Questions

Q1.

The reaction between nitrogen and hydrogen happens at a pressure of 200 atmospheres.

Another unit of pressure is Pascals, Pa (1 atmosphere = 101 325 Pa).

Calculate the value of 200 atmospheres in Pascals.

(2)

.....

.....

pressure = ... Pa

(Total for question = 2 marks)

Q2.

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 ☒.

When chloride ions are added to a pale blue solution containing copper ions, the mixture turns yellow.
This is a reversible reaction.

pale blue solution + chloride ions ↔ yellow solution + water

What effect does the removal of chloride ions have on the colour of the yellow mixture?

(1)

- ☐ A does not change colour
- ☐ B turns blue
- ☐ C turns colourless
- ☐ D turns darker yellow

(Total for question = 1 mark)

Q3.

Figure 5 shows molecules of nitrogen, hydrogen and ammonia before the reaction and at equilibrium.

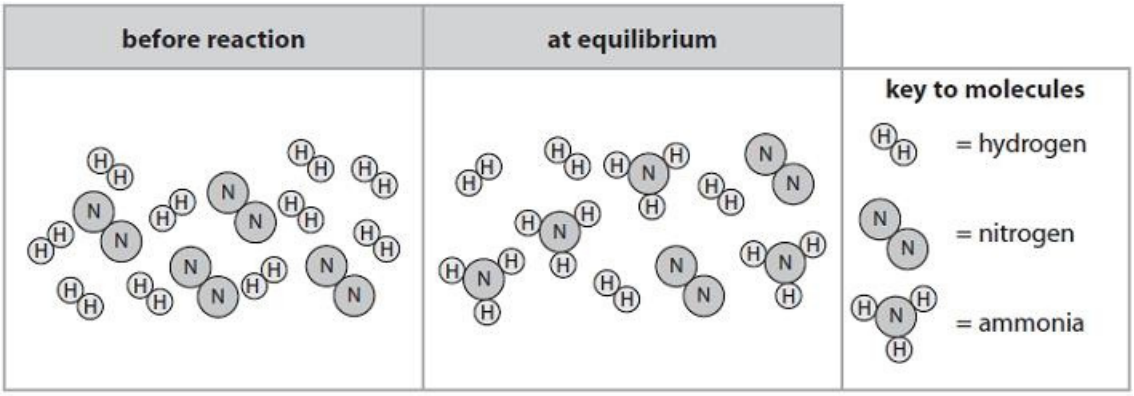

Figure 5

(i) Complete the table showing

- the number of hydrogen molecules before reaction
- the number of hydrogen molecules at equilibrium
- the change in the number of hydrogen molecules.

(1)

	number of molecules before reaction	number of molecules at equilibrium	change in number of molecules
nitrogen	4	2	–2
hydrogen	.....	.....	.....
ammonia	0	4	+4

(ii) Complete the equation for this reaction.

(2)

..... + ... ↔ 2 NH3

(Total for question = 3 marks)

Q4.

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)

Q5.

Hydrated copper sulfate, CuSO4.5H2O, is a blue solid.
Anhydrous copper sulfate, CuSO4, is a white solid.
Heat energy is needed to convert hydrated copper sulfate to anhydrous copper sulfate.
This is a reversible reaction.

$$CuSO_4.5H_2O \rightleftharpoons CuSO_4 + 5H_2O$$

Devise an experiment to show that this is a reversible reaction.

(4)

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(Total for question = 4 marks)

Q6.

Hydrogen reacts with iodine to form hydrogen iodide.
Iodine gas is purple and hydrogen iodide gas is colourless.

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

Hydrogen and iodine are placed in a sealed container.
The container is left until equilibrium is reached.
The conditions are changed favouring the forward reaction.

Explain what you would see.

(2)

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(Total for question = 2 marks)

Q7.

In the Haber process, hydrogen and nitrogen react to form ammonia.

hydrogen + nitrogen ⇌ ammonia

(i) The ⇌ symbol in the word equation shows that the reaction goes forwards and backwards at the same time.

Give the name of this type of reaction.

(1)

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(ii) State the formula of a molecule of ammonia.

(1)

.....

(iii) Figure 7 shows a graph of world ammonia production, in millions of tonnes, from 1945 to 2015.

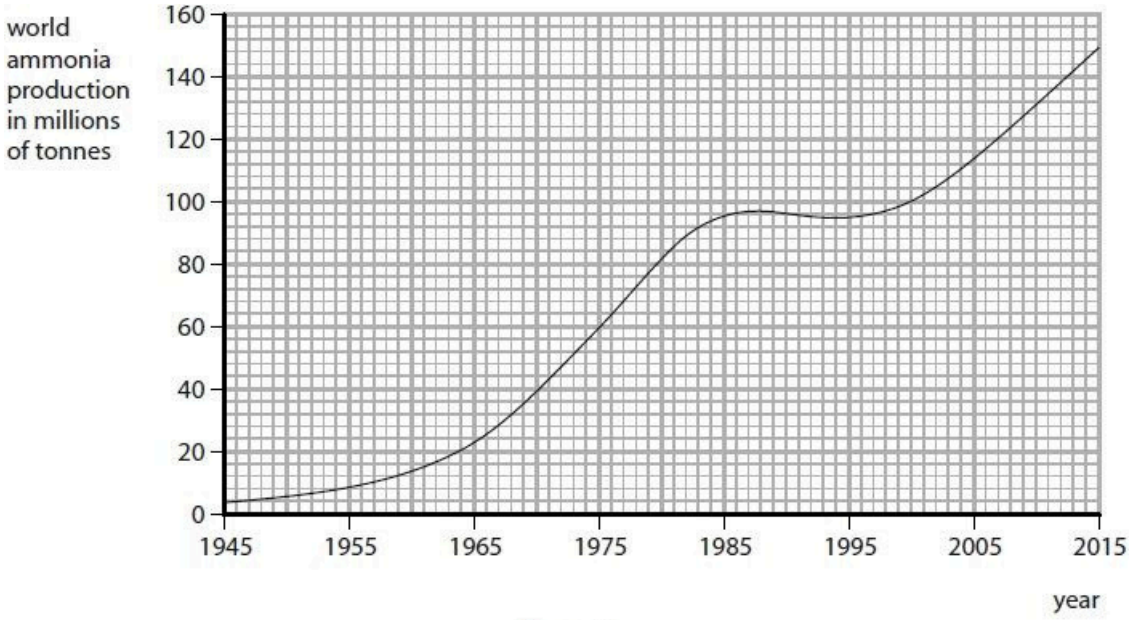

Figure 7

State the overall trend in world ammonia production from 1945 to 2015.

(1)

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.....

(Total for question = 3 marks)

Q8.

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)

Q9.

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

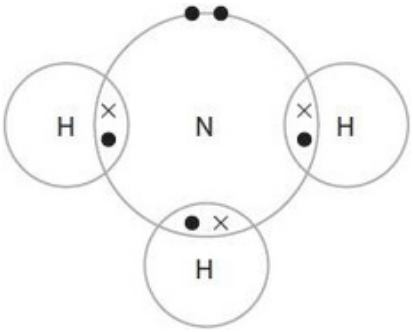

Figure 1

(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)

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(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.

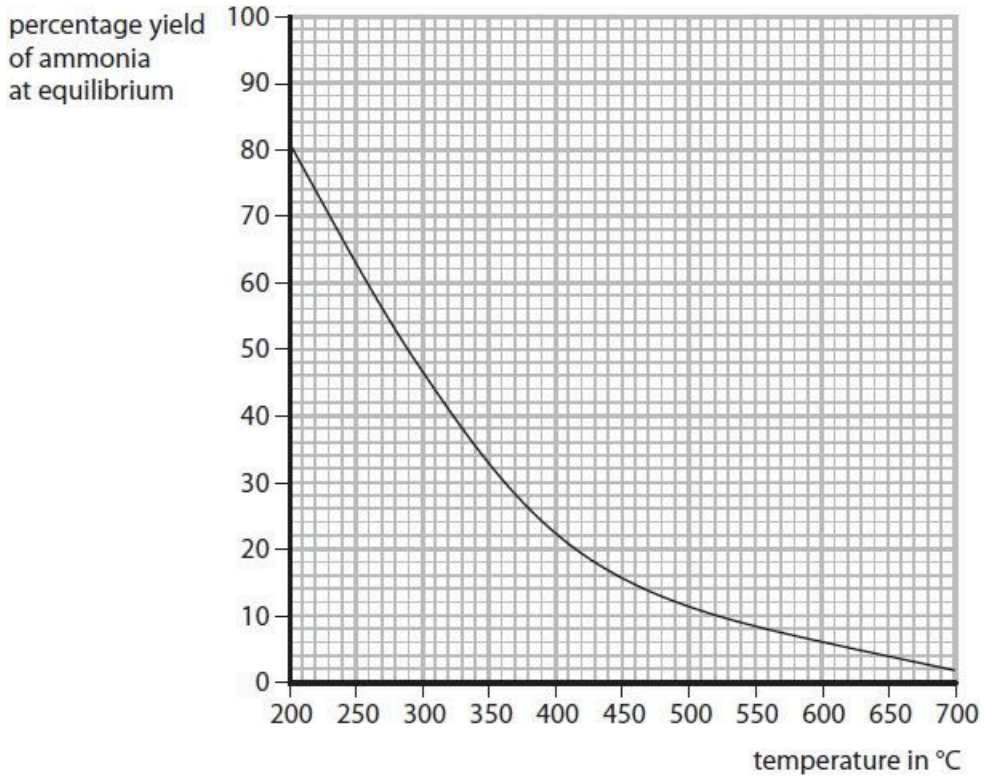

Figure 2

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

(1)

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.....

(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)

Q10.

When nitrogen and hydrogen are reacted together, the reaction can reach a dynamic equilibrium.

Use words from the box to complete the sentences about dynamic equilibrium.

(2)

backward	different	equal	faster	reversible

In a dynamic equilibrium two reactions occur at the same time.

These are the forward reaction and the ..... reaction.

The rates of the two reactions are .....

(Total for question = 2 marks)

Q11.

* 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)

Q12.

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)

Q13.

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)

Q14.

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)

Q15.

* 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)

Q16.

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)

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

(1)

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(Total for question = 3 marks)

Mark Scheme

Q1.

Question number	Answer	Additional guidance	Mark
	20265000 with or without working scores 2 101325 x 200 (1) = 20265000 (Pascals) (1)	allow 20270000 / 20300000 for 2 506.625/ 506.63/ 506.6/ 507 scores 1	**(2)** **AO2**

Q2.

Question number	Answer	Mark
	B turns blue is the only correct answer. **A, C and D are incorrect because the position of equilibrium will shift to the left-hand side**	**(1)** **AO2**

Q3.

Question number	Answer	Mark
(i)	hydrogen row: 10 4 -6	**(1)** **AO2**

Question number	Answer	Additional guidance	Mark
(ii)	$N_2 + 3\ H_2 \rightleftharpoons 2\ NH_3$ (2) Formulae of nitrogen **and** hydrogen (1)	balancing mark only if formulae correct	**(2)** **AO2**

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 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)

Q5.

Question number	Answer	Additional guidance	Mark
	A description including DECOMPOSITION • **heat** the (hydrated) {crystals / solid} (1) • (solid) goes white/ steam is observed / water produced (1) REVERSE REACTION • add water / water rejoins / water reacts with anhydrous solid (1) • (solid) goes blue (again) / heat is released (1)	ignore anything to do with Le Chatelier etc.. ignore 'closed system' MP4 independent of MP3	**(4)**

Q6.

Question number	Answer	Additional guidance	Mark
	An explanation linking • less purple / lighter/ paler / fades (1) • because less iodine (1)	Ignore equilibrium shifts right, forward reaction favoured reject 'goes colourless' for MP1 reject **ALL** iodine reacts to give HI for MP2 (credit **some** iodine reacts / **some** iodine is used up) ignore 'more HI' ignore forwards reaction is favoured	**(2)**

Q7.

Question number	Answer	Additional guidance	Mark
(i)	reversible	allow equilibrium / equilibria /dynamic equilibrium ignore static equilibrium	**(1)**
(ii)	NH_3	allow H_3N reject NH3, NH^3	**(1)**
(iii)	world ammonia production increases over time		**(1)**

Q8.

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)**

Q9.

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

Q10.

Question number	Answer	Mark
	backward (1) equal (1)	(2) AO1

Q11.

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)

Q12.

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)

Q13.

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)

Q14.

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

Q15.

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)

Q16.

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)