Sulphur and its Compounds

Charles Kidega
Kidegalize Network
✉ es.gulu1910@gmail.com
✆ +256(0)702816081

KNET
Making the future tangible

Kidegalize

Introduction to sulphur

Sulphur (symbol S) is a yellow non-metallic solid element.

It belongs to Group VI and Period 3 in the Periodic Table.

Sulphur occurs as a free element underground and also occurs in combined form as sulphides, sulphates, sulphites, petroleum oil and natural gas.

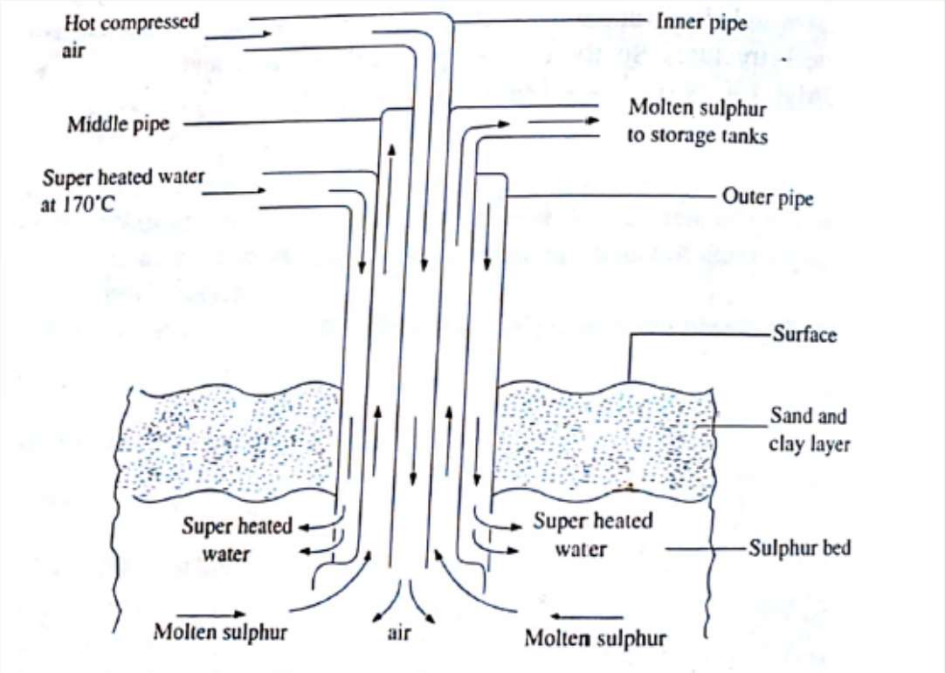
Making the future tangible

Kidegalize

Extraction of sulphur

Sulphur is extracted by the Frasch process.

Set up



Making the future tangible

Kidegalize

Three concentric pipes are sunk into the ground up to sulphur deposits.

Superheated water at 170°C and 10atm is forced down the outermost pipe to melt the sulphur.

Hot compressed air is pumped down the innermost pipe.

Making the future tangible

Kidegalize

The pressure created by the air pumps the molten sulphur out through the middle pipe to the surface.

The froth of molten sulphur, water and air is forced up to the central pipe by pressure and it is run into large tanks where it solidifies to yellow roll sulphur.

Making the future tangible

Kidegalize

Allotropes of sulphur

Sulphur has two major crystalline forms:

- **Rhombic sulphur which consist of large bright yellow octahedral shaped crystals. It has a density of 2.06gcm^{-3}, melts at 114^{o}C and stable below 96^{o}C.**

Making the future tangible

Kidegalize

Preparation of rhombic sulphur

Powdered Sulphur is dissolved in methylbenzene or carbon disulphide in a test tube and the mixture shaken vigorously for sometime.

The mixture is filtered using dry filter paper and the filtrate collected in a beaker.

Making the future tangible

Kidegalize

The beaker is covered with a filter paper with a few holes in it to allow the methylbenzene or carbon disulphide to evaporate slowly.

When all the volatile solvent has evaporated, bright yellow octahedral crystals are deposited.

Making the future tangible

Kidegalize

- **Monoclinic sulphur** which consist of pale yellow needle (prismatic) shaped crystals. It has a density of $1.98gcm^{-3}$, melts at $119^{o}C$ and stable above $96^{o}C$.

KNET
Making the future tangible

Kidegalize

Preparation of monoclinic sulphur

Heat powdered sulphur in an evaporating dish and keep stirring while adding more sulphur until the dish is almost brimful.

After all the sulphur is molten, allow it cool. When a thin solid crust forms on the surface, pierce it using glass rod to create two spaced holes.

Making the future tangible

Kidegalize

Pour out the liquid Sulphur through one hole into a beaker. Carefully cut away the crust and lift it out.

Thin needle-like pale yellow crystals form both beneath the crust and inside the dish.

Making the future tangible

Kidegalize

Remember: When one gram of each allotrope is separately burnt in air, the same mass volume of sulphur dioxide is formed.

$$S(s) + O_2(g) \longrightarrow SO_2(g)$$

This shows that rhombic and monoclinic sulphur are allotropes of sulphur.

Making the future tangible

Kidegalize

Reactions of sulphur

- Sulphur burns in air with a blue flame to form Sulphur dioxide.

$$S(s) + O_2(g) \longrightarrow SO_2(g)$$

- Sulphur reacts with heated metals to form sulphides (black solids).

$$Fe(s) + S(s) \longrightarrow FeS(s)$$

$$Cu(s) + S(s) \longrightarrow CuS(s)$$

Making the future tangible

Kidegalize

- Sulphur react with carbon to form liquid carbon disulphide.

$$S(s) + C(s) \longrightarrow CS_2(l)$$

- Molten Sulphur reacts with hydrogen to form hydrogen sulphide.

$$S(l) + H_2(g) \longrightarrow H_2S(g)$$

- **Concentrated sulphuric acid oxidizes Sulphur to sulphur dioxide.**

$$S(s) + 2H_2SO_4(l) \longrightarrow 3SO_2(g) + 2H_2O(l)$$

- **Sulphur is oxidized to sulphuric acid by hot concentrated nitric acid.**

$$S(s) + 6HNO_3(l) \longrightarrow H_2SO_4(aq) + 6NO_2(g) + 2H_2O(l)$$

Making the future tangible

Kidegalize

Uses of sulphur

- Manufacture of sulphuric acid.
- Manufacture of dyes and fireworks.
- Vulcanisation of natural rubber.
- Manufacture of ointments and tablets used to treat ringworm.

KNET
Making the future tangible
Kidegalize

Sulphur dioxide, SO_2

Preparation of sulphur dioxide from sodium sulphite and dilute sulphuric acid

Dilute sulphuric acid from a tap funnel is added to sodium sulphite in a flask fitted with a delivery tube and the mixture warmed gently.

Sulphur dioxide is produced according to the equation.

Making the future tangible

Kidegalize

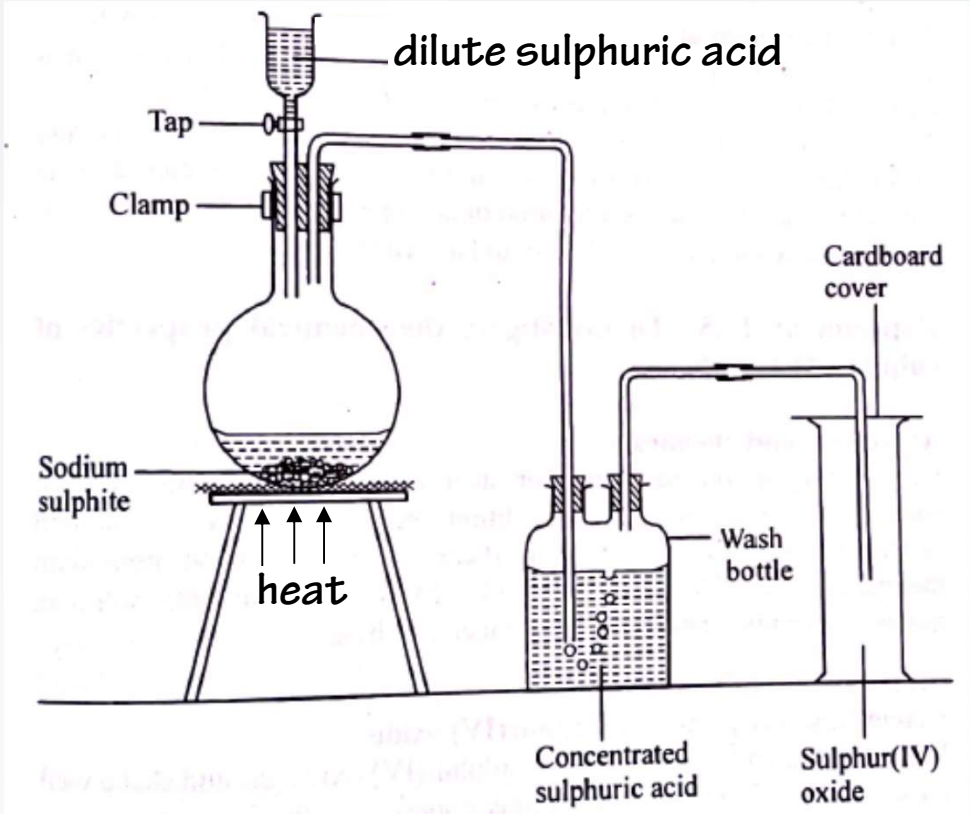
$H_2SO_4(aq) + Na_2SO_3(s) \longrightarrow Na_2SO_4(aq) + H_2O(l) + SO_2(g)$

The gas is passed through concentrated sulphuric acid for drying and then collected by downward delivery because it is denser than air.

Making the future tangible

Kidegalize

Set up



Making the future tangible

Kidegalize

Remember

- Hydrogensulphite can be used instead of sulphite.
- Hydrochloric acid can be used instead of sulphuric acid.
- The gas is not collected over water because it is very soluble in water.
- Copper and conc. sulphuric acid can also be used.

Making the future tangible

Kidegalize

Ionic equation

For sulphite

$SO_3^{2-}(aq) + 2H^+(aq) \longrightarrow SO_2(g) + H_2O(l)$

For hydrogensulphite

$HSO_3^-(aq) + H^+(aq) \longrightarrow SO_2(g) + H_2O(l)$

Making the future tangible

Kidegalize

Physical properties

- It is denser than air.
- It is a colourless poisonous gas with a choking irritating smell.
- It has a sweet smell.
- It is very soluble in water.

Making the future tangible

Kidegalize

Reactions of sulphur dioxide

- **Sulphur dioxide turns damp blue litmus paper red because it is acidic.**
- **It dissolves in water to form sulphurous acid.**

$$H_2O(l) + SO_2(g) \longrightarrow H_2SO_3(aq)$$

- It combines with oxygen in the presence of vanadium(V) oxide as catalyst to form sulphur trioxide gas.

$$2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g)$$

- **Limited sulphur dioxide reacts with sodium hydroxide solution to form sodium sulphite.**

$$2NaOH(aq) + SO_2(g) \longrightarrow Na_2SO_3(aq) + H_2O(l)$$

Excess sulphur dioxide reacts with sodium hydroxide solution to form sodium hydrogensulphite (acidic salt).

$$NaOH(aq) + SO_2(g) \longrightarrow NaHSO_3(aq)$$

Making the future tangible

Kidegalize

Reducing reactions of sulphur dioxide

- Sulphur dioxide reduces acidified potassium permanganate solution to manganese(II) ions.

Observation: Purple solution turns colourless.

Making the future tangible

Kidegalize

- Sulphur dioxide reduces acidified potassium dichromate(VI) solution to chromium(III) ions.

Observation: Orange solution turns green.

Remember: The two reactions are used to test for sulphur dioxide.

Making the future tangible

Kidegalize

- **Sulphur dioxide reduces concentrated nitric acid to nitrogen dioxide(reddish brown) when the mixture is warmed.**

$$SO_2(g) + 2HNO_3(l) \longrightarrow H_2SO_4(aq) + NO_2(g)$$

- **Sulphur dioxide bleaches dyes in presence of water.**

$$SO_2(g) + 2H_2O(l) + dye \longrightarrow H_2SO_4(aq) + (dye + 2H)$$

Making the future tangible

Kidegalize

- **Sulphur dioxide reduces halogens to their hydrogen compounds.**

$SO_2(g) + H_2O(l) + Cl_2(aq) \longrightarrow H_2SO_4(aq) + HCl(aq)$

Observation: Yellowish-green chlorine, red bromine and brown iodine turns colourless.

Making the future tangible

Kidegalize

Oxidation reactions of sulphur dioxide

- Sulphur dioxide oxidizes burning magnesium to magnesium oxide.

$2Mg(s) + SO_2(g) \longrightarrow 2MgO(s) + S(s)$

Observation: Yellow solid and white solid observed.

Making the future tangible

Kidegalize

- **Sulphur dioxide oxidizes hydrogen sulphide to sulphur.**

$$SO_2(g) + 2H_2S(g) \longrightarrow 3S(s) + 2H_2O(l)$$

KNET
Making the future tangible
Kidegalize

Uses of sulphur dioxide

- Manufacture of sulphuric acid by contact process.
- Bleaching of pulp in the paper factory during the manufacture of paper.
- Preservation of tinned food and drinks.
- Refrigeration as a refrigerant.

Making the future tangible

Kidegalize

Knowledge Check 1

Qn.1(UNEB 2006/P1/16)

The gas that changes the colour of acidified potassium dichromate solution orange to green is.

A. ammonia

B. Chlorine

C. carbon dioxide

D. sulphur dioxide

Making the future tangible

Kidegalize

Qn.2(UNEB 2013/P1/30)

Which one of the following is formed when excess sulphur dioxide gas is bubbled through sodium hydroxide solution?

A. Sodium sulphate

B. Sodium sulphite.

C. Sodium hydrogen sulphite.

D. Sodium hydrogen sulphate.

KNET
Making the future tangible

Kidegalize

Qn.3(UNEB 2002/P1/15)

Sulphur dioxide is used in the following ways except in the

A. bleaching of materials such as wool and silk.

B. treating of wool pulp when manufacturing paper.

C. large-scale production of sulphuric acid.

D. manufacture of vulcanised rubber.

Making the future tangible

Kidegalize

Qn.4(UNEB 1995/P1/12)

Sulphur dioxide behaves as an oxidising agent when it reacts with

A. concentrated nitric acid.

B. iron(III) sulphate.

C. hydrogen sulphate.

D. potassium dichromate.

Making the future tangible

Kidegalize

Qn.5(UNEB 2000/P1/13)

Which one of the following reagents is used to test for sulphur dioxide?

A. Chlorine water.

B. Acidified potassium permanganate.

C. Cobalt chloride.

D. An hydrous copper sulphate.

Making the future tangible

Kidegalize

Qn.6(UNEB 1992/P2/11)

(a)Draw a well labeled diagram to show how a dry sample of sulphur dioxide can be prepared in the laboratory.

(b)Write an equation for the reaction that takes place in (a).

Making the future tangible

Kidegalize

(c) Describe a test that can be carried out to confirm the presence of sulphur dioxide.

(d) Excess sulphur dioxide was bubbled through a solution of sodium hydroxide. Write an equation for the reaction that took place.

Making the future tangible

Kidegalize

Qn.7(UNEB 2002/P2/11)

(a)(i) Name one substance that is reacted with hydrochloric acid to produce sulphur dioxide in the laboratory.

(ii) State the conditions for the reaction.

Making the future tangible

Kidegalize

(iii) Name a substance that can be used to dry the sulphur dioxide formed.

(iv)Write equation for the reaction leading to the formation of sulphur dioxide.

KNET
Making the future tangible
Kidegalize

(b) State what would be observed and explain what would happen if sulphur dioxide is passed through a solution containing

(i) acidified potassium dichromate

(ii) a dye.

Making the future tangible

Kidegalize

(c) Briefly describe how sulphur dioxide can be converted to sulphuric acid.

Your answer should include equations and conditions for the reactions(s).

KNET
Making the future tangible

Kidegalize

Qn.7(UNEB 2003/P2/5)

(a) Write an ionic equation to show how sulphur dioxide can be formed from sodium sulphate and hydrochloric acid.

(b)(i)Name one reagent that can be used to test for sulphur dioxide.

(ii) State what would be observed if sulphur dioxide was reacted with the reagent you have named in (b)(i).

KNET
Making the future tangible

Kidegalize

(c) Sulphur dioxide was passed into a beaker containing a red flower and water.

(i) State what was observed.

(ii) Give a reason for your answer in (c)(i).

KNET
Making the future tangible
Kidegalize

Qn.8(UNEB 2014/P2/11)

(a) (i) With the aid of a labeled diagram, explain how a pure dry sample of sulphur dioxide can be prepared in the laboratory using sodium sulphite and sulphuric acid.

(ii) Write an equation for the reaction leading to the formation of sulphur dioxide.

Making the future tangible

Kidegalize

(b) Name one reagent that would be used to confirm the presence of sulphur dioxide and state what would be observed if the reagent you have named was treated with sulphur dioxide.

Making the future tangible

Kidegalize

(c) Write an equation to show the reaction between sulphur dioxide and

(i) water

(ii) oxygen in the presence of hot platinum.

Making the future tangible

Kidegalize

(d) The product of the reaction in c(ii) was mixed with water and barium nitrate solution added to the resultant mixture

(i) State what was observed.

(ii) Explain what took place
(No equation required)

Making the future tangible

Kidegalize

Qn.8(UNEB 2005/P2/9)

(a) Write an equation for the formation of sulphur dioxide from sulphuric acid and sodium sulphite.

(b) Sulphur dioxide was bubbled through an acidified solution of potassium dichromate.

(i) State what was observed.

(ii) Briefly explain your observation in (b)(i).

Making the future tangible

Kidegalize

Qn.9(UNEB 2008/P2/5(a))

(i) Name one substance that when reacted with dilute hydrochloric acid can produce sulphur dioxide.

(ii) State the condition for the reaction.

(iii) Write an ionic equation for the reaction leading to the formation of sulphur dioxide.

Making the future tangible

Kidegalize

Sulphuric acid, H_2SO_4

Manufacture of sulphuric acid by contact process

Sulphur is burned in air to form sulphur dioxide.

$S(s) + O_2(g) \longrightarrow SO_2(g)$

The sulphur dioxide is mixed with air. The mixture is dried and passed over vanadium(V) oxide catalyst heated at 500°C and pressure of 1atm.

Making the future tangible

Kidegalize

The sulphur dioxide is oxidized to sulphur trioxide.

$2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g)$

The sulphur trioxide formed is absorbed into 98% concentrated sulphuric acid forming a fuming sulphuric acid (*oleum*).

$SO_3(g) + H_2SO_4(l) \longrightarrow H_2S_2O_7(l)$

Making the future tangible

Kidegalize

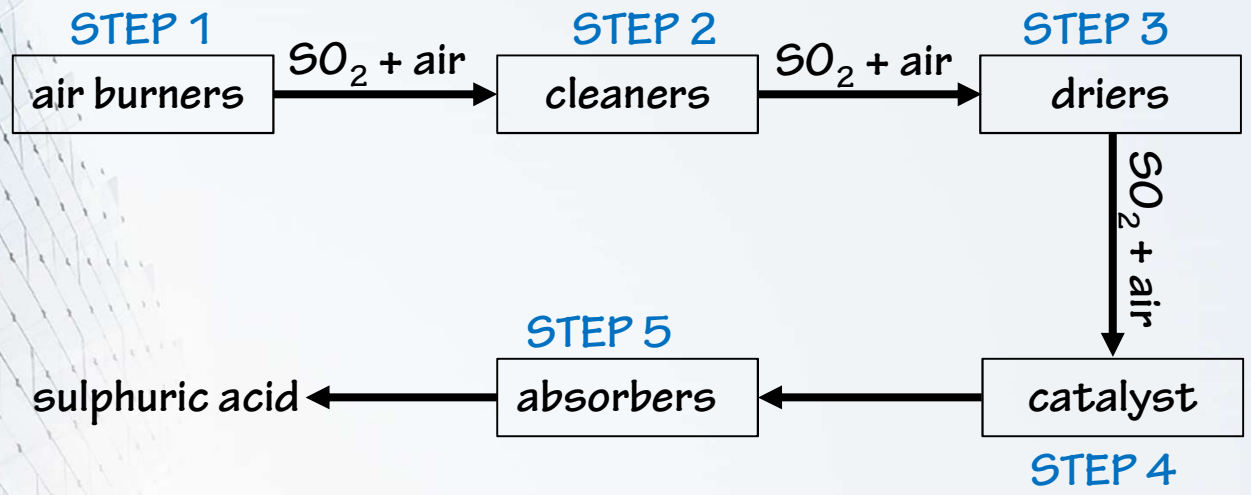
The oleum formed is absorbed, cooled and carefully diluted with water to form sulphuric acid.

$$H_2S_2O_7(l) + H_2O(l) \longrightarrow 2H_2SO_4(aq)$$

Making the future tangible

Kidegalize

The flow diagram for the Contact Process



Making the future tangible

Kidegalize

- **Step 1:** Production of SO_2.
- **Step 2:** Purification/removal of impurities.
- **Step 3:** Drying SO_2-air mixture using concentrated sulphuric acid
- **Step 4:** Passing hot SO_2-air mixture over vanadium(V) oxide catalyst.
- **Step 5:** Absorption of SO_3 in fuming sulphuric acid.

Making the future tangible

Kidegalize

Physical properties

- It is a colorless liquid
- It has sour taste
- Has density of 1.8gcm^{-3}
- Has boiling point of 330^{o}C

KNET
Making the future tangible
Kidegalize

Reactions of sulphuric acid

As a strong acid (dilute H_2SO_4)

- It ionizes completely in solution.

$$H_2SO_4(aq) \longrightarrow 2H^+(aq) + SO_4^{2-}(aq)$$

- It turns blue litmus paper red.
- It reacts with metals to form sulphates and hydrogen gas.

$$Mg(s) + H_2SO_4(aq) \longrightarrow MgSO_4(aq) + H_2(g)$$

- It reacts with carbonates and hydrogencarbonates to form sulphates, water and carbon dioxide gas.

$ZnCO_3(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2O(l) + CO_2(g)$

Remember: When $CaCO_3$, $PbCO_3$ or $BaCO_3$ are mixed with dilute H_2SO_4 a reaction starts but soon stops because the sulphates formed are insoluble.

Making the future tangible

Kidegalize

- **It reacts with oxides and hydroxides to form sulphates and water only.**

$$CuO(s) + H_2SO_4(aq) \longrightarrow CuSO_4(aq) + H_2O(l)$$

$$2NaOH(aq) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O(l)$$

As an oxidizing agent

- Hot concentrated sulphuric acid oxidizes copper(brown solid), carbon and Sulphur to copper(II) sulphate (blue solution), carbon dioxide and Sulphur dioxide respectively.

Making the future tangible

Kidegalize

$$Cu(s) + H_2SO_4(l) \longrightarrow CuSO_4(aq) + 2H_2O(l) + SO_2(g)$$

$$C(s) + H_2SO_4(l) \longrightarrow CO_2(aq) + 2H_2O(l) + 2SO_2(g)$$

$$S(s) + 2H_2SO_4(l) \longrightarrow 2H_2O(l) + 3SO_2(g)$$

Making the future tangible

Kidegalize

As a dehydrating agent

- Concentrated sulphuric acid at 180°C dehydrates alcohols to form alkenes.

$$C_2H_5OH(aq) \xrightarrow{Conc.H_2SO_4} C_2H_4(g) + H_2O(l)$$

Making the future tangible

Kidegalize

- When concentrated sulphuric acid is added to sugar crystals, the white solid turns black and a colorless vapour given off.

$$C_{12}H_{22}O_{11}(s) \xrightarrow{Conc.H_2SO_4} 12C(s) + 11H_2O(g)$$

Making the future tangible

Kidegalize

- When concentrated sulphuric acid is added to hydrated copper(II) sulphate, the blue solid turns white and a colorless vapour given off.

$$CuSO_4.5H_2O(s) \xrightarrow{Conc.H_2SO_4} CuSO_4(s) + 5H_2O(g)$$

Making the future tangible

Kidegalize

- When concentrated sulphuric acid is added to hydrated iron(II) sulphate, the green solid turns white and a colorless vapour given off.

$$FeSO_4.7H_2O(s) \xrightarrow{Conc.H_2SO_4} FeSO_4(s) + 7H_2O(g)$$

Making the future tangible

Kidegalize

Uses of sulphuric acid

Sulphuric acid is used in the manufacture of:

- **fertilizers**
- **drugs**
- **dyes**
- **detergents**
- **plastics**

Making the future tangible

Kidegalize

Remember: When diluting concentrated sulphuric acid, the acid is added to water and continuously stirred.

Making the future tangible

Kidegalize

Knowledge Check 2

Qn.1(UNEB 2001/P1/12)

Which one of the following compounds is used as a catalyst in the manufacture of sulphur trioxide?

A. Alumina.

B. Vanadium(V) oxide.

C. Manganese (IV) oxide

D. Iron powder

Making the future tangible

Kidegalize

Qn.2(UNEB 2007/P1/19)

During the manufacture of sulphuric acid, sulphur trioxide is dissolved in

A. cold water

B. hot water

C. dilute sulphuric acid

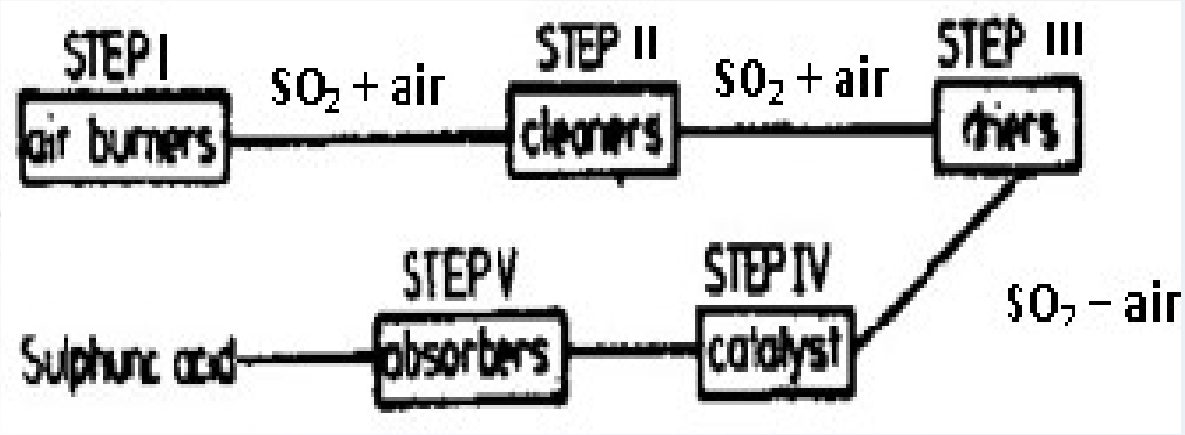
D. concentrated sulphuric acid

Making the future tangible

Kidegalize

Qn.3(UNEB 1996/P2/13)

The following flow chart shows the steps in the manufacture of sulphuric acid by the contact process.



(a) Write an equation for the reaction that takes place in step 1.

(b) Why is step II necessary?

(c) Name

(i) the drying agent in step III,

(ii) the catalyst IV.

(d) Describe the process that takes place in step V.

Making the future tangible

Kidegalize

Qn.4(UNEB 2007/P2/9(b))

During the manufacture of sulphuric acid by the contact process, sulphur dioxide is heated with oxygen in the presence of a catalyst.

(i) Name the catalyst.

(ii) Write the equation for the reaction between sulphur dioxide and oxygen.

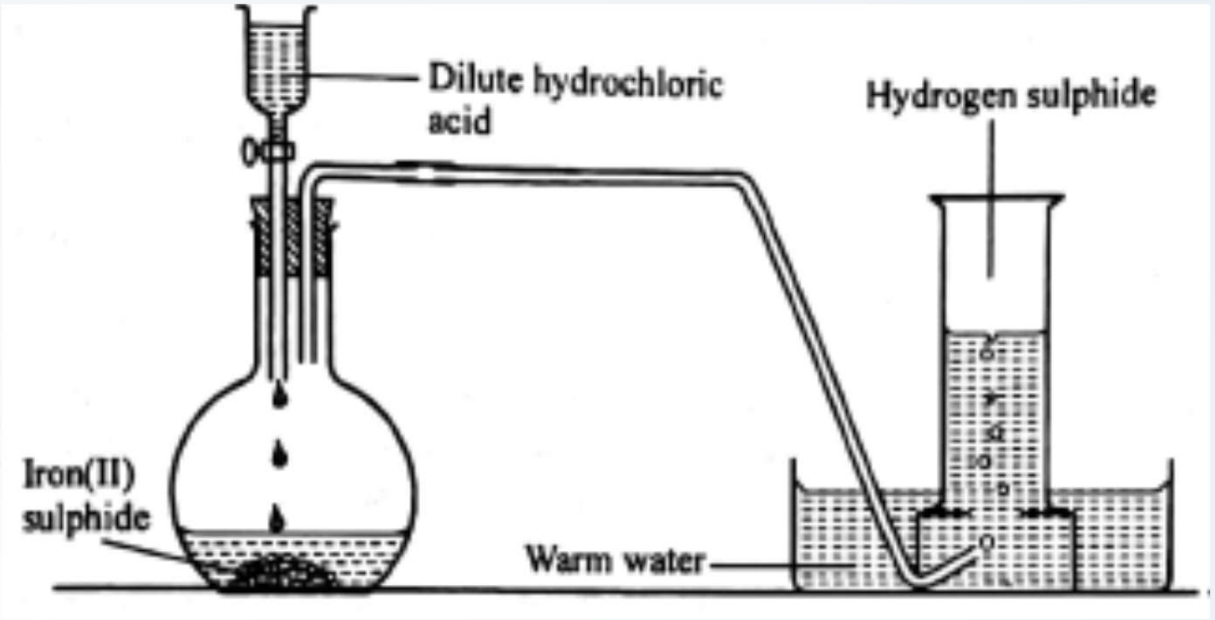
Making the future tangible

Kidegalize

Hydrogen sulphide, H_2S

Preparation of hydrogen sulphide

Set up



Making the future tangible

Kidegalize

Dilute hydrochloric acid from a tap funnel is added to iron(II) sulphide covered with a little water in a flat-bottomed flask fitted with a delivery tube.

Hydrogen sulphide gas is produced according to the equation:

$$FeS(s) + 2HCl(aq) \longrightarrow H_2S(g) + FeCl_2(aq)$$

Making the future tangible

Kidegalize

The gas is collected over warm water because it is soluble in cold water.

Remember

- Concentrated hydrochloric acid or dilute sulphuric acid can be used instead of dilute hydrochloric acid.

Making the future tangible

Kidegalize

- The gas is dried using silicon dioxide or phosphorus pentoxide packed in a u-tube and is collected by downward delivery.

Making the future tangible

Kidegalize

Physical properties

- It is a colorless gas.
- It is slightly denser than air.
- It is slightly soluble in water.
- It has a rotten egg smell.

Making the future tangible

Kidegalize

Chemical properties

- It is an acidic gas and dissolves in water forming weak acidic solution.
- It burns in limited air supply to form Sulphur and water.

$$2H_2S(g) + O_2(g) \longrightarrow 2S(s) + H_2O(l)$$

- It burns in excess air supply to form sulphur dioxide and water.

$$2H_2S(g) + 3O_2(g) \longrightarrow 2SO_2(s) + 2H_2O(l)$$

- Hydrogen sulphide reduces concentrated nitric acid to nitrogen dioxide and itself oxidized to sulphur.

$$2HNO_3(l) + H_2S(g) \longrightarrow 2NO_2(g) + 2H_2O(l) + S(s)$$

Making the future tangible

Kidegalize

- Hydrogen sulphide reacts with concentrated sulphuric acid to form a yellow precipitate.

$H_2SO_4(l) + 3H_2S(g) \longrightarrow 4H_2O(l) + 4S(s)$

- It reduces iron(III) chloride to iron(II) chloride and itself oxidized to Sulphur.

$2FeCl_3(aq) + H_2S(g) \longrightarrow 2FeCl_2(aq) + 2HCl(aq) + S(s)$

- Hydrogen sulphide reduces acidified potassium permanganate (purple) to manganese(II) ions (colorless) and a yellow solid is formed.
- Hydrogen sulphide reduces acidified potassium dichromate(VI) (orange) to chromium(III) ions (green) and a yellow solid is formed.

Making the future tangible

Kidegalize

- Hydrogen sulphide reduces hydrogen peroxide to water and itself oxidized to sulphur.

$H_2S(g) + H_2O_2(aq) \longrightarrow 2H_2O(l) + S(s)$

- Hydrogen sulphide reduces moist Sulphur dioxide to Sulphur (yellow solid)

$2H_2S(aq) + SO_2(g) \longrightarrow 2H_2O(l) + 3S(s)$

- **Hydrogen sulphide reacts with bases as a dibasic acid.**

$2NaOH(aq) + H_2S(g) \longrightarrow Na_2S(aq) + 2H_2O(l)$

- **Hydrogen sulphide reacts with lead(II) nitrate solution to form black precipitate.**

$Pb(NO_3)_2(aq) + H_2S(g) \longrightarrow PbS(s) + 2HNO_3(aq)$

Making the future tangible

Kidegalize

- **Hydrogen sulphide reacts with copper(II) sulphate solution to form dark brown precipitate.**

$$CuSO_4(aq) + H_2S(g) \longrightarrow CuS(s) + H_2SO_4(aq)$$

Making the future tangible

Kidegalize

Knowledge Check 3

Qn.1(UNEB 2008/P2/5(b))

A gas jar containing hydrogen sulphide was inverted over a gas jar containing moist sulphur dioxide.

(i) State what was observed.

(ii) Write an equation for the reaction that took place.

KNET
Making the future tangible

Kidegalize

Qn.2

(a) When dilute hydrochloric acid was added to iron(II) sulphide, a gas W was evolved.

(i) Identify gas W.

(ii) Write an equation for the reaction that took place.

(b) State

(i) how the gas could be identified.

(ii) why the gas is normally prepared in a fume cupboard.

(c) The gas was reacted with sulphur dioxide.

(i) State what was observed.

(ii) Explain your answer in (c)(i).

Making the future tangible

Kidegalize

Qn.3

(a)With a help of diagram, describe how dry hydrogen sulphide can be prepared in the laboratory.

(b) Hydrogen sulphide gas was bubbled into iron(III) chloride solution.

(i) State what was observed.

(ii) Write an equation for the reaction.

(iii) Explain your observation in (i).

Making the future tangible

Kidegalize

Qn.4(UNEB 1989/P1/33)

Which one of the following is formed when hydrogen sulphide is bubbled through hydrogen peroxide?

A. SO_4^{2-}

B. SO_3

C. SO_2

D. S

KNET
Making the future tangible
Kidegalize

Qn.5(UNEB 2006/P2/6)

(a) When dilute hydrochloric acid was added to iron(II) sulphide , a gas was evolved.

Write an equation for the reaction that took place.

(b) State;

(i) how the gas was identified.

(ii) Why the gas is normally prepared in a fume cupboard

or outside the laboratory.

(c) The gas was reacted with sulphur dioxide.

(i) State what was observed.

(ii) Give a reason for your answer in (c)(i).

KNET

Making the future tangible

Kidegalize