



GCSE Chemistry

Haber Process

Question Paper

Time available: 65 minutes

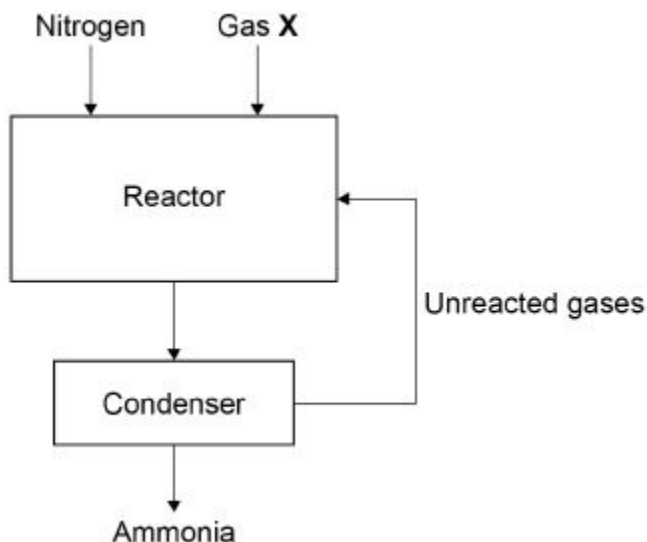
Marks available: 59 marks

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1.

This question is about gases.

The diagram below shows how nitrogen is used in the Haber Process to produce ammonia.



(a) Gas X in the diagram above is obtained from methane.

Name gas X.

(1)

(b) Give the approximate temperature and pressure used in the reactor.

Temperature _____

Pressure _____

(2)

(c) The mixture of gases from the reactor cools in the condenser.

Suggest why ammonia condenses but the other gases do not.

(1)

- (e) Why are scientists **not** certain about the percentage of each gas in the Earth's early atmosphere?

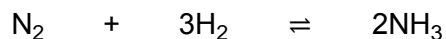
(1)

(Total 11 marks)

2.

The Haber Process is used to produce ammonia from nitrogen and hydrogen.

The equation for the reaction is:



- (a) An ammonia molecule has the formula NH_3

How many atoms are there in one molecule of ammonia?

Tick (✓) **one** box.

2 3 4 6

(1)

- (b) What does the symbol \rightleftharpoons mean?

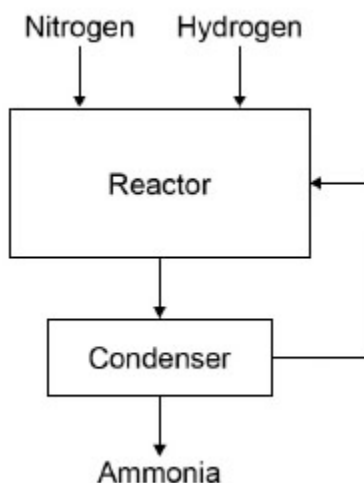
(1)

- (c) Draw **one** line from each gas to the source of that gas.

Gas	Source
<input type="text" value="Hydrogen"/>	<input type="text" value="Air"/>
<input type="text" value="Nitrogen"/>	<input type="text" value="Alcohol"/>
	<input type="text" value="Ammonia"/>
	<input type="text" value="Iron"/>
	<input type="text" value="Natural gas"/>

(2)

The diagram shows the Haber process.



A mixture of ammonia, hydrogen and nitrogen gases leave the reactor.

Table 1 shows the boiling points of the gases.

Table 1

Gas	Boiling point in °C
Ammonia	- 33
Nitrogen	- 196
Hydrogen	- 253

(d) The mixture is cooled to a temperature at which **only** the ammonia condenses to a liquid.

Which temperature could be used?

Tick (✓) **one** box.

- 20 °C

- 40 °C

- 200 °C

- 260 °C

(1)

(e) What happens to the unreacted nitrogen?

Tick (✓) **one** box.

Collected and sold	<input type="checkbox"/>
Recycled to the reactor	<input type="checkbox"/>
Released into the air	<input type="checkbox"/>
Used as a catalyst	<input type="checkbox"/>

(1)

Ammonia from the Haber process can be used to produce fertilisers.

Table 2 gives information about two compounds used in fertilisers.

Table 2

Fertiliser	Compound	Cost in £ / kg
A	Potassium chloride	0.24
B	Diammonium phosphate	0.35

(f) What type of bonding is present in potassium chloride?

Tick (✓) **one** box.

Covalent	<input type="checkbox"/>
Ionic	<input type="checkbox"/>
Metallic	<input type="checkbox"/>

(1)

- (g) Diammonium phosphate has the chemical formula $(\text{NH}_4)_2\text{HPO}_4$
Which **two** elements in $(\text{NH}_4)_2\text{HPO}_4$ improve agricultural productivity?

Tick (✓) **two** boxes.

Chlorine	<input type="checkbox"/>
Hydrogen	<input type="checkbox"/>
Nitrogen	<input type="checkbox"/>
Oxygen	<input type="checkbox"/>
Phosphorus	<input type="checkbox"/>

A farmer uses fertilisers **A** and **B** on a field with an area of 0.05 km^2

(2)

- (h) 50 kg of fertiliser A will cover an area of 0.01 km^2

Calculate the cost of fertilising a field with an area of 0.05 km^2 with fertiliser **A**.

Use **Table 2**.

Cost = £ _____

(2)

- (i) Fertiliser **B** is more expensive than fertiliser **A**.

Suggest why the farmer uses **both** fertilisers.

(1)

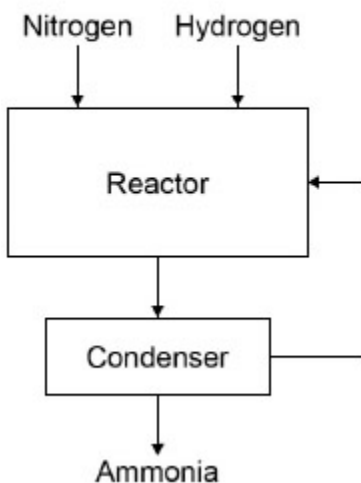
(Total 12 marks)

3.

Nitrogen and hydrogen react to produce ammonia in the Haber process.

Figure 1 shows the Haber process.

Figure 1



A gaseous mixture of ammonia, hydrogen and nitrogen leaves the reactor.

Table 1 shows the boiling points of the gases.

Table 1

Gas	Boiling point in °C
Ammonia	-33
Nitrogen	-196
Hydrogen	-253

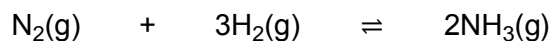
(a) Suggest how ammonia is separated from the other gases.

(2)

(b) What happens to the unreacted hydrogen and nitrogen?

(1)

The equation for the reaction is:



The forward reaction is exothermic.

(c) Calculate the volume of ammonia produced from the complete reaction of 825 dm³ of hydrogen.

Volume of ammonia = _____ dm³

(2)

(d) The Haber process uses a temperature of 450 °C and a pressure of 200 atmospheres.

Why are these conditions used?

Tick **two** boxes.

A higher pressure is maintained using less energy

A higher temperature would increase the equilibrium yield

A lower pressure would decrease the equilibrium yield

A lower temperature would make the reaction too slow

There are more product molecules than reactant molecules

(2)

Most of the ammonia produced is used to make fertilisers.

Table 2 shows information about compounds used as fertilisers.

Table 2

Compound	Formula	Cost in £ / tonne
A	NH_4NO_3	220
B	$(\text{NH}_4)_2\text{HPO}_4$	350
C	KCl	235

(e) Which element in compound A improves agricultural productivity?

(1)

(f) Which **two** compounds can be mixed to make a fertiliser containing three elements that improve agricultural productivity?

Give a reason why you have chosen these compounds.

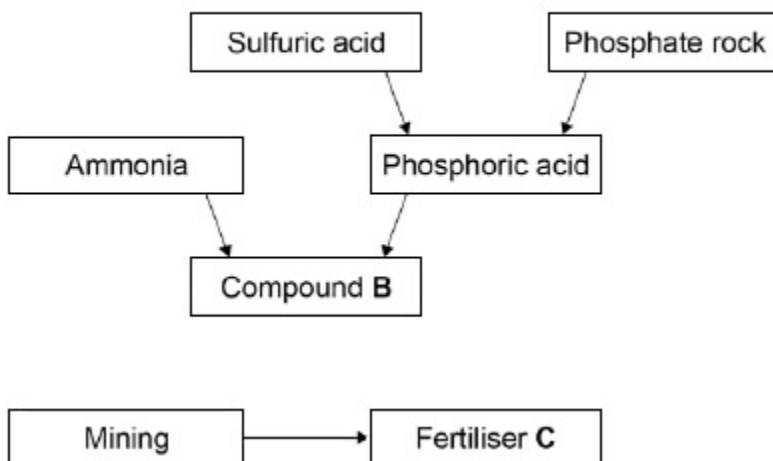
Compounds _____ and _____

Reason _____

(2)

(g) **Figure 2** shows a flow chart for the production of compounds B and C.

Figure 2



Suggest **two** possible reasons for the difference in cost between compounds **B** and **C**.

1. _____

2. _____

(2)

(Total 12 marks)

4.

Fertilisers are used to improve agricultural productivity.

(a) Ammonium nitrate is used in fertilisers.

Name the **two** compounds used to manufacture ammonium nitrate.

(1)

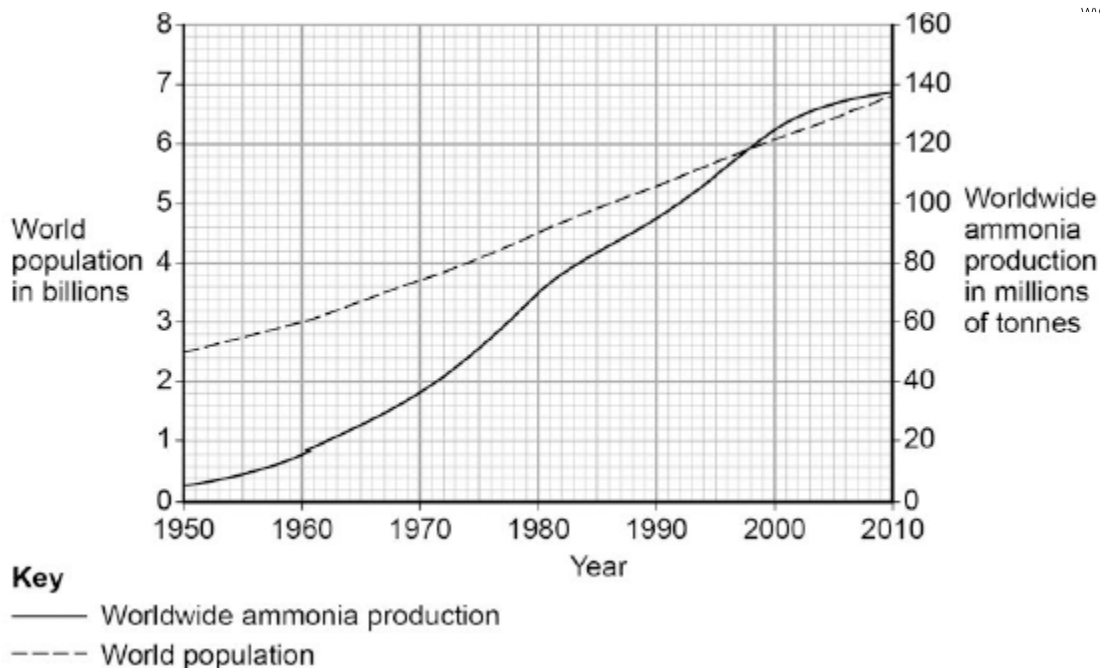
(b) A fertiliser contains the following information on the label:

NPK value = 14 : 11 : 11

Explain why this information is useful to farmers.

(2)

(c) The figure below shows worldwide ammonia production and world population from 1950 to 2010.



Use the figure above and your knowledge to explain the relationship between ammonia production and world population.

(3)

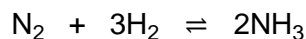
(Total 6 marks)

5.

This question is about ammonia and fertilisers.

(a) Ammonia is produced by a reversible reaction.

The equation for the reaction is:



Complete the sentence.

The forward reaction is exothermic, so the reverse reaction

is _____

(1)

(b) Calculate the percentage by mass of nitrogen in ammonia (NH₃).

Relative atomic masses (A_r): H = 1; N = 14

You **must** show how you work out your answer.

Percentage by mass of nitrogen = _____ %

(3)

(c) A neutral solution can be produced when ammonia reacts with an acid.

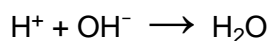
(i) Give the pH of a neutral solution.

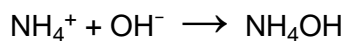
pH _____

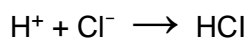
(1)

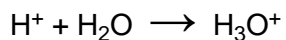
(ii) Which of these ionic equations shows a neutralisation reaction?

Tick (✓) **one** box.









(1)

(iii) Name the salt produced when ammonia reacts with hydrochloric acid.

(1)

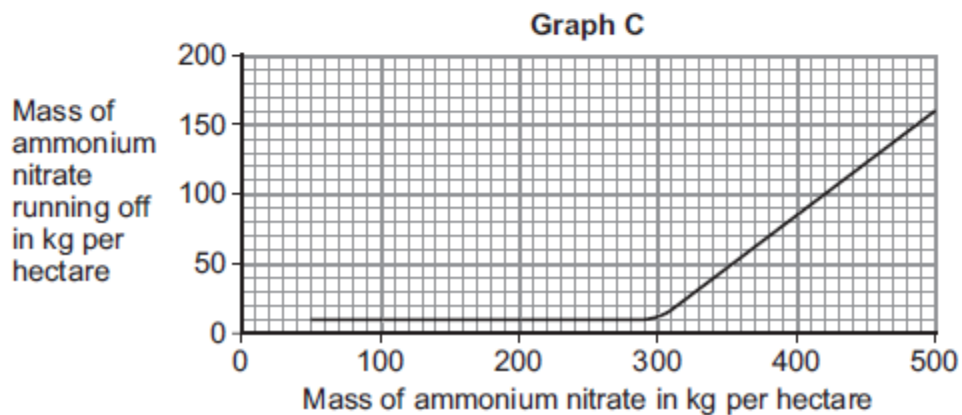
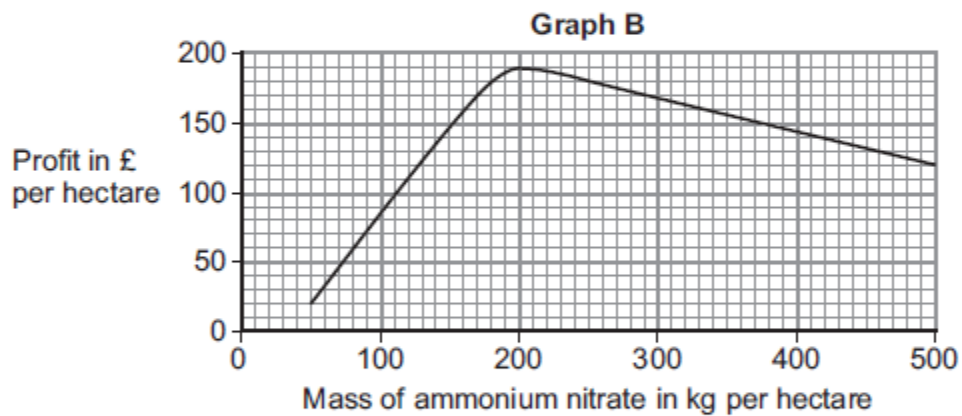
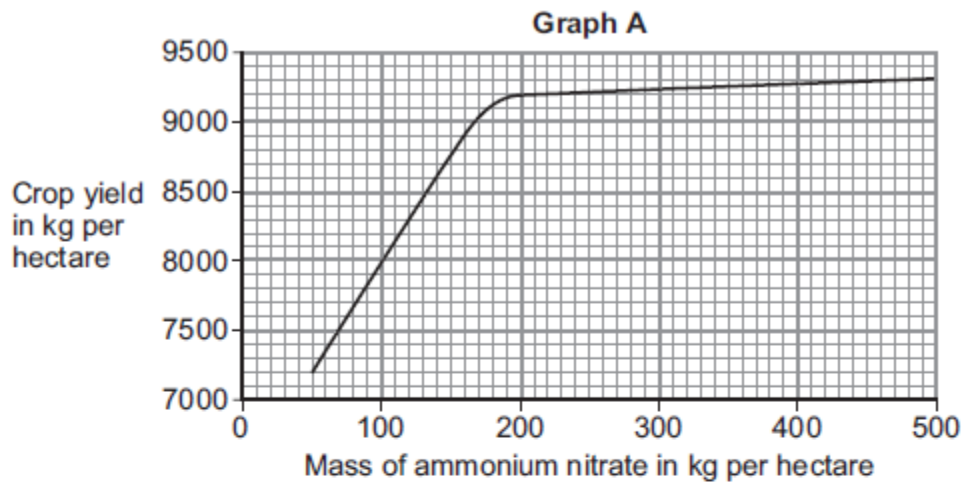
(d)

Farmers use ammonium nitrate as a fertiliser for crops.

Rainwater dissolves ammonium nitrate in the soil.

Some of the dissolved ammonium nitrate runs off into rivers and lakes.

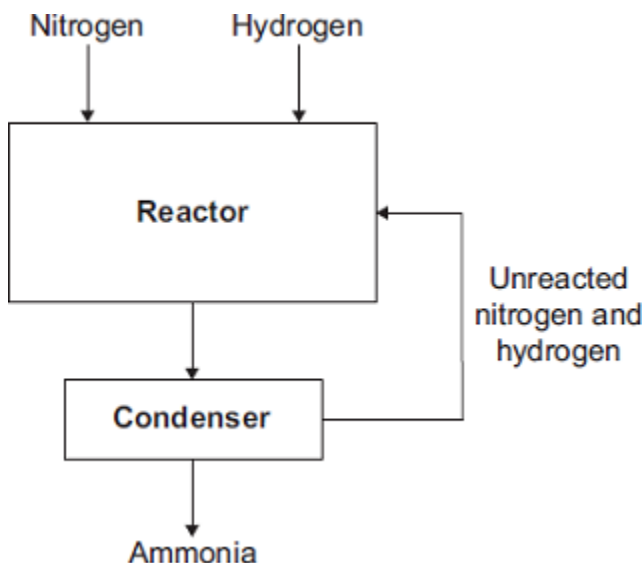
The graphs **A**, **B** and **C** below show information about the use of ammonium nitrate as a fertiliser. A hectare is a measurement of an area of land.



Suggest how much ammonium nitrate farmers should use per hectare.

6.

The flow diagram shows the Haber process. In the Haber process ammonia is produced from nitrogen and hydrogen.



(a) The word equation for the production of ammonia is:



Draw a ring around the correct answer to complete the sentence.

The symbol \rightleftharpoons in the word equation shows the reaction is

- exothermic.
- reversible.
- slow.

(1)

(b) The reactor contains iron.

Complete the sentence.

The iron speeds up the reaction because it is a _____

(1)

(c) What happens to the unreacted nitrogen and hydrogen?

(1)

(d) The sentences describe how ammonia is produced in the Haber process.

The sentences are in the wrong order.

P Ammonia is separated as a liquid.

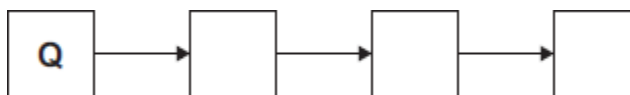
Q Nitrogen and hydrogen are mixed together.

R A mixture of gases enters the condenser.

S Nitrogen and hydrogen react to produce ammonia.

Complete the boxes below to show the correct order of the sentences.

The first box has been done for you.



(2)
(Total 5 marks)