AQA GCSE CHEMISTRY (HIGHER) · 8462

CHEMISTRY



EXAM QUESTION PACK

4.10.4 THE HABER PROCESS AND THE USE OF NPK FERTILISERS (PACK 1)

SCORE	PERCENTAGE
/302	%

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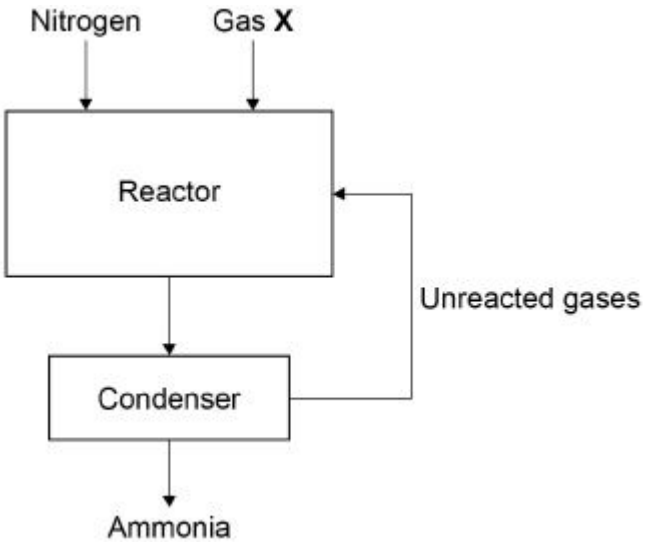
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Q1.

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)

The Earth's early atmosphere was different to Earth's atmosphere today.

Scientists think that the Earth's early atmosphere was like the atmosphere found on Venus today.

The table below shows the amounts of carbon dioxide and oxygen in the atmospheres of Venus and Earth today.

Gas	**Percentage (%) in**	**Percentage (%) in**

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	Venus' atmosphere today	Earth's atmosphere today
Carbon dioxide	96.50	0.04
Oxygen	0.00	20.95

(d) The percentages of carbon dioxide and oxygen have changed from Earth's early atmosphere to Earth's atmosphere today.

Explain the processes that led to these changes.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(6)

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

_____

_____

(1)

(Total 11 marks)

Q2.

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

The equation for the reaction is:

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$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

(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 ⇌ mean?

_____

(1)

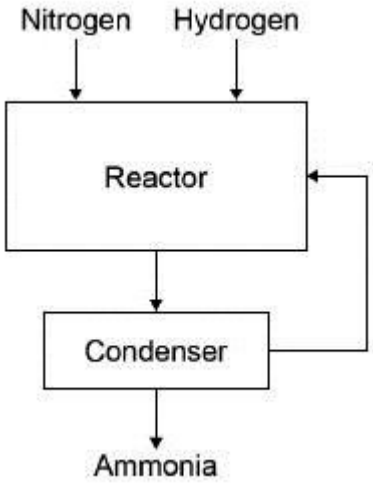
(c) Draw **one** line from each gas to the source of that gas.

Gas	Source
	Air
Hydrogen	Alcohol
	Ammonia
Nitrogen	Iron
	Natural gas

(2)

The diagram shows the Haber process.

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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.

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Collected and sold ☐

Recycled to the reactor ☐

Released into the air ☐

Used as a catalyst ☐

(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 ☐

Ionic ☐

Metallic ☐

(1)

(g) Diammonium phosphate has the chemical formula $(NH_4)_2HPO_4$

Which **two** elements in $(NH_4)_2HPO_4$ improve agricultural productivity?

Tick (✔) **two** boxes.

Chlorine ☐

Hydrogen ☐

Nitrogen ☐

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Oxygen ☐

Phosphorus ☐

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.

_____

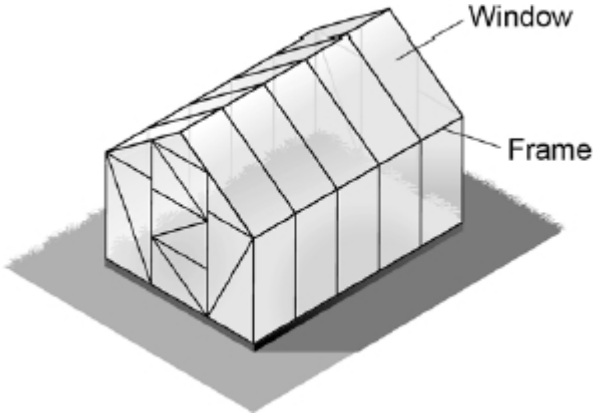
_____

(1)

(Total 12 marks)

Q3.

The diagram shows a greenhouse.



A greenhouse frame can be made from wood or aluminium.

Table 1 gives some information about wood and aluminium.

Table 1

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	Wood	Aluminium
Raw material	Renewable	Non-renewable
Mass of greenhouse frame in kg	80	20
Useful lifetime in years	20	50
End of useful life	Can be chopped up and used as fuel	Can be recycled into new aluminium products

(a) Evaluate the use of each material for making greenhouse frames.

Use **Table 1**.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(b) Greenhouse frames are transported by lorry.

The lorry used can carry a maximum load of 12 tonnes.

Calculate the largest number of wooden greenhouse frames which could be transported by the lorry.

Use **Table 1**.

100 kg = 1 tonne

_____

_____

_____

Number of wooden greenhouse frames = _____

(2)

(c) It is more sustainable to make greenhouse frames from recycled aluminium than from aluminium from aluminium ore.

Give **two** reasons why.

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1. _____

_____

2. _____

_____

(2)

(d) Greenhouse windows can be made from glass or from polymers.

Table 2 gives information about glass and a polymer.

Table 2

	Glass	**Polymer**
Density in g / cm^3	2.8	1.2
Cost in £ per m^2	20	28
Effect of sunlight	No effect	Discolours over time

Suggest **one** advantage of making greenhouse windows from the polymer rather than from glass.

Use **Table 2**.

_____

_____

(1)

(Total 9 marks)

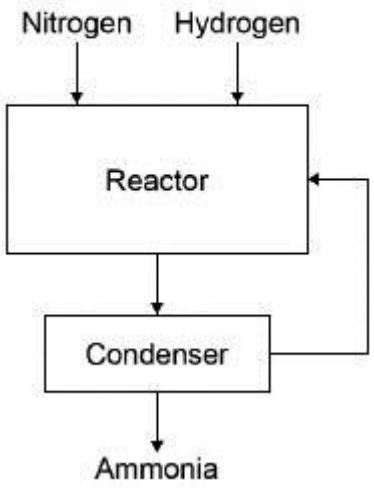
Q4.

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

Figure 1 shows the Haber process.

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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:

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

The forward reaction is exothermic.

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(c) Calculate the volume of ammonia produced from the complete reaction of 825 dm^3 of hydrogen.

_____

_____

_____

_____

Volume of ammonia = _____ dm^3

(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	$(NH_4)_2HPO_4$	350
C	KCl	235

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

_____

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(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 _____

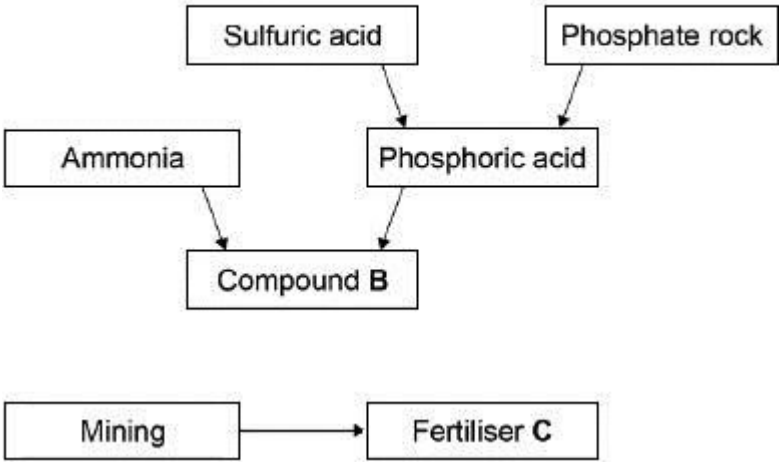
Reason _____

_____

(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)

Q5.

(a) Nitrogen and hydrogen are passed over iron to produce ammonia in the Haber Process.

Balance the equation for the reaction.

$$N_2 + H_2 \rightarrow NH_3$$

(1)

(b) What is iron used for in the Haber process?

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Tick **one** box.

catalyst ☐

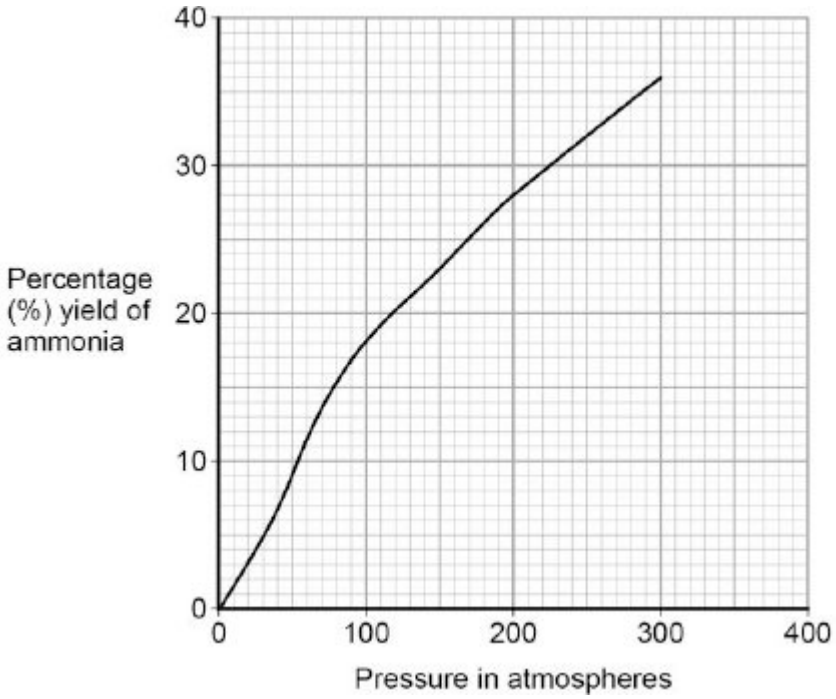
fuel ☐

monomer ☐

reactant ☐

(1)

(c) The figure below shows how the percentage yield of ammonia changes with pressure.



Describe the trend shown in the figure above.

_____

_____

(1)

(d) Use the figure above to determine the difference in percentage yield of ammonia at 150 atmospheres pressure and 250 atmospheres pressure.

Difference in percentage yield of ammonia = _____ %

(2)

(Total 5 marks)

Q6.

Fertilisers are used to improve agricultural productivity.

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(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.

_____

_____

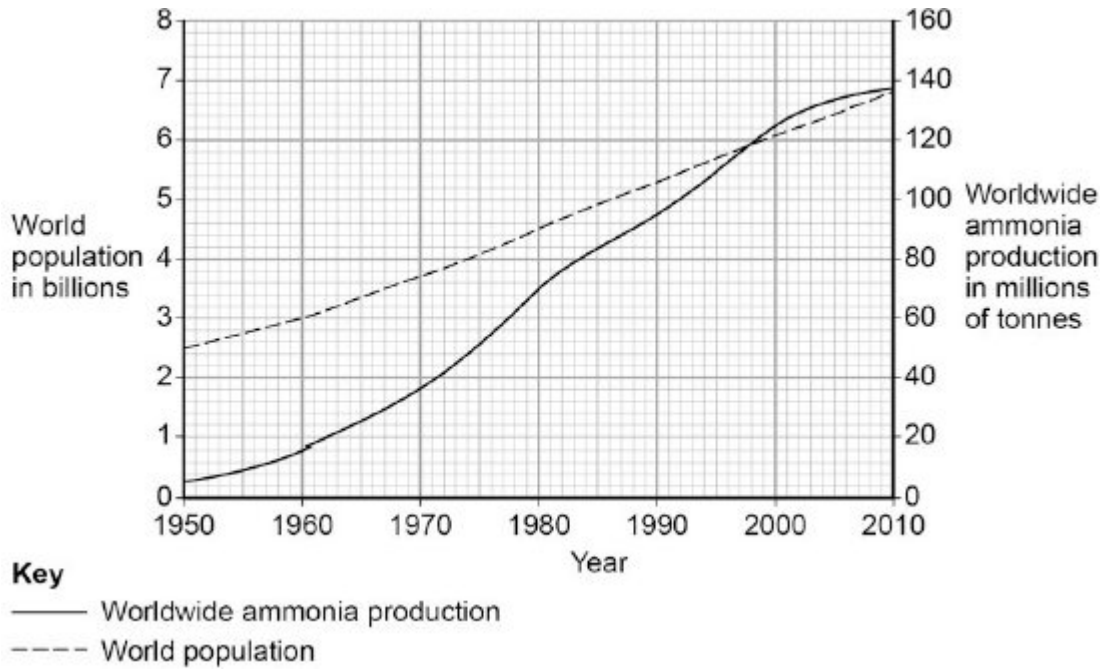
_____

_____

_____

(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.

_____

_____

_____

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_____

_____

_____

(3)

(Total 6 marks)

Q7.

This question is about ammonia and fertilisers.

(a) Ammonia is produced by a reversible reaction.

The equation for the reaction is:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Complete the sentence.

The forward reaction is exothermic, so the reverse reaction

is _____

(1)

(b) Calculate the percentage by mass of nitrogen in ammonia (NH_3).
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.

$H^+ + OH^- \longrightarrow H_2O$ ☐

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$NH_4^+ + OH^- \longrightarrow NH_4OH$ ☐

$H^+ + Cl^- \longrightarrow HCl$ ☐

$H^+ + H_2O \longrightarrow H_3O^+$ ☐

(1)

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

_____

(1)

(d) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

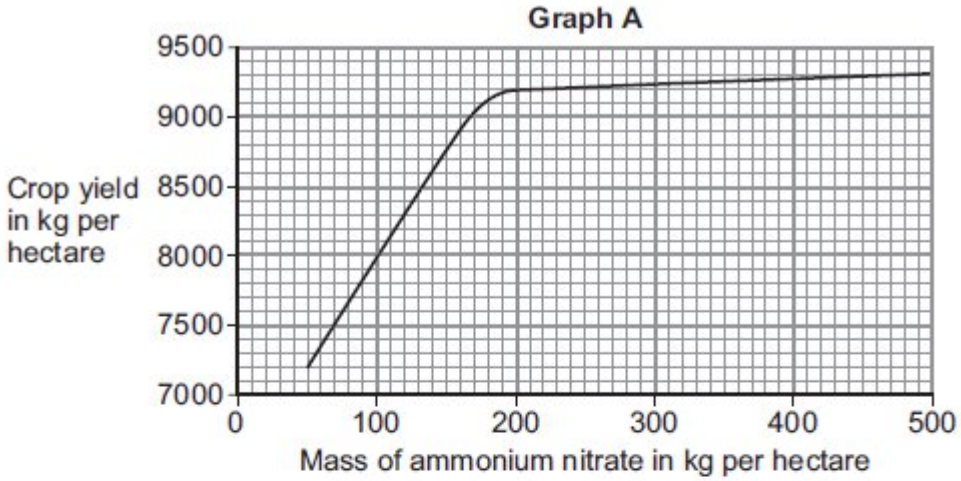
Farmers use ammonium nitrate as a fertiliser for crops.

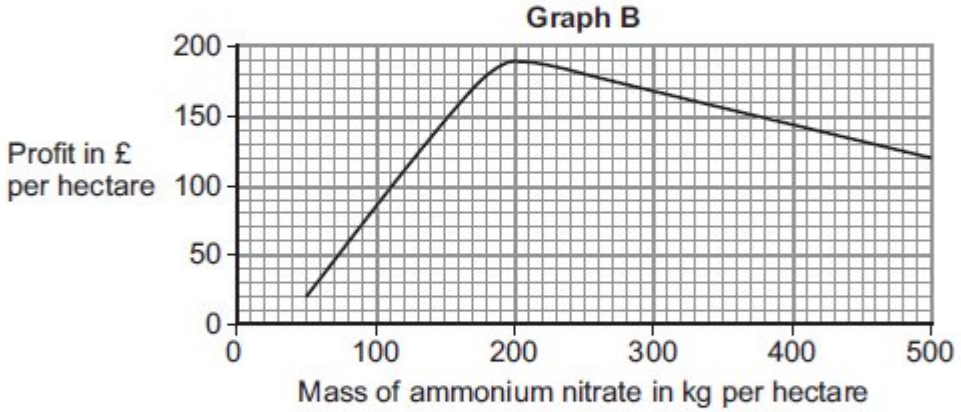
Rainwater dissolves ammonium nitrate in the soil.

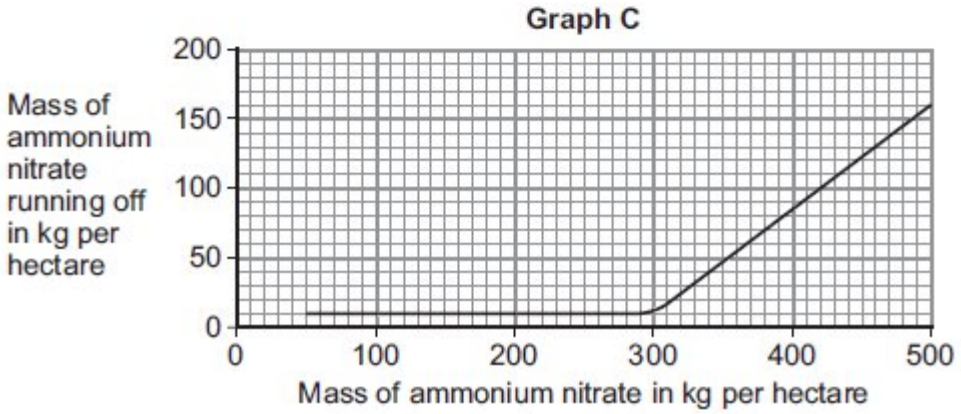
Some of the dissolved ammonium nitrate runs off into rivers and lakes.

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.

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Suggest how much ammonium nitrate farmers should use per hectare.

Give reasons for your answer.

Use information from graphs **A**, **B** and **C**.

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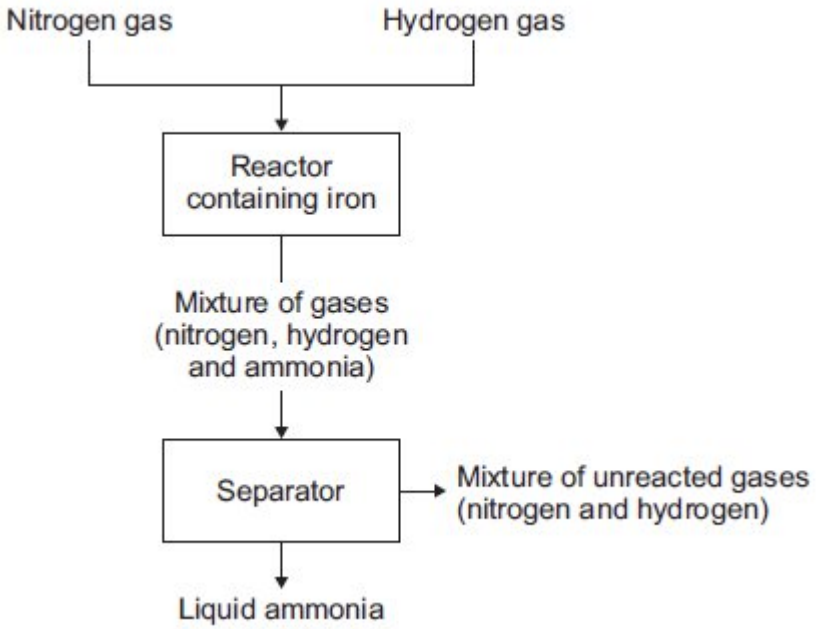
(6)

(Total 13 marks)

Q8.

This question is about the Haber process.

The diagram below shows a flow diagram for the Haber process.



(a) (i) Nitrogen gas and hydrogen gas are obtained from different sources.
Draw **one** line from each gas to its source.

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Gas	Source
	Air
Nitrogen	Iron ore
Hydrogen	Limestone
	Natural gas

(2)

(ii) Explain why iron is used in the reactor for the Haber process.

_____

_____

_____

(2)

(iii) Describe how the ammonia is separated from the other gases.

_____

_____

_____

(2)

(iv) What happens to the mixture of unreacted gases (nitrogen and hydrogen)?

_____

_____

_____

(1)

(b) The reaction to produce ammonia is reversible.

Complete the word equation for this reaction.

nitrogen + _____

(2)

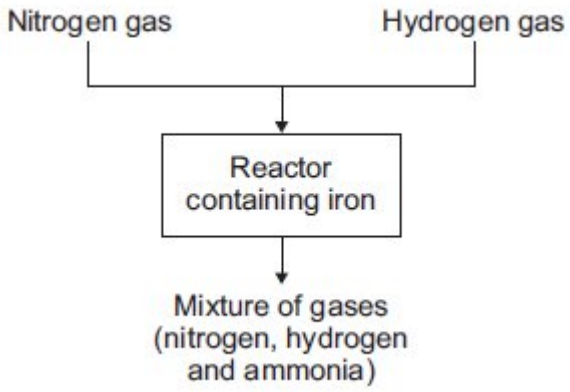
(Total 9 marks)

Q9.

The graph in **Figure 1** shows a flow diagram for the Haber process.

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Figure 1



(a) (i) Hydrogen gas is obtained from methane.
Name **one** source of methane.

_____

(1)

(ii) Air is the source used to produce nitrogen for the Haber process.
Suggest why air must **not** get into the reactor.

_____

_____

_____

(2)

(iii) Describe what happens to the mixture of gases from the reactor.

_____

_____

_____

_____

_____

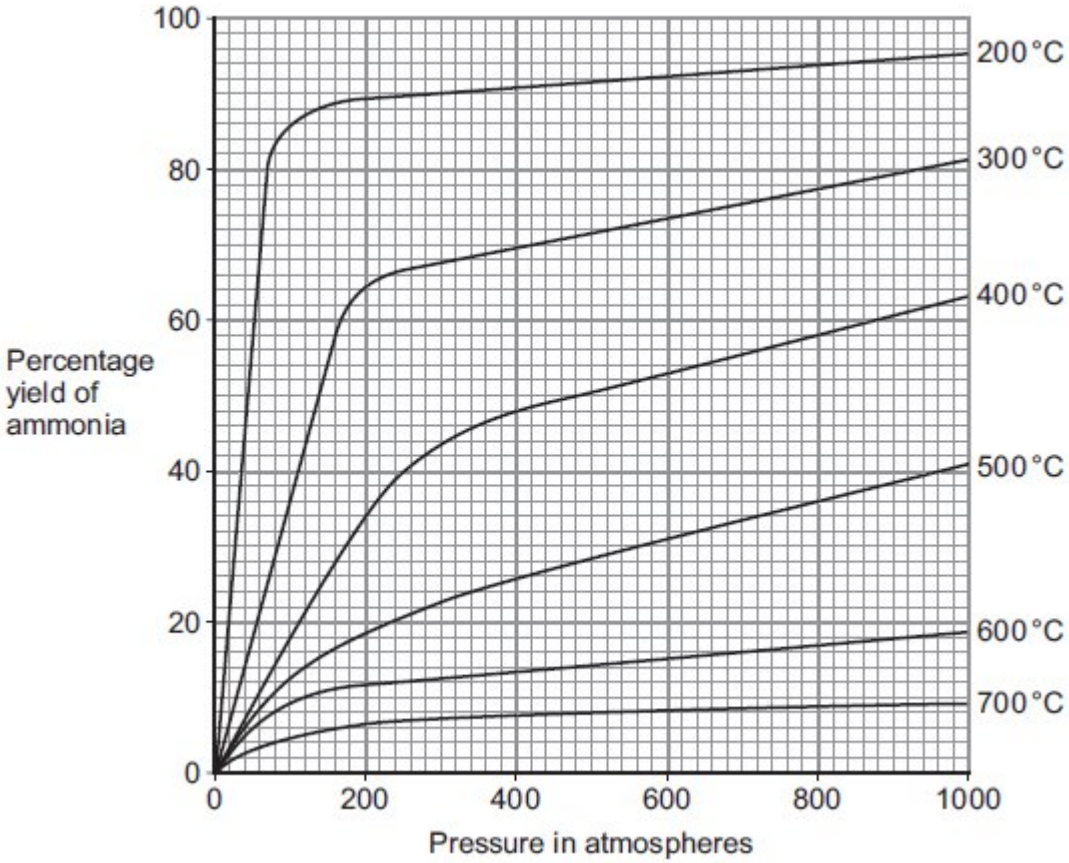
_____

(3)

(b) The graph in **Figure 2** shows the percentage yield of ammonia using different conditions.

Figure 2

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(i) Use **Figure 2** to suggest the conditions that produce the greatest yield of ammonia.

_____

_____

(1)

(ii) Use **Figure 2** to suggest and explain why the conditions used to produce ammonia in the Haber process are a temperature of 450 °C and a pressure of 200 atmospheres.

_____

_____

_____

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(5)

(Total 12 marks)

Q10.

This question is about salts.

(a) Salt (sodium chloride) is added to many types of food.

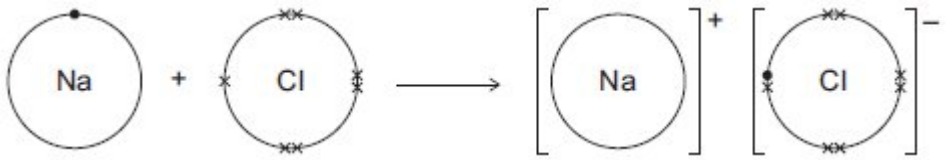
Sodium chloride is produced by reacting sodium with chlorine.

sodium + chlorine ⟶ sodium chloride

The diagram shows what happens to atoms of sodium and chlorine in this reaction.

The dots (•) and crosses (×) represent electrons.

Only the outer electrons are shown.



Describe, in terms of electrons, what happens when a sodium atom reacts with a chlorine atom to produce sodium chloride.

_____

_____

_____

_____

_____

_____

(3)

(b) Lack of iodine can affect the learning ability of children.

One idea is that salt (sodium chloride) should have iodine added.

(i) Iodine consists of simple molecules.

What is a property of substances that have simple molecules?

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Tick (✓) **one** box.

Have no overall electric charge ☐

Have high boiling points ☐

Have giant covalent structures ☐

(1)

(ii) Which one of the following questions cannot be answered by science alone?

Tick (✓) **one** box.

How much sodium chloride is in food? ☐

What harm does a lack of iodine do? ☐

Should iodine be added to salt in food? ☐

Give **one** reason why this question cannot be answered by science alone.

_____

_____

(2)

(c) A student produced the salt ammonium nitrate by adding an acid to ammonia solution.

(i) Name the acid used.

_____

(1)

(ii) Use the correct answer from the box to complete the sentence.

an acid	**an alkali**	**a salt**

Ammonia solution (ammonium hydroxide) is _____ .

(1)

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(iii) The student added a few drops of a solution which changed colour when the reaction was complete.

Complete the sentence.

The solution added is an _____ .

(1)

(d) Farmers buy solid ammonium nitrate in poly(ethene) sacks.

(i) How is solid ammonium nitrate made from a solution of ammonium nitrate?

Tick (✓) **one** box.

Crystallisation ☐

Decomposition ☐

Electrolysis ☐

(1)

(ii) Why do farmers use ammonium nitrate on their fields?

_____

_____

(1)

(iii) The properties of poly(ethene) depend on the reaction conditions when it is made.

State **one** reaction condition that can be changed when making poly(ethene).

_____

_____

(1)

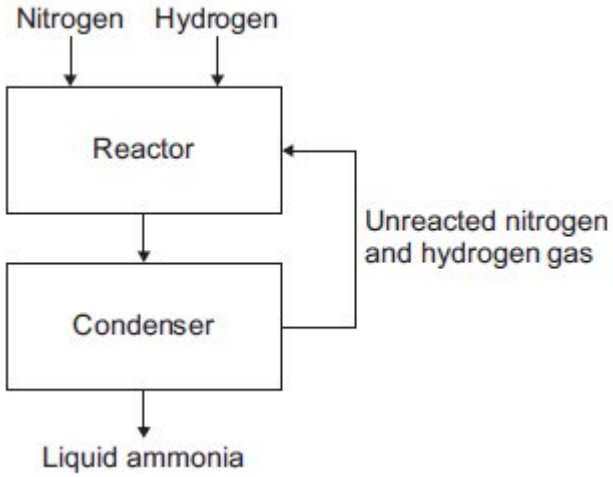
(Total 12 marks)

Q11.

A flow diagram of the Haber process is shown below.

The Haber process produces ammonia from nitrogen and hydrogen.

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(a) Use the correct answer from the box to complete the sentence.

air	limestone	natural gas

Hydrogen is obtained from _____ .

(1)

(b) In the reactor, nitrogen and hydrogen at a high pressure are heated and passed over a catalyst.

(i) Use the correct answer from the box to complete the sentence.

25	100	450

The temperature in the reactor is _____ °C

(1)

(ii) Use the correct answer from the box to complete the sentence.

copper	iron	nickel

The catalyst used in the reactor is _____ .

(1)

(iii) How does a catalyst speed up a reaction?

Tick (✓) **one** box.

The catalyst lowers the activation energy. ☐

The catalyst gives the reactants extra energy. ☐

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The catalyst increases the pressure in the reactor. ☐

(1)

(c) A mixture of gases leaves the reactor.

The mixture contains ammonia, nitrogen and hydrogen.

Describe what happens to this mixture of gases in the condenser.

Use the flow diagram to help you.

_____

_____

_____

_____

_____

_____

(3)

(Total 7 marks)

Q12.

This question is about reversible reactions and chemical equilibrium.

(a) Reversible reactions can reach equilibrium in a closed system.

(i) What is meant by a closed system?

_____

_____

(1)

(ii) Explain why, when a reversible reaction reaches equilibrium, the reaction appears to have stopped.

_____

_____

_____

_____

(2)

(b) In the Haber process, the reaction of nitrogen with hydrogen to produce ammonia is reversible.

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

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(i) Name a natural resource from which hydrogen is produced.

_____

(1)

(ii) The Haber process uses a catalyst to speed up the reaction.

Explain how a catalyst speeds up a reaction.

_____

_____

_____

_____

(2)

(iii) What happens to the amount of ammonia produced at equilibrium if the pressure is increased?

Give a reason for your answer.

_____

_____

_____

_____

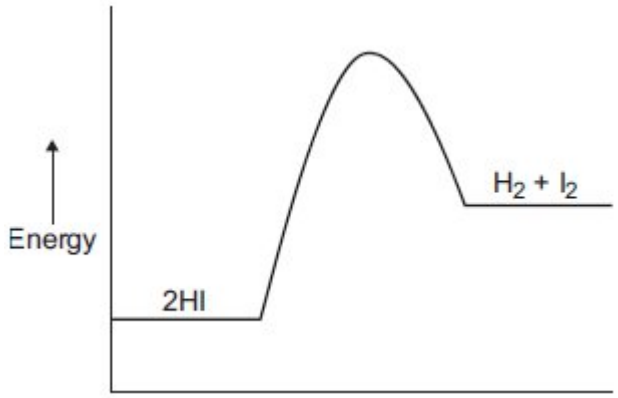
(2)

(c) The decomposition of hydrogen iodide into hydrogen and iodine is reversible.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

The forward reaction is endothermic.

The energy level diagram shown below is for the forward reaction.



(i) Draw an arrow to show the activation energy on the diagram.

(1)

(ii) How does the diagram show that the reaction is endothermic?

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_____

_____

(1)

(iii) Suggest what effect, if any, increasing the temperature will have on the amount of hydrogen iodide at equilibrium.

Give a reason for your answer.

_____

_____

_____

_____

(2)

(Total 12 marks)

Q13.

In 1909 Fritz Haber invented a process to produce ammonia from nitrogen and hydrogen.

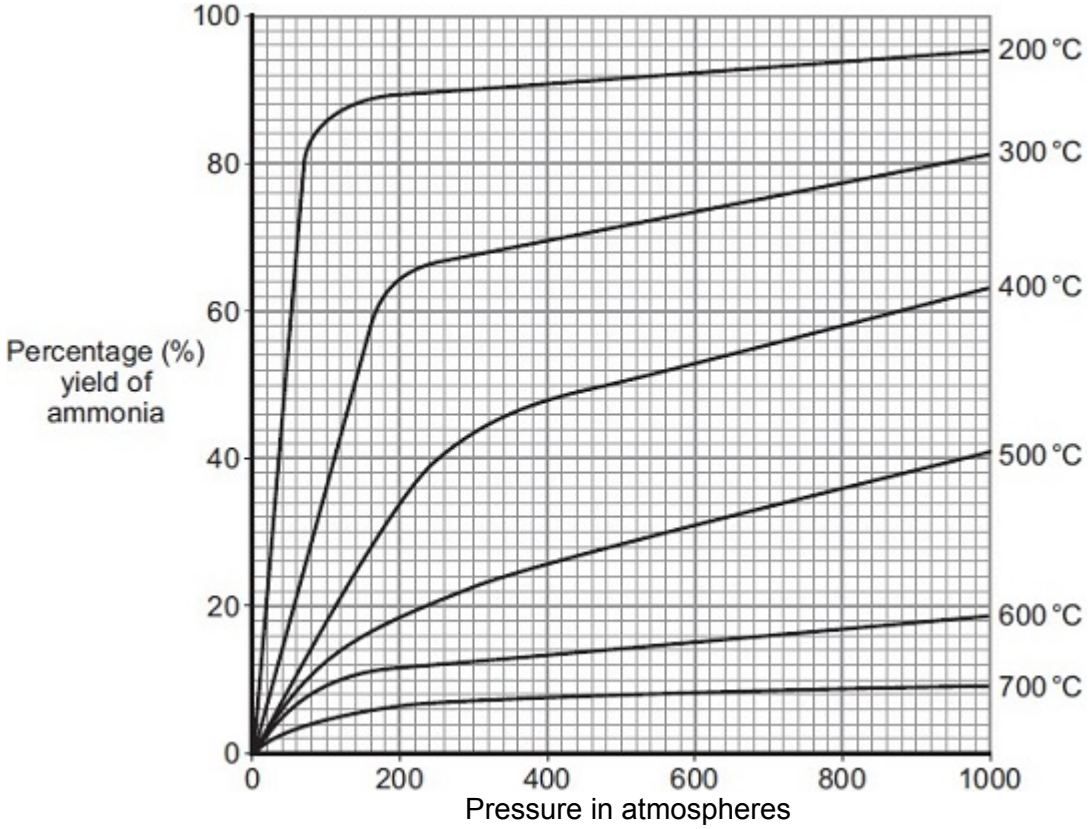
(a) Complete and balance the chemical equation for the production of ammonia from nitrogen and hydrogen.

$N_2 + 3\ H_2 \rightleftharpoons$ _____

(2)

(b) The figure below shows how the equilibrium yield of ammonia changes with pressure at different temperatures.

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(i) Use the information in given in the figure to complete the sentence.

The temperature on the graph that gives the highest yield of ammonia is

_____ °C.

(1)

(ii) The temperature used in the Haber process for the production of ammonia is 450 °C.

Why is a temperature much lower than 450 °C **not** used for the Haber process?

_____

_____

(1)

(iii) Use the information in the figure to answer this question.

Draw a ring around the pressure that gives the highest yield of ammonia.

100 **200** **300** **400**

(1)

(iv) The pressure used in the Haber process for the production of ammonia is 200 atmospheres.

Why is a pressure lower than 200 atmospheres **not** used for the Haber process?

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_____

_____

(1)

(c) Explain how ammonia is separated from unreacted nitrogen and hydrogen in the Haber process.

_____

_____

_____

_____

(2)

(Total 8 marks)

Q14.

Ammonium salts, such as ammonium sulfate, are used to help farmers grow crops.



© Artur Synenko/iStock

(a) Use the correct word from the box to complete the sentence.

fertilisers	**insecticides**	**pesticides**

Ammonium salts contain nitrogen and are used by farmers as

_____to replace the nitrogen lost from the soil.

(1)

(b) Ammonia is made by reacting nitrogen with hydrogen.

Which raw material provides nitrogen?

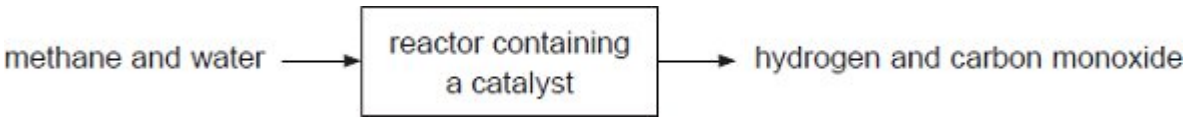
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Draw a ring around your answer.

air **crude oil** **water**

(1)

(c) Methane and water react together to form hydrogen.



How does the catalyst help this reaction?

_____

(1)

(d) The reaction between nitrogen and hydrogen to make ammonia can be represented by this equation.

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

What is the meaning of this symbol $\rightleftharpoons$?

Draw a ring around your answer.

endothermic reaction **precipitation reaction** **reversible reaction**

(1)

(e) A solution of ammonia in water is alkaline.

(i) Which **one** of these values could be the pH of a solution of ammonia?

Draw a ring around your answer.

4 **7** **10**

(1)

(ii) Ammonium sulfate can be made by reacting ammonia solution with sulfuric acid.

Use the correct answer from the box to complete the sentence.

ammonium sulfate	**hydrogen**	**sulfuric**	**water**

During the reaction the hydrogen ions (H^+) from the acid react with hydroxide ions

(OH^-) from the alkali to make

_____ .

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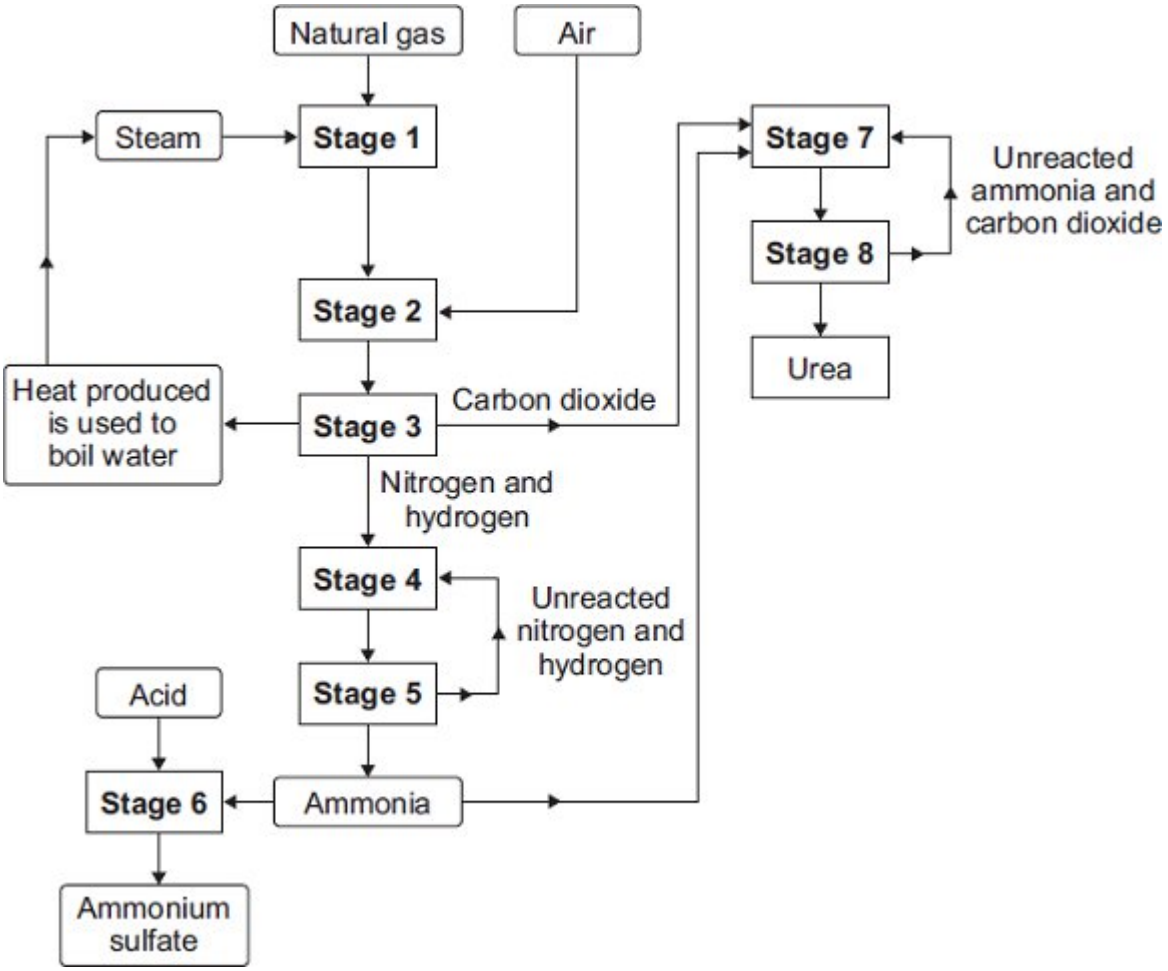
(1)

(Total 6 marks)

Q15.

Ammonium sulfate and urea are made from ammonia. These compounds are used by farmers.

The flow diagram shows the stages to make ammonium sulfate and urea.



(a) Give **two** examples from the flow diagram of the efficient use of energy and raw materials.

_____

_____

_____

_____

_____

_____

(2)

(b) The equation for the reaction in Stage **4** is shown below.

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

The forward reaction is exothermic.

State **and** explain:

(i) how a **decrease** in temperature would affect the yield of ammonia at equilibrium

_____

_____

_____

_____

_____

(2)

(ii) how an **increase** in pressure would affect the yield of ammonia at equilibrium.

_____

_____

_____

_____

_____

(2)

(c) The equation for the reaction in Stage **7** is shown below.

$$\underset{\text{ammonia}}{2\,NH_3} + CO_2 \rightleftharpoons \underset{\text{urea}}{NH_2CONH_2} + H_2O$$

The table gives the relative formula masses (M_r) of the reactants and the products for this reaction.

Formula of reactant or product	**Relative formula masses (M_r)**
NH_3	17
CO_2	44
NH_2CONH_2	60
H_2O	18

Percentage atom economy can be calculated using:

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Percentage atom economy = $\frac{M_r \text{ of useful product}}{\text{total } M_r \text{ of all reactants added together}} \times 100\%$

Calculate the percentage atom economy for the reaction in Stage **7**.

_____

_____

_____

_____

_____

_____

Percentage atom economy = _____ %

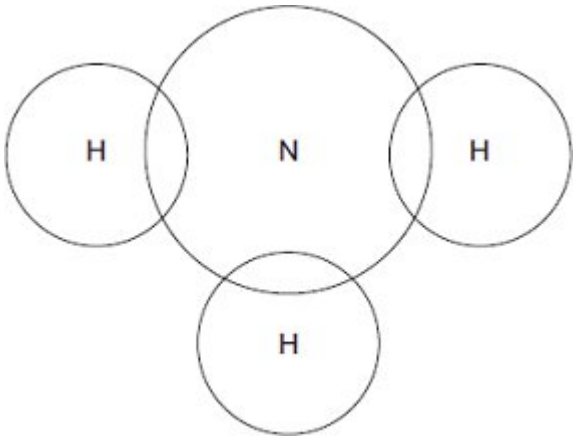
(2)

(Total 8 marks)

Q16.

(a) Complete the dot and cross diagram to show the electrons in the outer energy levels of ammonia (NH_3).

You may use the periodic table to help you.



(2)

(b) Ammonia can be used to make ammonium nitrate (NH_4NO_3).

(i) Draw a ring around the correct answer to complete the sentence.

Ammonium nitrate can be made by reacting ammonia with | ethanoic / hydrochloric / nitric | acid.

(1)

(ii) State **one** use of ammonium nitrate.

_____

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(1)

(iii) Calculate the relative formula mass (M_r) of ammonium nitrate (NH_4NO_3).

Relative atomic masses: H = 1; N = 14; O = 16.

_____

_____

Relative formula mass (M_r) = _____

(2)

(iv) Calculate the percentage by mass of nitrogen in ammonium nitrate.

_____

_____

_____

_____

Percentage by mass of nitrogen = _____ %

(2)

(c) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

Ammonia is manufactured from nitrogen and hydrogen by the Haber process:

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

The forward reaction is exothermic.

The conditions used in the Haber process are:

- 200 atmospheres pressure
- 450 °C
- iron catalyst.

Use the equation and your knowledge of reversible reactions to explain why these conditions are used in the Haber process.

To get full marks you must consider **both** yield **and** rate of reaction in your answer.

_____

_____

_____

_____

_____

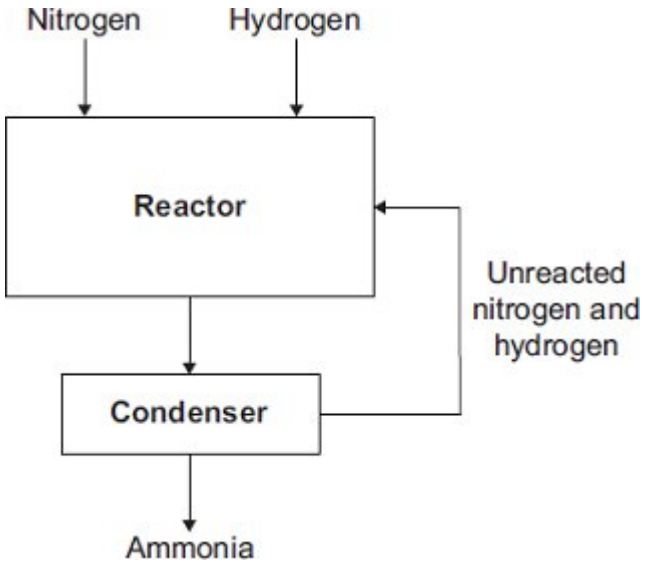
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(6)

(Total 14 marks)

Q17.

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:

nitrogen + hydrogen $\rightleftharpoons$ ammonia

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

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

exothermic.
reversible.

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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.

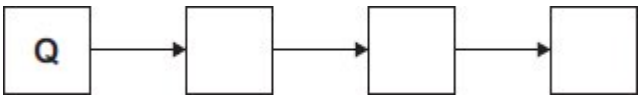
Q Nitrogen and hydrogen are mixed together.

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.



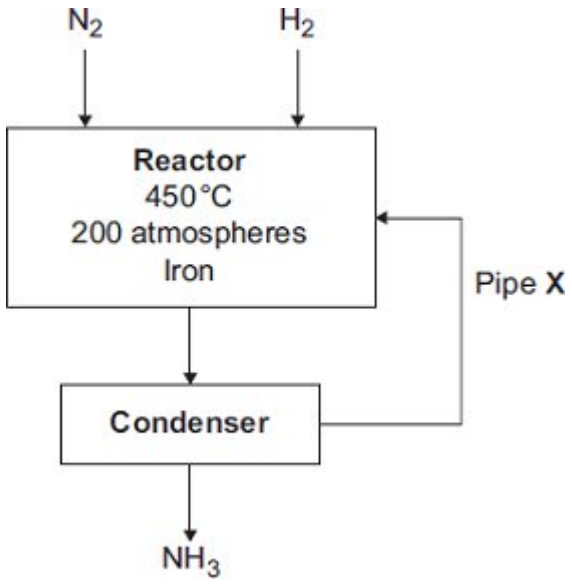
(2)

(Total 5 marks)

Q18.

The flow diagram shows the Haber process. In the Haber process, ammonia (NH_3) is produced from nitrogen (N_2) and hydrogen (H_2).

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(a) Which raw material is nitrogen obtained from?

_____

(1)

(b) What is the purpose of Pipe **X**?

_____

_____

_____

_____

(2)

(c) Balance the chemical equation below for the production of ammonia.

N_2 + _____H_2 $\rightleftharpoons$ _____NH_3

(1)

(d) A temperature of 450°C is used in the reactor.
The reaction of nitrogen with hydrogen is reversible.
The forward reaction is exothermic.

Explain why a temperature of 450°C is the optimum temperature for the Haber process.

_____

_____

_____

_____

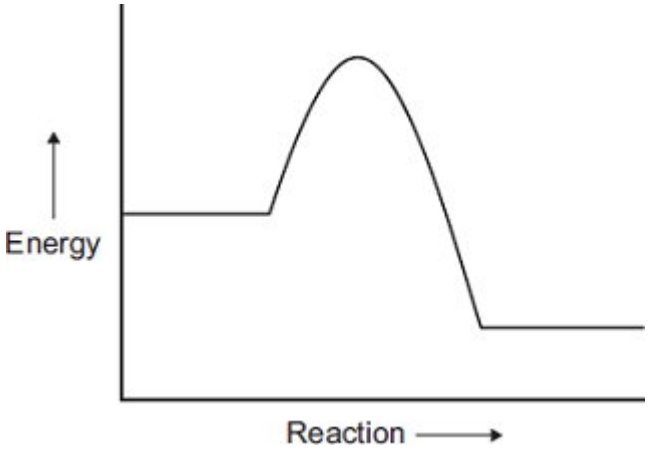
_____

_____

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(2)

(e) An energy level diagram for the reaction between nitrogen and hydrogen is shown below.



(i) How does the energy level diagram show this reaction is exothermic?

_____

_____

(1)

(ii) In the Haber process iron is used as a catalyst.

Draw a line on the energy level diagram to show the effect of adding a catalyst.

(1)

(Total 8 marks)

Q19.

(a) Ammonia solution is used in cleaning products to remove grease from kitchen surfaces.



Ammonia solution is alkaline.

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(i) Draw a ring around the number most likely to be the pH of ammonia solution.

1 **3** **7** **10**

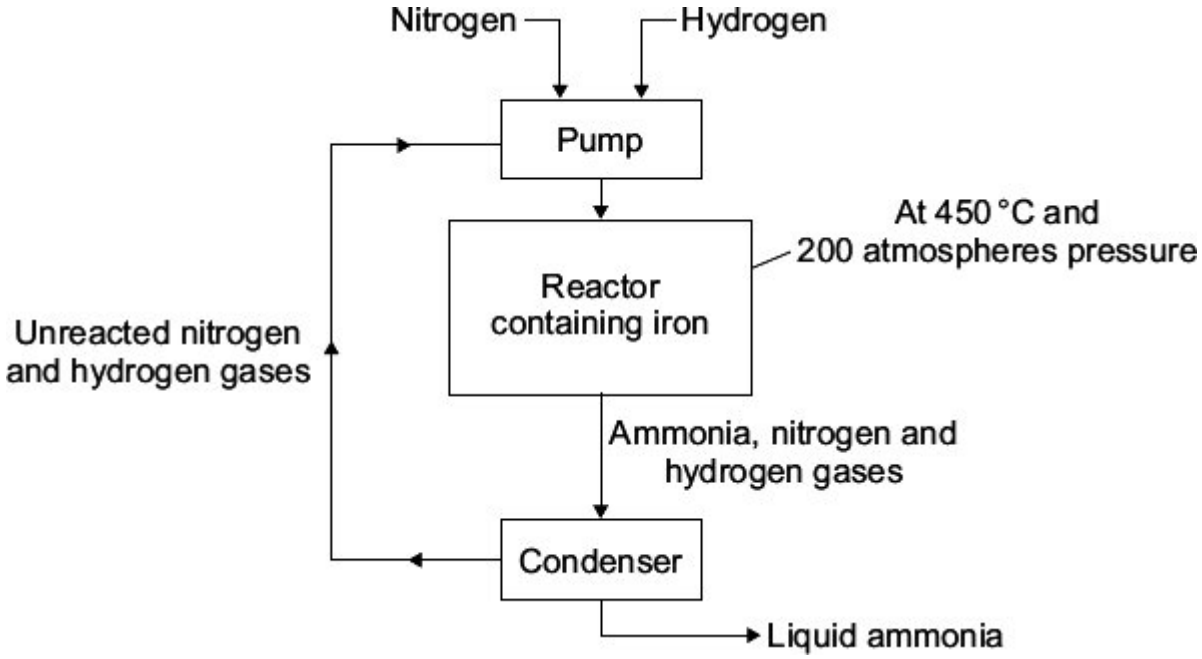
(1)

(ii) Draw a ring around the ion in ammonia solution which makes it alkaline.

Cl^- **H^+** **Na^+** **OH^-**

(1)

(b) Ammonia is made using the Haber process.



(i) Where does the nitrogen used in the Haber process come from?

Draw a ring around your answer.

air **natural gas** **water**

(1)

(ii) A high temperature of 450 °C is used in the reactor.

Tick (✓) **two** reasons in the table which explain why high temperatures make reactions faster.

Reasons	**Tick (✓)**
Particles move faster	
Particles are closer together	

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Particles collide more often	
Particles have less energy	

(2)

(iii) The iron in the reactor speeds up the reaction but is not used up.

What is the name given to substances that speed up the chemical reaction but which are not used up during the reaction?

_____

(1)

(c) Complete the sentence.

The condenser separates the ammonia from the unreacted nitrogen and hydrogen

by turning the ammonia into a _____

(1)

(Total 7 marks)

Q20.

(a) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

The salt called potassium chloride is made when potassium hydroxide solution reacts with hydrochloric acid.

potassium hydroxide solution + hydrochloric acid → potassium chloride solution + water

Describe a method for making **crystals** of potassium chloride from potassium hydroxide solution and hydrochloric acid.

In this method you should:

- describe how you will add the correct amount of the hydrochloric acid to neutralise the potassium hydroxide solution
- describe how you will get crystals of potassium chloride.

_____

_____

_____

_____

_____

_____

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_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(6)

(b) Ammonium nitrate is another salt.
Ammonium nitrate is made when ammonia solution is neutralised with an acid.

Name the acid to complete the word equation.

ammonia + _____ acid → ammonium nitrate

(1)

(c) Read the information.

Ammonium nitrate – good or bad?

Some farmers put a lot of ammonium nitrate on their farmland.

Many people are worried about this use of ammonium nitrate.

Rain water can wash the ammonium nitrate off the farmland and into rivers and lakes. The ammonium nitrate may get into drinking water supplies and could be harmful to health.

(i) Why do some farmers put ammonium nitrate on their farmland?

_____

_____

(1)

(ii) Which **one** of the questions in the table cannot be answered by science alone?

Tick (✓) **one** question.

Question	Tick (✓)

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How much ammonium nitrate is in drinking water?	
Should farmers stop using ammonium nitrate on their farmland?	
Is ammonium nitrate soluble in rain water?	

Give **two** reasons why this question **cannot** be answered by science alone.

_____

_____

_____

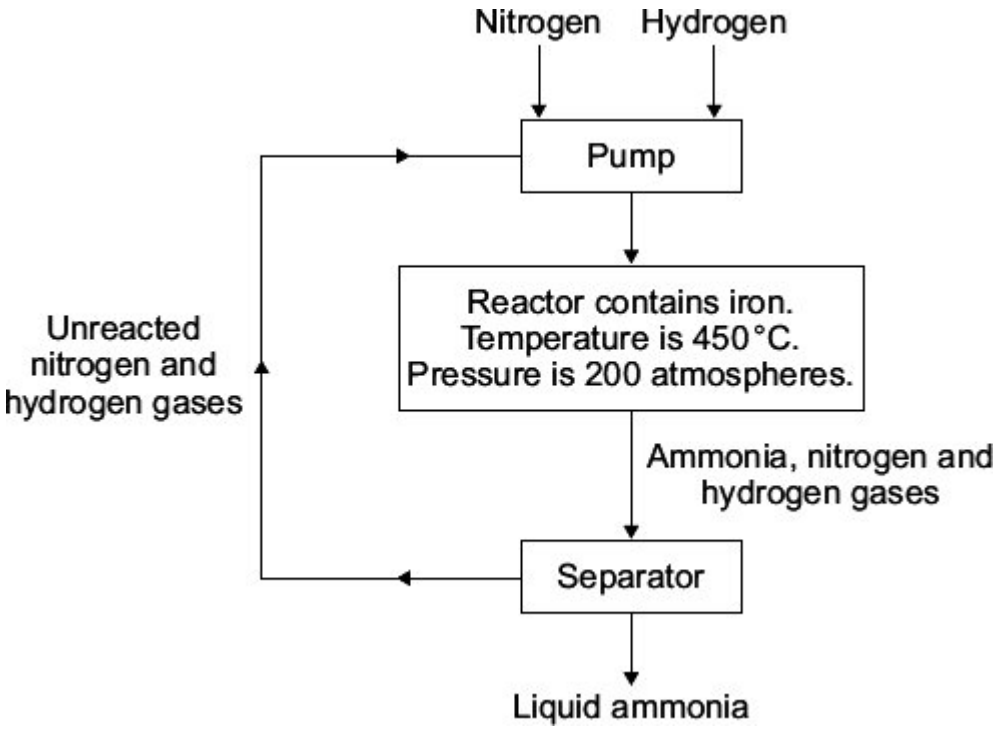
_____

(3)

(Total 11 marks)

Q21.

Ammonia is made using the Haber process.



(a) How is ammonia separated from unreacted nitrogen and hydrogen in the separator?

_____

_____

_____

_____

(2)

(b) The equation shows the reaction which takes place in the reactor:

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

(i) Why does the yield of ammonia at equilibrium increase as the temperature is decreased?

_____

_____

(1)

(ii) A temperature of 450 °C is used in the reactor to make the reaction take place quickly.

Explain, in terms of particles, why increasing the temperature makes a reaction go faster.

_____

_____

_____

_____

(2)

(iii) Why does the yield of ammonia at equilibrium increase as the pressure is increased?

_____

_____

(1)

(iv) The pressure used in the reactor is 200 atmospheres.
Suggest why a much higher pressure is **not** used.

_____

_____

(1)

(c) Use the equation for the reaction in the reactor to help you to answer these questions.

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

(i) It is important to mix the correct amounts of hydrogen and nitrogen in the reactor.

20 m^3 of nitrogen is reacted with hydrogen.

What volume of hydrogen (measured at the same temperature and pressure as the nitrogen) is needed to have the correct number of molecules to react with the nitrogen?

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Volume of hydrogen needed = _____ m^3

(1)

(ii) Calculate the maximum mass of ammonia that can be made from 2 g of nitrogen.

Relative atomic masses: H = 1; N = 14.

_____

_____

_____

_____

_____

_____

Maximum mass of ammonia = _____ g

(3)

(d) The expected maximum mass of ammonia produced by the Haber process can be calculated.

(i) In one process, the maximum mass of ammonia should be 80 kg.

The actual mass of ammonia obtained was 12 kg.

Calculate the percentage yield of ammonia in this process.

_____

_____

Percentage yield of ammonia = _____ %

(1)

(ii) Give **two** reasons why it does **not** matter that the percentage yield of ammonia is low.
Use the flow diagram at the start of this question to help you.

_____

_____

_____

_____

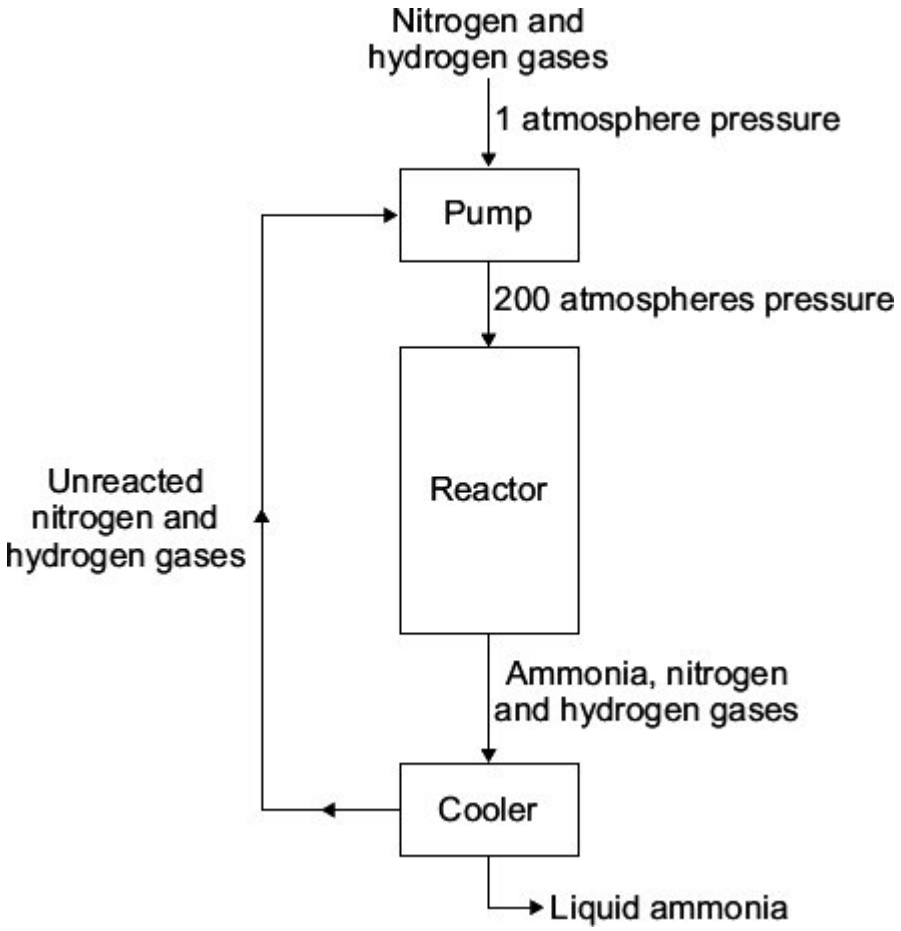
(2)

(Total 14 marks)

Q22.

The flow diagram shows how ammonia is made.

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(a) What effect, if any, does the **pump** have on the pressure of the nitrogen and hydrogen?

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

The pump [decreases / has no effect on / increases] the pressure.

(1)

(b) The word equation for making ammonia is:

$$\text{nitrogen} + \text{hydrogen} \rightleftharpoons \text{ammonia}$$

In the **reactor** only a small amount of the nitrogen and hydrogen is changed into ammonia.

Tick (✓) the reason why.

Reason why	**Tick (✓)**
Ammonia is formed from two elements.	

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Nitrogen and hydrogen are gases.	
The reaction is reversible.	

(1)

(c) In the **cooler** the mixture of gases is cooled.

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

The cooler turns the ammonia into

- a liquid.
- a solid.
- an element.

(1)

(d) What happens to the unreacted nitrogen and hydrogen from the **reactor**?

_____

_____

(1)

(Total 4 marks)

Q23.

Humberstone was a town in the desert of Northern Chile in South America. It was built for the people who worked in the nearby sodium nitrate mines.

The sodium nitrate was used as a fertiliser.

The sodium nitrate was exported by ship to countries all around the world.

Today the mines have closed and nobody lives in Humberstone.

One of the reasons for the mines closing was the invention of the Haber process.



By Sznegra (Own work) [CC-BY-SA-3.0], via Wikimedia Commons

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(a) The Haber process is used to make ammonia (NH_3).

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

The forward reaction is exothermic.

(i) Name the raw materials that are used to supply the nitrogen and hydrogen.

Nitrogen _____

Hydrogen _____

(2)

(ii) The Haber process uses a temperature of 450 °C.

Explain, as fully as you can, why a temperature of 450 °C is used rather than a much higher temperature or a much lower temperature.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(iii) Ammonia can be converted to ammonium nitrate by adding an acid.

Name this acid.

_____

(1)

(b) Suggest and explain why the invention of the Haber process caused the closure of the Humberstone mines in Chile.

_____

_____

_____

_____

_____

(2)

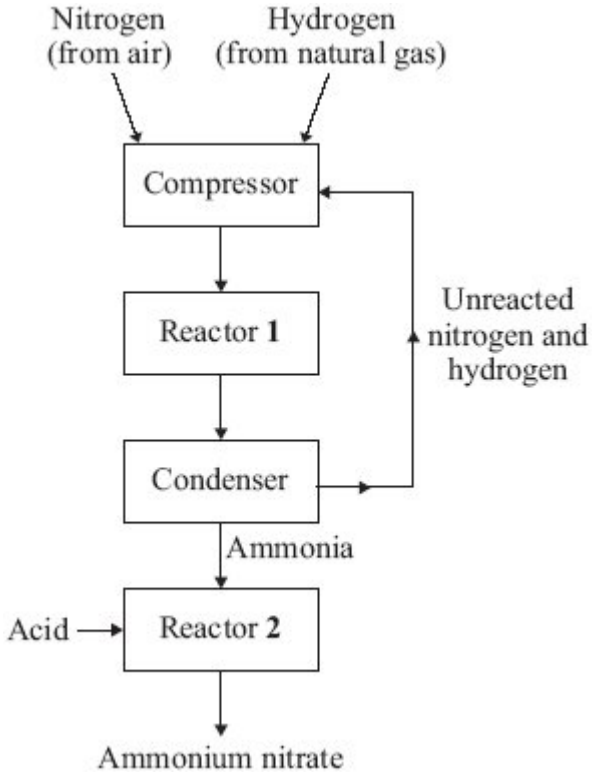
(Total 8 marks)

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Q24.

Ammonium nitrate is an important chemical. The diagram shows the main stages in the manufacture of ammonium nitrate.

Study the diagram and then answer the questions.



Draw a ring around the correct answer in each box to complete the sentences.

(a) The compressor increases the [pressure / temperature / volume] to 200 atmospheres.

(1)

(b) In reactor **1** ammonia is made by reacting [air / natural gas / nitrogen] with [air. / hydrogen. / natural gas.]

(2)

(c) In the condenser the mixture is [cooled / heated / reduced] and the ammonia is separated as a liquid.

(1)

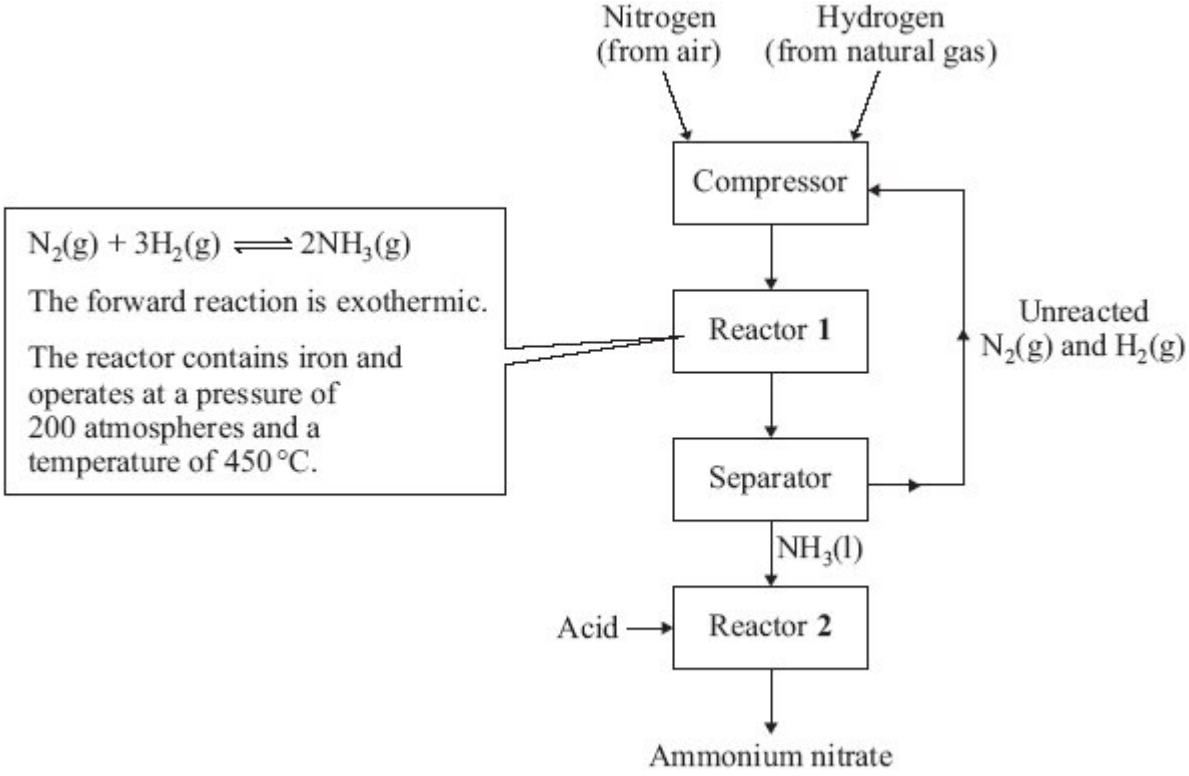
(Total 4 marks)

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Q25.

Ammonium nitrate is an important chemical. The diagram shows the main stages in the manufacture of ammonium nitrate.

Study the diagram and then answer the question.



(a) What is the purpose of the iron in reactor **1**?

_____

_____

(1)

(b) Explain why the best yield of ammonia at equilibrium is obtained:

(i) at low temperature

_____

_____

(1)

(ii) at high pressure.

_____

_____

(1)

(c) The temperature used in reactor **1** is 450 °C.

Explain why a much lower temperature is **not** used.

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_____

_____

(1)

(d) A mixture of ammonia, nitrogen and hydrogen leaves reactor **1**.

In the separator, what is done to the mixture to separate the ammonia from the other gases?

_____

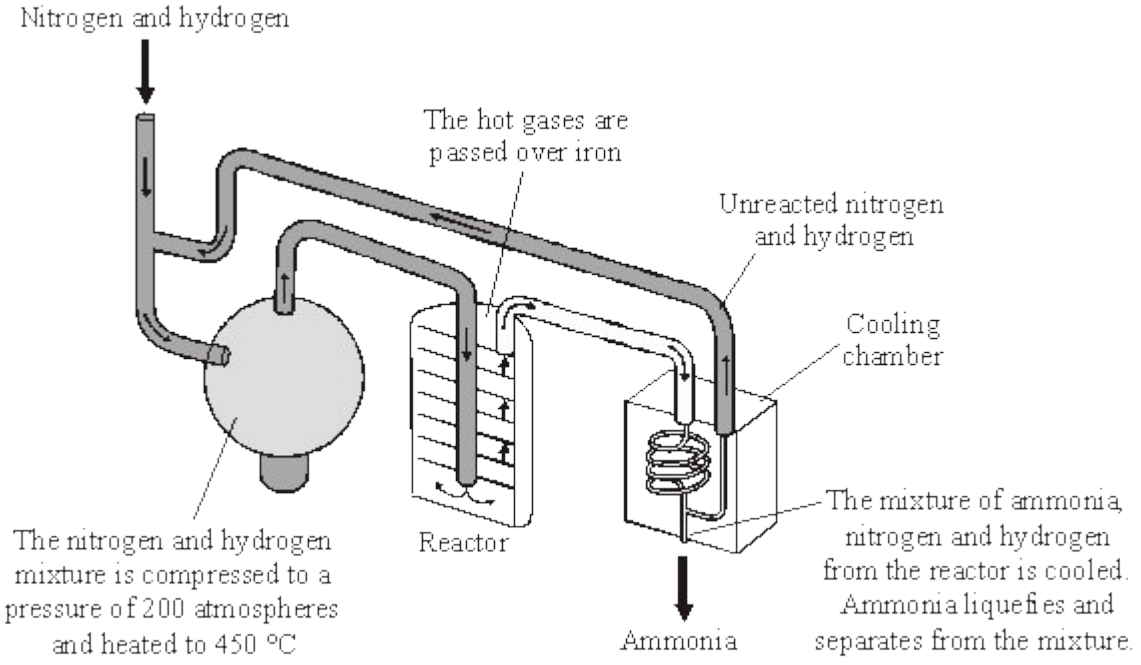
_____

(1)

(Total 5 marks)

Q26.

The Haber process is named after the German chemist, Fritz Haber.
The diagram shows the main stages in the Haber process.



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(a) Use the diagram to help you to answer these questions.

(i) Complete the word equation for the reaction that takes place in the reactor.

nitrogen + _____ ⇌ _____

(1)

(ii) What does the symbol ⇌ mean?

_____

(1)

(iii) What is the purpose of the iron in the reactor?

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_____

(1)

(iv) Ammonia is separated from unreacted nitrogen and hydrogen.

Draw a ring around the physical property that allows this separation to take place.

_____

(1)

(v) What is done with the unreacted nitrogen and hydrogen?

_____

(1)

(b) Some of the products that can be made from ammonia are:

- fertilisers
- dyes
- explosives
- medicines
- plastics

(i) The Haber process was invented a few years before the start of the First World War. It is thought that the First World War would have finished earlier if the Germans had **not** invented the Haber process.

Suggest why.

_____

_____

(1)

(ii) The Haber process has helped to increase food production.

Explain why.

_____

_____

(1)

(c) Factories that make ammonia are very large and operate night and day.

(i) Ammonia factories are often near towns.

Suggest why.

_____

(1)

(ii) Suggest and explain **one** reason why local people might not want an ammonia factory near their town.

_____

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_____

_____

_____

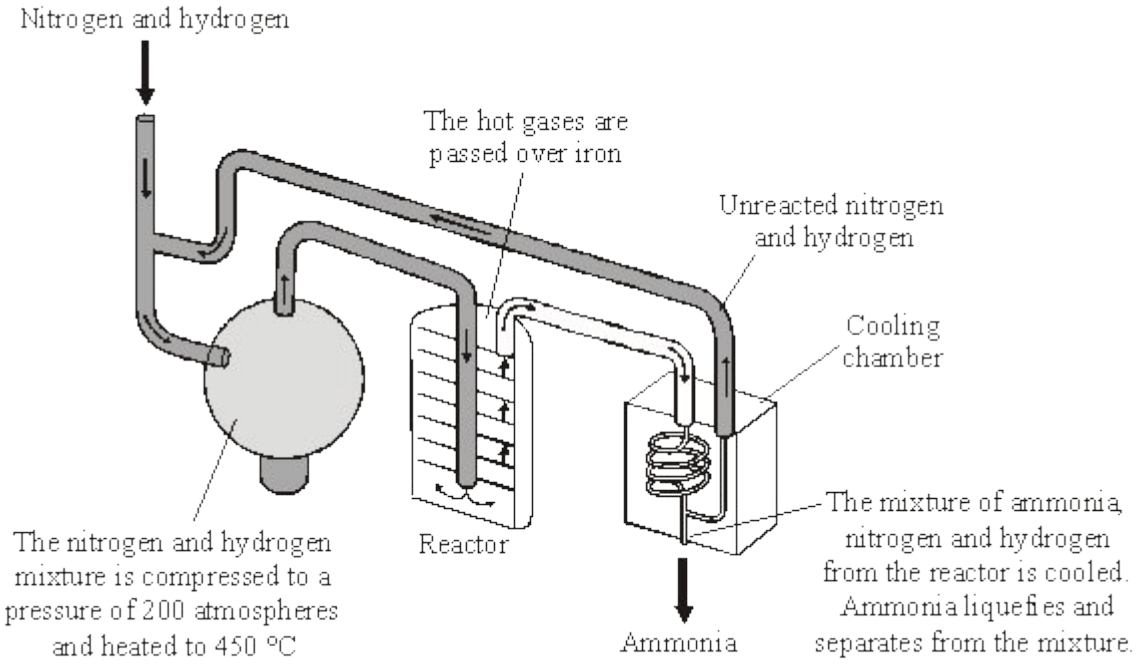
(2)

(Total 10 marks)

Q27.

The Haber process is named after the German chemist, Fritz Haber.

The diagram shows the main stages in the Haber process.



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An exothermic reaction takes place when nitrogen reacts with hydrogen to make ammonia.

The reaction can be represented by this equation.

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

(a) Calculate the maximum mass of ammonia that could be made from 1000 g of nitrogen.

Relative atomic masses: H = 1; N = 14

_____

_____

_____

_____

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Mass _____g

(3)

(b) At a temperature of 450 °C and 200 atmospheres the actual mass of ammonia produced when 1000 g of nitrogen is passed through the reactor is 304 g.

Calculate the percentage yield of ammonia produced in the reactor.

(If you did not answer part (a), then assume that the maximum mass of ammonia that can be made from 1000 g of nitrogen is 1100 g. This is **not** the correct answer to part (a).)

_____

_____

_____

_____

_____

Percentage yield of ammonia = _____ %

(2)

(c) State **and** explain:

(i) how a **decrease** in temperature would affect the yield of ammonia

_____

_____

_____

_____

(2)

(ii) how an **increase** in pressure would affect the yield of ammonia.

_____

_____

_____

_____

(2)

(d) Factories that make ammonia are often near to large towns.

Discuss the economic, safety and environmental factors to be considered when there is an ammonia factory near a town.

_____

_____

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_____

_____

_____

_____

_____

(3)

(Total 12 marks)

Q28.

Nitric acid can be neutralised by alkalis to make salts.

(i) The salt called potassium nitrate can be made from nitric acid.

Complete the word equation for this neutralisation reaction.
Choose the correct substances from the box.

hydrogen	**oxygen**	**potassium chloride**
potassium hydroxide		**water**

nitric acid + _____ →potassium nitrate + _____

(2)

(ii) Ammonium nitrate is another salt made from nitric acid.

Which **one** of the following is the main use of ammonium nitrate? Draw a ring around your answer.

dye **fertiliser** **plastic** **fuel**

(1)

(iii) Complete this sentence by choosing the correct ion from the box.

H^+	NH_4^+	NO_3^-	O^{2-}	OH^-

The ion that makes solutions acidic is _____ .

(1)

(Total 4 marks)

Q29.

Neutralisation reactions can be used to make salts.

(a) Write an ionic equation for a neutralisation reaction, including state symbols.

_____

(2)

(b) Ammonium nitrate is a salt used as a fertiliser.

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(i) Ammonium nitrate is made by mixing two solutions. Name these solutions.

_____ and _____

(1)

(ii) Hazard information about ammonium nitrate states:

- it is not itself a fire hazard (does not burn);
- it must not be allowed to come into contact with combustible materials such as fuels because it can cause these to catch fire.

Suggest why ammonium nitrate helps other substances to burn.

_____

_____

(1)

(Total 4 marks)

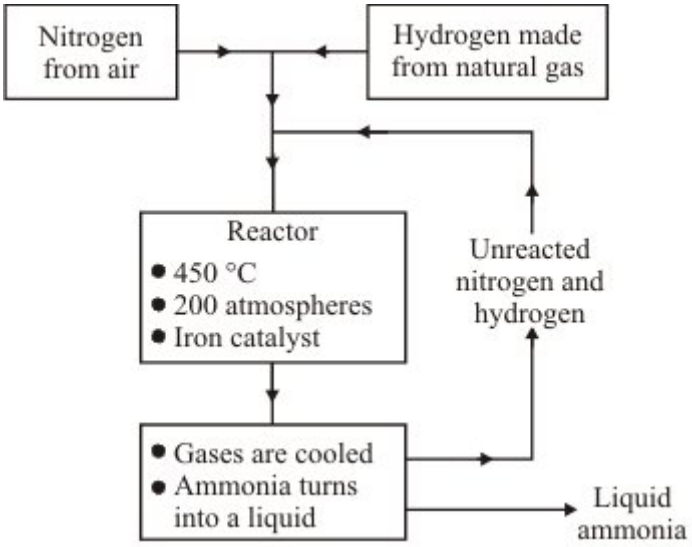
Q30.

Ammonia is made from nitrogen and hydrogen in the Haber process.

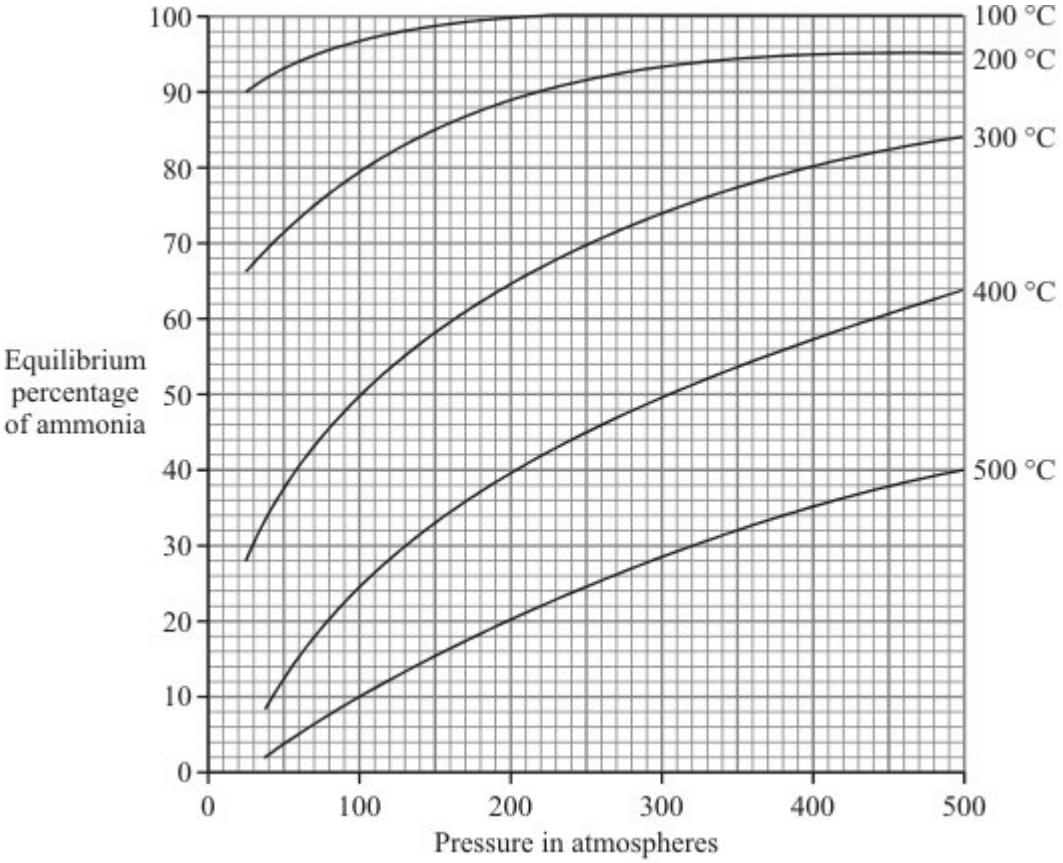
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ (+ heat)

Flow Chart for the Haber Process

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Effect of temperature and pressure on the amount of ammonia at equilibrium



(a) Use the information given above and your knowledge of the Haber process and reversible reactions to help you to answer this question.

State which conditions of temperature and pressure would give the highest percentage of
ammonia at equilibrium. Explain why.

_____

_____

_____

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_____

_____

_____

_____

_____

(4)

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

Explain why these conditions are chosen.

_____

_____

_____

_____

_____

_____

(3)

(Total 7 marks)

Q31.

As the world population increases there is a greater demand for fertilisers.



(a) Explain what fertilisers are used for.

_____

_____

_____

_____

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(2)

(b) The amount of nitrogen in a fertiliser is important.

(i) How many nitrogen atoms are there in the formula, NH_4NO_3?

_____

(1)

(ii) Work out the relative formula mass of ammonium nitrate, NH_4NO_3.

Relative atomic masses: H 1; N 14; O 16.

_____

_____

Relative formula mass of ammonium nitrate = _____

(1)

(Total 4 marks)

Q32.

Early atmospheres on Earth contained ammonia (NH_3).

(a) (i) Complete the sentence.

Our atmosphere today is made up of about _____ % nitrogen.

(1)

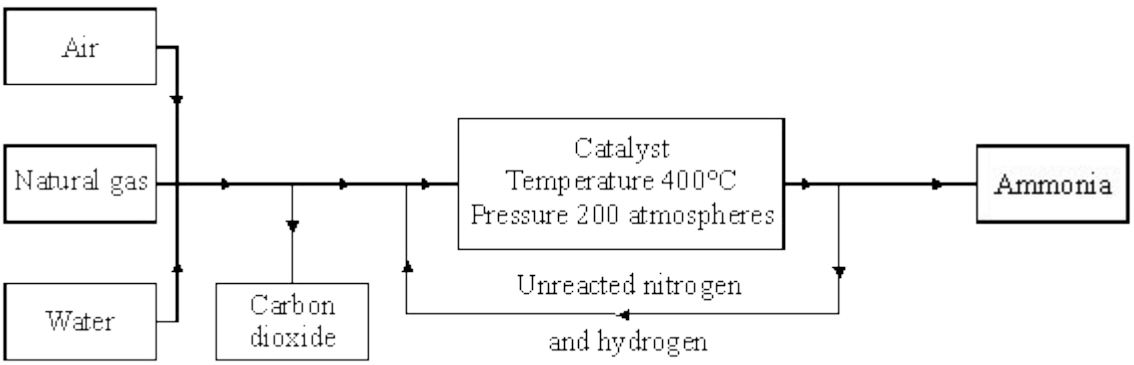
(ii) Today we convert nitrogen back to ammonia mainly for the production of fertilisers. What do plants convert the nitrogen in these fertilisers into?

_____

_____

(1)

(b) The conversion of nitrogen to ammonia is shown.



(i) When making ammonia, what is **one** source of hydrogen?

_____

(1)

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(ii) Apart from ammonia, name **one** other product formed during this conversion.

_____

(1)

(c) The main reaction is the formation of ammonia from nitrogen and hydrogen.

(i) Complete and balance the equation for this reaction.

_____(g) + _____(g) → _____NH_3(g)

(2)

(ii) Name the metal catalyst used in this reaction.

_____

(1)

(iii) This reaction does not work successfully at room temperature (20 °C) and needs a much higher temperature of 400 °C. Explain why.

_____

_____

_____

(2)

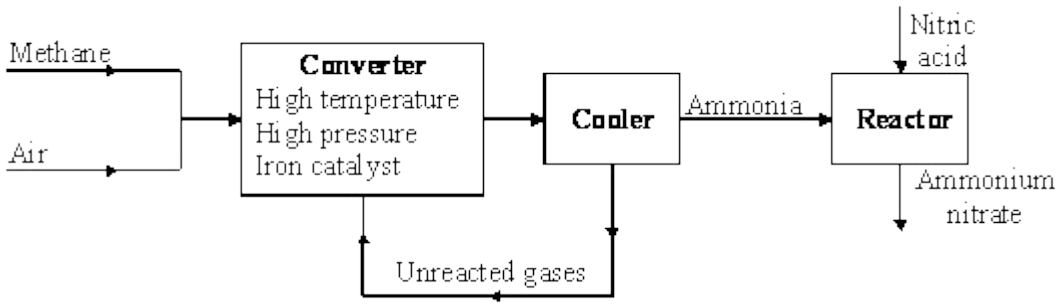
(d) Draw a diagram to show the arrangement of the electrons in a molecule of ammonia. The electron arrangement of each atom is hydrogen 1 and nitrogen 2.5.

(2)

(Total 11 marks)

Q33.

The flow diagram shows some stages in the manufacture of ammonium nitrate, NH_4NO_3.



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(a) Which elements are obtained from the raw materials to make ammonia in the converter?

_____

_____

(2)

(b) Suggest the purpose of the iron catalyst.

_____

_____

(1)

(c) Farmers add ammonium nitrate to the soil. Explain why.

_____

_____

_____

_____

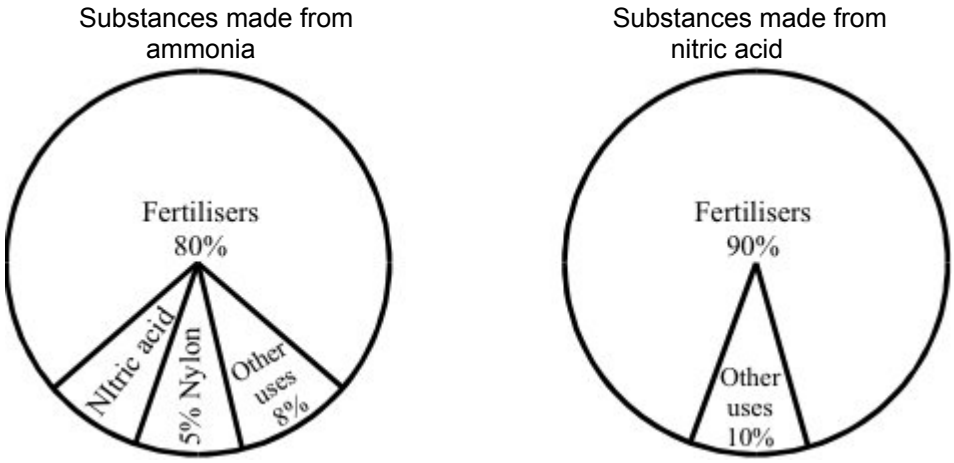
(2)

(Total 5 marks)

Q34.

Ammonia and nitric acid are both important chemicals. Nitric acid is made from ammonia.

The charts below show substances made from ammonia and nitric acid.



(a) Use the charts to help you answer these questions.

(i) What is the main use of both ammonia and nitric acid?

_____

(1)

(ii) Work out the percentage of ammonia used to make nitric acid.

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Percentage = _____ %

(1)

(iii) 100 million tonnes of ammonia are made in the world each year.

How much of this ammonia is used to make nylon?

_____ million tonnes

(1)

(b) The word equations below show how nitric acid is made.

1. nitrogen + hydrogen → ammonia
2. ammonia + oxygen → nitrogen monoxide + water
3. nitrogen monoxide + oxygen → nitrogen dioxide
4. nitrogen dioxide + water → nitric acid

Use the word equations to help you answer these questions.

(i) From which **two** elements is ammonia made?

_____ and _____

(1)

(ii) Name **two** of the raw materials needed to make nitric acid.

_____ and _____

(2)

(c) A large amount of nitric acid is reacted with ammonia to make a fertiliser.

nitric acid + ammonia → fertiliser

(i) The reaction is a neutralisation reaction.

What type of chemical must ammonia be?

_____

(1)

(ii) Complete the chemical name for the fertiliser made from ammonia and nitric acid.

ammonium _____

(1)

(iii) The reaction of nitric acid with ammonia is exothermic.

Name the piece of equipment you could put into the solution to prove that the reaction is exothermic.

_____

(1)

(Total 9 marks)

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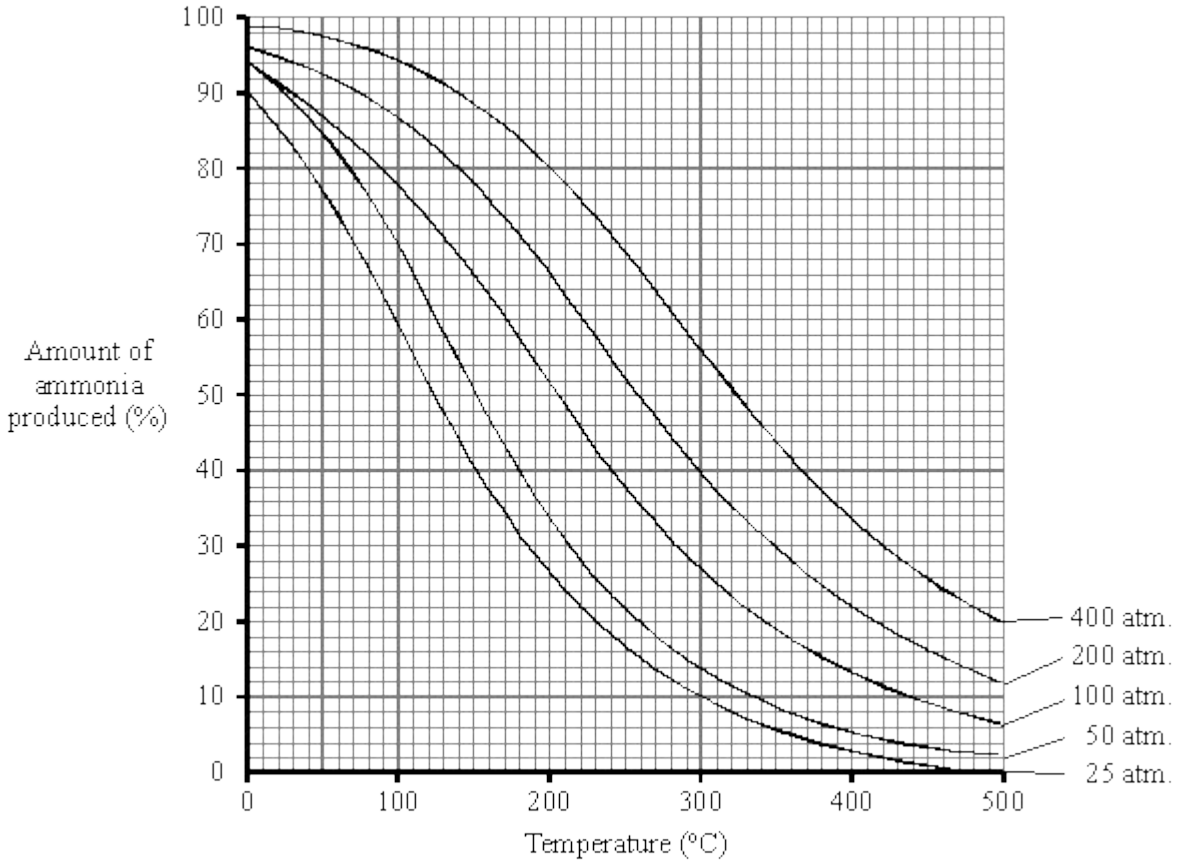
Q35.

The Haber process is used to make ammonia (NH_3) which is an important substance.

The equation below shows the reaction in which ammonia is formed.

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)} + \text{Heat}$$

The graph below shows how temperature and pressure affect how much ammonia is produced in the reaction.



In the industrial process a mixture of nitrogen and hydrogen is passed over iron at a temperature of about 450 °C and 200 atmospheres pressure.

(a) Use the graph to find the percentage of ammonia present when the temperature and pressure are 450 °C and 200 atmospheres.

_____ %

(2)

(b) Explain why the nitrogen and hydrogen mixture is passed over iron.

_____

_____

(2)

(c) Explain, as fully as you can, using the graph and your knowledge of the Haber process why 450 °C and 200 atmospheres were chosen as conditions for this process.

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_____

_____

_____

_____

_____

(8)

(Total 12 marks)

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