1. Sulfuric acid is produced by the Contact process. The steps of the Contact process are shown.



1. Sulfur is a common starting material for the Contact process.

Name a source of sulfur.

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1. Describe **step 2**, giving reaction conditions and a chemical equation. Reference to reaction rate and yield is not required.

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1. **Step 3** involves adding sulfur trioxide to concentrated sulfuric acid to form oleum.

Complete the chemical equation for this reaction.



1. Dilute sulfuric acid is a typical acid.

A student adds excess dilute sulfuric acid to a sample of solid copper(II) carbonate in a

test-tube.

1. Give **three** observations the student would make.

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1. Give the **names** of all products formed

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1. Concentrated sulfuric acid has different properties to dilute sulfuric acid.

When concentrated sulfuric acid is added to glucose, C6H12O6, steam is given off and a black

solid is formed.

1. Name the black solid.

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1. What type of reaction has occurred?

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 [Total: 12]

1. Sulfuric acid is made by the Contact process.
2. Sulfur is burned by spraying droplets of molten sulfur into air.

Suggest and explain an advantage of using this method.

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1. The following equation represents the equilibrium in the Contact process



Oxygen is supplied from the air.

The composition of the reaction mixture is 1 volume of sulfur dioxide to 1 volume of oxygen.

What volume of air contains 1 dm3 of oxygen?

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1. Sulfur dioxide is more expensive than air.

What is the advantage of using an excess of air?

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1. The forward reaction is exothermic. The reaction is usually carried out at a temperature between 400 and 450 °C.
2. What is the effect on the position of equilibrium of using a temperature above 450C?

 Explain your answer.

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1. What is the effect on the rate of using a temperature below 400C?

Explain your answer.

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1. A low pressure, 2 atmospheres, is used. At equilibrium, about 98% SO3 is present.

What is the effect on the position of equilibrium of using a higher pressure?

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Explain why a higher pressure is **not** used.

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1. Name the catalyst used in the Contact process.

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1. Describe how concentrated sulfuric acid is made from sulfur trioxide.

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[Total: 15]

1. The main use of sulfur dioxide is the manufacture of sulfuric acid.
2. State **two** other uses of sulfur dioxide.

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1. One source of sulfur dioxide is burning sulfur in air.

Describe how sulfur dioxide can be made from the ore zinc sulﬁde.

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1. The Contact process changes sulfur dioxide into sulfur trioxide.



1. What is the formula of vanadium(V) oxide?

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1. Vanadium(V) oxide is an efﬁcient catalyst at any temperature in the range 400 to 450C.

Scientists are looking for an alternative catalyst which is efﬁcient at 300C.

What would be the advantage of using a lower temperature?

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1. The process does not use a high pressure because of the extra expense.

Suggest **two** advantages of using a high pressure?

Explain your suggestions.

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1. Sulfuric acid is made by dissolving sulfur trioxide in concentrated sulfuric acid to form oleum.

Water is reacted with oleum to form more sulfuric acid.

Why is sulfur trioxide not reacted directly with water?

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[Total: 12]

1. Sulfuric acid is an important acid, both in the laboratory and in industry.

Sulfuric acid is manufactured in the Contact Process. Originally, it was made by heating metal

sulfates and by burning a mixture of sulfur and potassium nitrate.

1. Give a major use of sulfuric acid.

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1. A group of naturally occurring minerals have the formula of the type FeSO4.xH2O where x is 1,4, 5, 6 or 7. The most common of these minerals is iron(II) sulfate-7-water.

When this mineral is heated gently it dehydrates



1. Describe how you could show that this reaction is reversible.

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1. When the iron(II) sulfate is heated strongly, further decomposition occurs.



The gases formed in this reaction react with water and oxygen to form sulfuric acid.

Explain how the sulfuric acid is formed.

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1. A mineral of the type FeSO4.xH2O contains 37.2% of water.

Complete the calculation to determine x.

mass of one mole of H2O = 18 g

mass of water in 100 g of FeSO4.xH2O = 37.2 g

number of moles of H2O in 100 g of FeSO4.xH2O = .................

mass of FeSO4 in 100 g of FeSO4.xH2O = ................. g

mass of one mole of FeSO4 = 152 g

number of moles of FeSO4 in 100 g of FeSO4.xH2O = .................

x = .................

 [4]

1. When a mixture of sulfur and potassium nitrate is burned and the products are dissolved in water, sulfuric acid is formed

The sulfuric acid formed by this method is not pure. It contains another acid.

Deduce the identity of this acid.

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1. The heat causes some of the potassium nitrate to decompose.

Write the equation for the action of heat on potassium nitrate.

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 [Total: 12]

1. A major ore of zinc is zinc blende, ZnS. A by-product of the extraction of zinc from this ore is sulfur dioxide which is used to make sulfuric acid
2. Zinc blende is heated in air. Zinc oxide and sulfur dioxide are formed. Write the

balanced equation for this reaction.

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1. Zinc oxide is reduced to zinc by heating with carbon. Name **two** other reagents

which could reduce zinc oxide.

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1. The zinc obtained is impure. It is a mixture of metals. Explain **how** fractional distillation

could separate this mixture.

zinc bp = 908C, cadmium bp = 765C, lead bp = 1751C

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Sulfur dioxide is used to make sulfur trioxide in the Contact Process



The forward reaction is exothermic. The conditions used are:

temperature: 450C

pressure: 2 atmospheres

catalyst: vanadium(V) oxide

1. Explain, mentioning both position of equilibrium and rate, why these conditions give the

most economic yield.

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[Total: 10]

1. Sulphuric acid is made by the Contact process in the following sequence of reactions.



1. How is sulphur dioxide made from sulphur?

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1. Sulphur dioxide has other uses.

Why is it used in the manufacture of paper?

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1. How does it preserve food?

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1. The equation for a stage of the Contact process is



The percentage of sulphur trioxide in the equilibrium mixture varies with temperature.



1. How does the percentage of sulphur trioxide in the equilibrium mixture vary as the

temperature increases? Circle the correct answer.

Increases Stays Same Decreases



1. Explain, mentioning both rate and percentage yield, why the temperature used in

the Contact process is 450°C.

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1. Describe how the sulphur trioxide is changed into concentrated sulphuric acid.

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