
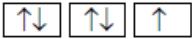


## ES – Exam Questions – Mark Scheme

This mark scheme follows the same order as the exam questions.

Any five points from:  1. kills bacteria / kills pathogens / disinfectant ✓  2. cheap compared to other water treatment chemicals. ✓  3. Cl <sub>2</sub> or chlorine is a gas, making it difficult to contain / it spreads easily. ✓  4. toxic / poisonous ✓  5. causes respiratory problems / breathing problems ✓  6. forms by-products / THMs that are suspected carcinogens ✓  7. dissolves in rivers / local water supplies ✓  8. forming bleach and acid ✓  9. (bleach and acid) kill life forms in the water ✓	5	DO NOT ALLOW just 'cheap'.  Answer must have 'gas' and either 'difficult to contain' or 'spreads easily' to gain the mark. <b>ALLOW</b> Cl <sub>2</sub> / chlorine is a gas so needs a strong container. <b>IGNORE</b> 'difficult to store / difficult to transport'  DO NOT ALLOW harmful / irritant / dangerous instead of toxic.  Answer must have 'by-products / THMs' and 'suspected carcinogens' to gain the mark.
Amount of phenylethene / product increases <b>OR</b> higher yield ✓  (increased temperature) moves (position of) equilibrium in the endothermic direction (ORA) ✓	2	Endothermic must be correctly spelled for the second mark to be awarded or 'exothermic' if reverse argument given  <b>ALLOW</b> 'reaction moves in / favours the endothermic direction' / forward reaction is endothermic / shifts towards the endothermic reaction <b>ALLOW</b> endothermic for QWC if written on equation 2.1.  Mark independently
Amount of phenylethene / product decreases / lower yield ✓  (increased pressure) moves (position of) <u>equilibrium</u> to the side with fewer molecules / moles / particles ✓	2	<b>NOT</b> just 'equilibrium moves to the left'. <b>NOT</b> atoms.  Mark independently
M <sub>r</sub> (NaCl) = 58.5 and M <sub>r</sub> (KCl) = 74.6 / 74.5 ✓  2/ M <sub>r</sub> (NaCl): 1/ M <sub>r</sub> (KCl) and evaluate as 1: something (= 1 : 0.39) ✓	2	'moles Na : moles K = 1: 0.39' scores both marks <b>ALLOW</b> any number of s.f. for 2 <sup>nd</sup> mp <b>ALLOW</b> 2 <sup>nd</sup> mp if A <sub>r</sub> values of K and Na have been used instead of M <sub>r</sub> values (= 1: 0.29)
White ✓	1	<b>IGNORE</b> colour changes on standing
Silver chloride ✓	1	
Ag <sup>+</sup> + Cl <sup>-</sup> → AgCl ✓	1	<b>ALLOW</b> with no state symbols <b>NOT</b> if state symbols are wrong
Green gas <b>OR</b> Green-yellow gas ✓	1	Both colour and 'gas' needed for mark <b>IGNORE</b> shades of colour, like dark or pale
[Ne] 3s  3p  ✓	1	<b>ALLOW</b> single arrow in any 3p atomic orbital pointing up or down <b>ALLOW</b> use of other arrow symbols (such as 1, as long as – in each box that contains a pair– one points up and one down)
Method 1 / burning potassium in chlorine, as KCl is the only product / all reacting atoms used / all products are useful (ORA) ✓	1	<b>ALLOW</b> 100% atom economy / only one product / no co-product / no other products / no by-products / no atoms lost / no waste / addition reaction. An incorrect statement about method 2 <b>CONs</b> the mark

A lot of energy / high temperature is required OR reaction produces a low yield of KCl ✓	1	ALLOW K and Cl <sub>2</sub> / reagents of method 1 are expensive ALLOW reagents are dangerous and safety precautions / reaction conditions are expensive
In H <sub>2</sub> S: -2 ✓ In H <sub>2</sub> SO <sub>4</sub> : +6 ✓	2	Answer must have sign before number to score both. ALLOW one mark for 2- AND 6+
Oxygen / O <sub>2</sub> ✓  Oxidation state or number has decreased / changed from 0 to -2 ✓	2	DO NOT ALLOW second mark if incorrect oxidation states are given. ALLOW gains electrons. Second mark depends on first.
Hydrogencarbonate ✓	1	ALLOW hydrogen carbonate IGNORE incorrect oxidation states
Rate of forward reaction = rate of back reaction OR reactants and products are formed at the same rate ✓  Concentrations of reactants and products remain constant OR closed system ✓	2	Mark independently  DO NOT ALLOW concentrations of reactants and products are the same/equal
CO <sub>3</sub> <sup>2-</sup> (concentration) decreases ✓  Equilibrium (position) moves to left / towards reactants / towards hydrogencarbonate ✓	2	MUST mention equilibrium for the second mark Mark independently
CO <sub>2</sub> + H <sub>2</sub> O ⇌ 2H <sup>+</sup> + CO <sub>3</sub> <sup>2-</sup> ✓	1	IGNORE state symbols DO NOT ALLOW H <sub>2</sub> CO <sub>3</sub> on right hand side
Ba <sup>2+</sup> (aq) + SO <sub>4</sub> <sup>2-</sup> (aq) → BaSO <sub>4</sub> (s)  Equation ✓ State symbols ✓	2	Completely correct equation (i.e. without spectator ions) scores the first mark  Mark state symbols separately – must have the idea of (aq) + (aq) → (s)
M <sub>r</sub> (SO <sub>4</sub> <sup>2-</sup> ) = (32.1 + 4 × 16) = 96.1 ✓  0.000074 × M <sub>r</sub> = 7.1(11) × 10 <sup>-3</sup> g dm <sup>-3</sup> ✓  7.1 × 10 <sup>-3</sup> for s.f. mark ✓	3	ALLOW M <sub>r</sub> = 96  Apply ecf for mass of sulfate from an incorrect M <sub>r</sub> value. DO NOT award second mark if another incorrect calculation follows 0.000074 × M <sub>r</sub>  Award sf mark for an answer that is the correct 2sf value of a shown calculation  The correct answer on its own scores all marks
Barium carbonate would precipitate out / solid barium carbonate forms / barium carbonate is insoluble ✓	1	

<table><tr><td>SO<sub>2</sub></td><td>+4</td><td>SO<sub>4</sub><sup>2-</sup></td><td>+6</td></tr><tr><td>I<sub>2</sub></td><td>0</td><td>I<sup>-</sup></td><td>-1</td></tr></table> <p>One mark for both I oxidation states ✓ One mark for each correct oxidation state for S ✓✓</p>	SO <sub>2</sub>	+4	SO <sub>4</sub> <sup>2-</sup>	+6	I <sub>2</sub>	0	I <sup>-</sup>	-1	3	ALLOW 2 marks if all number values are correct, but sign is to the right of the number (ie: 0, 1-, 4+, 6+)  ALLOW 1 mark for S if answer gives 4 <u>and</u> 6, but no +
SO <sub>2</sub>	+4	SO <sub>4</sub> <sup>2-</sup>	+6							
I <sub>2</sub>	0	I <sup>-</sup>	-1							
<p>Reducing agent: SO<sub>2</sub> ✓</p> <p>Explanation: The oxidation number of the S (in SO<sub>2</sub>) increases OR the SO<sub>2</sub> reduces the oxidation number of the I (in I<sub>2</sub>) OR (SO<sub>2</sub> is) oxidised to SO<sub>4</sub><sup>2-</sup> ✓</p>	2	ALLOW sulphur dioxide  ALLOW 'S / SO <sub>2</sub> is oxidised' OR 'SO <sub>2</sub> loses / donates electrons' IGNORE sulphur / S has lost electrons ALLOW 'I <sub>2</sub> is reduced' OR 'iodine gains electrons' ALLOW 'number' for 'state' 2 <sup>nd</sup> mark can be scored if S is incorrectly given as the reducing agent, otherwise 2 <sup>nd</sup> mark depends on first								
Grey / black solid ✓	1	Both colour and 'solid' needed for mark Any combination of these colours but no others IGNORE shades of colour, like dark or pale								
Burette ✓	1	ALLOW small spelling error (e.g.: 2 rs or one t) NOT biuret								

$15.8 \times 0.0100 / 1000 = 0.000158 / 1.58 \times 10^{-4} \checkmark$	1	
Answer to (ii) ( $=0.000158 / 1.58 \times 10^{-4}$ ) $\checkmark$	1	
Answer to (iii) / 50 $\times 1000 (= 0.00316 / 3.16 \times 10^{-3}) \checkmark$	1	ALLOW any number of sf
Any ONE from: If answer (c)(iv) below $1.56 \times 10^{-4} \text{ mol dm}^{-3}$ then wine not preserved $\checkmark$ If answer (c)(iv) between $1.56 \times 10^{-4}$ and $3.28 \times 10^{-3} \text{ mol dm}^{-3}$ then wine is preserved / below (legal) limit $\checkmark$ If answer (c)(iv) above $3.28 \times 10^{-3} \text{ mol dm}^{-3}$ then taste of wine is affected / above (legal) limit $\checkmark$	1	Comment will depend upon the answer from (c) (iv)
An (acid-base) indicator changes colour (at the end-point) $\checkmark$	1	DO NOT ALLOW just 'use an acid-base indicator' or named indicator or just 'there is a colour change' IGNORE a specific incorrect colour change for a named indicator

chlorine is volatile / a gas (1) ; toxic / poisonous / causes respiratory diseases / choking gas (1) ;	2	do not allow harmful / irritant / dangerous instead of toxic.
(i) (moles NaCl =) $100000 / 58.5 (= 1709)$ (1) ; moles $\text{Cl}_2 = \frac{1}{2}$ moles NaCl (1) ; volume $\text{Cl}_2 = \text{moles Cl}_2 \times 24 (= 20513 \text{ dm}^3)$ (1) ;	3	indication of halving mols of NaCl or doubling $58.5 = 117$ allow any number of significant figures including 1sf. allow a volume of $20508 \text{ dm}^3$ , which is obtained if the rounded up value for the moles of NaCl is used.

100% atom economy (1) ;	1	ignore high atom economy allow all products are useful allow no waste products ignore references to side reactions
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Diaphragm cell: advantage no environmental concerns / uses less electricity / uses less energy (1) ; disadvantage uses lots of steam / chlorine / $\text{Cl}_2$ / product must be purified (1) ;	2	
the required transportation links are already there / skilled workforce lives locally / near to necessary raw materials / links to electricity / shared facilities / shared resources / easier to obtain planning permission / existing infrastructure / risks concentrated in one area (1) ;	1	
$2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$ or balanced with $\frac{1}{2}$ (2) ;	2	$\text{Cl}^- \rightarrow \text{Cl}_2$ (1) ; adding electrons and balancing (1) ; ignore state symbols allow $2\text{Cl}^- - 2\text{e}^- \rightarrow \text{Cl}_2$ 2 <sup>nd</sup> mark depends on 1st
$1\text{s}^2 2\text{s}^2 2\text{p}^6 3\text{s}^2 3\text{p}^5$ (1) ;	1	allow upper or lower case letters but numbers must be superscripts allow [Ne] $3\text{s}^2 3\text{p}^5$
$\text{Cl}_2 = 0$ (1); $\text{Cl}^- = -1$ (1) ;	2	do not allow 1-

reduction (1) ; gain of electrons / oxidation state has decreased (1) ;	2	allow oxidation state becomes more negative ignore redox mark independently
chlorine is a more powerful / stronger / better oxidising agent / more oxidising (than bromine). ORA(1) ;	1	do not allow chlorine is more reactive than bromine. allow chlorine has a higher oxidising ability.
making medicines / making flame retardants (1) ;	1	allow water purification, making agricultural chemicals (like bromomethane), making dyes / photography / making solvents. allow testing for unsaturation or a stated laboratory use
white (1) ;	1	do not allow off white/cream/grey white ignore cloudy ignore changes of colour on standing
Ag <sup>+</sup> (aq) + Cl <sup>-</sup> (aq) → AgCl(s) equation (1) ; state symbols (1) ;	2	completely correct equation (i.e. without spectator ions) scores the first mark. allow answer with multiples mark state symbols separately – must have the idea of (aq) + (aq) → (s)
Ag <sub>2</sub> SO <sub>4</sub> (1) ;	1	ignore brackets around SO <sub>4</sub>
equilibrium (position) moves to left / towards reactants(1) ;	2	equilibrium moves to make more HCO <sub>3</sub> <sup>-</sup> gains both marks
HCO <sub>3</sub> <sup>-</sup> (concentration) increases(1) ;	2	
rate of forward reaction = rate of back reaction / reactants and products are formed at the same rate (1) ;	2	
concentrations of reactants and products remain constant / closed system (1) ;	2	do not allow concentrations of reactants and products are the same / equal
I in I <sup>-</sup> = -1 ✓	2	Must have a sign for mark to be awarded. ALLOW 1 mark for 1- AND 5+
I in IO <sub>3</sub> <sup>-</sup> = +5 ✓	2	
Sulfur ✓	1	ACCEPT S DO NOT ACCEPT sulfur dioxide / SO <sub>2</sub>
[IO <sub>3</sub> <sup>-</sup> ] = 174.9 × 0.15 & correct evaluation (= 26.235 g dm <sup>-3</sup> ) ✓ 26 g dm <sup>-3</sup> (2 significant figures) ✓	2	ALLOW first mark if candidate works out M <sub>r</sub> = 175, then calculates concentration as 26.25 g dm <sup>-3</sup> If they work out the M <sub>r</sub> incorrectly and use it, they do not get ECF  Award significant figure mark for an answer that is the correct 2 significant figures value of a shown calculation The correct answer on its own scores both marks
IO <sub>3</sub> <sup>-</sup> + 6H <sup>+</sup> + 6e <sup>-</sup> → I <sup>-</sup> + 3H <sub>2</sub> O ✓✓	2	Mark separately
6 in front of H <sup>+</sup> ✓ 6e <sup>-</sup> / 6e ✓ (Pale) yellow ✓	2	Mark separately DO NOT ALLOW off white / cream or combinations with yellow IGNORE cloudy IGNORE changes of colour on standing ALLOW ppt or minor spelling error
Precipitate / solid / suspension ✓	2	
Ag <sup>+</sup> (aq) + I <sup>-</sup> (aq) → AgI (s) ✓✓ Equation ✓ State symbols ✓	2	Completely correct equation (i.e. without spectator ions) scores the first mark ALLOW answer with multiples Mark state symbols separately – must have the idea of (aq) + (aq) → (s) [ignore (aq) with nitrate]
5p <sup>5</sup> ✓	1	ALLOW upper or lower case letters but numbers must be superscripts, except ALLOW ECF for subscript numbers if used in (e)(i) and (e)(ii)
Gain of electrons ✓	1	IGNORE references to oxidation state



Cl atom is smaller (than I atom) / has fewer (occupied) electron shells / outer (occupied) electron shell closer to nucleus / outer sub-shell for Cl is 3p but 5p for iodine ORA ✓  So extra electron added or gained (during reactions) is more strongly attracted by the nucleus / extra electron added or gained has less shielding from nuclear attraction ORA ✓	2	IGNORE references to electronegativity ALLOW energy levels for electron shells  The answer must have attraction by the nucleus for an added/gained electron
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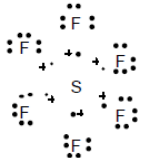
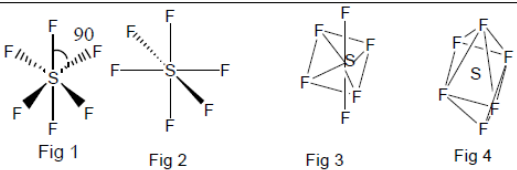
dinitrogen oxide / nitrogen(I) oxide / dinitrogen(I) oxide ✓	1	ALLOW dinitrogen monoxide IGNORE gaps
$\begin{array}{c} \cdot \ddot{\text{N}} : \text{N} : \ddot{\text{O}} : \\   \\ \cdot \end{array}$ dative bond ✓ completely correct ✓  shape – linear ✓ (depends on diagram – see advice)	3	To score first mark there must be (only) two electrons of the same symbol between the nitrogen and oxygen <b>ALLOW</b> (for this mark) if they are oxygen's electrons. To score the second mark there must be alternating dots and crosses for the elements' electrons as one moves from N to N to O <b>ALLOW</b> shared electron pairs horizontally (eg ••)  <b>ALLOW</b> alternatives to linear, eg "straight" or 180 <b>IGNORE</b> 'planar' <b>IF diagram is wrong, use it to determine shape mark:</b> <ul style="list-style-type: none"> <li>• No diagram no mark</li> <li>• No lone pairs on central N: linear, etc</li> <li>• One or two lone pairs/single electrons: bent (<b>NOT</b> triangular), allow 120±2 or 109±2 as appropriate</li> </ul>

+5 ✓ +1 ✓	2	5, 1 does not score. 5+, 1+ scores 1
10 H <sup>+</sup> + 2NO <sub>3</sub> <sup>-</sup> + 8 e <sup>-</sup> → N <sub>2</sub> O + 5 H <sub>2</sub> O  10 <b>AND</b> 5 ✓ 8 ✓  <i>Mark separately</i>	2	Each piece of additional material in the equation <b>CONS</b> a mark
(nitrogen / nitrate) gain of electrons ✓  oxidation number / state of nitrogen goes down / goes from (+)5 to (+)1 (or ecf from b(i), provided this is a fall) ✓	2	'gain of electrons' need not be qualified but any other reagents quoted apart from nitrogen/nitrate are <b>CON</b> <b>IGNORE</b> answers in terms of oxygen lost <b>IGNORE</b> what has gained electrons Answers can both be on same line <i>NB – 1(b)(i) answer line is shown on the screen to allow for ecf</i>
33% N <b>OR</b> 1:2 by moles (stated or implied) <b>OR</b> two-thirds oxygen ✓ NO <sub>2</sub> ✓ <i>no ecf from the wrong working</i>  <i>Mark separately</i>	2	Answer alone scores 1 ( <b>NOT</b> 2) if first marking point is not scored <b>IGNORE</b> Multiples of NO <sub>2</sub> (eg N <sub>2</sub> O <sub>4</sub> ) but working can score

Endothermic (forward reaction), (high / increasing temp moves) <u>equilibrium</u> (position) to right / towards products ✓  (high) pressure pushes <u>equilibrium</u> (position)* to the left ✓ more moles / molecules / particles on the right ORA ✓  one correct reference to yield related to equilibrium movement (ignore wrong references) ✓  *‘position’ must be mentioned <i>once</i> . Award one of these marks without ‘position’ but for both marks it must be mentioned <i>once</i> .	4	IGNORE references to rate ALLOW 'reverse reaction is exothermic' IGNORE 'moves in / favours endothermic direction'  NOT 'more atoms' or 'more products'  (can assume <i>high</i> pressure or temperature since given in the question)
K <sub>c</sub> = [CO] <sup>2</sup> [O <sub>2</sub> ] / [CO <sub>2</sub> ] <sup>2</sup> ✓	1	Must have square brackets; <b>NO</b> mark if p symbols. In top line: may have multiplication sign, <b>must not</b> have plus sign. <b>IGNORE</b> state symbols
4 x 10 <sup>-20</sup> ✓ 1sf ✓ mol dm <sup>-3</sup> ✓  <i>Mark separately</i>	3	<b>ALLOW</b> ecf for first and third marks from b(i) <b>UNLESS</b> plus sign used <i>The (b)(i) answer is shown on the screen to facilitate ecf</i> Award sf mark if the number is to 1 sf and is the correct or incorrect result of any calculation shown. units: <b>ALLOW</b> mol/dm <sup>3</sup> 4 x 10 <sup>-20</sup> on answer line scores 2

+3 ✓	1	ALLOW 3+
copper(II) arsenate(III) ✓	1	IGNORE gaps between words and numbers ALLOW ecf from a positive number in b(i)
1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>6</sup> 3s <sup>2</sup> 3p <sup>6</sup> 3d <sup>9</sup> ✓	1	ALLOW 4s <sup>0</sup> in addition

-3 ✓ +5 ✓	2	ALLOW one mark only for two correct numbers <i>followed</i> by correct signs
NH <sub>3</sub> + 3H <sub>2</sub> O → HNO <sub>3</sub> + 8e <sup>-</sup> + 8H <sup>+</sup> <b>OR</b> NH <sub>3</sub> + 3H <sub>2</sub> O → NO <sub>3</sub> <sup>-</sup> + 8e <sup>-</sup> + 9H <sup>+</sup> ✓✓	2	NH <sub>3</sub> → HNO <sub>3</sub> + 8e <sup>-</sup> scores one mark whatever else is there there are no other ways of scoring one mark

$\text{NH}_3 + \text{HNO}_3 \rightarrow \text{NH}_4\text{NO}_3$ ✓ 100% ✓	2	ALLOW $\text{NH}_4^+ \text{NO}_3^-$ no ecf second mark depends on first
hydrogencarbonate ✓	1	ALLOW hydrogencarbonate(IV) IGNORE gaps
none OR catalysts do not affect equilibrium positions ✓  catalysts / enzymes / carbonic anhydrase / it: speed up forward and backward / both reactions (equally) OR affect rate of reaction <u>only</u> / speed up reaction <u>only</u> OR speed up achievement of equilibrium AW ✓	2	Mark separately
titration with alkali / base / named strong alkali ✓ standard / known concentration ✓	2	IGNORE measuring out initial acid
0.70 ✓	1	ALLOW 0.7
Correct Kc expression, [RCOOR] x [H <sub>2</sub> O] / [ROH] x [RCOOH]  (answer from (f)(ii) squared) / 0.4(0) <sup>2</sup> (or correctly evaluated) ✓  Correct evaluation of a given expression with (answer from (f)(ii) squared) on top and any two numbers on the bottom ✓  (=3.1)	3	First mark can be awarded if second is correct  3.0625 (to one or more sf) scores 3 marks without reference to working Correct evaluation of mpt 2 scores 3 marks without reference to working  any units quoted <b>CON</b> third mark
S/sulfur ✓ from 0 to +4 ✓ S/sulfur ✓ from 0 to -2 ✓	4	second mark of each pair depends on first (i.e. 'S/sulfur' not present means <b>no</b> mark for that line) ALLOW 'sulphur' NOT signs after numbers, but use of 4+ and 2- scores <b>one</b> of the oxidation state marks
$3\text{SF}_4 + \text{O}_2 \rightarrow 2\text{SF}_6 + \text{SO}_2$ ✓	1	ALLOW multiples ALLOW one missing '+' ALLOW $2\text{SF}_4 + \text{O}_2 \rightarrow \text{SF}_6 + \text{F}_2 + \text{SO}_2$
$1s^2 2s^2 2p^6 3s^2 3p^4$ ✓	1	ALLOW [Ne] 3s <sup>2</sup> 3p <sup>4</sup> ALLOW capital letters but numbers <b>must</b> be superscripts
 6 shared pairs with F ✓ 3 lone pairs on F ✓	2	shape not important  ALLOW 'x' in a line between S and F ALLOW 'f' for fluorine  mark separately  ALLOW two fluorines with one lone pair missing but no single electrons on fluorine
 Fig 1      Fig 2      Fig 3      Fig 4  shapes as above ✓ bond angle clearly indicated ✓ bond angle labelled 90 ✓	3	Figs 1 and 2 - ALLOW dotted line for 'retreating wedge' Do NOT allow 2 wedges or 2 dashes at 180°  Fluorines and S must be shown for first mark, but not others ALLOW 'f' for fluorine  between any two adjacent bonds (even if bonds are 3-dimensionally incorrect)
Mr values Li = 6.9 (or 7) and SF <sub>6</sub> = 146.1 (or 146) ✓ stated or implied ALLOW 55.2 or 56 (8 moles) for Li 297/146.1 x 8 x 6.9 and evaluated (112.2) ✓ 2 or 3 sf for any calculated answer ✓	3	If full marks are not given please indicate with a tick where marks are awarded 110, 112 or 114 score all three marks with no reference to working ALLOW ecf for second and third mpts from wrong/rounded M <sub>r</sub> ALLOW working or answer for second mpt DO NOT AWARD sf mark if rounding is incorrect
lithium sulfide ✓	1	ALLOW 'lithium(I)' and 'sulphide' NOT 'dilithium sulfide' or 'sulfide(II)'
$\text{KClO}_4$ ✓	1	

<p>(rate) – molecules/particles in smaller volume OR increases concentration ✓</p> <p>greater frequency of collision ✓</p> <p>(yield) – fewer moles/molecules/particles on RHS(ora) ✓</p> <p>equilibrium (posn): moves to right / moves to products OR moves to oppose change ✓</p>	4	<p><b>Please use annotations</b>  <b>ALLOW</b> molecules/particles closer together            Use of other particles (eg atoms) CONs first mark (only)  <b>IGNORE</b> 'reactants' (for 'particles')  <b>ALLOW</b> less [or smaller] space [or area]</p> <p><b>NOT</b> just 'more collisions'; the answer must imply frequency  <b>IGNORE</b> 'chance/likelihood of collision'</p> <p><b>NOT</b> 'atoms' (CON first mark but not second)            'RHS' can be implied by equilibrium shift            (eg 'equilibrium shifts to right as there are fewer molecules' scores both marks) 'right' can be implied by 'greater yield'            Mark separately  <b>ALLOW</b> abbreviations of 'equilibrium' and 'equilibria'            'equilibrium moves to side with fewer molecules(etc)' scores 1</p>
<p>a lot of energy/electricity (needed for compressor) OR thick pipes/strong materials/materials to withstand high pressure needed ✓</p> <p>(forward) reaction exothermic (ora) ✓</p> <p>equilibrium position: moves to oppose (change) AW OR moves in endothermic direction/to endothermic side (ora) ✓</p> <p>yield decreases / less methanol formed ✓</p>	1  3	<p><b>ALLOW</b> 'specialised plant', 'specialist equipment' (but not just 'plant', 'equipment')  <b>IGNORE</b> 'safety precautions'</p> <p><b>IGNORE</b> references to rates</p> <p><b>ALLOW</b> 'left side is endothermic' (ora)</p> <p>this is the QWC link point (but mark separately with ecf from first marking point)            must say 'equilibrium position' [or abbreviations or 'equilibria']  <b>ALLOW</b> 'moves to left' / 'moves towards reactants' (ora) if first marking point scored            Mark separately</p> <p>no ecf</p>
<p><math>[\text{CH}_3\text{OH}]/[\text{CO}][\text{H}_2]^2</math> ✓</p>	1	<p>must have square brackets. <b>IGNORE</b> state symbols            terms in divisor may have dot or 'x' between them, <b>NOT</b> '+'</p>
<p>1000 ✓</p> <p><math>\text{dm}^6 \text{mol}^{-2}</math> ✓</p>	2	<p><b>ALLOW</b> 1030 or more sf <b>ALLOW</b> standard form  <b>ALLOW</b> ecf from (a)(iv) unless plus sign used  <b>ALLOW</b> <math>\text{mol}^{-2} \text{dm}^6</math> OR <math>(\text{mol dm}^{-3})^{-2}</math> OR <math>(\text{dm}^3 \text{mol}^{-1})^2</math> or ecf from (a)(iv)</p>
<p><math>(27.6 \times 100/279.6) = 9.87\%</math> ✓</p> <p>much waste OR uneconomical / inefficient / unprofitable OR little useful product ✓</p>	2	<p><b>ALLOW</b> 2 or more sf (9.8712446)</p> <p>must imply 'a lot of waste' not just 'waste'            no ecf from a medium or large miscalculated atom economy  <b>IGNORE</b> reference to the size of the number  <b>ALLOW</b> second mark only if atom economy is less than 40%</p>
<p>ionic ✓</p> <p><math>\left[ \text{Na} \right]^+ \left[ \text{H}^+ \right]^-</math></p> <p>two electrons (dot-cross) on hydrogen ✓ rest correct ✓</p>	3	<p>Mark separately  <b>ALLOW</b> eight electrons on sodium (all dot or all cross)  <b>ALLOW</b> without square brackets (signs must be there)</p> <p>shared electron diagram scores no diagram marks</p>
<p><math>\text{B}_2\text{H}_6 + 3\text{OF}_2 \rightarrow \text{B}_2\text{O}_3 + 6\text{HF}</math>  <math>\text{B}_2\text{O}_3</math> correct ✓            completely correct ✓</p> <p><math>\frac{25 \times 54}{27.6}</math> ✓  <math>\times 3 (= 146.7391\text{g})</math></p> <p>2 sf ✓ (150g)</p>	2  3	<p><b>IGNORE</b> state symbols</p> <p><b>ALLOW</b> ecf on the mole ratio from equation in e(i)</p> <p>correct answer (to any sf) scores two marks regardless of working  <b>ALLOW</b> different answers if intermediate rounding to 2 sf occurs            (eg 0.91 from 25/27.6)  <b>ALLOW</b> answers based on 2 sf <math>A_r</math> for B (11) [144.6 → 145]  <b>ALLOW</b> intermediate rounding (even to 1sf)            any number to 2 sf resulting from a shown correct evaluation scores this mark</p>
<p>3 ✓  <math>\text{Co}_3(\text{AsO}_4)_2</math> ✓</p>	2	<p><b>ALLOW</b> '3-' or '-3'  <b>ALLOW</b> with some/all correct charges shown (eg <math>\text{Co}^{2+}_3(\text{AsO}_4)^{3-}_2</math>)</p> <p>ecf from first to second mark</p>
<p>3d' ✓</p>	1	<p><b>ALLOW</b> capital letter and/or subscript or full size 7.</p>

<p>0.2/24 ✓ OR <math>8.3 \times 10^{-3} \times 24 = 0.2</math> AND comment that this is the fraction of oxygen in air</p> <p>0.033(2) or 0.033333 (to 2 or more sf) ✓ [or standard form]</p>	2	<p>Numbers 0.2 (or 1/5) and divided by 24 must be there OR 1/120 OR 2/240 <math>8.3 \times 10^{-3}</math> alone obviously does not score</p> <p>ie do not accept '0.03' Answer alone scores the mark. Working alone does not score ALLOW standard form eg <math>3.3 \times 10^{-2}</math> ACCEPT recurring decimal NOT rounding errors watch out for <math>3.3 \times 10^{-3}</math> (incorrect)</p>
<p><math>[\text{NO}_2]^2/[\text{N}_2][\text{O}_2]^2</math> ✓</p> <p><math>\sqrt{\{(\text{ans for } [\text{N}_2] \text{ from d(i)}) \times (8.3 \times 10^{-3})^2 \times 4 \times 10^{-13}\}}</math> ✓ OR <math>\sqrt{[\text{N}_2] \times [\text{O}_2]^2 \times K_c}</math> OR part numbers part symbols</p> <p>evaluation (eg <math>[\text{N}_2] = 0.033</math> gives <math>9.5(4) \times 10^{-13}</math>) ✓ (0.0332 gives <math>9.56/9.6 \times 10^{-13}</math>)</p> <p>one sig fig (eg <math>1 \times 10^{-12}</math>) ✓</p>	<p>1</p> <p>3</p>	<p><b>MUST</b> have square brackets. NOT 'p' (even if with square brackets) ALLOW <math>[\text{N}_2] \times [\text{O}_2]^2</math> or <math>[\text{N}_2].[O_2]^2</math> NOT <math>[\text{N}_2] + [\text{O}_2]^2</math> ALLOW '(g)' as state symbols. Others are CON</p> <p>correct evaluation of correct expression (even if expression is not written down) scores 2</p> <p>No ecf from d(ii); no ecf for evaluating an incorrect expression, except that omission of the square root and then correctly evaluated (eg <math>9(1) \times 10^{-25}</math>) or omission of square on <math>\text{O}_2</math> (eg <math>1(1) \times 10^{-11}</math>) score one mark. <i>A spreadsheet is available for other answers from (d)(i)</i> Mark sf separately, awarding the mark for any number to one sf. So proceed as follows: • check for the three possible answers (with ecf if necessary using spreadsheet) One is worth two, others are worth one • If no matching answer is present, look for square root expression and award 1 if it is correct • Award sf mark if relevant</p>
<p><math>K_c</math> larger ✓ (Forward) reaction endothermic OR right is endothermic direction OR ✓</p> <p><u>Equilibrium position</u> moves to right/towards products ✓</p>	3	<p>Mark separately No ecf from second marking point incorrect IGNORE references to rates</p> <p>must mention 'position' in connection with equilibrium</p>
<p>Equilibrium (position) moves to right/products ✓</p> <p>More <u>molecules/moles</u> on left-hand side/reactants OR ✓</p>	2	<p>Incorrect effects on <math>K_c</math> are CON of first mark (IGNORE 'no effect') ALLOW 'it' for 'equilibrium position' IGNORE 'favours the right-hand side' ALLOW 'particles' instead of 'molecules' IGNORE 'more reactants than products' (ie without mention of moles etc) Mark separately</p>