Industrial Manufacture of Chemicals

Question Paper

Level	GCSE
Subject	Chemistry
Exam Board	Edexcel IGCSE
Module	Double Award (Paper 1C)
Topic	Chemistry in Industry
Sub-Topic	Industrial Manufacture of chemicals
Booklet	Question Paper

Time Allowed: **68 minutes**

Score: **/57**

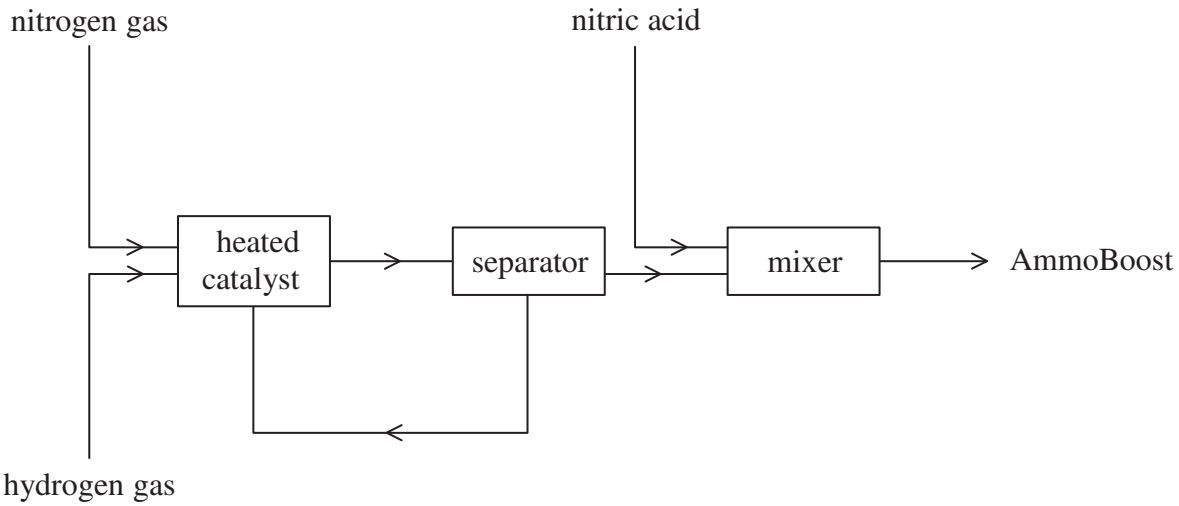
Percentage: **/100**

Grade Boundaries:

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

1 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)

.....

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

(1)

.....

(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

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3\ J \qquad \Delta H = -92\ kJ/mol$$

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

.....

.....

Effect of higher temperature on equilibrium position

.....

.....

(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)

.....

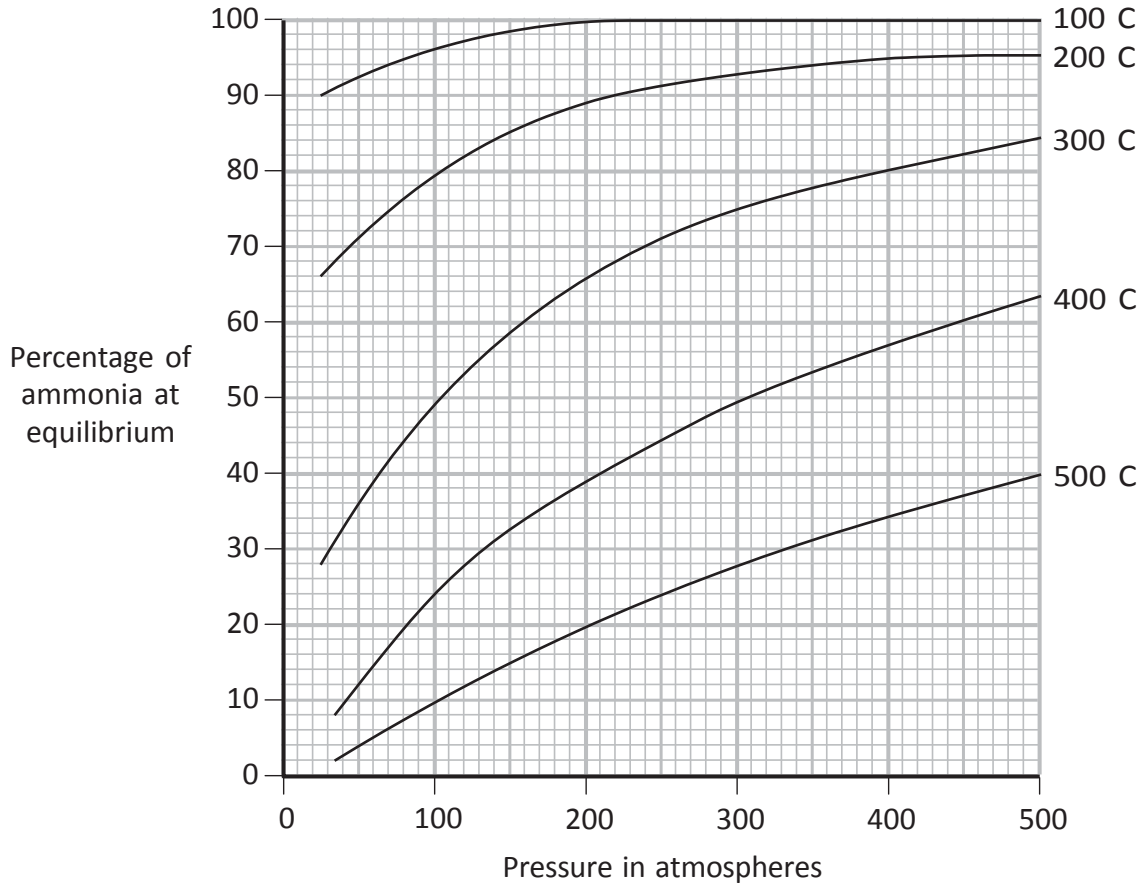
(Total for Question 1 = 18 marks)

2 Ammonia (NH_3) can be made by reacting nitrogen and hydrogen, in the presence of an iron catalyst, according to the equation

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ/mol}$$

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)

.....

.....

.....

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

(2)

.....

.....

.....

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

(1)

.....

(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)

.....

.....

.....

(e) The equation for the formation of ammonia is

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

(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.

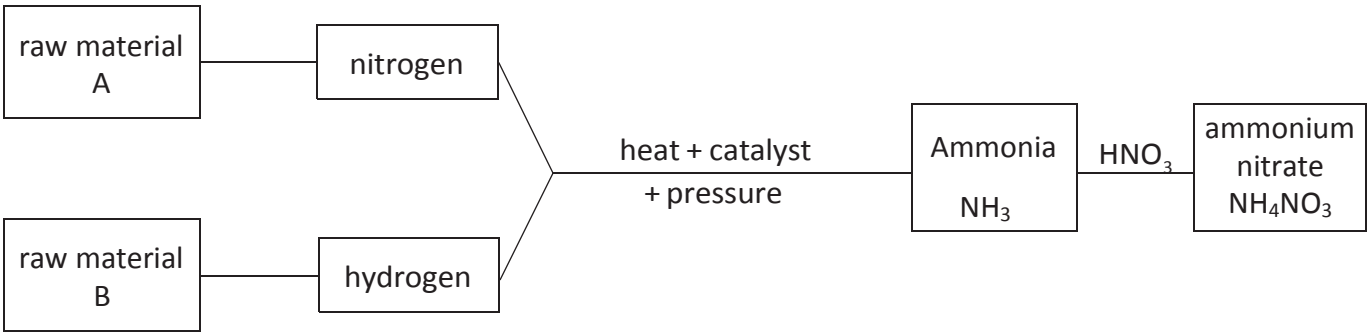
Calculate the actual amount, in moles, of ammonia that is formed from 112 kilograms of nitrogen.

(1)

Amount of ammonia = ... mol

(Total for Question 2 = 15 marks)

3 The diagram shows the manufacture of ammonia by the Haber process and its conversion into the fertiliser ammonium nitrate.



(a) Give the names of the raw materials A and B.

(2)

A .....

B .....

(b) State the temperature, pressure and catalyst used to convert the mixture of nitrogen and hydrogen into ammonia.

(3)

temperature .....

pressure .....

catalyst .....

(c) Give the name of the substance that has the formula HNO_3

(1)

.....

(d) The equation for the formation of ammonium nitrate from ammonia is

$$NH_3(aq) + HNO_3(aq) \rightarrow NH_4NO_3(aq)$$

25.0 cm^3 of a solution of ammonia of concentration 0.300 mol/dm^3 were reacted with a solution of HNO_3

15.0 cm^3 of HNO_3 were required to exactly neutralise the ammonia solution.

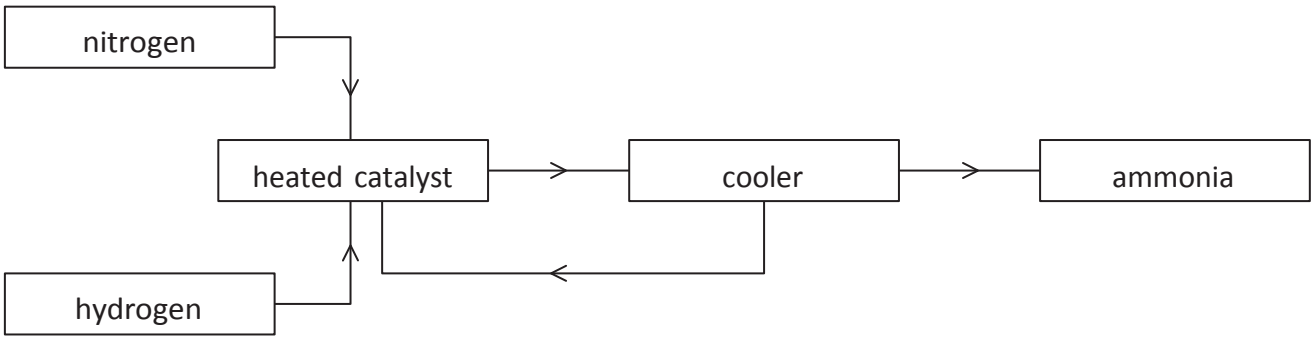
Calculate the concentration, in mol/dm^3, of the HNO_3 solution.

(3)

concentration of HNO_3 = ... mol/dm^3

(Total for Question 3 = 9 marks)

4 (a) The flow chart shows how ammonia is made using the Haber process.



(i) State one raw material that is used as the source of

(2)

nitrogen .....

hydrogen .....

(ii) Identify the catalyst and state the pressure, in atmospheres, used in the Haber process.

(2)

catalyst .....

pressure .....

(iii) Which substances pass from the cooler to the heated catalyst?

(1)

☒ **A** ammonia, hydrogen and nitrogen

☒ **B** hydrogen only

☒ **C** hydrogen and nitrogen

☒ **D** nitrogen only

(iv) When ammonia leaves the cooler it is

(1)

☒ **A** an aqueous solution

☒ **B** a gas

☒ **C** a liquid

☒ **D** a solid

(b) Hydrazine (N_2H_4) is a useful compound that can be manufactured from ammonia.

(i) Hydrogen peroxide can be used to convert ammonia to hydrazine.

Balance the equation for this reaction.

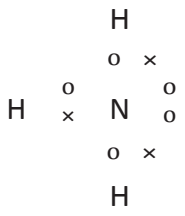
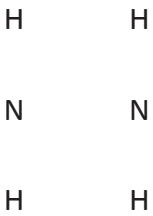
(1)

.....NH_3 + ...H_2O_2 $\rightarrow$ .....N_2H_4 + ...H_2O

(ii) The bonding in ammonia and hydrazine can be represented by dot and cross diagrams. The diagram for ammonia has been drawn.

All the bonds in hydrazine are single bonds. Complete the diagram for hydrazine. Show only the outer electrons.

(2)

ammonia	hydrazine
	

(c) Hydrazine was used as the fuel in the first rocket-powered fighter aircraft in World War II.

It is now used as a propellant in spacecraft. It slowed the descent of the Phoenix spacecraft as it landed on Mars.

The equations for its use as a rocket fuel and as a propellant are shown in the table.

Use	Equation	ΔH in kJ/mol
rocket fuel	$N_2H_4 + O_2 \rightarrow N_2 + 2H_2O$	−660
propellant	$N_2H_4 \rightarrow N_2 + 2H_2$	−50

(i) How does the information in the table show that both reactions are exothermic?

(1)

.....

.....

(ii) Why is it not correct to describe hydrazine as a fuel when it is used as a propellant?

(1)

.....

.....

(d) Some spacecraft use MMH, a compound similar to hydrazine, as a propellant. MMH has the composition by mass of 26.1% carbon, 60.9% nitrogen and 13.0% hydrogen.

(i) Calculate the empirical formula of MMH.

(3)

empirical formula.....

(ii) The M_r of MMH is 46

What is the molecular formula of MMH?

(1)

.....

(Total for Question 4 = 15 marks)