

Bleach is a solution of sodium hypochlorite (NaClO).

Chlorine gas is produced when bleach reacts with hydrochloric acid.

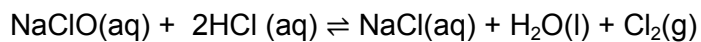
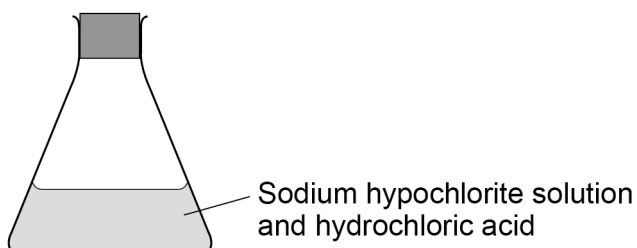


Figure 8 shows a sealed flask of sodium hypochlorite and hydrochloric acid at equilibrium.

Figure 8



1.1

Explain why equilibrium is reached in this reaction.

[2 marks]

1.2

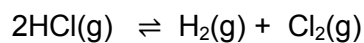
The stopper in **Figure 8** is removed and hydrochloric acid is added.

The stopper is replaced.

Explain what happens to the equilibrium.

[4 marks]

Chlorine gas is also produced when hydrogen chloride decomposes.



The forward reaction is endothermic.

1.3

Predict the effect of increasing the temperature on the amount of chlorine gas produced at equilibrium.

Explain your answer using Le Chatelier's Principle.

[2 marks]

1.4

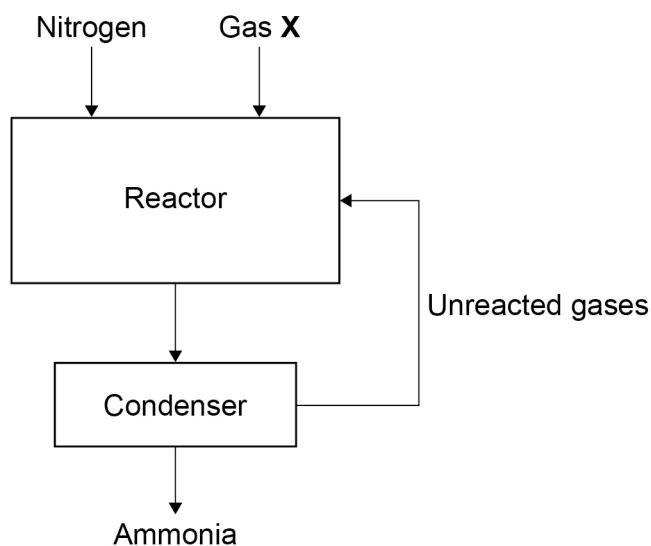
Explain the effect of increasing the pressure on this equilibrium.

[2 marks]

This question is about gases.

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

Figure 3



2.1

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

Name gas **X**.

[1 mark]

2.2

Give the approximate temperature and pressure used in the reactor.

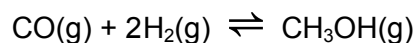
[2 marks]

Temperature _____

Pressure _____

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

The equation for the reaction is:



3.1

The reaction is carried out at a temperature of 250 °C 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 °C is used.

[2 marks]

3.2

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]

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

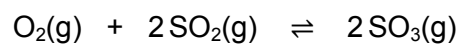
3.3

Suggest the effect of using the catalyst on the equilibrium yield of methanol.

[1 mark]

4.1

The reaction between oxygen and sulfur dioxide is at equilibrium.



Some of the sulfur trioxide (SO_3) is removed.

Explain what happens to the position of the equilibrium.

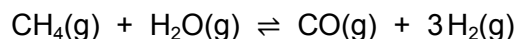
[2 marks]

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:



5.1

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

Give your answer in terms of equilibrium.

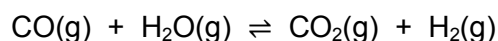
[2 marks]

5.2

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.

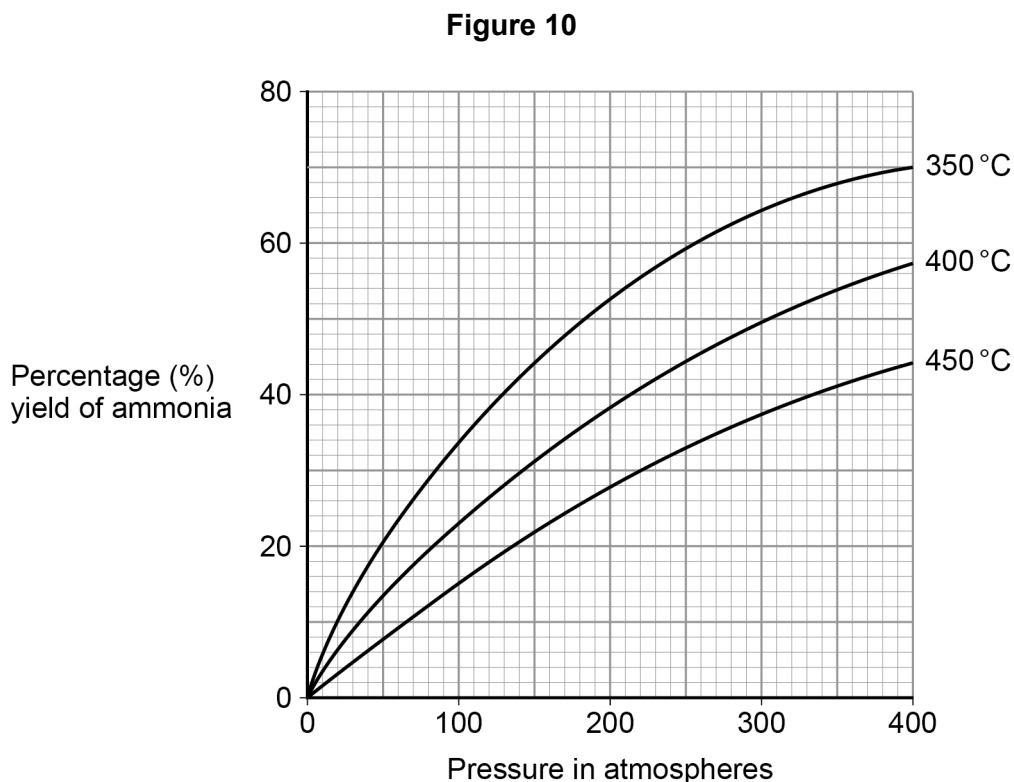
The equation for the reaction in **stage 2** is:



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

[1 mark]

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.

5.3

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

5.4

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

Give **one** reason why.

[1 mark]

5.5

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

[1 mark]

5.6

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]

This question is about equilibrium.

6.1

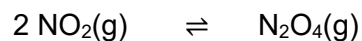
Describe how a reaction reaches equilibrium.

[2 marks]

Nitrogen dioxide gas reacts to form dinitrogen tetraoxide gas.

The reaction is reversible.

The equation for the reaction is:



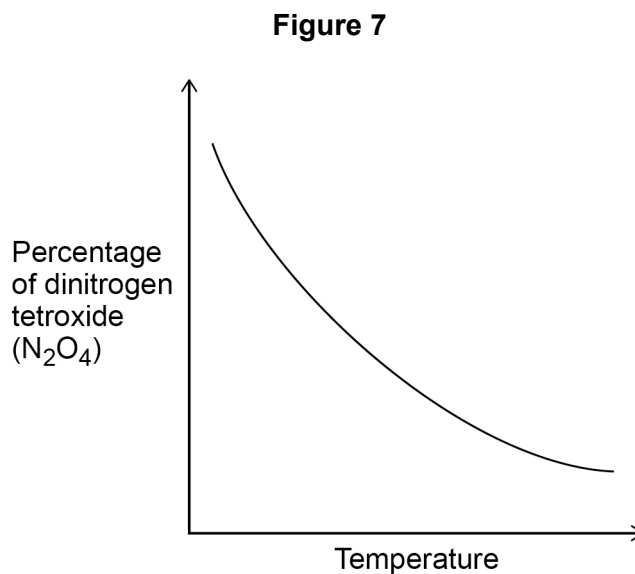
6.2

Explain the effect on the equilibrium position of increasing the pressure.

[2 marks]

6.3

Figure 7 shows the change in the percentage of dinitrogen tetroxide (N_2O_4) in the equilibrium mixture as the temperature of the equilibrium mixture is changed.



Explain the effect on the equilibrium position of increasing the temperature.

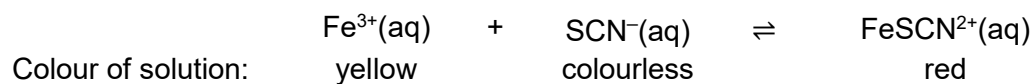
Use **Figure 7**.

[3 marks]

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:



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

7.1

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]

7.2

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.

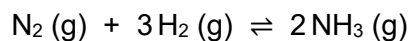
[3 marks]

7.3

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

[2 marks]

The equation for the reaction to produce ammonia is repeated here.



8.1

The reaction reaches equilibrium.

Explain how an equilibrium is reached.

[2 marks]

8.2

Suggest how the catalyst affects the equilibrium position.

Give **one** reason for your answer.

[2 marks]

8.3

What is the effect of increasing the pressure on the reaction to produce ammonia?

[1 mark]

Tick (✓) **one** box.

The yield of ammonia decreases.

☐

The yield of ammonia stays the same.

☐

The yield of ammonia increases.

☐

8.4

The forward reaction is exothermic.

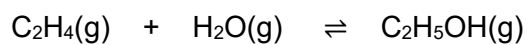
Explain the effect of increasing the temperature on the yield of ammonia gas produced at equilibrium.

[2 marks]

9.1

Ethanol can be produced from ethene and steam.

The equation for the reaction is:

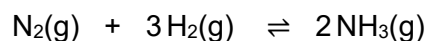


The forward reaction is exothermic.

Explain how the conditions for this reaction should be chosen to produce ethanol as economically as possible.

[6 marks]

The reversible reaction for the production of ammonia is:



10.1

What can scientists predict using Le Chatelier's Principle?

[1 mark]

10.2

Describe how a reversible chemical reaction is able to reach equilibrium.

[2 marks]

10.3

Explain the effect of increasing the pressure on the yield of ammonia.

[2 marks]

10.4

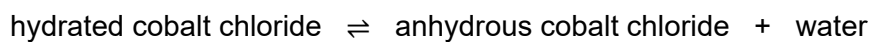
The forward reaction to produce ammonia is exothermic.

Explain the effect of increasing the temperature on the yield of ammonia.

[2 marks]

A student investigated the change in mass when hydrated cobalt chloride was heated.

The word equation for the reaction is:



This is the method used.

1. Add 2.0 g of hydrated cobalt chloride to an empty test tube.
2. Measure the mass of the test tube and contents.
3. Heat the test tube and contents gently for 30 seconds.
4. Allow the test tube and contents to cool.
5. Measure the mass of the test tube and contents.
6. Repeat steps 3 to 5 until the mass of the test tube and contents does not change.

Table 1 shows the results.

Table 1

Total heating time in seconds	Mass of test tube and contents in grams
0	26.5
30	26.2
60	25.9
90	25.6
120	25.6

11.1

Explain why the mass of the test tube and contents decreased.

[2 marks]

Energy is taken in from the surroundings when hydrated cobalt chloride is heated.

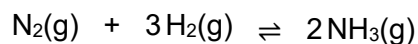
11.2

What type of reaction takes place when hydrated cobalt chloride is heated?

[1 mark]

12.1

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]

[illegible]

A gas is used to sterilise water.

The equation for the reaction is:



13.1

What is meant by the symbol $\rightleftharpoons$?

[1 mark]

13.2

The reaction is at equilibrium.

The reaction is exothermic.

What happens to the equilibrium position when the temperature is increased?

[1 mark]

Tick (✓) **one** box.

Shifts towards the left-hand side

☐

Stays in the same place

☐

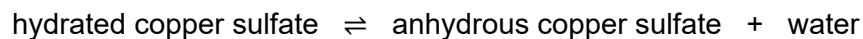
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☐

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:



14.1

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

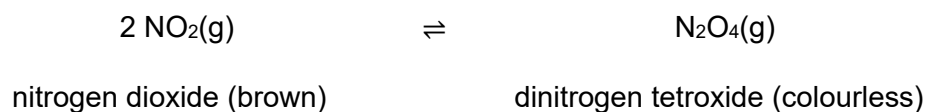
Calculate the amount of energy transferred to the surroundings.

[2 marks]

Energy = _____ kJ

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

The equation for the reaction is:



The forward reaction is exothermic.

14.2

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

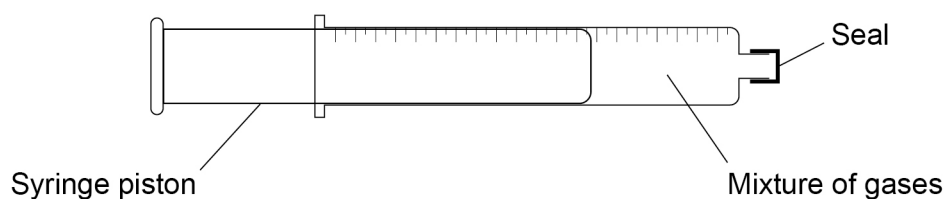
☐

14.3

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.

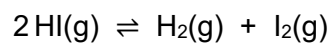
☐

The mixture is a lighter shade of brown.

☐

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

The equation for the reaction is:



14.4

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

[2 marks]

14.5

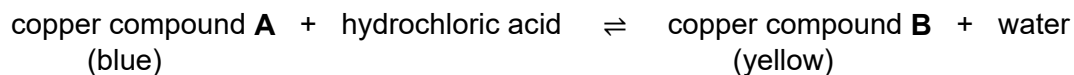
Suggest the effect of adding a catalyst on the equilibrium position of this reaction.

[1 mark]

Copper forms coloured compounds.

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

The word equation for the reaction is:



14.6

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

☐

14.7

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

Explain why.

[2 marks]
