All questions are for separate science students only

Q1.

This question is about fertilisers.

Some fertilisers are described as NPK fertilisers because they contain three elements needed for healthy plant growth.

(a) Which two compounds each contain two of these elements?

Tick (✓) two boxes.

Ammonium nitrate	☐
Ammonium phosphate	☐
Calcium chloride	☐
Calcium phosphate	☐
Potassium chloride	☐
Potassium nitrate	☐

(2)

(b) Rocks containing calcium phosphate are treated with acid to produce soluble salts that can be used as fertilisers.

Name the soluble salts produced when calcium phosphate reacts with:

- nitric acid
- phosphoric acid.

Nitric acid _____

Phosphoric acid _____

(2)

(c) Ammonium sulfate is a compound in fertilisers.

Ammonium sulfate can be made using an industrial process or in the laboratory.
In the industrial process, the following steps are used.

1. React streams of ammonia solution and sulfuric acid together.
2. Evaporate the water by passing the solution down a warm column.

3. Collect dry crystals continuously at the bottom of the column.

In the laboratory, the following steps are used.

1. React ammonia solution and sulfuric acid in a conical flask.
2. Evaporate water from the solution until crystals start to form.
3. Leave to cool and crystallise further.
4. Separate the crystals using filtration.
5. Dry the crystals between pieces of filter paper.

Evaluate the two methods for producing a large mass of ammonium sulfate.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)
(Total 8 marks)

Q2.

This question is about ammonia and fertilisers.

Ammonia is produced from nitrogen and hydrogen.

A catalyst is used to speed up the reaction.

The word equation for the reaction is:

nitrogen + hydrogen $\rightleftharpoons$ ammonia

(a) What does the symbol $\rightleftharpoons$ show about the reaction?

_____

_____

(1)

(b) Which catalyst is used when ammonia is produced from nitrogen and hydrogen?

Tick (✓) one box.

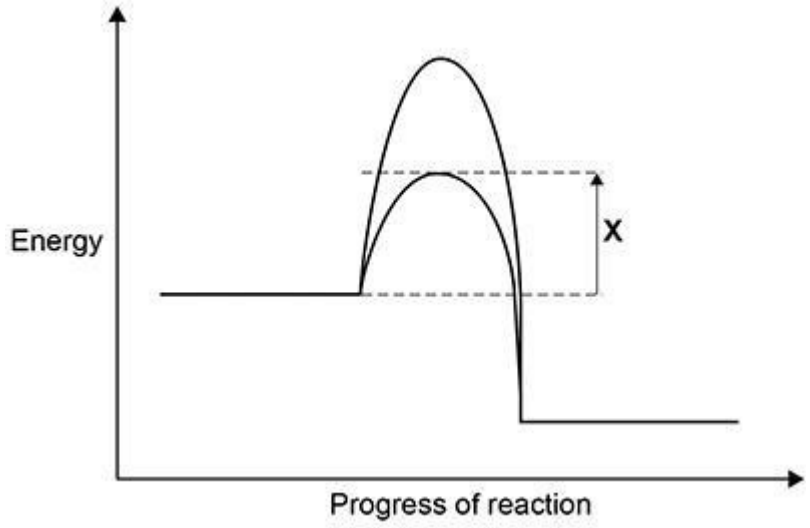
Chlorine ☐

Iron ☐

Oxygen ☐

(1)

(c) The diagram below shows the reaction profile for the production of ammonia both with a catalyst and without a catalyst.



What is represented by label X ?

Tick (✓) one box.

Activation energy with a catalyst ☐

Activation energy without a catalyst ☐

Overall energy change with a catalyst ☐

Overall energy change without a catalyst ☐

(1)

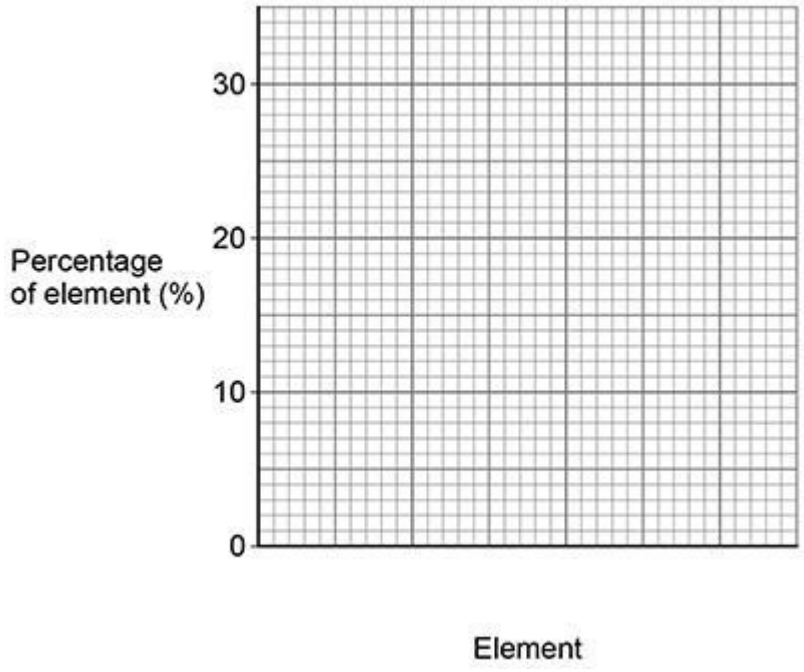
Ammonia is used to produce fertilisers.

NPK fertilisers contain the elements nitrogen, phosphorus and potassium.

A fertiliser contains:

- 22% phosphorus
- 25% potassium.

(d) Draw a bar chart on the graph below to show the percentages of phosphorus and of potassium in this fertiliser.



(2)

(e) Why do the percentages of phosphorus and of potassium in this fertiliser not add up to 100%?

_____

_____

(1)

Fertilisers help plants grow by adding essential elements to soil.

The table below shows the percentages of nitrogen, phosphorus and potassium in four fertilisers, A, B, C and D.

Fertiliser	Percentage (%) of essential element		
	Nitrogen (N)	Phosphorus (P)	Potassium (K)
A	14	0	39

B	25	16	23
C	21	23	0
D	21	0	0

(f) Plants lacking essential elements do not grow well because:

- too little phosphorus can cause slow plant growth
- too little potassium can cause leaves to have brown edges.

Which fertiliser helps prevent slow plant growth and brown leaf edges?

Use the table above.

Tick (✓) one box.

A ☐ B ☐ C ☐ D ☐

(1)

(g) Which fertiliser has the greatest total percentage of essential elements?

Use the table above.

Tick (✓) one box.

A ☐ B ☐ C ☐ D ☐

(1)

(Total 8 marks)

Q3.

Hydrogen is a raw material in the Haber process.

Hydrogen is produced from methane. The word equation for the reaction is:

methane + steam ⇌ carbon monoxide + hydrogen

(a) How can you tell that the reaction is reversible?

_____

_____

(1)

(b) The forward reaction is endothermic.

Name the type of energy change in the reverse reaction.

_____

_____

(1)

(c) A nickel catalyst is used in this reaction.

Why is a catalyst used in this reaction?

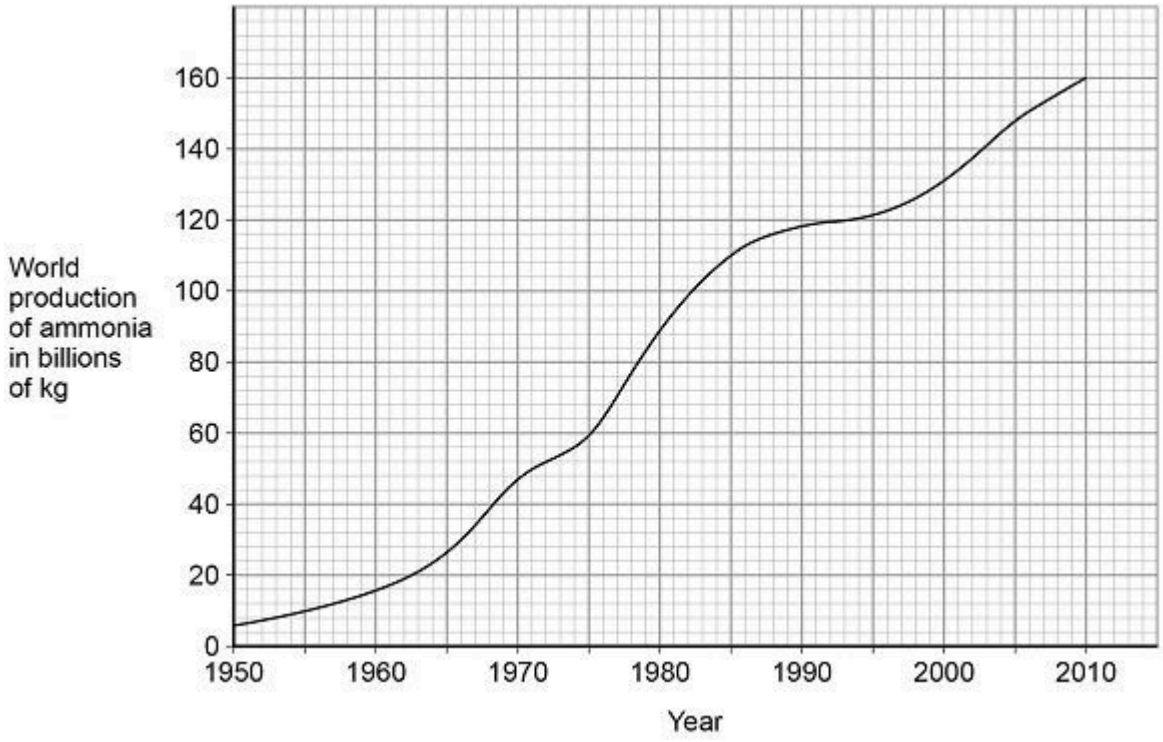
Tick (✓) two boxes.

To increase the temperature	☐
To produce less carbon monoxide	☐
To reduce costs	☐
To use less energy	☐
To use less methane	☐

(2)

(d) The Haber process also uses nitrogen to produce ammonia.

The graph below shows how the world production of ammonia changed between 1950 and 2010.



Describe how the world production of ammonia changed between 1950 and 2010.

_____

_____

_____

_____

(2)

Most of the ammonia produced is used to make fertilisers.

(e) Why did the world production of ammonia change between 1950 and 2010?

Tick (✓) two boxes.

- The demand for food changed. ☐
- The demand for fuels changed. ☐
- The nitrogen percentage in air changed. ☐
- The number of cars changed. ☐

The world population changed. ☐

(2)

The following table shows data about four fertilisers, A, B, C and D.

Fertiliser	Percentage by mass of nitrogen (%)	Percentage by mass of phosphorus (%)	Percentage by mass of potassium (%)
A	35.0	0.0	0.0
B	21.2	0.0	0.0
C	21.2	23.5	0.0
D	0.0	0.0	52.3

(f) Which combination of fertilisers A, B, C and D provides all of the elements needed for an NPK fertiliser?
Use the table.

Tick (✓) one boxes.

A and C ☐

A and D ☐

B and C ☐

C and D ☐

(1)

(g) Which fertiliser is not made using ammonia?

Use the table above.

Tick (✓) one boxes.

A ☐

B ☐

C ☐

D ☐

(1)

(Total 10 marks)

Q4.

This question is about reversible reactions and equilibrium.

Hydrogen is used to produce ammonia in the Haber process.

The hydrogen is made in two stages.

Stage 1 is the reaction of methane and steam to produce carbon monoxide and hydrogen.
The equation for the reaction is:

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3\,H_2(g)$$

(a) Calculate the atom economy for the formation of hydrogen in stage 1.

Relative atomic masses (*A*r): H = 1 C = 12 O = 16

_____

_____

_____

_____

Atom economy = _____%

(2)

(b) Explain why a low pressure is used in stage 1.

Give your answer in terms of equilibrium.

_____

_____

_____

_____

(2)

(c) Stage 2 uses the carbon monoxide produced in stage 1.

The carbon monoxide is reacted with more steam to produce carbon

dioxide and more hydrogen.

The equation for the reaction in stage 2 is:

$$CO(g) + H2O(g) \rightleftharpoons CO2(g) + H2(g)$$

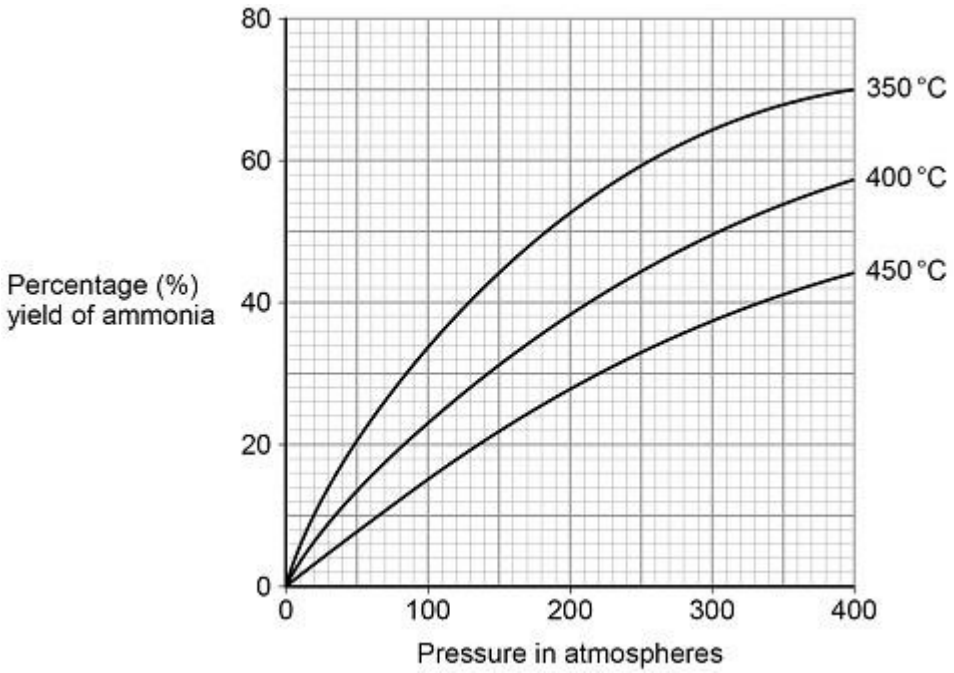
What is the effect of increasing the pressure on the equilibrium yield of hydrogen in stage 2?

_____

_____

(1)

The graph below shows the percentage yield of ammonia produced at different temperatures and pressures in the Haber process.



A temperature of 450 °C and a pressure of 200 atmospheres are used in the Haber process.

(d) A student suggested that a temperature of 350 °C and a pressure of 285 atmospheres could be used instead of those used in the Haber process.
Determine how many times greater the percentage yield of ammonia obtained would be.
Use the graph.

_____

_____

_____

_____

Percentage yield = _____ times greater

(3)

(e) A pressure of 285 atmospheres is not used in the Haber process instead of 200 atmospheres.

Give one reason why.

_____

_____

(1)

(f) How does the graph above show that the forward reaction in the Haber process is exothermic?

_____

_____

(1)

(g) World production of ammonia is now about 30 times greater than it was in 1950.

Suggest why the demand for ammonia has increased.

_____

_____

_____

_____

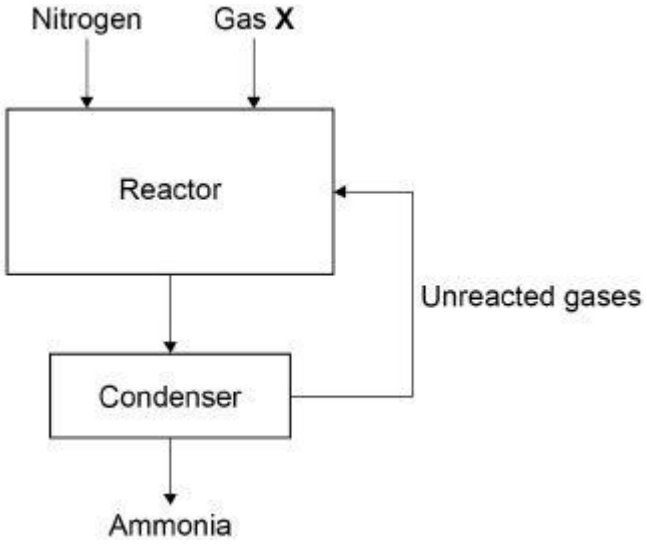
(2)

(Total 12 marks)

Q5.

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 Venus' atmosphere today	Percentage (%) in 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.

_____

_____

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_____

_____

_____

(6)

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

_____

_____

(1)

(Total 11 marks)

Q6.

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

The equation for the reaction is:

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

(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?

_____

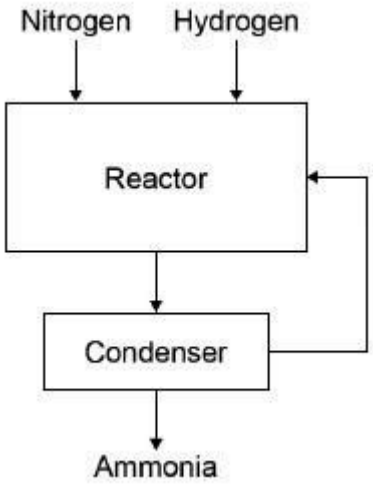
(1)

(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.



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 ☐

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 (NH4)2HPO4

Which two elements in (NH4)2HPO4 improve agricultural productivity?

Tick (✓) two boxes.

Chlorine ☐

Hydrogen ☐

Nitrogen ☐

Oxygen ☐

Phosphorus ☐

A farmer uses fertilisers A and B on a field with an area of 0.05 km2

(2)

(h) 50 kg of fertiliser A will cover an area of 0.01 km2

Calculate the cost of fertilising a field with an area of 0.05 km2 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)

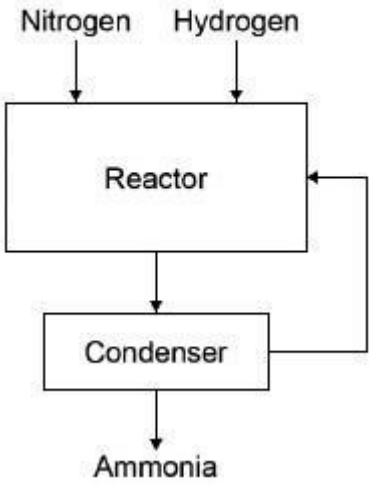
(Total 12 marks)

Q7.

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:

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

The forward reaction is exothermic.

(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	NH4NO3	220
B	(NH4)2HPO4	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 _____

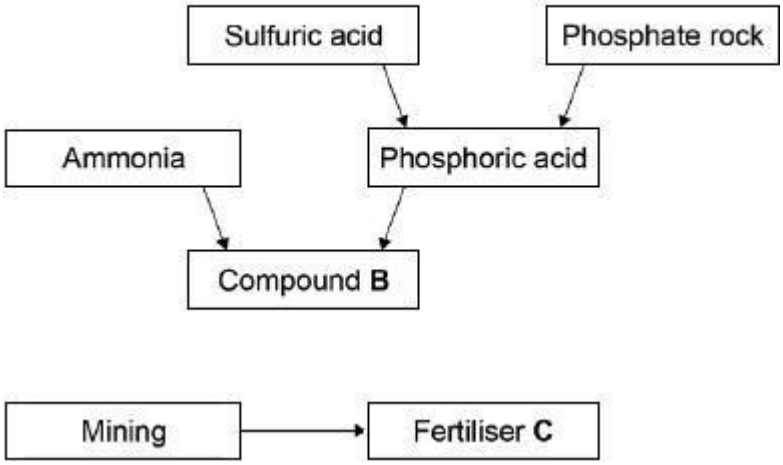
Reason _____

_____

(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)

Q8.

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

Balance the equation for the reaction.

N2 + H2 → NH3

(1)

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

Tick one box.

catalyst ☐

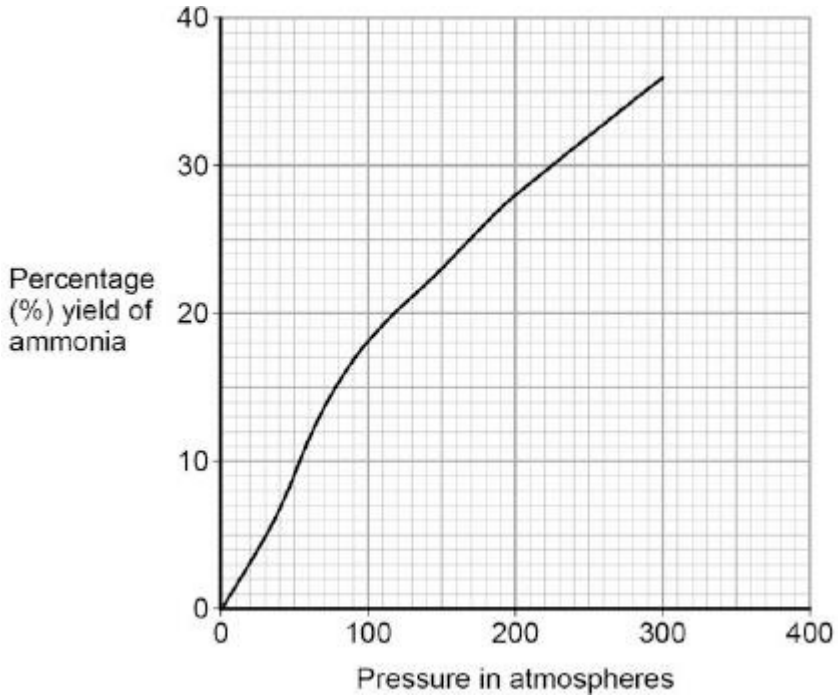
fuel ☐

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)

Q9.

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.

_____

_____

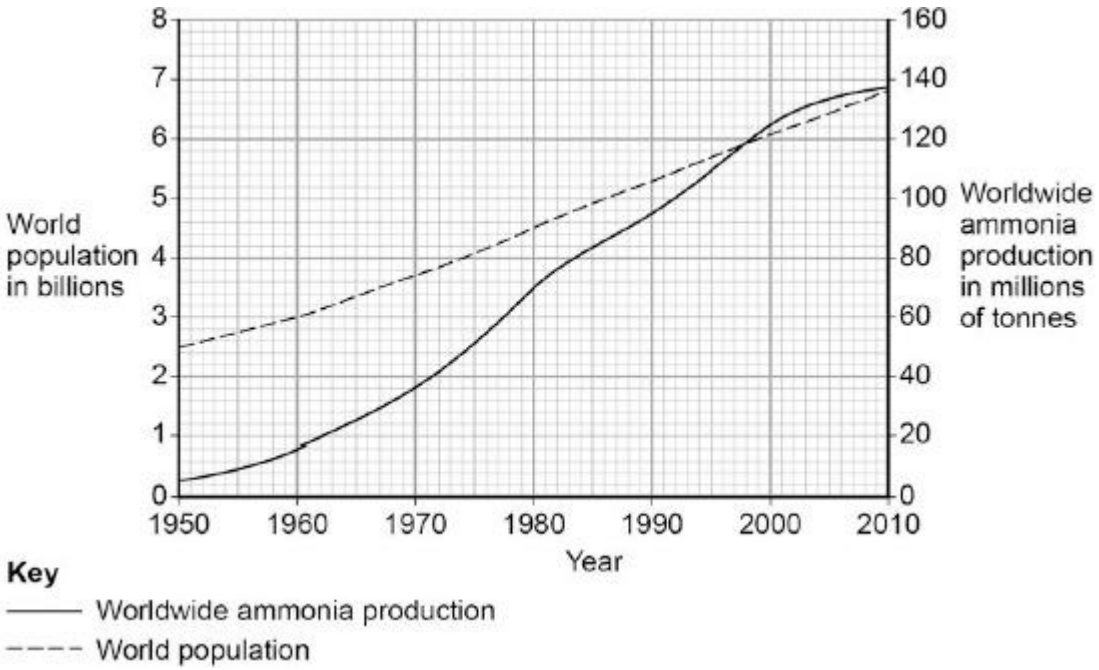
_____

_____

_____

(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)

Q10.

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 (Ar): 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.

$H^+ + OH^- \rightarrow H_2O$ ☐

$NH_4^+ + OH^- \rightarrow NH_4OH$ ☐

$H^+ + Cl^- \rightarrow HCl$ ☐

$H^+ + H_2O \rightarrow H_3O^+$ 

(1)

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

_____

(1)

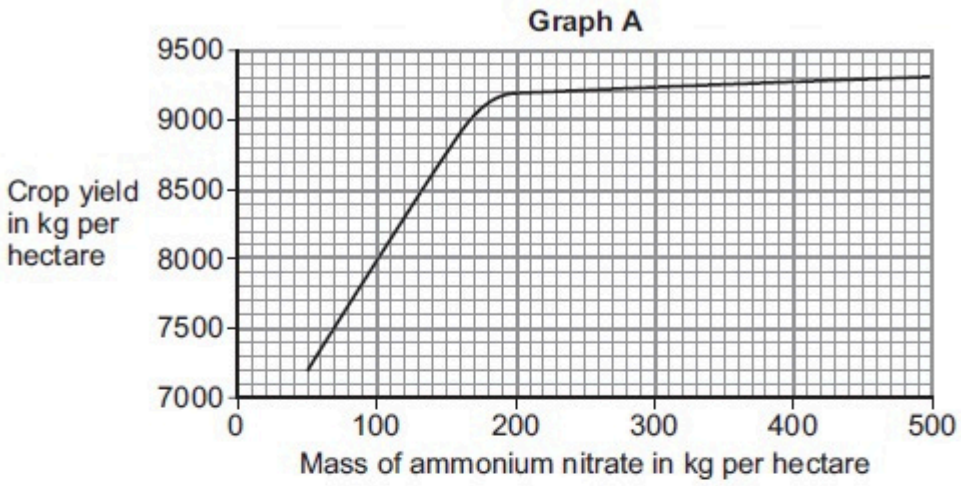
(d) In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.

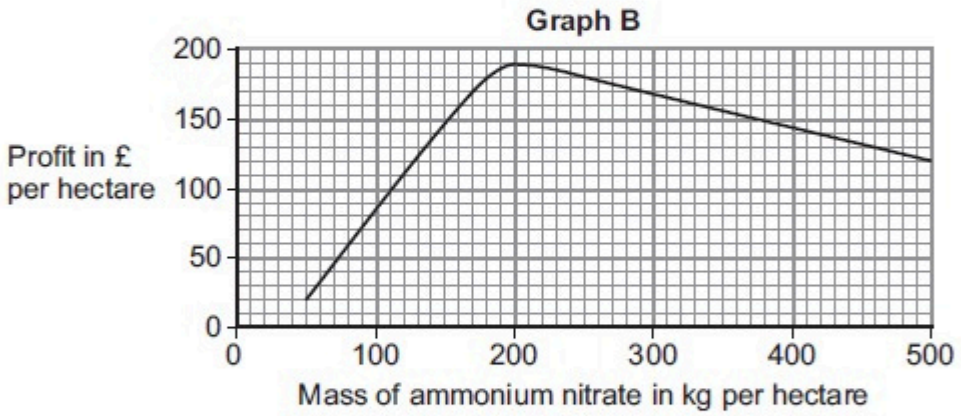
Farmers use ammonium nitrate as a fertiliser for crops.

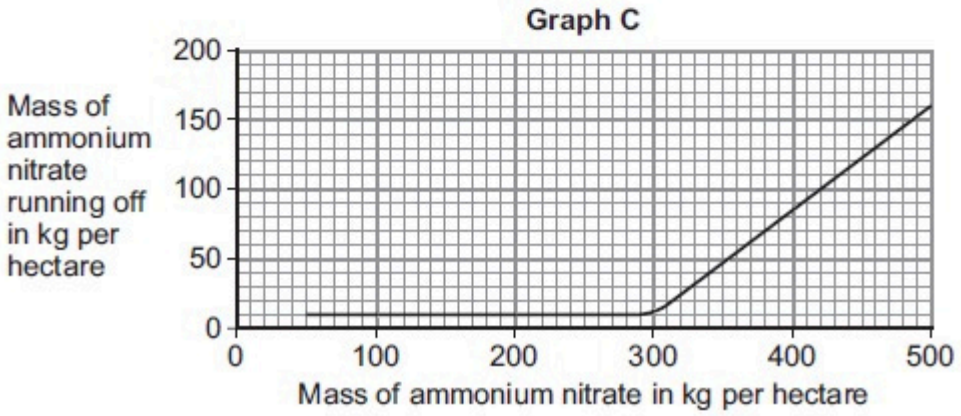
Rainwater dissolves ammonium nitrate in the soil.

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.







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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_____

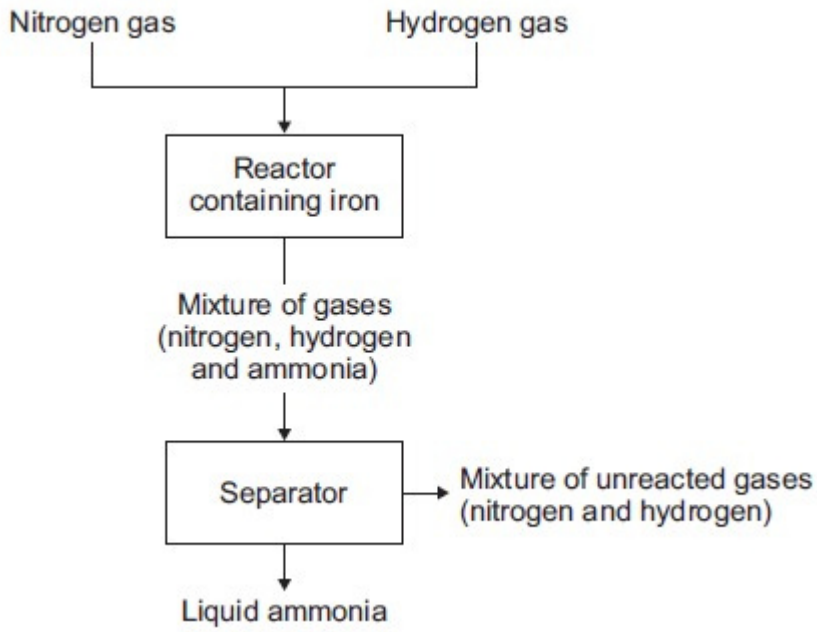
(6)

(Total 13 marks)

Q11.

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.

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 + _____

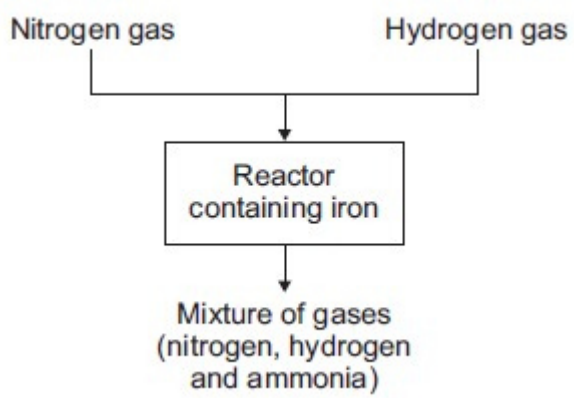
(2)

(Total 9 marks)

Q12.

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

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.

_____

_____

_____

_____

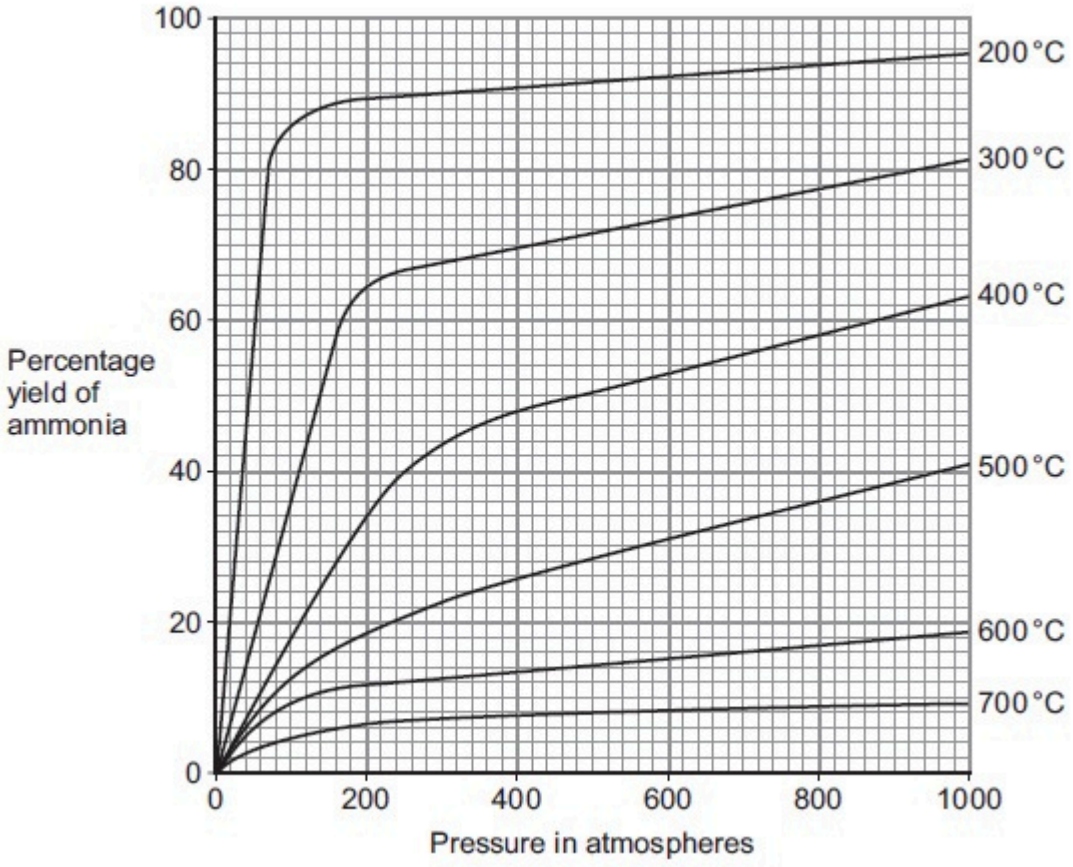
_____

_____

(3)

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

Figure 2



(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)