SUBJECT:CHEMISTRY
CLASS: SS1

SCHEME OF WORK

WEEK TOPIC

1. Introduction to Chemistry: Meaning of chemistry, Career prospects tied to chemistry, application of chemistry, adverse effects of chemicals and, Scientific methods.

2. Particulate Nature of Matter: Physical and chemical changes, elements and their symbols, Atoms, molecules, atomicity and Dalton's atomic theory and its Modifications.

3. Particulate Nature of Matter: Electronic configuration (K,L,M,N), Atomic number, mass number, Isotopy and Relative atomic mass based on C-12 isotope.

4. Valency, oxidation number, ions and Radicals: Valency of elements, oxidation number of elements in compounds, ions and radicals.

5. Formulae and Equations: Chemical formulae, Chemical equations, Empirical and Molecular formulae, Relative Molecular Mass, Molar mass and Percentage composition by mass of an element.

6. Laws of chemical combination: law of conservation of matters, law of constant composition, law of multiple proportions and Law of Reciprocal proportion

7. **Mid-Term Break and Holiday Assignment**

8. Chemical Combination: Types of chemical bonds, IUPAC system of naming inorganic compounds.

9. Chemical industries: Types of chemical industries, importance of chemical industries and excursion to chemical industries**.**

10. Revision and preparation for examination.

11/12. Examination

REFERENCE. TEXTS:

1. **Comprehensive certificate chemistry for senior secondary schools by G N C Ohia.et al**
2. **Chemistry for Senior Secondary Schools 1 by Magbagbeola O, et al; Melrose Books and Publishers.**
3. **New school chemistry for senior secondary schools by Osei yaw Ababio**

4. **Revised edition understanding chemistry for schools and colleges by Godwin O. Ojokuku.**

WEEK 1

TOPIC: Introduction to Chemistry

CONTENT:

1. Meaning of chemistry

2. Career prospects tied to chemistry

3. Application (i) Hospital (ii) Military (iii) Teaching (iv) Chemical and petrochemical industries.

4. Adverse effects of chemicals, drug abuse, poisoning,

Corrosion and pollution.

5. Scientific methods.

PERIOD 1: MEANING OF CHEMISTRY

Chemistry is the study of matter: its structure, composition, properties and the changes it undergoes.

Chemistry is one of the three main branches of pure science, the other two being physics and biology. Chemistry which probes into the principles governing the changes that matter undergoes also deals with the composition, properties uses of matter. Some of the chemical changes which matter undergoes include; lighting a match, cooking, burning fire wood, making palm wine, rusting of nails, rotting of leaves. Chemical changes are otherwise known as chemical reactions. The knowledge of chemistry helps us to subject some matter to chemical processes thereby producing some materials for our every day today use. Such materials include: soaps, detergents, hair cream, perfumes, oil, margarine and plastics among others.

There are three main branches of chemistry: inorganic, organic and physical chemistry.

Career prospects tied to chemistry

Career prospects tied to chemistry simply mean the job opportunities that are available for the students with knowledge of chemistry. Such students can be employed with private and public sectors which include: Teaching service, health service, food processing, petroleum and petrochemical industries, manufacturing industry, extractive industry, Agriculture and Forestry.

(i) **Teaching services:** Concern those who teach in primary, secondary schools, colleges of education and universities and even the laboratory assistants in schools and universities.
(ii) **Health service:** Involves pharmacists, biochemists, chemists, nutritionists, dieticians, doctors, nurses, medical assistants, laboratory assistants and dispensers.
(iii) **Food processing:** Food processing involves food technologists and research chemists.
(iv) **Petroleum and petrochemical industries** –Involves application of the following people; research chemists, chemical engineers and laboratory assistants.
(v) **Extractive industry-** Involves chemists, mining engineers and geologists.
(vi) **Manufacturing Industry:** This involves research chemists and chemical engineers in the wide variety of manufacturing industries such as iron and steel works and cement factories.
(vii) **Agriculture-**Involves agricultural scientists, chemists, biochemists and physiologists who engaged in research to improve the quality and yield of crops and livestocks, and to advise farmers.

(viii) Forestry: Scientists engaged in research to preserve and improve forests and forestry products.

EVALUATION

1. Define the term chemistry.
2. Mention five changes that matter undergoes.
3. Give the uses of chemistry in our day to day life.
4. List at least five career opportunities in chemistry
5. Explain any three of the career opportunities mentioned above.

PERIOD 2: APPLICATION/ USES OF CHEMISTRY

The knowledge of chemistry can be apply in the following areas; namely

1. **Hospital:** The knowledge of chemistry makes it possible for people to involve in chemical research and technology which lead to production of medicine that we use today.

2. **Military:** The duty of the military is defense, to defend the territorial integrity of a nation or state. Military cannot effectively do this without ammunition. Chemistry contributes to the discovery and description of the theoretical bases for the behavior of chemical substances such as explosives used by the military. The gun powder used in the earliest guns was made by mixing sulphur, charcoal and potassium trioxonitrates (v), compounded by early chemists. The manufacture of smokeless powder was based upon gun cotton, which is made from cotton fibers soaked in a strong mixture of HNO_3 and H_2SO_4.
3. **Teaching-** chemistry teachers and lecturers in secondary schools, polytechnics, colleges of education and universities.
4. **Chemical and petrochemical industries:** Application chemists, research chemists, chemical engineers and laboratory assistants.
5. **Space science:** chemistry is not out in space exploration. In our efforts to gain more knowledge of the other planets and outer space around us, special rockets called 'space rocket' are sent into space. The first rocket was sent into space on October 4, 1957 by Russia. In July, 1969, Apollo II astronauts Neil Armstrong and Edwin Aldrin landed on the moon. These are made possible by science and technology.
6. **Agriculture:** Agricultural scientists, chemists, biochemists and physiologists engaged in research to improve the quality and yield of crops and livestock, and to advise farmers.

EVALUATION

1. Enumerate and explain five application of chemistry you know.

PERIOD 3- ADVERSE EFFECTS OF CHEMICALS

The adverse effects of existence of chemistry

The existence of chemistry brought about the existence of chemicals. The adverse effects of chemicals include; drug abuse, poisoning, corrosion and pollution.

(a) **Drug Abuse:** simply involves wrong usage of drugs. Some of these drugs include heroin, cocaine and morphine which are used as addictive. Unscrupulous people produce and sell them at huge profits. Drug addiction is a major problem in our society, especially among young people. Many countries have imposed strict laws to control pollution and drug abuse. However, the most effective control measure is education. We must use what we learnt to improve our life and to control these abuses.

(b) **Poisoning:** This is where chemicals are used to poison the food we eat. This happens when the chemicals used as addictive probably as preservative are added more than required or expired in the food stuff

where it was added, then instead of the food stuff bringing health to our body, it turns to poison.

(c) **Corrosion:** Corrosion of iron can also be called rusting and requires the presence of water and oxygen. Rusting can also be regarded as the slow deterioration of iron to iron (iii) oxide. This iron (iii) oxide is permeable to both air and water and cannot protect the iron from further corrosion of iron.

This rusting can be prevented by four methods.

(i) Application of protective coating.
(ii) Application of sacrificial metal.
(iii) Alloying.
(iv) Cathodic protection.

(d) **Pollution:** Chemical industries through the action of production pollute our environment as the smoke enters into the air, and dirts of different kinds enter into the water thereby polluting the entire environment. Specifically chemical wastes from factories and oil refineries and radioactive wastes from nuclear plants pollute our environment. Oil spillage, exhaust from motor vehicles, pesticides, fertilizers and acid rain have made our environment unclean and endangered plant and animal life. Human health is also being threatened by environmental pollution. Presently, chemists are trying to come up with a fuel that will reduce the air pollution problem. They are also modifying chemical processes to recycle chemical wastes or change them to harmless products which can be safely discharged into the surrounding.

PERIOD 4: SCIENTIFIC METHOD

This is the method the scientist used to produce different materials that exists as a result of chemistry. In the light of this, the scientists use their senses to observe what is happening around them. From a given set of observations, they see a certain pattern. This often leads to a problem which they try to solve. They put forward a reasonable explanation or hypothesis and carry out appropriate experiments to test it. Then, they carefully record their observations and the results of their experiments.

If the experiments support the hypothesis, they carry out further investigations. They discuss the hypothesis and results with other scientists in the field so that the hypothesis can be further tested. When a hypothesis has been tested and found to be correct within the limits of available evidence. It becomes a theory. A scientific law or principle is established only after the theory has been extensively tested and proven true without any exception. If the experiments give negative results, then

the scientist goes back to his hypothesis and either modifies it or puts forward a new hypothesis. This way of studying a problem is known as the **scientific method**. It is the very foundation of all scientific discoveries.

EVALUATION

1. Mention five adverse effects of existence of chemistry in the world.
2. What do you understand by hypothesis?
3. Differentiate the terms hypothesis and theory
4. Explain fully what you understand by scientific method?

GENERAL EVALUATION

OBJECTIVE TEST:

1. Chemistry is defined as
   A. a branch of knowledge which produces chemicals
   B. the branch of science which deals with changes in matter
   C. the oldest branch science
   D. the branch of science which makes physics and biology career
2. Scientific approach to discoveries follows the order which includes:
   A. Observation, hypothesis, and results
   B. experiments, hypothesis and results
   C. further experiments and problems solving
   D. theory, negative and positive results and experiments

3. Chemical hypothesis is different from chemical law in that
   A. hypothesis is a reasonable explanation to observations made while law is a statement from a scientist.
   B. hypothesis is a reasonable explanation to observations while law is a statement which confirms the hypothesis after extensive tests.
   C.hypothesis is not reasonable while law is reasonable.
   D. none of the above
4. Chemical changes around us includes all **except;**
   A. rusting of iron nails
   B. sieving
   C. fading of coloured cloth
   D. decomposing of green leaves in a compost
5. One of these professions has no need for chemistry
   A. Miners
   B. Engineers
   C. Philosophers
   D. Geologists

ESSAY QUESTIONS

1. Give five reasons why chemistry is important in your life.

2. Explain in detail two of the reasons given above.
3. List three adverse effect of existence of chemistry in this world.
4. Explain two of those adverse effects mentioned above.
5. Explain the term scientific method full.

WEEKEND ASSIGNMENT:

PRE- READING ASSIGNMENT

Read about physical and chemical changes and differentiate them.

WEEKEND ACTIVITY

Explain fully what you understand by the following terms.

Atoms, Molecules, Constituents of atoms.

REFERENCE:

1. New school chemistry for senior secondary schools by Osei Yaw Ababio revised by L.E.S. Akpanisi Herbert Igwe.

WEEK 2

Topic: PARTICULATE NATURE OF MATTER

CONTENTS:

(1) Physical and chemical changes

(2) Elements and their symbols.

(3) Atoms, molecules, atomicity

(4) Dalton's atomic theory

PERIOD 1: PHYSICAL AND CHEMICAL CHANGES

PHYSICAL CHANGES:

DEFINITION: A Physical change is one which is easily reversed and in which no new substances are formed.

Examples:

i. Melting of solids to liquids.

ii. Freezing of liquids to solids.

iii. Vaporization of liquids to gases.

iv. Liquefaction of gases to liquids.

v. Sublimation of solids to vapour.

CHEMICAL CHANGE:

DEFINITION: A chemical change is one which is not easily reversed andin which a new substance is formed.

Examples:

i. Burning of substances.

ii. Dissolution of metals and limestone in acids.

iii. Chemical decomposition – like digestion of food.

iv. Rusting of iron.

v. Charring of sugar.

vi. Dissolution of metals in acids.

DIFFERENCES BETWEEN PHYSICAL AND CHEMICAL CHANGE

PHYSICAL CHANGE	CHEMICAL CHANGE
1. Easily reversible	Not easily reversible
2. No new substance is formed	New substance is formed
3. No change is mass.	There is a noticeable change in mass.
4. Not accompanied by heat Change.	usually accompanied by heat change.

EVALUATION:

1. Mention three familiar process/changes which you know to be: (a) Physical changes (b) chemical changes.

2. List three differences between physical change and chemical change.

3. Classify each of the following as physical change or chemical change.

(a) Boiling of egg (b) Burning of kerosene (c) Melting of wax (d) Rusting of iron (e) Digestion of glucose (f) Dissolving iron in an acid.

4. State with a reason in each case whether each of the following is physical or chemical change.

(a) Dissolving common salt in water.
(b) Burning of petrol.
(c) Digestion of glucose.

PERIOD 2: ELEMENTS AND THEIR SYMBOLS

An element is a substance that cannot be broken into simpler substances by any chemical methods. Examples of elements include: Iron, tin, aluminum etc.

There are about 118 known elements of which 92 are naturally exiting elements and the rest are artificially made.

Symbols are modern ways of representing atoms of elements by using abbreviations. The modern symbols were developed by Berzelius in 1814.

First, He used the first letter in the name of the element.

Examples

ELEMENT	**SYMBOL**
Hydrogen	H
Boron	B
Carbon	C
Nitrogen	N
Oxygen	O
Fluorine	F
Phosphorus	P
Sulphur	S
Iodine	I

The second principle uses the first two letters.

Examples:

ELEMENTS	**SYMBOL**
Helium	He
Lithium	Li
Beryllium	Be
Neon	Ne
Aluminum	Al
Silicon	Si
Argon	Ar
Calcium	Ca
Bromine	Br
Barium	Ba

The third principle is when the first letter and another letter in the name are used.

Example:

ELEMENTS	**SYMBOL**
Magnesium	Mg
Chlorine	Cl
Chromium	Cr
Manganese	Mn
Zinc	Zn

The fourth principle is the elements that derived symbols from their Latin names.

Example:

ELEMENT	LATIN NAME	SYMBOL
Sodium	Natrium	Na
Potassium	Kalium	K
Iron	Ferrum	Fe
Copper	Cuprum	Cu
Silver	Argentum	Ag
Tin	Stannum	Sn
Gold	Aurum	Au
Mercury	Hydrargyrum	Hg
Lead	Plumbum	Pb

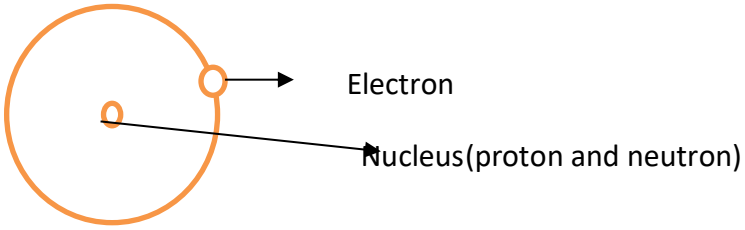
PERIOD 3: ATOMS, MOLECULES AND ATOMICITY

ATOMS

DEFINITION: An atom is the smallest particle of an element which can take part in a chemical reaction.

STRUCTURE AND CONSITITUENTS OF AN ATOM

An atom is made up of the three sub-particles known as protons, neutrons and electrons as shown in the diagram below. Their characteristics are also summarized in the table below:



CHARACTERISTICS OF THE SUB-PARTICLES

SUB-PARTICLE	LOCATION	RELATIVE CHARGE	RELATIVE MASS	SYMBOL
Proton	Nucleus	+	1	p
Electron	Outside nucleus	_	0.005	e^-
Neutron	Nucleus	Zero	1	n

MOLECULES

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

Some molecules can exist independently as single atoms e.g. He, Ne, Ar, Xe etc. Some molecules may be made up of atoms of the same element e.g. a molecule of hydrogen is H_2, that of chlorine is Cl_2, Oxygen is O_2, phosphorus

is P_4, Sulphur is S_8. Some molecules may be made up of different elements e.g. a molecule of water is H_2O, Methane is CH_4, ammonia is NH_3, carbon (iv) oxide is CO_2 etc.

ATOMICITY: Atomicity is the number of atoms in each molecule of an element.

Atomicity of some molecules

Element	Formula of molecule	Atomicity
Hydrogen	H_2	2
Oxygen	O_2	2
Ozone	O_3	3
Phosphorus	P_4	4
Sulphur	S_8	8
Chlorine	Cl_2	2
Neon	Ne	1
Argon	Ar	1
Tetraoxosulphate(vi) acid	H_2SO_4	7
Amonium tetraoxosulphate(vi)	$(NH_4)_2SO_4$	15

PERIOD 4: DALTONS ATOMIC THEORY

In 1808 John Dalton proposed the following Atomic theory.

1. All elements are made up of small indivisible particles called atoms.
2. Atoms can neither be created or destroyed
3. Atoms of the same element are alike in every aspect, and differ from atoms of all other elements.
4. When atoms combine with other atoms, they do so in simple ratios.
5. All chemical changes result from the combination or the separation of atoms.

MODIFICATIONS OF DALTON'S ATOMIC THEORY

The following are the modifications to Dalton's atomic theory.

1. All matter is made up of small particles, protons, neutrons and electrons.

2. An atom can be destroyed and created; when radioactive atoms disintegrate with the emission of particles, new atoms are produced.

3. The atoms of the same elements are not all alike, but may have different masses as proved by the phenomenon of isotopy.

4. In large organic molecules, such as proteins, fats and starch, the combining ratio are in large whole number.

EVALUATION:

1. What are the three fundamental units of all matter? Give their relative masses and charges.

2. Describe their relative positions to one another in an atom.

3. Name the two main part of an atom?

4. Mention the three subatomic particles in an atom.

5. Which particles are found in each part of the atom?

6. List three sub atomic particles with their corresponding charges.

7. State four Dalton's atomic theory with their modifications.

GENERAL EVALUATION

OBJECTIVE TEST:

(1) The simplest unit of Matter that retains its properties is called. (a) an atom (b) an element (c) an hydroxide (c) a molecule

(2) Of the basic particles that make up an atom, the one with the smallest mass is? (a) a proton (b) a neutron (c) an x- particle (d) an electron

(3) The following are physical changes except: (a) melting of candle wax (b) Dissolving common salt in water (c) Freezing of water (d) Rotting of leaves.

(4) Which of the following is **not** a molecule of the same element. (a) O_2 (b) P_4 (c) S_8 (d)CO_2

(5) The atomicity of O_3 is (a) 1 (b) 2 (c) 3 (d)4

ESSAY QUESTIONS

1. Write four examples in each case of (a) Physical change (b) Chemical change
2. Define the following giving two examples in each case. (a) Atom (b) Ion
3. Write the symbols for proton, electron and neutrons.
4. Define atomicity giving two examples.
5. Write four Dalton's atomic theory.

WEEKEND ASSIGNMENT

Write the electronic connfiguration of the first twenty element using the concept of K,L,M,N and the sub-energy atomic level configuration i.e. s,p,d,f.

WEEK 3

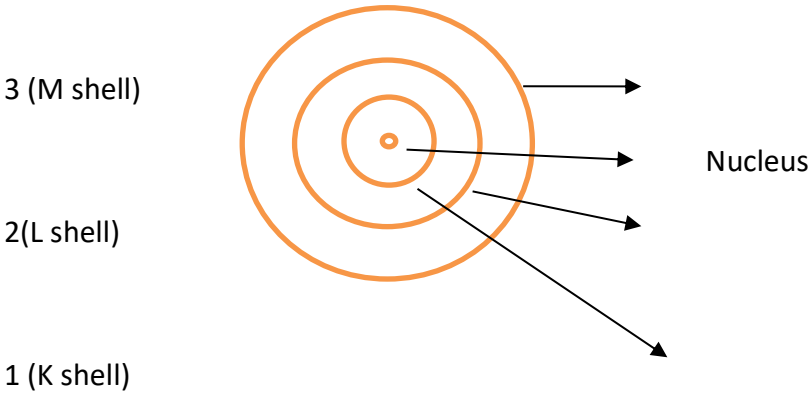
TOPICS: **PARTICULATE NATURE OF MATTER**

CONTENTS:

1. Electronic configuration
2. Atomic number and mass number (nucleon number)
3. Relative atomic mass based on C-12 isotope
4. Isotopy of elements

PERIOD 1: ELECTRONIC CONFIGURATION

Electrons are found revolving around the nucleus of an atom in circular paths known as rings, orbits, energy levels or shells. Each shell contains electrons with similar energy. Those with the lowest energies being nearest to the nucleus.



Thus, the arrangement of electrons in the atom according to energy is called ***ELECTRONIC CONFIGURATION***. Letters and figures are associated with these orbits or shells as shown above. The maximum possible number of electrons that can be accommodated in a shell is given by the formula:

$N_{max}= 2n^2$. Where N_{max} = Maximum no of electron. n= no, of shell.

Thus K- shell can contain $2 \times 1^2 = 2$ electrons.

L- Shell can contain $2 \times 2^2 = 8$ electrons.

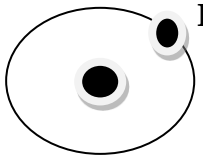
M- Shell can contain $2 \times 3^2= 18$ electrons etc

The electron structures of the atoms of the first twenty elements are given in the table below.

Element	Symbol	Number of protons(or atomic number)	Number of electrons and their distribution in the shells. K L M N
Hydrogen	H	1	1
Helium	He	2	2
Lithium	Li	3	2 1
Beryllium	Be	4	2 2
Boron	B	5	2 3
Carbon	C	6	2 4
Nitrogen	N	7	2 5
Oxygen	O	8	2 6
Fluorine	F	9	2 7
Neon	Ne	10	2 8
Sodium	Na	11	2 8 1
Magnesium	Mg	12	2 8 2
Aluminium	Al	13	2 8 3
Silicon	Si	14	2 8 4
Phosphorus	P	15	2 8 5
Sulphur	S	16	2 8 6
Chlorine	Cl	17	2 8 7
Argon	Ar	18	2 8 8
Potassium	K	19	2 8 8 1
Calcium	Ca	20	2 8 8 2

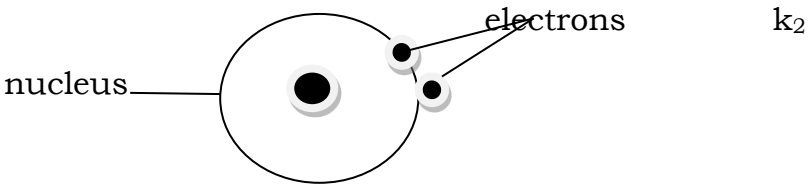
The electronic configurations of some elements are shown below:

Hydrogen, H (atomic number 1)



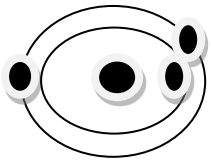
Nucleus

Helium, He(atomic number 2)



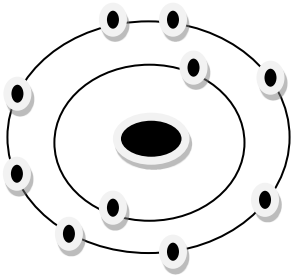
Lithium, Li (atomic number 3).

K_2 L_1



Neon, Ne (atomic number 10)

K_2 L_8

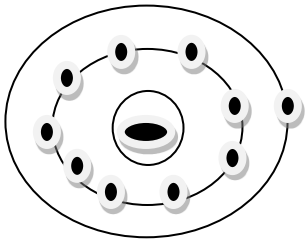


2,8

Sodium, Na (atomic number 11)

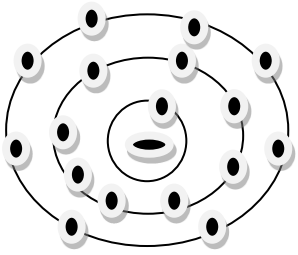
K L M

2 8 1



2, 8, 1

Argon, Ar (atomic number 18)

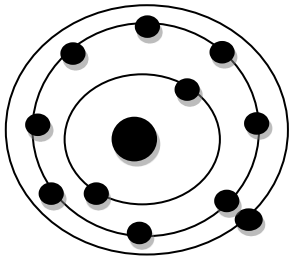


K L M

2 8 8

2,8,8

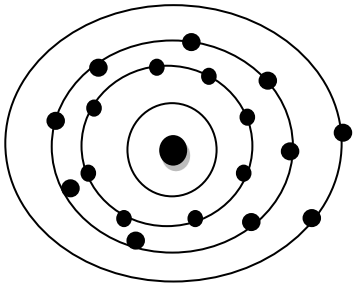
Potassium, K (atomic number 19) K L M N



2 8 8 1

2, 8, 8, 1

Calcium, Ca (atomic number 20)



K L M N

2 8 8 2

2,8,8,2

EVALUATION: Draw the electronic configuration of the following elements.

(a) Carbon (b) Fluorine (c) Aluminium (d) Nitrogen

PERIOD 2: ATOMIC NUMBER AND MASS NUMBER (NUCLEON NUMBER)

ATOMIC NUMBER:

DEFINITION: Atomic number is the number of protons in an atom of an element.

The atomic number of an element is a whole number and is designated ***z***. In a neutral atom the number of protons must be equal to the number of electrons (since protons are positively charged and electron are negatively charged).

All the atoms of a particular element have the same number of protons in their nuclei (i.e. they have the same atomic number). NO two elements have the same number of protons in their atoms.

DEFINITION:

MASS NUMBER (NUCLEON NUMBER): The mass number is the sum of the protons and neutrons in an atom of an element.

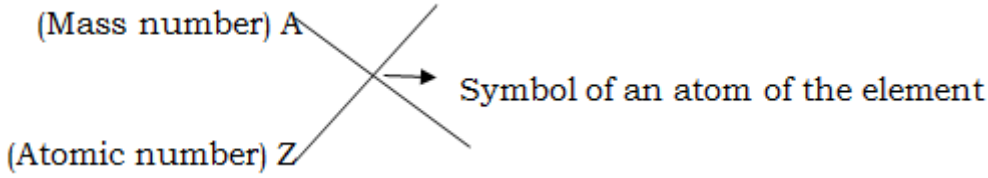
Mass number is represented by the letter A.

Mass number A = Number of protons + number of neutrons.

i.e. A =p + n. Where p=protons, n= neutrons.

Or number of neutrons n =A – Z.

An atom of an element can be described by writing its symbol together with its atomic number and mass number.



Examples: The atom of carbon, oxygen and sodium can be written as $^{12}_{6}C$, $^{16}_{8}O$ and$^{23}_{11}Na$ respectively.

EVALUATION:

(1) Define the following: (a) Atomic number (b) Mass number.

I (2) Describe the atoms of the following elements using their symbol, atomic number and mass number: (a) Phosphorus (b) Silicon (c) Calcium

PERIODS 3 AND 4: ISOTOPY AND RELATIVE ATOMIC MASS

Definition: Isotopy is a phenomenon whereby atoms of an element exhibit different mass number but have the same atomic number.

Mass spectrometric studies show that the atoms of most elements exist in more than one form. This is due to the difference in number of neutrons present in these atoms. Such atoms are known as isotopes. Isotope of an element is represented by the original symbol of the element with the mass number and atomic numbers. For example $^{12}_{6}C$, $^{13}_{6}C$, $^{14}_{6}C$ represent atoms of the isotopes of carbon. For each atom, the number of neutrons can be obtained by finding the difference between the mass number A and the atomic number Z i.e. A – Z. Each isotope of an element has its own mass known as isotopic mass.

Isotopes of an element have slightly different physical properties because neutrons contribute only to the mass of an atom and not its chemical behaviour. But isotopes of an element exhibit the same chemical properties because the number of valence electrons in an atom of an element determines its chemical behaviour (properties) and since isotopes have the same number of valence electrons they will be chemically alike.

NOTE:

(i) An analysis of the chlorine isotopes.

	Isotope $^{35}_{17}Cl$	Isotope $^{37}_{17}Cl$
Mass number, A	35	37
Atomic number,Z	17	17

Number of protons	17	17
Number of electrons	17	17
Number of neutrons (A-Z)	35 – 17=18	37 – 17=20
Abundance in nature (%)	75	25

ISOTOPES OF THE SAME ELEMENTS.

Element	Carbon	Oxygen
ISOTOPES	$^{12}_{6}C$ $^{13}_{6}C$	$^{16}_{8}O$ $^{17}_{8}O$ $^{18}_{8}O$
ABUNDANCE IN NATURE (%)	98.9 1.1	99.76 0.04 0.20

(ii) The names of the isotopic forms of hydrogen

$^{1}_{1}H$ --- Protium (or hydrogen)

$^{2}_{1}H$--- Deuterium (or heavy hydrogen or D)

$^{3}_{1}H$--- Tritium or T

(iii) The relative atomic mass, RAM of an element which exhibits isotopy is the average mass of its various isotopes as they occur naturally in any quantity of the element and they are not usually in whole numbers.

CALCULATION INVOLVING ISOTOPY.

WORKED EXAMPLE:

(1) Determine the relative atomic mass of element X from the data below

ISOTOPE	MASS	% ABUNDANCE
24X	24	78.70
25x	25	10.13
^{26}x	26	11.7

$$\frac{(24 \times 78.70) + (25 \times 10.13) + (26 \times 11.17) = X}{100}$$

$$\frac{1888.8 + 253.25 + 290.42 \quad = X}{100}$$

$$\frac{2432.47 = X}{100}$$

$$\therefore X = 24.3247$$

$$\cong 24$$

(2) An element X has two isotopes of $^{20}_{10}X$ and $^{22}_{10}X$ in the ratio 1:3. What is the relative atomic mass?
Add ratio of occurrence together.

1 + 3= 4

$$\frac{(20 \times 1) + (22 \times 3) = X}{4}$$

$$\frac{20 + 66 = X}{4}$$

$$\frac{86 = X}{4}$$

X = 21.5

(3) Isotopes of an element X have isotopic masses 65 and 63 respectively. If the relative atomic mass of X is 63.60. Find the relative abundance of each isotope of the element.

Let the relative abundance of element X be y and Z respectively.

Z +Y =100

∴ Z = 100 – y……. (i)

$$\frac{(65 \times y) + (63 \times y) = 63.60}{100}$$

65y + 63z = 63.60 × 100

65y + 63z = 6360 ……(ii)

65y +63(100 – y) = 6360

65y – 63y + 6300 = 6360

2y = 60

Y = $\frac{60}{2}$ = 30

Y= 30

Z = 100 – y= 100 – 30 = 70

Y = 30, Z = 70

The relative abundance of X = 30% 0f ^{65}X and 70% of ^{63}X

EVALUATION:

(a) How many neutrons are present on the isotopes of $^{41}_{19}X$ (45%) and $^{40}_{19}x$ (55%)

(b)Calculate the relative atomic mass of X.

RELATIVE ATOMIC MASSES BASED ON C-12 ISOTOPE

Definition: The Relative Atomic Mass of an element is the number of times the average mass of an atom of the element is heavier than one-twelfth of the mass of one atom of carbon -12

RAM of an element= $\frac{Average\ massofoneatomofX}{\frac{1}{2}massof\ 1\ atomofcarbon-12}$

Thus the atom of carbon -12 is adopted as the standard for defining the relative atomic mass of the other elements and is given a basic mass value of 12units.

The relative atomic mass of each element has been determined accurately with the aid of the mass spectrometer. This instrument measures the

masses of the isotopes of the elements and their abundance and the relative atomic mass is calculated from the data.

Relative atomic masses of the first twenty elements in the periodic table

Element	**Atomic number**	**Relative atomic mass**
Hydrogen	1	1.008
Helium	2	4.0026
Lithium	3	6.939
Beryllium	4	9.0122
Boron	5	10.81
Carbon	6	12.011
Nitrogen	7	14.0067
Oxygen	8	15.9994
Fluorine	9	18.9884
Neon	10	20.183
Sodium	11	22.9898
Magnesium	12	24.312
Aluminum	13	26.9812
Silicon	14	28.086
Phosphorus	15	30.9738
Sulphur	16	32.06
Chlorine	17	35.453
Argon	18	39.948
Potassium	19	39.102
Calcium	20	40.08

The relative atomic masses of the first twenty elements in the periodic table are given in the table below.

EVALUATION: From the complete periodic table of elements write out the relative atomic masses of (A) Magnesium (b) Oxygen (c) Chlorine (d) Carbon

GENERAL EVALAUATION

OBJECTIVES TEST :

(1) The maximum number of electrons that can be accommodated in the M-shell is. (a) 18 (b) 8 (c) 2 (d) 32
(2) The atomic number of chlorine is (a) 17 (b) 18 (c) 20 (d) 7
(3) Which of the following is an isotope of hydrogen?
(a)$^{4}_{1}H$ (b) $^{5}_{1}H$ (c) $^{3}_{1}H$ (d) $^{0}_{1}H$

(4) Which of the following is the electronic configuration of carbon?

(a) K L M	(b) K L M	(c) K L M	(d) K L M
2 2	2 2 4	1 2 3	2 1 3

ESSAY QUESTIONS

(1) Chlorine exists in two isotopic mixtures. The first has 17protons and 18 neutrons while the second isotope has 17 protons and 20 neutrons. If the two isotopes are present in ratio 3:1 respectively, calculate the relative atomic mass of chlorine.

(2) Show the electron structure of the following.

(a) Calcium (b) Magnesium (c) Sodium (d) Oxygen

(3) If the numbers of charged and unchanged particles in the centre of an atom are 6 and 7 respectively, what is the mass number of the atom?

(4) Calculate the number of neutrons in

(a) $^{23}_{11}Na$ (b) $^{37}_{17}Cl$

(5) (a)What is an 'isotopy'?

(b) Explain briefly why the chemical properties of isotopes of an element are similar.

WEEKEND ASSIGNMENT: Read about the topic "mass spectrometer"

WEEK ACTIVITY:

(a) Draw a labelled structure of a mass spectrometer showing its basic features. (b) Write two features of a mass spectrometer.

PRE-READING ASSIGNMENT:

Read the topic "symbols of elements" page 26 of New school Chemistry. By Osei Yaw Ababio.

WEEK: 4

TOPIC: VALENCY, OXIDATION NUMBER, IONS AND RADICALS

CONTENT

1. Valency of elements

2. Oxidation numbers of elements in compounds

3. Ions and radicals

PERIOD 1: VALENCY OF ELEMENTS

VALENCY

The valency of an element is the combining power of the element. It is defined as the number of atoms of hydrogen that will combine with or displace one atom of the element in chemical reactions. Some elements have more than one valency. For example.

First twenty elements with their valencies show this character.

Atomic Number	Element	Symbol	Valency
1	Hydrogen	H	1
2	Helium	He	Nil
3	Lithium	Li	2
4	Beryllium	Be	2
5	Boron	B	3
6	Carbon	C	2 or 4
7	Nitrogen	N	3 or 5
8	Oxygen	O	2
9	Fluorine	F	1
10	Neon	Ne	Nil
11	Sodium	Na	1
12	Magnesium	Mg	2
13	Aluminum	Al	3
14	Silicon	Si	2 or 4

15	Phosphorus	P	3 or 5
16	Sulphur	S	2, 4 or 6
17	Chlorine	Cl	1
18	Argon	Ar	Nil
19	Potassium	Ic	1
20	Calcium	Ca	2

EVALUATION:

1. What do you understand by the word chemical symbol?

2. Define valency of an element.

READING ASSIGNMENT:

Find out the valency of the following element.

(i) Gold (ii) Silver (iii) Zinc and copper

PERIOD 2: OXIDATION NUMBER OF ELEMENTS

To be able to write correctly chemical formulae for compounds, a system of small whole numbers, related to the combining ratio of element has been developed on the basis of arbitrary rules. Such numbers are called oxidation numbers or oxidation states.

Rules for assigning oxidation number

1. The ON of an uncombined free element, whether monoatomic or polyatomic is zero; e.g. Noble gases (He, Ne, etc), metals (Na, Zn, etc),solid non-metals (O_3, N_2, F_2,etc)
2. The oxidation number of a monoatomic ion is equal in magnitude and sign to its ionic charge; e.g., the ON of bromide ion, Br^{-1}, is -1; that of F^{+3}, is +3.
3. The ON of hydrogen atom is +1 in its compounds, except in hydrides of metals (e.g. NaH), where it is -1
4. For any neutral compound the sum of the ONs of all the atoms adds to zero.
5. The ON of oxygen in a compound is always -2 except in peroxides, H_2O_2, Na_2O_2, where it is -1
6. In any radical, the sum of the ON of all the atoms is equal to the charge on its ion.

Worked examples on oxidation numbers

1. Calculate the ON of copper in Cu_2O

Solution

Let y represents the ON of each copper atom.

ON of one hydrogen atom, O is -2.

In a neutral compound, sum of all ON is zero.

Therefore, in Cu_2O: Cu_2O

$2y + (-2) = 0$

$2y = +2$

$y = +2/2 = +1$

Thus, ON of a copper atom in Cu_2O = +1

2. Determine the ON of X in $X_2O_7^{2-}$

Solution

ON of each O atom = -2

The net charge on the ion = -2

Therefore, in $X_2O_7^{2-}$

$2X + 7(-2) = -2$

$2X - 14 = -2$

$2X = -2 + 14 = +12$

$X = +12/2 = +6$

Therefore, ON of each X in $X_2O_7^{2-}$ is +6

EVALUATION:

1. What do you understand by the term "oxidation number".

2. States four rules guiding the derivation of oxidation number of elements.

3. Determine the oxidation number of the boldened atoms in the following: (a) $H_2\mathbf{S}O_4$ (b) $\mathbf{Cr}_2O_7$ (c) $\mathbf{Fe}_2O_3$ (d) $\mathbf{Mn}O_4^-$

PERIOD 3: IONS AND RADICALS

DEFINITION:

An ion is any atom or group of atoms which possess an electric charge.

Some substances are not built of atoms or molecules but are made up of charged particles called ions. Ions are formed when an atom losses or gains electron.

There are two types of ions. The positively charged ions or cations e.g. K^+, Ca^{2+}, Zn^{2+}, Al^{3+} etc. they are formed when atoms loss electrons and negatively charged ions or anions which are formed when atom gain electrons e.g. Cl^-, N^{3-}, O^{2-}, S^{2-} etc.

RADICALS: These are groups of atoms of different elements that come together and react as a unit. These radicals are charged, that is, they either carry a positive or a negative charge. An acid radical is thus a small group or cluster of atoms carrying a negative charge that keeps its identity. These groups of atoms originate from the acids which have formed the salts. For examples

Radical	**Symbol**	**Valency**	**Oxidation No**
Ammonium ion	NH_4^+	1	+1
Hydroxyl ion	OH^-	1	-1
Trioxocarbonate (iv)	CO_3^{2-}	2	-2
Tetraoxosulphate(vi)	SO_4^{2-}	2	-2
Trioxonitrate(v)	NO_3^-	1	-1

EVALUATION:

1. Differentiate between ions and radicals.
2. List four examples each of ions and radicals.
3. State the valencies of the following radiclas: (a) PO_4^{3-}(b) MnO_4^-(c) $C_2O_4^{2-}$

WEEK: 5

FORMULAE AND EQUATIONS

CONTENTS:

1. Chemical formulae

2. Chemical equations

3. Empirical and Molecular formulae

4. Relative Molecular Mass and Percentage composition by mass of an element.

PERIOD 1: CHEMICAL FORMULAE

Chemical formula can be defined as a collection of two or more symbols to represent one molecule of the compound. For example, the formula of tetraoxosulphate(VI) acid is H_2SO_4. This formula shows that in a molecule of tetraoxosulphate(VI) acid, there are two atoms of hydrogen, one atom of sulphur and four atoms of oxygen.

The table below contain examples of compounds with their formulae

Compounds	**Formulae**
Oxygen molecule	O_2
Hydrogen molecule	H_2
Hydrogen chloride	HCl
Potassium chloride	KCl
Magnesium tetraoxosulphate(VI)	$MgSO_4$
Hydrogen sulphide	H_2S
Bromine Molecule	Br_2
Ozone	O_3

EVALUATION

Write the chemical formulae of the following:

(1) Sodium oxide, Calcium oxide, aluminium oxide,

(2) Carbon(IV) oxide, iron(II) oxide, copper(I) oxide

(3) Sodium tetraoxosulphate(VI), Calcium trioxonitrate(V), magnesium trioxocarbonate(IV).

PERIOD 2: CHEMICAL EQUATIONS

Chemical reactions are represented in form of equations which show the reactants and products in any given chemical reaction. For example, the reaction of aqueous hydrogen chloride and aqueous sodium hydroxide is represented by the equation:

$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$

Balancing Chemical Equations

All chemical equations must be balanced in order to comply with the law of conservation of mass. For example, to balance the equation for the reaction involving the combustion of ammonia gas in air, the following steps should be followed:

Step 1: The reactants (LHS) are NH_3 and O_2, while the products (RHS) are NO and H_2O

$NH_{3(g)} + O_{2(g)} \longrightarrow NO_{(g)} + H_2O_{(g)}$

Step 2: Place a 4 in front of NH_3 and a 6 in front of H_2O. There are now 12 hydrogen atoms on both sides of the equation.

$4NH_{3(g)} + O_{2(g)} \longrightarrow NO_{(g)} + 6H_2O_{(g)}$

Step 3: Place a 4 in front of NO to balance with the 4 nitrogen atoms of the LHS of the equation.

$4NH_{3(g)} + O_{2(g)} \longrightarrow 4NO_{(g)} + 6H_2O_{(g)}$

Step 4: Place a 5 in front of O_2. An "atom count" shows that the equation is balanced.

$4NH_{3(g)} + 5O_{2(g)} \longrightarrow 4NO_{(g)} + 6H_2O_{(g)}$

An equation must be balanced. A balanced equation contains the same number of atoms of the elements of the compounds on both sides of the equation.

The equation must also show the physical states of the reactants and the products i.e. whether in aqueous solution or gaseous or solid state.

Evaluation

Balance the equations below:

1. $CaCO_{3(s)} + HCl_{(aq)} \longrightarrow CaCl_{2(s)} + H_2O_{(l)} + CO_{2(s)}$
2. $CO_{2(g)} + NaOH_{(aq)} \longrightarrow Na_2CO_{3(aq)} + H_2O_{(l)}$

PERIOD 3: EMPIRICAL AND MOLECULAR FORMULAE

Empirical formula is the simplest formula which gives the ratio of the number of different atoms present in a compound. It does not give the exact number of each atom whereas the molecular formula gives the exact number of the atoms present in a molecule of a compound.

The molecular formula of a compound is a whole number multiple of its empirical formula.

Examples:

(1) Find the empirical formula of a compound which contains 80% carbon and 20% hydrogen by mass.

$[Relativeatomicmasses; (C = 12, H = 1)]$

	C	**H**
Percentage by mass	80%	20%
Percentage by mass	$\frac{80}{12}$	$\frac{20}{1}$
	6.6	20
Divide by the smaller number	$\frac{6.6}{6.6}$	$\frac{20}{6.6}$
	1	3
	C	H_3

Hence, the empirical formula is CH_3

(2) Find the empirical formula of a compound which on analysis yields the following as the reacting masses carbon= 2.0, hydrogen=0.34g, Oxygen = 2.67g. From your result find the molecular formula of the compound. If it's relative molecular mass is 60. (C=12, H=1, O=16)

Solution:

C	H	O
$\frac{2}{12}$	$\frac{0.34}{1}$	$\frac{2.67}{16}$
0.17	0.34	0.17

Divide by The smallest number

$\frac{0.17}{0.17}$	$\frac{0.34}{0.17}$	$\frac{0.17}{0.17}$
1	2	1

Empirical formula of the compound is CH_2O.

$(CH_2O)_x = 60$

$(12 + (2\times1) + 16)_x = 60$

$(12+2+16)x = 60$

$(30)x = 60$

$X = 2$

Molecular formula is therefore $(CH_2O)_2$

$= C_2H_4O_2$ or CH_3COOH

EVALUATION:

Calculate the empirical formula of 15.8% Al, 28.1% S, 56.1%O

PERIOD 4: RELATIVE MOLECULAR MASS, MOLAR MASS AND PERCENTAGE COMPOSITION

If the formulae of a substance and the relative atomic Masses of each of the elements are known, then it is possible to determine the relative molecular mass of that substance.

The **relative molecular mass** refers to the number of times a mole is heavier than one- twelfth the mass of one atom of carbon -12. It has no unit.

The relative molecular mass of a compound is the sum of the masses of all the atoms present in one molecule of the compound .e.g.

For NaCl, the relative molecular mass= (23 +35.5) = 58.5

For ethanol = C_2H_5OH (carbon=12, H=1, O =16)

The relative molecular mass of ethanol

= C_2H_5OH

$(12\times2) + (1\times5) + (16) + (1)$

$24 + 5 + 16 + 1 = 46$

THE MOLAR MASS

This is the relative molecular mass expressed in grams. E.g. the molar mass of ethanol is $46gmol^{-1}$

In 12g of carbon-12, there are 6×10^{23} atoms of carbon. This is one mole of carbon -12.

A mole of any substance is the amount of that substance which contains 6×10^{23} particles of that substance e.g. One mole of ethanol has a mass of 46g and contains 6×10^{23} ethanol molecules.

NOTE: The relative molecular mass has no units but the molar mass of any substance is expressed in grams.

PERCENTAGE COMPOSITION OF A COMPOUND

To calculate the percentage position of ethanol whose molecular formula is C_2H_5OH, given that the relative atomic masses of carbon, hydrogen and oxygen are 12, 1, and 16 respectively?

First calculate the molar mass of C_2H_5OH $=(12\times2) +(1\times5) + (16)+ (1) = 46gmol^{-1}$

Then determine the masses of C H and O present;

Mass of carbon= $12\times2=24g$

Mass of hydrogen= $6\times1 = 6g$

Mass of oxygen = $16\times 1 = 16g$

Molar mass of C_2H_5OH= 46g

Therefore, percentage of C= $\frac{24}{46} \times 100 = 52.17\%$

Percentage of hydrogen =$\frac{6}{46} \times 100 = 13.04\%$

Percentage of oxygen $= \frac{16}{46} \times 100 = 13.04\%$

(i) **Calculation of the chemical formula from percentage composition by mass**.

We can determine the simplest chemical formula of a compound, given its percentage composition e.g. If the formula for anhydrous disodium trioxocarbonate (iv) is not known, if its percentage composition by mass is known then it chemical formula could be calculated.

For example, the percentage composition of the compound was found to be **Na=43.40%,C= 11.32%** and **O = 45.28%.** This would mean that in every 100g of the compound, the masses of Na, C and O were 43.40g, 11.32g and 45.28g respectively.

∴The amount in moles of Na, C and O would be.

$\frac{43.40}{23}$, $\frac{11.32}{12}$ and $\frac{45.28}{16}$ respectively.

Therefore, the amount in moles of **Na** $=\frac{43.40}{23}$ **= 1.89.**

Amount in mole of **C=** $\frac{11.30}{12}$**= 0.94.**

Amount in mole of **O=** $\frac{45.28}{16}$**=2.83.**

Molar ratio of **H: C: O is 1.89: 0.94: 2.83.**

2: 1 : 3

Na: C: O= $Na_2C\ O_3$

The simplest formula is therefore, Na_2CO_3

GENERAL EVALUATION

ESSAY QUESTION

1. Diffentiate between valency and oxidation number.

2. Determine the empirical formula of an oxide of nitrogen containing 70% oxygen, if the relative molecular mass of the oxide is 92, deduce its molecular formula.

3. Balance this chemical equation

$NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O$

WEEK 6

TOPIC: LAWS OF CHEMICAL COMBINATION

CONTENT:

1. Law of conservation of matters

2. Law of constant composition

3. Law of multiple proportions.

PERIOD 1: CHEMICAL LAWS OF COMBINATIONS

There are four laws of chemical combination which describe the general features of a chemical change.

(a) **Law of conservation of mass:** This law was established by Lavoisier, a French chemist. The law of conservation of mass states that matter is neither created nor destroyed during chemical reaction, but changes from one form to another.

Experiment to verify the law of conservation of matter (mass)

Theory:

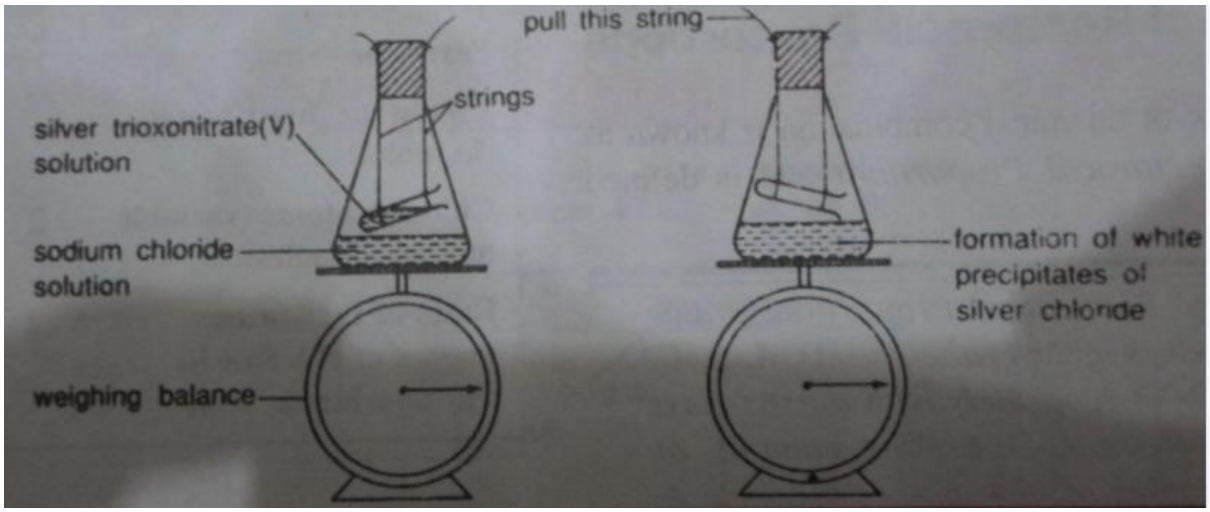
The equation of the chemical reaction chosen for study is as follows;

Silver nitrate + sodium chloride ⟶ Silver chloride + Sodium trioxonitrate(v)

(White precipitate)

Method:

1. Put some sodium chloride solution in a conical flask
2. Fill a small test tube with silver trioxonitrate (iv) solution of string, suspend it in a conical flask as shown below:



3. Insert the stopper and weight the whole apparatus on a balance, note the mass of the whole system.
4. Mix the two liquids by pulling the string attached to the bottom end of the small test tube.
5. Weigh the whole apparatus again.

Result: When the two reactants are mixed together, a white precipitate is formed indicating that a chemical reaction has taken place. The new substances formed are known as the products of the chemical reaction. The masses of the system taken before and after the reaction are found to be the same, indicating that the mass of the reactants equals that of the products.

CONCLUSION: Since there is no overall change in mass when the products are formed, we can infer that matter is neither created nor destroyed during the chemical reaction. The law is, hence valid.

EVALUATION:

(1) Mention another compound that could be used instead of silver trioxo-nitrate(v) with sodium chloride
(2) State the law of conservation of mass/matter.

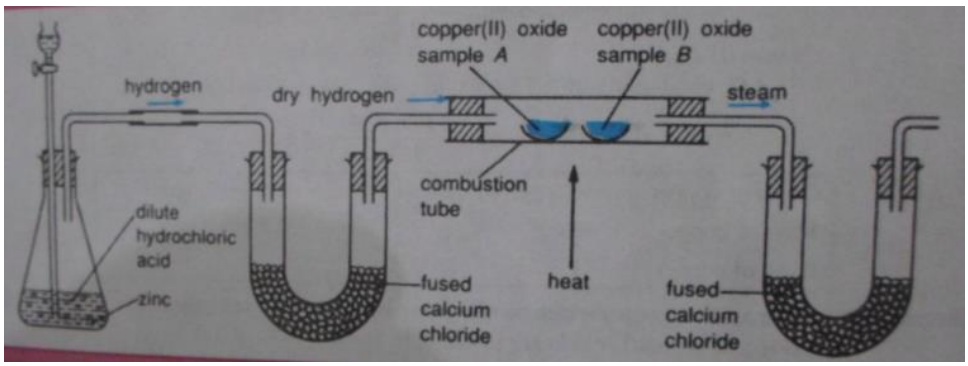
PERIOD 2: LAW OF DEFINITE PROPORTION OR LAW OF CONSTANT COMPOSITION

The second law of chemical combination which is supported by the Atomic theory was proposed by provost (1755-1826) known as the Law of definite proportions or constant composition.

The law of definite proportions states that all pure samples of a particular chemical compound contain similar elements combined in the same proportion by mass. It is based on the fact that when elements combine to form a given compound, they do so in fixed proportions by mass, so that all pure samples of that compound are identical in composition by mass. Water for example: chemical analyses showed that as long as it is pure, its composition is always in the ratio of one mole of oxygen to two moles of hydrogen. i.e. 32g of O to 4g of H. Irrespective of whether the water comes from river, sea, rain or anywhere.

Experiment to verify the law of definite proportion

Method: Prepare two samples of black copper (ii) oxide, each by a different method as given below:



Sample A: Place some coppers turning in a crucible and add some concentrated trioxonitrate (v) acid, a little at a time, until the copper dissolves completely. Evaporate the resulting green solution of copper II oxide trioxonitrate (v) to dryness; continue to heat the residue until it decomposes to give a black solid which is copper II oxide. Keep the black residue dry in desiccator.

Sample B: Place some copper (i) trioxocarbonate (iv) in a crucible and decompose it into copper (ii) oxide and carbon (iv) oxide store the residue in a desiccator.

ANALYSES:

Determine the amount of copper present in the two samples of copper oxide by reducing the oxide in a stream of hydrogen or carbon II oxide as follows.

1. Weigh two clean metal boats.
2. Add a reasonable amount of sample A to one and sample B to the other
3. Reweigh and determine the mass of each sample. Place the boats inside a hard glass tube as shown. Heat the samples strongly while passing a stream of dry hydrogen gas through the tube. After some time, a reddish- brown copper residue is left in each boat. Remove the flame, but continue passing the hydrogen as the copper residues cool down. This presents the re-oxidation of the hot copper residue by atmospheric oxygen. Any water formed during the reaction is absorbed by the fused calcium chloride in the adjacent U-tube.

Result:

Sample	**A**	**B**
Mass of copper II oxide	3.55g	3.02g
Mass of copper residue	2.81g	2.42g
Percentage of copper present in copper (ii) oxide	$\frac{2.81}{3.55} \times 100$	$\frac{2.42}{3.02} \times 100$
	79.2%	80.1%

The percentage of copper residue in the two samples in approximately 80.0, irrespective of the method of preparation of the copper(II) oxide samples.

CONCLUSION: In the pure copper(II) oxide copper and oxygen are always present in a definite proportion by mass of approximately 4 to 1 i.e.

Copper(II) oxide = copper + oxygen

100% 80% 20%

Ratio 4 : 1

EVALUATION:

1. State the Law of Definite proportion.

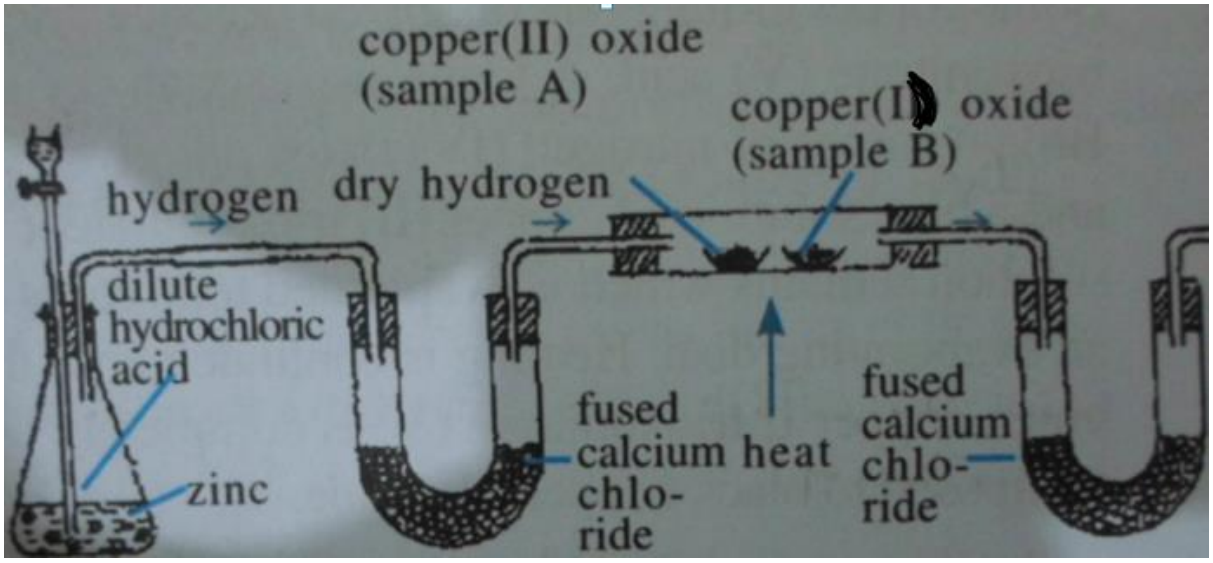
PERIOD 3: LAW OF MULTIPLE PROPORTIONS

This law states that if two elements combine to form more than one compound, the masses of one of the elements which separately combine with a fixed mass of the other element are in simple ratio.

VERIFICATION OF THE LAW OF MULTIPLE PROPORTIONS

Some elements form more than one compound, depending on the conditions of the reaction and the valency copper forms. Copper (I) and copper(II) with oxygen. Also in an insufficient supply of air, carbon burns to form carbon(II) oxide and when the supply of air is sufficient, carbon(iv) oxide is obtained.

The sample of the copper (I) oxide and copper(II) are placed in porcelain, boats and placed in a combination tube as in the diagram below.



A current of dry hydrogen is passed through the combustion tube until the oxides are reduced to metallic coppers. They are now cooled and weighed and the masses of copper and oxygen are determined in the two samples.

Calculations	***Sample A***	***Sample B***
(i)Mass of porcelain boat	4.55g	5.38g
(ii) Mass of porcelain boat + copper oxide	6.44g	8.21g
(iii) Mass of copper oxide	1.89g	2.83g

(iv) Mass of porcelain boat + copper	6.05g	7.90g
(v) Mass of copper (iv) – (i)	1.50g	2.52g
(vi) Mass of oxygen (iii) –(v)	0.39g	0.31g

For example A**1.50g of copper** combines with **0.39 of oxygen.**

∴ 100g of copper combines with $\frac{0.39}{1.50} \times 100 = 26g$

For sample (b) 2.52g of copper combines with 0.31g of oxygen

∴ 100g of copper combines with $\frac{0.31}{2.52} \times 100 = 12.3g$

From these calculations, the masses of oxygen (26g and 12.3g) which combine with a fixed mass (100g) of copper are in simple ratio 2:1

PERIOD 4: LAW OF RECIPROCAL PROPORTION

This is the fourth law of chemical combination. ***This law states that the masses of several elements,A,B,C,which combine separately with a fixed mass of another element,D,are the same as ,or simple multiples of ,the masses in which A,B,C,themselves combine with one another.*** For example C, H, O (12, 1, 16) respectively. Carbon and hydrogen combine to form methane (CH_4). Carbon and oxygen combine to form carbon (iv) oxide, (CO_2) and hydrogen and oxygen combine to form water (H_2O).

In water,

$H_2 + O \longrightarrow H_2O$

2moles + 1 mole

2g 16g $\longrightarrow H_2O$

Ratio= 2g: 16g or 4g : 32g $\longrightarrow H_2O$

This is the prediction of the law of reciprocal proportions. For example, 23g of calcium trioxocarbonate (iv) on heating decomposes to give calcium oxide (CaO) and carbon (iv) oxide. Calculate the masses of calcium oxide and carbon (iv) oxide produced [C= 40, O = 16, C= 12]

Solution

$CaCO_{3(s)} \longrightarrow CaO_{(s)} + CO_{2(g)}$

40+12+48 40+16 44

(1) 100g of $CaCO_3$ yield 56g of CaO

∴ 23g of $CaCO_3$ will yield $\frac{56\times23g}{100}$ = **12.88g**.

(2) 100g of $CaCO_3$ yields 44g of CO_2

∴ 23g of $CaCO_3$ will yield $\frac{44\times23g}{100}$= **10.12g**

EVALUATION:

(1) State the law of multiple proportion
(2) State the law of reciprocal proportions.
(3) $Zn_{(s)} + 2HCl_{(aq)} \longrightarrow ZnCl_{2(aq)} + H_{2(g)}$

GENERAL EVALUATION:

ESSAY QUESTIONS

	Copper(I)oxide	**Copper(II)oxide**
Mass of sample oxide	30.4g	1.91g
Mass of copper residue	2.55g	1.38g
Mass of oxygen removed from oxide	0.49g	0.53g

From the above table, calculate the various masses of copper which would combine separately with a fixed mass of 1 g of oxygen.

2. What mass of copper will be produced from the reduction of 7.95g of copper (II) oxide? (C= 63.5, O= 16)

3. Write down the names of these chemical compounds:(i) HNO_3 (ii) $CuCl_2$ (iii) $CaCO_3$ (iv) Fe_2O_3
4. Write the symbol and the valency of the following. (i) Boron (ii) Carbon (iii) Sulphur (iv) Argon
5. Calculate the formula of a compound with 31.9% potassium 28.93%, chlorine and the rest oxygen. K=39, Cl =355, O=16

OBJECTIVE TEST

1. Which of the following relative molecular mass has empirical formula CH_2O (H=1 C=12, O=16). (a) 42 (b) 80 (c) 4 (d) 60
2. The relative molecular mass of tetraoxosulphate(VI) acid is? (a) 98 (b) 49 (b) 49 (c) 96 (d) 106

3. Chemical equations will provide all these except. (a) State of chemicals is solved (b) Direction of reaction (c) Mass of products (d) Reactants
4. All pure samples of a particular compound contain the same elements combined in the same proportion by mass. The statement is the law of (a) Definite proportion (b) Multiple proportion (c) Conservation of mass or matter (d) Atomic proportion

WEEK 8

TOPIC: CHEMICAL COMBINATION

CONTENTS:

(a) Periodic table (First 20 elements)

(b) Types of chemical bonds

(c) IUPAC system of naming inorganic compounds.

PERIOD 1: PERIODIC TABLE (FIRST 20 ELEMENTS)

Chemical combination: The atoms of noble gases e.g. Helium He, Neon Ne are very stable; because their outermost shells are completely filled with electrons. The tendency of the other elements is to attain this stable structure possessed by the noble gases. This is achieved during **chemical combination.** Thus, **chemical bonding** is the coming together of atoms of the same or different elements, in order to form a stable structure.

The Periodic Table

Periodic table is the arrangement of chemical elements in order of their atomic numbers. ***Atomic number***, Z, of an element is the number of protons in one atom of that element while, ***Mass number***, A, of an element is the sum of the protons and neutrons in it.

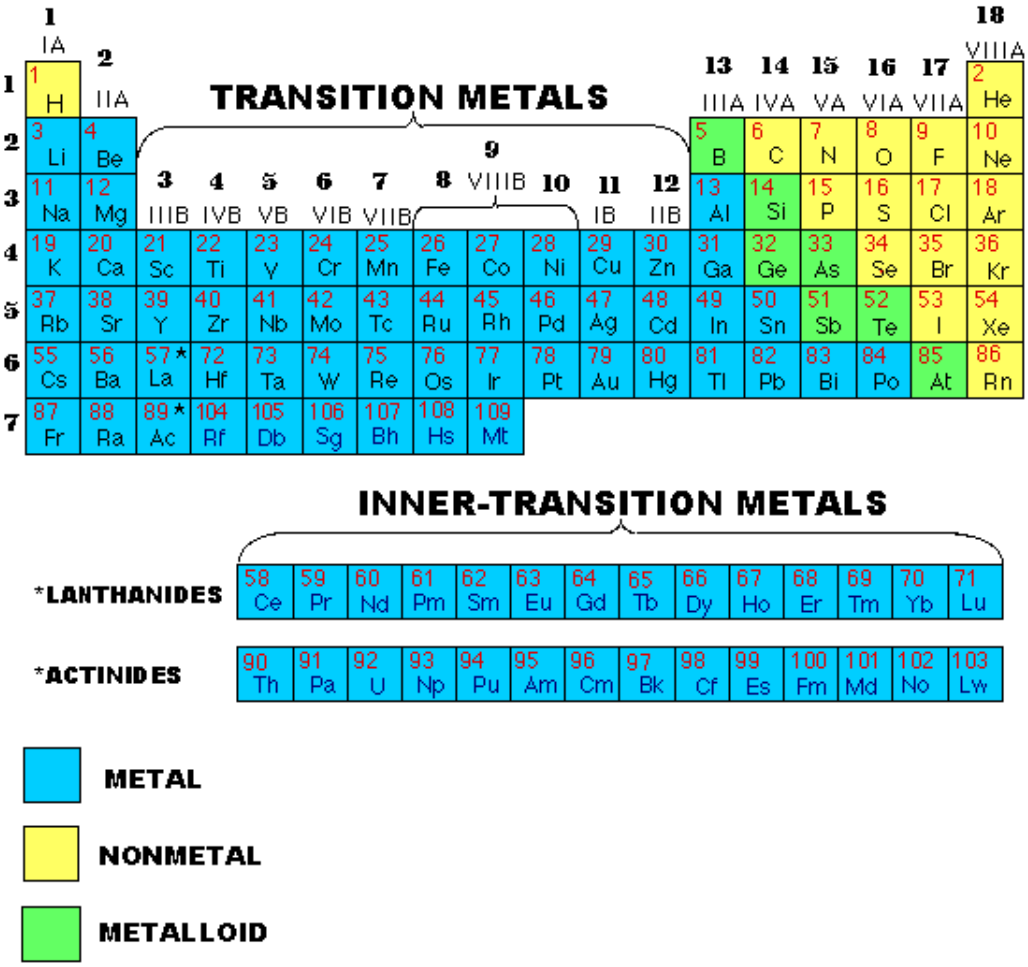
Many scientists have attempted to classify chemical elements based on their properties. They include Newland, Lothar Meyer, Dobereiner and Mendeleev. The modern periodic table is based on Mendeleev's original idea in 1869. The basic assumption behind the modern periodic table known as **Periodic Law** which states that "the properties of the elements are a periodic function of their atomic number"

The modern periodic Table

The modern periodic table is divided into vertical columns of elements called Groups and horizontal rows of elements called Periods. There are seven (7) periods and eight (8) groups. The first twenty (20) elements are:

1. Hydrogen
2. Helium
3. Lithium
4. Beryllium
11. Sodium
12. Magnesium
13. Aluminum
14. Silicon

5. Boron
6. Carbon
7. Nitrogen
8. Oxygen
9. Fluorine
10. Neon
15. Phosphorus
16. Sulphur
17. Chlorine
18. Argon
19. Potassium
20. Calcium



Periodic table of elements

EVALUATION

1. Define a periodic table
2. List the first twenty (20) elements
3. State the periodic law
4. How many groups and periods are there in the periodic table?
5. In the periodic table, elements are arranged according to their _____

PERIODS 2 and 3: TYPES OF CHEMICAL BONDS

The attractive force between atoms when they combine chemically is called a **chemical bond**. There are two main types of chemical bonds namely (i) Strong bonds (ii) Weak bonds.

(i) Strong bonds are: (a). Electrovalent (or Ionic) (b).Covalent (c).Co-ordinate (or Dative) (d). Metallic

(a) Electrovalent (Ionic) bond is defined as the electrostatic force of attraction between oppositely charged ions. It involves the transfer of

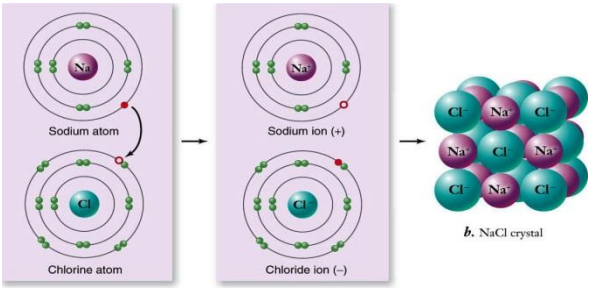
electrons from one atom, donor atom, (usually metallic) to another atom, acceptor atom, (usually non-metallic). The electrons involved reside in the outermost shells of the atoms and are called Valence electron(s).

IONIC COMPOUNDS are crystal lattices consisting of aggregates of oppositely charged ions. Examples of such compounds are Sodium chlorides, calcium oxides, ammonium chlorides etc. The formation of sodium chloride is illustrated below:

Na = 2, 8, 1 Cl =2, 8, 7

Na^+= 2, 8 Cl^- = 2, 8, 8

$Na^+ + Cl^- \rightarrow NaCl$



Characteristics of Electrovalent bonds

i. They have high melting and boiling points

ii. They are generally soluble in water

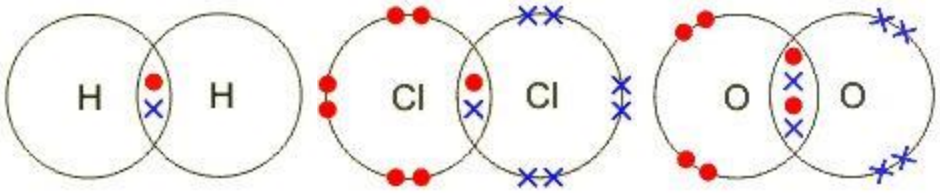
iii .They are good conductors of electricity when molten or in solution

iv. They do not conduct electricity when solid

v. The energy needed to separate them is relatively high.

(b) Covalent bonds: This is defined as the bonds formed when two atoms donate equal numbers of electrons and share the donated electrons to attain stable octet structure. In covalent bonding, electrons are shared between atoms of the same or different elements such that each atom contributes the shared electrons so as to attain stable noble gas configuration. During the process, discrete or separate molecules are formed with covalent bonds between the atoms.

If electrons are shared between similar atoms, the donated electrons are equally shared which give rise to a **non-polar covalent bond** e.g. F_2, H_2, O_2, Cl_2 but if the shared pair of electrons involves two different elements with difference in electronegativity, the electrons are then not equally shared, this results in the formation of **polar covalent bond**, e.g. the formation of HCl, H_2O, HF..



Characteristics of Covalent bonds

i. Low melting and boiling points.

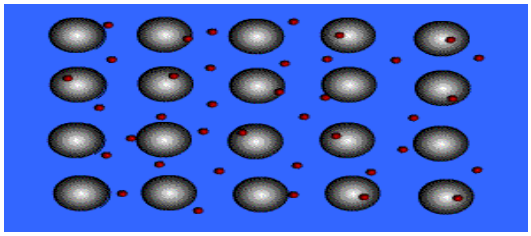
ii. Energy required for separation is low

iii. Do not conduct electricity in the solid or molten state, or in solution

iv. They generally have a strong, easily noticeable smell
v. They are not easily soluble in water, but are usually soluble in organic solvents

(c) Co-ordinate covalent or Dative bond involves sharing of electrons as in the normal covalent bonding, but the shared pair is donated by only one of the participating atoms. For instance, Ammonia and water molecules possess lone pairs and so readily enter into coordinate covalent bonding.

(d) Metallic bond: The electrostatic force of attraction between the positive nuclei and the sea of mobile electrons is called **metallic bond.** Metallic bonding, therefore, is the process whereby the positively charged nuclei of metal atoms are simultaneously attracted to the sea (or cloud) of mobile electrons. Metallic bond increase with increase in valence electrons of the metal. For example, in period 3, metallic bond increases from sodium to aluminium.



(ii) **Weak bonds:** These are intermolecular forces of attraction that hold atoms and covalent molecules together in gases, liquids and solids. The most common ones are: (a). Van der Waals forces (b). Hydrogen bond (c) Dipole-Dipole (Dipolar)

(e) Van der Waals forces: They were first described by J.D. van der Waals, and are known as van der Waals forces. They are weak short-ranged attractive forces formed between covalent molecules. They are the only attractive forces between the atoms of the noble gases and non-polar covalent molecules, and are responsible for the low melting and boiling point of covalent compounds. Due to increase in van der Waals forces, there is gradation in the physical properties of the Halogens: Fluorine and chlorine are gases; bromine is a liquid; and iodine is a solid.

Van der Waal force becomes stronger as the relative atomic mass increases among the non-metals.

(f) Hydrogen bond: This is an intermolecular force which arises when hydrogen is covalently linked to highly electronegative elements like nitrogen, oxygen and fluorine.

The presence of hydrogen bonds between H_2O molecules is responsible for water being a liquid at room temperature and with a high boiling point; if

not, it would have been a gas, like hydrogen H_2S. HF is a liquid at room temperature, while HCl is a gas.

EVALUATION

- What is a chemical bond?
- List three (3) general properties of electrovalent compounds.
- Define covalent bond and state its characteristics
- State two (2) differences between covalent and electrovalent compounds.
- Explain the term *Metallic bonding*

PERIOD 4: IUPAC SYSTEM OF NAMING INORGANIC COMPOUNDS

Chemical compounds are named according to the International Union of Pure and Applied Chemistry (IUPAC) system. In order to understand the basic principles behind the IUPAC system, a good knowledge of the concept of Oxidation Number (ON) is very essential.

Concept of oxidation number

An oxidation number (ON) is a positive or negative number assigned to an atom according to a set of rules. It is sometimes called **Oxidation State**.

Naming of inorganic compounds

1. Binary compounds. Binary compounds contain two elements only. The metal is named first, followed by the name of the second element ending with ***–ide***. If the metal is one that has variable valencies, the valency exhibited will be written in Roman numeral examples are given below:

Name of compounds

Formula	**Conventional Name**	**IUPAC Name**
Na_2O		Sodium oxide
Fe_2O_3		Iron (III) oxide
CO	Carbon monoxide	Carbon (II) oxide
CO_2	Carbon dioxide	Carbon (IV) oxide
N_2O	Nitrous oxide	Dinitrogen (I) oxide

2. Radicals. In naming radicals, the last element is mentioned first with its number of atoms given as mono (1), di (2), tri (3), tetra (4), penta (5), etc. The other element's name ends with –ate.

Formula	**Name**
CO_3^{2-}	trioxocarbonate (iv) ion
MnO_4^-	tetraoxomanganate (vii) ion
SO_4^{2-}	sulphate (vi) ion

NO_3^-	Trioxonitrate (iv) ion

EVALUATION

- Define oxidation number and, determine the ON of sulphur in SO_3^{2-}
- Give the IUPAC name of the following: (i) $Al(NO_3)_3$ (ii) MnO_2 (III) $CuSO_4 .5H_2O$
- What is the correct IUPAC name for NO^{2-}?

GENERAL EVALUATION

OBJECTIVE TEST:

1. Which of these are found in the nucleus of an atom?
   A. electrons and protons B. electrons and neutrons C. protons and neutrons D. photons and electrons E. photons and neutrons.
2. The type of bond between two atoms of an element with atomic number 7 is? A. ionic B. covalent C. hydrogen bond D. metallic bond E. coordinate covalent bond.
3. The ON of phosphorus, P in $PH_3$is? A. +2 B. -3 C. -1 D. +3
4. Give the IUPAC name of the compound NO_2. A. nitrogen dioxide B. nitrogen monoxide C. nitrogen (II) oxide D. nitrogen (iv) oxide
5. Atomic number, Z, is the number of _____ in one atom an element. A. protons B. neurons C. electrons D. atoms

ESSAY QUESTIONS

1. By means of a diagram, show the arrangement of electrons in one atom of Sodium.

2. The electronic configurations for the metal calcium, the non-metals silicon and chlorine can be represented as:

Ca : 2, 8, 8, ; Si : 2, 8, 4 ; and Cl : 2, 8, 7. (a) Explain, in terms of electrons, the formation of calcium chloride and silicon chloride. (b) Give two (2) differences in physical properties you would expect between calcium chloride and silicon chloride.

3. Compare the characteristics of ionic with those covalent compounds.

Use this fig. to answer questions 4 and 5.

I	II	III	IV	V	VI	VII	VIII
Y							W
	J		X				
Q						M	Z

(a) Which of the following pairs of letters denotes elements containing the same number of electrons in their outermost shell?

(b) What letter presents an element that participates in covalent rather than ionic bonding?

WEEKEND ASSIGNMENT:

New School Chemistry for Senior Secondary Schools by Osei Yaw Ababio;

PRE–READING ASSIGNMENT:

Read about States of matter, its kinetic theory and application.

WEEK 9

TOPIC: **CHEMICAL INDUSTRIES**

CONTENT:

1. Types of Chemical industries

2. Importance of chemicals industries to individuals and the nation

3. Excursion to chemical industries.

PERIOD 1: Types of Chemical industries/divisions

Chemical industry is an industry that uses the principle of chemistry to convert raw materials to useful products.

Factors to be considered in sitting chemical industry

The following factors are to be considered in sitting chemical industry:

1. Nearness to the source of materials

2. Energy (power or fuel) supply

3. Human Resources (Labour Force)

4. Transport Cost

5. Nearness to the market

6. Nearness to A Source of Water

7. Conducive climate.

Chemical industries are easily categories base on the type of products they manufacture. The major chemical industries are listed and explained below:

1. Heavy chemical industries
2. Fine chemical industries
3. Pharmaceutical industries
4. Fertilizer industries
5. Cement industries
6. Plastic industries
7. Ceramic industries
8. Food and Beverages industries
9. Glass industries
10. Metallurgical industries
11. Soaps and Detergents industries
12. Paint industries
13. Cosmetic industries

1. HEAVY CHEMICALS INDUSTRIES: These industries produce chemicals used as raw materials by other chemical industries. Their products are usually manufactured in very large quantities because many industries depend on their product and so are in high demand. Some heavy chemicals and some of their uses are listed below. These industries have nature as their sources of raw materials.

CHEMICAL INDUSTRIES

- Tetraoxosulphate (VI) acid (H_2SO_4) which is the most important of them all.It is used in the fertilizer industries.
- Sodium hydroxide (NaOH) and potassium hydroxide (KOH) used in soap making, fiber and paper industries.
- Sodium trioxocarbonate (IV) (Na_2CO_3) is used in glass, detergent and water works.
- Sodium hydrogen trioxocarbonate (IV), ($NaHCO_3$) is used in baking powder industries.
- Sulpur (IV) oxide is used in the manufacture of tetraoxosulphate (VI) acid (H_2SO_4).

- Chlorine (Cl_2) is used in textile and paper industries and also for bleaching.

2. FINE CHEMICALS INDUSTRIES: Fine chemicals are produced in smaller quantities than heavy but are equally important. These industries pay great attention to purity products because the chemicals are used for sensitive and specific purpose. Some products like drugs, cosmetics, additive for vehicle engine performances, analytical reagents are some of the examples.

3. PHARMACEUTICAL INDUSTRIES: Produces various chemicals used in hospitals e.g. potassium bromide (used as sedatives), mercury (ii) nitrate (v) (used as antiseptic for skin diseases) calcium sulphate (plaster of Paris), iodine, antibiotics, insulin, magnesium tetraoxosulphate (VI).heptahydrate (Epsom salt), etc.

4. FERTILIZER INDUSTRIES: This industry produces fertilizers of various grades such as, (NH_4) SO4, NH_4NO_3 and urea as well as pesticides, germicides, herbicides and fungicides.

5. CEMENT INDUSTRIES: These industries are important to us beacause their products are used in the construction industries in bulding bridges , house, roads, and drainages.Cement becomes a very hard substances when mixed with water,sand and gravels.Cement contains quicklime powder (calcium oxide),clay(silicon (iv)oxide and some aluminium oxide. All these chemicals are obtained naturallyfrom the earth in form of limestone(calcium trioxocarbonate(iv),and aliuminim oxide.when heated strongly,the lime stone changes to quicklimeand carbon (iv) oxide.

6. PLASTIC INDUSTRIES: These use simple organic compounds like ethane, ethyne, phenol, and benzene and styrene obtained from the petroleum and coal tar industries to make plastics in form of pellets or granules. Other raw materials for plastics are phenol, Cellulose and vinyl Chloride.

There are two main types of plastics, **thermoset** and **thermoplastic. Thermoplastic** materials like plastic bottles, polyethene bags and some household's materials can be remoulded after melting. These can be recycled

by some factories to form other materials for human use. **Thermoset Plastics** cannot be recycled, but are stronger and more durable and so are usually used for furniture.

PLASTICS

7. GLASS INDUSTRIES: Glass is made from sand and it is cheap when compared with other materials. Silicon (iv) oxide in sand when treated with other chemical like lead from glass. These industries produce a lot of materials like glass waves (cups, bowls etc.), window panes, laboratory wares and apparatus, light bulbs and mirrors etc. Glass can be colored or transparent depending on its use.

RAW MATERIALS

Raw materials are starting materials ingredients for manufacturing. The raw materials for a product may be the products of another industry. For example:-the raw materials for the plastic industry are products of the petroleum industry.

Most primary (or starting) raw materials are obtained from nature e.g. petroleum, metal ores, common salt from the sea, coal, limestone, clay, sand, etc. These primary raw materials are used to produce other materials or chemicals that are used to produced other materials or chemicals. Some examples are listed in the table below:

Raw materials from some chemicals and their by-products

Natural Raw materials	**Some Chemical gotten from it**	**Materials**
Petroleum	Petrochemicals e.g. Ethane, Benzene, Ethene etc.	Plastic, Pesticides, Alkanols (alcohol), beverages, fertilizers etc.
Earth	Limestone	cement
	Metals ores	Metallic products like containers, roofing sheet, vehicle bodies etc.

	Clay/sand	Ceramic products like floor tiles, dishwares, bathtub, toilet bows etc.
Plants	Palm oil	Soap and margarine
	Cocoa	Chocolate and beverages.
	Rubber	Tyres and other rubber products.
Sea water	Common salt(sodium chloride)	Seasoning for cooking and starting materials for many chemicals.
Air	Oxygen	Used in welding and hospitals.
	Nitrogen	Used to produced ammonia an important raw materials in the manufacture of fertilizers.

EVALUATION

1. Which chemical industry would you associate these with
   (a) Tetraoxosulphate (vi) acid (b) paracetamol(c) floor tiles (d) Yoghourt (e) Baby powder
2. Name four heavy chemicals and fine chemicals and their uses in the chemical industries
3. Name any four divisions of chemicals industries. Mention one product produced by each of them.
4. Mention one type of chemical industry that utilizes ethane as raw materials.

PERIOD 2: IMPORTANCE OF CHEMICALS INDUSTRIES

(A) To an individual:

(i) Chemical industries provide employment for both skilled and unskilled.

(ii) It is used for treating of woods.

(B) To the nation

(i) The chemical industries provide earnings from foreign trade.

(ii) Chemical industries improved the standard of living by providing many materials for domestic use (which can be too expensive if imported).

ENVIRONMENTAL PROBLEMS CREATED BY CHEMICAL INDUSTRIES

Despite all the advantages of these industries, they can constitute health hazards and menace to the communities where they are located. Such as:-

i. Its waste can contaminate the air we breathe and water we drink.
ii. It is also noisy. To avoid this, careful thought may be placed on the selection of a site to locate an industry.

EVALUATION

1. Write one importance of chemical industry to you as a person and two to the nation.
2. How can the activities of these industries affect the communities?

PERIOD 3: Excursion to chemical industries.

Your teacher or your science club should organize a visit to some of the local industries which make use of the raw materials we have so far discussed. This could be a soap factory, a cement factory, or even a petroleum refinery in the country.

EVALUATION

Write a compressive report of your excursion and submit it to your teacher.

GENERAL EVALUATION

OBJECTIVE TEST

1. An elastic rubber is formed by a process known as (A) Vulcanization (B) thermoplasticity (C) polymerization (D) thermosetting.

2. Factors which can contribute to environmental pollution include:

i. Overpopulation ii.Chemical warfare iii. Agricultural activities

iv. Industrialization (A) I only (B)I and II only (C) I,II,III and IV.(D) IV only

3. One of the adverse effects of chemical industries on the community is (A) increased population (B) increased job opportunities (C) increased earning power (D) increased environmental pollution.

4. The major raw material in a plastic industry is (A) Ethanol (B) Sulphur (C) methylethanoate (D) Ethene.

5. The following are heavy chemicals except (A) Tetraoxosulphate(vi) acid (B) Caustic soda (C) Sodium trioxocarbonate (iv) (D) Ethane

ESSAY QUESTIONS:

1. Name two of raw materials used in the manufacture of the following:

i.Polythene ii.Margarine. iii. Cement.

2. Name two industries and their locations where cement is produces.

3. List two industrial processes in which limestone is used as raw materials.

4. Name two uses of cement.

5. State one problem associated with the oil producing areas.

WEEKEND ASSIGNMENT

Read comprehensive certificate chemistry by G N C Ohia et al;

PRE-READING ASSIGNMENT

Read the major factors that determine siting of chemical industries.

WEEKEND ACTIVITY:

Suggest one method of disposing polythene materials.

10. Revision.

11/12. Examination