SCRIPTED LESSONS

3RD TERM WEEK 3

CHEMISTRY

S.S.2

CHEMISTRY SS2
3RD TERM WEEK 3

PERIOD 1

Subject	Chemistry			
Theme	Chemistry and Environment			
Topic	Sulphur-Properties of Hydrogen Sulphide			
Class Level	SS2			
Lesson Duration	40 Minutes			
Period	1			
Instructional Objectives/Learning Outcome	By the end of the lesson, students should be able to: 1) State the physical and chemical properties of hydrogen sulphide 2) Give the uses			
Instructional Resources/Materials	Text book, apparatus, board and marker			
Teacher's Preparation for the lesson	The teacher prepares the in structural material and the class			
Teaching Method	Interactive, collaboration discussion			
Lesson Procedure	**Time**	**Teacher activity**	**Students activity**	**Core Skill**
STEP I: Introduction Of Prior Ideas	5 Minutes	1) Revises the last topic. 2) Ask the students questions that leads to the new topic	1) Students answers the questions	• Critical Thinking
STEP II: Main Lesson	15 Minutes	Teacher 1) List the physical properties of hydrogen sulphide 2) State the chemical properties of hydrogen sulphide and explain it 3) Give the uses	1) Students listen 2) Ask questions	Critical thinking

		of hydrogen sulphide		
STEP III: Class Exercise	15 Minutes	1) Teacher revises the topic 2) Ask the students questions. 3) Copy notes on the board	1) Students answer the questions 2) Copy notes from the board	
STEP IV: Evaluation	5 Minutes	1) List the physical properties of hydrogen sulphide 2) State the chemical properties of H_2S 3) Give the uses of H_2S 4) Collects and marks the students notes	1) Students copies from the board. 2) Guides students to draw the extraction of sulphur	
Assignment		Explain in detail sulphides		

BOARD SUMMARY

Physical Properties of Hydrogen Sulphide

1. Hydrogen sulphide is a colourless gas with a repulsive smell like that of a rotten egg.
2. It is very poisonous.
3. It is about 1.18 times denser than air
4. It is moderately soluble in water. Three volumes of the gas dissolves in every volume of water to form a very weak acidic solution.
5. It burns with a pale blue flame.

Chemical Properties of Hydrogen Sulphide

a) As an Acid:

Hydrogen sulphide ionizes slightly in water to form a weak, basic acid exhibiting acidic properties

$H_2S_{(g)} + H_20_{(L)} \rightleftharpoons H_30^+_{(aq)} + HS^-_{(aq)}$

$HS_{(aq)} + H_20_{(L)} \rightleftharpoons H_30^+_{(aq)} + S^{2-}_{(aq)}$

In reacting with alkalis; the gas hydrogen sulphide forms both a normal salt (sulphide) and an acid salt (a hydrogen sulphide).

$2K0H_{(aq)} + H_2S_{(a)} \rightarrow K_2S_{(aq)} + 2H_20_{(L)}$

excess normal

$K0H_{(aq)} + H_2S_{(g)} \rightarrow KHS + H_20_{(L)}$

excess (acid salt)

b) **Combustion reaction/Reaction With Oxygen:**

Hydrogen sulphide does not support combustion. It however burns in excess oxygen with a bright blue flame to form sulphur (iv) oxide, but if in limited supply of oxygen, the reaction leads to the formation of a deposit of sulphur

$2H_2S_{(g)} + 30_{2(g)} \rightarrow 2H_20_{(L)} + 2\,S0_{2(g)}$

Excess

$2H_2S_{(g)} + 0_{2(g)} \rightarrow 2H_20_{(L)} + 2S_{(g)}$

(limited)

c) As a Precipitating Agent:

Since many metals form insoluble sulphides which are coloured, hydrogen sulphide precipitates the insoluble coloured sulphide when it is bubbled into the solution of the metal salt.

$(US0_{4(aq)} + H_2S_{(g)} \rightarrow (US_{(s)} + H_2S0_{4(aq)}$

dark brown

$Pb(CH_3(00)_{2(ag)} + H_2S_{(g)} \rightarrow PbS_{(s)} + 2\,CH_3C00H_{(aq)}$

(black)

$ZnS0_{4(aq)} + H_2S_{(g)} \rightarrow ZnS_{(s)} + H_2S0_{4(aq)}$

(white)

d) As a reducing Agent:

Hydrogen sulphide is a strong reducing agent because the oxidation number of sulphur is -2. In reacting with many **oxidizing agents**, the hydrogen sulphide is oxidized to elemental sulphur and an increased in oxidation state from -2 to 0.

$H_2S \quad 2H^+ + S^{2-}$

$S^{2-} \rightleftharpoons + 2e^-$

i. With halogen: In the presence of moisture, halogens oxidizes hydrogen sulphide to sulphur

$CL_{2(g)} + H_2S_{(s)} \rightarrow 2HCL_{(g)} + S_{(s)}$

ii. With sulphur (iv) oxide: Hydrogen sulphide reduces sulphur (iv) oxide to sulphur in the presence of moisture.

$S0_2 ++ 2.H_2 S_{(g)} \rightarrow 2H_2 0_{(l)} + 3S_{(s)}$

iii. With oxidizing acids:

i) Tetraoxosulphate (iv) acid oxidizes Hydrogen Sulphide to Sulphur, but with concentrated trioxonitrate (v), it oxidizes hydrogen sulphide to tetraoxosulphate (vi) acid to some extent with evolution of brown fumes of $N0_2$

$H_2S0_{4(aq)} + H_2S_{(g)} \rightarrow 2H_20_{(l)} + S0_{2(g)} + S_{(s)}$

$2HN0_{3(aq)} + H_2S_{(g)} \rightarrow 2H_20_{(L)} +$

$8HN0_{3(aq)} + H_2S_{(g)} \rightarrow 4H_20_{(l)} + 8N0_{2(g)} + H_2S0_{4(aq)}$

iv. With iron (iii) chloride

When hydrogen sulphide reacts with iron (iii) chloride, itself is oxidized to sulphur and hydrogen chloride and in the process reduced brownish-yellow solution of iron (iii) chloride to a green solution of iron (ii) chloride.

$2FeCL_{3(aq)} + H_2S_{(g)} \rightarrow 2FeCL_{2(ag)} + 2HCL_{(ag)} + S+(s)$

ionically

$2Fe^{3+}_{(aq)} + H_2S_{(g)} \rightarrow 2Fe^{2}+_{(aq)} + 2H^{+}_{(aw)} + S_{(s)}$

v. With tretraoxomanganate (vii):

vi. Bubbling Hydrogen Sulphide through a purple solution of acidified potassium tetraoxomanganate (vii) changes the purple colour to pale pink i.e. tetraoxomagaes (viii) ion to magnganses (ii) ion.

vii. $2KMn0_{4(aq)} + 5H_2S_{(g)} \rightarrow K2\ S0_4\ (q(+ 2MnS04(ag) = 5S_{(s)}$

ionically:

$2Mn0^{-}_{4(aq)}\ 6H^{2}_{(aq)} + 5H_2S(g) \rightarrow 2Mn^{2+}_{(aq)} + 8H20_{(l)} + 5S_{(s)}$

viii. With heptaoxochromate (vi)

Bubble hydrogen sulphide through an orange solution of acidified potassium heptaoxodichromate (vi), the colour of the solution changes to green and sulphur is deposited at the same time. The colour change is due to the reduction of the orange heptaxodichromate (vi) ion to the green chromium (iii) ion.

$K_2C_20_{7(aq)} + 4h_2s0_{4(aq)} + 3H_2S_{(g)} \rightarrow K_2S0_{4(aq)} + Cr_2\ (S0_4)_{3(aq)} + 7H_20_{(L)} + 3S_{(g)}$

ionically:

$K_2C_20_{7(aq)} + 4H_2S0_{4(aq)} + 3H_2S_{(g)} \rightarrow K_2S0_{4(aq)} + Cr_2\ (S0_4)_{3(aq)} + 7H_20_{(L)} + 3S_{(g)}$

$C_20_7^{2-}{}_{(aq)} + 8H^{+}_{(aq)} + 3H_2S_{(g)} \rightarrow 2Cr^{3+}_{(aq)} + 7H_2\ 0_{(L)} + 3S_{(s)}$

Test for Hydrogen Sulphide

Test	Observation	Inference
Sample	Repulsive smell like that of rotten Egg	H_2S Present
Filter Paper Pb $(N0_3)_2$ + Sample	Filter paper turns black	H_2S confirmed

$Pb(N0_3)_{2(aq)} + H_2S_{(g)} \rightarrow PbS_{(s)} + 2HN0_{3(aq)}$

black

$(CH_3\ C00)_2\ Pb_{(aq)} + H_2\ S_{(g)} \rightarrow PbS_{(s)} + 2CH_3C00H_{(aq)}$

black

Uses of Hydrogen Sulphide

1. In the analysis of ores and metals
2. In the precipitation of sulphide (coloured), identification of cations
3. In the preparation of sulohides of metals and other compounds.

PERIOD 2

Subject	Chemistry			
Theme	Chemistry and Environment			
Topic	Sulphur-Sulphur (iv) oxide			
Class Level	SS2			
Lesson Duration	40 Minutes			
Period	2			
Instructional Objectives/Learning Outcome	By the end of the lesson, students should be able to: 1) Explain the preparation of sulphur (iv) oxide 2) State the physical and chemical properties 3) List the uses of sulphur (iv) oxide			
Instructional Resources/Materials	Text book, board, marker and learners notes			
Teacher's Preparation for the lesson	The teacher prepares the class making it conducive for learning to take place.			
Teaching Method	Class discussion, demonstration, learner report back			
Lesson Procedure	**Time**	**Teacher activity**	**Students activity**	**Core Skill**
STEP I: Introduction Of Prior Ideas	5 Minutes	1) Revises the last topic 2) Ask the students questions to refresh the students interests and will lead to the new topic	Students answers the questions	• Critical Thinking • Collaboration
STEP II: Main Lesson	15 Minutes	Teacher explains: 1) The preparation of sulphur (iv) oxide 2) Give the properties 3) List the uses 4) Teacher responds to the	Students answers the questions	• Critical Thinking • Collaboration

		questions asked by the students		
STEP III: Class Exercise	15 Minutes	1) Ask the students questions 2) Give correct answer when necessary 3) Copy Board Summary on the board 4) Collects students notes and mark	1) Students answer the questions 2) Students copy notes 3) Submit for making	• Critical Thinking • Collaboration
STEP IV: Evaluation	5 Minutes	1) Explain briefly the preparation of sulphur (iv) oxide 2) List the physical properties $S0_2$ 3) State the chemical properties of $S0_2$ 4) List the uses of $S0_2$	Students answer the questions	• Critical thinking • Discussion
Assignment		1. Give the differences between hydrogen sulphide and sulphur (iv) oxide 2. List the uses of sulphur (iv) oxide		

BOARD SUMMARY

Sulphur (iv) oxide is an oxide of sulphur found in volcanic gases, water of certain sulphur springs, burnt coal which causes acid rain (air pollutant). It has an oxidation number of +4.

Laboratory Preparation

Sulphur (iv) oxide is prepared by heating sodium or potassium trioxosulphate (iv) with tetroaxosulphate (vi) or hydrochloric acid. The trioxosulphate (iv) acid formed breaks down to produce water and sulphur (iv) oxide.

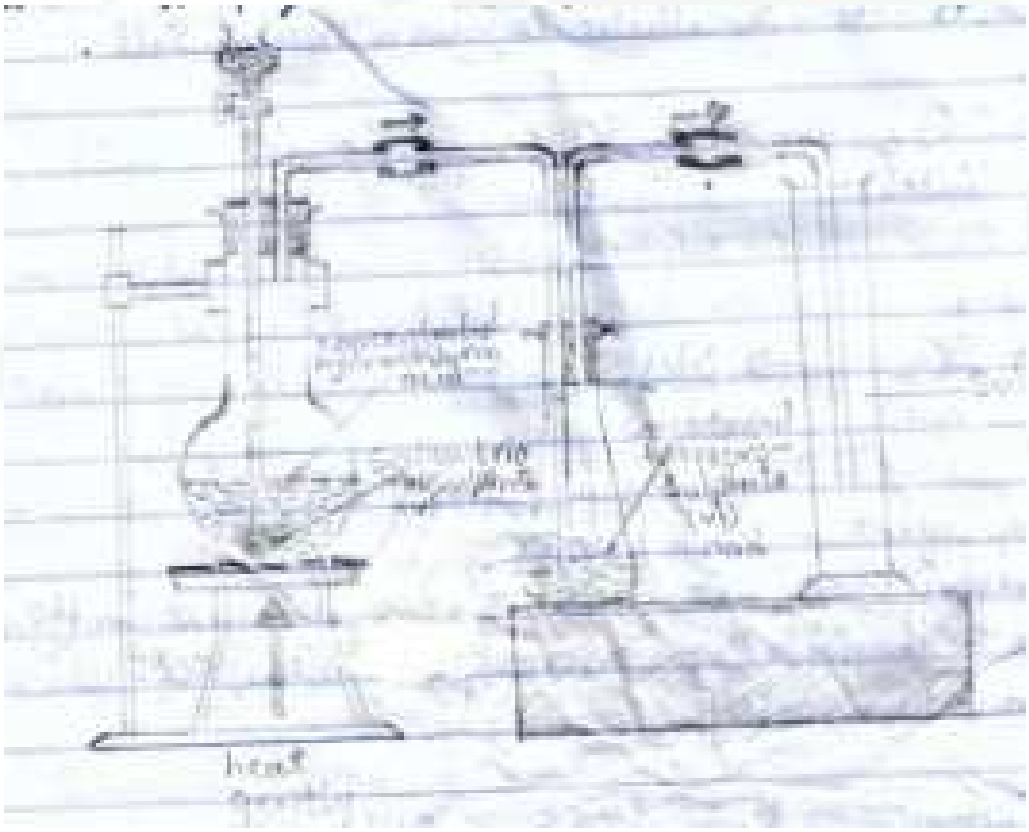
$Na_2S0_{3(aq)} + 2HCL_{(aq)} \rightarrow 2NaCl_{(aq)} + H_20_{(L)} + S0_{2(g)}$

ionically

$S0^{2-}_{3(aq)} + 2H^+_{(aq)} \rightarrow 2H_20_{(L)} + S0_{2(g)}$

Sulphur (iv) oxide can also be prepared by heating concentrated tetraoxosulphate (vi) acid with copper.

$Cu_{(s)} + 2H_2\ S0_{4(ag)} \rightarrow Cu50_{4(aq)} + 2H_20_{(L)} + S0_{2(g)}$



Industrial Preparation

Sulphur (iv) oxide is prepared by burning sulphur or metallic sulphide in oxygen. The gas formed is then liquefied and stored under pressure

$S_{(s)} + 0_{2(g)} \rightarrow S0_{2(g)}$

$4FeS_{(s)} + 70_2 \rightarrow 2Fe_20_3 + 4S0_2$

Physical Properties of Sulphur (iv) Oxide

1. Sulphur (iv) oxide is a colouress and poisonous gas with a very irritating smell like burning matches.
2. It is very soluble in water resulting in the formation of trioxosulphate (iv) acid. Hence it is anhydride of trioxosulphate (iv)
3. It is about 2.5 times denser than air.
4. It can be easily liquefied under pressure (about 3 atm) at room temperature.

Chemical Properties of Sulphur (iv) Oxide

1. **As an Acid:**

   The gas reacts with alkalis to form a normal salt.

   $2Na0H_{(ag)} + S0_{2(g)} \rightarrow Na_2\ S0_{3(aq)} + H_20_{(L)}$

   Limited — Sodium trioxo-Sulphate (iv)

   $NaOH_{(ag)} + S0_2 \rightarrow NaHS0_{3(aq)}$

   excess

2. **As a Reducing Agent:**

   Sulphur (iv) oxide, $S0_2$, is a strong reducing agent in the presence of water due to the formation trioxosulphate (iv) ion, $S0_3^{2-}$ which readily donates electrons to an oxidizing agent.

   $H_20_{(L)} + S0_{2(g)} \rightleftharpoons H_2S0_{3(aq)} \rightleftharpoons 2H^+_{(aq)} + S0_3^{2-}{}_{(aq)}$

   a) With Tetraoxomanganate (vii):

   Sulphur (iv) oxide decolourizes an acidified potassium tetraoxomanganate (vii) solution by reducing to managanese (ii) tetraoxosulphate (vi). While itself is oxidized to tetraoxosulpohate (vi)

   $2KM_n0_{4(aq)} + 5S0_{2(g)} + 2H_20_{(l)} \rightarrow K_2S0_{4(aq)} + 2MnS0_{4(aq)} + 2H_2S04_{(aq)}$

   ionically

   $2Mn0_{4(aq)} + 5S0_{2(g)} + 2H_20_{(l)} \rightarrow 2M^{2+}{}_{n(aq)} + 5S0^{2-}{}_{4(aq)} + 4H^+_{(aq)}$

   b) With Heptaoxochromate (vi):

   Sulphur (iv) oxide changes the colour of acidified potassium heptaoxochromate (vi) solution from orange to green by reducing it to chromium (iii) tetraoxosulphate (vi)

   $K_2Cr_20_{7(aq)} + 3S0_{2(g)} + H_2S0_{4(aq)} \rightarrow K_2S0_{4(aq)} + Cr_2(S0_4)_{3(aq)} + H_2)_{(l)}$

ionically:

$Cr_20^{2-}{}_{7(aq)} + 3S0_{2(g)} + 2H^+_{(aq)} \rightarrow 2Cr^{3+}_{(aq)} + 3S0^{2-}{}_{4(aq)} + H_20$

c) With iron (iii) Chloride:

Brown iron (iii) chloride solution is reduced to green iron (ii) chloride solution by sulphur (iv) oxide while oxidizing itself to tetra0xosulphate (vi) acid.

$2FeCl_{3(aq)} + S0_{2(g)} + 2H_20_{(l)} \rightarrow 2FeCl_{2(aq)} + H_2S0_{4(aq)} + 2HCl_{(aq)}$

ioniclaly

$2Fe^{3+}\ S0_{2(g)} + 2H_20_{(l)} \rightarrow 2Fe^{2+}_{(aq)} + S0^{2-}{}_{4(aq)} + 4H^+_{(aq)}$

d) With trioxonitrate (v) acid:

Sulphur (iv) oxide reduces concentrated trioxonitrate (v) acid to liberate reddish-brown nitrogen (iv) oxide

$2HN0_{3(aq)} + S0_{2(g)} \rightarrow H_2S0_{4(aq)} + 2N0_{2(g)}$

ionically:

$2N0^-{}_{3(aq)} + S0_{2(g)} \rightarrow S0^{2-}{}_{4(aq)} + 2N0_{2(g)}$

e) With the Halogen:

Sulphur (iv) oxide reduces the colour solutions of chlorine, bromine and iodine to the colourless solutions of their hydrogen compounds.

3. **<u>As a Bleaching Agent:</u>**

Sulphur (iv) oxide bleaches in the presence of water like chlorine, but it bleaches with both natural and artificial dyes. And It bleaches by reducing the dye to a colourless compound. In the presence of water sulphur (iv) oxide form trioxosulphate (iv) which donates its electrons to the dye and its axidized. Sulphur (iv) oxide bleaching does not last long as that of chlorine because the bleached dye may become reoxidized by atmospheric oxygen to form the original coloured compound. That is why a white straw hat often turns yellow after some time.

$H_2S0_{3(aq)}$ + $dye_{(aq)} \rightarrow$ $H_2S0_{4(aq)}$ + bleached $dye_{(aq)}$

trioxosulphate (coloured) (colourless)

4. **<u>Direct Combination Reactions:</u>**

a) <u>With certain metallic oxides</u>

Oxides like lead (iv) oxide and sodium peroxide reacts similar with sulphur (iv) oxide. The oxide is heated and lowered into a gas jar of sulphur (iv) oxide. The lead (iv) oxide combines to form white deposits of lead (ii) tetraoxosulphate (vi).

$Pb0_{2(s)} + S0_{2(g)} \rightarrow PbS0_{4(s)}$

$Na_20_{2(s)} + S0_{2(g)} \rightarrow Na_2\ S0_{4(s)}$

b) <u>With Oxygen</u>

Sulphur (iv) oxide combines reversibly with oxygen in the presence of a catalyst to form sulphur (vi) oxide. The forward reactions is exothermic

$2S0_{2(g)} + 0_{2(g)} \rightleftharpoons 2S0_{3(g)}$

c) <u>As an Oxidizing Agent:</u>

Sulphur (iv) oxide act as an oxidizing agent in the presence of a stronger reducing agent while itself is reduced to sulphur. This reaction is used to recover sulphur from industrial fuel gases.

$2H_2S_{(g)} + S0_{2(g)} \rightarrow 2H_20_{(l)} + 35_{(s)}$

$C_{(s)} + S0_{2(g)} \rightarrow C0_{2(g)} + S.$

<u>Test for Sulphur</u>

1. Bleaching action
2. Action on oxidizing agents

PERIOD 3

Subject	Chemistry
Theme	Chemistry and Environment
Topic	Sulphur-Sulphur (iv) oxide
Class Level	SS2
Lesson Duration	40 Minutes
Period	3
Instructional	By the end of the lesson, students should be able to:

Objectives/Learning Outcome	1) Describe the preparation of sulphur (iv) oxide 2) State the properties of sulphur (vi) oxide 3) Determine the oxidation states of sulphur in its major compounds.			
Instructional Resources/Materials	Text book, board, marker and learners notes			
Teacher's Preparation for the lesson	The teacher prepares the class making it conducive for learning to take place.			
Teaching Method	Demonstration and class discussion			
Lesson Procedure	**Time**	**Teacher activity**	**Students activity**	**Core Skill**
STEP I: Introduction Of Prior Ideas	5 Minutes	1) Revises the previous topic 2) Ask the students questions to refresh the students interests and will lead to the new topic	Students answers the questions	• Critical Thinking • Collaboration
STEP II: Main Lesson	15 inutes	1) Explains the preparation of sulphur (vi) oxide 2) State the properties of sulphur (vi) oxide 3) Explain how to determine the oxidation state of sulphur in its major compounds 4) Responds to student's questions	1) Listen attentively 2) Ask questions	
STEP III: Class Exercise	15 Minutes	1) Ask the students questions.	1) Students answer the questions	• Critical Thinking • Collaboration

		2) Give the correct answers when necessary 3) Copy board summary on the board 4) Collects students notes and mark	2) Students copy notes 3) Submit for making	
STEP IV: Evaluation	5 Minutes	1) Explain briefly the preparation of sulphur (iv) oxide 2) What is/are the conditions necessary to obtain a good yield of sulphur (vi) oxide. 3) State the properties of sulphur (vi) oxide. 4) Give the oxidation state of sulphur in the compounds a) H_2S (b) H_2S0_3 (c) H_2S0_4	Students answer the questions	• Critical thinking • Discussion
Assignment		1) Explain the properties of H_2S0_3 2) Give its properties 3) List its uses		

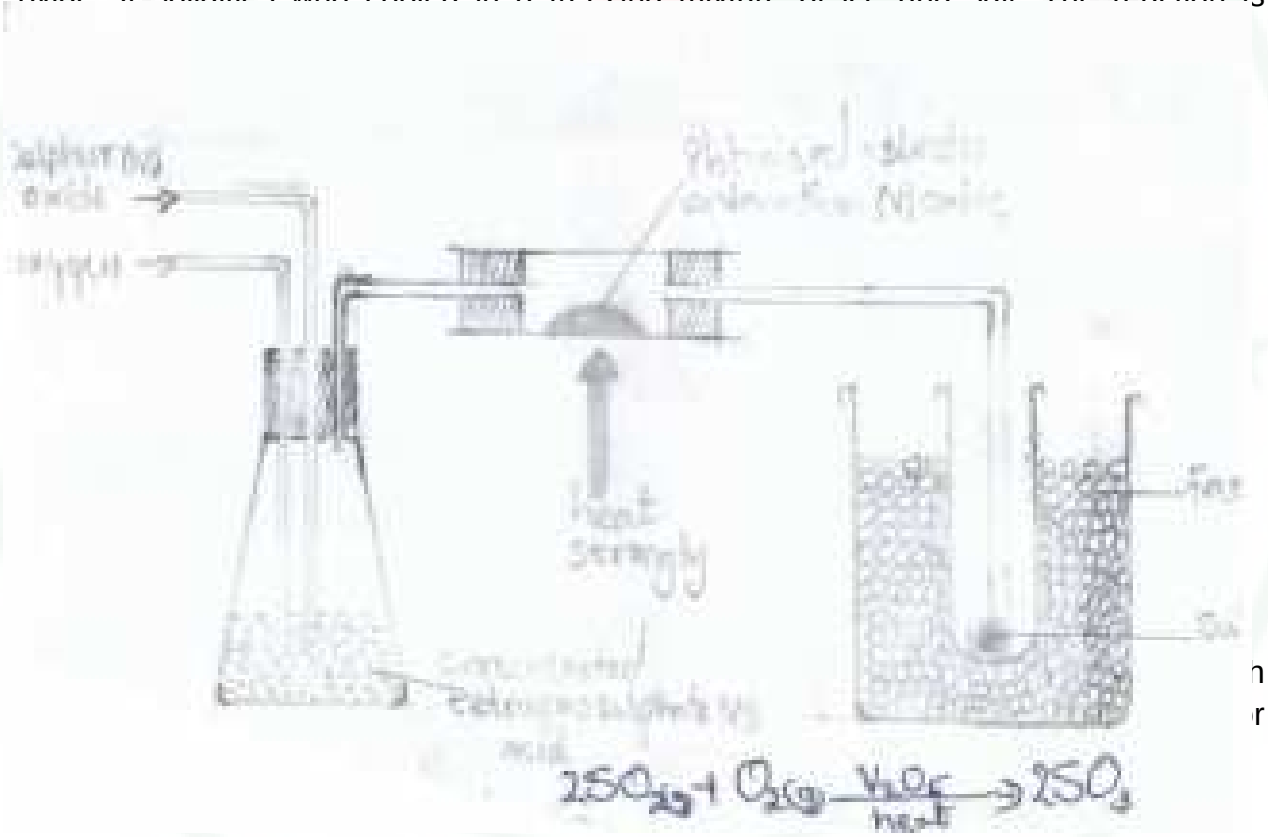
BOARD SUMMARY

Sulphur (iv) oxide $S0_2$, under normal condition doesn't readily combine with oxygen, 0_2, to form sulphur (vi) oxide, $S0_3$, except under some necessary conditions to obtain a good yield of it.

i. Presence of a catalyst platinized abestor or vanadium (v) oxide
ii. A slight pressure
iii. Temperature of 400-450^{0}C.

Laboratory Preparation

A mixture of sulphur (iv) and oxygen is passed through concentrated tetraoxosulphate (vi) acids to dry them; the gaseous mixture passed over a strongly heated catalyst platinized absetor/vanadium (v) oxide. A dense white fume is seen which is sulphur (vi) oxide. It solidifies who cooled in a freezing mixture of ice and salt. The reaction is



Properties of Sulphur (vi) Oxide

1. At room temperature, sulphur (vi) oxide exist as white needle-shaped crystals
2. It has low boiling point (45^{0}C) and hence on gentle heating readily vapourizes.
3. It is an acidic oxide
4. It reacts exothermically with water/dissolve readily in water to form an hydride of tetraoxosulphate (vi) acid which neutralizes bases to form tetraoxosulphates (vi)
   $H_20_{(l)} + S0_{3(g)} \rightleftharpoons H_2S0_{4(aq)}$

5. On dissolving sulphur (vi) oxide in concentrated (vi) acid, oleum/fuming tetraoxolphate (vi) acid

$S0_3 + H_2 S0_{4(aq)} \rightleftharpoons H_2 S_2 0_{7(aq)}$

Oxidation State of Sulphur in Compounds of Sulphur

S/N	Name of Compounds	Formula	Oxidation State
1.	Tetraoxosulphate (vi) acid	H_2S0_4	+6
2.	Sulphur (iv) oxide	$S0_2$	+4
3.	Sulphur	S_8	0
4.	Hydrogen Sulphide	$H_2S(15)$	-2

PERIOD 4

Subject	Chemistry			
Theme	Chemistry and Environment			
Topic	Sulphur-Tetraoxosulphate			
Class Level	SS2			
Lesson Duration	40 Minutes			
Period	4			
Instructional Objectives/Learning Outcome	By the end of the lesson, students should be able to: 1) Describe the industrial preparation of tetraoxosulphate (vi) by contact process 2) State the physical properties of H_2S0_4 3) State the chemical properties of H_2S0_4 4) Give the use sof H_2S0_4			
Instructional Resources/Materials	1. Chart on the contact process for the preparation of H_2S0_4 2. Car battery acid, litmus paper			
Teacher's Preparation for the lesson	The teacher provides the car battery acid, chart and prepares the class: making it conducive for learning to take place.			
Teaching Method	Demonstration and interaction			
Lesson Procedure	**Time**	**Teacher activity**	**Students activity**	**Core Skill**
STEP I: Introduction Of Prior Ideas	5 Minutes	1) Revises the previous topic 2) Ask the students questions to refresh their knowledge and lead them to the new topic	1) Students answer the questions 2) Answer questions	• Critical Thinking • Imagination
STEP II: Main Lesson	15 Minutes	1) Explain the preparation of tetraoxosulphate (vi) acid. 2) State the properties of H_2S0_4 3) Give the uses	1) Students listen attentively. 2) Ask questions for a better understanding of the	Critical thinking

		of H_2S0_4	topic	
STEP III: Class Exercise	15 Minutes	1) Ask the students questions 2) Give the correct answers when necessary 3) Copy board summary on the board. 4) Collects and mark students notes students notes	1) Students answers the questions 2) Students copy notes from the board summary 3) Submit for marking	• Collaboration
STEP IV: **Evaluation**	5 Minutes	1) With the aid of a diagram, explain the contact process for the preparation of H_2S0_4 2) State the physical properties of H_2S0_4. 3) Give the chemical properties of H_2S0_4 4) List the uses of H_2S0_4	Students answer the questions	• Critical thinking • Discussion
Assignment		1) Explain tetraoxosulphates (vi) salt 2) State the properties and uses		

BOARD SUMMARY

Tetraoxosulphate (vi) acid is one of the most used chemicals in the laboratory and industries directly or indirectly at some stage.

Industrial Preparation

H_2S0_4 acid is manufactured by contact process which is a catalytic combination of sulphur (iv) oxide and oxygen to form sulphur (vi) oxide.

$S_{(s)} + 0_{2(g)} \rightleftharpoons S0_{2(g)}$

$2S0_{2(g)} + 0_{2(g)} \rightleftharpoons 2S0_{3(g)} + \text{heat}$

The produced sulphur (iv) oxide mixes with excess air and passes through AN electric chamber to remove impurities and dust which may poison the catalyst. The gaseous mixture is passed through concentrated tetraoxosulphates (iv) to dry it and then pass into the reaction pressure where the sulphur (iv) oxide combines with the excess oxygen in the presence of the catalyst (vanadium (iv) oxide) to yield about 98% of sulphur (vi) oxide).

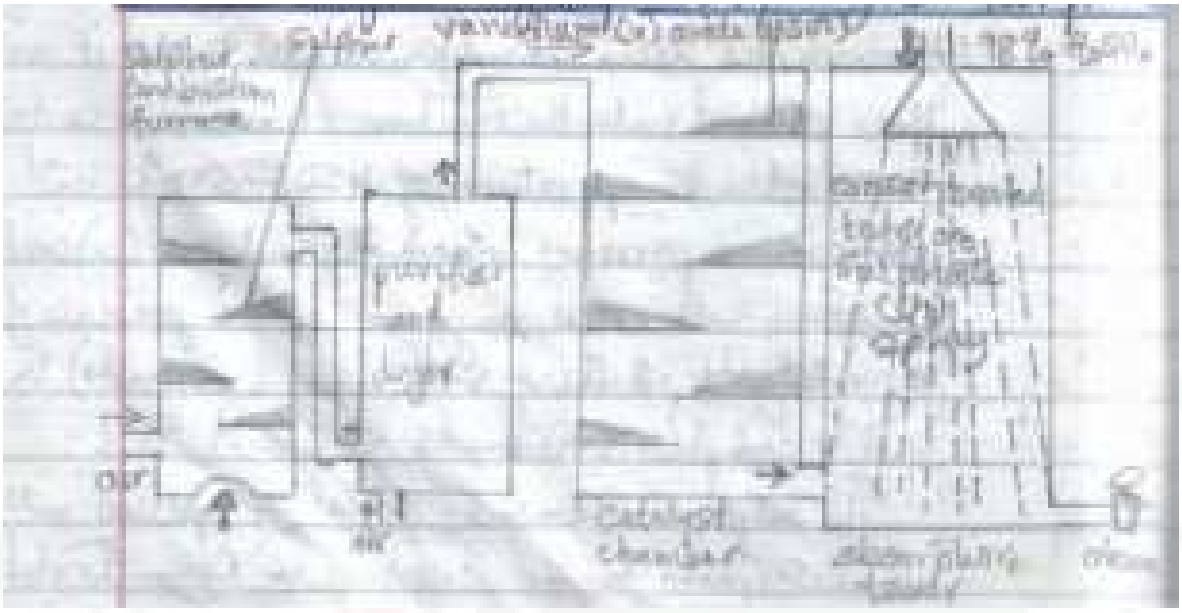
The sulphur (vi) oxide is cooled and passed into an absorption tower, dissolved in concentrated tetraoxosulphate (vi) to produce a thick liquid, oleum, $H_2S_20_7$. Sulpur (vi) oxide is not dissolved directly in water because the solution will boil producing a mist of acid droplets.

$S0_{3(g)} + H_2S0_{4(aq)} \rightarrow H_2S_20_7$.

The oleum is then diluted with appropriate amount of water to produce 98% tetraoxosulphate (vi) acid.

$H_2S_20_{7(aq)} + H_20_{(l)} \rightarrow 2H_2\ S0_{4(aq)}$.

Industrial Preparation of Sulphur (vi) Oxide by the Contact Process



Scheme of the Contact Process

$S + 0_2 \rightarrow SO_2 \rightarrow SO_3 \rightarrow H_2S_2O_7 + \rightarrow H_2SO_4$

$|+ \quad |+ \quad$ oleum $|$

0_2 concentrated

(excess air) H_2SO_4 H_2O

Physical Properties

1. Concentrated tetraoxosulphate (vi) acid, called **oil of vitriol** is a colourless, viscous liquid with a density of $1.84gcm^{-3}$.
2. On contact with the skin because it is corrosive causing severe burns.
3. Concentrated tetraoxosulphate (vi) acid has a great affinity for water, evolving a large amount of heat as it dissolves because of the hydration of H_2SO_4 ions. Concentrated tetraoxosulphate (vi) acid is hygroscopic (absorb water vapour from the surrounding).

Chemical Properties

a) As an Acid:

Dilute H_2S0_4 acid is a strong dibasic acid which ionizes in two stages.

$H_2S0_{4(aq)} + H_20_{(L)} \rightarrow H_3{}^+0_{(aq)} + HS0^-{}_{4(aq)}$

Hydrogen tetraoxzosulphate (v) ion

$HS0^-{}_{4(a)} + H_20_{(L)} \rightarrow H_3{}^+0_{(aq)} + S0_4{}^{2-}{}_{(aq)}$

Tetraoxosulphate (vi) ion

(i) With Metals:

Dilute $H_2S0_{4(aq)}$ reacts with metal and liberate hydrogen because the metals are higher than hydrogen in the electrochemical series

$H_2S0_{4(aq)} + Zn_{(s)} \rightarrow ZnS0_{4(aq)} + H_20_{(g)}$

(ii) With Bases:

Dilute $H_2S0_{4(aq)}$ reacts with bases or alkalis to form salt and water

$H_2S0_{4(aq)} + Mgcl_{(s)} \rightarrow MgS0_{4(aq)} + H_20_{(L)}$

Since tetraoxosulphate (vi) acid is dibasic, it forms normal salts, tetraoxosulphates and acid salt, the hydrogentetraoxosulphate (vi)

$H_2+S0_{4(aq)} + NaOH_{(aq)} \rightarrow NaHS0_{4(aq)} + H_20_{(L)}$

$H_2S0_{4(aq)} + 2Na0H_{(aq)} \rightarrow Na_2S0_{4(aq)} + 2H_20_{(L)}$

excess

(iii) With Trioxocarbonates:

Dilute tetraoxosulphate (vi) acids reacts with trioxocrbonates (iv) to liberate carbon (iv) oxide

$H_2S0_{4(aq)} + CuC0_{3(aq)} \rightarrow CuS0_{4(aq)} + H_20_{(l)} + C0_{2g}$

ionically

$2H^+{}_{(aq)} + C0^{2-}{}_{(aq)} \rightarrow H_20_{(L)} + C0_{2(g)}$

b) **As an Oxidizing Agent:**

Hot concentrated tetraoxosulphate (vi) acid exhibits oxidizing properties by accepting electron(s) from the reducing agents. The acid itself is reduced to trioxosulphate (iv) acid or sulphur (iv) oxide. Sulphur oxidation number decreases + 6 to +4.

$S0_4{}^{2-}{}_{(aq)} + 4H^+{}_{(aq)} + 2e^- \rightarrow 2H_20_{(L)} + S0_{2(g)}$

With Metals:

The concentrated acid oxidizes metals to produce the corresponding metallic tetraoxosulphate (vi) and sulphur (iv) oxide. In these reactions, the metals supply the electron(s) and becomes oxidized to the metallic ions.

$Zn(s) + 2H_2S0_{4(aq)} \rightarrow ZnS0_{4(aq)} + 2H_20_{(L)} + S0_{2(g)}$

ionically

$Zn(s) + 4H^+{}_{(aq)} + S0_4{}^{2-}{}_{(aq)} \rightarrow Zn^{2+}{}_{(aq)} + 2H_20_{(L)} + S0_{2(g)}$

With Non-Metal

The concentrated acid oxidizes non-metals to produce their corresponding oxides and sulphur (iv) oxide for example, when powdered carbon is heated with the concentrated acid, carbon (iv) oxide is formed.

$C_{(s)} + 2H_2S0_{4(aq)} \rightarrow C0_{2(g)} + 2H_20_{(L)} + 2S0_{2(g)}$

With Hydrogen Sulphide

Tetraoxosulphate (vi) acid oxidized hydrogen sulphide to sulphur. The reaction takes place readily when hydrogen sulphide is bubbled into hot or cold concentrated tetraoxosulphate (vi) acid.

$H_2S_{(g)} + H_2S0_{4(aq)} \rightarrow S0_{2(g)} + 2H_20_{(L)} + S_{(b)}$

c) As a dehydrating Agent:

Concentrated tetraoxosulphate (vi) acid is able to remove water from compounds like sugar, ethanol, methanonic acid and ethanedioic acid by the processes as dehydration.

$C_{12}\ H_{22}\ 0_{11(s)} \xrightarrow{-H_20_{(L)}} 12\ C\ (s)$

Sugar $conc H_2S0_{4(aq)}$ Sugar charcoal

$C_{12}\ H_{22}\ 0_{11(s)} \xrightarrow{-H_20_{(L)}}$

|

$C00H^{(s)} \xrightarrow{Conc H_2S0_{4(aq)}} C0_{2(g)} + C0_{(g)}$

Ethanedioic acid

Dehydration affects the chemical composition of a compound while drying do not and the acid itself remains chemically unchanged at the end of the reaction. Although it may be deluted by the water formed.

Displacement of other Acids from their Salts

Concentrated tetraoxosulphate (vi) acid is able to displace volatile acids from their corresponding salts, when a chloride or a trioxonitrated (v) is heated with concentrated tetraoxosulphate (vi) acid, hydrochloric or trioxonitrate (vi) acid distills over a vapour because of its lower boiling point. In some instances, the acids displaced are unstable and break down to give volatile products.

$Kcl_{(s)} + H_2S0_{4(aq)} \rightarrow KHS0_{4(aq)} + HCL_{(g)}$

$Na_2S0_{3(s)} + 2H_2S0_{4(aq)} \rightarrow 2NaHS0_{4(aq)} + H_20_{(L)} + S0_{2(g)}$

$Na_2C0_{3(s)} + H_2S0_{4(aq)} \rightarrow Na_2S0_{4(aq)} + H_20_{(L)} \_ + C0_{2(g)}.$

The above reactions are used in qualitative analysis to detect the presence of many acid radicals depending on the high boiling point of concentrated H_2S0_4 (vi) acid

Hydrogen Tetraoxosulphates (vi)

Hydrogen tetraoxosulphates (vi) are acid salts, they are formed when an excess of tetraoxosulphate (vi) acid is reacted with alkalis or soluble trioxocarbonates (iv)

$K0H_{(aq)} + H_2S0_{4(aq)} \rightarrow KHS0_{4(aq)} + H_20_{(L)}$

$Na_2\ C0_{3(aq)} + 2H_2S0_{4(aq)} \rightarrow 2NaHS0_{4(aq)} + H_20_{(L)} + C0_{2(g)}$

Properties

Hydrogen tetraoxosulphates (ii) are acidic because they still contain an ionized hydrogen. They change the colour of blue litmus solution red. They react with excess alkalis to form normal salts.

$KOH_{(aq)} + KHS0_{4(aq)} \rightarrow K_2S0_{4(aq)} + H_20_{(L)}$

ASSIGNMENT

Read up oxidation –

Education (REDOX) reaction

Conclusion:

The teacher collects and marks their notes