WJEC Chemistry GCSE

2.6: Reversible Reactions, Industrial Process and Important Chemicals

Practice Questions

Wales Specification

1.

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]

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(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 .....

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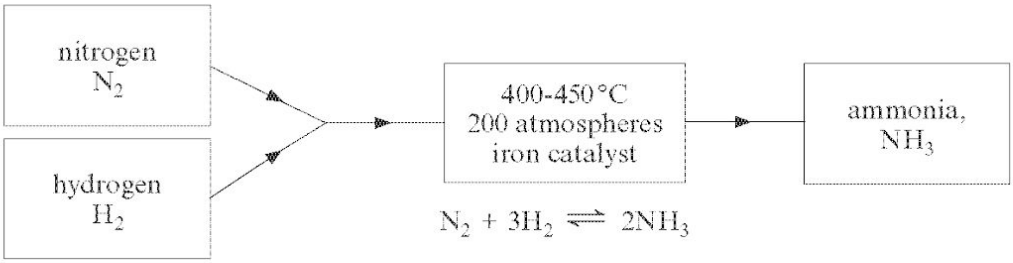
2.

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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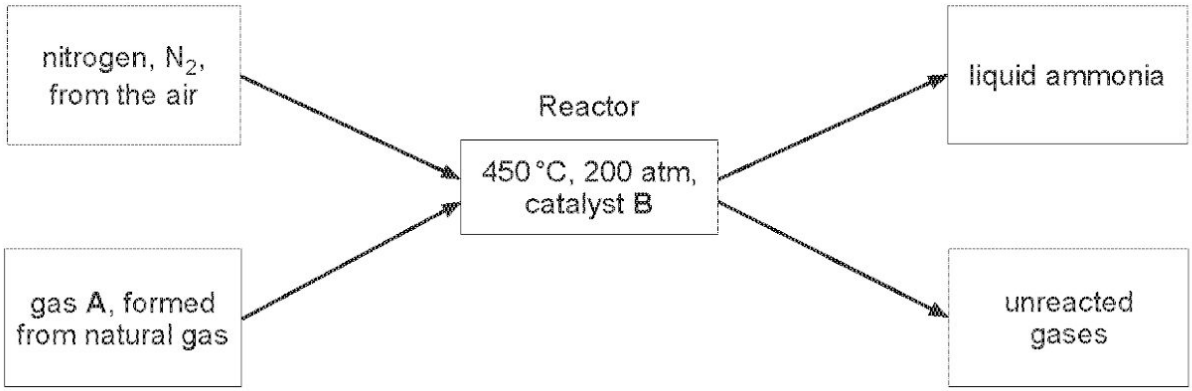
3.

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]

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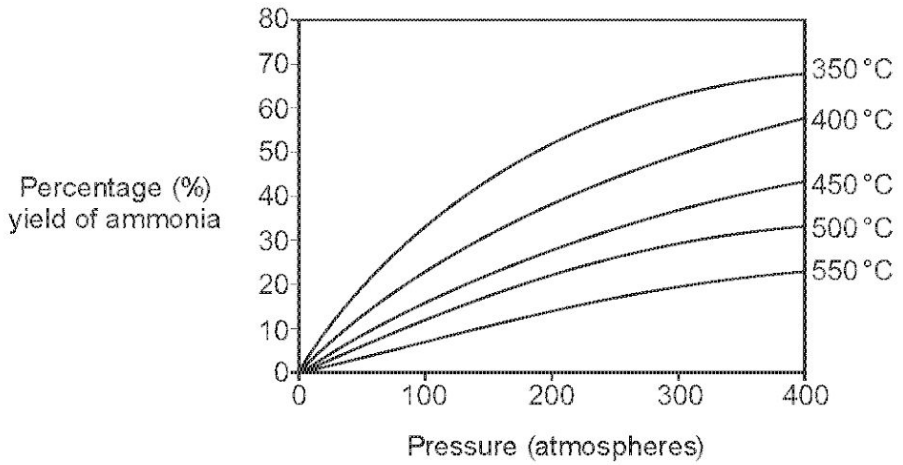
(d) The following graph shows the effect of temperature and pressure on the yield of ammonia during the Haber process.



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

Temperature

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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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4.

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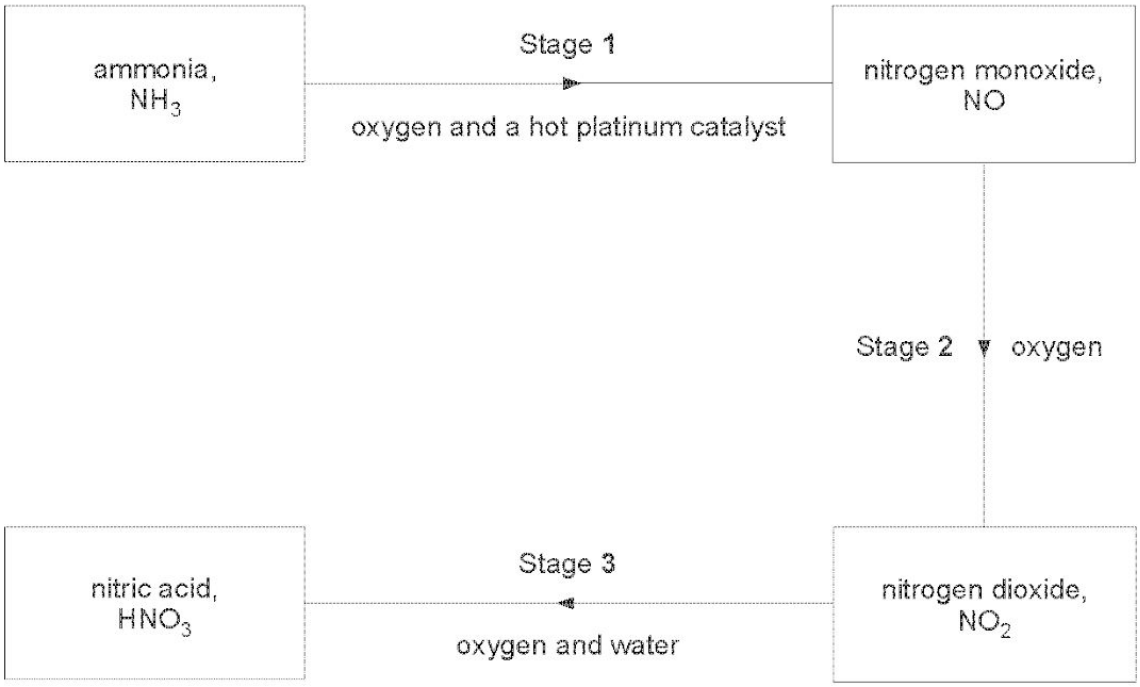
(b) Ammonia is used to form nitric acid in a three-stage reaction.



(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]

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(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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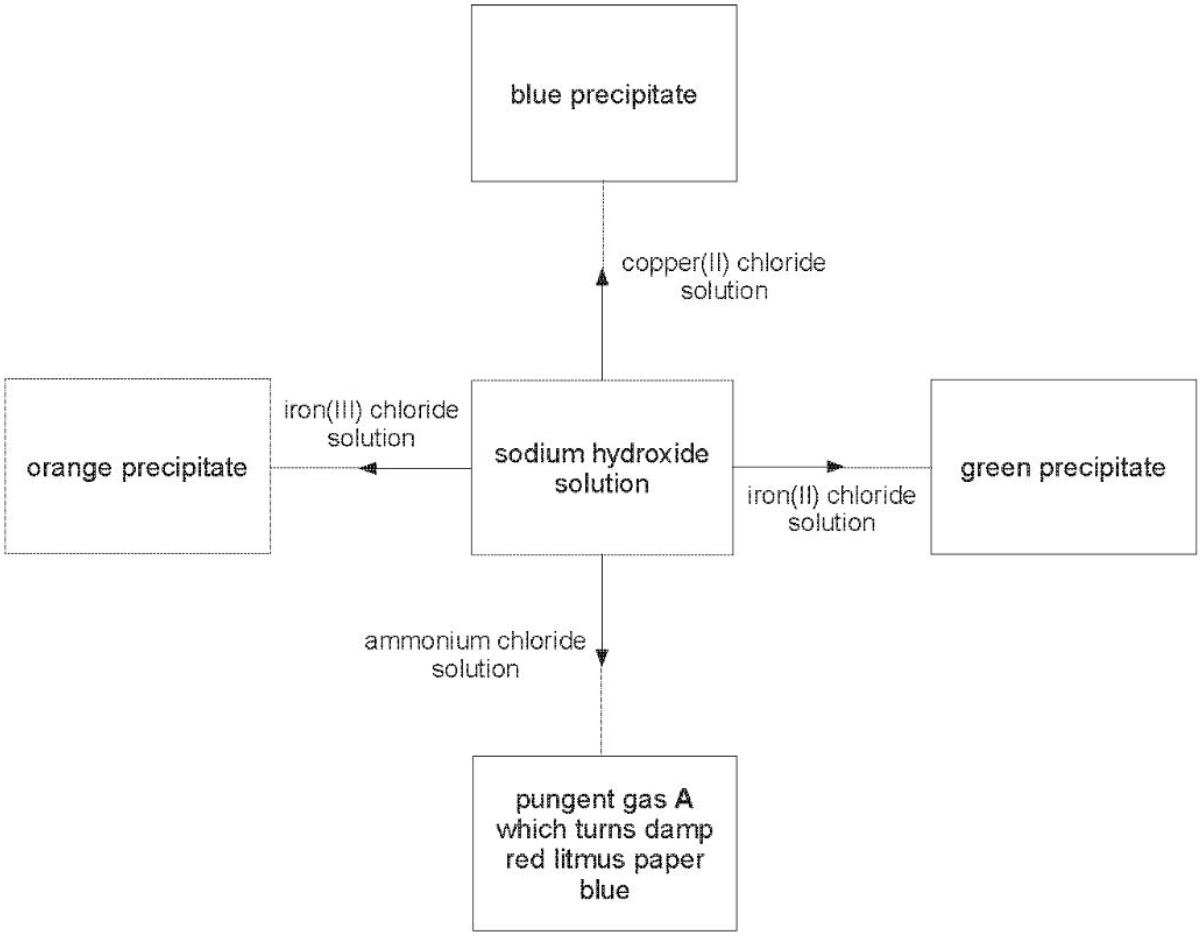
5.

(a) A Year 11 pupil added sodium hydroxide to solutions of four compounds.
The observations made by the pupil are shown below.



(i) Name pungent gas **A**. [1]

.....

(ii) Give the chemical name of the blue precipitate formed. [1]

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(iii) The green precipitate formed is iron(II) hydroxide. Give the chemical formula for this compound. [1]

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(b) The following table shows the colours of universal indicator at different pH values.

Colour	red	orange	yellow	green	blue	navy blue	purple
pH	0-2	3-4	5-6	7	8-9	10-12	13-14

(i) Universal indicator turns red in sulfuric acid and orange in ethanoic acid.
State what these results tell you about the **relative** strength of these acids. [1]

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(ii) Both acids react with magnesium ribbon forming hydrogen gas.

I. State how the reactions would differ. [1]

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II. Give the test you would carry out to identify hydrogen. Include the result of your test. [1]

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6.

(a) Draw a line from each gas below to the observation made in identifying it. [3]

Gas	Observation
	relights a glowing splint
carbon dioxide	turns flame red
ammonia	turns limewater milky
oxygen	pops with a burning splint
	turns damp red litmus blue

(b) The following box contains observations made when testing for some common metal ions.

lilac flame	yellow flame	green flame
blue precipitate	brown precipitate	green precipitate
	white precipitate	

Choose from the box the result you would expect for the following tests. [3]

A flame test is carried out on a sample of sodium chloride

.....

A flame test is carried out on a sample of copper(II) sulfate

.....

Sodium hydroxide solution is added to a solution of iron(III) chloride

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7.

(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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8.

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 .....

.....

Stage 4 .....

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

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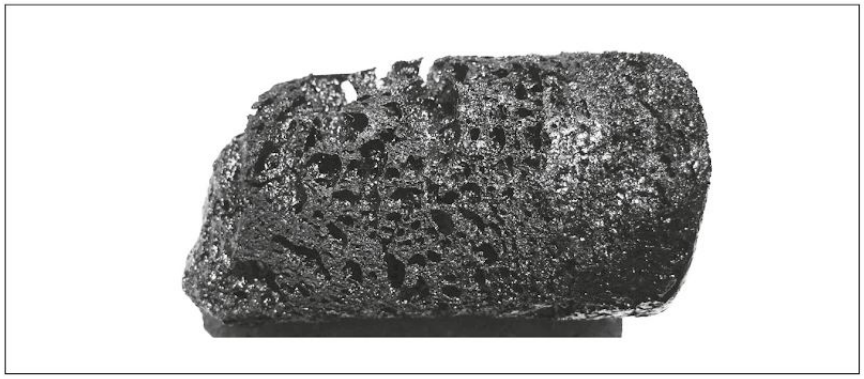
(b) When concentrated sulfuric acid is added to sugar a black solid is formed.



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

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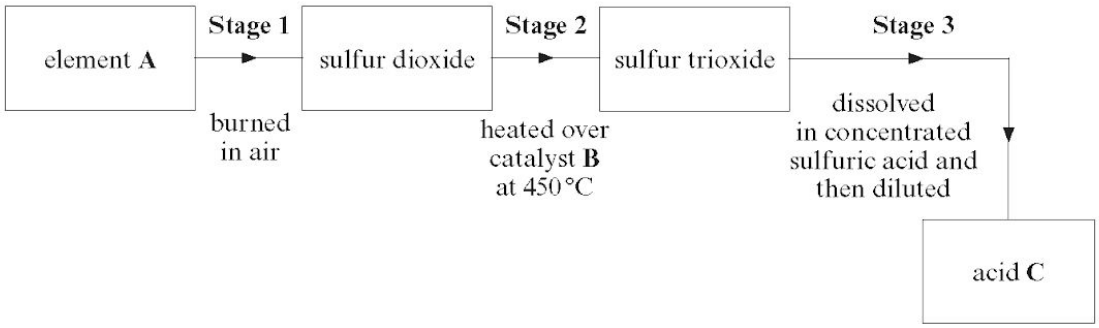
9.

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



(i) Give the name of

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

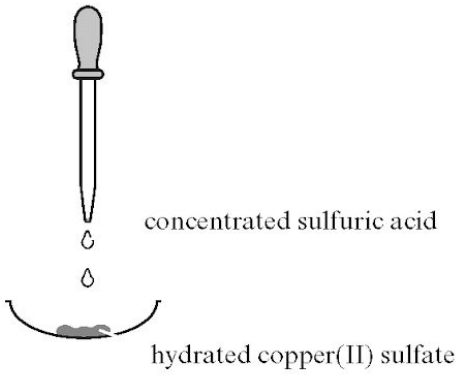
II catalyst **B**, ... [1]

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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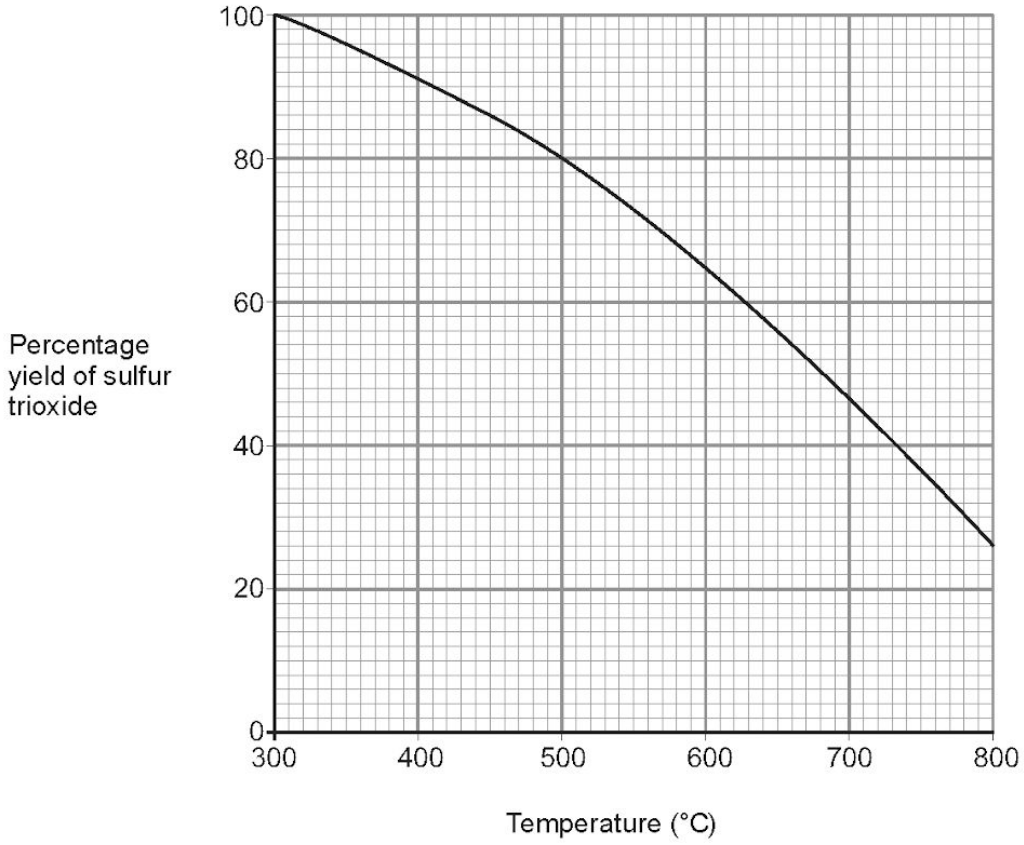
10.

(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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11.

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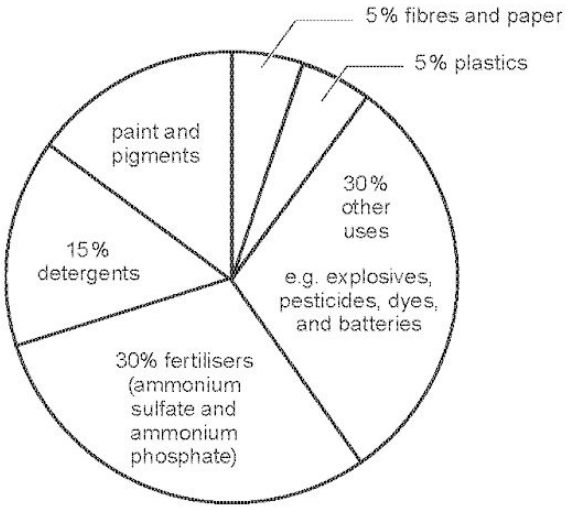
(b) The following pie chart shows the uses of sulfuric acid.



(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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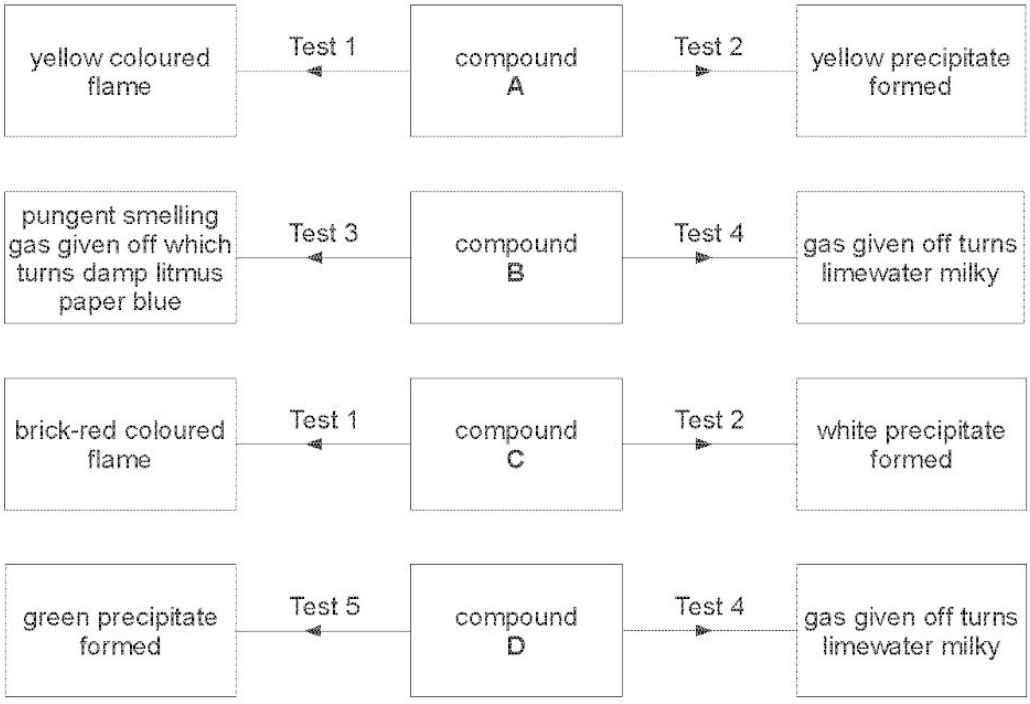
12. *(a)* A pupil used the following tests to identify unknown compounds **A**, **B**, **C** and **D**.

add sodium hydroxide solution and warm mixture, test gas given off with damp litmus paper	add dilute hydrochloric acid, bubble gas given off into limewater	
add silver nitrate solution	add sodium hydroxide solution	flame test

These are described as tests 1 to 5 but not necessarily in this order.

The flow charts show the results obtained for each compound.



Deduce which test is which and hence give the **names** of compounds **A**, **B**, **C** and **D**. [4]

A .....

B .....

C .....

D .....

(b) Describe the test for sulfate ions in solution. Include the result for your test. [1]

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13.

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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14.

(a) The following box contains the names of six ionic compounds.

sodium chloride	**sodium carbonate**	**copper(II) sulfate**
ammonium chloride	**potassium sulfate**	**lithium carbonate**

State which of the compounds in the box you would expect to

(i) give a yellow flame in a flame test, [1]

.....

(ii) produce bubbles when reacting with hydrochloric acid. [1]

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(b) A student has two colourless solutions in unlabelled bottles. He knows that one is potassium chloride and that the other is potassium iodide. Describe a test that could be carried out to distinguish between the solutions, giving the observations expected in **both** cases. [3]

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(c) Compounds containing ammonium ions can be identified by heating gently with sodium hydroxide solution and testing the gas produced.

Name the gas produced and describe how you would positively identify this gas. [2]

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(d) Iron(III) chloride solution produces a brown precipitate when it reacts with sodium hydroxide solution.

Write a balanced **ionic** equation for this reaction. You should include state symbols. [3]

..... + ... → .....

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15.

(a) A Year 11 class investigated tests used to identify positive and negative ions. The results recorded by one pupil are shown below.

Put a **circle** around the **three** *incorrect* observations. [3]

Flame tests

Metal ion	Flame colour
Na^+	yellow
K^+	lilac
Cu^{2+}	brick-red

Adding sodium hydroxide to metal ions in solution

Metal ion solution	Colour of precipitate
Cu^{2+}	blue
Fe^{2+}	green
Fe^{3+}	white

Testing negative ions

Ion	Test	Observation
Cl^-	add dilute nitric acid followed by silver nitrate solution	yellow precipitate
CO_3^{2-}	add dilute hydrochloric acid	bubbles formed
SO_4^{2-}	add dilute hydrochloric acid followed by barium chloride solution	white precipitate

(b) Compounds containing ammonium ions, NH_4^+, are identified by adding sodium hydroxide solution, warming and testing the gas formed with damp red litmus paper. The damp red litmus paper turns blue.

The symbol equation below shows the reaction between ammonium chloride and sodium hydroxide solution.

$$NH_4Cl + NaOH \longrightarrow NaCl + H_2O + NH_3$$

Name the **three** products of the reaction. [1]

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16.

(a) Choose words from the box below to answer parts (i) and (ii).

chlorine	**copper**	**electron**
lithium	**magnesium**	**proton**

Give the name of

(i) a particle found in the nucleus of an atom, [1]

.....

(ii) an alkali metal. [1]

.....

(b) Complete the table below by naming the elements and the type of bonding present in ammonia, NH_3. [2]

Compound	Names of elements	Bonding
ammonia, NH_3		

4