by sublimation. The following mixtures can be separated by sublimation
   a. ammonium chloride NH_4Cl and Sand, SiO_2
   b. Sulphur, S, and sodium chloride, NaCl



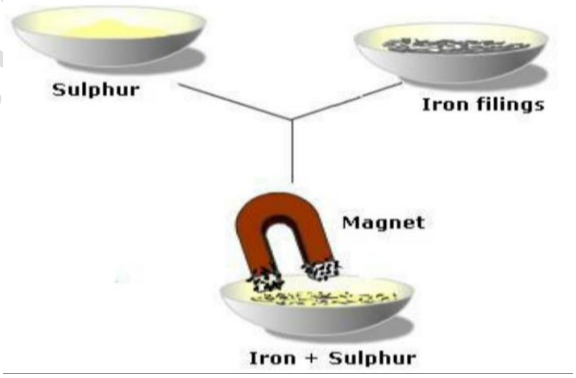
4. **Decantation**; this is a technique used to separate a mixture of liquid and a solid by carefully pouring out the top clear liquid known as the supernatant leaving behind the solid layer known as sediment.



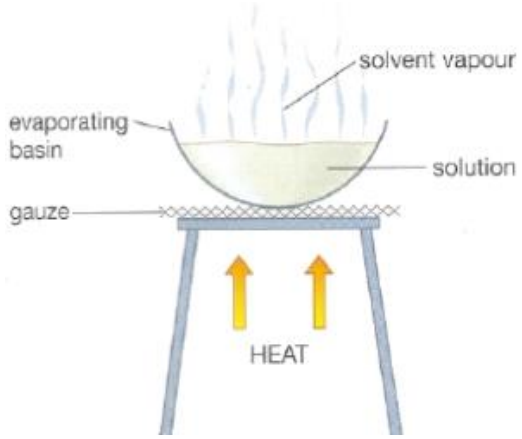
5. **Separating funnel**; this technique is used to separate a mixture of two **immiscible** liquid by taking advantage of the difference in their densities and polarities (polar solvents are immiscible with non-polar solvents). The less dense liquid will float on the denser one. Kerosene and water can be separated by this procedure



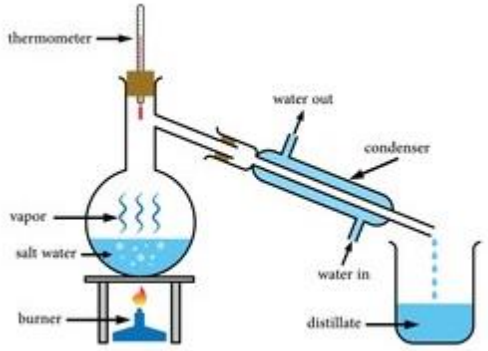
6. **Magnetic separation**; with this technique magnetic substances (usually metals) can be separated from not magnetic substances (non-metals) using a magnet.
   Note: some metals are not magnetic. They include Gold, silver, aluminium, copper, zinc, etc.



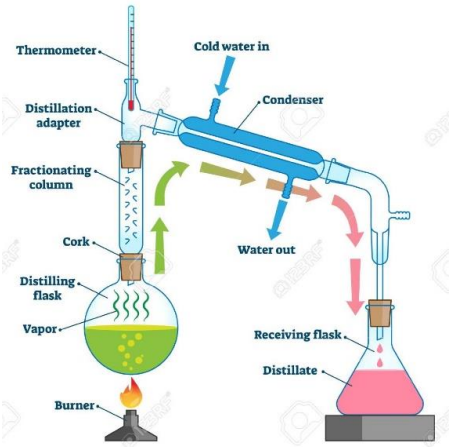
7. **Evaporation** to **dryness**; this can be used to recover a solid solute, that does not decompose when heated (chloride and carbonate of sodium and potassium do not decompose on heating) from a solution. In this process, the solvent is usually sacrificed



8. **Distillation:** this is the process involving the conversion of a liquid into vapour that is subsequently condensed back to liquid form.
   a. Simple distillation: this is a method for separating the solvent from a solution. For example, water can be separated from salt solution by simple distillation. This method works because water has a much lower boiling point than salt.



   b. Fractional distillation: this is a method for separating a mixture of two or more miscible liquids with at least a 10^0C difference in their boiling point by using a fractionating column while employing the distillation technique. Industrially fractional distillation has been employed in separating the **constituents of crude oil** and **liquefied air**



Assignment 4

1. Describe how a mixture of sand, ammonium chloride and sodium chloride can be separated
2. Outline a suitable procedure for separating a mixture containing P, Q, and R into its components

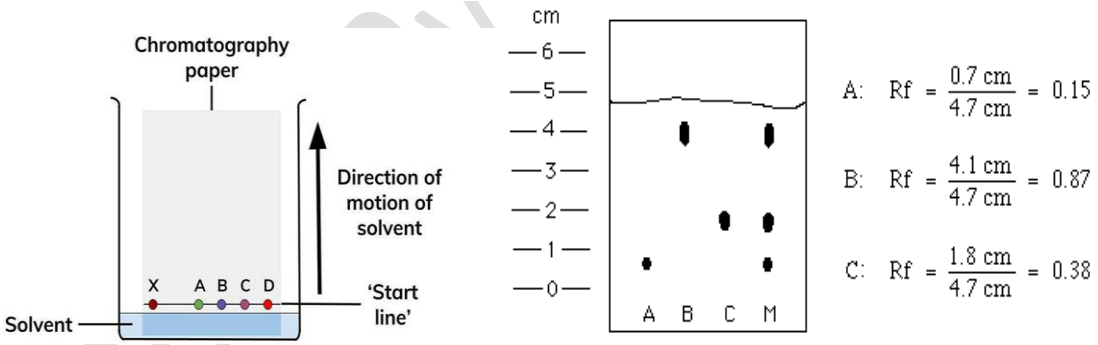
Component	Solubility in tetrachloromethane	Solubility in water
P	Insoluble	Insoluble
Q	Soluble	Slightly soluble
R	Insoluble	Soluble

9. **Crystallization:** crystallization is used to separate salts which decompose easily by heating by taking advantage of their solubility at different temperatures in the solvent
   Steps to crystallization

- Heat to saturate or concentrate the solution
- Cool to crystallize the solute
- Filter to obtain crystals
- Dry crystals between filter papers

10. **Paper Chromatography**: This is a technique for separating dissolved chemical substances by taking advantage of their different rates of migration across sheets of **paper**. Then the Retention/Retardation Factor, RF, is calculated. The solvent is called the mobile phase whereas the paper is the stationary phase

$$Rf = \frac{\text{distance moved by the compound}}{\text{distance moved by the solvent}}$$



Paper chromatography can be used to separate pigments, dyes and amino acids and can also be used to identify poison and drugs.

Pure and Impure Substances

A pure substance is made up of only one substance and is not mixed with any other substance. An impure substance on the other hand is a mixture.

Test for Purity

There are three major ways to determine the purity of a substance

1. By their melting point (for solids)

2. By their boiling point (for liquids)
3. By chromatography

A pure solid melts completely at a definite temperature and a pure liquid boils at a definite temperature. Impurities lower the melting point of solids and increase the boiling point of liquid. An impure liquid will boil over a temperature range and an impure solid will melt over a temperature range

A pure substance will give just one spot on a paper chromatogram

Critical thinking: Tap water is clean but not pure. Do you agree with this statement and why?

Exercise

Use the prep50 for more exercise

Assignment 5

1. The table below shows the physical properties of substances A, B, and C

Substance	**Melting point**	**Boiling point**	**Solubility in water at 25°C**
A	30	117	Insoluble
B	31	160	Insoluble
C	861	1200	soluble

If A and B are miscible when melted and B and C react when heated, describe how a mixture of A, B, and C could be separated

2. Briefly describe centrifugation technique

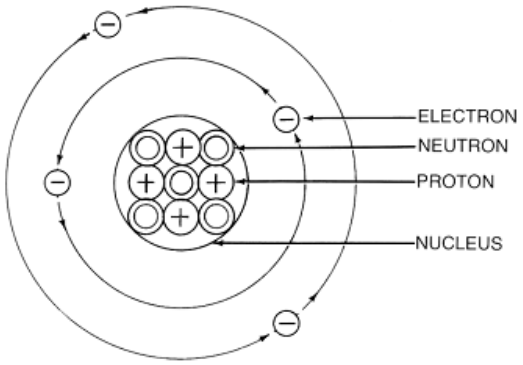
WEEK 7-10: Particulate Nature of Matter

Matter is made up of discrete particles the main ones being atoms, molecules and ions

Atom

An atom is the smallest particle of an element which can take part in a chemical reaction. It is the smallest unit of matter that uniquely defines an element

An atom consists of a neutron, a proton and an electron. The nucleus of an atom lies at its center and consists of protons and neutrons, which are collectively called the **nucleons.** Electrons a found in a space around the nucleus known as **orbitals.**



A neutral atom has equal number of protons and electrons. The positive charge of a proton equals the negative charge of an electron. The charges cancel each other out and the atom is neutral. The volume of the atom is determined by the space that the electrons occupy.

The properties of the three sub atomic particles are as follows

Particle	Relative mass	Relative charge	location
Proton, p	1	+1	Nucleus
Neutron, n	1	No charge (0)	Nucleus
Electron, e	1/1840 (negligible)	-1	Shells/orbitals

Molecule

A molecule is the smallest particle of a substance that can normally exist alone and still retain the chemical properties of that substance, be it an element or a compound.

Molecules may be made up of atoms of the same element or of different elements. **Atomicity** is defined as the number of atoms in each molecule of an **element**.

Atomicity	Elements	Formula of molecule (e.g)
Monoatomic	All noble gases and metals	He, Ne, Ar, Kr
Diatomic	Hydrogen, Nitrogen, Fluorine, Oxygen, Iodine, Chlorine, Bromine	H_2, N_2, O_2 etc
triatomic	Oxygen as Ozone	O_3
Tetra-atomic	Phosphorus	P_4
Poly atomic	Sulphur	S_8

A molecule of a compound may be small or large. Eg. A hydrogen chloride molecule contains only two atoms, while a starch molecule contains thousands of atoms.

Ions

An ion is an atom or group of atoms which possess an electric charge**.** There are two types of ions

1. Cation; positively charged ions. Generally, metals form cations. These are formed by loss of electrons e.g Ca^{2+}, Na^{+}, Fe^{3+}
2. Anions; negatively charged ions. Generally, non-metals form anions. These are formed by gain of electrons e.g Cl^{-}, O^{2-}

Phenomena supporting the particulate nature of matter

Evidence that matter is made up of particles are suggested by the following phenomenon

1. Diffusion and osmosis
2. Sublimation
3. Brownian motion
4. Evaporation etc.

Assignment 6

1. Define any of the **evidence** that matter is made up of particles and describe how it shows that matter is made up of particles

Dalton's Atomic Theory and Modification

1. All elements are made up of small indivisible particles called atom
   MOD: the discovery of the subatomic particles modifies this theory
2. Atoms can neither be created nor destroyed
   MOD: during nuclear fusion and fission atoms can be created and destroyed respectively
3. Atoms of an element are alike in every aspect and differ from atoms of other elements
   MOD: the discovery of isotopes modifies this theory
4. During a chemical reaction there is a combination of atoms in small whole numbers
   MOD: this is only true for inorganic compounds/reactions
5. All chemical changes result from the combination or the separation of atoms.

Atomic Structure

Electrons hold the key to almost all chemistry. Protons and neutrons give atoms their mass but electrons make up the outer part and are able to interact with one another. The arrangement of electrons determines the chemical property of the element.

The electrons move round the nucleus in clearly defined regions called shells. Electrons closest to the nucleus have the lowest energy while electrons that are further away from the nucleus have higher energies

An atoms shell can hold $2n^2$ electrons where n is the electron shell level; represented as K, L, M, N, O

Maximum number of electrons per shell

Shell number	Formula] [2 $(n)^2$]	Maximum e^-
1	2 x $(1)^2$	2
2	2 x $(2)^2$	8
3	2 x $(3)^2$	18
4	2 x $(4)^2$	32
5	2 x $(5)^2$	50
6	2 x $(6)^2$	72
7	2 x $(7)^2$	98

Atomic or Proton number

This is the number of protons in an atom. The atomic number is represented by the symbol z. in a **neutral** atom, the number of protons equals the number of electrons (p=e)

Mass or Nucleon Number

This is the sum of protons and neutrons in an atom. It is represented by the letter A (A= p + n)

Elements and their symbols

In 1814 Berzeluis suggested a simple system for representing elements with symbols.

- The first letter of the element was taken as the symbol
- Where the first letter had already been adopted, the initial letter, in capital, together with a small letter from its name was used
- The symbols of some metals are derived from their Latin names

Atomic number	Element	Symbol
1	hydrogen	H
6	Carbon	C
20	Calcium	Ca
17	Chlorine	Cl
11	Sodium (Natrium)	Na
79	Gold (Aurium)	Au
47	Silver (Argentum)	Ag
19	Potassium (Kalium)	K

Electronic Configuration

This is the arrangement of electrons in energy levels around an atomic nucleus. This can be expressed by the following models

1. Shell atomic model
2. Spdf notation or Quantum mechanical model

Shell atomic model

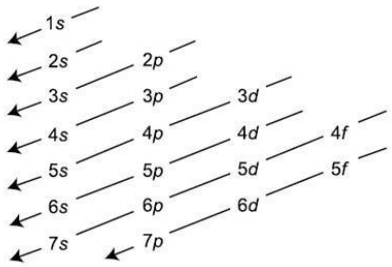
This may be expressed by indicating the number of electrons in each shell beginning with the first

Example

	K	L	M	N
$_{17}Cl$	2	8	7	
$_{20}Ca$	2	8	8	2

Spdf Notation

This follows Aufbau principle which states that in the building up of atoms, electrons enter into orbitals in order of increasing energy.



1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 5f, 6d, and 7p

The minimum number of electrons for each sub orbital are as follows

s=2
p=6
d= 10
f= 14

Example

$_{17}Cl = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

$_{20}Ca = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

(More examples on electron configuration of **ions**)

Assignment 7

1. Describe the oil drop experiment and state the purpose of the experiment
2. Complete the following table

particles	number of neutrons	Number of electrons	Number of protons	Mass number
W^{2+}	12			24
X^{2-}			8	16
Y		13		27
Z	12	11		

Valency and Oxidation number

Valency; this is the combining capacity/power of an element. It means the number of electrons the atom of an element needs to lose, gain or share in order to acquire the closest inert gas configuration

The number of valence electrons determines the valency of that element. For example, the valency of oxygen is 2 because it needs 2 electrons in its outermost orbit to complete its octet state.

Oxidation Number/state; this is the total number of electrons that an atom either gains, losses or shares in order to form a chemical bond with another atom.

For valences, charges are not assigned to the values whereas in the case of oxidation number, a positive or negative charge is assigned to their values

Oxidation number	**+1**	**+2**	**+3**	**Variable**		**-2**	**-1**	**0**
Valency	1	2	3			2	1	0
Period 1	H							He
Period 2	Li	Be	B	C	N	O	F	Ne
Period 3	Na	Mg	Al	Si	P	S	Cl	Ar
Period 4	K	Ca						

Valences of Some Radicals

Radicals are group of atoms of different elements acting as a single unit.

Radical	Formula	Valency
Ammonium ion	**NH_4^+**	**1**
Hydroxide ion	**OH^-**	**1**
Trioxonitrate (V) ion	**NO_3^-**	**1**
Dioxonitrate (III) ion	**NO_2^-**	**1**
Hydrogen Trioxocarbonate (IV) ion	**HCO_3^-**	**1**
Trioxocarbonate (IV) ion	**CO_3^{2-}**	**2**
Tetraoxosulphate (VI) ion	**SO_4^{2-}**	**2**

Writing chemical Formula

Rules for writing chemical formula

1. Write the symbols or formula for the element and radical respectively
2. Write the valences of the elements/radicals
3. Exchange the valences and write the numbers below and to the right of the symbols or formula

Examples *(give sufficient examples; every student **must** learn to write chemical formulas)*

Naming simple inorganic Compounds

The IUPAC nomenclature of inorganic chemistry is a systematic method of naming inorganic compounds as recommended by the International Union of Pure and Applied Chemistry (IUPAC)

Examples: give sufficient examples on the naming of

1. Binary compounds
2. Ternary compounds and
3. Acids

Assignment 8

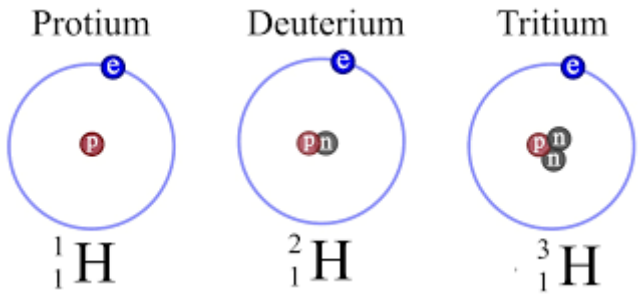
1. What is the formula of the compound formed when $_{20}A$ combines with element $_{8}Y$
2. An element Q forms a compound QCl_5 in which group of the periodic table does Q belong?
3. What is the compound formed by two elements X and Y with the electron configurations $1s^2$ $2s^2$ $2p^4$ and $1s^2$ $2s^2$ $2p^6$ $3s^2$ respectively?
4. Write the correct chemical formula of the following organic compounds
   a. Ammonium tetraoxosulphate (VI)
   b. Lead (II) bromide
   c. Copper (II) trioxonitrate (V)
   d. Carbon (II) oxide

(More exercises from Prep50)

Isotopy

This is the existence of **atoms of an element** with the same atomic number but different mass number.

Most element have isotopes. For example, the isotopes of hydrogen are



Relative Atomic Mass (RAM), Ar

RAM can be defined as the number of times the average mass of an atom is greater than one-twelfth the mass of one atom of carbon-12.

The mean weight of various isotopes of an element are used to calculate ram

Example

1. It was found from the determination in a mass spectrometer the element neon has three isotopes of mass 19, 21 and 22 respectively. The relative abundance of these isotopes are 90.92%, 0.25% and 8.83% respectively. Calculate the value of the relative atomic mass of neon
2. An element X has two isotopes of $^{20}_{10}X$ and $^{22}_{10}X$ in the ratio of 1:3. What is the ram of X

(More exercises from Prep50)

Assignment 9

1. Give reason(s) for the difference in mass number of isotopes
2. State the isotopes of three other elements with naturally occurring isotopes

Relative Molecular Mass, (RAM) Mr

This is the ratio of the average mass of one molecule of an element or compound to one-twelfth of the mass of an atom of carbon-12

Example; calculate the relative molecular mass of the following compounds and calculate the percentage composition of each element that make up the compound.

1. Al_2O_3
2. $Ca(NO_3)_2$
3. $(NH_4)_2SO_4$
   [Al=27, O=16, Ca=40, N=14, H=1, S=32]

The Mole Concept

One mole of a substance is the amount containing as many elementary entities as the number of atoms in exactly 12 grams of carbon-12
A mole corresponds to the mass of a substance that contains 6.023×10^{23} (Avogadro's number) particles of that substance
i.e. 1 mole of a substance contains 6.02×10^{23} particles (atoms, molecules or ions)
.-. 1 mole= 6.02×10^{23} particles (atoms, molecules or ions)

Number of moles or amount of substance $= \frac{mass}{molar\ mass}$

$n = \frac{m}{mm}$

Example

1. What is the mass of 3 moles of oxygen, gas O_2? [O=16]
2. How many atoms are there in 6g of carbon, C? [1 mole = 6×10^{23}; C=12]
3. How many moles are there in 20g of $CaCO_3$? [Ca=40; C=12; O=16]

[Exercise from prep50]

Empirical Formula

The empirical formula of a chemical compound is the simplest whole number ratio of atoms present in a compound.

Example/Exercise (more from prep50)

1. A hydrocarbon contains 7.7% by mass hydrogen and 92.3% by mass carbon. The relative molecular mass of the compound is 78. Derive the empirical formula of the compound and hence the molecular formula.
2. A compound has an empirical formula of CHO_2 and its molar mass is 90. Deduce the molecular formula of the compound. [H=1, C=12, O=16]
3. Find the empirical formula of a compound which on analysis yields the following as the reacting masses. Carbon = 2.0g, hydrogen =0.34g, oxygen = 2.67g. From your result, find the molecular formula of the compound, if its relative molecular mass is 60. (C=12; H=1; O=16)