OCR GCSE GATEWAY CHEMISTRY A · J248

CHEMISTRY



MARK SCHEME

C5.3 EQUILIBRIA

SCORE	PERCENTAGE
/79	%

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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
	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.

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Question			Answer/Indicative content	Marks	Guidance
			Total	8	

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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
	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.

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			Total	8	

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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.

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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**	

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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 related to the energy e.g. maintaining the

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Question			Answer/Indicative content	Marks	Guidance
					pressure or temperature, these answers were not given any credit.
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
5	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	

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Question			Answer/Indicative content	Marks	Guidance
6	a		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.
	b	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	**4**	

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Question			Answer/Indicative content	Marks	Guidance
7	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**	

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Question			Answer/Indicative content	Marks	Guidance
8			[Level 3] Deduces how increasing temperature and pressure affects the percentage yield AND Explains how addition of carbon dioxide will shift the 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 pressure affects the percentage yield AND Describes how adding carbon dioxide shifts the position of equilibrium 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 and how changing pressure affects the percentage yield OR Describes how adding carbon dioxide shifts the position of equilibrium 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 A. Indicative scientific points at level 3 must include: • To minimise addition of carbon dioxide reaction uses up carbon dioxide i.e. shifts to the right Relevant points at all levels could include explanations • as temperature increases percentage yield decreases / as temperature increases position of equilibrium shifts to the left / ora • as pressure increases percentage yield increases / as pressure increases position of equilibrium shifts to the right / ora • Addition of carbon dioxide shifts position of equilibrium to the right / ora Use the L1, L2, L3 annotations in scoris. Do not use ticks. Examiner's Comments Candidates often focused too much on the interpretation of the data regarding percentage yield. The command word used in the question was describe and all candidates had to do was describe how increasing pressure or increasing temperature changed the position of equilibrium. Candidates needed to explain the effect of adding extra carbon dioxide to the position of equilibrium and in this case had to use Le Chatelier's principle to explain why the position of equilibrium moved to the right. Most candidates could interpret the tabulated data but this only gave them level 1. Only the best answers could explain why adding carbon dioxide shifts the position of equilibrium to the right.

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Question			Answer/Indicative content	Marks	Guidance
					Some candidates confused shifting to the left or to the right with the change in percentage yield.
			Total	6	

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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 did not specify the direction of the change.

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Question			Answer/Indicative content	Marks	Guidance
					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	

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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	

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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	

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Question			Answer/Indicative content	Marks	Guidance
13			**Level 3 (5–6 marks)** Includes an explanation of both a reversible reaction **and** an equilibrium and correctly describes the effect of pressure and temperature on the position of equilibrium. Quality of written communication does not impede communication of the science at this level. **Level 2 (3–4 marks)** Includes an explanation of either a reversible reaction **or** an equilibrium and correctly describes the effect of pressure **or** temperature on the position of equilibrium **OR** includes an explanation of both a reversible reaction and an equilibrium **OR** correctly describes the effect of pressure and temperature on the position of equilibrium Quality of written communication partly impedes communication of the science at this level. **Level 1 (1–2 marks)** Explains what is meant by either a reversible reaction **or** an equilibrium **OR** includes one correct description of the effect of either pressure **or** temperature on the position of equilibrium. 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 grade C.** **Relevant points include:** • idea that reversible reactions can proceed in both directions / go forwards and backwards • idea that, at equilibrium, rate of forward reaction equals the rate of the backward reaction • idea that, at equilibrium, concentrations of reactants and products do not change • as the pressure increases the position of equilibrium moves to the right or concentration of products increases or vice versa • as the temperature increases the position of equilibrium moves to the left or the concentration of reactants increases or vice versa. • increase temperature less ammonia • increase pressure more ammonia **Examiner's Comments** The Haber process appeared to be fairly well known, but the principles behind it were not. Descriptions of reversible reactions were poor at best, and there were very few even partly correct descriptions of equilibrium. The better candidates were able to state the effect of changes in temperature and pressure in terms of the amount of ammonia.
			Total	**6**	

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Question			Answer/Indicative content	Marks	Guidance
14		i	Idea that rate of forward reaction equals rate of backward reaction ✓	1(AO 1.1)	**ALLOW** balanced / becomes the same **IGNORE** stays the same Examiner's Comments That the rates become equal was well understood by higher ability candidates. Others often showed a partial understanding, suggesting 'the rates stayed the same' which is not correct. The lower ability candidates limited themselves to 'the rate increased (or decreased)'.
		ii	Idea that the concentrations of the reacting substances remain constant ✓	1(AO 1.1)	**ALLOW** stays the same / unchanged **IGNORE** 'are' the same Examiner's Comments This was less well understood, with many candidates saying that the concentrations became the same.
			Total	2	
15			B ✓	1(AO 1.1)	Examiner's Comments  Misconception A and C were both common misconceptions in this question.
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
16	a	i	Increases / AW ✓	1(AO 1.1)	Examiner's Comments Candidates usually appreciated that the rate of a reaction increases when the temperature is increased.
		ii	(No) (because) higher temperature favours endothermic reaction / backward reaction / ORA ✓ (so) equilibrium shifts to left hand side / yield of ammonia is reduced / ORA ✓	2(AO 2.1)	Marks are for explanation ALLOW idea that the yield does not increase, in correct context References to reduced yield must not be in the context of rate Examiner's Comments This question required candidates to apply their knowledge of Le Chatelier's principle and assessed AO2. Good responses described that an increase in temperature will favour the endothermic (or backward) reaction and so the yield of ammonia will be reduced. Lower ability candidates tended to gain just one mark for the idea that the equilibrium will shift to the left-hand side and / or the yield of ammonia is reduced, without being able to explain the shift in terms of a higher temperature favouring the endothermic reaction. Misconception A common misconception was to treat this as a kinetics question and to give an answer in terms of increased rate making ammonia quicker and therefore increasing the yield. Exemplar 2

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Question			Answer/Indicative content	Marks	Guidance
					The company is incorrect as when the temperature increases the equilibrium position will shift to the endothermic side so the backward reaction will be favoured and the yield will decrease. [2] This response shows clear understanding of Le Chatelier's principle and describes that an increase in temperature would favour the endothermic / backward reaction and so the yield of ammonia will be reduced.
	b		**Any two from:** Idea that rate of reaction will be slower ✓ As there will be less frequent collisions / less collisions per second / particles collide less often ✓ Idea that yield of ammonia will be less ✓ (Lower pressure) favours backward reaction / equilibrium shifts to left hand side / ORA ✓ As there are fewer (gaseous) molecules on right hand side / ORA ✓	2(AO 2.1)	**ALLOW** idea that reaction will take longer time **IGNORE** idea that the reaction will not be at equilibrium Examiner's Comments Two marks were usually gained in this question for reduced yield and lower rate of reaction.
			Total	**5**	
17			**D ✓**	1 (AO1.1)	
			Total	**1**	
18			**B ✓**	1 (AO1.1)	
			Total	**1**	

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