AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.6.2.4

The effect of changing conditions on equilibrium (HT only)

Past-paper questions

Tier	**Higher**
Question groups	**9**
Available paper years	**2008–2023**

Using this booklet

1. Answer the questions in order and show your working.
2. Original question numbers and marks are retained.
3. Print at actual size (100%) for measuring questions.
4. Use the companion answer booklet to check your work.

Name: _____ **Date:** _____

Whole questions are retained for context, so some parts assess other specification points. Current and legacy sources are labelled. Continue on extra paper if needed.

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 01

June 2008 | CHY2H | Original Q8 | Legacy

8 Epoxyethane has the formula C_2H_4O. It is used to make antifreeze and some types of plastic.

When choosing a method of making a chemical, it is important to consider:

- the percentage yield
- the atom economy.

Epoxyethane can be made from ethene by two different methods. The overall equation for each method is shown below.

Method 1

$$\underset{\text{ethene}}{C_2H_4} + Cl_2 + Ca(OH)_2 \rightarrow \underset{\text{epoxyethane}}{C_2H_4O} + CaCl_2 + H_2O$$

Method 2

$$\underset{\text{ethene}}{2C_2H_4(g)} + O_2(g) \overset{\text{catalyst}}{\rightleftharpoons} \underset{\text{epoxyethane}}{2C_2H_4O(g)}$$

8 (a) The table gives the relative formula masses (M_r) of the reactants and products for **Method 1**.

Formula of reactant or product	Relative formula mass (*Mr*)
H_2O	18
C_2H_4	28
C_2H_4O	44
Cl_2	71
$Ca(OH)_2$	74
$CaCl_2$	111

The percentage atom economy can be calculated using:

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

The percentage atom economy for **Method 2** is 100%.

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 01 · continued

for mark

8 (a) Calculate the percentage atom economy for **Method 1**.

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(2 marks)

8 (b) **Method 2** has the higher atom economy.

Suggest why this is an advantage.

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(2 marks)

8 (c) State and explain how an increase in pressure would affect the equilibrium yield of epoxyethane using **Method 2**.

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(2 marks)

8 (d) One problem with **Method 2** is that ethene can also react with oxygen to make carbon dioxide and water.

$$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$$

How might this reaction affect the percentage yield of epoxyethane?

.....

.....

(1 mark)

7

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 02

June 2010 | CHY2H | Original Q6 | Legacy

6 The equation for a reaction to produce hydrogen is:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

6 (a) Explain why changing the pressure does **not** affect the yield of hydrogen at equilibrium.

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(1 mark)

6 (b) Suggest why the best yield of hydrogen at equilibrium is obtained at **low** temperatures.

.....

.....

(1 mark)

6 (c) The temperature used in industry needs to be high enough for the reaction to take place quickly. Explain, in terms of particles, why the rate of reaction increases when the temperature is increased.

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(3 marks)

6 (d) Scientists have developed catalysts which allow the reaction to take place quickly at lower temperatures. How could this be good for the manufacturer and for the environment?

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(2 marks)

7

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 03

June 2014 | CH3HP | Original Q5 | Legacy

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

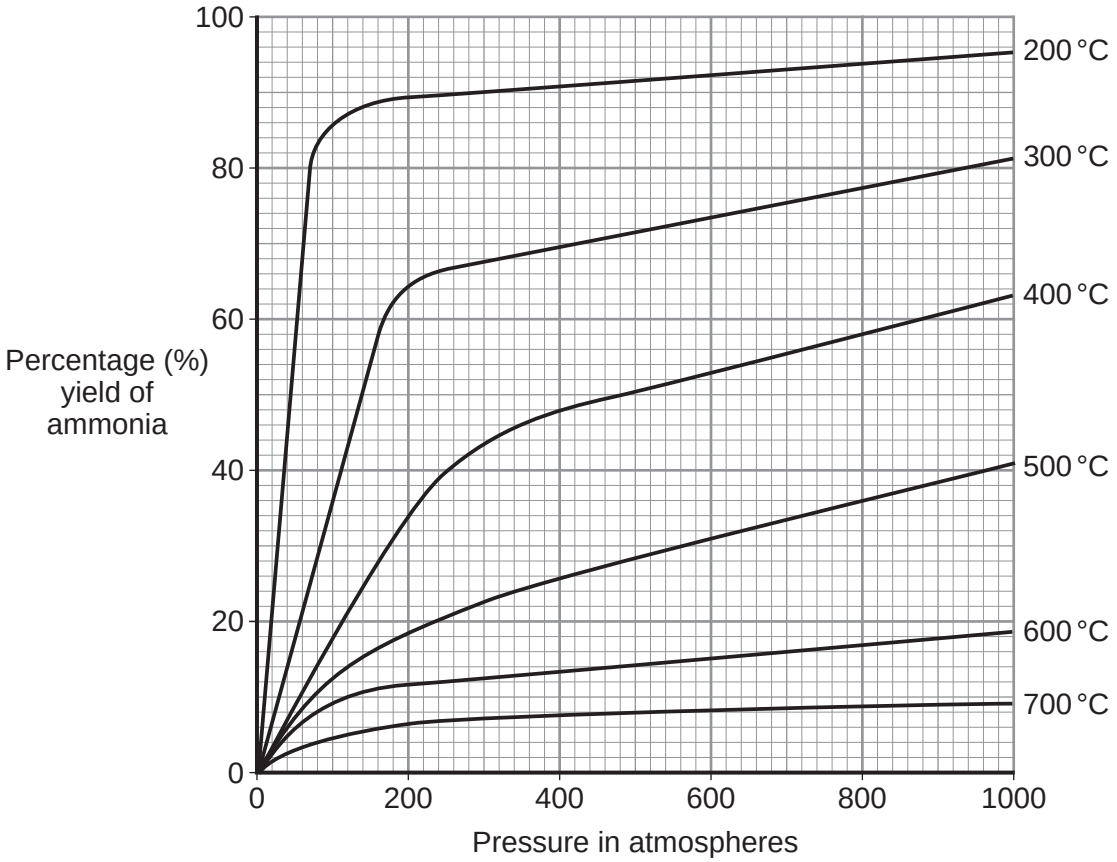
5 (a) Complete and balance the chemical equation for the production of ammonia from nitrogen and hydrogen.

[2 marks]

$$N_2 \quad + \quad 3H_2 \quad \rightleftharpoons \quad .....$$

5 (b) **Figure 5** shows how the equilibrium yield of ammonia changes with pressure at different temperatures.

Figure 5



5 (b) (i) Use the information in **Figure 5** to complete the sentence.

[1 mark]

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

5 (b) (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 mark]

.....

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4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 03 · continued

5 (b) (iii) Use the information in **Figure 5** to answer this question.

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

[1 mark]

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

5 (b) (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?

[1 mark]

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

[2 marks]

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8

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 04

June 2015 | CH3HP | Original Q6 | Legacy

6 This question is about reversible reactions and chemical equilibrium.

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

6 (a) (i) What is meant by a closed system?

[1 mark]

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

[2 marks]

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4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 04 · continued

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

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

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

[1 mark]

.....

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

Explain how a catalyst speeds up a reaction.

[2 marks]

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

Give a reason for your answer.

[2 marks]

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Question 6 continues on the next page

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 04 · continued

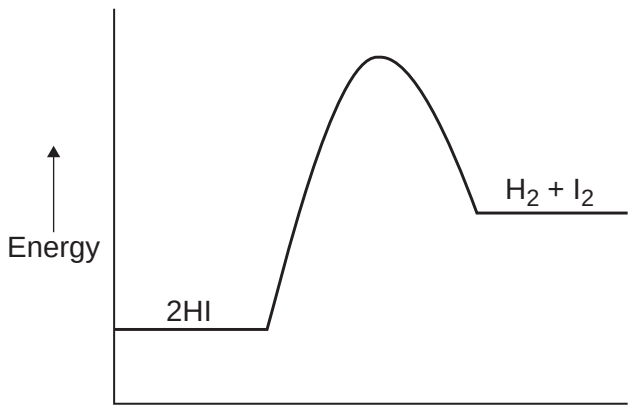
6 (c) The decomposition of hydrogen iodide into hydrogen and iodine is reversible.

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

The forward reaction is endothermic.

The energy level diagram in **Figure 3** is for the forward reaction.

Figure 3



6 (c) (i) Draw an arrow to show the activation energy on the diagram in **Figure 3**.

[1 mark]

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 04 · continued

6 (c) (ii) How does the diagram in **Figure 3** show that the reaction is endothermic?

[1 mark]

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6 (c) (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 marks]

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12

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 05

June 2018 | 8462/2H | Original Q9

0 9 This question is about methanol.

0 9 . 1 Methanol is broken down in the body during digestion.

What type of substance acts as a catalyst in this process?

[1 mark]

Tick **one** box.

- Amino acid ☐
- Enzyme ☐
- Ester ☐
- Nucleotide ☐

In industry, methanol is produced by reacting carbon monoxide with hydrogen.

The equation for the reaction is:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

0 9 . 2 How many moles of carbon monoxide react completely with 4.0×10^3 moles of hydrogen?

[1 mark]

Tick **one** box.

- 1.0×10^3 moles ☐
- 2.0×10^3 moles ☐
- 4.0×10^3 moles ☐
- 8.0×10^3 moles ☐

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 05 · continued

0 9 . 3 The reaction is carried out at a temperature of 250 ºC and a pressure of 100 atmospheres.

The forward reaction is exothermic.

Explain what happens to the yield of methanol if a temperature higher than 250 ºC is used.

[2 marks]

0 9 . 4 A pressure of 100 atmospheres is used instead of atmospheric pressure.

The higher pressure gives a greater yield of methanol **and** an increased rate of reaction.

Explain why.

[4 marks]

Question 9 continues on the next page

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 05 · continued

A catalyst is used in the reaction to produce methanol from carbon monoxide and hydrogen.

0 9 . 5 Explain how a catalyst increases the rate of a reaction.

[2 marks]

0 9 . 6 Suggest why a catalyst is used in this industrial process.

Do **not** give answers in terms of increasing the rate of reaction.

[1 mark]

0 9 . 7 Suggest the effect of using the catalyst on the equilibrium yield of methanol.

[1 mark]

12

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 06

June 2019 | 8462/2H | Original Q10

1 0 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:

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

1 0 . 1 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 = _____ %

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 06 · continued

1 0 . 2 Explain why a low pressure is used in **stage 1**.

Give your answer in terms of equilibrium.

[2 marks]

1 0 . 3 **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:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

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

[1 mark]

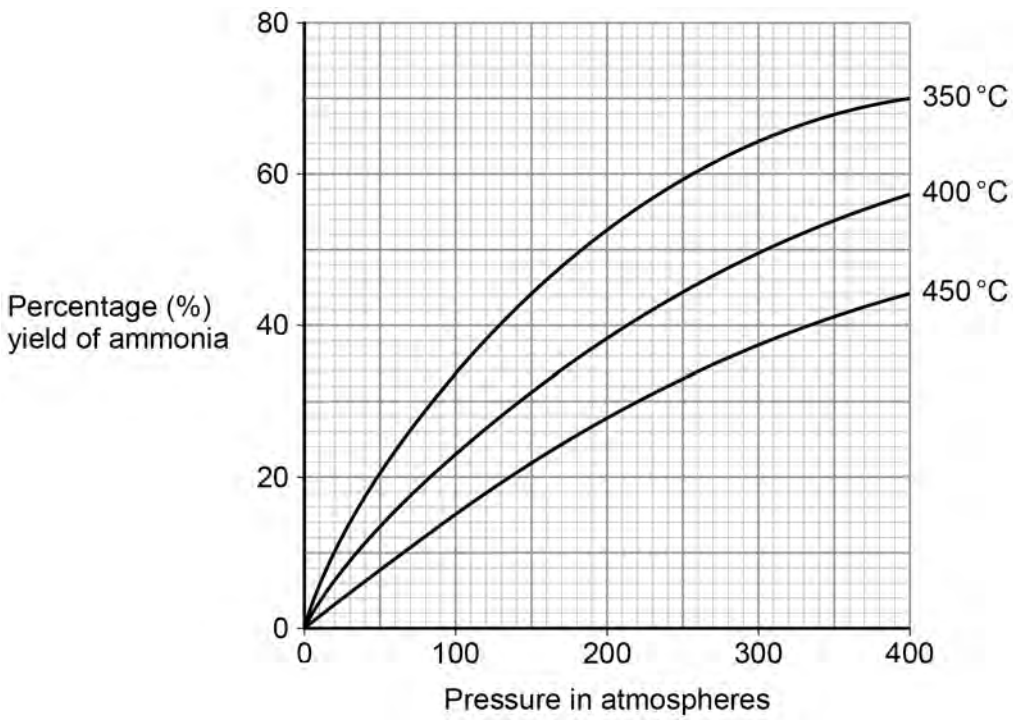
Question 10 continues on the next page

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 06 · continued

Figure 10 shows the percentage yield of ammonia produced at different temperatures and pressures in the Haber process.

Figure 10



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

1 0 . 4 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

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 06 · continued

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

Give **one** reason why.

[1 mark]

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

[1 mark]

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

Suggest why the demand for ammonia has increased.

[2 marks]

12

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 07

November 2020 | 8462/2H | Original Q10

1 0 This question is about a reversible reaction.

The reaction between solutions of iron(III) ions (Fe^{3+}) and thiocyanate ions (SCN^-) is reversible.

The ionic equation for the reaction is:

	$Fe^{3+}(aq)$	+	$SCN^-(aq)$	$\rightleftharpoons$	$FeSCN^{2+}(aq)$
Colour of solution:	yellow		colourless		red

The colour of the equilibrium mixture is orange at room temperature.

1 0 . 1 Give the name of the solvent used to dissolve the ions in this reaction.

[1 mark]

1 0 . 2 A few drops of a colourless solution containing a high concentration of thiocyanate ions (SCN^-) are added to the orange equilibrium mixture.

Explain the colour change observed.

[3 marks]

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 07 · continued

10.3 A water bath is set up at a temperature above room temperature.

When a test tube containing the orange equilibrium mixture is placed in the water bath, the mixture becomes more yellow.

Explain what this shows about the energy change for the forward reaction.

[3 marks]

10.4 Explain why a change in pressure does **not** affect the colour of the equilibrium mixture.

[2 marks]

10.5 Other metal ions form coloured equilibrium mixtures with thiocyanate ions.

Which metal ion could form a coloured equilibrium mixture with thiocyanate ions?

[1 mark]

Tick (✓) **one** box.

- Al^{3+} ☐
- Co^{2+} ☐
- Mg^{2+} ☐
- Na^{+} ☐

10

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 08

June 2022 | 8462/2H | Original Q7

0 7 Ammonia is produced in the Haber process.

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

The equation for the reaction is:

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

0 7 . 1 Give the sources of the nitrogen and of the hydrogen used in the Haber process.

[2 marks]

Nitrogen _____

Hydrogen _____

0 7 . 2 How does the equation for the reaction show that the atom economy of the forward reaction is 100%?

[1 mark]

_____

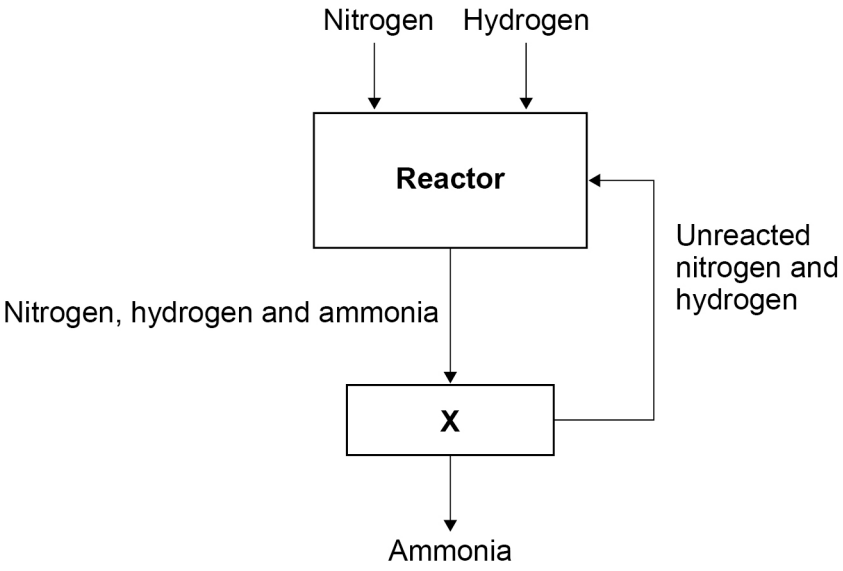
_____

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 08 · continued

0 7 . 3 **Figure 4** represents the Haber process.

Figure 4



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

[2 marks]

Question 7 continues on the next page

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 08 · continued

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

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 08 · continued

0 7 . 4 Complete **Figure 5**.

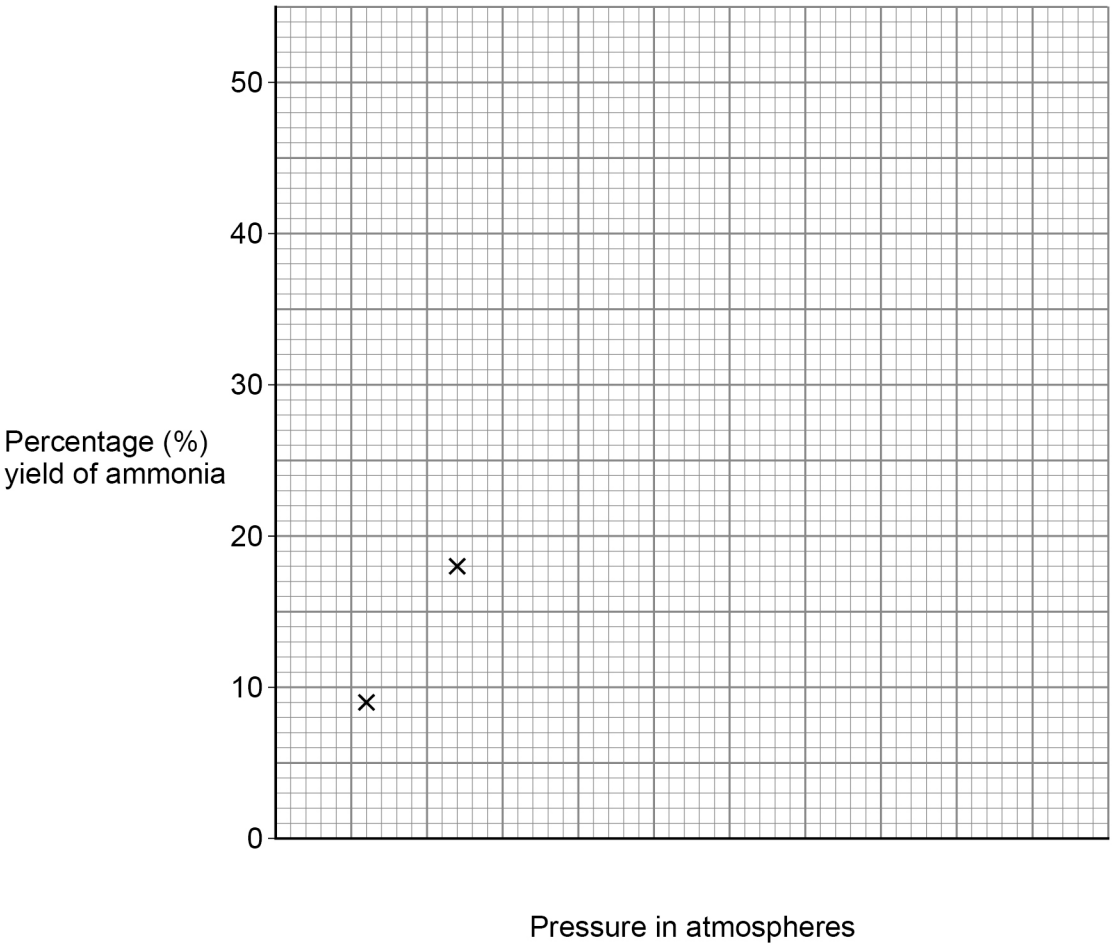
The first two points have been plotted.

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



0 7 . 5 Determine the percentage yield of ammonia at 450 °C and 500 atmospheres.

Show your working on **Figure 5**.

[2 marks]

Percentage yield = _____ %

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 08 · continued

0 7 . 6 The equation for the production of ammonia in the Haber process is:

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

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]

17

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 09

June 2023 | 8462/2H | Original Q9

0 9 This question is about reversible reactions.

When 4.68 g of hydrated copper sulfate changes into anhydrous copper sulfate:

- 2.99 g of anhydrous copper sulfate is produced
- 1.47 kJ of energy is taken in from the surroundings.

The equation for the reversible reaction is:

hydrated copper sulfate ⇌ anhydrous copper sulfate + water

0 9 . 1 Calculate the maximum mass of water that can be produced from 11.7 g of hydrated copper sulfate.

[3 marks]

Mass = _____ g

0 9 . 2 15.0 g of anhydrous copper sulfate completely changes into hydrated copper sulfate when water is added.

Calculate the amount of energy transferred to the surroundings.

[2 marks]

Energy = _____ kJ

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 09 · continued June 2023 | 8462/2H | Original Q9

The gases nitrogen dioxide and dinitrogen tetroxide reach dynamic equilibrium in a sealed container.

The equation for the reaction is:

$$2\ NO_2(g) \rightleftharpoons N_2O_4(g)$$

nitrogen dioxide (brown) dinitrogen tetroxide (colourless)

The forward reaction is exothermic.

0 9 . 3 What happens to the position of the equilibrium in this reaction if the temperature is increased?

[1 mark]

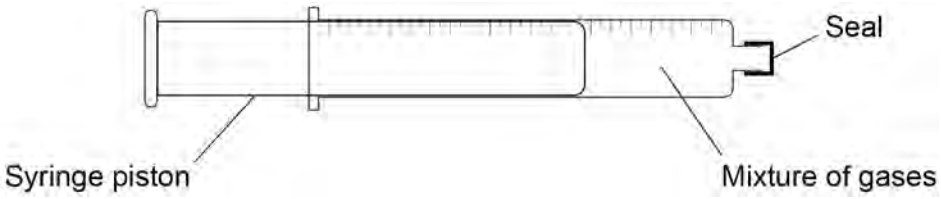
Tick (✓) **one** box.

- Shifts to the left ☐
- Stays the same ☐
- Shifts to the right ☐

0 9 . 4 A teacher seals a brown-coloured mixture of nitrogen dioxide and dinitrogen tetroxide in a gas syringe.

Figure 8 shows the sealed gas syringe.

Figure 8



The teacher pushes the syringe piston in.

This increases the pressure in the gas syringe.

What is the colour of the mixture when a new equilibrium position is reached?

[1 mark]

Tick (✓) **one** box.

The mixture is a darker shade of brown. ☐

The mixture is the same shade of brown. ☐

The mixture is a lighter shade of brown. ☐

Question 9 continues on the next page

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 09 · continued June 2023 | 8462/2H | Original Q9

Hydrogen iodide gas decomposes into hydrogen gas and iodine gas at high temperatures.

The equation for the reaction is:

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

0 9 . 5 Explain the effect of increasing the pressure on the equilibrium position of this reaction.

[2 marks]

0 9 . 6 Suggest the effect of adding a catalyst on the equilibrium position of this reaction.

[1 mark]

4.6.2.4 The effect of changing conditions on equilibrium (HT only)

Question 09 · continued

Copper forms coloured compounds.

Hydrochloric acid is added to an aqueous solution of copper compound **A**.

The word equation for the reaction is:

copper compound **A** (blue) + hydrochloric acid ⇌ copper compound **B** (yellow) + water

0 9 . 7 The reaction mixture is green when both copper compounds are present in a solution at equilibrium.

How can the equilibrium position be shifted to make the reaction mixture more yellow?

[1 mark]

Tick (✓) **one** box.

- Add more hydrochloric acid ☐
- Add more water ☐
- Leave the reaction mixture for 30 minutes ☐

0 9 . 8 The concentrations of the substances in this reaction do **not** change at dynamic equilibrium.

Explain why.

[2 marks]

13