Answer **all** the questions.

1(a). The reversible reaction between carbon dioxide and hydrogen makes methane and water.

$$\text{carbon dioxide} + \text{hydrogen} \rightleftharpoons \text{methane} + \text{water}$$

In a sealed container this reversible reaction forms a **dynamic equilibrium**.

What is meant by the term dynamic equilibrium?

Refer to both concentration and rate of reaction in your answer.

---

[2]

(b). * Kayvan investigates the effect of changing the pressure and changing the temperature on this reaction.

$$\text{carbon dioxide} + \text{hydrogen} \rightleftharpoons \text{methane} + \text{water}$$

The table shows the percentage yield of methane in the equilibrium mixture under different conditions.

		Pressure in atmospheres			
		100	**200**	**300**	**400**
Temperature in °C	**300**	35%	52%	65%	80%
	600	30%	46%	58%	74%
	900	23%	37%	47%	62%
	1200	14%	25%	36%	48%

Describe what happens to the percentage yield as the pressure and temperature change and explain the effect of increasing the pressure on the rate of reaction.

[6]

2(a). The reversible reaction between carbon dioxide and hydrogen makes methane and water.

$$\text{carbon dioxide} + \text{hydrogen} \rightleftharpoons \text{methane} + \text{water}$$

In a sealed container this reversible reaction forms a **dynamic equilibrium**.

What is meant by the term dynamic equilibrium?

Refer to both concentration and rate of reaction in your answer.

---

[2]

(b). * Kayvan investigates the effect of changing the pressure and changing the temperature on this reaction.

carbon dioxide + hydrogen ⇌ methane + water

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

The table shows the percentage yield of methane in the equilibrium mixture under different conditions.

		Pressure in atmospheres			
		100	**200**	**300**	**400**
Temperature in °C	**300**	35%	52%	65%	80%
	600	30%	46%	58%	74%
	900	23%	37%	47%	62%
	1200	14%	25%	36%	48%

Kayvan predicts that the reaction between carbon dioxide and hydrogen is endothermic and involves a reduction in the volume of gases.

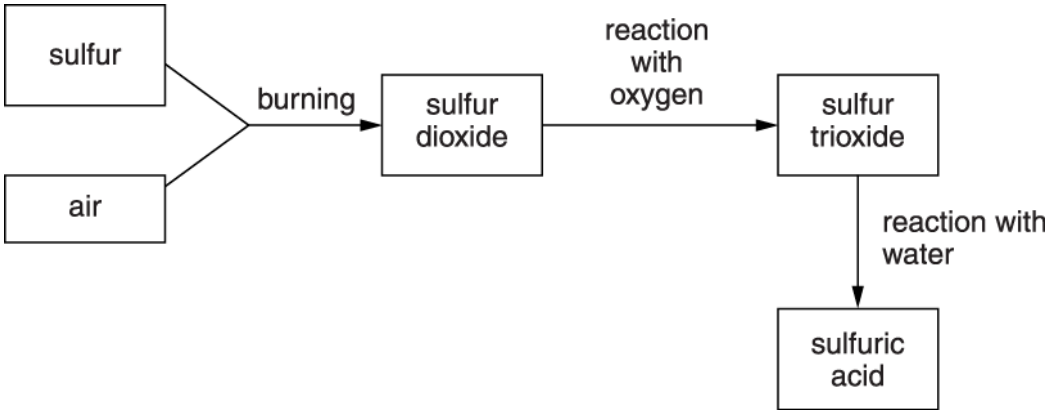
Describe and explain whether Kayvan's predictions are supported by the reaction and results in the table.

---

[6]

3(a). This question is about the Contact Process used for the manufacture of sulfuric acid.

Look at the flow chart for the process.



In the process, sulfur dioxide reacts with oxygen to make sulfur trioxide.

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

The forward reaction is **exothermic**.

Two of the conditions used are:

- a temperature of 450 °C
- a low pressure of 3 atmospheres.

Write down **one other** condition used in the process.

---

[1]

(b). Explain the choice of conditions used in the process.

---

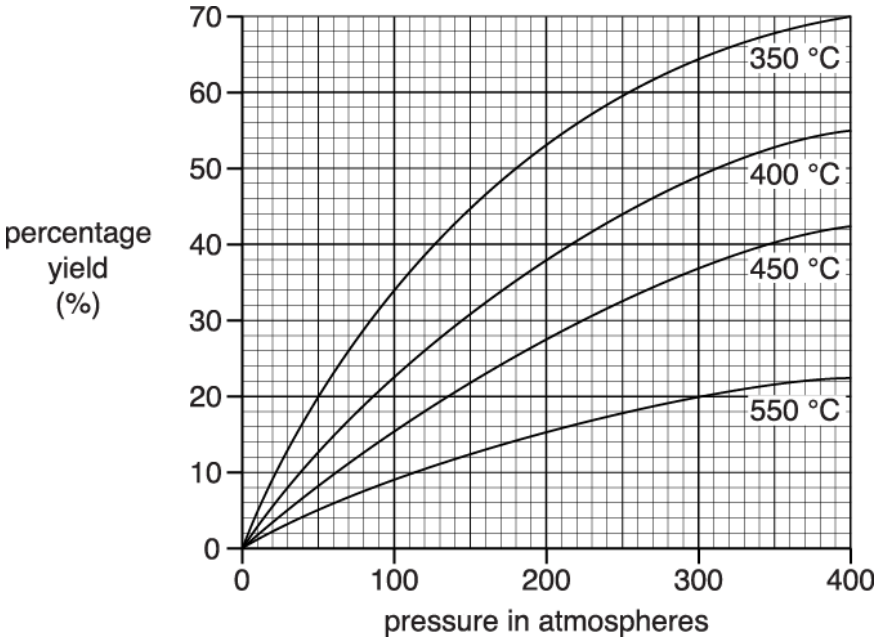
[3]

4. This question is about making ammonia by the Haber process.

Nitrogen and hydrogen react to make ammonia.

Look at the graph.

It shows the yield of ammonia under different conditions of temperature and pressure.



One cost of making ammonia is the **energy** needed.

Write about some of the **other** costs of making ammonia.

Use the graph to decide the conditions that give the **highest** yield of ammonia.

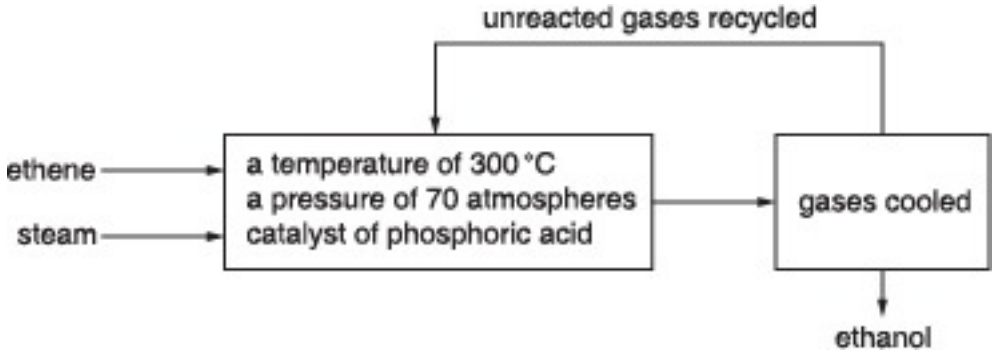
The quality of written communication will be assessed in your answer to this question.

---**[6]**

5. Ethanol (alcohol) is made by reacting ethene with steam.

ethene + steam ? ethanol

Look at the flowchart.



Look at the table.

It gives some information about the percentage yield of ethanol at different temperatures and pressures.

Pressure in atmospheres	**Percentage yield**		
200 °C	**300 °C**	**400 °C**	
40	16	12	6
80	30	22	12
120	42	30	17
160	50	36	21

(i) What conditions give the **highest** percentage yield?

pressure _ _ _ _ _ _ _ _ atmospheres

temperature _ _ _ _ _ _ _ °C

[1]

(ii) Suggest why a pressure of 70 atmospheres is used rather than the pressure you answered in part **(i)**.

---

[2]

6(a). In a closed system a reversible reaction will form an equilibrium mixture.

Which of the following statements are true for a reversible reaction at **equilibrium**?

Tick (✓) the **two** correct answers.

The rate of the forward reaction is faster than the rate of the backward reaction. ☐

The position of equilibrium will not change if more product is added. ☐

The concentration of the reactants does not change. ☐

The rate of the forward reaction is the same as the rate of the backward reaction. ☐

The concentration of the reactants is the same as the concentration of the products. ☐

The position of equilibrium moves to the left when product is removed from the equilibrium. ☐

[2]

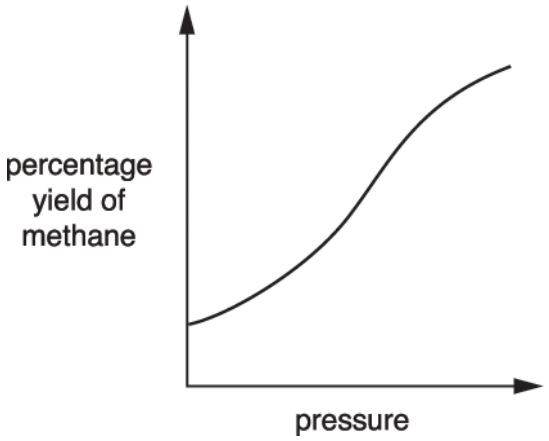
(b). Methane is a fuel that can be made by the reaction between carbon dioxide and hydrogen.

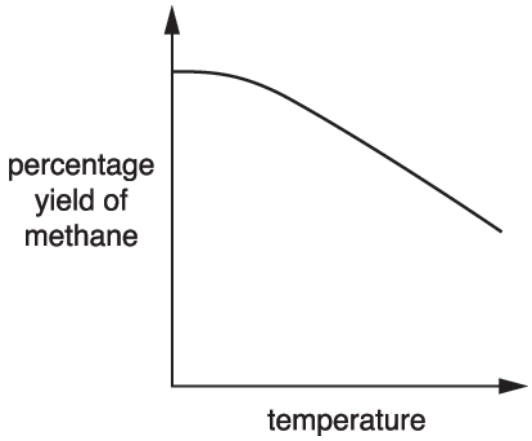
$$CO_2(g) + 4H_2(g) \rightleftharpoons CH_4(g) + 2H_2O(g)$$

Paul predicts that

- the reaction is exothermic
- there are more moles of gas on the right-hand side of the equation.

Look at the two graphs.





Do the graphs support Paul's predictions?

Explain your answer.

---

[2]

7. Ethanol (alcohol) is made by reacting ethene with steam.

ethene + steam ? ethanol

What is meant by the symbol ? in the equation?

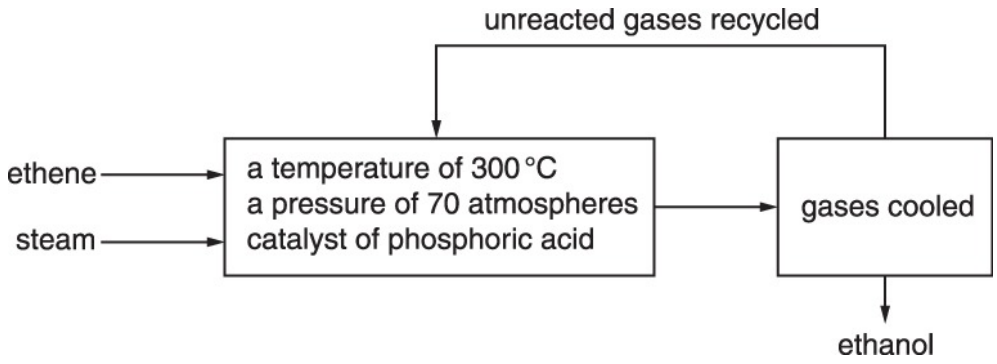
---

[1]

8(a). Ethanol (alcohol) is made by reacting ethene with steam.

$$\text{ethene} + \text{steam} \rightleftharpoons \text{ethanol}$$

Look at the flowchart.



Look at the table.

It gives some information about the percentage yield of ethanol at different temperatures and pressures.

Pressure in atmospheres	**Percentage yield**		
	200 °C	**300 °C**	**400 °C**
40	16	12	6
80	30	22	12
120	42	30	17
160	50	36	21

(i) What happens to the percentage yield as the **pressure** increases?

---

[1]

(ii) What happens to the percentage yield as the **temperature** increases?

---

[1]

(b). The highest percentage yield is achieved with a temperature of 200 °C and 160 atmospheres.

The actual conditions used to make ethanol are:

- catalyst of phosphoric(V) acid
- a pressure of 70 atmospheres
- a temperature of 300 °C.

Use ideas about percentage yield and rate of reaction to suggest why each condition is used.

---

[3]

(c). This process is automated.

Explain why automation is used.

---

[1]

9. Ammonia is made from nitrogen and hydrogen in an equilibrium reaction.

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

The forward reaction is **exothermic**.

Look at **Table 1**.

It shows the percentage of ammonia in the equilibrium mixture at 450 °C and different **pressures**.

Pressure in atmospheres	Percentage (%) of ammonia at 450 °C
1	0.2
50	9.5
100	16.2
200	25.3

Table 1

Look at **Table 2**.

It shows the percentage of ammonia in the equilibrium mixture at 300 atmospheres and different **temperatures**.

Temperature in °C	Percentage (%) of ammonia at 300 atmospheres
400	50
450	35
500	25
550	17

Table 2

Describe and explain how changing the pressure and changing the temperature affect the position of equilibrium in the reaction between nitrogen and hydrogen.

The quality of written communication will be assessed in your answer to this question.

---

[6]

10. Carbon dioxide, CO_2, reacts with hydrogen, H_2, to make methanol, CH_3OH.

$$CO_2 + 3H_2 \text{ ? } CH_3OH + H_2O$$

Phil investigates this reversible reaction.

He mixes carbon dioxide with hydrogen.

He lets this mixture reach equilibrium.

Phil measures the percentage yield of methanol in this equilibrium mixture.

He uses different temperatures and pressures.

Look at his results for different temperatures at a pressure of 100 atmospheres.

Temperature in °C	**Percentage yield (%)**
100	99
200	97
300	94
400	90

Look at his results for different pressures at a temperature of 400 °C.

Pressure in atmospheres	**Percentage yield (%)**
20	38
40	58
60	73
80	83
100	90

How does the percentage yield change with temperature and with pressure?

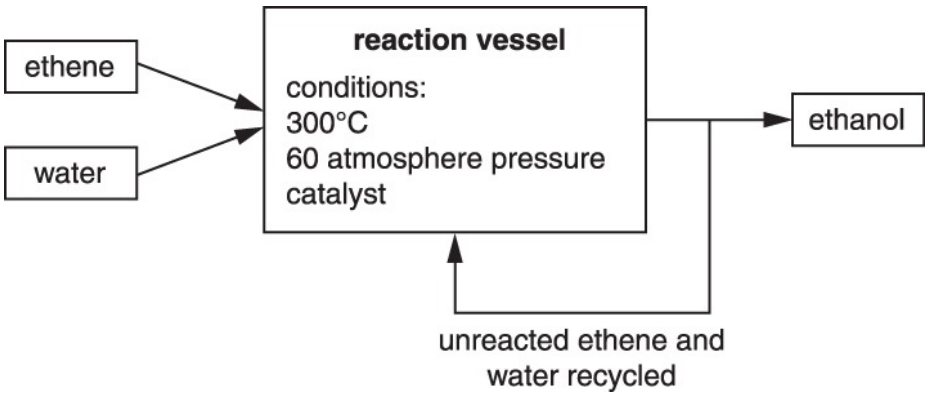
Describe how the percentage yield is linked to the position of equilibrium.

The quality of written communication will be assessed in your answer to this question.

[6]

11(a). Ethanol can be made from ethene and water.

The flowchart shows this process.



The symbol equation for the reaction is:

$$C_2H_4 + H_2O \rightleftharpoons C_2H_6O$$

The percentage of ethanol changes as the temperature and pressure change.

Look at the table.

It shows the percentage of ethanol at different temperatures and pressures.

Pressure in atmospheres	**Percentage of ethanol (%)**			
	At 100°C	**At 200°C**	**At 300°C**	**At 400°C**
20	15	10	5	2
40	20	15	10	5
60	40	30	20	10
80	60	50	40	20

Which of the following conditions gives the **highest** percentage of ethanol?

1 high pressure with high temperature
2 high pressure with low temperature
3 low pressure with high temperature
4 low pressure with low temperature

Choose from **A**, **B**, **C** or **D**.

answer _____

[1]

(b). The conditions used for making **ethanol** are:

- 300°C
- 60 atmospheres pressure.

Suggest why these conditions are used even though the percentage of ethanol is only 20%.

---

[2]

12(a). Ammonia is made from nitrogen and hydrogen in the Haber process.

Look at the equation for this reaction.

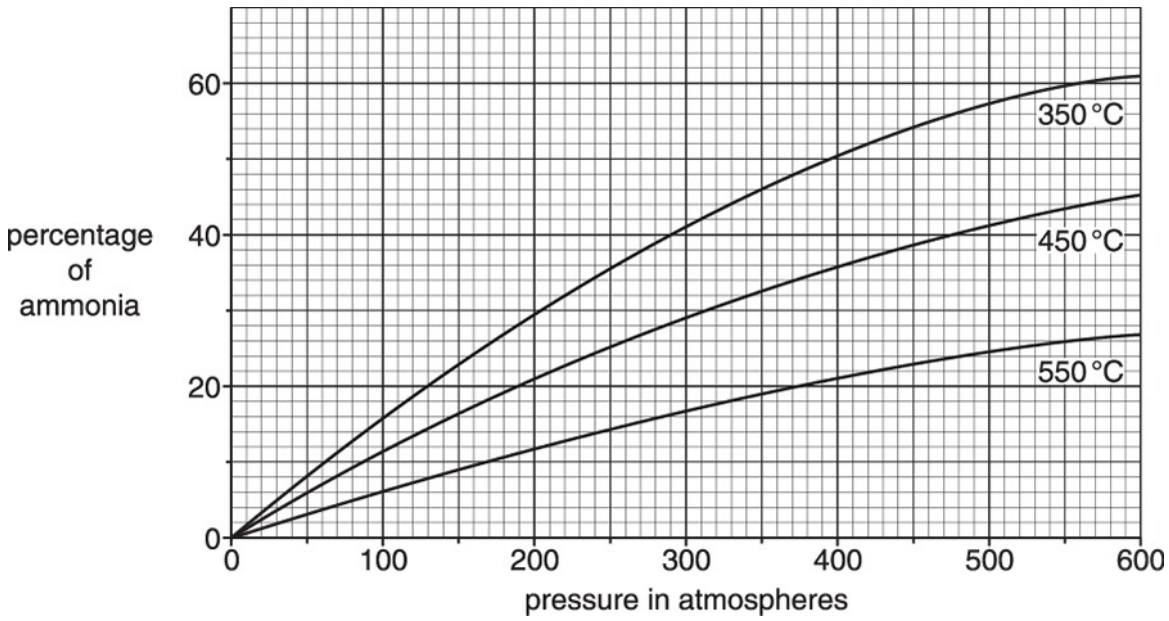
nitrogen + hydrogen ? ammonia

What does the symbol ? mean?

[1]

(b). The percentage of ammonia changes as the temperature and pressure change.

Look at the graph.



Look at the graph for **350 °C**.

What is the percentage of ammonia at **400 atmospheres**?

answer _____ %

[1]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1	a		Rate of forward reaction equals the rate of the backward reaction (1) Concentration of reactants and products do not change (1)	2	**DO NOT ALLOW** concentration of reactant and products are the same **ALLOW** concentration of reactants and products stay the same

Question			Answer/Indicative content	Marks	Guidance
	b		* *Please refer to the marking instruction point 10 for guidance on how to mark this question.* **Level 3 (5–6 marks)** **Describes the effect of changing the temperature and pressure on the percentage yield from the table and includes clear explanations on the effect of increasing the pressure on the rate of reaction.** *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** **Describes the effect of changing the temperature and pressure on the percentage yield from the table and either describes the effect of increasing the pressure on the rate of reaction or explains the effect increasing the pressure on the rate of reaction.** *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** **Describes the effect of changing the temperature and pressure on the percentage yield from the table or describes the effect of increasing the pressure on the rate of reaction.** *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** *No response or no response worthy of credit.*	6	**AO1.1: Knowledge of pressure on rate of reaction** • Increasing the pressure increases the rate of reaction. • Increasing the pressure means particles are closer together. • Increasing the pressure means more crowded particles / more particles in the same space. • Increasing the pressure means more collisions between particles. • More collisions the quicker the reaction. • More collisions more percentage yield. **AO3.1a: Analyse information in the table to interpret percentage yield** • As temperature increases the percentage yield decreases. • As pressure increases the percentage yield increases. • The highest yield is when the temperature is low and the pressure is high.
			Total	**8**	

Question			Answer/Indicative content	Marks	Guidance
2	a		Rate of forward reaction equals the rate of the backward reaction (1) Concentration of reactants and products do not change (1)	2	**ALLOW** concentration of reactant and product do not change **DO NOT ALLOW** concentration of reactant and products are the same

Question			Answer/Indicative content	Marks	Guidance
	b		**Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** **Describes and explains the effect of changing the temperature and pressure on the position of equilibrium in both theoretical terms and from the table and explains that one prediction is supported and the other prediction is not** *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** **Describes and explains the effect of changing the temperature and pressure on the position of equilibrium in both theoretical terms and from the table** *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** **Describes the effect of changing the temperature and pressure on the position of equilibrium in theoretical terms or describes the effect of changing the temperature and pressure on the position of equilibrium from the table** *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** *No response or no response worthy of credit.*	6	**AO1.1: Knowledge of temperature and pressure on percentage yield** • As temperature increases the position of equilibrium shifts to the left in an exothermic reaction. • As pressure increases the position of equilibrium shifts to the side with the least number of moles of gas. • Decreasing the temperature of a system in dynamic equilibrium favours the exothermic reaction. **AO3.1a: Analyse information in the table to interpret equilibrium position** • As temperature increases the percentage yield decreases. • As temperature increases position of equilibrium moves to the left. • As the pressure increases the percentage yield increases. • As the pressure increases position of equilibrium moves to the right. **AO3.2a: Analyse information in the table / equation to make judgements / predictions** • The prediction is not supported since reaction must be exothermic rather than endothermic because position of equilibrium moves to the left as temperature increases. • The prediction is supported in terms of the moles of gas as pressure increases the position of equilibrium moves to the right. • The prediction is supported because as the pressure increases the percentage yield increases.
			Total	**8**	

Question			Answer/Indicative content	Marks	Guidance
3	a		catalyst / vanadium(V) oxide / V_2O_5 (1)	1	**allow** vanadium pentoxide if a named catalyst is given it must be correct including oxidation number except **allow** vanadium oxide catalyst if formula and name given **both** must be correct **Examiner's Comments** This question was about the Contact Process. The need for a catalyst was well known but many candidates gave the name of the wrong catalyst for example iron or nickel. A small proportion of candidates referred to a high concentration as a condition.

Question			Answer/Indicative content	Marks	Guidance
	b		**any three from:** catalyst increases rate of reaction (1) catalyst does not change position of equilibrium (1) increasing temperature - increases rate of reaction / temperature used to have a high rate of reaction (1) but increasing temperature position of equilibrium to left / temperature used to not shift the equilibrium to the left (1) at low pressure position of equilibrium is already on right (1) so expensive high pressures are not needed / at low pressure rate is low so reaction is easier to control (1)	3	**allow** ora where appropriate **allow** catalyst does not change (percentage) yield **allow** increasing temperature decreases (percentage) yield / increasing temperature favours backward reaction (1) reference to it is a compromise temperature is **not** sufficient **allow** good product (percentage) yield at low pressure **not** use low pressure to shift equilibrium to the right **Examiner's Comments** This question was about the Contact Process. There were many different marking points that could be accessed by the candidates. In terms of temperature the idea that the reaction would be fast and was low enough to keep the equilibrium on the right was sufficient – many candidates only mentioned the reference to rate. In terms of the pressure many candidates thought that the low pressure was to force the position of equilibrium to the right. Only the best answers appreciated that even at low pressure the position of equilibrium was on the right. Many candidates appreciated that a higher pressure would be more expensive. Most candidates appreciated that the catalyst increases the rate of reaction but the candidates did not often mention that the position of equilibrium was unaffected.
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
4			**[Level 3]** **Extracts the correct conditions from the graph** **AND** **states at least two costs of making ammonia.** Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) **[Level 2]** **Extracts one correct condition from the graph and states at one cost of making ammonia.** **OR** **Extracts the correct conditions from the graph** **OR** **States at least two costs of making ammonia.** Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) **[Level 1]** **Extracts one correct condition from the graph** **OR** **States one cost of making ammonia.** Quality of written communication impedes communication of the science at this level. (1 – 2 marks) **[Level 0]** Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	**This question is targeted at grades up to C.** **Costs** • cost of starting materials • labour costs • cost of the plant / apparatus or equipment • cost of catalyst • rent or rates • health and safety • pollution control **ignore** references to advertising / environment / transport / storage / packaging / energy / temperature and pressure **Conditions** • any temperature from 350oC or below • any pressure from 400 atmospheres or above **Use the L1, L2, L3 annotations in Scoris; do not use ticks.** **Examiner's Comments** This question was about the manufacture of ammonia by the Haber process. This was a six-mark question that involved date interpretation. Many candidates could interpret the information in the graphs and gave a possible temperature and a possible pressure to get the highest yield. Most candidates chose figures from the graphs although some gave lower temperatures and/or higher pressures instead. The other part of this question involved stating possible costs of making ammonia by the Haber process. Typically candidates were able to give one or two costs. Some candidates ignored the stem to the question and gave costs that were

Question			Answer/Indicative content	Marks	Guidance
					related to the energy e.g. maintaining the pressure or temperature, these answers were not given any credit.
			Total	**6**	
5		i	160 atm and 200 oC (1)	1	**both** required **Examiner's Comments** Most candidates could identify the conditions giving the highest yield. Only a minority could explain why these conditions were not used by reference to higher cost to generate high pressures or higher plant costs to withstand high pressures.
		ii	**any two from:** idea that higher energy cost with higher pressure (1) idea that higher plant costs with higher pressures (1) idea that greater safety risks with higher pressure (1)	2	if in doubt assume answer refers to 70atm **allow** it is cheaper (1) if no other marks awarded **allow** 70atm to avoid breaking the equipment (1) **allow** uses less energy (1) **Examiner's Comments** Most candidates could identify the conditions giving the highest yield. Only a minority could explain why these conditions were not used by reference to higher cost to generate high pressures or higher plant costs to withstand high pressures.
			Total	**3**	

Question			Answer/Indicative content	Marks	Guidance
6	a		The rate of the forward reaction is faster than the rate of the backward reaction ☐ The position of equilibrium will not change if more product is added ☐ The concentration of the reactants does not change ✓ The rate of the forward reaction is the same as the rate of the backward reaction ✓ The concentration of the reactants is the same as the concentration of the products ☐ The position of equilibrium moves to the left when product is removed from the equilibrium ☐ **one** correct answer (1) **but** **two** correct answers (2)	2	**?Examiner's Comments?**? Most candidates did not choose both of the correct answers. The answers to the last two boxes were common errors.
	b		(yes) it is exothermic because the percentage yield goes down as **temperature** increases (1) (no) there are less moles on right hand side because the percentage yield goes up as **pressure** increases (1)	2	**Answers must refer to yield, or amount of product reference to only position of equilibrium is not sufficient** **ignore** references to bond making and bond breaking **allow** ora if specified **Examiner's Comments** This question that assessed evaluation skills was extremely demanding. Candidates had to apply their understanding of le Chatelier's principle to decide if the statements were supported. Many candidates were not able to relate the pattern shown by a graph to the correct statement and then decide if the pattern supported the statement.
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
7			reversible reaction / reaction goes both ways (1)	1	**allow** forms an equilibrium (1) **Examiner's Comments** The idea of a reversible reaction was well understood by about three quarters of candidates.
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
8	a	i	increases / gets bigger / AW (1)	1	**Examiner's Comments** This question was about the manufacture of ethanol by the hydration of ethene. Most candidates could interpret the data in the table.
		ii	decreases / gets less / AW (1)	1	**Examiner's Comments** Most candidates could interpret the data in the table.
	b		idea of catalyst used to speed up the reaction or increase the rate of reaction (1) 70 atm used as is cheaper to generate than higher pressures (1) 300 °C is used to increase the rate of reaction but sacrifice percentage yield / it is a compromise or optimum temperature (1)	3	**allow** catalyst does not affect percentage yield (1) **allow** answer relating to the risks associated with high pressure (1) **Examiner's Comments** Was a challenging question and only a small proportion of candidates were able to explain why the temperature chosen was a compromise. Candidates were most likely to be awarded a mark for stating that the catalyst increased the rate of reaction or for the idea that a higher pressure will cost more money.
	c		idea of **reduction** of wage bill / idea of **reduction** of number of workers (1)	1	**ignore** rule out human error **ignore** to make the process work faster **ignore** references to safety **ignore** it is a continuous process **not** no labour costs **Examiner's Comments** Many candidates appreciated that fewer workers would be employed. However some stated that no workers would be needed, which was not allowed on the mark scheme.
			Total	**6**	

Question			Answer/Indicative content	Marks	Guidance
9			**Level 3 (5–6 marks)** **Manipulates the data to describe and explain how the position of equilibrium changes with pressure** **AND** **Manipulates the data to describe and explain how the position of equilibrium changes with temperature** Quality of written communication does not impede communication of the science at this level. **Level 2 (3–4 marks)** **Manipulates the data to describe and explain how the position of equilibrium changes with pressure** **OR** **Manipulates the data to describe and explain how the position of equilibrium changes with temperature** Quality of written communication partly impedes communication of the science at this level. **Level 1 (1–2 marks)** **Manipulates the data to describe how the position of equilibrium changes with pressure AND with temperature** Quality of written communication impedes communication of the science at this level. **Level 0 (0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	6	**This question is targeted at grades up to A*.** **Relevant points at levels 2 and 3 include:** • increasing the pressure moves the equilibrium to the right because there are fewer molecules (or number of moles)on the rhs • increasing the temperature moves the equilibrium to the left because the forward reaction is exothermic or the backward reaction is endothermic. **Relevant points at level 1 include:** • as the pressure increases the position of equilibrium moves to the right or vice versa • as pressure increases percentage of ammonia increases • as the temperature increases the position of equilibrium moves to the left or vice versa • as temperature increases the percentage of ammonia decreases **ignore** references to rate **Examiner's Comments** This was a very challenging six mark question that involved data analysis and le Chatelier's principle. It was targeted up to grade A*. Some candidates only described the trends shown in the two tables and found it very difficult to explain the trends. Other candidates contradicted themselves in terms of percentage yield and the position of equilibrium, incorrectly stating that with a low percentage yield the position of equilibrium is on the right. A significant proportion of candidates referred to changing the temperature and pressure but

Question			Answer/Indicative content	Marks	Guidance
					did not specify the direction of the change. Candidates were more likely to be able to explain the effect of increasing temperature on the position of equilibrium rather than the effect of increasing the pressure. The best answers for increasing temperature referring to the reaction being exothermic or the reverse reaction being endothermic. The best answers for increasing pressure referred to the reaction moving to the side with the least number of moles. A significant proportion of the candidates answered a completely different question to the one set, since they tried to explain the conditions used in the reaction and referred to optimum conditions and rate of reaction.
			Total	**6**	

Question			Answer/Indicative content	Marks	Guidance
10			**[Level 3] Deduces how changing temperature and pressure affects the percentage yield** **AND explains the connection between percentage yield and position of equilibrium** Quality of written communication does not impede communication of the science at this level (5 – 6 marks) **[Level 2]** **Deduces how changing temperature and changing the pressure affects the percentage yield** Quality of written communication partly impedes communication of the science at this level (3 – 4 marks) **[Level 1]** **Deduces how changing temperature affects the percentage yield** **OR** **deduces how changing pressure affects the percentage yield** Quality of written communication impedes communication of the science at this level (1 – 2 marks) **[Level 0]** Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	**This question is targeted at grades up to C.** **Indicative scientific points at level 3 must include**: • As percentage yield increases position of equilibrium shifts to the right / high percentage yield has position of equilibrium is on the right / ora **Relevant points at all levels could include explanations** • as temperature increases percentage yield decreases / ora • as pressure increases percentage yield increases / ora **Use the L1, L2, L3 annotations in scoris. Do not use ticks.** **Examiner's Comments** Most candidates could state the relationship between the temperature and the percentage yield and between pressure and percentage yield and gained level 2 (4 marks). If only one of these relationships was given then level 1 (1 or 2 marks) was achieved. Few candidates could describe how the percentage yield was linked to the position of equilibrium which was necessary to reach level 3 (5 or 6 marks)
			Total	**6**	

Question			Answer/Indicative content	Marks	Guidance
11	a		**B** (1)	1	**allow** correct answer ticked, circled or underlined in list if the answer line is blank **Examiner's Comments** Most candidates identified the conditions that give the highest percentage of ethanol.
	b		**any two from:** the temperature or pressure chosen is a compromise (1) the high temperature gives a high rate of reaction (1) high pressure increases the percentage yield of ethanol (1) at higher temperatures the percentage yield is lower (1) higher pressures are expensive to maintain or generate (1)	2	**allow** answer relating to the risks associated with high pressure (1) **Examiner's Comments** This was a challenging question and only a small proportion of candidates were able to suggest why these conditions are used, even though they do not give the highest percentage yield. Candidates were most likely to be awarded a mark for suggesting that the high temperature gives a high rate of reaction or that higher pressures are expensive to generate.
			Total	**3**	
12	a		reversible (1)	1	**allow** reaction goes both ways / goes backwards and forwards / reaction forms an equilibrium mixture **Examiner's Comments** This part was fairly well answered.
	b		50% (1)	1	**allow** any value 50 - 51 **Examiner's Comments** This part was fairly well answered.
			Total	**2**	