

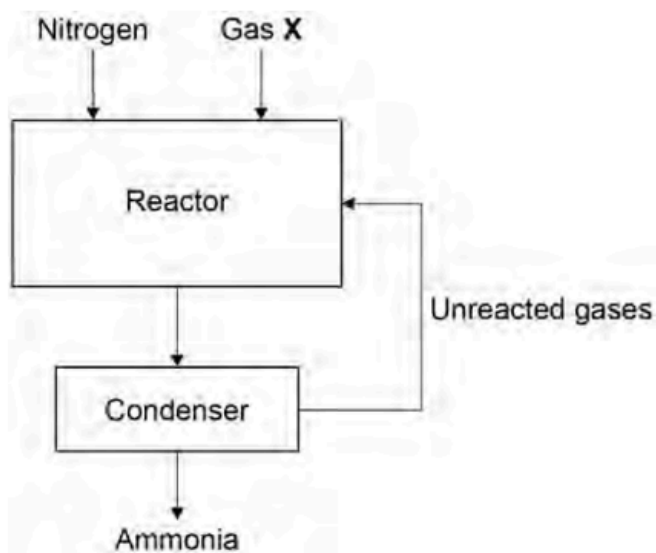
(The Haber process (conditions, yield, equilibrium))

Q1. a). (2018)

This question is about gases.

Figure 3 shows how nitrogen is used in the Haber Process to produce ammonia.

Figure 3



Gas **X** in **Figure 3** is obtained from methane.

Name gas **X**.

[1 mark]

Q1. b). (2018)

Give the approximate temperature and pressure used in the reactor.

[2 marks]

Temperature _____

Pressure _____

Q1. c). (2018)

The mixture of gases from the reactor cools in the condenser.

Suggest why ammonia condenses but the other gases do not.

[1 mark]

Q2. a). (2019)

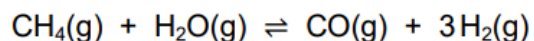
This question is about reversible reactions and equilibrium.

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:



Calculate the atom economy for the formation of hydrogen in **stage 1**.

Relative atomic masses (A_r): H = 1 C = 12 O = 16

[2 marks]

Atom economy = _____ %

Q2. b). (2019)

Explain why a low pressure is used in **stage 1**.

Give your answer in terms of equilibrium.

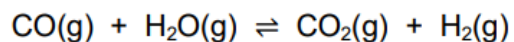
[2 marks]

Q2. c). (2019)

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:

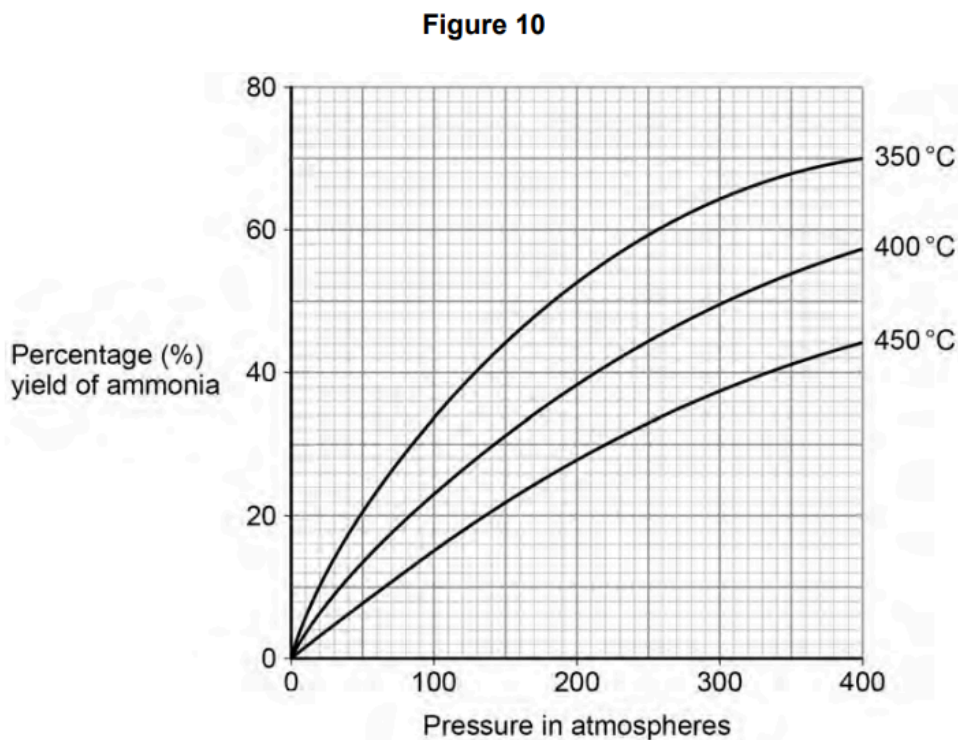


What is the effect of increasing the pressure on the equilibrium yield of hydrogen in **stage 2**?

[1 mark]

Q3. a). (2019)

Figure 10 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.

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 **Figure 10**.

[3 marks]

Percentage yield = _____ times greater

Q3. b). (2019)

A pressure of 285 atmospheres is **not** used in the Haber process instead of 200 atmospheres.

Give **one** reason why.

[1 mark]

Q3. c). (2019)

How does **Figure 10** show that the forward reaction in the Haber process is exothermic?

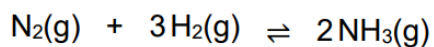
[1 mark]

Q4. (2022)

Ammonia is produced in the Haber process.

The raw materials for the Haber process are nitrogen and hydrogen.

The equation for the reaction is:



Give the sources of the nitrogen and of the hydrogen used in the Haber process.

[2 marks]

Nitrogen _____

Hydrogen _____

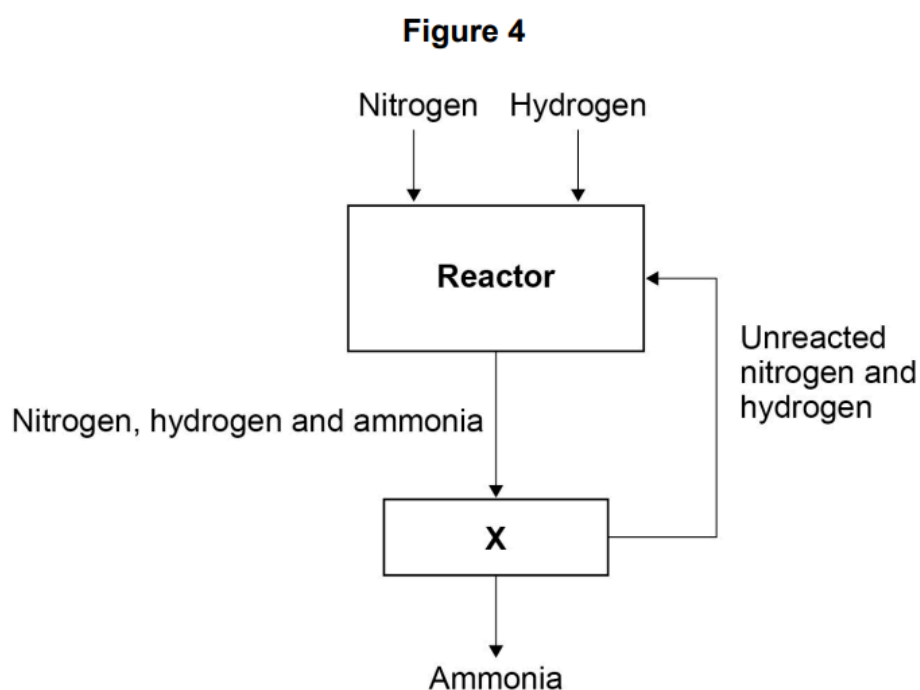
Q5. (2022)

How does the equation for the reaction show that the atom economy of the forward reaction is 100%?

[1 mark]

Q6. (2022)

Figure 4 represents the Haber process.



Explain how the ammonia produced is separated from the unreacted nitrogen and hydrogen in **X**.

[2 marks]

Q7. a). (2022)

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

Table 6 shows the percentage yield of ammonia produced at 450 °C using different pressures.

Table 6

Pressure in atmospheres	Percentage (%) yield of ammonia
60	9
120	18
180	25
240	31
300	36
360	40
420	43

Complete **Figure 5**.

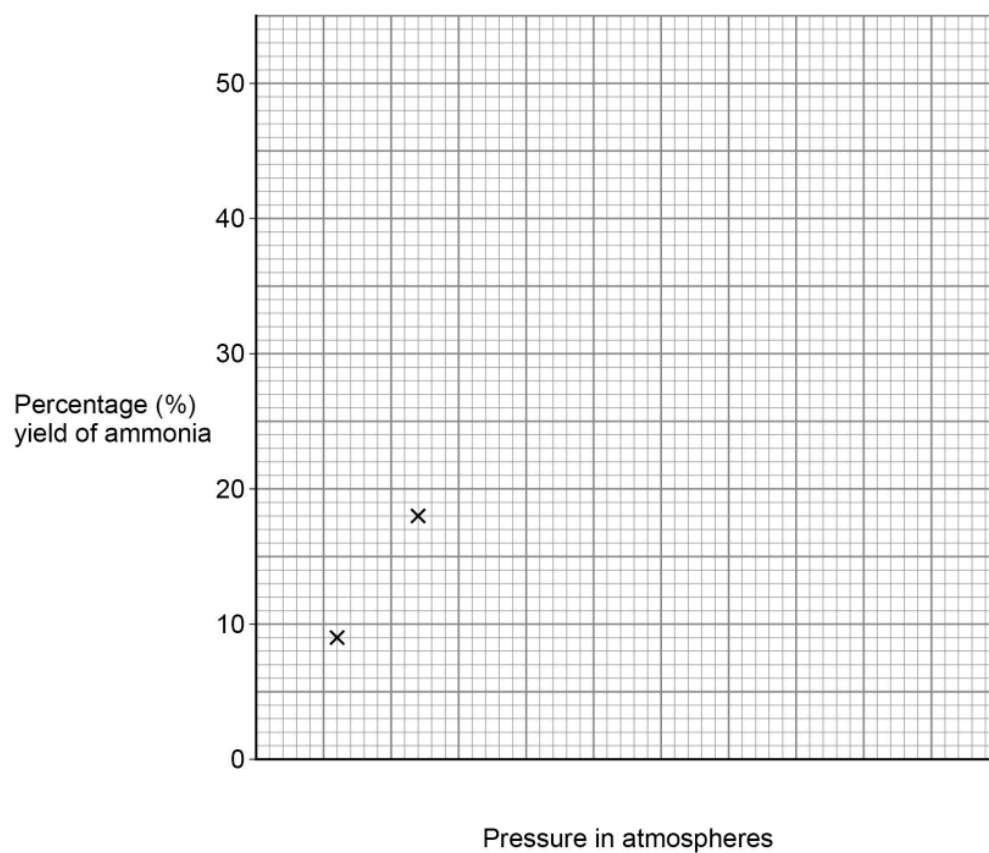
The first two points have been plotted.

You should:

- use a suitable scale for the x-axis
- plot the remaining data from **Table 6**
- draw a line of best fit.

[4 marks]

Figure 5

Figure 5

Q7. b). (2022)

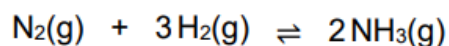
Determine the percentage yield of ammonia at 450 °C and 500 atmospheres.

Show your working on **Figure 5**.**[2 marks]**

Percentage yield = _____ %

Q8. (2022)

The equation for the production of ammonia in the Haber process is:



The forward reaction is exothermic.

The conditions used are:

- a temperature of 450 °C
- a pressure of 200 atmospheres
- the presence of an iron catalyst.

Explain why these conditions are chosen for economical production of ammonia in the Haber process.

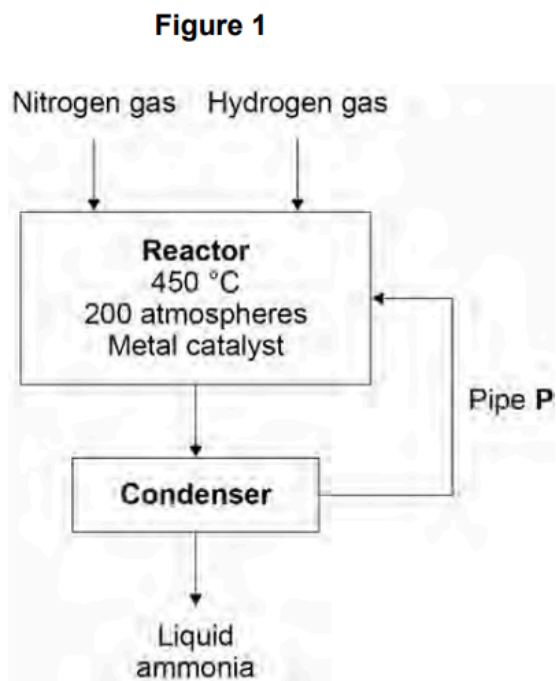
You should include references to the rate of reaction and the position of equilibrium.

[6 marks]

This question is about ammonia and nitric acid.

In the Haber process ammonia is produced from nitrogen and hydrogen.

Figure 1 represents the Haber process.



Pipe **P** links the condenser to the reactor.

Why is the condenser linked to the reactor?

Use **Figure 1**.

[1 mark]

Which metal is used as a catalyst in this reaction?

[1 mark]
