Reversible reactions & Industrial Processes C3

Question	Maximum Mark	Mark Awarded
1	6	
2	8	
3	6	
4	5	
5	10	
6	7	
7	10	
8	8	
9	7	
10	10	
11	6	
12	6	
13	8	
14	10	
15	8	
16	10	
17	9	
Total Mark		

1. Describe the benefits of the use of nitrogenous fertilisers and the problems that arise when they are washed into rivers. [6 QWC]

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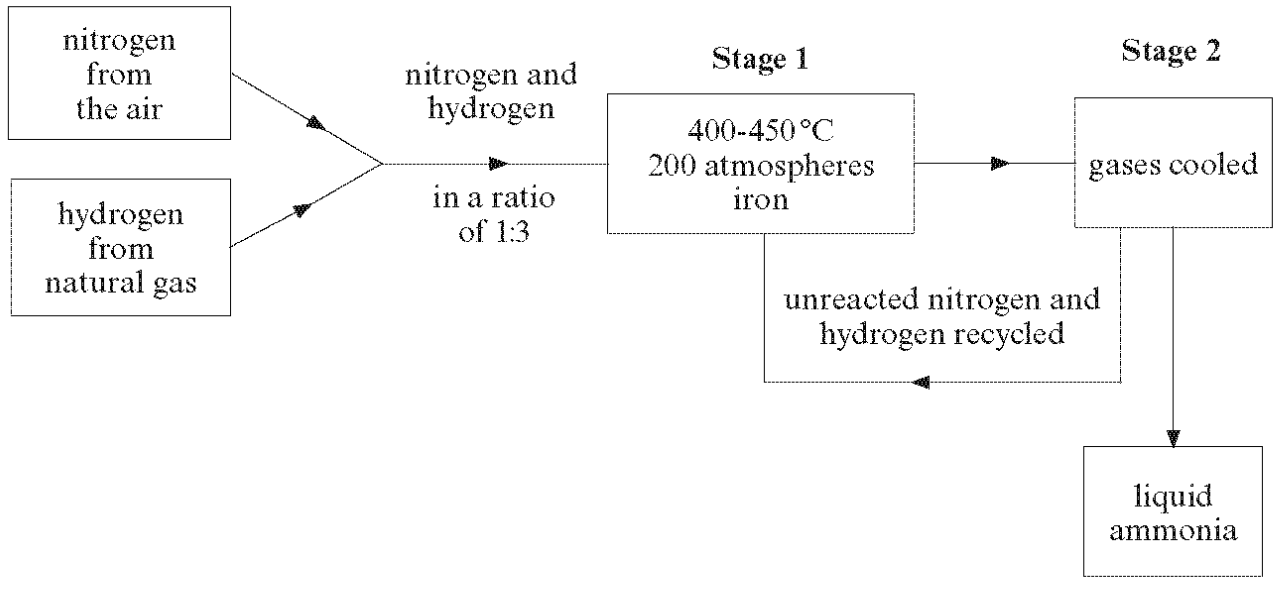
2. *(a)* The flow diagram below outlines the manufacture of ammonia by the Haber process.



(i) Name the **two** *raw materials* used in the Haber process. [1]

..... and .....

(ii) Balance the **symbol** equation for the production of ammonia. [1]

$$N_2 + \square\ H_2 \rightleftharpoons \square\ NH_3$$

(iii) State why iron is added in **stage 1**. [1]

.....

(iv) Give the reason why gases are cooled in **stage 2**. [1]

.....

(v) Suggest a reason why recycling unreacted nitrogen and hydrogen saves money. [1]

.....

(b) One of the main uses of ammonia is in the production of nitrogenous fertilisers.

ammonium chloride	**ammonium nitrate**
ammonium phosphate	**ammonium sulfate**

Choose from the box above the fertiliser which is made by reacting ammonia with nitric acid. [1]

.....

(c) The box below contains some statements relating to the use of nitrogenous fertilisers.

causes overgrowth of plants in canals	**increases crop yield**	**pollutes water supplies**
releases land for building houses	**increases soil acidity**	

Choose the **main** [2]

(i) benefit to farmers, ...

(ii) problem for farmers. .....

8

3. Describe the benefits of the use of nitrogenous fertilisers and the problems that arise when they are washed into rivers. [6 QWC]

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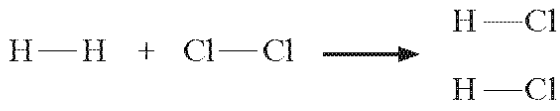
4. The reaction between hydrogen and chlorine to give hydrogen chloride can be represented by the following equation.



The relative amounts of energy needed to break the bonds shown are given in the table below.

Bond	Amount of energy needed to break the bond (kJ)
H—H	436
Cl—Cl	242
H—Cl	431

NOTE: *The amount of energy* ***released*** *in making a bond is equal and opposite to that* ***needed*** *to break the bond.*

(a) Using the bond energy values in the table, calculate

(i) the relative energy needed to break all the bonds in the **reactants**, [2]

.....

.....

(ii) the relative energy given out when all the bonds in the **product** are formed. [2]

.....

.....

(b) Using your answers to part *(a)*, state whether the reaction between hydrogen and chlorine is exothermic or endothermic and give a reason for your answer. [1]

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5

5.

(a) Sulfuric acid is produced by the contact process. The main stages in the process are shown below.

Stage 1: Burning sulfur in air to produce gas **A**

Stage 2: Passing gas **A** over a catalyst at 450 °C to produce gas **B**

Stage 3: Dissolving gas **B** in concentrated sulfuric acid to produce oleum

Stage 4: Diluting oleum to produce sulfuric acid

(i) Give the names of gases **A** and **B**. [2]

Gas **A** .....

Gas **B** .....

(ii) Which stage involves a reversible reaction? ..... [1]

(iii) Give a reason why gas **B** is not dissolved directly in water during stage 3. [1]

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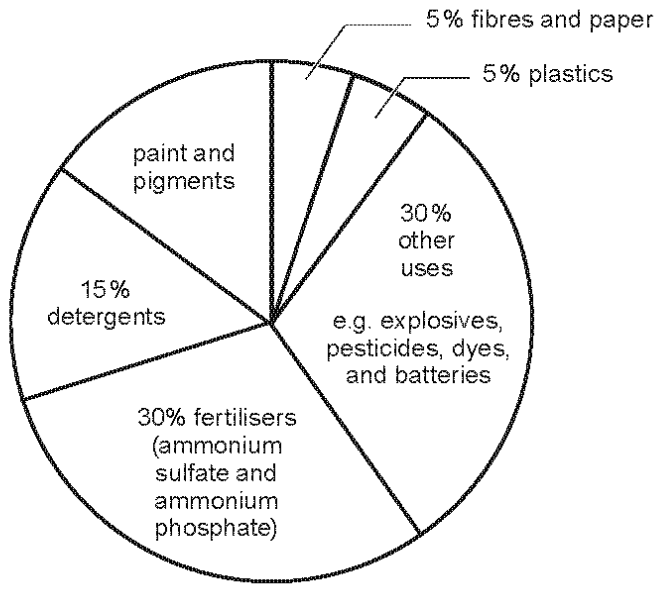
(b) The following pie chart shows the uses of sulfuric acid.



(i) Calculate the percentage of sulfuric acid used for making paint and pigments. [2]

Percentage used for making paint and pigments = ... %

(ii) One important use of sulfuric acid is in the production of fertilisers. Complete the following **word** equation for the production of ammonium sulfate. [1]

sulfuric acid + ... ⟶ ammonium sulfate

(iii) This type of fertiliser can be washed into rivers. Explain why this is a cause for concern. [3]

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6. Ammonia is manufactured from nitrogen and hydrogen using the Haber process.

(a) The equation below shows the formation of ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(i) State the numbers of nitrogen atoms and hydrogen atoms on the **left** hand side of the equation. Use these numbers to show that the equation is balanced. [2]

Number of nitrogen atoms ..... *Number of hydrogen atoms* .....

.....

(ii) Give the meaning of (g) in the equation. [1]

.....

(b) The box below shows some of the conditions and terms used when describing the Haber process.

ammonia	**hydrogen**	**450 °C**	**iron**	**cooling**
nitrogen	**reversible**	**200 atmospheres**		**recycling**

(i) Choose from the box

I. the process used to remove the product from the reaction mixture, [1]

.....

II. the method used to reduce the waste of reactants. [1]

.....

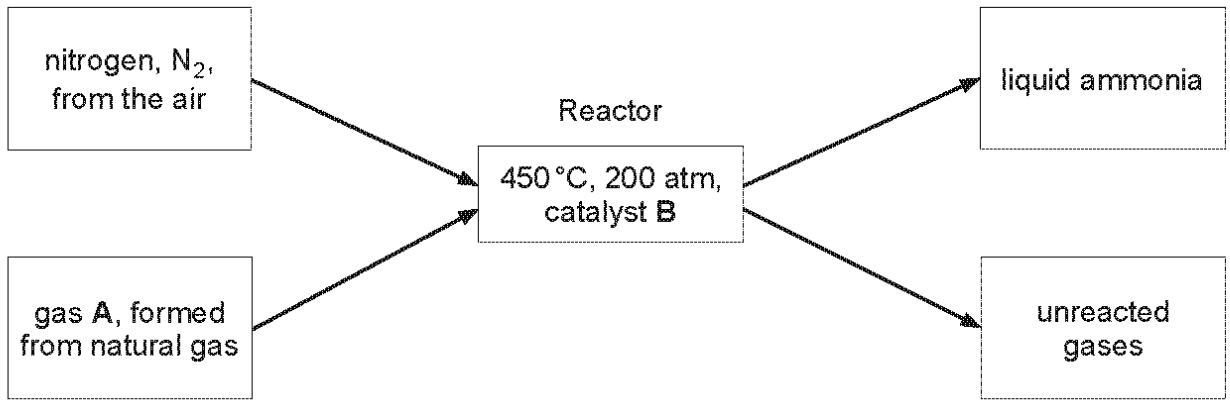
(ii) Choose from the box the catalyst used in the reaction. State the purpose of a catalyst. [2]

Catalyst .....

Purpose .....

7

7. Ammonia is produced during the Haber process. The reaction is summarised in the diagram below.



(a) Give the name of gas **A**. ..... [1]

(b) Name catalyst **B** and state why it is used. [2]

.....

.....

(c) The yield of ammonia is only 28 % therefore 72 % of the gases remain unreacted.

Describe what happens to these unreacted gases and state why this is important. [2]

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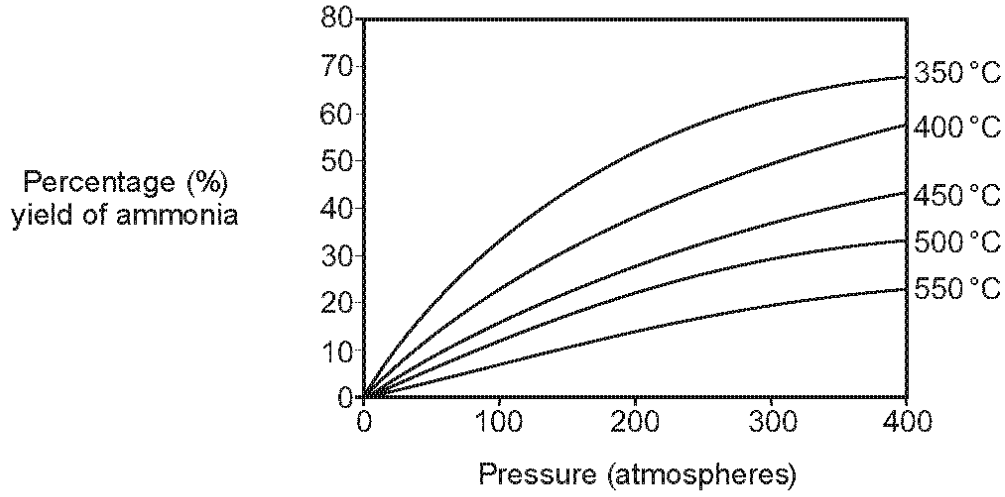
(d) The following graph shows the effect of temperature and pressure on the yield of ammonia during the Haber process.



Describe how the yield of ammonia varies with temperature and pressure. [2]

Temperature

.....

.....

Pressure

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.....

(e) Write a balanced **symbol** equation for the production of ammonia. [3]

..... + ... ⇌ .....

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8.

(a) Ammonia is made industrially from nitrogen and hydrogen by the Haber process.

The table below shows the yield of ammonia under different pressure and temperature conditions.

Pressure (atmospheres)	Temperature (°C)				
	100	200	300	400	500
	Yield of ammonia (%)				
10	88.2	50.7	14.7	3.9	1.2
50	94.5	75.0	39.5	15.3	5.6
100	96.7	81.7	52.5	25.2	10.6
200	98.4	89.0	66.7	40.0	18.3
400	99.4	94.6	79.7	55.4	31.9
1000	99.9	98.3	92.6	79.8	57.5

(i) Using **only** the data in the table suggest the conditions that should be chosen for the process. [1]

Pressure ..... atmospheres *Temperature* ..... °C

(ii) Give the disadvantage of using a low temperature in the process and state how this problem is overcome. [2]

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(iii) The actual pressure used in the process is 200 atmospheres. Apart from safety issues, suggest a disadvantage of using a higher pressure. [1]

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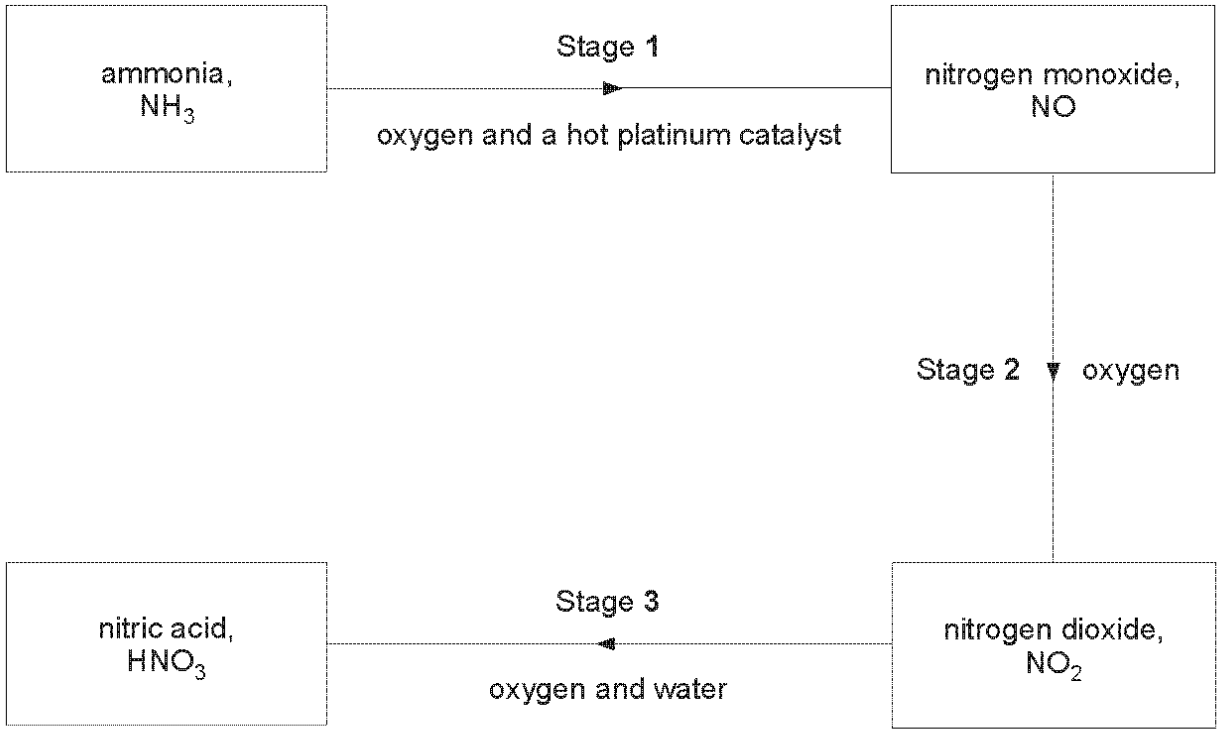
(b) Ammonia is used to form nitric acid in a three-stage reaction.



(i) Once the reaction in stage **1** has started there is sufficient heat to maintain the reaction. Give the term used to describe a reaction that produces heat. [1]

.....

(ii) Balance the symbol equation below that represents the reaction taking place in stage **3**. [1]

$$\square\ NO_2 + O_2 + 2H_2O \longrightarrow \square\ HNO_3$$

(iii) Write a balanced symbol equation for the reaction that occurs when nitric acid is added to copper(II) carbonate. [2]

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8

9. *(a)* Sodium reacts with oxygen to give sodium oxide.

(i) Using the electronic structures below, draw dot and cross diagrams to show the transfer of electrons and the formation of ions that occur as sodium oxide is formed. [3]

sodium 2,8,1 oxygen 2,6

(ii) Give the **electronic structure** of the sodium and oxide **ions**. [1]

	Electronic structure
sodium ion	
oxide ion	

(b) Name the **type of structure** present in ammonia, NH_3, and explain why ammonia has a low melting point. [3]

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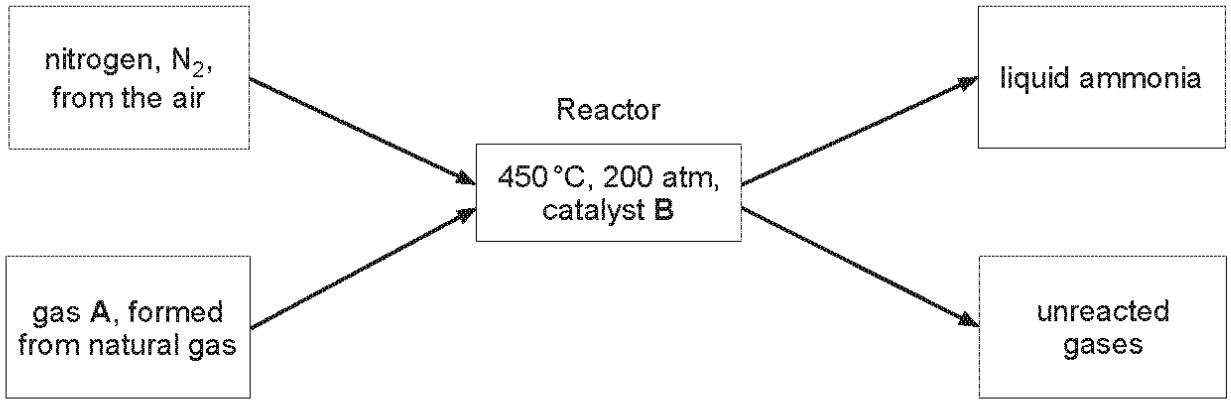
10. Ammonia is produced during the Haber process. The reaction is summarised in the diagram below.



(a) Give the name of gas **A**. ..... [1]

(b) Name catalyst **B** and state why it is used. [2]

.....

.....

(c) The yield of ammonia is only 28 % therefore 72 % of the gases remain unreacted.

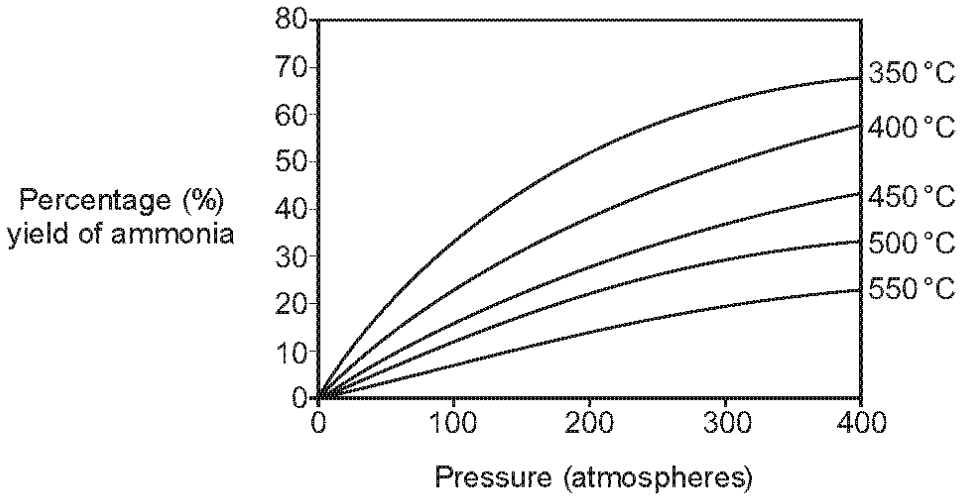
Describe what happens to these unreacted gases and state why this is important. [2]

.....

.....

.....

(d) The following graph shows the effect of temperature and pressure on the yield of ammonia during the Haber process.



Describe how the yield of ammonia varies with temperature and pressure. [2]

Temperature

.....

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Pressure

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.....

(e) Write a balanced **symbol** equation for the production of ammonia. [3]

..... + ... ⇌ .....

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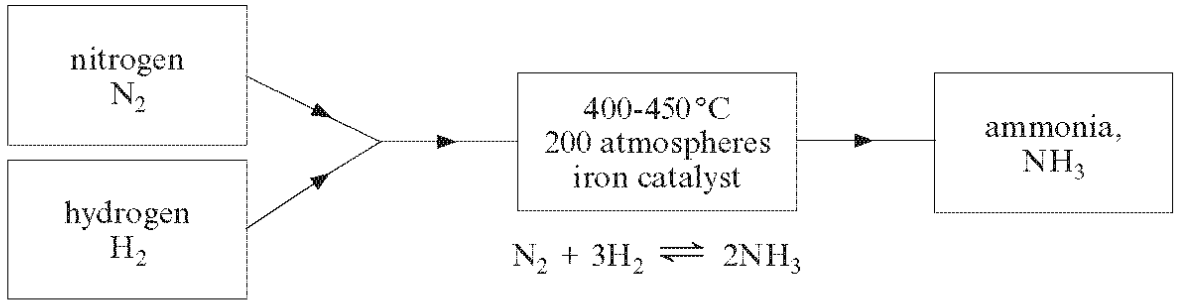
11. The diagram and equation below outline the manufacture of ammonia by the Haber process.



Explain the choice of temperature and pressure used in the process and why it is necessary to use a catalyst. [6 QWC]

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12. Sulfuric acid is produced in industry by the contact process.

(a) The contact process involves four stages. The first two are shown below.

Stage 1 sulfur + oxygen $\longrightarrow$ sulfur dioxide

Stage 2 sulfur dioxide + oxygen $\rightleftharpoons$ sulfur trioxide

(i) Name the **raw material** that provides oxygen in stage 1. [1]

.....

(ii) Describe the last two stages in the contact process (stages 3 and 4). [2]

Stage 3 .....

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Stage 4 .....

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(iii) Name the catalyst used in stage 2. [1]

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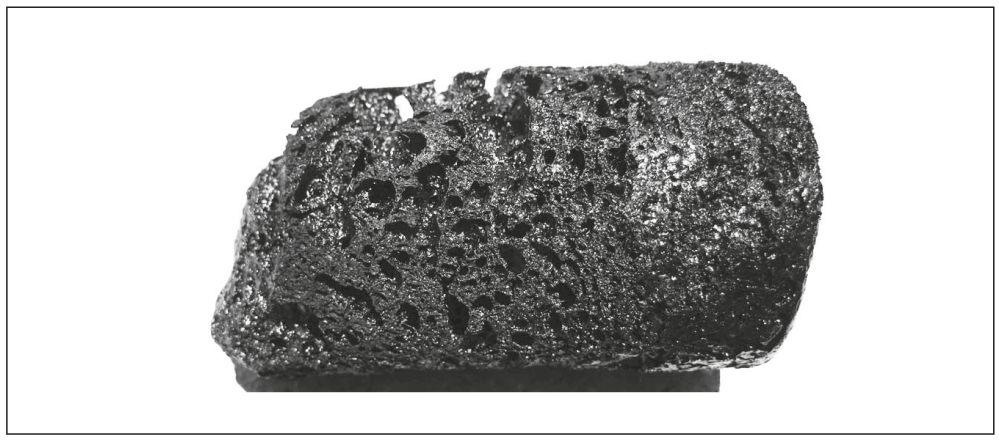
(b) When concentrated sulfuric acid is added to sugar a black solid is formed.



In terms of the elements present in sugar, describe what happens during this reaction. [2]

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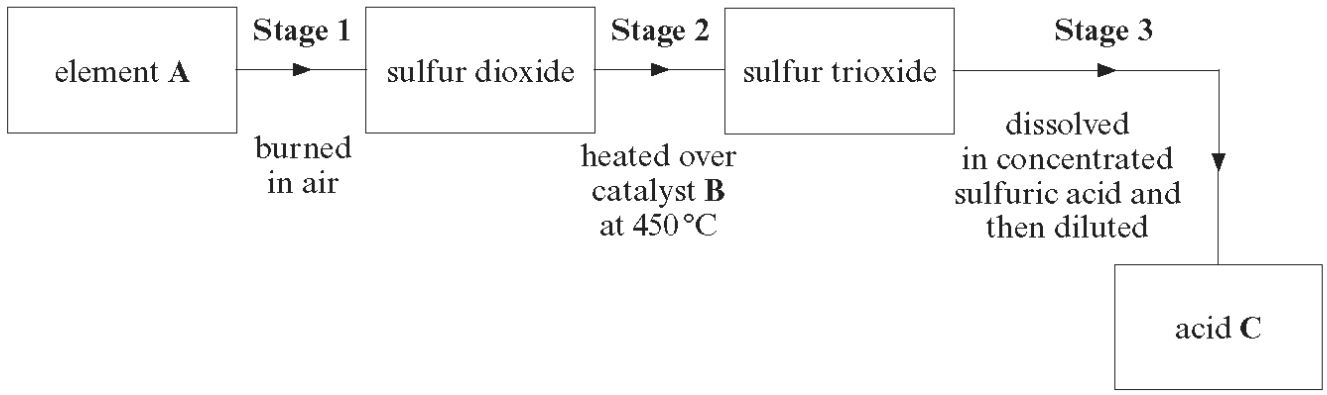
13.

(a) The flow diagram below shows the stages in the Contact Process.



(i) Give the name of

I element **A**, ... [1]

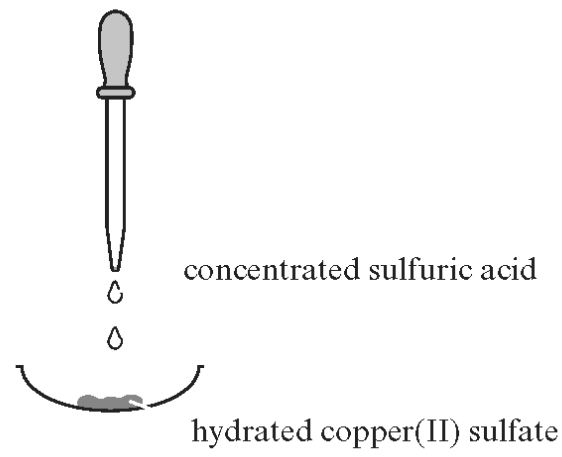
II catalyst **B**, ... [1]

III acid **C**. ..... [1]

(ii) Write a **balanced symbol** equation for the formation of sulfur trioxide, in **stage 2**. [3]

..... + ... ⇌ .....

(b) A few drops of concentrated sulfuric acid were added to some crystals of hydrated copper(II) sulfate, $CuSO_4.5H_2O$.



Describe **two** changes in the appearance of copper(II) sulfate as it is dehydrated. [2]

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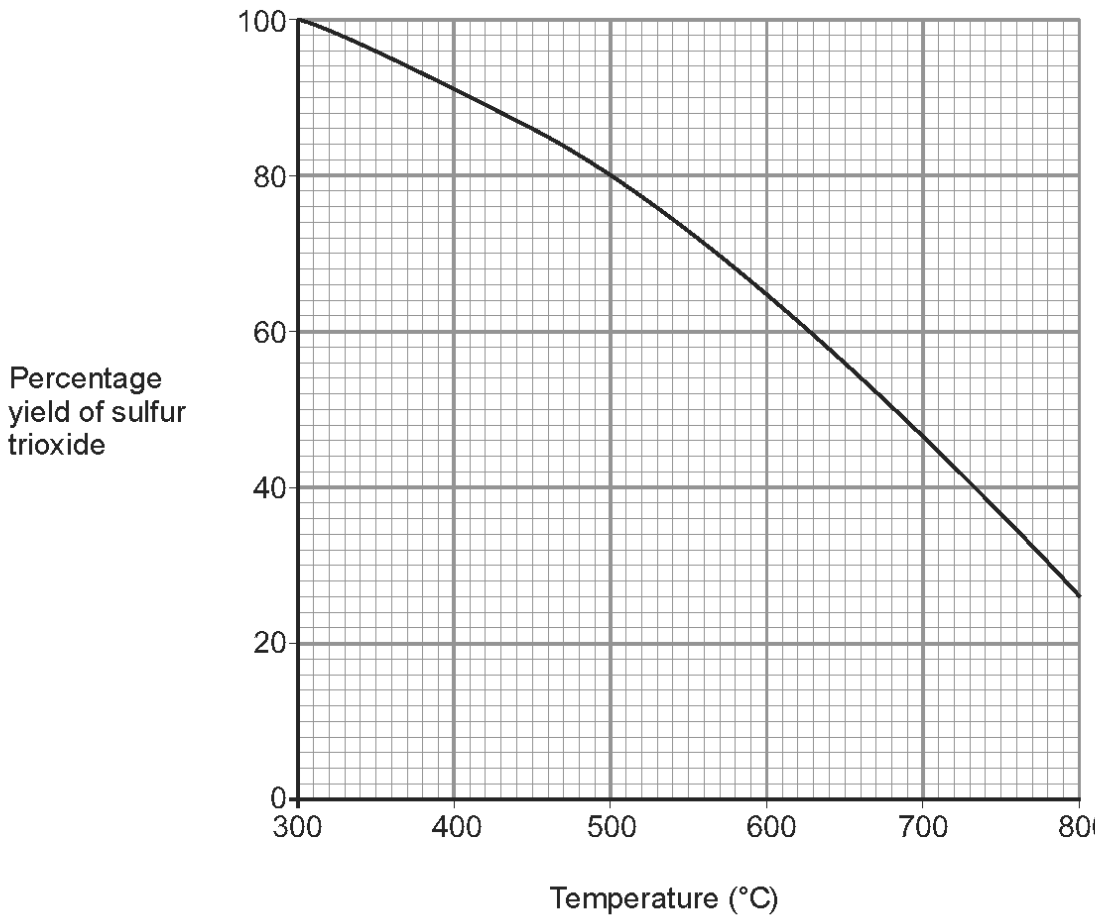
14. *(a)* One of the main stages in the manufacture of sulfuric acid is the reaction between sulfur dioxide and oxygen to form sulfur trioxide.

(i) Write the balanced **symbol** equation which represents this reaction. [3]

..... + ... ⇌ .....

(ii) The graph below shows how the percentage yield of sulfur trioxide changes with temperature between 300 °C and 800 °C.



Use the graph to find the increase in percentage yield if the temperature is reduced from 650 °C to 450 °C. [2]

Increase in percentage yield = ... %

(iii) One molecule of sulfur trioxide reacts with one molecule of sulfuric acid to form one molecule of oleum as the **only** product.

Write a balanced **symbol** equation for this reaction. [2]

..... + ... ⟶ .....

(b) State what you would observe when a few drops of concentrated sulfuric acid are added to a beaker containing a small amount of sugar. Name the product left in the beaker. [3]

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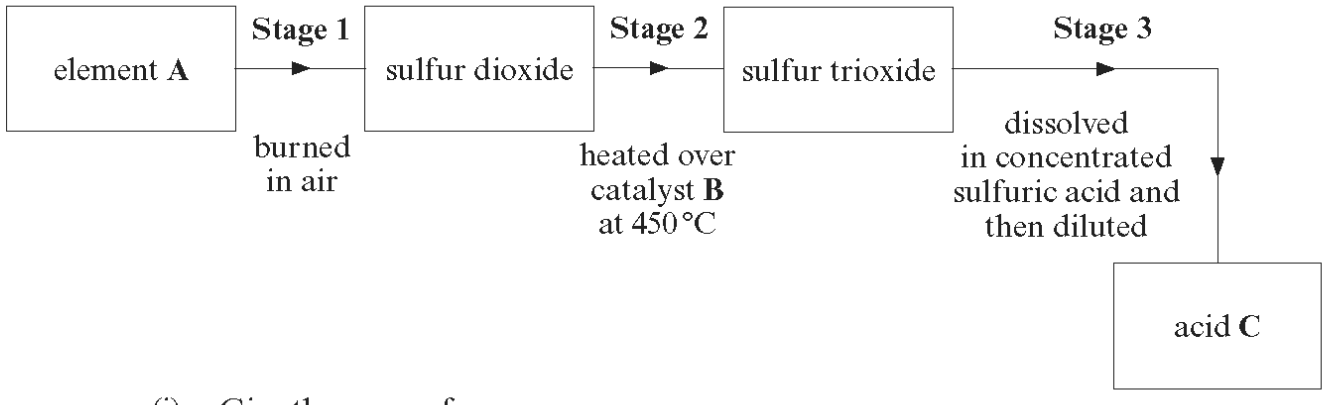
15. *(a)* The flow diagram below shows the stages in the Contact Process.



(i) Give the name of

I element **A**, ... [1]

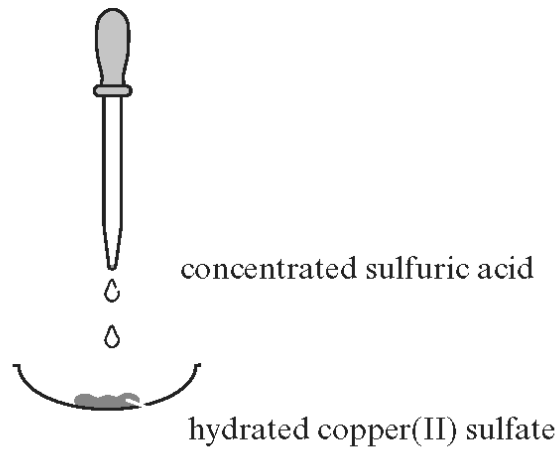
II catalyst **B**, ... [1]

III acid **C**. ..... [1]

(ii) Write a **balanced symbol** equation for the formation of sulfur trioxide, in **stage 2**. [3]

..... + ... ⇌ .....

(b) A few drops of concentrated sulfuric acid were added to some crystals of hydrated copper(II) sulfate, $CuSO_4.5H_2O$.



Describe **two** changes in the appearance of copper(II) sulfate as it is dehydrated. [2]

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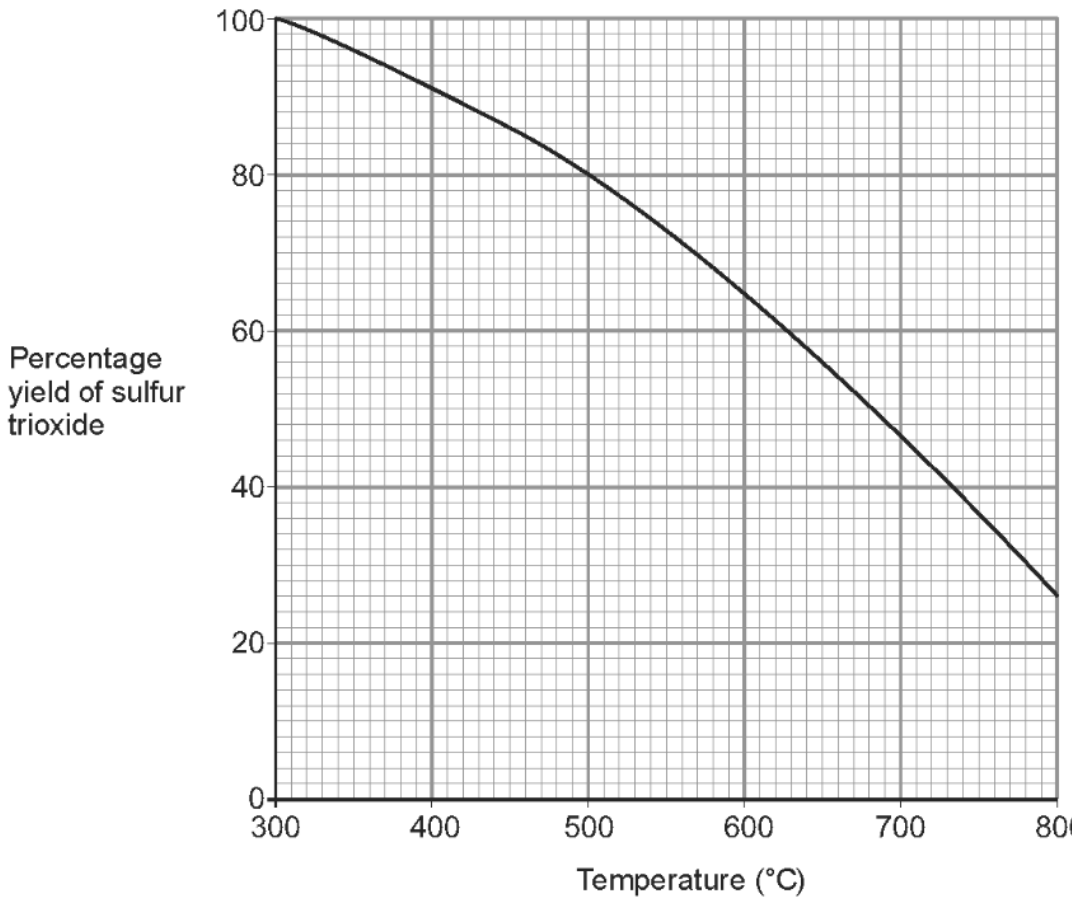
8

16. *(a)* One of the main stages in the manufacture of sulfuric acid is the reaction between sulfur dioxide and oxygen to form sulfur trioxide.

(i) Write the balanced **symbol** equation which represents this reaction. [3]

..... + ... ⇌ .....

(ii) The graph below shows how the percentage yield of sulfur trioxide changes with temperature between 300 °C and 800 °C.



Use the graph to find the increase in percentage yield if the temperature is reduced from 650 °C to 450 °C. [2]

Increase in percentage yield = ... %

(iii) One molecule of sulfur trioxide reacts with one molecule of sulfuric acid to form one molecule of oleum as the **only** product.

Write a balanced **symbol** equation for this reaction. [2]

..... + ... ⟶ .....

(b) State what you would observe when a few drops of concentrated sulfuric acid are added to a beaker containing a small amount of sugar. Name the product left in the beaker. [3]

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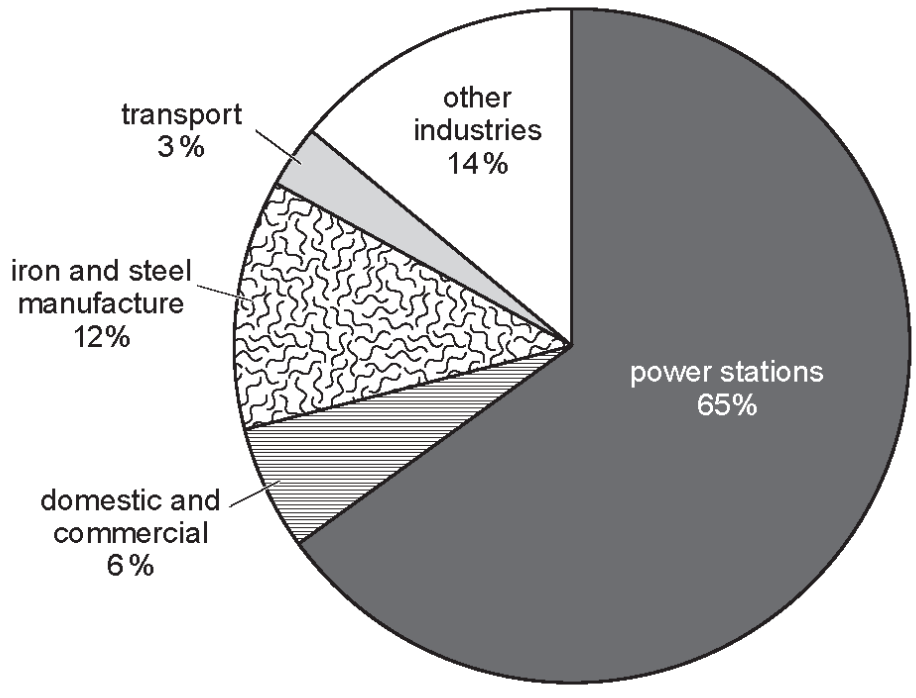
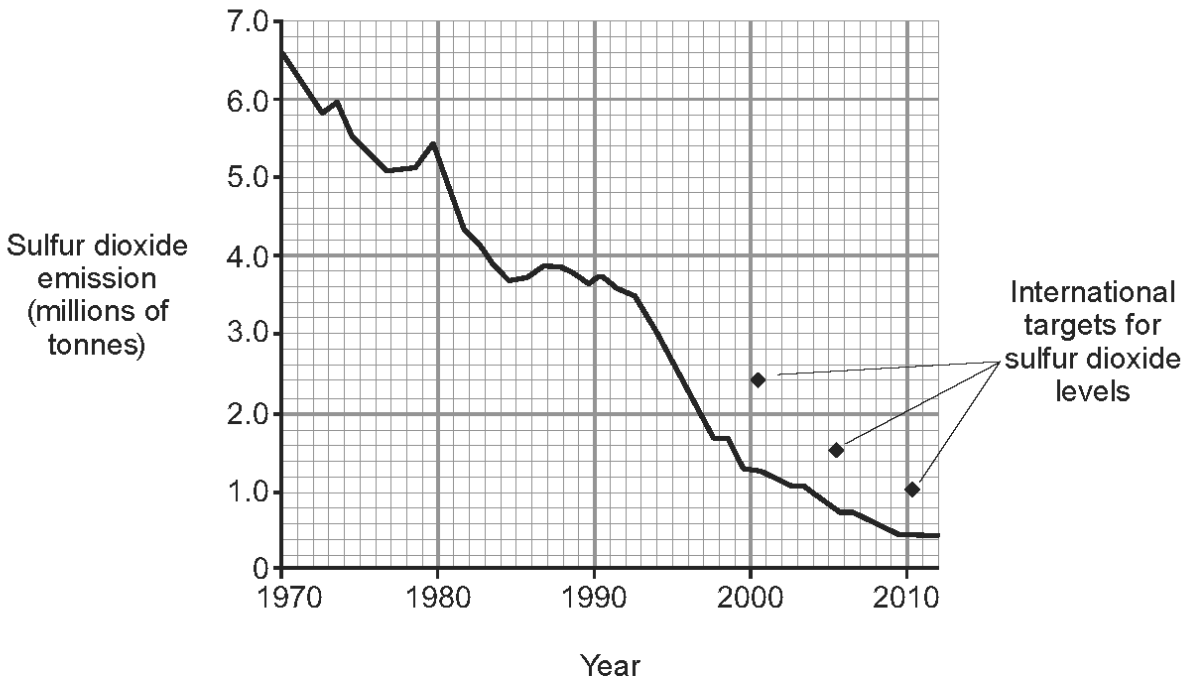
17. *(a)* The pie chart below shows sources of sulfur dioxide in the UK.



Industrial sources of sulfur dioxide include power stations, iron and steel manufacture and other industries. Calculate the total percentage (%) of sulfur dioxide from industrial sources. [1]

Total percentage from industrial sources = ... %

(b) The graph below shows the total sulfur dioxide emissions in the UK between 1970 and 2012. International targets for sulfur dioxide levels are also shown (◆).



(i) Use the information to give **two** conclusions that describe sulfur dioxide emissions in the UK between 2000 and 2012. [2]

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.....

(ii) The generation of electricity in power stations is the main source of sulfur dioxide. Suggest an explanation for the small peak in sulfur dioxide emission in 1979. [2]

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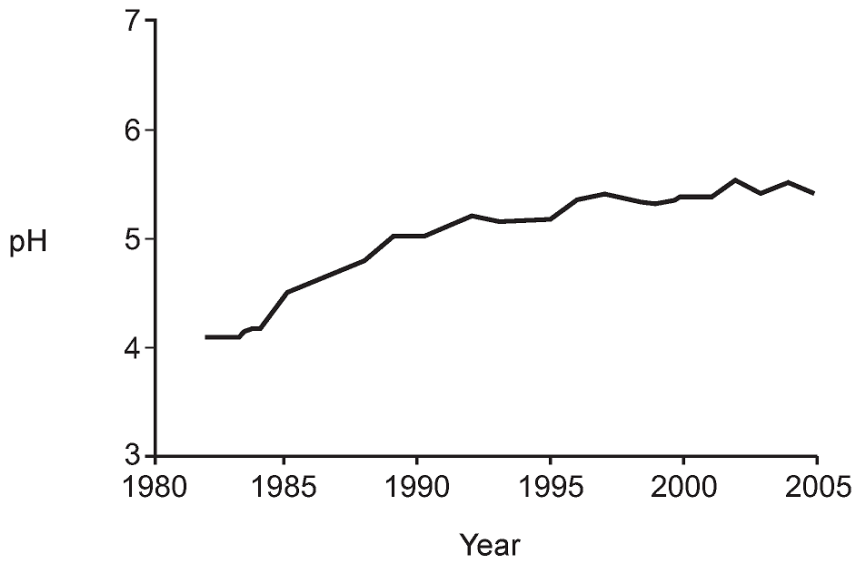
.....

(c) One of the major consequences of sulfur dioxide emission is the formation of acid rain. Acid rain causes the pH in lakes and reservoirs to decrease.

The graph below shows the change in the pH of a reservoir between 1982 and 2005.



(i) Describe how the pH **and** the acidity changes between 1982 and 2005. [2]

pH .....

Acidity .....

(ii) The reservoir is in a remote part of the country and difficult to reach.
pH readings were taken daily and used to produce the graph above.

pH meter

A

datalogger and pH sensor

B

pH paper

C

litmus paper

D

Give the **letter** of the equipment above that you would choose to record and store the pH of the reservoir several times a day. Give a reason for you choice. [2]

Letter .....

Reason .....

.....

9

Marking Scheme

1.

Question Number			
FT	HT	Mark	Answer
8	3	6	**Indicative content** **Benefits e.g.** increase crop yield, more food, healthier plants, improves quality of soil, cheaper food and releases land for other purposes. **Problems e.g.** increased soil acidity (which needs neutralising using lime), pollutes water supplies/ nitrates in drinking water (possible health problems), overgrowth of plants in canals (which requires unblocking) and 'eutrophication' or full description – (algae over growth, bloom formation, sunlight blocked, plants die, bacteria removes oxygen during decomposition, water de-oxygenated and water becomes lifeless) **5-6 marks** The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar. **3-4 marks** The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar. **1-2 marks** The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar. **0 marks** The candidate does not make any attempt or give a relevant answer worthy of credit.

2.

Question Number		Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
FT	HT								
2		(a)	(i)		1	air and natural gas – both needed	methane		nitrogen and hydrogen
			(ii)		1	3 : 2			
			(iii)		1	catalyst / speeds up reaction / increases rate			
			(iv)		1	remove / separate / get ammonia (from the unreacted gases)		condenses ammonia / turns ammonia to liquid	
			(v)		1	re-use (unreacted nitrogen and hydrogen) not to waste (unreacted nitrogen and hydrogen) not having to make more nitrogen and hydrogen	conserves natural gas less energy needed		
		(b)			1	ammonium nitrate			
		(c)	(i)		1	increases crop yield			
			(ii)		1	increases soil acidity			

3.

Question Number			
FT	HT	Mark	Answer
8	3	6	**Indicative content** **Benefits e.g.** increase crop yield, more food, healthier plants, improves quality of soil, cheaper food and releases land for other purposes. **Problems e.g.** increased soil acidity (which needs neutralising using lime), pollutes water supplies/ nitrates in drinking water (possible health problems), overgrowth of plants in canals (which requires unblocking) and 'eutrophication' or full description – (algae over growth, bloom formation, sunlight blocked, plants die, bacteria removes oxygen during decomposition, water de-oxygenated and water becomes lifeless) **5-6 marks** The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar. **3-4 marks** The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar. **1-2 marks** The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar. **0 marks** The candidate does not make any attempt or give a relevant answer worthy of credit.

4.

Question Number									
FT	HT	Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
9	2	(a)	(i)		2	436 + 242 (1) = 678 (1) – correct answer only (cao) (2)			
			(ii)		2	2 × 431 (1) = 862 (1) – cao (2)			
		(b)			1	exothermic since energy given out (as bonds made) > energy needed (to break the bonds) energy given by reaction is negative / –184 credit 'endothermic' with correct reason if calculation error followed through (ft)			

5.

Question Number									
FT	HT	Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
5		*(a)*	(i)		2	sulfur dioxide (1) sulfur trioxide (1)	SO_2 SO_3		
			(ii)		1	2			
			(iii)		1	far too / very exothermic or acid forms mist / white fumes form or acid is difficult to collect		dangerous / explosive / reactive	
		(b)	(i)		2	5 + 5 + 30 + 30 + 15 (1) 15 (1) follow through error (ft) correct answer only (cao) (2)			
			(ii)		1	ammonia	NH_3		
			(iii)		3	overgrowth of algae (1) good description of eutrophication – up to (3) gets into water supplies (1) must be some linking of points in explanation for full marks to be awarded	 gets into water supplies and can lead to blue baby syndrome (2)	kills fish pollution	

6.

Question Number									
FT	HT	Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
3		(a)	(i)		2	number of nitrogen atoms **2** number of hydrogen atoms **6** **both** needed for (1) equal / same number (of these atoms) on right hand side (1)			
			(ii)		1	gas / gaseous			
		(b)	(i)	I	1	cooling			
				II	1	recycling			
			(ii)		2	iron (1) speeds up reaction (1)			

7.

Question Number									
FT	HT	Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
7	1	*(a)*			1	hydrogen	H_2	H	
		(b)			2	iron (1) speeds up the reaction / increases the rate of the reaction (1)			
		(c)			2	recycled / returned into reactor (1) basic qualification required e.g. reduces cost of process / less waste of raw materials (1)	fed back in re-used	more efficient / reacted again / more yield / saves time	
		(d)			2	lower yield with higher temperature (1) higher yield with a higher pressure (1)	vice versa		
		(e)			3	$N_2 + H_2$ (1) NH_3 (1) (1), 3, 2 (1) formulae must be correct to award balancing mark			

8.

Question Number									
FT	HT	Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
	6	(a)	(i)		1	1000 atmospheres 100 °C both needed for (1)			
			(ii)		2	low rate/ slow reaction (1) (iron) catalyst (1)	decreased rate		incorrectly named catalyst e.g. V_2O_5
			(iii)		1	cost of container/more expensive to build/thicker container walls/ cost of getting to high pressure		'cost'	
		(b)	(i)		1	exothermic			
			(ii)		1	4 $\longrightarrow$ 4			
			(iii)		2	$CuCO_3 + 2HNO_3 \longrightarrow Cu(NO_3)_2 + H_2O + CO_2$ formulae correct (1) balancing (1) formulae must be correct for balancing mark to be awarded			

9.

Question Number									
FT	HT	Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
	7	*(a)*	(i)		3	diagrammatic representation showing clearly two Na atoms losing 1 outer electron each (1) one O atom gaining 2 electrons (1) Na^+ and O^{2-} (both needed) (1) there must be no ambiguity e.g. electrons cannot be on atoms and ions at the same time			
			(ii)		1	sodium ion 2, 8 oxide ion 2, 8 both needed			
		(b)			3	simple molecular (1) weak bonds between molecules (1) only a small amount of energy needed to break them (1)	simple covalent	covalent	

10.

Question Number					Mark	Answer	Accept	Neutral answer	Do not accept
FT	HT	Sub-section							
7	1	*(a)*			1	hydrogen	H_2	H	
		(b)			2	iron (1) speeds up the reaction / increases the rate of the reaction (1)			
		(c)			2	recycled / returned into reactor (1) basic qualification required e.g. reduces cost of process / less waste of raw materials (1)	fed back in re-used	more efficient / reacted again / more yield / saves time	
		(d)			2	lower yield with higher temperature (1) higher yield with a higher pressure (1)	vice versa		
		(e)			3	$N_2 + H_2$ (1) NH_3 (1) (1), 3, 2 (1) formulae must be correct to award balancing mark			

11.

Question Number		Mark	Guidance
FT	HT		
	10		Indicative content: Explanation of choice of temperature and pressure conditions and rationale of presence of catalyst e.g. reversible reaction, left to right reaction required to produce ammonia (left to right reaction is exothermic and) higher yield is favoured by lower temperature however lower temperature results in lower rate so compromise made – moderately high temperature increases rate at the expense of yield rate further increased by using iron catalyst higher yield is favoured by higher pressure however increasing pressure increases plant costs and is potentially more hazardous – moderate pressure chosen provides moderate yield lower yield acceptable because unreacted nitrogen/hydrogen can be easily separated and returned to reaction vessel 5-6 marks: The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar. 3-4 marks: The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar. 1-2 marks: The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar. 0 marks: The candidate does not make any attempt or give a relevant answer worthy of credit.

12.

Question Number					Mark	Answer	Accept	Neutral answer	Do not accept
FT	HT	Sub-section							
	4	*(a)*	(i)		1	air			
			(ii)		2	dissolve sulfur trioxide in concentrated sulfuric acid (1) dilute with water to produce concentrated sulfuric acid (1)		add to oleum	
			(iii)		1	vanadium pentoxide	V_2O_5		
		(b)			2	acid dehydrates the sugar removing the **elements of water / hydrogen and oxygen** (1) carbon remains (1)	 C		

13.

Question Number									
FT	HT	Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
7	1	(a)	(i)	I	1	sulfur / S			
				II	1	vanadium(V) oxide / vanadium oxide / vanadium pentoxide / V_2O_5		VO	
				III	1	sulfuric acid / H_2SO_4	oleum	dilute / conc	
			(ii)		3	reactants: $SO_2 + O_2$ (1) product: SO_3 (1) balancing: $2(SO_2)$ $2(SO_3)$ (1) – reactants and product must be correct before balancing mark awarded			
		(b)			2	(blue hydrated copper(II) sulfate) turns white (1) (crystalline hydrated copper (II) sulfate) turns powdery / turns crumbly / loses its crystalline appearance (1)		changes colour	

14.

Question Number									
FT	HT	Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
6	1	(a)	(i)		3	SO_2 O_2 (1) SO_3 (1) formulae must be correct to get balancing mark 2, 1, 2 (1)			
			(ii)		2	30 (2) if incorrect answer credit (1) for two correct readings from graph i.e. 86 and 56			
			(iii)		2	H_2SO_4 (1) [no mark for SO_3] $H_2S_2O_7$ (1)			
		(b)			3	black mass forms / black solid forms / sugar turns black (1) steam / water vapour / hissing (1) smell (1) any two for (1) each carbon (1)		temperature rise / water formed / bubbles / fizzing	

15.

Question Number		Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
FT	HT								
7	1	(a)	(i)	I	1	sulfur / S			
				II	1	vanadium(V) oxide / vanadium oxide / vanadium pentoxide / V_2O_5		VO	
				III	1	sulfuric acid / H_2SO_4	oleum	dilute / conc	
			(ii)		3	reactants: $SO_2 + O_2$ (1) product: SO_3 (1) balancing: $2(SO_2)$ $2(SO_3)$ (1) – reactants and product must be correct before balancing mark awarded			
		(b)			2	(blue hydrated copper(II) sulfate) turns white (1) (crystalline hydrated copper (II) sulfate) turns powdery / turns crumbly / loses its crystalline appearance (1)		changes colour	

16.

Question Number		Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
FT	HT								
6	1	(a)	(i)		3	SO_2 O_2 (1) SO_3 (1) formulae must be correct to get balancing mark 2, 1, 2 (1)			
			(ii)		2	30 (2) if incorrect answer credit (1) for two correct readings from graph i.e. 86 and 56			
			(iii)		2	H_2SO_4 (1) [no mark for SO_3] $H_2S_2O_7$ (1)			
		(b)			3	black mass forms / black solid forms / sugar turns black (1) steam / water vapour / hissing (1) smell (1) any two for (1) each carbon (1)		temperature rise / water formed / bubbles / fizzing	

17.

Question Number		Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
FT	HT								
5		(a)			1	91	±½ square		
		(b)	(i)		2	(SO_2 emissions) decreasing / go from 1.3 → 0.4 (1) (SO_2 emissions) below international targets (1)	idea of 'levelling out'		
			(ii)		2	Any **two** from: • more electricity generated / used • increased fuel consumption / more coal burned / more oil burned / more gas burned • harsh winter / colder weather *Any **two** for (1) each*			
		(c)	(i)		2	pH: increases (1) acidity: decreases (1)	gets weaker		stronger
			(ii)		2	**B** (1) (pH readings recorded) **continuously** / **remotely** / without someone being there / (pH) readings can be **stored** (1)	over a long period of time	'graph plotted automatically'	