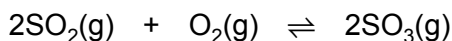


1 Sulfuric acid is made by the Contact process.

(a) 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 dm<sup>3</sup> of oxygen?

..... [1]

(b) Sulfur dioxide is more expensive than air.

What is the advantage of using an excess of air?

.....  
..... [2]

(c) The forward reaction is exothermic. The reaction is usually carried out at a temperature between 400 and 450 °C.

(i) What is the effect on the position of equilibrium of using a temperature above 450 °C?  
Explain your answer.

.....  
.....  
..... [2]

(ii) What is the effect on the rate of using a temperature below 400 °C?  
Explain your answer.

.....  
.....  
..... [3]

(d) A low pressure, 2 atmospheres, is used. At equilibrium, about 98% SO<sub>3</sub> is present.

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

..... [1]

**(ii)** Explain why a higher pressure is **not** used.

..... [1]

[Total: 10]

**2** Sulfuric acid is made by the Contact process.

Describe how concentrated sulfuric acid is made from sulfur trioxide.

.....  
.....  
.....  
.....

[2]

[Total: 2]

**3** Sulfuric acid is made by the Contact process.

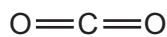
Name the catalyst used in the Contact process.

..... [1]

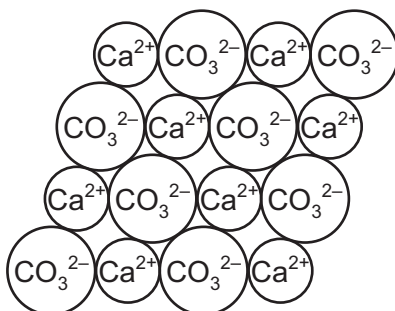
[Total: 1]

4 The structures of six substances containing carbon are shown below.

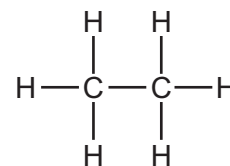
A



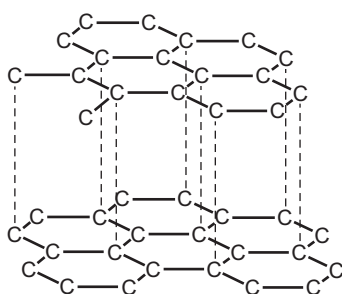
B



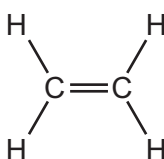
C



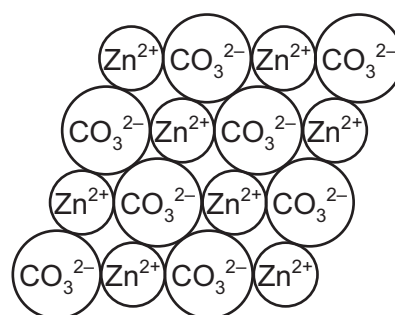
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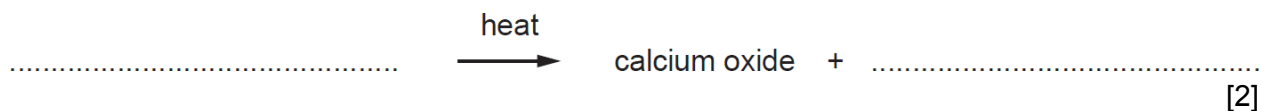
E



F



Complete the word equation for the thermal decomposition of substance **B**.



[Total: 2]

5 Sulfur is used in the manufacture of sulfur dioxide and sulfuric acid.

Give **one** different use of sulfur dioxide.

..... [1]

[Total: 1]

6 Name **one** source of sulfur.

..... [1]

[Total: 1]

- 7 Answer the following question using only the substances in the list.

ammonia      bauxite      carbon dioxide      carbon monoxide  
 hematite      oxygen      sodium chloride      sulfur dioxide

State which substance is used to bleach wood pulp.

..... [1]

[Total: 1]

- 8 The following are the symbols and formulae of some elements and compounds.

Ar Ca(OH)<sub>2</sub> Cl<sub>2</sub> CO<sub>2</sub> Cu Fe SO<sub>2</sub> V<sub>2</sub>O<sub>5</sub>

State which element or compound in the list is used as a food preservative.

..... [1]

[Total: 1]

- 9 The following are the symbols and formulae of some elements and compounds.

Ar Ca(OH)<sub>2</sub> Cl<sub>2</sub> CO<sub>2</sub> Cu Fe SO<sub>2</sub> V<sub>2</sub>O<sub>5</sub>

State which element or compound in the list is used as a catalyst in the Contact process.

..... [1]

[Total: 1]

- 10 This question is about the elements in Period 3 of the Periodic Table.

Na	Mg	Al	Si	P	S	Cl	Ar
----	----	----	----	---	---	----	----

State which Period 3 element forms **two** different oxides during the Contact process.

..... [1]

[Total: 1]

- 11 Preservatives stop the growth of bacteria and fungi.

State the name of an acidic gas used to preserve food.

..... [1]

[Total: 1]

12 Which statement about sulfuric acid is correct?

- A It is made by the Haber process.
- B It is made in the atmosphere by the action of lightning.
- C It reacts with ammonia to produce a fertiliser.
- D It reacts with copper metal to produce hydrogen gas.

[1]

[Total: 1]

13 Give **one** source and **one** use of sulfur.

source .....

use ..... [2]

[Total: 2]

14 The ions present in ammonium sulfate are formed from the products of the Contact and Haber processes.

Both of these processes involve the use of a catalyst.

Which row is correct?

	ion	formed from	process	catalyst
<b>A</b>	ammonium	ammonia	Contact	iron
<b>B</b>	ammonium	ammonia	Haber	vanadium(V) oxide
<b>C</b>	sulfate	sulfuric acid	Contact	vanadium(V) oxide
<b>D</b>	sulfate	sulfuric acid	Haber	iron

[1]

[Total: 1]

15 The Contact process is used for the manufacture of sulfuric acid.

Which statement about this process is **not** correct?

- A A catalyst of iron is used.
- B Oxygen from the air is used to react with sulfur dioxide.
- C Sulfur trioxide dissolves in sulfuric acid to form oleum.
- D The temperature used is around 450 °C.

[1]

[Total: 1]

16 This question is about sulfur and its compounds.

(a) Name the acid manufactured from sulfur.

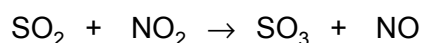
..... [1]

(b) When fossil fuels containing sulfur are burned, sulfur dioxide is formed.  
Sulfur dioxide contributes to acid rain.

Give **one** harmful effect of acid rain on buildings.

..... [1]

(c) Sulfur dioxide is oxidised by nitrogen dioxide in the atmosphere to form sulfur trioxide.



How does this equation show that sulfur dioxide is oxidised?

.....

..... [1]

[Total: 3]

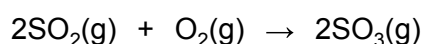
17 Which row shows the conditions used in the manufacture of sulfuric acid by the Contact process?

	temperature /°C	pressure /atm	catalyst
<b>A</b>	40	200	Fe
<b>B</b>	40	200	V <sub>2</sub> O <sub>5</sub>
<b>C</b>	400	2	Fe
<b>D</b>	400	2	V <sub>2</sub> O <sub>5</sub>

[1]

[Total: 1]

18 The equation for an exothermic reaction in the Contact process is shown.



Which effects do increasing the temperature and using a catalyst have on the rate of formation of sulfur trioxide, SO<sub>3</sub>?

	increasing the temperature	using a catalyst
<b>A</b>	rate decreases	rate decreases
<b>B</b>	rate decreases	rate increases
<b>C</b>	rate increases	rate decreases
<b>D</b>	rate increases	rate increases

[1]

[Total: 1]

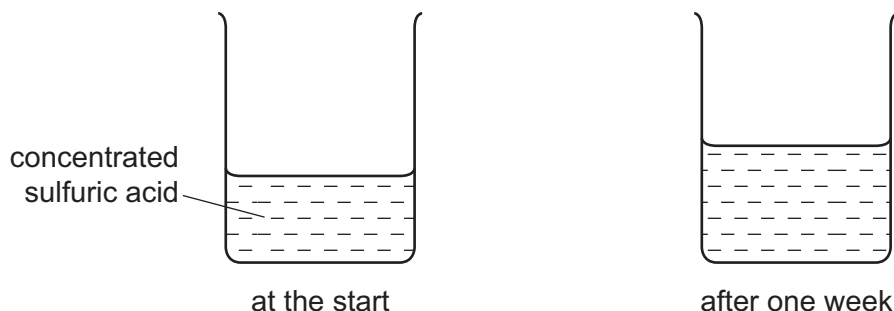
19 What is a property of concentrated sulfuric acid but **not** of dilute sulfuric acid?

- A** It is a dehydrating agent.
- B** It neutralises alkalis.
- C** It produces a white precipitate with barium nitrate.
- D** It reacts with metals to give a salt and hydrogen.

[1]

[Total: 1]

- 20** Clean air contains mainly nitrogen, noble gases, oxygen and water vapour.  
A teacher left a beaker of concentrated sulfuric acid open to the air for a week.  
After a week, the concentration of sulfuric acid in the beaker had decreased.



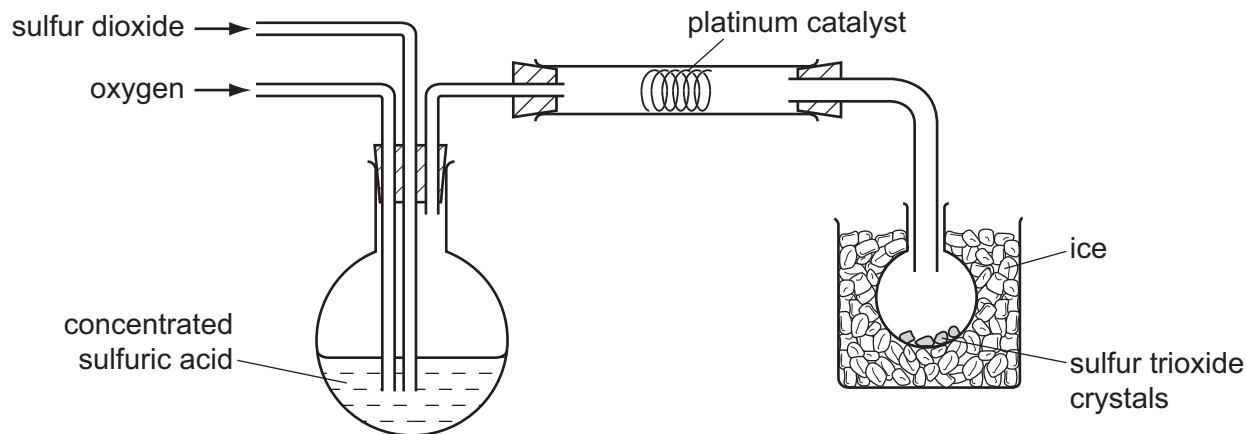
Explain these results by referring to one or more of the substances present in the air.

.....  
 .....

[1]

[Total: 1]

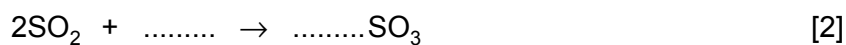
- 21** Sulfur dioxide reacts with oxygen to form sulfur trioxide.  
Sulfur trioxide can be made in the laboratory using the apparatus shown below.  
Sulfur trioxide has a melting point of 17 °C and a boiling point of 45 °C.



- (a)** What is the purpose of the platinum catalyst?

..... [1]

- (b)** Complete the symbol equation for the reaction.





(c) Suggest why the sulfur trioxide is collected in a flask surrounded by ice.

..... [1]

[Total: 4]

**22** 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?

..... [1]

[Total: 1]

**23** The main use of sulfur dioxide is the manufacture of sulfuric acid.

State **two** other uses of sulfur dioxide.

.....

..... [2]

[Total: 2]

**24** One source of sulfur dioxide is burning sulfur in air. Describe how sulfur dioxide can be made from the ore zinc sulfide.

.....

..... [2]

[Total: 2]

**25** 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.

Give a major use of sulfuric acid.

..... [1]

[Total: 1]

**26** The manufacture of sulfuric acid by the Contact process occurs in four stages.

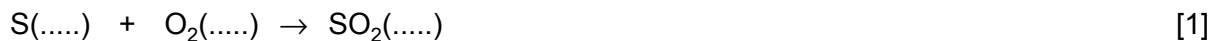
**stage 1** Molten sulfur is burned in air to produce sulfur dioxide gas.

**stage 2** Sulfur dioxide is reacted with oxygen to form sulfur trioxide.

**stage 3** Sulfur trioxide is combined with concentrated sulfuric acid to form oleum,  $\text{H}_2\text{S}_2\text{O}_7$ .

**stage 4** Oleum is added to water to form sulfuric acid.

(a) Complete the chemical equation for **stage 1** by adding the appropriate state symbols.



(b) Name the catalyst used in **stage 2** and state the temperature used.

catalyst .....

temperature ..... °C [2]

(c) Write chemical equations for the reactions in **stage 3** and **stage 4**.

**stage 3** .....

**stage 4** ..... [2]

[Total: 5]

**27** Ammonia is a base and reacts with sulfuric acid to form the salt, ammonium sulfate.

(a) What is meant by the term *base*?

..... [1]

(b) Name the industrial process used to manufacture sulfuric acid.

..... [1]

(c) Write a chemical equation for the reaction between ammonia and sulfuric acid.

..... [2]

[Total: 4]

**28** When concentrated sulfuric acid is added to glucose,  $\text{C}_6\text{H}_{12}\text{O}_6$ , a black solid is produced. The concentrated sulfuric acid acts as a dehydrating agent.

(a) What is removed from the glucose in this reaction?

..... [1]

(b) Name the black solid produced in this reaction.

..... [1]

[Total: 2]

**29** Sulfuric acid is made industrially by a four-step process.



(b) State the conditions and name the catalyst used in this reversible reaction.

temperature .....

pressure .....

catalyst ..... [3]

(c) Describe how the sulfur trioxide formed is converted into sulfuric acid in the next steps of the Contact process.

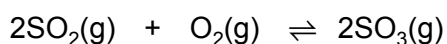
.....

.....

..... [2]

[Total: 7]

31 The Contact process changes sulfur dioxide into sulfur trioxide.



the forward reaction is exothermic

temperature 400 to 450 °C

low pressure 1 to 10 atmospheres

catalyst vanadium(V) oxide

(a) What is the formula of vanadium(V) oxide?

..... [1]

(b) 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?

.....

.....

..... [2]

- (c) The process does not use a high pressure because of the extra expense. Suggest **two** advantages of using a high pressure? Explain your suggestions.

.....  
.....  
.....  
.....  
.....

[4]

[Total: 7]

- 32 The main ore of zinc is zinc blende, ZnS.

- (a) The ore is heated in the presence of air to form zinc oxide and sulfur dioxide. Write the equation for this reaction.

.....  
.....

[2]

- (b) Give a major use of sulfur dioxide.

.....  
.....

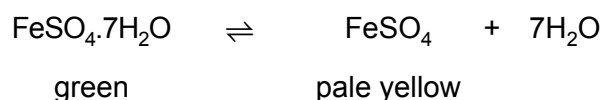
[1]

[Total: 3]

- 33 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.

A group of naturally occurring minerals have the formula of the type  $\text{FeSO}_4 \cdot x\text{H}_2\text{O}$  where x is 1, 4, 5, 6 or 7. The most common of these minerals is iron(II) sulfate-7-water.

- (a) When this mineral is heated gently it dehydrates.



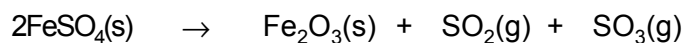
Describe how you could show that this reaction is reversible.

.....

.....

..... [2]

- (b) 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.

.....

..... [2]

- (c) A mineral of the type  $\text{FeSO}_4 \cdot x\text{H}_2\text{O}$  contains 37.2% of water. Complete the calculation to determine x.

mass of one mole of  $\text{H}_2\text{O}$  = 18 g

mass of water in 100 g of  $\text{FeSO}_4 \cdot x\text{H}_2\text{O}$  = 37.2 g

number of moles of  $\text{H}_2\text{O}$  in 100 g of  $\text{FeSO}_4 \cdot x\text{H}_2\text{O}$  = .....

mass of  $\text{FeSO}_4$  in 100 g of  $\text{FeSO}_4 \cdot x\text{H}_2\text{O}$  = ..... g

mass of one mole of  $\text{FeSO}_4$  = 152 g

number of moles of  $\text{FeSO}_4$  in 100 g of  $\text{FeSO}_4 \cdot x\text{H}_2\text{O}$  = .....

x = .....

[4]

[Total: 8]