Study of Sulphur Compound - Sulphuric Acid

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Solution 1:

Sulphuric acid is found in some of the hot springs.

Solution 2:

The theory of manufacture of sulphuric acid by contact process involves following steps:

i. Production of SO_2: SO_2 is produced by burning sulphur or roasting iron pyrites.

$$S + O_2 \rightarrow SO_2$$

or

$$4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$$

ii. Catalytic oxidation of SO_2 by air to give sulphur trioxide:

$$2SO_2 + O_2 \rightleftharpoons 2SO_3 + \text{Heat}$$

iii. Absorption of sulphur trioxide in 98% sulphuric acid to form oleum :

$$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$$

iv. Dilution of oleum to get sulphuric acid of desired concentration:

$$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$$

Solution 3:

(i) Constant boiling mixture: Mixture which boils without any change in composition is known as constant boiling mixture.

(ii) Hygroscopic substance: The compound which absorbs water vapour from the atmosphere.

(iii) Oleum: Oleum is called pyrosulphuric acid or orthosulphuric acid. Formula is $H_2S_2O_7$

(iv) Dehydrating agent: The compound which has more affinity for water. It removes atoms of hydrogen and oxygen in the form of water from the composition of a substance.

Solution 4:

(a)Products obtained by dissolving sulphur dioxide and chlorine in water are sulphuric acid and hydrochloric acid.

$$SO_2 + 2H_2O + Cl_2 \rightarrow H_2SO_4 + 2HCl$$

(b)Vanadium pentoxide is used as catalyst in contact process.

(c) When SO_3 is dissolved in 98% sulphuric acid it forms oleum.

$$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$$

(d)Zinc is treated with Sulphuric acid it forms Zinc sulphate and hydrogen.

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$$

(e)When ferrous sulphide is treated with sulphuric acid it forms ferrous sulphate and hydrogen sulphide.

$$FeS + H_2SO_4 \rightarrow FeSO_4 + H_2S$$

(f) The precipitate of $PbSO_4$ is formed when lead nitrate is treated with dilute sulphuric acid.

$$Pb(NO_3)_2 + H_2SO_4 \rightarrow PbSO_4 \downarrow + 2HNO_3$$

(g)When $BaCl_2$ is treated with sulphuric acid , precipitate of $BaSO_4$ is formed.

$$BaCl_2 + H_2SO_4 \rightarrow BaSO_4 \downarrow + 2HCl$$

(h) When carbon is treated with hot conc. Sulphuric acid then Water, sulphur dioxide and carbon dioxide are formed.

$$C + 2H_2SO_4 \rightarrow 2H_2O + 2SO_2 + CO_2$$

(i) The property used to prepare HCl and HNO_3 from H_2SO_4 is that Suphuric acid is non-volatile acid .So when treated with salts of more volatile acids and heated, concentrated sulphuric acid displaces the more volatile acids.

$$KCl + H_2SO_4 \xrightarrow{<200^\circ C} KHSO_4 + HCl$$

$$KNO_3 + H_2SO_4 \xrightarrow{<200^\circ C} KHSO_4 + HNO_3$$

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Solution 5:

(i) When water is dissolved in large scale then sulphuric acid is formed.

$$SO_3 + H_2O \rightarrow H_2SO_4$$

(ii) When concentrated sulphuric acid is added to equal volume of cold water it limit down the heat which is released.

(iii) When 100 ml of 98% sulphuric acid is kept in open it absorbs water vapours from atmosphere and its level goes up.

(iv) When hot concentrated sulphuric acid is added to sodium chloride crystals then white dense fumes are seen if a rod dipped in ammonia solution is brought near it.

(v) No visible change is observed.

Solution 6:

(i) In contact process sulphur trioxide formed is dissolved in sulphuric acid and not water because sulphur trioxide when directly dissolved in water gives highly exothermic reaction.

(ii) Sulphur dioxide gets oxidized when exposed to air to form sulphur trioxide which reacts with water vapours to form sulphuric acid.

$$SO_2 + H_2O + O_2 \rightarrow 2H_2SO_4$$

(iii) When water is added to concentrated sulphuric acid the heat evolved may be sufficient to raise the temperature of water to its boiling point. This may throw acid violently out of the container. Thus concentrated sulphuric acid is diluted by adding a small amount of sulphuric acid to large amount of water.

(iv) When concentrated sulphuric acid is exposed to air, it absorbs water vapours from the atmosphere thus increasing its volume and becoming dilute.

(v) Sulphuric acid when reacts with sodium chloride it forms sodium bisulphate and hydrochloric acid because sulphuric acid when treated with salts of more volatile acids displaces the more volatile acid.

$$NaCl + H_2SO_4 \xrightarrow{200^{\circ}C} NaHSO_4 + HCl$$

(vi) When barium chloride is added to dilute sulphuric acid a white precipitate of barium sulphate is

$$BaCl_2 + H_2SO_4 \rightarrow BaSO_4 \downarrow + 2HCl$$

(vii) Hot concentrated sulphuric acid act as a powerful oxidizing agent. Due to heat it decomposes to form nascent oxygen which helps in oxidation of carbon to carbon dioxide.

$$H_2SO_4 \rightarrow H_2O + SO_2 + [O]$$
$$C + 2[O] \rightarrow CO_2$$

(viii) Ammonia gas being basic in nature cannot be dried by using concentrated sulphuric acid.

(viii) Ammonia gas being basic in nature cannot be dried by using concentrated sulphuric acid.

(ix) The carbohydrates contain carbon, hydrogen and oxygen. The hydrogen and oxygen are always in ratio of 2:1 which is absorbed by acid in the form of water, thus leaving carbon behind .This is also called as charring.

(x) Concentrated sulphuric acid should not be added to oxalic acid or formic acid as it removes water and forms Carbon monoxide.Carbon monoxide is harmful for health so this addition must be done in an open laboratory.

(xi) When concentrated sulphuric acid is added to blue crystalline copper sulphate, it removes water from salt and turns it into powdery white.

(xii) Concentrated sulphuric acid must be stored in air tight bottles as it gains water from air and gets slightly diluted thus resulting in increase in volume .

(xiii) Cotton contains cellulose. When cotton is treated with concentrated sulphuric acid it removes water from cotton and carbon is left behind .This way cotton clothes get burnt.

$$(C_6H_{10}O_5)_n \xrightarrow{conc.H_2SO_4} 5(C)_n + 6(H_2O)_n$$

(xiv) As sulphuric acid is non volatile, it is used to prepare volatile acids like HCl and HNO_3 .Thus these acids cannot be used to prepare sulphuric acid.

Solution 7:

(i) Sulphur trioxide to sulphur acid: There is absorption of sulphur trioxide in 98% sulphuric acid to form oleum.

$$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$$

Dilution of oleum to get sulphuric acid of desired concentration.

$$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$$

(ii) Sulphur trioxide to oleum:

Absorption of sulphur trioxide in 98% sulphuric acid to form oleum.

$$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$$

(iii) Dilute sulphuric acid to hydrogen: Dilute sulphuric acid react with metals above hydrogen in the activity series to form sulphate salts and Hydrogen.

$$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$$

(iv) Aqueous barium chloride to barium sulphate: Dilute sulphuric acid when added to the aqueous solution of barium form their insoluble sulphates.

$$BaCl_2 + H_2SO_4 \rightarrow BaSO_4 \downarrow + 2HCl$$

(v) Aqueous lead nitrate to lead sulphate: Dilute sulphuric acid when added to the aqueous solution of lead form their insoluble sulphates.

$$Pb(NO_3)_2 + H_2SO_4 \rightarrow PbSO_4 \downarrow + 2HNO_3$$

(vi) Sodium chloride to hydrogen chloride: Sulphuric acid when reacts with sodium chloride it forms sodium bisulphate and hydrochloric acid because sulphuric acid when treated with salts of more volatile acids displaces more volatile acids.

$$NaCl + H_2SO_4 \xrightarrow{200^0C} NaHSO_4 + HCl$$

(vii) Sucrose to sugar charcoal : Carbohydrates contain carbon ,hydron and oxygen. Thus sulphuric acid removes hydrogen and oxygen in form of water leaving behind carbon.

$$C_{12}H_{22}O_{11} \xrightarrow{Conc\ H_2SO_4} 12C + 11H_2O$$

(viii) Oxalic acid to carbon monoxide: Sulphuric acid is used to remove moisture from oxalic acid.

$$2COOH + H_2SO_4 \rightarrow 2CO + H_2SO_4.H_2O$$

Solution 8:

(i) Concentrated sulphuric acid is non- volatile hence it displaces more volatile acids.

$$NaCl + H_2SO_4 \xrightarrow{200^0C} NaHSO_4 + HCl$$

(ii) Concentrated sulphuric acid act as dehydrating agent as it removes water of crystallization of hydrated salts and renders them anhydrous.

$$CuSO_4.5H_2O \xrightarrow{H_2SO_4} CuSO_4 + 5H_2O$$

(iii) Concentrated sulphuric acid is an oxidizing agent as sulphuric acid decomposes to form nascent oxygen which helps in the oxidation of sulphur and carbon.

$$H_2SO_4 \rightarrow H_2O + SO_2 + [O]$$
$$c + 2[O] \rightarrow CO_2$$

(iv) Concentrated sulphuric acid ionize in two steps . Hence it is dibasic.

$$H_2SO_4 + H_2O \rightleftharpoons HSO_4^- + H_3O^+$$
$$H_2SO_4 + H_2O \rightleftharpoons SO_4^{-2} + H_3O^+$$

Solution 9:

Sulphuric acid is known as king of chemicals because in almost all industries it is used directly or indirectly.

In 8th century it was obtained by distillation of green vitriol ($FeSO_4.7H_2O$). It is called oil of green vitriol because of its oily appearance and because of the fact that it was present in vitreous or glassy substances like ferrous sulphate etc.

Solution 10:

(i) In manufacturing of fertilizers sulphuric acid act as an electrolyte.
(ii) In chemical industry for the manufacturing of hydrochloric acid & nitric acid it acts as a non-volatile acid.
(iii) In petroleum industry sulphuric acid act as oxidizing agent.

Solution 11:

(i) Difference between dilute H_2SO_4 and Conc. H_2SO_4 :

S.No.	Dilute sulphuric acid	Concentrated sulphuric acid
1.	Barium Chloride test: Barium chloride is added to dilute sulphuric acid white ppt.s of barium sulphate is formed. The precipitate is insoluble in dil.hydrochlroic acid or nitric acid. $BaCl_2 + H_2SO_4 \rightarrow BaSO_4 \downarrow + 2HCl$	1. Addition to copper: conc. Sulphuric acid is added to Copper and heated. Sulphur dioxide , which is colourless gas with the smell of burnt sulphur is evolved. $Cu + 2H_2SO_4 \rightarrow CuSO_4 + 2H_2O + SO_2$ SO_2 gas turns $K_2Cr_2O_7$ paper green.
2.	Lead nitrate test: Lead nitrate is added to dil. Sulphuric acid. white ppt. of lead sulphate is formed. The ppt. is insoluble in dil. Hydrochloric acid or nitric acid. $Pb(NO_3)_2 + H_2SO_4 \rightarrow PbSO_4 \downarrow + 2HNO_3$	Addition of common salt: common salt is added to conc. Sulphuric acid. Hydrogen chloride a colourless pungent smelling acidic gas is evolved. Dense white fumes are seen if a rod dipped in ammonia solution is brought near it. $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$

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Solution 1993-1:

Concentrated sulphuric acid absorbs water vapours from the atmosphere .Hence it should be kept in air tight bottles.

Solution 1994-1:

Sulphuric acid when treated with sulphites gives sulphate salts, water and sulphur dioxide gas. Sulphur dioxide turns potassium dichromate solution green.

Thus the negative ion is Sulphite ion.

Solution 1994-2:

Oxalic acid reacts with sulphuric acid to produce carbon monoxide

Solution 1994-3:

(i) The purpose of contact process is to manufacture sulphuric acid.
(ii) Two gases that are combined during contact process are sulphur dioxide and sulphur trioxide.
(iii) Vanadium pentoxide is the catalyst used in the process.
(iv) $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

Solution 1995-4:

When crystals of $CuSO_4.5H_2O$ is placed in concentrated sulphuric acid ,it removes the water of crystallization of hydrated salt and renders them anhydrous. Its colour change to white.

Solution 1995-5:

Balanced equations for the chemical reactions that take place during the conversion of sulphur dioxide to sulphuric acid are:

(i) $2SO_2 + O_2 \rightleftharpoons 2SO_3 + \text{Heat}$
(ii) $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$
(iii) $H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

Vanadium pentoxide is used as a catalyst.

Solution 1995-1:

Two other acids other than sulphuric acid which can be prepared by using sulphuric acid are hydrochloric acid and nitric acid.

Solution 1995-2:

Sulphuric acid is non-volatile. So when it is treated with salts of more volatile acids, and heated, concentrated sulphuric acid displaces the more volatile acids.

Solution 1995-3:

(i) Hydrogen:

$$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$$

(ii) Carbon dioxide

$$Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2$$

(iii) Sulphur dioxide

$$Na_2SO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + SO_2$$

Solution 1996-1:

When barium chloride solution is added to dilute sulphuric acid a white precipitate of barium sulphate is formed. The precipitate is insoluble in dil. Hydrochloric acid.

$$BaCl_2 + H_2SO_4 \rightarrow BaSO_4 \downarrow + 2HCl$$

Solution 1998-1:

Balanced equation for the reaction between iron and dilute sulphuric acid is:

$$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$$

Solution 1998-2:

Oxide of sulphur which reacts with water to give sulphuric acid is sulphur dioxide.

$$SO_2 + 2H_2O + O_2 \rightarrow 2H_2SO_4$$

In the contact process Oxide of sulphur react with sulphuric acid to form Oleum.

$$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$$

Solution 1998-3:

Balanced equations are:

(i) Copper carbonate:

$$CuCO_3 + H_2SO_4 \rightarrow CuSO_4 + H_2O + CO_2$$

(ii) Lead nitrate solution:

$$Pb(NO_3)_2 + H_2SO_4 \rightarrow PbSO_4 \downarrow + 2HNO_3$$

(iii) Zinc hydroxide:

$$Zn(OH)_2 + H_2SO_4 \rightarrow ZnSO_4 + 2H_2O$$

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Solution 1999-1:

Sulphuric acid removes water of crystallization from Hydrated copper sulphate.

Solution 1999-2:

Balanced equation for the reaction between Zinc and dilute sulphuric acid is:

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$$

(i) The purpose of contact process is to manufacture sulphuric acid.
(ii) Vanadium pentoxide is the catalyst used in the contact process.
(iii) Balanced equation for the reaction in the contact process which takes place in the presence of catalyst is :

$$2SO_2 + O_2 \rightleftharpoons 2SO_3 + \text{Heat}$$

Solution 2000-1:

When concentrated sulphuric acid is added to copper sulphate -5water ,its colour change to white.

Solution 2002-1:

Column 1	Column 2	Column 3
Substance reacted with acid	**Dilute or concentrated sulphuric acid**	**Gas**
Metal	Dilute sulphuric acid	Hydrogen
Carbonate	Dilute sulphuric acid	Carbon dioxide
Metal chlorides	Conc. sulphuric acid	Only chlorine

Equations are:

(i) $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

(ii) $Pb(NO_3)_2 + H_2SO_4 \rightarrow PbSO_4 \downarrow + 2HNO_3$

Solution 2003-1:

Hot concentrated nitric acid oxidizes sulphur directly into sulphuric acid.

$$S + 6HNO_3 \xrightarrow{\Delta} H_2SO_4 + 6NO_2 + 2H_2O$$

The name of the process by which sulphuric acid is manufactured is contact process.

Vanadium pentoxide is the catalyst used during the process.

Solution 2003-2:

Less volatile.

Solution 2003-3:

Equations:

(i) $Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$

(ii) $Cu + H_2SO_4 \rightarrow CuSO_4 + H_2$

(iii) $Pb(NO_3)_2 + H_2SO_4 \rightarrow PbSO_4 \downarrow + 2HNO_3$

(iv) $Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2$

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Solution 2004-1:

(i) C=Vanadium pentoxide is the catalyst which helps in the conversion of sulphur dioxide to sulphur trioxide.

(ii) D involves the following two steps:

a) $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$

b) $H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

(iii) In stepE, Dilute sulphuric acid will help in the liberation of sulphur dioxide from sulphites.

(iv) This is the reaction by which sulphur dioxide is converted to sodium sulphite in step F

$2\,NaOH + SO_2 \rightarrow Na_2SO_3 + H_2O$

Solution 2005-3:

Balanced equation :

$KHCO_3 + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O + 2CO_2$

Solution 2005-2:

(i) B

(ii) C

(iii) A

Solution 2006-1:

(a) Contact process is used for the large scale manufacture of sulphuric acid.

(b) Sulphuric acid has great affinity for water hence it is used as dehydrating agent.

(c) As an oxidizing agent:

$H_2SO_4 \rightarrow H_2O + SO_2 + [O]$

$C + 2[O] \rightarrow CO_2$

As a non-volatile acid:

$NaCl + H_2SO_4 \xrightarrow{200^{\circ}C} NaHSO_4 + HCl$

Solution 2007-1:

$Pb(NO_3)_2 + H_2SO_4 \rightarrow PbSO_4 \downarrow + 2HNO_3$ $Cu + 2H_2SO_4 \rightarrow CuSO_4 + 2H_2O + SO_2$ $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

Solution 2007-2:

(a) B
(b) D
(c) C
(d) A
(e) A

Solution 2007-3:

(a) HCl has higher boiling point where as sulphuric acid has lower boiling point.
(b) When barium chloride is added to dilute sulphuric acid, white precipitate of barium sulphate is formed but with dilute hydrochloric acid no change is observed.

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Solution 2008-1:

Lead nitrate

Solution 2008-2:

(i) Zinc, Dilute sulphuric
$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

(ii) Sodium sulphite, Dilute sulphuric acid
$NaSO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + SO_2$

(iii) Sodium carbonate, Dilute sulphuric acid
$Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2$

(iv) Zinc, calcium carbonate, dilute sulphuric acid
$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$
$ZnSO_4 + CuCO_3 \longrightarrow ZnCO_3 + CuSO_4$

Solution 2009-1:

Hydrogen chloride is a colourless pungent acidic gas produced by the action of concentrated sulphuric acid on sodium chloride.