Questions

Q1.

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 ☒ .

An equation for the formation of ammonia using the Haber process is shown.

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

(i) Calculate the enthalpy change for the forward reaction shown in the equation, selecting from the bond enthalpies in the table.
Include a sign in your answer.

(3)

Bond	Mean bond enthalpy / kJ mol^{-1}
N—N	158
N═N	410
N≡N	945
N—H	391
H—H	436

(ii) A data book gives the standard enthalpy change of formation of ammonia as –46.1 kJ mol^{-1}.

Give two reasons for the difference between this value and the value that you calculated in (a)(i).

(2)

Reason 1

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Reason 2

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(iii) What is the percentage atom economy, by mass, for ammonia in the forward reaction?

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

(1)

- ☒ **A** 17.6 %
- ☒ **B** 50.0 %
- ☒ **C** 82.4 %
- ☒ **D** 100 %

(iv) What is the equilibrium expression for K_c?

(1)

- ☒ **A** $K_c = \frac{[N_2][3H_2]}{[2NH_3]}$
- ☒ **B** $K_c = \frac{[2NH_3]}{[N_2][3H_2]}$
- ☒ **C** $K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$
- ☒ **D** $K_c = \frac{[N_2][H_2]^3}{[NH_3]^2}$

(Total for question = 7 marks)

Q2.

Methanol is manufactured from a mixture of carbon monoxide and hydrogen.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \quad \Delta H = -90.8\,kJ\,mol^{-1}$$

Explain why, in the industrial process involving this reaction, a catalyst is used.

(2)

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(Total for question = 2 marks)

Q3.

This question is about equilibrium systems.

An equilibrium exists in aqueous solution between the chromate(VI) ions and the dichromate(VI) ions.

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$$

Explain any change in the position of equilibrium if a few drops of sodium hydroxide solution are added to this equilibrium system.

(2)

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(Total for question = 2 marks)

Q4.

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 ☒.

Methanol is manufactured from a mixture of carbon monoxide and hydrogen.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \quad \Delta H = -90.8\,kJ\,mol^{-1}$$

(i) How does the equilibrium yield of methanol change if the temperature is increased at constant pressure or the pressure increased at constant temperature?

(1)

	Equilibrium yield when temperature is increased	Equilibrium yield when pressure is increased
☒ **A**	decrease	decrease
☒ **B**	decrease	increase
☒ **C**	increase	decrease
☒ **D**	Increase	increase

(ii) Explain your answer to (i).

(2)

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(Total for question = 3 marks)

Q5.

Phosphorus(V) chloride, PCl_5, can be thermally decomposed to phosphorus(III) chloride, PCl_3, and chlorine, Cl_2 . The equation for this reaction is

$$PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$$

The enthalpy change for this reaction cannot be measured directly.

Another source gave a different value for the enthalpy change of this reaction.

$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ $\Delta_r H = +87.9$ kJ mol^{-1}

Explain the effect, if any, of increasing the temperature on the position of the equilibrium at constant volume.

(2)

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(Total for question = 2 marks)

Q6.

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 ☒.

This question is about equilibrium systems.

The equilibrium for the reaction between hydrogen gas and an oxide of iron is

$$Fe_3O_4(s) + 4H_2(g) \rightleftharpoons 3Fe(s) + 4H_2O(g)$$

The K_c expression for this equilibrium is

(1)

☒ **A** $K_c = \dfrac{[Fe] \times [H_2O]}{[Fe_3O_4] \times [H_2]}$

☒ **B** $K_c = \dfrac{[Fe]^3 \times [H_2O]^4}{[Fe_3O_4] \times [H_2]^4}$

☒ **C** $K_c = \dfrac{[H_2O]}{[H_2]}$

☒ **D** $K_c = \dfrac{[H_2O]^4}{[H_2]^4}$

(Total for question = 1 mark)

Q7.

An equation for the formation of ammonia using the Haber process is shown.

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

In the chemical industry, many processes involve reversible reactions. The product is often removed before equilibrium is attained.

Give three reasons why the product may be removed before its maximum concentration is achieved.

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(Total for question = 3 marks)

Q8.

This question is about the oxidation of ammonia.

In fact, this oxidation to form nitrogen(II) oxide is an equilibrium reaction.

(i) Explain the effect, if any, of increasing pressure on the equilibrium **yield** of NO in this reaction.

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

(2)

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(ii) Explain the effect, if any, of an increase in pressure on the **rate** of this reaction.

(2)

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(iii) The platinum-rhodium catalyst used in this reaction is a **heterogeneous** catalyst. State what is meant by the term 'heterogeneous' and why a catalyst has no effect on the yield of the products in the reaction.

(2)

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(Total for question = 6 marks)

Q9.

One of the stages in the production of sulfuric acid from sulfide ores involves the oxidation of sulfur dioxide to sulfur trioxide. The equation for the reaction is

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta rH = -197 \text{ kJ mol}^{-1}$

The conditions used in one industrial process are: 420°C and a pressure of 1.7 atm together with a vanadium(V) oxide catalyst.

It is proposed to change the conditions to 600°C and 10 atm pressure, while still using the same catalyst.

* Evaluate the feasibility of each of these changes in terms of their effect on the rate, yield and economics of the reaction.

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(Total for question = 6 marks)

Q10.

This question is about the oxidation of ammonia.

One equation for the oxidation of ammonia is

$$4NH_3(g) + 3O_2(g) \rightleftharpoons 2N_2(g) + 6H_2O(g)$$

Write the expression, including units, for the equilibrium constant K_c for for this reaction.

(2)

Expression

Units .....

(Total for question = 2 marks)

Q11.

This question concerns alkenes and some halogen compounds.

Chloroethene can be manufactured by a two-stage process.

(i) In stage 1, chlorine is reacted with ethene at a temperature between 50 °C and 80 °C

$$Cl_2 + CH_2{=}CH_2 \rightleftharpoons CH_2Cl{-}CH_2Cl \qquad \Delta H = -178\,kJ\,mol^{-1}$$

Give **one** reason why a temperature below 50 °C and **another** reason, apart from costs, why a temperature above 80 °C would not be used for this process.

(2)

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(ii) In stage 2, the product from the first reaction is converted to chloroethene:

$$CH_2Cl{-}CH_2Cl \rightarrow CH_2{=}CHCl + HCl \qquad \Delta H = +71\,kJ\,mol^{-1}$$

Both products are required for use in other processes.
Which method would be most suitable for the separation of these two products?

(1)

- ☒ **A** fractional distillation
- ☒ **B** solvent extraction using a separating funnel
- ☒ **C** heating under reflux
- ☒ **D** bubble through dilute alkali

(Total for question = 3 marks)

Q12.

Methanol, CH_3OH, is a liquid fuel.

Methanol can be synthesised from methane and steam by a process that occurs in two steps.

Step **1** $CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$ $\Delta H = +206\,kJ\,mol^{-1}$

Step **2** $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ $\Delta H = -91\,kJ\,mol^{-1}$

(i) Explain the effects of increasing the pressure on the yield of the products and on the rate of the reaction in Step **1**.

(4)

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(ii) Step **2** is carried out at a compromise temperature of 500 K.

Explain why 500 K is considered to be a compromise for Step **2** by considering what would happen at higher and lower temperatures.

(3)

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(Total for question = 7 marks)

Q13.

Methanol is manufactured from a mixture of carbon monoxide and hydrogen.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \quad \Delta H = -90.8\,kJ\,mol^{-1}$$

Give **two** characteristics of all reactions at equilibrium.

(2)

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(Total for question = 2 marks)

Q14.

Nitrogen monoxide and chlorine gases react together to form a single product, nitrosyl chloride, NOCl.

Below 100 °C the yield of NOCl is almost 100 %, but as the temperature rises the yield of NOCl decreases as the equilibrium position shifts to the left.

$$2NO(g) + Cl_2(g) \rightleftharpoons 2NOCl(g) \qquad \Delta_r H^{\ominus} = -75.6 \text{ kJ mol}^{-1}$$

A 1 dm^3 reaction vessel, initially containing 2 mol of NO and 1 mol of Cl_2, was allowed to come to equilibrium at 225 °C to produce 1.82 mol of NOCl.

(i) Calculate the number of moles of NO and Cl_2 at equilibrium.

(2)

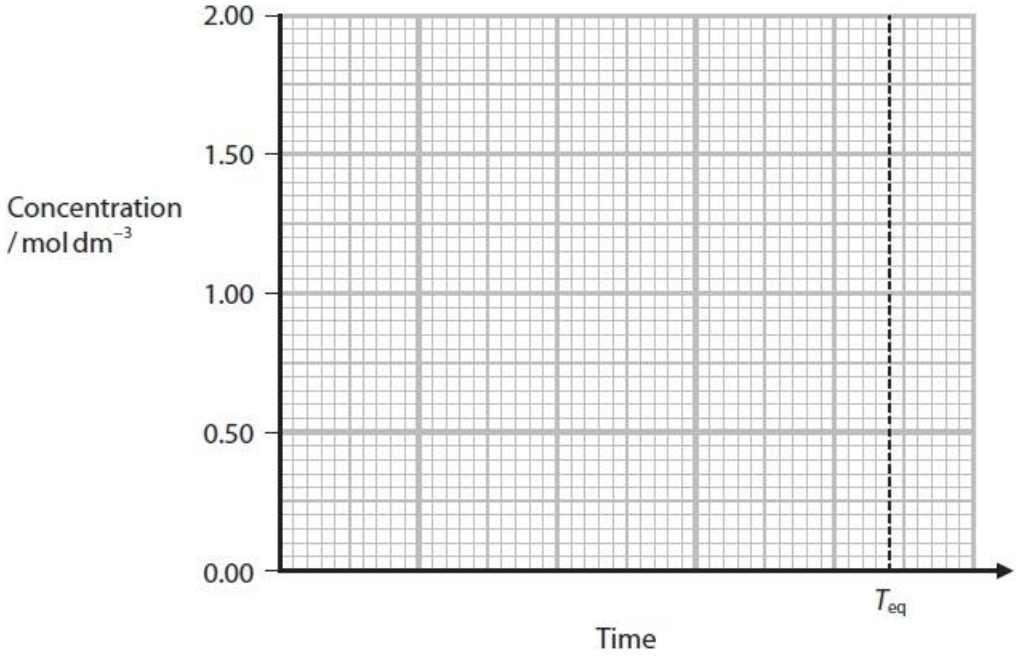
Moles of NO .....

Moles of Cl_2 .....

(ii) Sketch three lines showing the change in concentration over time of the three components of the reaction using the axes given.

You should assume that the reaction reaches equilibrium at time T_{eq}.

(3)



(iii) The expression for the equilibrium constant, K_c , for this reaction is

(1)

☒ **A** $K_c = \dfrac{2[NOCl]}{2[NO][Cl_2]}$

☒ **B** $K_c = \dfrac{[NOCl]^2}{[NO]^2[Cl_2]}$

☒ **C** $K_c = \dfrac{2[NO][Cl_2]}{2[NOCl]}$

☒ **D** $K_c = \dfrac{[NO]^2[Cl_2]}{[NOCl]^2}$

(iv) Give the reason why the equilibrium yield of NOCl decreases when the temperature changes from 25 °C to 225 °C.

The enthalpy change for the reaction at 25 °C is −75.6 kJ mol^{-1}.

(1)

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(Total for question = 7 marks)

Q15.

Ethene reacts with steam to form ethanol in a reversible reaction.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \quad \Delta H = -45 \text{ kJ mol}^{-1}$$

At 300°C and a pressure of 65 atm, the equilibrium yield of ethanol is 5%.

(i) State the effect, if any, on the yield of ethanol when the temperature is **increased**.

(1)

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(ii) State the effect, if any, on the yield of ethanol when the pressure is **decreased**.

(1)

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(iii) What is the expression for the equilibrium constant, K_c, for this reaction?

(1)

☒ **A** $\dfrac{[C_2H_4(g)]+[H_2O(g)]}{[C_2H_5OH(g)]}$

☒ **B** $\dfrac{[C_2H_4(g)][H_2O(g)]}{[C_2H_5OH(g)]}$

☒ **C** $\dfrac{[C_2H_5OH(g)]}{[C_2H_4(g)]+[H_2O(g)]}$

☒ **D** $\dfrac{[C_2H_5OH(g)]}{[C_2H_4(g)][H_2O(g)]}$

(Total for question = 3 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
(i)	• sum of bond energies of all reactants (1) • sum of bond energies of all products (1) • calculation of $\Delta_c H$ (1)	Example of calculation $945 + (3 \times 436) = (+)2253$ (kJ mol^{-1}) $6(N{-}H) = 6 \times 391 = (-)2346$ (kJ mol^{-1}) $-2346 + 2253 = -93$ (kJ mol^{-1}) TE from either/both M1 and M2 Correct answer with no working scores 3	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following points: • the equation in 9(a)(i) is for the formation of two moles of ammonia (1) • the bond energies in the table are mean / not specific to ammonia (1)	Ignore any references to differing conditions for the Haber process Ignore heat losses	(2)

Question Number	Answer	Mark
(iii)	**The only correct answer is D** (100 %) **A** *is not correct because this is the percentage of hydrogen* **B** *is not correct because this is half the atom economy for making ammonia* **C** *is not correct because this is the percentage of nitrogen*	(1)

Question Number	Answer	Mark
(iv)	**The only correct answer is C** $K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$ **A** *is not correct because this expression shows molar quantities, not powers and is inverted* **B** *is not correct because this expression shows molar quantities, not powers* **D** *is not correct because this expression is for the reverse equation*	(1)

Q2.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation which makes reference to the following points: • a catalyst increases the rate at which the reaction moves towards equilibrium / decreases the time a reaction takes to arrive at a particular yield of product / (provides a reaction pathway with) a lower activation energy **(1)** • allows milder conditions to be used (lowering cost) **(1)**	Allow a catalyst increases the rate of attainment of equilibrium / decreases the time a reaction takes to arrive at equilibrium Do not award just 'a catalyst increases the rate of reaction' Allow lower temperature and/or lower pressure and/or lower energy conditions Allow more product for the same energy Do not award just 'decreases the cost'	**(2)**

Q3.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: • equilibrium position shifts to the left **(1)** • (because) the hydroxide ions combine with/neutralise the H^+ ions to remove them from the equilibrium **(1)**	'Equilibrium moves to the right' scores (0) Allow Hydroxide ions react with H^+ ions to make water/ hydroxide ions react with H^+ ions to reduce their number/concentration Ignore reference to 'more products formed'	**(2)**

Q4.

Question Number	Answer	Mark
(i)	**The only correct answer is B decrease/increase** **A** *is not correct because an increase in pressure results in an increase in yield* **C** *is not correct because an increase in temperature results in a decrease in yield* **D** *is not correct because an increase in temperature results in a decrease in yield*	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An explanation which makes reference to the following points: • (The yield of methanol decreases because a rise in temperature causes) the equilibrium shifts to the endothermic direction (which is the backward reaction) **(1)** • (The yield of methanol increases because) the equilibrium shifts to the side of fewer moles (of gas molecules) **(1)**	Allow TE on incorrect answers in (b)(i). e.g. if candidate gives forward reaction is endothermic allow increase in yield due to rise in temperature shifts the equilibrium to the endothermic direction can be awarded Allow the forward reaction is exothermic so the reaction favours the left hand side	**(2)**

Q5.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: • (increasing the temperature) will move the equilibrium position to the right/ in forward direction (1) • because the (forward) reaction is endothermic (1)	Allow more products will form M2 conditional on M1	(2)

Q6.

Question Number	Answer	Mark
	The only correct answer is D $K_c = \frac{[H_2O]^4}{[H_2]^4}$ **A** is not correct because the solids should not be included in the expression and the powers of the remaining substituents have been omitted **B** is not correct because the solids should not be included in the expression **C** is not correct because the powers of the substituents have been omitted	**(1)**

Q7.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to any **three** of the following points: • the equilibrium position will shift to the right OR this will favour forward reaction (1) • (in an equilibrium) removal of product decreases rate of back reaction / rate of formation of reactant(s) (1) • time to attain / reach equilibrium may be too long (1) • unreacted reactants can be recycled (1)		**(3)**

Q8.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following points: • yield (of NO) decreases **(1)** • increase in pressure shifts equilibrium (position) to the side of fewer moles (of gas molecules) **(1)**	if M1 and M2 are contradictory then do not award any marks allow 9 mol on LHS and 10 mol on RHS, may be shown above the equation allow more moles of product allow fewer moles of reactant allow marking points in either order	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following points: (on increasing the pressure) • Rate increases because there are more molecules per unit volume **(1)** so increase in frequency of collisions (between reacting molecules) **(1)**	allow increase in concentration of (gas) molecules allow any implication of more particles in a given volume, e.g. particles are closer together allow more collisions per unit time ignore just 'more collisions'/'more successful collisions' with no reference to time allow answers based on a solid catalyst	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to: • heterogeneous: (the catalyst is in) a different phase/state to the reactants **(1)** • increases the rate of the forward and backward / reverse reactions **(1)**	ignore reference to products	**(2)**

Q9.

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*</td>
<td>
This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.
Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.
The following table shows how the marks should be awarded for indicative content.
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
The following table shows how the marks should be awarded for structure and lines of reasoning.
<table>
<tr><th></th><th>Number of marks awarded for structure and sustained lines of reasoning</th></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning.</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured.</td><td>0</td></tr>
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<td>
Guidance on how the mark scheme should be applied:

The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning, scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).

If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).

In general it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning.

If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).
Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning.
</td>
<td>(6)</td>
</tr>
</table>

	Indicative content: • IP1 increase in temperature will increase rate • IP2 (but) increase in temperature will decrease yield/move the equilibrium to the LHS/ produce less SO_3 **because** it is an exothermic reaction (in the forward direction) • IP3 increase in temperature increases **energy** costs • IP4 increase in pressure has no effect on rate (because all the active sites are already occupied on a heterogeneous catalyst). **OR** increase in pressure will increase rate (of reaction) • IP5 increase in pressure will move position of eqm to RHS/increase yield **because** there are less moles/molecules (of gas) on the RHS • IP6 but increased pressure increases (construction and running) costs/reduces economic viability	Decreased yield with no reference to exothermic reaction does not get IP2. Allow increases yield of reactants/SO_2 **and** O_2 (with reference to exothermic reaction) Increased yield with no reference to number of moles does not get IP5. Award one mark for IP2 and IP5 if correct references to yield in both but reasons not given Allow IP3 and IP6 if increased costs of higher temperature and pressure are mentioned together **provided** that the temperature costs are linked to energy costs. Otherwise only IP6 can be awarded. Ignore any reference to catalyst	

Q10.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• K_c expression **(1)**	(K_c =) $\frac{[N_2(g)]^2\,[H_2O(g)]^6}{[NH_3(g)]^4[O_2(g)]^3}$ ignore missing state symbols do not award round brackets	
	• units based on their K_c expression **(1)**	mol dm^{-3} or mol/dm^3	**(2)**

Q11.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following: • at lower temperatures (below 50°C) the reaction will be slow **(1)** • at higher temperatures (above 80°C) yield will be lower <u>because</u> (forward) reaction is exothermic **(1)**	allow reverse argument allow other products produced at higher temperatures	**(2)**

Question Number	Acceptable Answer	Mark
(ii)	**The only correct answer is A** ***B*** *is not correct because separating funnel is inappropriate for an industrial process* ***C*** *is not correct because not a separation process* ***D*** *is not correct because both will react with alkaline solution*	**(1)**

Q12.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to the following points: • (increasing the pressure) decreases the yield **(1)** • as the right hand side / products contain more moles of gas **(1)** • (increasing the pressure) increases the rate of reaction **(1)** • as collisions occur at an increased frequency **(1)**	Award 4 moles of product formed from 2 moles of reactant Allow more particles in a given volume / particles are more likely to collide Ignore more collisions are of the correct orientation	**(4)**

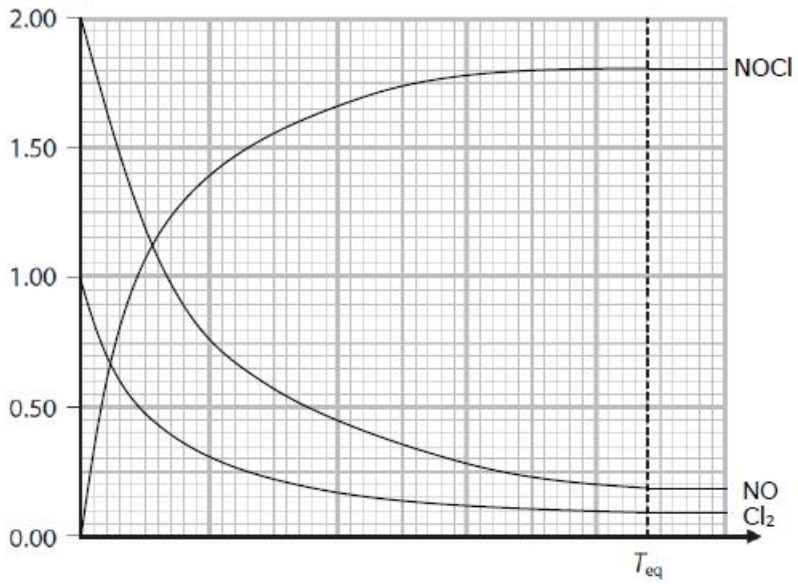
Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following points: • at higher temperatures the yield of product would be less (as forward reaction is exothermic) **(1)** • at lower temperatures the reaction would be slower **(1)** • (500 K is a compromise) giving a reasonable yield at a reasonable rate / between yield and rate **(1)**		**(3)**

Q13.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An answer which makes reference to the following points: • the concentration / amount of all components / of all reactants and products is constant **(1)**	Allow concentrations remain constant Do not award the concentration / amount of reactants and products are equal / the same	**(2)**
	• the rate of the forward reaction is equal to the rate of the backward reaction **(1)**	Ignore in a closed system	

Q14.

Question Number	Answer	Additional Guidance	Mark
(i)	• calculation of the moles of NO present at equilibrium **(1)** • calculation of the moles of Cl_2 present at equilibrium **(1)**	Example of calculation 2 – 1.82 = 0.18 (mol) 1 – $\frac{1.82}{2}$ = 0.09 (mol) Allow TE	**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	• line starting at 2.00 and ending at 0.18 **(1)** • line starting at 1.00 and ending at 0.09 **(1)** • line starting at 0.00 and ending at 1.82 **(1)**	 Ignore lack of labels Allow any reasonable curves, curving in the direction shown, with no maximum or minimum Do not award straight lines If no marks awarded, allow (1) for 3 correct starting points and / or (1) for 3 correct finishing points Ignore lines going past T_{eq} unless they are clearly far from horizontal (allow the line to go up or down by 1 square from value at T_{eq} Allow TE on answers to (i)	**(3)**

Question Number	Answer	Mark
(iii)	The only correct answer is **B** ($K_c = \frac{[NOCl]^2}{[NO]^2[Cl_2]}$) ***A** is not correct because this is multiplying [NOCl] and [NO] by 2 rather than squaring* ***C** is not correct because this is multiplying by 2 and is upside down* ***D** is not correct because this is upside down*	**(1)**

Question Number	Answer	Additional Guidance	Mark
(iv)	An answer that makes reference to the following points: • equilibrium shifts to favour the endothermic direction (which is the backward reaction)	Answer must make reference to either exo- or endothermic or to significance of negative ΔH Allow the backward reaction is endothermic (so yield decreases) Allow the forward reaction is exothermic so reaction shifts to the left Ignore just forward reaction is exothermic Do not award 'the rate of the forward reaction decreases'	**(1)**

Q15.

Question Number	Acceptable Answers	Additional Guidance	Mark
(i)	• (yield) decreases / lower yield	Allow less ethanol is produced Ignore equilibrium shifts to the left but do not allow equilibrium shifts to the right Ignore any reference to Le Chatelier's principle Do not allow high temperature favours the exothermic direction	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(ii)	• (yield) decreases / lower yield	Allow less ethanol is produced Ignore equilibrium shifts to the left but do not allow equilibrium shifts to the right Ignore any reference to Le Chatelier's principle Ignore fewer collisions	(1)

Question Number	Answer	Mark
(iii)	**D** $\left(\frac{[C_2H_5OH(g)]}{[C_2H_4(g)][H_2O(g)]}\right)$	(1)