

The Manufacture of Sulphuric Acid

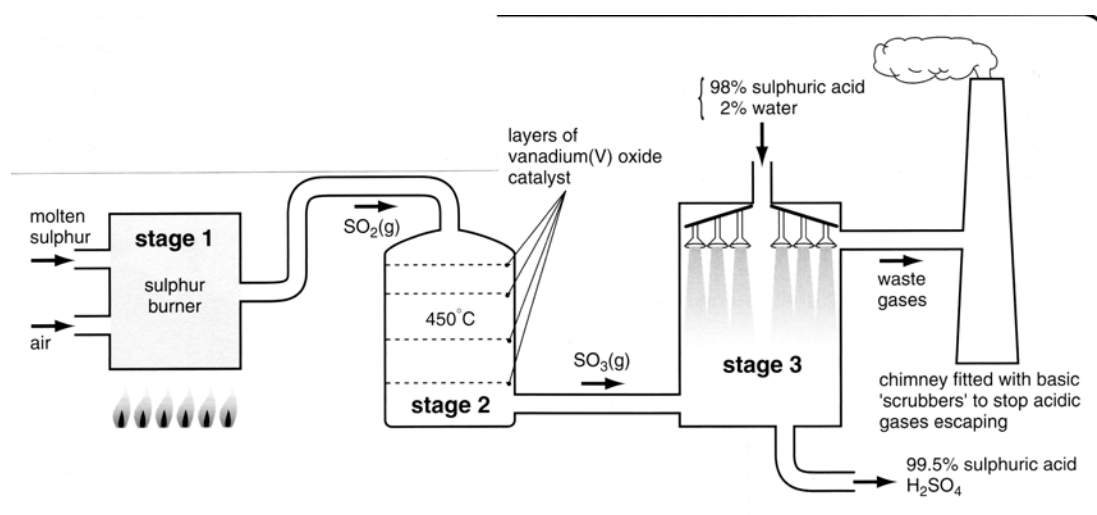


Introduction

It was once said that a country's wealth could be measured by its production of sulphuric acid (H_2SO_4). That may no longer be true, but the acid is still used in the manufacture of paints, fertilizers, plastics, fabrics, dyes, detergents, and many other useful products. In this unit you can find out how we make the acid in industry.

The Contact process

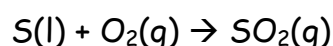
The most important process for making sulphuric acid in industry is the Contact process. We can think of the Contact process as involving three stages. Look at the process shown in below:



Stage 1

Sulphur is imported from Poland or the USA. We can also obtain sulphur from the impurities in fossil fuels such as coal. In the first stage of the process, sulphur is burned in air to make sulphur dioxide gas:

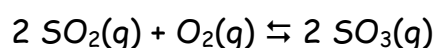
Sulphur + oxygen → sulphur dioxide



Stage 2

In the next stage, we convert the sulphur dioxide to sulphur trioxide:

Sulphur dioxide + oxygen ⇌ sulphur trioxide

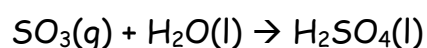


The reaction happens on a catalyst of vanadium(V) oxide to speed up the reaction. As much sulphur dioxide as possible is changed into sulphur trioxide, and releases of sulphur dioxide are prevented because it is a gas that causes acid rain.

Stage 3

In the final stage, the sulphur trioxide is converted into sulphuric acid. The sulphur trioxide gas is absorbed into very concentrated sulphuric acid (a 98 per cent solution of H_2SO_4 in water), producing a thick fuming liquid called oleum. The oleum is mixed carefully with water, and the sulphur trioxide in the oleum reacts with the water as follows:

Sulphur trioxide + water → sulphuric acid



You may wonder why the sulphur trioxide is not mixed directly with pure water. The problem is that this is a highly exothermic reaction, which would produce a fine mist of sulphuric acid that is difficult to condense and could escape to pollute the air.

Q: Which step in the Contact process involves a reversible reaction?

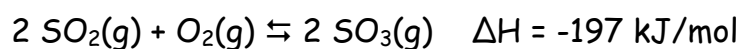
- Burning sulphur
- Changing sulphur dioxide into sulphur trioxide
- Changing sulphur trioxide into sulphuric acid

Q: Why are there strict limitations set on the release of sulphur dioxide gas into the air as a waste product from the process?

- It causes global warming.
- It causes acid rain.

Conditions in the Contact process

Look at the reversible reaction in which sulphur dioxide is converted into sulphur trioxide:



The forward reaction is exothermic (gives out heat), so the formation of sulphur trioxide will be favoured by low temperatures. However, the vanadium(V) oxide catalyst will not work below 400 °C, so the reaction is conducted at 450 °C to increase the rate of reaction. You still get an excellent yield of sulphur trioxide (97 per cent) at this temperature, and at a reasonable rate with the help of the catalyst.

The forward reaction is also favoured by high pressures. But with a yield of about 95 per cent anyway, it's not worth spending more money to compress the reacting gases. The pressure used is just enough to move the gases through the plant.

Q: Decide whether the following statements about the conversion of sulphur dioxide to sulphur trioxide are true or false.

You get a higher yield of sulphur trioxide at equilibrium with a low temperature. True/False

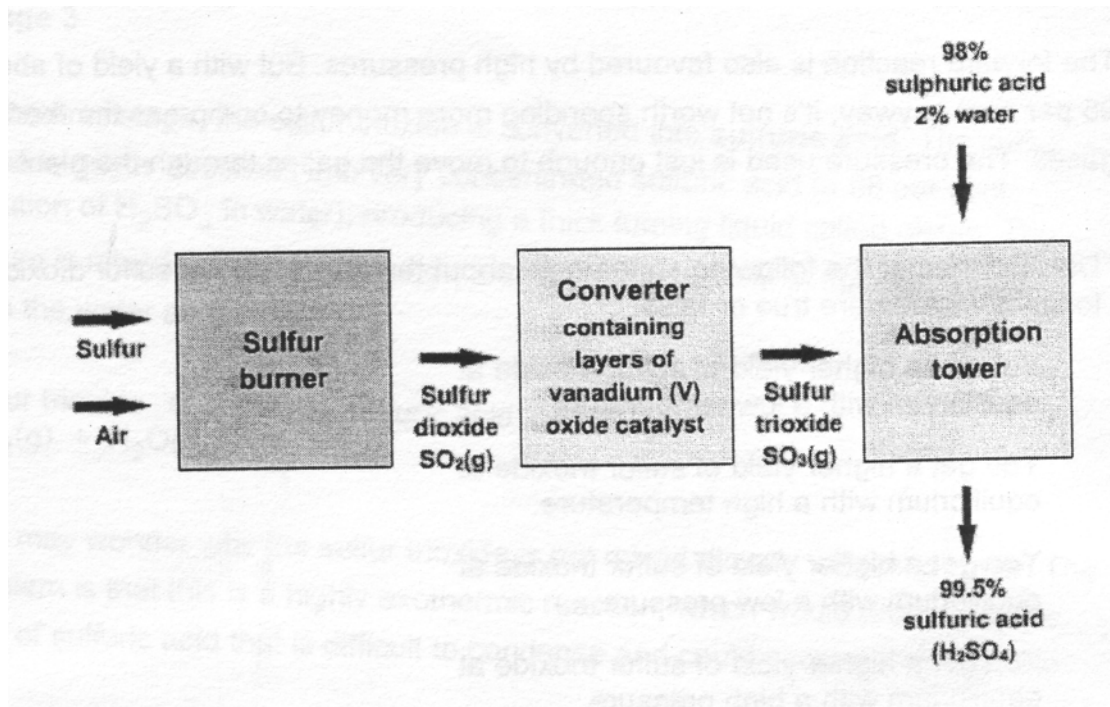
You get a higher yield of sulphur trioxide at equilibrium with a high temperature. True/False

You get a higher yield of sulphur trioxide at equilibrium with a low pressure. True/False

You get a higher yield of sulphur trioxide at equilibrium with a high pressure. True/False

Summary

Sulphuric acid is manufactured in the Contact process. First, sulphur is burned in air to give sulphur dioxide. Then sulphur dioxide is mixed with more air to yield sulphur trioxide in a reversible reaction. A compromise temperature of 450 °C is chosen to speed up the reaction. The gases pass through layers of vanadium(V) oxide catalyst which also increase the rate of reaction. Finally, sulphur trioxide is mixed with a mixture of 98 per cent solution of sulphuric acid to form an even more concentrated form of sulphuric acid (99.5 per cent).



Exercises

1. What is the formula of sulphuric acid?

HSO_3

HSO_4

H_2SO_4

H_2S

2. Which element is burned in the first stage of the manufacture of sulphuric acid?

Hydrogen

Sulphur

Vanadium

3. What is the name of the catalyst used in the Contact process?

Iron

Iron(III) oxide

Vanadium(V) oxide

4. What temperature is chosen for the Contact process?

150°C

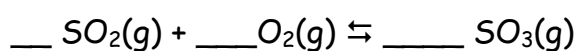
250 °C

350 °C

450 °C

550 °C

5. Insert the same number in both boxes to balance the equation below. :



6. In the Contact process, the final stage involves dissolving the sulphur trioxide in ...

pure water.

98 per cent sulphuric acid solution.

vanadium(V) oxide.

7. Does the catalyst used in the Contact process increase the percentage of sulphur trioxide formed?

Yes

No

8. Explain the temperature used in the Contact process.