

Mark schemes

1

(a)
$$K_c = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2[\text{O}_2]}$$

Penalise () in this part but can score units; mark on in (b)

If K_c expression wrong no marks in this part but can score M1 & M3 in (b)

1

units = mol⁻¹ dm³

1

(b)
$$[\text{O}_2] = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2 K_c} \text{ or } \frac{(0.072/1.4)^2}{(0.055/1.4)^2 \times 27.9} \text{ or } \frac{(0.072)^2}{(0.055)^2 \times 27.9}$$

Correct answer scores three marks

Ignore () in this part

Penalise contradiction in M1

M1

1

0.061(4)

If K_c expression wrong in (a) can score M1 here for rearrangement of their K_c & M3 for multiplication by 1.4

M2

mol O₂ = 0.0614 × 1.4 = 0.086 (allow 0.085–0.087)

If K_c or rearrangement wrong here score only M3 for multiplication by 1.4

1

M3 = correct answer of (M2 × 1.4)

M3

1

(c) (i) No effect **OR** none **OR** no change **OR** stays the same

1

(ii) Effect: Increase or more SO₃

Increase or more SO₃

If wrong effect, no further marks, but M2 and M3 are independent of each other

M1

1

Fewer mole(cule)s on RHS
or 3 moles to 2 moles
or (eqm shifts) to side with fewer moles
(V³ or) residual V decreases in numerator of K_c expression

M2

1

Equilibrium moves / shifts to reduce the pressure /
oppose the increase in pressure

to keep K_c constant,

ratio $\frac{(\text{mol SO}_3)^2}{(\text{mol SO}_2)^2(\text{mol O}_2)}$

must increase

Allow to oppose the change only if increase pressure mentioned

M3

1

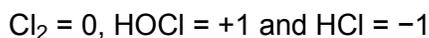
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Allow the products shown as ions.

1



*1 mark for all three oxidation states correct. Allow a reaction arrow
in this equation.*

Oxidation states must match the species

1

(b) Hydroxide / alkali ions react with the acids

Mark independently

1

Equilibrium moves to the right

1

(c) Only used in small amounts

1

The health benefits outweigh the risks

1

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3

(a) (i) Award mark for **X on the time axis** at the point where the lines just become
horizontal

*Allow this mark if X is above the letters "sh" in the word "show" in
part(ii) - in the range of lines 31 to 33.*

1

(ii) They are equal / the same

OR

Forward (rate) = Reverse / backward (rate)

Allow the word 'speed' in this context.

Ignore reference to concentration.

1

(b) Both **OR** forward and reverse reactions occur at the same time

OR both are occurring at once

OR both occur all of the time

OR both are ongoing

OR both never stop

Ignore 'at equal rates'.

Ignore reference to concentration or equilibrium.

The idea that both reactions occur simultaneously is essential.

The simple idea of 'both reactions occurring' is insufficient for the mark.

1

(c) (i) **M1** No effect / no change / none / stays the same

M2 requires correct **M1**

*In **M2**, ignore reference to particles or atoms.*

M2 Equal (number of) moles / molecules on both sides

2

- (ii) **M1** Less time or it decreases or (equilibrium) reached faster (ie **M1** is a reference to time taken)

If **M1** is 'more time / it increases' or 'no effect', then **CE=0** for the clip.

Reference to faster / increased rate / increased speed alone penalises **M1**, but mark on **M2** and **M3**.

M2 More particles / molecules in a given volume / space

OR the particles / molecules are closer together

If **M1** is blank, then look for all three marks in the text.

M3 More successful / productive collisions in a given time

OR more collisions with $E > E_{Act}$ in a given time

OR more frequent successful / productive collisions

OR increased / greater successful / productive collision frequency / rate

Ignore reference to reactants / products.

Penalise **M3** if an increase / decrease in the value of E_{Act} is stated.

3

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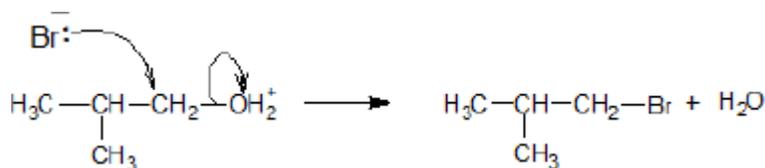
4

- (a) (i) **M1** double-headed curly arrow from the lone pair of the bromide ion to the C atom of the CH_2

Penalise additional arrows.

M2 double-headed arrow from the bond to the O atom

As follows



2

- (ii) **M1** nucleophilic substitution

M1 both words needed (allow phonetic spelling).

M2 1-bromo(-2-)methylpropane

M2 Require correct spelling in the name but ignore any hyphens or commas.

2

(b) **M1** hydrolysis

*For **M1** give credit for 'hydration' on this occasion only.*

M2 C≡N with absorption range 2220–2260 (cm⁻¹)

*Credit 1 mark from **M2** and **M3** for identifying C≡N **and** either O–H(acids) **or** C=O **or** C–O without reference to wavenumbers or with incorrect wavenumbers.*

M3 O–H(acids) with absorption range 2500–3000 (cm⁻¹)

OR

C=O with absorption range 1680–1750 (cm⁻¹)

OR

C–O with absorption range 1000–1300 (cm⁻¹)

*Apply the list principle to **M3***

3

(c) (i) **M1** Yield / product **OR** ester increases / goes up / gets more

M2 (By Le Chatelier's principle) the position of equilibrium is driven / shifts / moves to the right / L to R / in the forward direction / to the product(s)

M3 – requires a correct statement in M2

(The position of equilibrium moves)

to oppose the increased concentration of ethanol

to oppose the increased moles of ethanol

to lower the concentration of ethanol

to oppose the change and decrease the ethanol

*If no reference to **M1**, marks **M2** and **M3** can still score BUT if **M1** is incorrect CE=0*

*If there is reference to 'pressure' award **M1** ONLY.*

3

(ii) **M1**

Catalysts provide an alternative route / pathway / mechanism

OR

surface adsorption / surface reaction occurs

For M1, not simply 'provides a surface' as the only statement.

M1 may be scored by reference to a specific example.

M2

that has a lower / reduced activation energy

OR

lowers / reduces the activation energy

Penalise M2 for reference to an increase in the energy of the molecules.

For M2, the student may use a definition of activation energy without referring to the term.

Reference to an increase in successful collisions in unit time alone is not sufficient for M2 since it does not explain why this has occurred.

2

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(a) Mol of **E** 1.6(00)
Ignore extra zeros.

1

Mol of **F** 0.2(00)

1

(b) $K_c = \frac{[G]^2}{[E][F]^2}$
Penalise expression containing V.
Penalise missing brackets or ().

1

mol⁻¹ dm³

If K_c wrong, allow units consequential to their K_c, but no marks in (c) unless correct K_c used in (c).

1

(c) $K_c = \frac{(0.85/1.5)^2}{(2.50/1.5)(1.20/1.5)^2}$
Vol missed or used wrongly – no marks.
If K_c correct in (b) but squared term missed here, no further marks.

1

= 0.3(01) Allow 0.299–0.304

Ignore units.

1

(d) M1 Decrease

If M1 is incorrect CE=0 for the clip.

If M1 is blank, mark on and seek to credit the correct information in the explanation.

1

M2 More moles on LHS / reactants or fewer / less moles on RHS / products
(allow correct ratio 3:2)

M2 not just a generic statement 'shifts to more moles'.

1

M3 (Equilibrium) shifts / moves either to oppose reduction in pressure / or to increase the pressure

M3 depends on a correct statement for M2.

Not 'favours'.

Allow 'to oppose change' only if reduction in pressure noted.

1

(e) M1 T_1

If M1 is incorrect, CE=0 for the clip.

If M1 is blank, mark on and seek to credit the correct information in the explanation.

1

M2 (Forward*) reaction is exothermic
OR Backward reaction is endothermic

**Assume answer refers to forward reaction unless otherwise stated.*

1

M3 (at T_2 or lower temperature)

(Equilibrium) shifted / moved to oppose reduction in temp

OR

at T_1 or higher temp, (Equilibrium) shifted / moved to oppose (increase in temp)

M3 depends on a correct statement for M2

Allow "to oppose change" only if change in temperature is stated.

Not 'favours'.

1

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(a) (i) M1 c(oncetrated) phosphoric acid / c(onc.) H₃PO₄

OR c(oncetrated) sulfuric acid / c(onc.) H₂SO₄

In M1, the acid must be concentrated.

Ignore an incorrect attempt at the correct formula that is written in addition to the correct name.

M2 Re-circulate / re-cycle the (unreacted) ethene (and steam) / the reactants

OR pass the gases over the catalyst several / many times

In M2, ignore "remove the ethanol".

Credit "re-use".

2

(ii) M1

(By Le Chatelier's principle) the equilibrium is driven / shifts / moves to the right / L to R / forwards / in the forward direction

M2 depends on a correct statement of M1

The equilibrium moves / shifts to

- oppose the addition of / increased concentration of / increased moles / increased amount of water / steam
- to decrease the amount of steam / water

Mark M3 independently

M3 Yield of product / conversion increase **OR** ethanol increases / goes up / gets more

3

(iii) M1 Poly(ethene) / polyethene / polythene / HDPE / LDPE

M2 At higher pressures

More / higher cost of electrical energy to pump / pumping cost

OR

Cost of higher pressure equipment / valves / gaskets / piping etc.

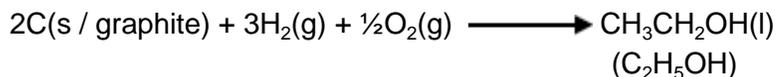
OR expensive equipment

Credit all converse arguments for M2

2

(b) M1 for balanced equation

M2 for state symbols in a correctly balanced equation



Not multiples but credit correct state symbols in a correctly balanced equation.

Penalise C₂H₆O but credit correct state symbols in a correctly balanced equation.

2

(c) (i) M1 The enthalpy change / heat change at constant pressure when 1 mol of a compound / substance / element

*If standard enthalpy of formation **CE=0***

M2 is burned / combusts / reacts completely in oxygen

OR burned / combusted / reacted in excess oxygen

M3 with (all) reactants and products / (all) substances in standard / specified states

OR (all) reactants and products / (all) substances in normal states under standard conditions / 100 kPa / 1 bar and specified T / 298 K

*For **M3***

Ignore reference to 1 atmosphere

3

(ii) M1

Correct answer gains full marks

$$\underline{\Sigma B(\text{reactants}) - \Sigma B(\text{products}) = \Delta H}$$

Credit 1 mark for (+) 1279 (kJ mol⁻¹)

OR

$$\underline{\text{Sum of bonds broken} - \text{Sum of bonds formed} = \Delta H}$$

OR

$$\begin{aligned} &B(\text{C-C}) + B(\text{C-O}) + B(\text{O-H}) + 5B(\text{C-H}) + 3B(\text{O=O}) \text{ (LHS)} \\ &- 4B(\text{C=O}) - 6B(\text{O-H}) \text{ (RHS)} = \underline{\Delta H} \end{aligned}$$

M2 (also scores **M1**)

$$348+360+463+5(412)+3(496) \text{ [LHS = 4719]}$$

(2060) (1488)

$$- 4(805) - 6(463) \text{ [RHS = - 5998]} = \Delta H$$

(3220) (2778)

OR using only bonds broken and formed (**4256 - 5535**)

For other incorrect or incomplete answers, proceed as follows

- *check for an arithmetic error (AE), which is either a transposition error or an incorrect multiplication; this would score 2 marks (**M1** and **M2**)*
- *If no AE, check for a correct method; this requires either a correct cycle with 2C and 6H and 7O OR a clear statement of **M1** which could be in words and scores only M1*

M3

$$\Delta H = \underline{-1279} \text{ (kJ mol}^{-1}\text{)}$$

Allow a maximum of one mark if the only scoring point is LHS = 4719 OR RHS = 5998

Award 1 mark for +1279

Candidates may use a cycle and gain full marks

3

(d) (i) Reducing agent OR reductant OR electron donor
OR to reduce the copper oxide

Not "reduction".

Not "oxidation".

Not "electron pair donor".

1

(ii) CH₃COOH

1

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(a) Cl₂ 0.4

1

$$(b) \quad (i) \quad K_c = \frac{[NO]^2 [Cl_2]}{[NOCl]^2}$$

*Penalise expression containing V
Allow () here, but must have all brackets.
If K_c expression wrong, max 2 in (b)(ii) for
M1 for correct rearrangement of their K_c and
M4 for multiplying by 15*

1

$$(ii) \quad M1 \quad [Cl_2] = K_c \times \frac{[NOCl]^2}{[NO]^2}$$

*Mark is for rearrangement of correct K_c expression.
If K_c rearrangement wrong, can only score max 2 for:
M3 and M4*

1

M2

$$[Cl_2] = \frac{(7.4 \times 10^{-3}) \times (1.90/15)^2}{(0.86/15)^2} \quad (= \frac{(7.4 \times 10^{-3}) \times (0.127)^2}{(0.0573)^2})$$

Rounding 1.90 / 15 wrongly to 0.126 is AE

1

M3 $[Cl_2] = 0.0361$ to 0.0365 (min 2 sfs)

Mark for correct calculation of $[Cl_2]$

1

M4 mol $Cl_2 = 0.54$ to 0.55

Correct answer scores 4 ignore working

Mark is for answer of (M3 \times 15)

1

(iii) $(\sqrt{7.4 \times 10^3}) = 0.086$

Allow 0.085 to 0.086)

Mark for answer **OR** conseq on their Cl_2

$$K_c = \sqrt{\frac{M4}{15}} \times \frac{0.86}{1.90} = \sqrt{M4} \times 0.117$$

Or $\sqrt{M3} \times 0.453$

1

mol^{1/2} dm^{-3/2} **OR** mol^{0.5} dm^{-1.5}

NOT $\sqrt{\text{mol dm}^{-3}}$ nor $(\text{mol dm}^{-3})^{1/2}$

1

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