

Equilibria

Question Paper

Level	GCSE
Subject	Chemistry
Exam Board	Edexcel IGCSE
Module	Double Award (Paper 1C)
Topic	Physical Chemistry
Sub-Topic	Equilibria
Booklet	Question Paper

Time Allowed: 89 minutes

Score: /74

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	75%	70%	60%	55%	50%	<50%

1 Ammonium chloride contains oppositely charged ions.

(a) State the formula of each ion.

(2)

Positive ion

Negative ion

(b) (i) Describe a chemical test to show that a substance contains ammonium ions.

(3)

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(ii) Describe a chemical test to show that a substance contains chloride ions.

(3)

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(c) Ammonium chloride decomposes when heated:

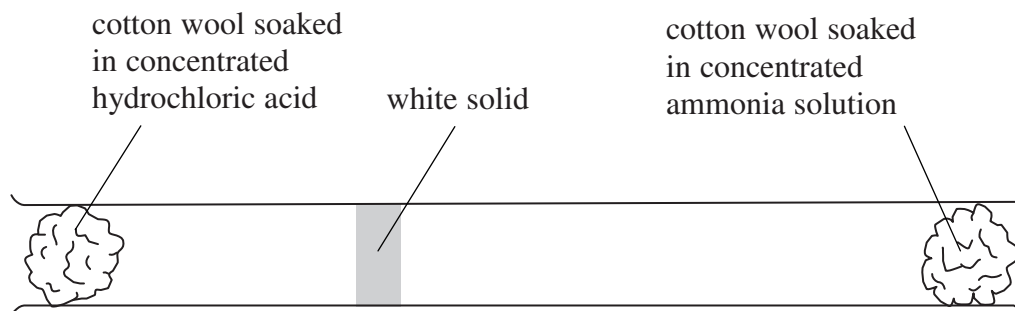


What does the \rightleftharpoons symbol indicate about the reaction?

(1)

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.....

(d) The reaction between ammonia and hydrogen chloride can be used to illustrate diffusion with the following apparatus.



After a few minutes, a white solid appears inside the tube.

(i) Identify the white solid. (1)

(ii) What does the diagram show about the speed of the ammonia molecules compared to the speed of the hydrogen chloride molecules? (1)

(e) State the main hazard when using concentrated hydrochloric acid in the experiment in (d).

Suggest **one** precaution you could use to minimise this hazard. (2)

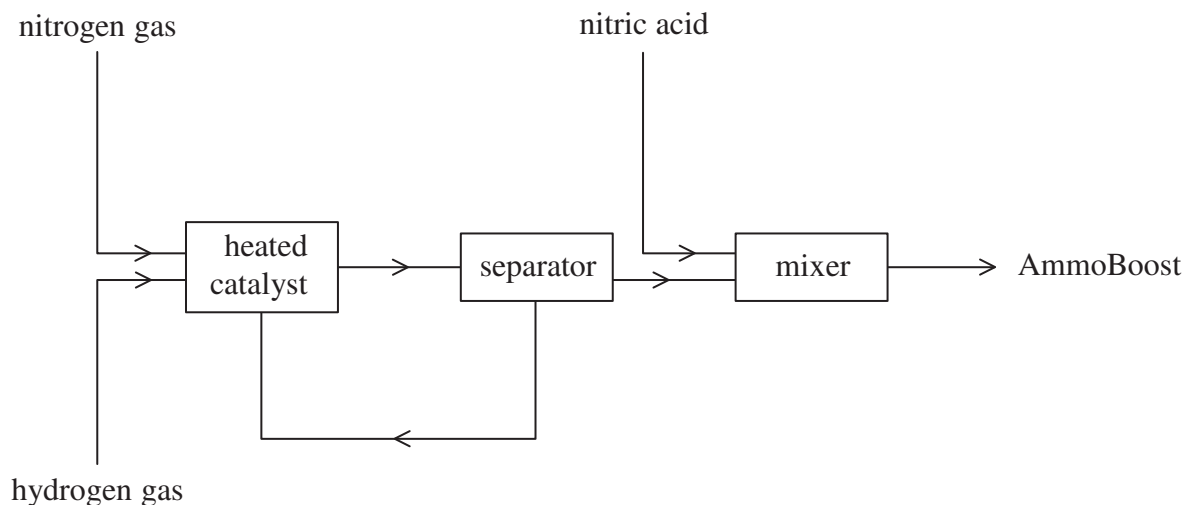
Hazard

Precaution

(Total for Question 1 = 13 marks)

2 AmmoFert Chemicals is a company that manufactures fertilisers.

The flow chart shows how the company manufactures a fertiliser called AmmoBoost.



(a) The first step in the process is the conversion of nitrogen gas and hydrogen gas into ammonia.

(i) State a raw material used as the source of each gas. (2)

nitrogen

hydrogen

(ii) Identify the catalyst used in this conversion. (1)

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(iii) State **one** other condition used in this conversion. (1)

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(iv) Only a small percentage of the nitrogen gas and hydrogen gas is converted into ammonia. Explain how the unreacted gases are separated from the ammonia. (2)

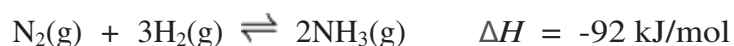
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(b) The equation for the production of ammonia is



Calculate the maximum mass of ammonia that can be obtained from 56 tonnes of nitrogen.
(1 tonne = 1 000 000 grams)

(3)

(c) EnAitchThree is another company that manufactures ammonia using the same reaction as AmmoFert but using different conditions.

EnAitchThree uses a higher temperature and a higher pressure than AmmoFert.

(i) Predict the effect on the rate of reaction and on the equilibrium position by changing to the temperature used by EnAitchThree.

(2)

Effect of higher temperature on rate of reaction

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Effect of higher temperature on equilibrium position

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.....

(ii) Predict the effect on the equilibrium position by changing to the pressure used by EnAitchThree. Justify your prediction.

(2)

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(d) The main compound in AmmoBoost contains 35% nitrogen and 5% hydrogen by mass. The remainder is oxygen.

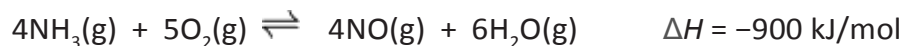
(i) Calculate the percentage by mass of oxygen in the compound. (1)

(ii) Determine the empirical formula of the compound. (3)

(iii) What is the **name** of the main compound in AmmoBoost? (1)

(Total for Question 2 = 18 marks)

3 The equation for a reaction that occurs in the manufacture of nitric acid is



(a) (i) State the meanings of the symbols \rightleftharpoons and ΔH .

(2)

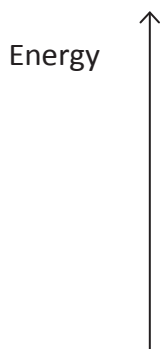
H

(ii) What does the negative sign of ΔH indicate about the reaction?

(1)

(b) Complete the energy level diagram for this reaction.

(2)



(c) Typical conditions used for this reaction are a temperature of 900 °C and a pressure of 10 atmospheres.

Deduce the effects of changing the conditions as shown in the table. Choose from the words **increased**, **decreased** or **unchanged** to complete the table.

(4)

Change	Effect on rate of reaction	Effect on yield of products
increase in temperature		
addition of catalyst		

(d) A manufacturer considers using a pressure of 5 atm instead of 10 atm.

(i) Predict and explain the effect on the rate of reaction of changing the pressure to 5 atm.

(3)

Effect on rate of reaction

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Explanation

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(ii) Predict and explain the effect on the position of equilibrium of changing the pressure to 5 atm.

(2)

Effect on position of equilibrium

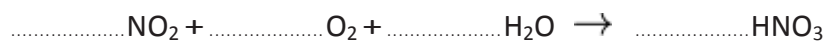
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Explanation

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(e) Balance the equation that represents the last stage in the manufacture of nitric acid.



(1)

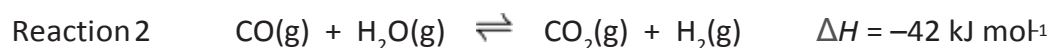
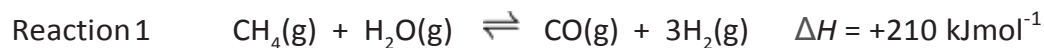
(Total for Question 3 = 15 marks)

4 The Haber process is used to convert nitrogen and hydrogen into ammonia.

(a) Which raw material is the source of the nitrogen?

(1)

(b) The hydrogen for this process is obtained using reactions 1 and 2



(i) Predict what will happen to the equilibrium position in reaction 1 when the pressure is increased. Give a reason for your prediction.

(2)

Prediction

Reason

(ii) Predict what will happen to the equilibrium position in reaction 2 when the temperature is increased. Give a reason for your prediction.

(2)

Prediction

Reason

(c) Predict what will happen to the rate of reaction 1 when the pressure and temperature are increased.

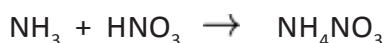
(2)

Effect of increased pressure

Effect of increased temperature

- (d) Some of the ammonia from the Haber process is made into fertilisers such as ammonium nitrate.

The equation for the formation of ammonium nitrate is



A manufacturer makes a batch of 40 kg of ammonium nitrate.

- (i) Calculate the amount, in moles, of NH_4NO_3 in 40 kg of ammonium nitrate.

(2)

Amount of NH_4NO_3 mol

- (ii) Deduce the amount, in moles, of ammonia needed to make this amount of ammonium nitrate.

(1)

Amount of ammonia mol

- (iii) Calculate the mass, in kg, of ammonia needed.

(2)

Mass of ammonia kg

- (e) The manufacturer also produces fertilisers that are labelled NPK.

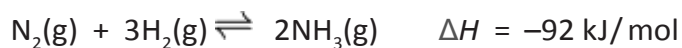
Suggest the names of two elements, other than nitrogen, that are likely to be present in NPK fertilisers.

(1)

..... and

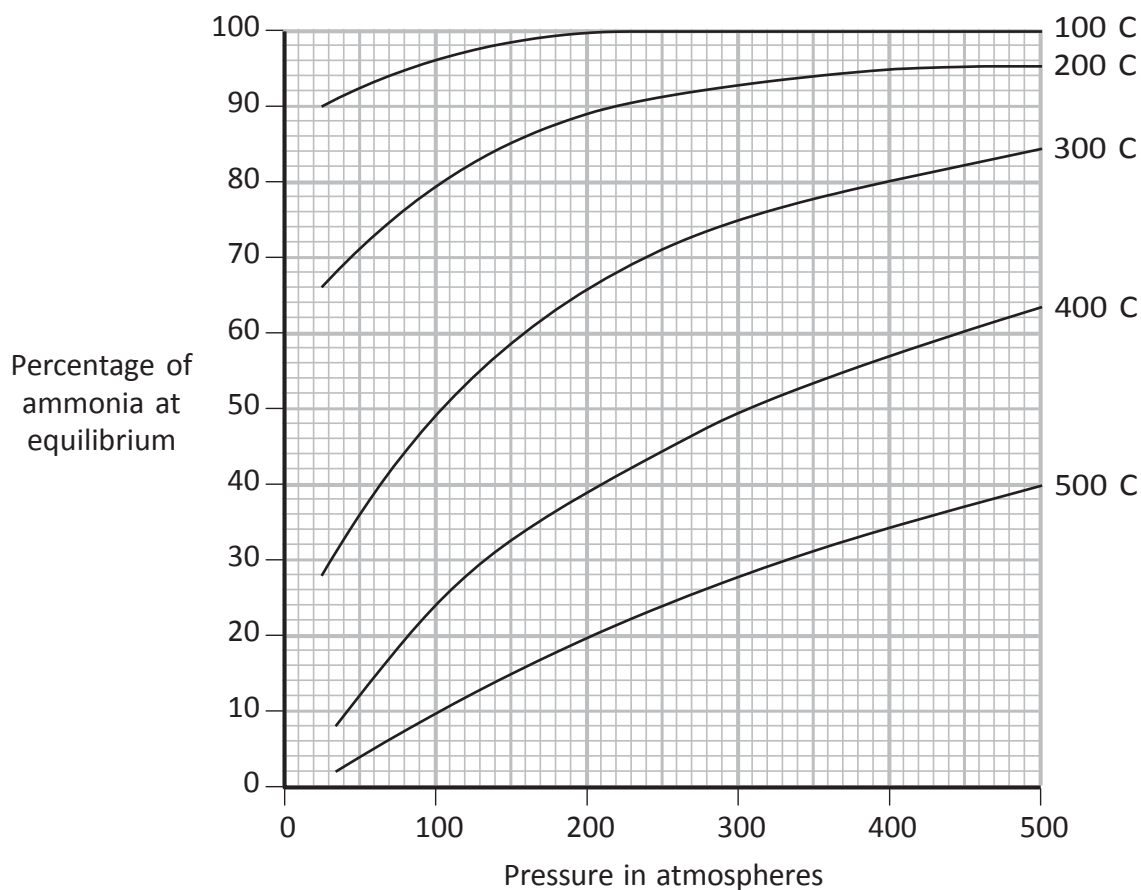
(Total for Question 4 = 13 marks)

5 Ammonia (NH₃) can be made by reacting nitrogen and hydrogen, in the presence of an iron catalyst, according to the equation



The reaction is reversible and the reaction mixture can, if left for long enough, reach a position of dynamic equilibrium.

The graph shows how the percentage of ammonia at equilibrium depends on the temperature and pressure used.



(a) State two features of a reaction mixture that is in dynamic equilibrium.

(2)

1

2

- (b) (i) Use the graph to state the effect on the percentage of ammonia at equilibrium of the following changes
- an increase in temperature at constant pressure
 - an increase in pressure at constant temperature

Write your answers in the table.

(2)

	Effect on percentage of ammonia at equilibrium
increase in temperature	
increase in pressure	

- (ii) Explain why these changes have the effects you have given in (b)(i).

(2)

Increase in temperature.....

Increase in pressure.....

- (c) The reaction between nitrogen and hydrogen is used to manufacture ammonia in the Haber process. This process operates at a pressure of 200 atmospheres and a temperature of 450 °C, with an iron catalyst.

If the reaction mixture reached a position of equilibrium, the expected yield of ammonia would be about 30%.

The actual yield of ammonia obtained in the Haber process is about 15%.

- (i) Suggest why the actual yield of ammonia is lower than the expected yield.

(1)

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- (ii) How is the ammonia separated from the unreacted nitrogen and hydrogen?

(2)

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(iii) What happens to the unreacted nitrogen and hydrogen? (1)

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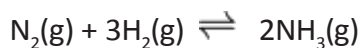
(d) The reaction would be faster if a higher temperature were used.
Suggest why a higher temperature is not used in the Haber process. (1)

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(e) The equation for the formation of ammonia is



(i) Calculate the amount, in moles, of ammonia, that could be formed in the Haber process from 112 kilograms of nitrogen, assuming all the nitrogen is converted into ammonia. (3)

Amount of ammonia = mol

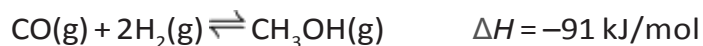
(ii) Only 15% of the nitrogen is converted into ammonia.
Calculate the actual amount, in moles, of ammonia that is formed from 112 kilograms of nitrogen. (1)

Amount of ammonia = mol

(Total for Question 5 = 15 marks)

6 Carbon monoxide and hydrogen are used in the manufacture of methanol (CH₃OH).

The reaction is reversible and can reach a position of dynamic equilibrium.



The reaction is carried out at a pressure of about 100 atmospheres and a temperature of 250°C.

(a) State two features of a reaction that is in dynamic equilibrium.

(2)

1

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2

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(b) (i) How would a decrease in temperature at constant pressure affect the amount of methanol in the equilibrium mixture?

Explain your answer.

(2)

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(ii) How would an increase in pressure at constant temperature affect the amount of methanol in the equilibrium mixture?

Explain your answer.

(2)

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(c) Methanol (CH_3OH) can be converted into methanal (H_2CO).

A mixture of methanol and oxygen is passed over an iron oxide catalyst at 250°C .

Methanal and water are the only two products.

(i) Write a chemical equation for the conversion of methanol into methanal.

(2)

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(ii) What is meant by the term **catalyst**?

(2)

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(iii) Explain how a catalyst works.

(2)

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(d) Methanol can be used in racing cars as an alternative fuel to petrol.

Write the chemical equation for the complete combustion of methanol.

(2)

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(Total for Question 6 = 14 marks)