Questions

Q1.

The volume of dilute sulfuric acid required to neutralise 25.0 cm3 of ammonia solution can be found by titration.
In the titration, a few drops of methyl orange indicator were added to the ammonia solution in a conical flask before adding the dilute sulfuric acid.
When the ammonia solution was neutralised by the dilute sulfuric acid, a solution of ammonium sulfate was formed.
Complete the balanced equation for the reaction between ammonia solution and sulfuric acid.

(2)

..... NH_3 + H_2SO_4 → .....

(Total for question = 2 marks)

Q2.

The industrial production of sulfuric acid involves several steps.

One of these steps is the reaction of sulfur dioxide, SO2, with oxygen to form sulfur trioxide, SO3.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

* The reaction to produce sulfur trioxide reaches an equilibrium.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The forward reaction is exothermic.
The rate of attainment of equilibrium and the equilibrium yield of sulfur trioxide are affected by pressure and temperature.

A manufacturer considered two sets of conditions, A and B, for this reaction.
In each case sulfur dioxide is mixed with excess oxygen.
The manufacturer changed the temperature and the pressure and only used a catalyst in B.
The sets of conditions A and B are shown in Figure 7.

set of conditions	pressure in atm	temperature in °C	catalyst
A	2	680	no catalyst used
B	4	425	catalyst used

Figure 7

The manufacturer chooses set of conditions B rather than set of conditions A.

Explain, by considering the effect of changing the conditions on the rate of attainment of equilibrium and on the equilibrium yield of sulfur trioxide, why the manufacturer chooses the set of conditions B rather than the set of conditions A.

(Total for question = 6 marks)

Q3.

The fertiliser ammonium phosphate was made by reacting ammonia solution with dilute phosphoric acid.

(i) In the first step, 25 cm3 of dilute phosphoric acid was placed in a beaker.

Give the name of a piece of apparatus that could be used to measure out the 25 cm3 dilute phosphoric acid.

(1)

.....

(ii) Complete the word equation for this reaction.

(1)

ammonia + ... → .....

(iii) Some ammonium phosphate solution was made.

Describe how pure, dry crystals of ammonium phosphate are obtained from the ammonium phosphate solution.

(2)

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(Total for question = 4 marks)

Q4.

Ammonia solution and dilute sulfuric acid are used to prepare pure, dry ammonium sulfate crystals.

In an experiment a titration is carried out to determine the volumes of ammonia solution and dilute sulfuric acid that react together.
Then an ammonium sulfate solution is prepared from which the pure, dry crystals are obtained.

Describe in detail, using suitable apparatus, how this experiment should be carried out.

(Total for question = 6 marks)

Q5.

Ammonium sulfate and ammonium nitrate are used as fertilisers as they both contain nitrogen, which will increase the yield of crops.

(i) Suggest one other reason for using solid ammonium sulfate and solid ammonium nitrate as nitrogenous fertilisers.

(1)

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(ii) Ammonium nitrate can be made by the reaction of ammonia with nitric acid.

Write the balanced equation for this reaction.

(2)

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(iii) Describe one similarity and one difference between the industrial production of ammonium sulfate and the laboratory preparation of ammonium sulfate.

(2)

similarity .....

.....

difference .....

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(Total for question = 5 marks)

Q6.

When hydrogen is removed from an alkane, an alkene is formed.

This is an example of a dehydrogenation reaction.

Under certain conditions the dehydrogenation of propane forms propene and a dynamic equilibrium is reached.

(i) State what is meant by dynamic in this context.

(1)

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*(ii) The equation for this equilibrium reaction is

$$\underset{\text{propane}}{C_3H_8(g)} \rightleftharpoons \underset{\text{propene}}{C_3H_6(g)} + H_2(g)$$

The forward reaction takes in heat energy and is endothermic. A manufacturer produces large quantities of propene using this equilibrium reaction.
Suggest, with explanations, suitable conditions that the manufacturer could use to maximise the yield and rate of production of propene from propane.

(6)

(Total for question = 7 marks)

Q7.

* The reaction between nitrogen and hydrogen is exothermic.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

If nitrogen and hydrogen were reacted at 150 atm pressure and 300 °C, without a catalyst, some ammonia would be formed.
In the Haber process a pressure of 150 atm and a temperature of 450 °C are used, in the presence of an iron catalyst.
Explain why the conditions used in the Haber process are better than the first set of conditions for the manufacture of ammonia.

(6)

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(Total for question = 6 marks)

Q8.

Methane reacts with steam to form hydrogen and carbon dioxide.

The reaction takes place in two stages.

stage 1: $CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$

stage 2: $CO(g) + H_2O(g) \rightleftharpoons H_2(g) + CO_2(g)$

(i) Stage 1 takes in heat energy, it is endothermic.

Explain the effect of increasing the temperature on the yield of the products of stage 1.

(2)

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(ii) The overall equation for the process is

$$CH_4(g) + 2H_2O(g) \rightarrow 4H_2(g) + CO_2(g)$$

0.40 g of methane were fully reacted with steam to form carbon dioxide and hydrogen.

Calculate the maximum volume of hydrogen in dm3, measured at room temperature and pressure, that could be made in this reaction.

(relative formula mass: CH4 = 16, 1 mol of any gas at room temperature and pressure occupies 24 dm3)

(3)

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maximum volume of hydrogen = ... dm3

(Total for question = 5 marks)

Q9.

Sulfur trioxide is produced by reacting sulfur dioxide with oxygen.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

(i) This reaction takes place in industry at 1–2 atm pressure and can reach a dynamic equilibrium.

Explain the effect on the rate of attainment of equilibrium, if the process is carried out at a pressure higher than 1–2 atm.

(3)

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(ii) What volume of oxygen, in cm3, would react completely with 500 cm3 sulfur dioxide?

(1)

- ☒ A 500 ÷ 2
- ☒ B 500
- ☒ C 500 × 2
- ☒ D 500 × 32

(Total for question = 4 marks)

Q10.

In another stage in the production of nitric acid, ammonia is reacted with oxygen to form nitrogen oxide and water.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

Heat energy is given out when ammonia reacts with oxygen.

The conditions chosen for the reaction are

- excess air, rather than just the right amount
- a pressure of 10 atm, rather than atmospheric pressure
- a temperature of 900 °C, rather than room temperature.

Explain the effect of the conditions chosen on the equilibrium yield of nitrogen oxide and on the rate of attainment of equilibrium.

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(Total for question = 6 marks)

Q11.

* The hydrogen used in a hydrogen-oxygen fuel cell can be produced from methanol, CH_3OH.

$$CH_3OH + H_2O \leftrightarrow CO_2 + 3H_2$$

In this reaction the forward reaction is endothermic and heat energy is taken in from the surroundings.
The conditions used for this reaction are

- a nickel catalyst
- a temperature of 220 °C

Explain, in terms of their effects on the rate of attainment of equilibrium and the equilibrium yield of hydrogen, why the reaction is carried out using a catalyst at 220 °C rather than without a catalyst at a lower temperature.

(6)

(Total for question = 6 marks)

Q12.

Figure 1 shows the dot and cross diagram for a molecule of ammonia.

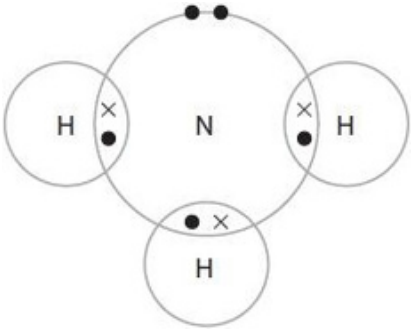

Figure 1

Ammonia reacts with nitric acid to form ammonium nitrate.

(i) Complete the word equation for this reaction.

(1)

..... + ... → .....

(ii) An ammonium ion has the formula NH_4^+.

A nitrate ion has the formula NO_3^-.
Which of the following is the formula for ammonium nitrate?

(1)

- ☒ A (NH)4NO3
- ☒ B (NH4NO)3
- ☒ C NH4NO3
- ☒ D (NHNO)12

(iii) Explain why farmers spread ammonium nitrate on their fields.

(2)

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.....

(Total for question = 4 marks)

Q13.

Ammonium phosphate and ammonium sulfate are made from ammonia.

These compounds can be used as fertilisers.

Give one advantage of using fertilisers made from ammonia rather than using manure.

(1)

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(Total for question = 1 mark)

Q14.

Ammonium nitrate is produced from ammonia and nitric acid on a large scale in industry.

Ammonium nitrate can also be made in the laboratory by titrating ammonia solution with dilute nitric acid.

$$NH_3 + HNO_3 \rightarrow NH_4NO_3$$

Ammonium nitrate crystals can then be obtained by evaporating off some of the water from the solution.
Give two reasons why this laboratory method is not suitable for use on a large scale in industry.

(2)

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(Total for question = 2 marks)

Q15.

In industry, ammonia is manufactured by reacting nitrogen with hydrogen.

(i) Give the name of the industrial process used to manufacture ammonia.

(1)

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(ii) Write the word equation for this reaction, including the correct symbol to show that the reaction is reversible.

(3)

.....

.....

(Total for question = 4 marks)

Q16.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Ammonia is manufactured by the Haber process.

The equation for the reaction is

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

The reaction is reversible and can reach equilibrium.

(i) An iron catalyst can be used in the reaction.

Which row of the table shows how adding the iron catalyst affects the rate of attainment of equilibrium and the equilibrium yield of ammonia?

(1)

		rate of attainment of equilibrium	equilibrium yield of ammonia
☒	**A**	increases	increases
☒	**B**	decreases	does not change
☒	**C**	decreases	increases
☒	**D**	increases	does not change

(ii) Which of the following statements is correct when the reaction reaches equilibrium?

(1)

☒ A the reverse reaction starts to take place

☒ B the amounts of nitrogen, hydrogen and ammonia are equal

☒ C the amounts of nitrogen, hydrogen and ammonia become constant

☒ D the reaction stops

(iii) The reaction is carried out at a pressure of 200 atmospheres.

Explain what effect a pressure higher than 200 atmospheres would have on the rate of attainment of equilibrium and on the equilibrium yield of ammonia.

(4)

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(Total for question = 6 marks)

Q17.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

In industry, ammonia is manufactured by reacting nitrogen with hydrogen.

Most of the ammonia manufactured in industry is used to produce fertilisers.

(i) A fertiliser is made by reacting ammonia with nitric acid.

What is the name of this fertiliser?

(1)

☐ A ammonia nitrate

☐ B ammonia nitric

☐ C ammonium nitrate

☐ D ammonium nitric

(ii) Explain the importance of fertilisers in farming.

(2)

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.....

(Total for question = 3 marks)

Q18.

Figure 1 shows a bag of NPK fertiliser.

Figure 1

N, P and K are the symbols of three elements that are essential for plant growth.

N is the symbol for nitrogen.

Name the other two elements, P and K, that are essential for plant growth.

You may want to refer to the periodic table.

(2)

P .....

K .....

(Total for question = 2 marks)

Q19.

Figure 1 shows the dot and cross diagram for a molecule of ammonia.

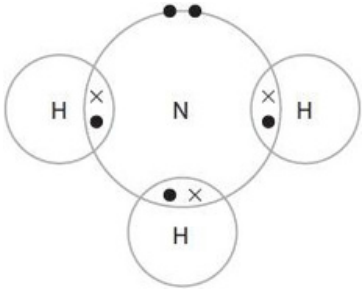


Figure 1

(i) Ammonia can be manufactured by the Haber process.

The word equation for the reaction is

nitrogen + hydrogen ⇌ ammonia

State the meaning of the ⇌ symbol.

(1)

.....

(ii) In the Haber process, the percentage yield of ammonia at equilibrium changes with temperature.

Figure 2 shows how the percentage yield of ammonia at equilibrium changes with temperature.

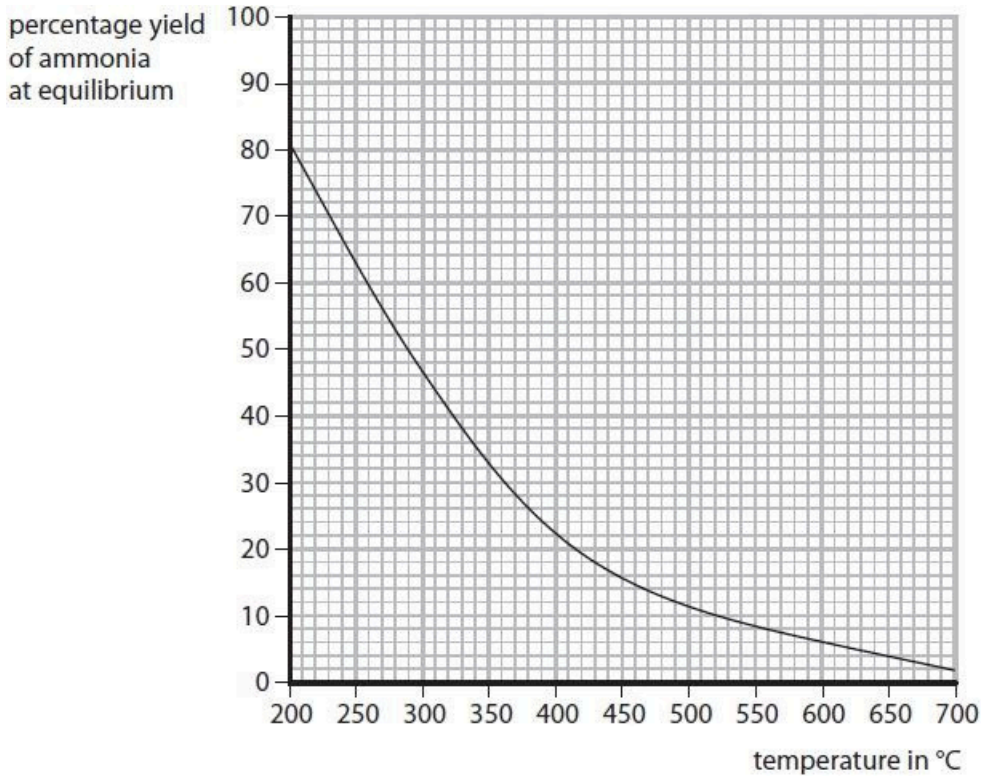


Figure 2

State what happens to the percentage yield of ammonia at equilibrium as the temperature increases.

(1)

.....

.....

(iii) Use the graph to find the percentage yield of ammonia at equilibrium at 450°C.

(1)

percentage yield of ammonia at equilibrium = ...

(Total for question = 3 marks)

Q20.

Fertilisers contain compounds that promote plant growth.

(i) State the name of an element in these compounds that promotes plant growth.

(1)

.....

(ii) Potassium nitrate is present in some fertilisers.

Potassium nitrate is formed by the reaction of potassium hydroxide solution with nitric acid.
Complete the balanced equation for this reaction.

(2)

$KOH + HNO_3 \rightarrow$ ..... +
.....

(Total for question = 3 marks)

Q21.

Some questions must be answered with a cross in a box (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

Many fertilisers are produced using ammonia.

Ammonia is produced on an industrial scale from the reaction of nitrogen with hydrogen.

The equation for the reaction is

nitrogen + hydrogen ↔ ammonia

(i) State the name of this industrial process.

(1)

.....

(ii) State the meaning of the ↔ symbol in the equation.

(1)

.....

(iii) Figure 2 shows the electronic configurations for an atom of nitrogen and an atom of hydrogen.

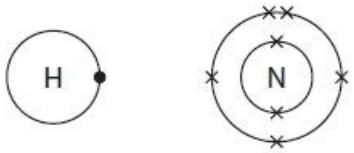
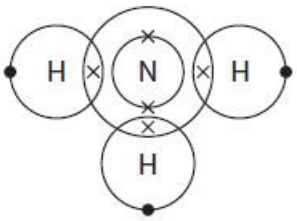


Figure 2

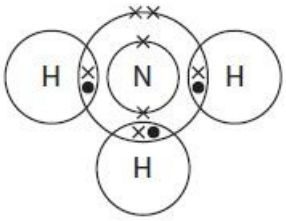
Which dot and cross diagram for ammonia, NH3, is correct?

(1)

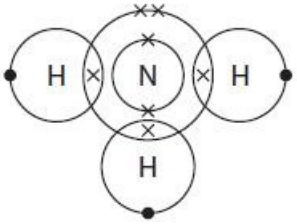
☐ **A**



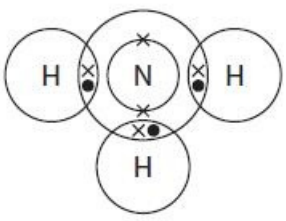
☐ **B**



☐ **C**



☐ **D**



(Total for question = 3 marks)

Q22.

Many metals corrode.

Ammonia is used to make hydrazine.

In the industrial process to manufacture ammonia, nitrogen and hydrogen are combined in the presence of an iron catalyst.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

(i) State the name of the industrial process to manufacture ammonia.

(1)

.....

(ii) Predict the effect that adding the catalyst has on the rate of attainment of equilibrium.

(1)

.....

.....

(iii) Predict the effect that adding the catalyst has on the equilibrium yield of ammonia.

(1)

.....

.....

(Total for question = 3 marks)

Q23.

Fertilisers are sometimes added to soil.

(i) State why fertilisers are added to soil.

(1)

.....

.....

(ii) Fertilisers contain compounds of different elements.

Three of these elements have the symbols K, N and P.
Use the periodic table to state the names of these three elements.

(2)

K .....

N .....

P .....

(Total for question = 3 marks)

Q24.

Ammonia reacts with nitric acid to produce ammonium nitrate.

Write the word equation for this reaction.

(2)

..... + ... →
.....

(Total for question = 2 marks)

Mark Scheme

Q1.

Question number	Answer	Additional guidance	Mark
	$2\ NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$ (2) MP1 : formula of product (1) MP2 : balancing (of correct formulae) (1)	 MP2 dependent on MP1 allow correct multiples throughout	**(2)** AO2-1

Q2.

Question Number	Indicative content	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlines in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • equilibrium reached faster because of higher temperature in set A / equilibrium reached slower because of lower temperature in set B • higher temperature means more frequent collisions because molecules have more energy / ORA for lower temperature in set B • decrease in temperature increases equilibrium yield but system takes longer to reach equilibrium • temperature chosen for optimum conditions • yield lower as forward reaction is exothermic • high temperature favours back reaction which is endothermic • equilibrium reached faster because of higher pressure in set B / equilibrium reached slower because of lower pressure in set A • higher pressure causes molecules to be closer together so more frequent collisions / ORA for lower pressure in set A • yield higher because products occupy smaller volume than reactants for set B • catalyst in set B causes equilibrium to be reached faster • catalyst increases rate of both forward and back reactions • equilibrium position not affected so catalyst does not affect yield • catalyst reduces the need for the higher temperature	**(6)** AO 2 1 AO 3 1a AO 3 1b

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	• Interpretation and evaluation of the information attempted but will be limited with a focus on mainly just one variable. Demonstrates limited synthesis of understanding. (AO3) • The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
Level 2	3–4	• Interpretation and evaluation of the information on both variables, synthesising mostly relevant understanding. (AO3) • The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5–6	• Interpretation and evaluation of the information, demonstrating throughout the skills of synthesising relevant understanding. (AO3) • The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

Q3.

Question number	Answer	Additional guidance	Mark
(i)	measuring cylinder	allow burette or pipette	(1)

Question number	Answer	Mark
(ii)	(ammonia) + phosphoric acid → ammonium phosphate	(1)

Question number	Answer	Mark
(iii)	An answer that combines the following points of application of knowledge and understanding to provide a logical description: • first heat the solution/leave water to evaporate (1) • and then filter off/dry crystals formed (1)	(2)

Q4.

Question number	Indicative content	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 (3 marks) AO2 (3 marks)** • pipette to measure out the ammonia solution (25 cm^3) • into a suitable container, e.g. conical flask • add few drops of methyl orange indicator • put flask on a white tile • fill burette with sulfuric acid solution • read level of liquid in burette • add acid from the burette • swirl flask gently / mix • add drop-wise near end-point • until {indicator just changes colour} • read level on burette • repeat experiment until concordant results owtte • mix the same volumes of sulfuric acid and ammonia solution (determined from the titration experiment) • but leaving out the indicator/methyl orange • pour solution into an evaporating dish • heat the solution to point of crystallisation • leave to cool • filter off crystals • leave to dry	EXP (6)

Level	Mark	Descriptor
	0	• No awardable content
Level 1	1-2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
Level 2	3-4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5-6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

Level	Mark	Additional Guidance	General additional guidance – the decision within levels
			Eg - At each level, as well as content, the scientific coherency of what is stated backed up by planning detail will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance Describes at least two steps of any of the three stages in the preparation of the ammonium sulfate crystals	Possible candidate responses • add sulfuric acid using a burette to ammonium solution • use a pipette to measure out the ammonia solution and fill a burette with sulfuric acid • mix correct volumes of sulfuric acid and ammonia solution together without indicator • heat the ammonium solution until crystals start to form
Level 2	3–4	Additional guidance Describes at least two of the three stages in some detail, at least three steps, OR all three stages but lacking detail	Possible candidate responses • use a pipette to measure out the ammonia solution into a conical flask add few drops of indicator, add acid from a burette to ammonia solution. Crystallise the ammonium sulfate solution. • use a pipette to measure out the ammonia solution. Add sulfuric acid using a burette to ammonia solution. Mix correct volumes of sulfuric acid and ammonia solution together without indicator to produce ammonium sulfate solution. • carry out a titration adding acid to ammonia to find amounts of acid and ammonia solution needed. Mix correct amounts of sulfuric acid and ammonia solution together without indicator. Crystallise the ammonium sulfate solution.
Level 3	5–6	Additional guidance Describes all three stages in the preparation of the ammonium sulfate crystals in some detail to include without use of indicator (6 marks) OR two stages in detail to include repeating without indicator (5 marks)	Possible candidate responses • use a pipette to measure out the ammonia solution into a conical flask. Add a few drops of indicator. Add acid from a burette to ammonia solution, swirling flask, until indicator just changes colour. Mix correct volumes of sulfuric acid and ammonia solution together without indicator to produce ammonium sulfate solution. Heat the ammonium sulfate solution until crystals start to form. Leave to cool and filter off crystals. • use a pipette to measure out the ammonia solution into a conical flask. Add a few drops of indicator. Place flask on white tile. Fill a burette with sulfuric acid and read level on burette. Add acid to ammonia solution, swirling flask, until indicator just changes colour. Read level on burette. Use the results of titration, mixing the correct volumes of sulfuric acid and ammonia leaving out indicator.

Q5.

Question number	Answer	Additional guidance	Mark
(i)	both are {soluble/will dissolve} (in water)		(1)

Question number	Answer	Additional guidance	Mark
(ii)	$NH_3 + HNO_3 \rightarrow NH_4NO_3$ LHS (1) RHS (1)	allow multiples	(2)

Question number	Answer		Mark
(iii)	a similarity from : both use sulfuric acid (1) both (are examples of) neutralisation (1) and a difference from : the industrial process is on a much larger scale than the laboratory process / ORA (1) the industrial process involves more stages than the laboratory process / ORA (1) ammonia is a gas in the industrial process but a solution in the laboratory process (1) laboratory preparation uses titration and crystallisation (1)	 ignore both produce ammonium sulfate allow both use same reactants allow both give out heat energy / exothermic (1) allow laboratory preparation is a batch process, industrial preparation is continuous process (1) ignore industrial is more dangerous	(2)

Q6.

Question number	Answer	Additional guidance	Mark
(i)	both forward and back(ward) reactions take place at same time	allow forward and back(ward) reactions occur at same rate	(1) AO1-1

Question number	Indicative content	Mark
*(ii)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material that is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 (3 marks) AO2 (3 marks)** • use of suitable catalyst (any suitable metal eg Pt) • helps increase rate of forward reaction • and helps increase rate of back reaction • so increases rate of attainment of equilibrium • but has no effect on equilibrium yield • increase temperature would increase rate of reaction • shifts equilibrium to right hand side • so increases equilibrium yield • so use a high temperature (range 200–600 °C – anything would be reasonable) • use of very high temperatures increases energy use • so makes product more expensive • as fewer molecules on left hand side than right • so use low pressures • moves equilibrium to right hand side • so increases equilibrium yield • high pressure increases rate but decreases yield OR low pressure increases yield but decreases rate • pressure used is a compromise between rate and yield	**(6)** AO1-1 AO2-1

Level	Mark	Descriptor
	0	• No awardable content
Level 1	1-2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
Level 2	3-4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5-6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

Level	Mark	Additional Guidance	General additional guidance - the decision between levels
	0	No rewardable material.	Read whole answer and ignore all incorrect material/ discard any contradictory material then:
Level 1	1-2	Additional Guidance • One factor is discussed with a statement of effect on yield and/or rate (1) • One factor is discussed with explanation of yield and/or rate (2) • Two or three factors are discussed with statement of effect on yield and/or rate (2)	Possible Candidate Responses High temperature gives high yield of propene as equilibrium moves to products side. A low pressure gives a higher yield because there are more gas molecules on the right-hand side (ORA) Addition of catalyst increases rate of attainment of equilibrium Factor and reason – 2 marks
Level 2	3-4	Additional Guidance • One factor is fully discussed with explanation of yield and rate (3) • Two factors are discussed with explanation of yield and/or rate in one case and just statement of yield and/or rate in one case (3) • Two factors are discussed with explanation of yield and/or rate in each case (4) • Three factors are discussed with statement of effect on yield and/or rate with explanation for at least one (4)	Possible Candidate Responses A higher pressure gives a lower yield because there are more gas molecules on the right-hand side. A higher temperature gives a higher yield because the forward reaction is endothermic. 2 factors both with reasons – 4 marks
Level 3	5-6	Additional Guidance To get into level 3 yield and rate must be both discussed at least once. • All three factors are discussed, with explanation of yield and/or rate in each case (6) • All three factors are discussed, with explanation of yield and/or rate in two cases (5)	Possible Candidate Responses use of catalyst increases rate of forward reaction and increases rate of back reaction so increases rate of attainment of equilibrium but has no effect on equilibrium yield; increase temperature increases rate of reaction and shifts equilibrium to product side so use a high temperature; use low pressures as fewer molecules on reactant side than products so moves equilibrium to right hand side & yield increases but high pressure increases rate but decreases yield 3 factors detailed with at least 2 reasons – 6 marks

Q7.

Question Number	Indicative content
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 (6 marks)** The effect of the temperature rise on the rate of attainment of equilibrium and on the equilibrium yield are considered by: • higher temperature reaches equilibrium faster because molecules move faster • therefore there are more frequent collisions because molecules have more energy • therefore more collisions have required energy but yield will be lower • because higher temperature favours endothermic reaction and so equilibrium shifts to left hand side • which is decomposition of ammonia / ammonia reforms elements • catalyst causes reaction to reach equilibrium faster / catalyst increases rates (of both forward and back reactions) • lowers the activation energy (of both forward and back reactions) but does not affect yield • equilibrium position not affected.

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1-2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Q8.

Question number	Answer	Additional guidance	Mark
(i)	an explanation linking • shift equilibrium to right / in forward direction (1) • increase yield of {product / hydrogen / carbon monoxide} (1)	allow favours forward/endothermic reaction ignore references to decreasing amounts of reactants. marks are independent	(2)

Question number	Answer	Additional guidance	Mark
(ii)	final answer of 2.4 with or without working (3) OR $\frac{0.4}{16} = 0.025$ (1) $0.025 \times 4 = 0.1$ (1) $0.1 \times 24 = 2.4$ (1)		(3)

Q9.

Question number	Answer	Mark
(i)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (2 marks): • rate increased/time to reach equilibrium reduced (1) • because gas molecules closer/more concentrated (1) • so increased collision rate/more frequent collisions(1)	(3)

Question number	Answer	Mark
(ii)	A	(1)

Q10.

Question number	Indicative content	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlines in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 & AO2 (6 marks)** EXCESS AIR • increases oxygen concentration • so excess air favours right hand side • and gives higher yield • excess air increases concentration of oxygen • equilibrium reached faster PRESSURE • 9 molecules on left and 10 on right • so higher pressure favours left hand side • and gives lower yield • higher pressure increases concentration of gases • more frequent collisions • equilibrium reached faster TEMPERATURE • heat energy given out in forward reaction • higher temperature favours reaction that takes in heat energy • so higher temperature favours left hand side • hence lower yield • molecules move faster at higher temperature • more frequent collisions • therefore more reactions in given time • equilibrium reached faster	**(6)**

Level	Mark	Descriptor
	0	• No awardable content
Level 1	1-2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
Level 2	3-4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5-6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

Level	Mark	Descriptor	Additional guidance
	0	No rewardable material.	Read whole answer and ignore all incorrect material/ discard any contradictory material then:
Level 1	1–2	Additional guidance **One** factor is discussed with a **statement** of effect on yield **and/or** rate (1) **One** factor is discussed with **explanation** of yield **and/or** rate (2) **Two or three** factors are discussed with **statement** of effect on yield **and/or** rate (2)	Possible candidate responses A higher pressure gives a lower yield because there are more gas molecules on the right hand side. Factor and reason – 2 marks
Level 2	3–4	Additional guidance **One** factor is **fully** discussed with **explanation** of yield **and** rate. (3) **Two** factors are discussed with **explanation** of yield **and/or** rate in one case and just **statement** of yield **and/or** rate in one case(3) **Two** factors are discussed with **explanation** of yield **and/or** rate in each case (4) **Three** factors are discussed with **statement** of effect on yield **and/or** rate with **explanation** for at least one (4)	Possible candidate responses A higher pressure gives a lower yield because there are more gas molecules on the right hand side. A higher temperature gives a lower yield because the forward reaction is exothermic. 2 factors both with reasons – 4 marks
Level 3	5–6	Additional guidance All **three** factors are discussed, with **explanation** of yield **and/or** rate in each case (6) All **three** factors are discussed, with **explanation** of yield **and/or** rate in two cases (5)	Possible candidate responses Excess air gives a higher yield. A higher pressure gives a higher rate because the gas molecules are closer and collide more frequently. A higher temperature gives a higher rate because more molecules have the activation energy. 3 factors, 2 have reasons, 1 statement (air) – 5 marks

Q11.

Question number	Indicative content	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material that is indicated as relevant. Additional content included in the response must be scientific and relevant. (effect of using a catalyst) • increases rate of attainment of equilibrium • increasing rate of both forward and back reaction • lowers activation energy • provides an alternative reaction pathway • no effect on equilibrium yield (effects of using a temperature of 220°C rather than lower temperatures) • equilibrium attained in a shorter period of time / faster rate of attainment of equilibrium • because particles move faster/ have higher (kinetic) energy • increased collision frequency and more energetic collisions • equilibrium yield of hydrogen increases with higher temperatures • because heat energy is taken in the forward reaction (endothermic) • increasing the temperature shifts equilibrium further to the right-hand side	(6) AO1

Level	Mark	Additional Guidance	General additional guidance – the decision within levels Eg - At each level, as well as content, the scientific coherency of what is stated backed up by detail will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance Identifies at least ONE way that use of a catalyst OR temperature affects equilibrium. OR A simple explanation of one way that catalyst or temperature affects equilibrium.	Possible candidate responses • Increasing temperature increases rate of attainment. • Increasing temperature shifts equilibrium to the right. • Using a catalyst has no effect on the equilibrium yield / position of equilibrium • Using a catalyst increases rate of attainment. • Increasing temperature increases the rate of attainment and produces more hydrogen (2) • Using a catalyst lowers activation energy so equilibrium is reached faster (2)
Level 2	3–4	Additional guidance A simple explanation of at least TWO ways that the use of a catalyst OR temperature affects equilibrium. OR A detailed explanation of ONE way that equilibrium is affected	Possible candidate responses • Increasing temperature favours the endothermic reaction so more hydrogen is produced. • A catalyst has no effect on the equilibrium yield but provides an alternative reaction pathway, so the rate of attainment of equilibrium increases. • Increasing temperature means that particles have more kinetic energy, so there are more frequent, successful collisions and the rate of attainment of equilibrium increases.
Level 3	5–6	Additional guidance A detailed explanation of at least TWO ways that the use of a catalyst AND temperature affects equilibrium	Possible candidate responses • Increasing the temperature favours the endothermic reaction and so a higher temperature will produce more hydrogen. A catalyst has no effect on the equilibrium yield as it increases the rate of both the forward and reverse reaction. • Increasing temperature gives the particles more kinetic energy and increases the frequency of collisions, so the rate of attainment of equilibrium increases. Using a catalyst lowers the activation energy, so more particles have the minimum energy required for a successful collision

Level	Mark	Descriptor
	0	No awardable content
Level 1	1-2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Q12.

Question Number	Answer	Additional guidance	Mark
(i)	ammonia + nitric acid → ammonium nitrate	accept reactants in either order ignore formula	(1) AO 2 1

Question Number	Answer	Mark
(ii)	C NH_4NO_3 **1. The only correct answer is C** ***A*** *is factually incorrect* ***B*** *is factually incorrect* ***D*** *is factually incorrect*	(1) AO 2 1

Question Number	Answer	Additional guidance	Mark
(iii)	An explanation linking two from: • as a fertiliser (1) • contains (a high percentage of) nitrogen (1) • help promote plant growth / increases crop yield (1)	allow make crops grow faster ignore use as a pesticide	(2) AO 1 1

Q13.

Question number	Answer	Mark
	Any **one** advantage from: • reliable composition of fertiliser • produced in large quantities as required • all soluble therefore fertiliser will reach roots as required	**(1)**

Q14.

Question number	Answer	Mark
	• volumes of solution too large for titration method (1) • large volumes of liquid need to be heated and then allowed to crystallise (1)	**(2)**

Q15.

Question number	Answer	Additional guidance	Mark
(i)	Haber	ignore spelling	**(1)**

Question number	Answer	Additional guidance	Mark
(ii)	nitrogen + hydrogen = ammonia (3) reactants {= / →}(1) {= / →} product (1) = (1)	allow reactant either way round nitrogen + hydrogen → ammonia (2) $N_2 + 3H_2 = 2NH_3$ (3) incorrectly balanced equation scores 2 max allow: correct formulae (1) reversible sign (1) balancing (1)	**(3)**

Q16.

Question number	Answer	Mark
(i)	**D** increases does not change **A, B, C** are incorrect because catalysts increase rate of attainment of equilibrium and do not change equilibrium yield	**(1)**

Question number	Answer	Mark
(ii)	**C** the amounts of nitrogen, hydrogen and ammonia become constant **A, B, D** are incorrect because when the reaction reaches equilibrium the amount of nitrogen, hydrogen and ammonia remain constant	(1)

Question number	Answer	Additional guidance	Mark
(iii)	an explanation linking • equilibrium attained in a shorter period of time / rate of attainment of equilibrium {faster/ increases} (1) • equilibrium yield increases (1) • equilibrium shifts to the {right / forward / to products side} (1) • decrease in number of molecules (1)	allow moves to fewer molecules	(4)

Q17.

Question number	Answer	Additional guidance	Mark
(i)	**C** ammonium nitrate **A, B, D** are incorrect names		(1)

Question number	Answer	Additional guidance	Mark
(ii)	An explanation linking any two from • crops require fertilisers to grow (1) • fertilisers contain N / P / K compounds (1) • promote plant growth (1) • increased yield (means greater profits) (1)		(2)

Q18.

Question number	Answer	Additional guidance	Mark
	phosphorous (1) potassium (1)	allow phonetic spelling	**(2)** **AO1-1**

Q19.

Question Number	Answer	Additional guidance	Mark
(i)	reversible (reaction) / reaction can go both ways	OWTTE allow reaction is happening forwards and backwards allow equilibrium	**(1)** AO 1 1

Question Number	Answer		Mark
(ii)	(the percentage of ammonia produced) decreases / goes down	allow goes lower	**(1)** AO 3 1a

Question Number	Answer		Mark
(iii)	any number between 15 and 16 inclusive		**(1)** AO 3 2b

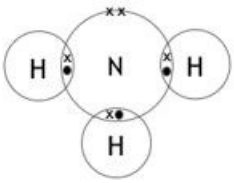
Q20.

Question number	Answer	Additional guidance	Mark
(i)	phosphorus /potassium /nitrogen	accept phonetically correct spellings allow P / K / N	(1)
(ii)	$KOH + HNO_3 \rightarrow$ KNO_3 (1) + H_2O (1)	incorrect balancing of correct species 1 mark max allow OH_2 / HOH / NO_3K	(2)

Q21.

Question number	Answer	Mark
(i)	Haber (1)	(1) AO1-1

Question number	Answer	Additional guidance	Mark
(ii)	(reaction is) {reversible / can go both ways / can go backwards and forwards}	allow (dynamic) equilibrium ignore 'reversed' alone	(1) AO1-1

Question number	Answer	Mark
(iii)	**B** is  the only correct answer **A** is incorrect as there are no shared pairs and the nitrogen atom shown only has 3 electrons **C** is incorrect as there are no shared pairs **D** is incorrect as the nitrogen atom shown only has 3 electrons	(1) AO2-1

Q22.

Question number	Answer	Additional guidance	Mark
(i)	Haber process (1)	accept phonetically correct spellings e.g Harber	(1)

Question number	Answer	Mark
(ii)	rate increased / speeded up / quicker / faster (1)	(1)
(iii)	yield unchanged/ stays same / none (1)	(1)

Q23.

Question number	Answer	Mark
(i)	to make plants grow more/ faster/ bigger	(1) AO1

Question number	Answer	Mark
(ii)	K: potassium N: nitrogen P: phosphorus all three correct (2); one or two correct (1)	(2) AO2

Q24.

Question number	Answer	Additional guidance	Mark
	ammonia + nitric acid (1) ammonium nitrate (1)	allow reactants in either order if symbol equation given, formulae must be fully correct if both word and symbol equations are given, ignore symbols	(2) AO2-1