**CHEMISTRY SS 2**

**THIRD TERM**

**SCHEME OF WORK**

**WEEK TOPIC**

1. Water

* Sources, Types, Uses and Structure of Water.
* Laboratory Preparation of Water.
* Test for Water
* Causes/ Removal of Hardness of Water.
* Purification of Water for Municipal Supply.

1. Solubility and Solutions

* Definition of Terms.
* Calculations based on Solubility.
* Solubility Curves.
* Uses of Solubility.

1. Mass/Volume Relationship

* Mole and Molar Quantities
* Relative Atomic Mass and Relative Molecular Mass.
* Calculations involving Mass and Volume.

1. Acid/ Base Reactions

* Preparation of Standard Solutions.
* Indicators
* Calculations based on Acid-Base Titration.

1. Hydrocarbons

* Unique Nature of Carbon.
* Characteristics Features of Organic Compounds
* Classification of Hydrocarbons.
* Definition of Terms used in Organic Chemistry

1. Saturated Hydrocarbon (Alkanes)

* Nomenclature
* Preparation, Properties and Uses

1. Unsaturated Hydrocarbon (Alkenes)

* Nomenclature
* Preparation, Properties and Uses

1. Unsaturated Hydrocarbon (Alkynes)

* Nomenclature
* Preparation, Properties and Uses

Aromatic Hydrocarbons

* Benzene Structure
* Preparation, Properties and Uses

1. Alkanols

* Types and Classes
* Industrial Production by Fermentation
* Properties and Uses

**REFERENCE MATERIALS**

* New School Chemistry for Senior Secondary Schools by O. Y. Ababio
* New System Chemistry for Senior Secondary Schools by T. Y. Toon et al
* S.S.C.E Past Questions and Answers on Chemistry
* U.T.M.E Past Questions and Answers on Chemistry

**WEEK ONE**

**TOPIC: WATER**

**CONTENT**

* Sources, Types, Uses and Structure of Water.
* Laboratory Preparation of Water.
* Test for Water
* Causes/ Removal of Hardness of Water.
* Purification of Water for Municipal Supply.

**WATER**

Water is regarded as the universal solvent. It is a good solvent for many substances.

**SOURCES OF WATER**

The following are the sources of water:

1. Natural water:Rainwater, Well water, Spring water and Sea water
2. Treated water*:* Distilled water, Pipe – borne water and chlorinated water.

**TYPES OF WATER**

Water is of two types namely: soft water and hard water. Soft water forms lather with soap easily while hard water does not form lather readily with soap since it contains some dissolved salt in it.

**STRUCTURE OF WATER**

In a molecule of water, H2O, the central atom is Oxygen. Oxygen has the following electronic configuration: 1s2 2s2 2p4.

The valence shell of oxygen has two lone pairs of electrons (2s22p2) and two unpaired electrons (2py12pz1). Each unpaired electron forms a covalent bond with an electron from a hydrogen atom. The water molecule has two lone pairs and two bond pairs of electrons in the valence shell of its central atom, thereby satisfying the octet rule for stability.

Ideally, the four electron pairs should be directed towards corners of a tetrahedron. However, when lone pairs of electrons is located near another lone pair, the repulsion between them is so great that they squeeze the other two bond pairs of electrons closer together. As a result, the bond angle in water is compressed to approximately 105o, such that the structure of the water molecule is V-shaped or angular shape.

O

H H

**LABORATORY PREPARATION OF WATER**

To prepare water in laboratory, dry hydrogen gas is ignited in air. It burns with a faint blue flame to give steam, which will condense on contact with any cold surface to form water.

**PHYSICAL PROPERTIES OF WATER**

1. Water boils at 100oC and freezes at 0oC
2. It has a maximum density of 1gcm-3 at 4oC
3. It is neutral to litmus.

**CHEMICAL PROPERTIES**

1. Water reacts with electropositive metals to form alkali and liberate hydrogen gas. E.g

Na(s) + H2O(aq) NaOH(aq) + H2(g)

Mg & Zn react with steam

Cu, Au, Ag, Hg do not react with water to form alkaline solution

1. Non-metal like chlorine reacts with water to form acid solution.

H20(aq) + Cl2(g) HCl(aq) + HOCl(aq)

**TEST FOR WATER**

When few drops of water are added to

1. White anhydrous copper (II) tetraoxosulphate (VI), it turns blue.
2. Blue cobalt (II) chloride, it turns pink.

**NOTE**: These two tests are not specific for water. They only indicate the presence of water. Any aqueous solution or substance containing water will give a positive test for water.

**EVALUATION**

1. Describe the structure of water.
2. How will you identify a give solution to be water?

**HARDNESS OF WATER**

Hard water is the water that does not form lather readily with soap.

Water acquired hardness when insoluble salts of CaSO4, MgSO4 and Ca(HCO3)2 dissolves in it from the soil which it flows through.

**TYPES OF HARDNESS OF WATER**

1. Temporary hard water
2. Permanent hard water

**TEMPORARY HARDNESS*:*** This is caused by the presences of Ca2+ and Mg2+ in the form of hydrogen trioxocarbonate IV i.e. Ca(HCO3)2

**REMOVAL OF TEMPORARY HARDNESS**

1. Physical method: By boiling

Ca(HCO3)2(aq)heat CaCO3(s) + H2O(l) + CO2(g)

1. Chemical method: By using of slaked lime (calcium hydroxide solution)

Ca(HCO3)2(aq) + Ca(OH)2(aq) 2CaCO3(s)+ 2H2O(l)

**EFFECTS OF TEMPORARY HARDNESS**: It causes

* 1. Furring of kettles and boilers.
  2. Stalagmite and stalactites in caves.

**PERMANENT HARDNESS**

Permanent hardness in water is caused by the presence of Calcium and Magnesium ions in the form of soluble tetraoxosulphate (VI) and chlorides (i.e. CaSO4, MgSO4, MgCl2, CaCl2)

**Removal of permanent hardness**: By chemical method only

1. Addition of washing soda

Na2CO3(aq) + CaSO4(aq) CaCO3(s) + Na2SO4(aq)

1. Addition of caustic soda

2NaOH(aq) + CaSO4(aq) Ca(OH)2(s) + Na2SO4(aq)

3. Ion exchange resin

CaSO4(aq) + Sodium zeolite Calcium zeolite + NaSO4(aq)

(insoluble)

**ADVANTAGES OF HARD WATER**

1. It has better taste than soft water.
2. Calcium salts in it helps to build strong teeth and bones.
3. It provides CaCO3, that crab and snail use to build their shells.
4. It does not dissolvelead, hence it can be supplied in lead pipes.

**DISADVANTAGES OF HARD WATER**

1. It causes furring of kettles and boilers.
2. It wastes soap.
3. It cannot be used in dying and tanning.

**EVALUATION**

1. Mention TWO compounds that can cause permanent hardness of water.
2. Write two equations to show the removal of permanent hardness of water.

**TREATMENT OF WATER FOR MUNICIPAL SUPPLY**

The following are the processes of treating river water for town supply

1. Coagulation:Chemicals like potash alum, KAl(SO4)2, or sodium aluminate III, NaAlO2 is added to water in a large settling tank.
2. Sedimentation: The coagulated solid particles or flocs are allowed to settle in the settling tank to form sediments at the bottom of the tank.
3. Filtration*:* The water above the sediment still contains some suspended particles. The water is passed through a filter bed to remove the remaining fine dirt particles.
4. Chlorination (Disinfection): Chemicals like chlorine is then added to the water to kill germs. Iodine and fluorine are also added as food supplements to prevent goiter and tooth decay respectively. The treated water is then stored in a reservoir and distributed to the town.

**GENERAL EVALUATION/REVISION**

1. Mention two compounds that causes permanent hardness in water
2. State two ways of removing permanent hardness in water
3. List two advantages of hard water
4. State Faraday’s second law of electrolysis
5. Using electron dot-cross representation, show the formation of carbon (IV) oxide and name the type of bond formed

**READING ASSIGNMENT**

New School Chemistry for Senior Secondary School by O.Y.Ababio (6th edition) pages 296-302

**WEEKEND ASSIGNMENT**

**SECTION A:**Write the correct option ONLY

1. Treated town water undergoes the following steps except A. co-agulationB. precipitation C. sedimentation D. chlorination
2. Water is temporarily hard because it contains A. CaSO4B. MgSO4C. chlorine D.Ca(HCO3)2
3. Temporary hardness of water is removed by the use of one of the following A. boiling B. use of use of Ca(OH)2C. use of Na2CO3D. use of alum
4. A substance that turns white anhydrous CuSO4 blue is A. water B.liquid ammonia C. hydrochloric acid D. molten sulphur
5. Distilled water is different from deionized water because A. distilled water is a product of condensed steam while deionized water is filtered laboratory water B. distilled water is always pure and sold in packs while deionized is not packaged for consumption C. distilled water is condensed steam but deionized water is produced using ion-exchange resins which absorbs undesired ions. D. distilled water is man-made while deionized water is both natural and artificial

**SECTION B**

1. State the steps involved in the treatment of river water for town supply.

2. Write two equations to show the removal of permanent hardness of water.

**WEEK TWO**

**TOPIC: SOLUBILITY AND SOLUTIONS**

**CONTENT**

* Definition of Terms.
* Calculations based on Solubility.
* Solubility Curves.
* Uses of Solubility.

**SOLUTIONS**

A solution is a uniform or homogenous mixture of two or more substances.

Solution = Solvent + Solute

A solute is a dissolved substance which may be a solid, liquid or gas.

A solvent is a substance (usually liquid) which dissolves a solute.

**TYPES OF SOLUTIONS**

1. Aqueous Solution: This is formed when a solute is dissolved in water.
2. Chemical Solution: This is the apparent solution of a solute in a solvent accompanied by a chemical change. For example, magnesium appears to dissolve in dilute hydrochloric acid, what actually happens is that the magnesium attacks the acid to form magnesium chloride, which dissolves in water present.

**TRUE SOLUTION AND COLLOIDAL SOLUTION**

A true solution is formed when solute particles dissolve such that they are able to get in between the solvent particles. Example of true solution is aqueous solution of sodium chloride and copper (II) tetraoxosulphate (VI).

A False or Colloidal solution is one in which the individual particles are larger than the particles of a true solution, but not large enough to be seen by the naked eye. Examples of colloids are starch and albumen.

**TYPES OF COLLOIDS**

1. Sols and Gels: These are colloids where solid particles are dispersed in liquid medium. Example: starch, glue, jelly, etc
2. Aerosols: In aerosols, liquid particles are dispersed in a gas. Fog, smoke, spray of insecticide is examples of aerosol.
3. Emulsion: For emulsions, a liquid is dispersedin another liquid. Examples of emulsions are milk, hair cream; cleaning action of detergents is due to their ability to form emulsion.

**EVALUATION**

1. Define the term ‘Solution’.
2. State THREE differences between True solution and False solution.

**SOLUBILITY**

The solubility of a solute (substance) in a solvent at a particular temperature is the maximum amount of solute in moles or grams that will dissolve in 1 dm3 of the solvent at that temperature.

The concentration in moldm-3 of a saturated solution is termed the solubility of the substance i.e. Solubility (moldm3) = Concentration in gdm3

Molar mass

Solubility in mol/dm3 can also be expressed as = mass x 1000

Molar mass volume

Solubility in g/dm3 = mass x 1000

volume 1

Solubility of a solid solute in a solvent increases with rise in temperature while solubility of gases decreases with rise in temperature.

**DEFINITION OF TERMS**

1. Saturated Solution: A saturated solution at a particular temperature is one which contains as much solute as it can dissolves at that temperature in the presence of undissolved solute particles.
2. Unsaturated solution: This is a solution which contains less of the solute than it can dissolve at a particular temperature.
3. Super saturated solution: This is a solution which contains more of the solute than it can dissolve at a particular temperature.

**EVALUATION**

1. Define Solubility
2. Differentiate between Saturated solution and Unsaturated solution

**DETERMINATION OF SOLUBILITY**

Solute: KCl, Solvent: water

**Method**

1. A saturated solution of KCl is prepared by dissolving excess of the solid in water in a beaker
2. Allow the solution in the beaker to settle down to obtain a clear saturated solution
3. Decant a portion of clear solution into another beaker and measures its temperature
4. Transfer the solution into a weighed evaporation dish and record the mass of the solution
5. Evaporate the solution to a complete dryness in a water bath
6. Allow the resulting solid to cool and reweigh the basin with content
7. Obtain mass of the dissolved salt and calculate the mass of the salt that would dissolve in 1dm3 of water at that temperature.

**CALCULATION**

Mass of basin = xg

Mass of basin + solution = yg

Mass of basin + salt = zg

Mass of solution = (y-x)g

Mass of salt = (z-x)g

Mass of water used = (y-z)g

:. (y – z)g H2O dissolves (z – x)g salt

:. 100g H2O dissolves (z – x)/(y – z) x 100g salt

[Density of water = 1gcm3]

:. No of moles of salt = 100(z – x)

(y-z) x M.M

:. Moles of salt dissolves in 1 dm3 water = 100(z-x)

(y-z) x M.M

**FACTORS THAT AFFECT SOLUBILITY**

1. Nature of solvent and solute

2. Temperature

3. Pressure (often neglected)

**SOLUBILITY CURVES**

These are the graphs of solubility against temperature. The graph provides useful source of information.

**USES OF SOLUBILITY CURVES**

1. It provides useful information about suitable solvent and temperature for solvent extraction from natural sources

2. It provides useful information about temperature for fractional crystallization of a mixture of soluble salts.

3. The curves enable pharmacists to determine the amount of solid drugs that must be dissolved in a given quantity of solvent to give a prescribed drug mixture.

**EVALUATION**

1. Define super-saturated solution

2. State two applications of solubility curves

**CALCULATION ON SOLUBILITY**

1. If 12.2g of Pb(NO3)2 were dissolved in 21cm3 of distilled water at 20oC. Calculate the solubility of the solute in moldm-3

Solution**:**

Molar mass of Pb(NO3)2 = 331g

No of moles of Pb(NO3)2 = 12.2/331 = 0.037moles

If 21cm3 of water at 200C dissolved 0.037mole salt

:. 1000cm3 of water at 200C dissolves 0.037 x 1000/21

= 176moles Pb(NO3) per dm3 H2O

2. 1.0dm3 of an aqueous solution at 90oC contains 404g of KNO3 and 245g of KClO3.

a. Determine which of the two salts will separate out when the solution is cooled to 60oC

b. mass of salt that will separate out at 60oC

(Solubility of KNO3 in H2O at 60oC = 5.14moldm-3, solubility of KClO3 in H2O at 60oC = 1.61moldm-3)

Solution:

No of moles of KNO3 = 404/101 = 4.0moles dm-3

No of moles of KClO3 = 245/122.5 = 2.0 moldm-3

The solubility of KClO3 at 60oC (5.14 moldm-3) is higher than the amount in solution (4.0 moldm-3), then KNO3 will remain in solution while KClO3 will crystallize out at 60oC since the solubility at 60oC is lower than the amount in solution.

b. Mass of salt that will separate out at 60oC = 2.0 – 1.61 = 0.39mole

Mass of salt = Number of moles x Molar mass

= 0.39 x 122.5 = 47.78g

3. The solubility of KNO3 is exactly 1800g per 1000g water at 83oC and 700g per 1000g water at 40oC. Calculate the mass of KNO3 that will crystallize out of solution if 155g of the saturated solution at 83oC is cooled to 40oC.

Solution:

Saturated solution of KNO3 at 83oC = 1000 + 1800 = 2800g

Saturated solution of KNO3 at 40oC = 1000 + 700 = 1700g

Mass of solute deposited = 2800 – 1700 = 1100g

From 83oC to 40oC, 2800 of saturated solution deposited 1100g of solute

155g of saturated solution will deposit 1100 x 155/2800 = 60.80g of salt.

**EVALUATION**

1. Define the following terms: Solubility, Saturated solution, Unsaturated solution.
2. 1.33 dm3 of water at 70oC are saturated by 2.25 moles of lead (II) trioxonitrate (V) and 1.33 dm3 of water at 18oc are saturated by 0.53 mole of the same salt. If 4.50dm3 of the saturated solution are cooled from 70oC to 18oC, calculate the mount of solute that will be deposited in (a) moles (b) grams.

**GENERAL EVALUATION/REVISION**

1. Calculate the solubility of KCl in g/dm3 if 5g of the salt was dissolved in 50cm3 of water at 40oC
2. If 50cm3 of a saturated solution of potassium chloride at 30oC yielded 18.62g of dry salt, calculate the solubility of the salt in mol/dm3 at 30oC
3. Define solubility
4. A certain mass of a gas occupies 300cm3 at 35oC. At what temperature will it have its volume reduced by half, assuming its pressure remains constant?
5. A certain mass of hydrogen gas collected over water at 10oc and 760mm Hg pressure has a volume of 37cm3. Calculate the volume when it is dry at s.t.p. (Saturated vapour pressure of water at 10oC = 9.2mmHg)

**READING ASSIGNMENT**

New School Chemistry for Senior Secondary School by O.Y.Ababio (6thedition) pages 303-310

**WEEKEND ASSIGNMENT**

**SECTION A:** Write the correct option ONLY

1. A saturated solution is a solution a. in which the solute is in equilibrium with the solvent b. in which the solute saturates the solution c. the solvent can still accept more solute except when the temperature is lowered d. whose solvent has low solubility at a given temperature
2. A graph of solubility against temperature is called a. sigmoid curve

b. supernant curve c. solubility curve d. dispersion curve

1. On heating 25g of a saturated solution to dryness at 60oC, 4g of anhydrous salt was recovered. Calculate its solubility in g/dm3. a. 160 b. 180 c. 200 d. 220
2. The solubility of alcohols in water is due to a. their covalent nature b. hydrogen bonding c. their low boiling point d. their ionic character
3. A common solvent of sulphur is a. water b. carbon(IV)sulphide c. alcohol d. ethanoic acid

**SECTION B**

1. Define the following:

(a) Solubility (b) Saturated solution (c) Unsaturated solution

2. If the solubility of KNO3 at 0oC is 1.33mol/dm3, determine whether a solution containing 30.3g/dm3 at 0oC is saturated or unsaturated.

**WEEK THREE**

**TOPIC: MASS/VOLUME RELATIONSHIP**

**CONTENT**

* Mole and Molar Quantities
* Relative Atomic Mass and Relative Molecular Mass.
* Calculations involving Mass and Volume.

**MOLE AND MOLAR QUANTITIES**

**THE MOLE**

A mole is a number of particles of a substance which may be atoms, ions, molecules or electrons. This number of particles is approximately 6.02 x 1023 in magnitude and is known as Avogadro’s number of particles.

**The mole is defined** as the amount of a substance which contains as many elementary units as there are atoms in 12g of Carbon-12.

**RELATIVE ATOMIC MASS**

The relative atomic mass of an element is the number of time the average mass of one atom of that element is heavier than one twelfth the mass of one atom of Carbon-12. It indicates the mass of an atom of an element. For e.g, the relative atomic mass of hydrogen, oxygen, carbon, sodium and calcium are 1, 16, 12, 23, and 40 respectively.

The atomic mass of an element contains the same number of atoms which is 6.02 x 1023atoms; 1 mole of hydrogen having atomic mass of 2.0g contains 6.02 x 1023 atoms.

**RELATIVE MOLECULAR MASS**

The relative molecular mass of an element or compound is the number of times the average mass of one molecule of it is heavier than one-twelfth the mass of one atom of Carbon-12

It is the sum of the relative atomic masses of all atoms in one molecule of that substance. It is also called the formula mass. The formula mass refers not only to the relative mass of a molecule but also that of an ion or radical.

**CALCULATION**

Calculate the relative molecular mass of:

1. Magnesium chloride
2. Sodium hydroxide
3. Calcium trioxocarbonate

[Mg=24, Cl=35.5, Na=23, O=16, H=1, Ca=40,C=12]

Solution:

1. MgCl 2 = 24 + 35.5x2 = 24 + 71 = 95gmol-1
2. NaOH = 23 + 16 + 1 = 40gmol-1
3. CaCO3 = 40 + 12 +16x3 = 100gmol-1

**EVALUATION**

1. What is relative molecular mass of a compound?
2. Calculate the relative molecular mass of (a) NaNO3 (b) CuSO4.5H2O

**MOLAR VOLUME OF GASES**

The volume occupied by 1 mole of a gas at standard conditions of temperature and pressure (s.t.p) is 22.4 dm3. Thus 1 mole of oxygen gas of molar mass 32.0gmol-1 occupies a volume of 22.4dm3 at s.t.p and 1 mole of helium gas of molar mass 4.0gmol-1 occupies a volume of 22.4 dm3 at s.t.p.

Note: When the conditions of temperature and pressure are altered, the molar volume will also change. Also, standard temperature = 273K and standard pressure = 760mmHg.

**RELATIONSHIP BETWEEN QUANTITIES**

Molar mass = mass (g) i.e. M = m gmol-1

Amount (moles) n

Note: Amount = Number of moles

Molar volume of gas = volume ( cm3 or dm3) i.e. Vm = v dm3mol-1

Amount (mole) n

Amount = Reacting mass (g)

Molar mass (gmol-1)

Also, Amount of substance = Number of particles

Avogadro’s constant

But, Avogadro’s constant = 6.02 x 1023

Combining the two expressions:

Reacting mass = Number of particles

Molar mass 6.02 x 1023

**CALCULATIONS**

1. What is the mass of 2.7 mole of aluminium (Al=27)?

Solution:

Amount = Reacting mass

Molar mass

Reacting mass = Amount x Molar mass

= 2.7mole x 27 gmol-1 = 72.9g.

1. What is the number of oxygen atoms in 32g of the gas? (O=16, NA = 6.02 x 1023)

Solution:

Reacting mass = Number of atoms

Molar mass 6.02 x 1023

Number of atoms = Reacting mass x 6.02 x 1023

Molar mass

Molar mass of O2 = 16x2 =32gmol-1

Number of atoms = 32g x 6.02 x 1023

32gmol-1

= 6.02 x 1023

The number of oxygen atoms is 6.02 x 1023

**EVALUATION**

1. Define the molar volume of a gas
2. How many molecules are contained in 1.12dm3 of hydrogen gas at s.t.p?

**STOICHIOMETRY OF REACTION**

The calculation of the amounts (generally measured in moles or grams) of reactants and products involved in a chemical reaction is known as stoichiometry of reaction. In other words, the mole ratio in which reactants combine and products are formed gives the stoichiometry of the reactions.

From the stoichiometry of a given balanced chemical equation, the mass or volume of the reactant needed for the reaction or products formed can be calculated.

**CALCULATION OF MASSES OF REACTANTS AND PRODUCTS**

1. Calculate the mass of solid product obtained when 16.8g of NaHCO3was heated strongly until there was no further change.

Solution:

The equation for the reaction is:

2NaHCO3(s) → Na2CO3(s) + H2O(g) CO2(g)

Molar mass of NaHCO3 = 23 + 12 + 16x3 = 84gmol-1

Molar mass of Na2CO3 = 23x2 +12+16x3 = 106gmol-1

From the equation:

2 moles NaHCO3 produces 1 mole Na2CO3

2x84g NaHCO3 produces 106g Na2CO3

16.8g NaHCO3 will produce Xg Na2CO3

Xg Na2CO3 = 106g x 16.8g =10.6g

2x84g

Mass of solid product obtained = 10.6g

1. Calculate the number of moles of CaCl2 that can be obtained from 25g of limestone [CaCO3] in the presence of excess acid.

Solution:

The equation for the reaction is:

CaCO3(s) + 2HCl → CaCl2(s) + H20(l) + CO2(g)

Number of moles = Reacting mass

Molar mass

Molar mass of CaCO3 = 40 + 12 + 16x3 = 100gmol-1

Number of moles of CaCO3 = 25g = 0.25 mole

100gmol-1

From the equation of reaction,

1 mole CaCO3 yields 1 mole CaCl2

Therefore, 0.25 mole CaCO3 yielded 0.25 mole CaCl2.

**EVALUATION**

1. What does the term ‘Stoichiometry of reaction’ mean?

Ethane [C2H6] burns completely in oxygen. What amount in moles of CO2will be produced when 6.0g of ethane are completely burnt in oxygen?

**CALCULATION OF VOLUME OF REACTING GASES**

1. In an experiment, 10cm3 of ethene [C2H4] was burnt in 50cm3 of oxygen.
2. Which gas was supplied in excess? Calculate the volume of the excess gas remaining at the end of the reaction.
3. Calculate the volume of CO2 gas produced

Solution:

The equation for the reaction is:

C2H4(g) + 3O2(g) → 2CO2(g) + 2H2O(g)

1. From the equation,

1 mole of ethene reacts with 3mole of oxygen

1 volume of ethene reacts with 3 volumes of oxygen

10cm3 of ethene will react with 30cm3 of oxygen

Since 50cm3 of oxygen was supplied, oxygen was in excess

Hence volume of the excess gas = initial volume – volume used up = 50-30 = 20cm3

1. 1 volume of ethene produces 2 volumes of CO2

10 cm3 of ethene will produce 20cm3 of CO2

Therefore, 20cm3 of CO2 was produced

1. 20cm3 of CO was mixed and sparked with 200cm3 of air containing 21% of O2. If all the volumes are measured at s.t.p, calculate the total volume of the resulting gases.

Solution**:**

In 200cm3 of air,

Volume of O2 = 21 x 200cm3 = 42cm3

100

Volume of N2 and rare gases = 200-42 = 158cm3

The equation for the reaction is:

2CO(g) + O2(g) → 2CO2(g)

Volume ratio 2 : 1 : 2

Before sparking 20cm3 42cm3

Reacting volume 20cm3 10cm3

After sparking 32cm3 20cm3

Volume of resulting gases = 32 + 20 + 158 = 210cm3

**GENERAL EVALUATION/REVISION**

1. Find the volume of oxygen produced by 1 mole of KClO3 at s.t.p in the following reaction: 2KClO3(s)  → 2KCl(s) + 302(g)
2. Define the term ‘Relative atomic mass’
3. Balance the following redox equations I- + MnO4-  IO3- + MnO2 in basic medium
4. Write the symbols of the following elements: mercury, silver, gold, lead, tin, antimony.
5. Define valency.

**READING ASSIGNMENT**

New School Chemistry for Senior Secondary School byO. Y. Ababio, Pg 156-164

**WEEKEND ASSIGNMENT**

**SECTION A:** Write the correct option ONLY

1. Amount of a substance is expressed in a. mole b. grams c. kilograms d. mass
2. Determine the mass of CO2 produced by burning 104g of ethyne [C2H2]a. 256g b.352g c. 416g d. 512g
3. The mole ratio in which reactants combine and products are formed is known as a. rate of reaction b. stoichiometry of reaction C. equation of reaction d. chemical reaction
4. The unit for relative molecular mass is a. mole b. gmol-1 c. grams d. mass
5. What mass of Pb(NO3)2 would be required to 9g of PbCl2 on the addition of excess NaCl solution? [Pb=207, Na=23, O=16, N=14] a. 10.7g b. 1.2g c. 6.4g d. 5.2g

**SECTION B**

1. Calculate the number of molecules of CO2 produced when 10g of CaCO3 is treated with 100cm3 of 0.20moldm-3HCl
2. Calculate the volume of nitrogen that will be produced at s.t.p from the decomposition of 9.60g ammonium dioxonitrate (III), NH4NO2.

**WEEK FOUR**

**TOPIC: ACID/BASE REACTIONS**

**CONTENT**

* Preparation of Standard Solutions.
* Indicators
* Calculations based on Acid-Base Titration.

**TITRATION**

There are two types of quantitative analysis namely: volumetric and gravimetric analysis. Volumetric analysis is based on volume measurement while gravimetric analysis involves direct mass measurement.

Volumetric analysis is carried art using Titration. In titration, a standard solution (one of known concentration must be using be used to react with a solution of unknown of concentration)

**PREPARATION OF A STANDARD SOLUTION**

A standard solution is a solution of which the concentration is known .A standard solution is prepared by weighing a pure solute, for instance, and dissolving it in a suitable solvent, usually water, and making up the solution to a definite volume in a volumetric flask.

For instance, a solution known to contain exactly 10.6g of anhydrous sodium trioxocarbonate (IV), Na2CO3, in 1 dm3 of solution is a standard solution.

**Preparation of 0.1mol/dm3NaOH**

40g NaOH dissolved in 1 dm3 of the water gives 1.0mol/dm3 solution

XgNaOH will be dissolved in 1 dm3 of water to give 0.1mol/dm3

Xg = 40g x 0.1mol/dm3

1.0mol/dm3

= 4g

Therefore, 4g of sodium hydroxide pellet is measured, dissolved in water and made up to 1dm3 mark to obtain 0.1mol/dm3NaOH

**Preparation of 0.1mol/dm3HCl**

To prepare 0.1mol/dm3HCl, the dilution formula is used to determine the volume of the stock acid that will be measured and dissolved in water to obtain the desired concentration.

The dilution formula is C1V1 = C2V2

Where C1 = concentration of stock acid = 11.6mol/dm3 (for HCl)

V1 = volume of stock acid

C2 = desired concentration of acid = 0.1mol/dm3

V2 = volume of water = 1000cm3 (1dm3)

V1 = C2V2 = 0.1 x 1000 = 8.6cm3

C1  11.6

Thus, 8.6cm3 of the stock acid is measured using a measuring cylinder and added to water, then made up to 1dm3 to obtained 0.1 mol/dm3HCl.

**EVALUATION**

1. Describe how to prepare 0.05mol/dm3 H2SO4
2. List the apparatuses used during volumetric analysis(titration)

**INDICATORS FOR ACID/BASE TITRATION**

Acid-base indicators are dyes that change colour when according to the pH of the medium. The table below shows some titration and their suitable indicator:

**Acid / base Indicator**

Strong acid and strong base methyl orange or phenolphthalein

Strong acid and weak base methyl orange

Weak acid and strong base phenolphthalein

Weak acid and weak base No suitable indicator

**CONCENTRATION**

The concentration of a solution is the amount of solute in a given volume of the solution. It can be expressed as mol/dm3 or g/dm3.

**Molar concentration**

The molar concentration of a compound is one which contains one mole or the molar mass of the compound in 1dm3 of the solution. Unit of molar concentration is mol/dm3

**Mass concentration**

The mass concentration of a compound is the mass of the compound contained in 1 dm3 of solution. The unit is g/dm3

**Relationship between Molar concentration and Mass concentration**

Concentration = number of moles = n/V………………(i)

volume

Number of moles, n = C x V ……………………..(ii)

But, number of moles, n= m/M

Where M = molar mass and m = mass

Substituting n=m/M into …….(ii)

We have m/M = C x V

That is, m/V = C x M

But m/V = mass concentration

Therefore, mass concentration = molar concentration x molar mass = C x M

**TITRATION REPORT**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Burette reading in (cm3)** | **Rough** | **1st titration** | **2nd titration** | **3rd titration** |
| Final burette reading | 23.40 | 23.20 | 28.20 | 34.10 |
| Initial burette reading | 0.00 | 10.00 | 05.00 | 11.00 |
| Volume of acid used (titre) | 23.40 | 23.20 | 23.20 | 23.10 |

Average volume of acid used = 23.20 + 23.20 + 23.10

3

= 23.17cm3

**GENERAL EVALUATION/REVISION**

1. Which substance is added to the base during titration experiment?
2. What is the colour of methyl orange in a base?
3. What is the point at which the titration experiment appears to complete called?
4. State three differences between electrolytic cell and electrochemical cell
5. Calculate the standard e.m.f of a cell given that the e.m.f of Zn2+/Zn and Cu2+/Cu are -0.76V and +0.34V respectively

**READING ASSIGNMENT**: New School Chemistry SSS by O. Y. Ababio (6th edition) pages 165-168

**WEEKEND ASSIGNMENT**

**SECTION A:** Write the correct option ONLY

1. The indicator used when titrating a weak acid against a strong base isA. methyl orange B. phenolphthalein C. methyl redD. any indicator

2. The colour of phenolphthalein in acids is A. blue B. red C.colourlessD. yellow

3. Which of the following formulae is direct for amount n? A. n=C/p B. n=M/m C. n=C x V D. n=C x m

4. The mass concentration of a substance can be expressed as A. mass/densityB. molar concentration/molar mass C. mass/volume D. number of moles x volume

5. At the end point there is A. a colour change B. no change of colourC. decrease in mass D. an increase in mass

**SECTION B**

1. Define the following terms (a) molar concentration (b) Equivalent point
2. 160cm3 of distilled water is added to 40cm3 of 0.500mol/dm3 H2SO4 solution. Determine the concentration of the diluted solution.

**WEEK FIVE**

**TOPIC: INTRODUCTION TO ORGANIC CHEMISTRY**

**CONTENT**

* Unique Nature of Carbon.
* Characteristics Features of Organic Compounds
* Classification of Hydrocarbons.
* Definition of Terms used in Organic Chemistry

Organic chemistry is the chemistry of carbon compounds with the exception of compounds such as carbon (II) oxide, carbon (IV) oxide the trioxocarbonate (IV).Carbon has unique ability to form numerous organic compounds because it has ability to catenate. Catenation is the ability of atoms of an element to form bonds between its own atoms and produce long chain structure.

All organic compounds contain carbon as the main element together with one or more other elements such as hydrogen, oxygen, chlorine, nitrogen and sulphur.

**UNIQUE NATURE OF CARBON**

1. The valency of carbon: the electronic configuration of carbon is as follows:

C = 6: 1s2 2s1 2px1 2py1 2pz1

Carbon form covalent bonds and after bond formation it has neither vacant orbital nor lone pair of electrons. This makes many carbon compounds chemically stable.

1. The bond between carbon and hydrogen is non-polar. Thus, hydrogen atoms attached to carbon do not weaken carbon-carbon bonds.
2. The types of orbital hybridization available to carbon: carbon can form three types of hybridizations: SP3, SP2 and SP hybridization. Hence, it has ability to form single, double or triple covalent bonds between its atoms.
3. Large amount of energy is required to break carbon single bond.

**CHARACTERISTICS FEATURE OF ORGANIC COMPOUNDS**

1. Organic compounds are covalent in nature.
2. They are non-polar substances and are insoluble in polar solvents.
3. They have low melting and boiling points.
4. They are highly flammable.
5. Their reactions are relatively slow compared to inorganic chemical reactions.

**CLASSIFICATION OF ORGANIC COMPOUNDS**

Organic compounds are classified into Aliphatic and Aromatic compounds***.***

**Aliphatic Compounds:** These are compounds whose molecules are composed of chains of carbon atoms. They can be

1. Straight chain compounds e.g pentane
2. Branched chain compounds e.g 2-methylbutane

Straight and branched chain aliphatic compounds exist as open chain and are called ACYCLIC compounds. Aliphatic compounds which exist as closed chain are called the CYCLIC compounds e.gcyclo propane.

**Aromatic Compounds*:*** Benzene, C6H6, is a typical aromatic compound. Other aromatics compounds are derivatives of benzene e.g C6H5OH.

**EVALUATION**

1. List four reasons why carbon forms numerous organic compounds
2. State five characteristic features of organic compounds.

**DEFINITION OF TERMS USED IN ORGANIC CHEMISTRY**

**HOMOLOGOUS SERIES**

Homologous series is a family of organic compounds which follows a regular structural pattern and in which each successive member differs in its molecular formula by –CH2- group.

The simplest series of compounds in organic chemistry is the Alkane series. The general molecular formula of the alkane series is CnH2n+2. It is the parent series from which every other series is obtained. Other homologous series include the Alkenes, Alkynes, Alkanols, Alkanoic acids, etc.

**CHARACTERISTICS OF HOMOLOGOUS SERIES**

1. All members conform to general molecular formula , e.g for alkanes, CnH2n+2
2. Each successive member differs in molecular formula by – CH2- group.
3. All members undergo similar chemical reactions.
4. The physical properties of members change gradually along the series.
5. All members are prepared by the same method.

**ALKYL AND FUNCTIONAL GROUPS**

**Alkyl groups**: Alkyl groups are all groups derived from the alkanes by the loss of a hydrogen atom. Alkyl groups have a general formula of CnH2n+1.They are named after the parent alkane by replacing the ending –ane by –yl. The alkyl group derived from the first two members of the parent alkane series are:

Parent alkane Alkyl group Formula

Methane, CH4 Methyl -CH3

Ethane, C2H6 Ethyl -C2H5

**Functional groups**: The substituent of hydrogen atom in the alkane series to form the alkyl group determines the chemical properties of the compound formed thereafter. This substituent is called FUNCTIONAL GROUP.

A functional group is an atom, a radical or a bond common to a homologous series and which determines the chemical properties of the series.

Examples of functional groups include: Hydroxyl group -OH, amino group NH2, carboxyl group -COO, double and triple bonds.

Alkyl group in a compound determines the physical properties of the compound; while functional group determine the chemical properties of the compound.

**EVALUATION**

1. Define a homologous series.

2. Define a functional group and give two examples.

**SATURATED AND UNSATURATED COMPOUNDS**

Saturated compounds are compounds containing atoms joined together by single covalent bond. Alkanes are saturated compounds, e.g ethane, C2H6

H H

H C C H

H H

Unsaturated compounds are compounds containing atoms joined together by double or triple bonds. Alkenes and alkynes are unsaturated compounds,

e.gEthene, C2H4 H H

C C

H H

Ethyne: H C C H

**FORMULAE OF ORGANIC COMPOUNDS**

Organic compounds are characterized by the following formulae

1. Empirical formula

2. Molecular formula

3. Structural formula

-Empirical Formula is the simplest formula which indicates the component elements and ratio of combination of atoms in a compound.

- Molecular Formula is a chemical formula of a compound which indicates the actual number of atoms of each element in a compound.

-Structural Formula is a formula which indicates how atoms are arranged within the molecule of a substance.

Structural formula can be

* + - 1. Open structural formula
      2. Condensed structural formula

Open structure Condensed structure

H H

H C C H CH3CH3

H H

**GENERAL EVALUATION/REVISION**

1. Differentiate between saturated and unsaturated compounds.
2. Write the open and condensed structural formula of pentane[C5H12].
3. Define the following terms: Homologous series and functional group.
4. Determine the oxidation number of Cl in each of the following compounds and give the IUPAC name of the compound (a) NaOCl (b) KClO3
5. Split the following redox equations into oxidation and reduction half equation (a) Cu(s) + 2Ag+(aq) → Cu2+(aq) + 2Ag(s)

(b) Cl2(g) + 2I-(aq) → 2Cl- + I2(s)

**READING ASSIGNMENT**

New School Chemistry for Senior Secondary School by O .Y. Ababio (6th edition), pages 514-520

**WEEKEND ASIGNMENT**

**SECTION A:** Write the correct option ONLY.

1. Exceptional large number of carbon compounds is essentially due to the ability of

(a). carbon to catenate liberally (b).various groups to catenate

(c). nitrogen, hydrogen, phosphorus and the halogens to catenate with themselves

(d). hydrocarbons to dominate other groups.

1. Which of the following is not a characteristics feature of organic compounds?

(a). Covalent in nature (b). They dissolve in all polar solvents (c).Low melting and boiling points (d).Highly flammable

1. Functional groups in organic compounds (a).determine the chemical properties of the homologous series (b).does not modify the other when they are more than one in a molecule (c).have a general formula which may include the functional group (d). are responsible for the physical properties.
2. Homologues have the same (a).empirical formula (b).structural formula (c).general formula (d). molecular formula
3. The four main classes of hydrocarbons are (a).methane, ethene, ethyne and benzene(b).ethane, ethene, ethyne and toluene (c).cycloalkane, cycloalkene, alkynes and arenes(d). alkanes, alkenes, alkynes and aromatics

**SECTION B**

1. Define the following terms: a. Functional group b. Homologous series
2. Write the open chain structure of the following
3. CH3C(CH3)2CH2CH(CH3)CH2CH3
4. (CH3)2CHCH2CH(CH2Cl)CH3
5. CH3C(Br)2CH2CH3

**WEEK SIX**

**TOPIC: ALKANES**

**CONTENT**

* IUPAC Nomenclature
* Preparation, Properties and Uses.

The alkanes are aliphatic hydrocarbons. Their general molecular formula is CnH2n+2. Hence

For n=1 CH4 Methane

n=2 C2H6 Ethane

n=3 C3H8 Propane

n=4 C4H10 Butane

n=5 C5H12 Pentane and so on.

There is no functional group in the alkane series.

**THE IUPAC NOMENCLATURE FOR ALIPHATIC COMPOUNDS**

In IUPAC nomenclature, every name of organic compound consists of a ROOT, SUFFIX and PREFIX names.

Root name: Name of the parent aliphatic hydrocarbon of the longest carbon chain in a molecule.

Suffix name: Name of the principal functional group on the longest carbon chain in a molecule.

Prefix name: Name of the other substituents on the longest carbon chain which are not functional groups. For example, 1- chloroethane- 1- ol; has 1-chloro as prefix, ethane as root and -1-ol as suffix.

**RULES FOR THE IUPAC NOMENCLATURE**

1. Select the longest continuous carbon chain as parent hydrocarbon.
2. Number the longest carbon chain starting from the end that gives lowest possible number to the suffix (functional group).
3. Indicate the other substituents by prefixes preceded by numbers to show their position on the carbon chain.
4. If the same alkyl or other substituents group occurs more than once as side chain, show how many are present by using prefix di, tri, tetra etc and indicate by various numbers the position of each group on the longest carbon chain.
5. If there are several different alkyl groups attached to the parent chain, name them in alphabetical order.

Examples: H HH

H C1 C2 C3 H

H CH3 H 2- methyl propane

H HH CH3 H

H C5C4 C3 C2 C1 H

H HHHH 2- methylpentane

H HHH CH3 C2H5 H H

H C8 C7 C6 C5 C4C3C2 C1 H

H HH C3H7H C2H 5H H

3,3- diethyl-4-methyl-5-propyloctane

6. If there are halogens together with alkyl groups attached to the parent chain, name the halogens first in alphabetical order and the alkyl group as explained earlier.

Example

H Cl

H C C OH

Br CH3

1- bromo-2- chloropropan-2-ol

**EVALUATION**

Name the following compounds

1. H HH 2. CH3CHClCH2OH

H C CC H

H HH

**METHANE (CH4)**

**LABORATORY PREPARATION**

Methane is prepared in the laboratory by heating ethanoate salt with corresponding alkalis e.g sodium ethanoate and soda-lime. Soda-lime is quick lime slaked with a concentrated solution of sodium hydroxide. It is used in preference to caustic soda because it is not deliquescent and does not attack glass so readily.

**PHYSICAL PROPERTIES**

1. Methane is a colourless and odourless gas.

2. It is slightly soluble in water.

3. It is less dense than air

4. It has no action on litmus paper

**CHEMICAL PROPERTIES**

1. Combustion: Methane burns in air or oxygen to produce steam, carbon(IV) oxide and a lot of heat

CH4(g) + 2O2(g) 2H2O(l) + CO2(g).

The general equation for combustion of alkanes is represented as

CxHy(g) + ( x + y/4)O2 y/ 2H2O(g) + xCO2(g).

1. Substitution reaction: Substitution reaction involves the direct displacement of atom or group by another atom or group. Methane reacts with chlorine in the presence of ultra-violet light to yield a mixture of products.

CH4(g) + Cl2(g) CH3Cl(g)  + HCl(g)

Chloromethane

**USES OF METHANE**

1. Methane is used as fuel by itself or mixed with other gases.

2. It is used for making hydrogen gas.

3. It is used in making carbon black.

4. Trichloromethane is used in surgical operations as an anaesthetic.

**Evaluation**

1. Describe laboratory preparation of methane.

2. Write two equations to show the chemical properties of methane.

**Isomerism**

This is the existence of two or more organic compounds with the same molecular formula but different molecular structures.

**TYPES OF ISOMERISM**

1. Structural Isomerism

2. Stereoisomerism.

The structural isomerism occurs in organic compound with the same molecular formula but different structural arrangement of the carbon atom.

**TYPES OF STRUCTURAL ISOMERISM**

1. Chain isomerism:This is the kind of isomerism which occurs due the differences in the way by which the carbon atoms are arranged in the chain.Example

H HHH H H H

H- C - C - C - C - H H- C - C - C - H

H HHHH H

Butane H – C – H

H

2- methyl propane

1. Functional isomerism: This is the kind of isomerism which is due to the differences in functional group.Example

H H H H

H- C - C – OH H- C – O- C- H

H HHH

Ethanol Methoxymethane.

1. Positional isomerism: This is the kind of isomerism which occurs as a result of the difference in the way the functional group is positioned. Example:

H HH H H

H- C =C- C- C- H H – C – C = C – C – H

H HHHHHHH

But-1-ene But-2- ene

**STEREO ISOMERISM:** This arises as a result of differences in spatial orientation of atoms or groups of atoms about a carbon-carbon double bond or ring structure or a carbon atom surrounded by four different groups.

**TYPES OF STEREO ISOMERISM**

1. Geometric isomerism : This is the existence of compound with the same

molecular formula but different spatial structural formula.Example

CH3CH3 CH3 H

C = C C = C

H HH CH3

Cis but -2-ene Trans but-2-ene

1. Optical isomerism: They have different configuration and they rotate plane polarized light.Example

H H

CH3 – C – COOH HOOC – C – CH3

OH OH

**GENERAL EVALUATION/REVISION**

Give the structure of the following organic compounds:

1. 1-chloro-2-methyl pentane
2. 2,2,4-trimethyl hexane
3. 1-bromo-2-methyl butane
4. a. What is meant by the term isomerism?

b. Draw the structure of the two isomers of the compound with the molecular formula C2H6O. Give the name of each of the isomers.

c. State the major difference between the isomers.

5. Give the two reasons why soda-lime is used instead of caustic soda in the laboratory preparation of methane.

**READING ASSIGNMENT**

New School Chemistry for Senior Secondary School by O.Y. Ababio(6th edition) Pages 520-525, 530-532

**Weekend Assignment**

**SECTION A:** Write the correct option ONLY

1. The name of C(CH3)4 is a. butane b. 2-methyl propane c. methyl propane d. 2,2-dimethyl propane 2
2. The structure of the organic compound 1,1-dichloro-2-methyl pentane is

**A**. H HH CH3Cl**B**. H H CH3  H

H C CCCC H H C CCC H

H HHHHHHHH

**C**. H HHHH **D**. Cl H HHH

H C CCCC H H C CCCC H

ClCl H CH3 H Cl CH3H HH

1. The carbon atoms in alkanes are a. not hybridized b. sp3 hybridized c. sp2 hybridized d. sp hybridized
2. The general formula for the alkanes is a. RCHO b. CnH2n+1 c. CnH2n+2 d. RCOOR
3. C4H10 belongs to the same homologous series as a. C4H8 b. C2H2 c. C3H8 d. C5H10

**SECTION B**

1. a. Define the term isomerism

b. Name the alkanol that is isomeric with Methoxy methane (CH3OCH3)

2 a. Name the following compound:(i) CH3(CH2)3CH3 (ii) C2H4Cl2

b. Write the structure of the following compounds

(i) 1-methyl cyclopropane (ii) 2-bromo-4-methyl pentane

**WEEK SEVEN**

**TOPIC: ALKENES**

**CONTENT**

* Nomenclature
* Preparation, Properties and Uses.

**UNSATURATED HYDROCARBONS**

These are hydrocarbons in which carbon atoms join with each other by multiple bonds. The multiple bonds can be double bonds e.gAlkenes or triple bonds e.gAlkynes.

**NOMENCLATURE**

The process of naming in alkenes is obtained by substituting “ane” in alkane with ‘ene’ e.g Ethane changes to Ethene, propane to propene

**LABORATORY PREPARATION**

Ethene is prepared by heating ethanol with excess concentrated tetraoxosulphate(VI) acid at 170o C. The acid acts as a dehydrating agent by removing water from the ethanol.  Thus the process is called dehydration.

The reaction occurs in two stages

C2H5OH(aq) + H2SO4(aq) C2H5HSO4(aq) + H2O(l)

C2H5HSO4(aq) C2H4(g) + H2SO4.

The overall reaction is represented by the equation

C2H5OH(aq)H2SO4C2H4(g) + H2SO4(aq)

-H2O

**PHYSICAL PROPERTIES**

1. Ethene is a colourless gas with faint sweetish smell.

2. It is sparingly soluble in water.

3. It is slightly less dense than air.

4. It has no action on litmus paper.

**Evaluation**

1. How would you prepare a jar of ethene gas in the laboratory?
2. Mention four physical properties of Ethene.

**CHEMCIAL PROPERTIES**

1. Combustion: Ethene undergoes combustion in air or in the presence of oxygen and produce carbon (IV) oxide and steam.

C2H4(g) + 3O2(g) 2CO2(g)  + 2H2O(l)

2. Addition reaction: This is a reaction in which two molecules combine to form one molecule.

a. Reaction with hydrogen (Hydrogenation):

H H H        H

H-C= C – H + H2 H - C - C – H

Ethene

H H Ethane

b. Reaction with halogens (Halogenation):

H H HH

H - C = C- H + Cl2 H - C - C - H

Ethene ClCl 1,2- dichloroethane

c. Reaction with hydrogen halides(Halohydrogenation):

H H

H- C = C – H + HBr H - C C - H

H HH Br

Ethene 1-bromoethane.

d. Reaction with acidified /Alkaline KMnO4 (Hydroxylation): It decolourises acidified KMnO4, but turns alkaline KMnO4 to green and ethane -1,2- diol is formed.

OH     OH

H – C = C – H + KMnO4 H - C - C - H

H H      H H

Ethane-1,2-diol (glycol)

e.  Reaction with Hydrogen peroxide in the presence of osmium trioxde to form ethan -1,2- diol.

OH OH

H - C = C - H + H2O2 H – C - C - H

H HHH

Ethane -1,2- diol.

f.  Reaction with concentrated H2SO4produces a fuming liquid (ethyl hydrogen       sulphate)

C2H4  + H2SO4  C2H5HSO4

When ethyl hydrogen sulphate is hydrolyzed, tetraoxosulphate (VI) acid and ethanol are produced.

C2H5SO4 C2H5OH + H2SO4

g. Ethene gas decolourizes bromine water to produce bromoethanol.

H H

H – C = C – H+HBrO H – C –C - H

H H( brown) Br OH

Bromoethanol

h. Polymerization of ethane to produce polythene.

H HHHH H

C = C- C - C - C - C-

n H HHHHH n

                                                                Polyethene

i. Ethene can also undergo addition reaction with oxygen in the presence of silver catalyst at about250oC to form epoxy ethane.

H H HH

H – C = C - H + ½ O2 H – C - C - H

O

**USES OF ETHENE:** Ethene is used

1. In the manufacture of plastics.
2. In making synthetic rubber.
3. To hasten the ripening of fruits.
4. In the production of other organic compounds e.g halo-alkane, ethane and ethanol.

**GENERAL Evaluation/REVISION**

* + 1. Write balanced equations to show the reaction of ethene with the following:

1. Bromine water
2. Chlorine water
3. Acidified KMnO4
4. State four uses of ethene.
5. Why is an empty flask inserted between the flat bottom flask and the conical flask holding the drying agent in the laboratory preparation of ethene?
6. State THREE factors that determine the spontaneity of a chemical reaction.
7. 0.92g of ethanol raised the temperature of 100g of water from 298K to 312.3K when

burned completely. What is the heat of combustion of ethanol?

**READING ASSIGNMENT**

New School Chemistry for Senior Secondary School by O.Y. Ababio (6thedition) Pages 532-535

**Weekend Assignment**

**SECTION A:** Write the correct option ONLY

1. The name of the organic compound with the structure below is

CH3 H

C = C

H CH3

A. Cis- but-2-eneB.Trans –cis-but-2-eneC.Trans-1-2- but-2-eneD.1,2- dimethyl ethane.

2. In the reaction given below:

C2H5OH Conc H2SO4  C2 H4Conc H2SO4is acting as

-H2O

A. oxidizing agent B. reducing agent C. dehydrating agent D. drying agent.

3. One of the following is not a chemical property of ethene.

A. Polymerization B. Substitution reaction C. Hydration D. Addition reaction

4. Function of the empty bottle during the preparation of ethane gas is

A. to remove oxygen B. to remove CO2C. to prevent sucking back of the gas D. None of the above

5. Addition reaction of hydrogen and ethene is known as

A. polymerization B. halogenation C. combustion D. hydrogenation

**SECTION B**

1. Write and name the geometric isomers of compound with the molecular formula C5H10

2. Write balanced chemical equation to show how ethene reacts with the following:

a. concentrated H2SO4b. bromine water c. acidified KMnO4

**WEEK EIGHT**

**TOPIC:ALKYNES**

**CONTENT**

* Nomenclature
* Preparation, Properties and Uses
* Aromatic Hydrocarbons: Benzene Structure
* Preparation, Properties and Uses

**NOMENCLATURE**

Alkynes are the homologous series of unsaturated hydrocarbon with a general molecular formula CnH2n-2.

Alkynes show a high degree of unsaturation than alkenes, hence, they are chemically more reactive than the corresponding alkenes or alkanes.

They are named by replacing the ‘ane’ of alkanes with ‘yne’.

Examples

H

H – C C – H H - C - C C- H

H

Ethyne Prop-1-yne

**ETHYNE**

Ethyne is the first member of the alkynes series. It has a molecular formula,

C2H2, and a structural formula of HC = CH.

**LABORATORY PREPARATION**

Ethyne is usually prepared in the laboratory by the action of cold water on calcium carbide. The reaction is carried out on a heap of sand to prevent the flask from cracking as a result of the large quantity of heat evolved.

**Evaluation**

1. Write and name all possible structure of C6H8

2. How can you prepare a few jars of ethyne in the laboratory?

**PHYSICAL PROPERTIES**

1. Ethyne is a colourless gas with a characteristic sweet smell when pure.

2. It is only sparingly soluble in water

3. It is slightly less dense than air.

4. It is unstable and may explode on compression to liquid.

**CHEMICAL PROPERTIES**

1.  Combustion: It undergoes combustion reaction in air to form water and carbon(IV) oxide

2C2H2(g) + 5O2(g) 2H2O(l) + 4CO2(g)

NB: In limited air, it burns with very smoky and luminous flame because of its high carbon content. But in plenty of air and appropriate proportion, it burns with non-luminous very hot flame of about 3000oC.

2.  Addition Reaction:Ethyne undergoes addition reaction to produce unsaturated product with double bonds and then a saturated compound with single bond.

a. Reaction with hydrogen in the presence of nickel as catalyst.

H HHH

H- C C – H + H2  H – C = C – H H2(g) H – C - C - H

EtheneH H Ethane

b. Reaction with halogens:

ClClClCl

H- CC – H + Cl2  H – C = C – H Cl2 H – C – C - H

ClCl

1,2- dichloroethene1,1,2,2-tetrachloroethane

c. Reaction with hydrogen halide: Hydrogen halide reacts with ethyne toproduce halo-alkene and further halogenation produce halo-alkane.

    ClCl

H – C = C – H +HCl H – C = C – H HCl H – C – C – H

H ClH H

Chloroethene 1,2- dichloro ethane.

d. Reaction with water: When ethyne is passed through dilute tetraoxosulphate (vi) acid in the presence of mercury (II) tetraoxosulphate (VI) as catalyst, addition of water takes place to form ethanal.

           H OH H

H-C=C-H + H2O H- C = C – H H- C – C – H

Ethenol H O Ethanal

e. Reaction with acidified KMnO4: If ethyne is added to acidified KMnO4, it decolourises it. But with alkaline KMnO4, the solution turns to green.

O O

H – C = C – H + 4[O] HO – C - C- OH

KMnO4Ethanedioic acids

3. Polymerization: In the presence of complex organic –nickel as catalyst ethyne polymerizes to produce benzene.

3 C2H2 C6H6

4. Substitution Reaction

a. Ethyne reacts with ammoniacal solution of copper (1) chloride to form reddish brown solution of copper (I) dicarbide

C2H2 + 2CuCl Cu2C2 + 2HCl

b. With ammoniacal silver trioxonitrate (v), ethyne forms white silver dicarbide

C2H2 + 2AgNO3Ag2C2 + 2HNO3

These reactions to form dicarbide are used to distinguish ethyne from ethene.

**USES OF ETHYNE:** Ethyne is

1. Mixed with oxygen to produce oxy ethyne flame for cutting and welding of metals.
2. Used in the manufacture of PVC plastics.
3. Used in miner’s lamp as fuel.
4. Used in making synthetic fiber.

**TEST FOR UNSATURATION**

Unsaturated compound decolorizes bromine water.

**Evaluation**

1. Give a chemical test to distinguish between ethyne and ethene.
2. Write two balanced equations to show addition reaction of ethyne.

**AROMATIC HYDROCARBONS**

These are hydrocarbons that have the same structure as benzene.

Benzene is a typical aromatic compound with molecular formula of C6H6.

**STRUCTURE OF BENZENE**

Over the years, there has been a controversy on the structure of benzene. But in 1865, August Kekule suggested a structure for benzene. Kekule proposed that benzene has a ring structure with alternate single and double carbon-carbon bonds as shown below:

which can be conveniently represented as

These two forms of benzene structure are known as resonance forms. Resonance occurs when two forms of the same compound have the same arrangement of atoms but differ in the arrangement of electrons that form the bonds.

The Kekule structure of benzene accounted for the stability of the six carbon atoms but it was unable to explain why a highly unsaturated compound failed to undergo many of the addition reactions like decolourising bromine water, reaction with hydrogen halides etc; characteristic of alkenes.

Benzene undergoes mostly substitution reactions. Thus, the structural formula with threedouble bonds describing the benzene molecule does not agree with the chemical behaviour of benzene. Therefore, the bonding in benzene cannot be described as three double bonds and three single bonds as proposed by Kekule but rather the bonding must be considered as a delocalized electron cloud spread out over the whole benzene ring. Hence, the modern structure of benzene is considered to be a plain hexagon with an inscribed ring which represents the electron cloud spread out over the whole benzene ring as shown below:

**PREPARATION:** Benzene can be prepared from:

1. Coal tar: The destructive distillation of coal produced coal tar which contains benzene.

2. Petroleum: The dehydrogenated of alkane using vanadium (V) oxide (V2O5) as catalyst at 500oC and 20 atm gives benzene.

C6H14  V2O2C6H6 + 4H2

The process is known as catalytic reforming.

3. Polymerization of ethyne

3 ( H – C = C – H ) C6H6

**Evaluation**

1. Describe three methods of preparing benzene.
2. Draw the resonance structures of benzene structure of benzene.

**PHYSICAL PROPERTIES**

1. It has a pleasant smell.

2. It has boiling point of 80oC.

3. It is insoluble in water.

4. It burns with sooty flame.

**CHEMICAL PROPERTIES**

Benzene can undergo both addition reaction and substitution reaction.

1. Addition Reaction:

i. Hydrogenation: Benzene reduces to cyclo-hexane if hydrogen gas is passed through finely divided nickel at 150oC.

ii. Halogenation: In the presence of ultra-violet light, benzene reacts with halogen to produce cyclic compound.

2. Substitution Reaction: Benzene undergoes substitution reaction due to presence of single bonds in its structure.

i. Halogenation:

ii. Nitration: This occurs in the mixture of HNO3 and H2SO4 together with benzene

iii. Sulphonation: Benzene react with concentrated H2SO4 to form benzene sulphonic acid.

iv. Alkylation:- It involves reactions of benzene with halo-alkanes in the presence of AlCl3.

**USES**

1. It is used as a solvent to dissolve organic.

2. It is used as fuel in petrol.

3. It is used in the manufacture of aromatic compound e.g. benzoic acid.

**GENERAL Evaluation/REVISION**

* + 1. How would you obtain ethanal from ethyne? Give the equation for the reaction.
    2. Describe how to prepare ethyne in the laboratory.
    3. What is resonance? Give the resonance structure of benzene.
    4. Explain why hydrogen fluoride exists as a liquid whereas hydrogen chloride is a gas at room temperature.
    5. Explain why HCl in water conducts electricity but HCl in methyl benzene does not conduct electricity.

**READING ASSIGNMENT**

New School Chemistry for Senior Secondary School by .O.Y. Ababio (6th edition), pages 535-539.

**WEEKEND ASSIGNMENT**

**SECTION A:** Write the correct option ONLY

1. Which of the following hydrocarbons is alkyne?

a. C2H4 b. C2H6 c. C2H2 d. C3H8

2. The final product of complete reaction between ethyne and hydrogen gas is

a. ethane b. methyl ethane c. ethane d. hydroethyne

3. Ethynepolymerizes in the presence of organo nickel complex as catalyst to form a. polythene b. benzene c. polythene d. methyl benzene

4. Which of these compounds exhibits resonance? a. Ethanol b. Ethane

c. Benzene d. Butyne

5. Which of these is an aromatic hydrocarbon? a. Benzene b. Cyclohexane

c. Ethene d. Methylamine

**SECTION B**

1 a.With the aid of a labeled diagram, describe the laboratory preparation of ethyne.

b. Give a chemical test to distinguish between ethane and ethyne.

2 a.What is resonance? Draw two resonance structure of benzene.

b. Write balanced equation to the following reactions of benzene:

1. Reaction with ethene(ii) Reaction with chlorine.

**WEEK NINE**

**TOPIC: ALKANOLS**

**CONTENT**

* Types and Classes
* Industrial Production by Fermentation
* Properties and Uses

Alkanols is a homologous series with general molecular formula of CnH2n+1OH or ROH.

The functional group in alkanols is the hydroxyl (-OH) group.

**NOMENCLATURE:**

The names of alkanols are obtained by substituting “e” in alkanes with “ol”.

Example:

Methanol - CH3OH, Ethanol - CH3CH2OH

**CLASSIFICATION**

The alkanols are classified based on the number of alkyl groups directly linked to the carbon atom carrying the hydroxyl group.

1. **Primary alkanols** (10): It has only one alkyl group attached to the carbon atom that carries the hydroxyl group. Example

H H H

H C C OH H C OH

H H H

Ethanol Methanol

1. **Secondary alkanols** (20): They have two alkyl groups directly linked with the carbon atom carrying the hydroxyl group. Example

H H H

HC C C H

H OH H

Propan - 2- ol

1. **Tertiary alkanols** (30 ): The alkanols here have three alkyl groups attached to the carbon atom holding the hydroxyl group

CH3

CH3 C CH3

OH

2 – methylpropan -2 –ol

**TYPES OF ALKANOLS**

The type of alkanols is determined by the number of the hydroxyl group –OH, present in the molecule.

1. **Monohydric alkanols**: This type has only one hydroxyl(–OH), present in its molecule.

Example: C2H5OH, C3H7OH.

1. **Dihydric alkanols**: This type has two of hydroxyl group per molecule.

H H

H C OH H C OH

H C OH H C H

H H C OH

H

Ethan -1, 2- diol Propan- 1,3-diol

1. **Polyhydric alkanols**: This type has three or more hydroxyl groups per molecule.

Example

H

H C OH

H C OH

H C OH

H

**EVALUATION**

1. Name the functional group in the alkanol.

2. Give an example each by writing the structure and names of the classes of alkanols.

**ETHANOL**

**LABORATORY PREPARATION**

1. Hydrolyzing ethyl esters with hot alkali
2. Reducing ethanol with nascent hydrogen

**COMMERCIAL PREPARATION**

1. From ethene: Ethene is obtained by the cracking of petroleum. It is then absorbed in 95% H2SO4 at 800C and 30 atm to form ethyl hydrogen tetraoxosulphate (VI)

C2H4  + H2SO4 C2H5HSO4

The ethyl hydrogen tetraoxosulphate (VI) is hydrolyse by boiling in water to produce ethanol.

C2H5HSO4+ H2O C2H5OH + H2SO4.

The ethanol is distilled off leaving the acid behind which can be used again.

1. Preparation by fermentation: Ethanol is prepared industrially from raw materials containing starch or sugar by the process of fermentation. Fermentation is an enzymatic process which involves the decomposition of large organicmolecules to simple molecule by micro-organism.The common micro-organism used is YEAST

**PRODUCTION OF ETHANOL FROM STARCHY FOOD**

Ethanol can be prepared from starchy food like rice, potatoes, maize etc.

The following steps are involved;

* Crush and pressure cook the starchy materials.
* Extract the starch granules by mixing with water.
* Allow the starch granules to settle and decant
* Treat the starch granules with malt (partially germinated barley which contains the enzyme, DIASTASE) at 500C for one hour.
* The starch is then converted to MALTOSE.

2(C6H10O5)n + nH2O nC12H22O11

* Then yeast is added at room temperature for some time (at least one day). Yeast contains two enzymes, namely MALTASE and ZYMASE. Maltase converts maltose to two glucose units, while Zymase converts the glucose to ethanol and carbon (IV) oxide.

C12H22O11 + H2O maltase2C6H12O6

C6 H12 O6 Zymase 2C2H3OH + CO2

Ethanol

**EVALUATION**

1. Describe fully, the production of ethanol from a named starchy material/food.

2. What type of chemical reaction is involved in fermentation of sugar?

**PHYSICAL PROPERTIES**

1. Ethanol is a colourless volatile liquid.

2. It is soluble in water.

3. It has boiling point of 780C.

4. It has no action on litmus paper.

**CHEMICAL PROPERTIES**

1. Combustion: The lower members of alkanols burn with clean flames in plenty air

2CH3OH + 3O2 2CO2+H2O

2. Oxidation: The products of oxidation depend on the structure of the alkanol.

- Primaryalkanols are oxidized to alkanal first and then to alkanoic acid in the presence of oxidizing agent e.g KMnO4

CH3CH2OH O CH3CHO O CH3COOH

- Secondary alkanols oxidize to alkanone. Example

CH3 CH3

CH3 C OH [O ] CH3 C = O + H2O

propanone

H

Propon-2-ol

- Tertiary alkanols are not oxidized because there is no carbon-hydrogen bond to be broken for the oxidation to take place.

Note: The colour change of oxidizing agent if acidified is purple KMnO4 change to colourless and range K2Cr2O7 turns green.

3. Esterification:

This is the reversible reaction between alkanol and alkanoic and to produce sweet smelling compound known as ester. The reaction is catalysed by concentrated H2SO4. Example

CH3CH2OH +CH3COOH H+ CH3COOCH2CH3 + H2O

4. Dehydration:

Alkanols are dehydrated to alkenes in the presence of concentrated H2SO4.

CH3CH2OH + H2SO4 CH3CH2HSO4 + H2O

CH3CH2HSO4170oCC2H4 + H2SO4

5. Reaction with sodium and potassium: Sodium and potassium react vigorously with alkanols to liberate hydrogen gas and form corresponding organic salt of sodium and potassium.

2C2H3OH + Na 2C2H3ONa + H2

6. Reactions with the chlorides of phosphorus: Ethanol reacts vigorously with PCl5 in the cold to produce fumes of HCl and chloroethanevapour.

C2H5OH + PCl5C2H5Cl + POCl3  + HCl

PCl3 gives a similar reaction, but less vigorous.

C2H5OH + PCl3 3C2H5Cl + H3PO3

**USES OF ETHANOL**

1. It is used as organic solvent.

2. It is the main constituent of methylated spirit used to clean wounds and to dissolve paint.

3. It is used as petrol addictive for use as fuel in vehicles.

4. It is used to manufacture other chemicals such as ethanol and ethanoic acid.

5. It is used as ingredient in making alcoholic drinks e.g. beers, wines and spirits.

6. It is used as anti-freeze in automobile radiator because of its low freezing point (-1170C).

**GENERAL EVALUATION/REVISION**

1. Describe how ethanol can be prepared from cane sugar.

2. Using balanced equations, state five chemical properties of ethanol.

3. Describe a test to identify an unknown solution to be ethanol.

4. What is the number of oxygen atoms in 32g of the gas? [NA = 6.02 x 1023]

5. 5.6dm3 of oxygen gas was evolved at the anode during the electrolysis of dilute copper (II) tetraoxosulphate (VI) using platinum electrodes. What mass of copper is deposited at the cathode during the process? [Cu = 64, Molar volume of a gas at s.t.p = 22.4dm3, 1F = 96500C]

**READING ASSIGNMENT**

New School Chemistry for Senior Secondary School by O.Y.Ababio (6th edition) pages 539-544.

**WEEKEND ASSIGNMENT**

**SECTION A:**Write the correct option ONLY.

1. The functional groups of the alkanolis(a).double bond (b). carboxyl group (c). hydroxyl group (d). triple bond

2. Primaryalkanols are oxidized to carboxylic acid; secondary alkanols are oxidized to alkanones while tertiary alkanols are (a). oxidized to alkanols(b). oxidized to alkanones(c). not oxidized (d).oxidized to alkenes

3. The solubility of alkanols in water is due to (a). the covalent nature(b).hydrogenbonding

(c).their low melting point (d).their low melting point

4. When acidified KMnO4 is used as oxidizing agent for alkanol, the colour change observed is(a). yellow to red (b). purple to colourless(c). orange to green (d).white to black

5. Which of the following enzymes converts glucose to ethanol?(a). maltose (b).zymase

(c).diastase (d).amylase

**SECTION B**

1 (a).Write the structural formula of two named primaryalkanols.

(b). Explain the structural different between secondary and tertiary alkanols giving one example each.

2 (a).What is fermentation?

(b). Describe the preparation of ethanol from table sugar.