

- 1) B (1)
 2.a) A (1)
 2.b) D (1)
 3) B (1)
 4) A (1)
 5) D (1)
 6) C (1)
 7.a) B (1)
 7.b) C (1)
 7.c) D (1)
 8) A (1)
 9) D (1)
 10) B (1)
 11) C (1)
 12)

(a)	Pale/light and green/yellow Allow (virtually) colourless	clear yellow green any other colour	1
(b)(i)	Red/brown (solution) Allow yellow Ignore (From....) to....	Purple (or in combination with red or brown) Pale yellow Orange (or in combination with red or brown) Reject any other colours alone or in combination Grey/black (or any other colour alone or in combination) solid	1
(b)(ii)	$\text{Cl}_2(\text{aq}) + 2\text{I}^-(\text{aq}) \rightarrow 2\text{Cl}^-(\text{aq}) + \text{I}_2(\text{aq})/(\text{s})$ Entities (1) Balancing and all four state symbols Dependent on correct entities (1) $\text{Cl}_2(\text{aq}) + 2\text{KI}(\text{aq}) \rightarrow 2\text{KCl}(\text{aq}) + \text{I}_2(\text{aq})/(\text{s})$ 1 max $\text{K}^+(\text{aq})$ on both sides of otherwise correct equation 1 max		2
(c)(i)	Starch (1) Blue/black to colourless Dependent on starch indicator (1) Accept: no indicator needed (1) Yellow to colourless (1) Blank for indicator and yellow to colourless 1max	Any other indicator e.g. methyl orange/ phenolphthalein = 0/2 Colourless to blue/black Blue/black to clear Any mention of purple	2

(c)(ii)	<p>(ii) – (vi) General comments:</p> <p>Allow correct answers with no working in all parts</p> <p>N.B. Mark each part to mark scheme answer first then allow TE from earlier parts.</p> <p>Minimum correct to 2SF. Penalise SF for 1SF once only.</p> <p>But incorrect rounding e.g. 4.525 to 4.52 is penalised once separately as well.</p> <p>Penalise wrong units once only as well.</p> <p>(Mean titre = 9.05)</p> $\frac{9.05 \times 0.01}{1000} = 9.05 \times 10^{-5} / 0.0000905(\text{mol})$ <p>Allow $9.1 \times 10^{-5} / 0.000091(\text{mol})$</p>	$9.(0) \times 10^{-5} / 0.00009(0)$	1
(c)(iii)	<p>$(\text{I}_2(\text{aq}) + 2\text{S}_2\text{O}_3^{2-}(\text{aq}) \rightarrow 2\text{I}^{-}(\text{aq}) + \text{S}_4\text{O}_6^{2-}(\text{aq}))$</p> <p style="text-align: center;">(1) (1)</p> <p>Marks stand alone for entities with balancing</p> <p>Either of these on their own scores 1 mark regardless of anything else that is written</p> <p>Multiples/fractions of equation allowed</p> <p>Ignore state symbols even if incorrect</p>		2
(c)(iv)	$\frac{9.05 \times 10^{-5}}{2} = 4.525 \times 10^{-5} / 0.00004525(\text{mol})$ <p>Allow $4.53 \times 10^{-5} / 0.0000453$ etc</p> <p>Allow TE <u>ans (ii)</u></p> <p>Accept TE from (iii) if you see it</p>		1
(c)(v)	<p>$4.525 \times 10^{-5} / 0.00004525 (\text{mol})$</p> <p>Allow TE = ans (iv)</p> <p>[Allow 'ans (iv)' with no numbers for this part only]</p>		1
(c)(vi)	<p>$4.525 \times 10^{-5} \times \frac{1000}{10} = 4.525 / 4.53 \times 10^{-3} / 0.004525 / 0.00453 (\text{mol dm}^{-3})$</p> <p>Accept TE ans (v) x 100 [a calculated number must be given]</p>		1

(d)(i)	Lilac Allow (light) purple or mauve	Violet Reject any other colours alone or in combination	1
(d)(ii)	$2K + Cl_2 \rightarrow 2KCl$ Accept multiples/fractions Ignore state symbols even if incorrect Ignore correct charges on ions in KCl	K_2 and/or KCl_2 Charges on reactants K and/or Cl_2	1
(e)(i)	Hydrogen chloride This may be accompanied by HCl	Hydrochloric acid HCl /HCl(g)/HCl (gas) alone SO_2 H_2S Anything else	1
(e)(ii)	Dissolves in moisture/water/water vapour (in the air) Or reacts with moisture/water/water vapour (in the air)	HCl condenses	1
(e)(iii)	NH_4Cl / Ammonium chloride/ $ClNH_4$ $NH_4^+Cl^-$ / $H_4N^+Cl^-$ / $Cl^-NH_4^+$ Ignore any states even if incorrect	Ammonia chloride / NH_3Cl	1
(f)(i)	Any one of: Phosphorus(V) chloride/pentachloride Phosphorus(III) chloride/trichloride Allow (III/V) anywhere Concentrated hydrochloric acid Hydrogen chloride (gas) Sodium/potassium chloride and concentrated sulfuric acid Thionyl chloride Allow correct formula(e) for all above But note: conc HCl / conc H_2SO_4	Phosphorus chloride Hydrochloric acid/HCl/ HCl(aq) Chlorine	1

(f)(ii)	<p>Be generous here</p> <p>Horizontal test tube with ceramic fibre/ any sort of wool except iron (1)</p> <p>soaked in 2-chlorobutane and (alcoholic) potassium hydroxide/reactants/ reagents/ chemicals/reaction mixture...</p> <p>...with heat (or any diagram of a heat source or the word heat) (1)</p> <p>OR</p> <p>Round bottom/pear shaped flask/sloping test/boiling tube and heat (or any diagram of a heat source or the word heat) (1)</p> <p>containing 2-chlorobutane and (alcoholic) potassium hydroxide/reactants/ reagents/ chemicals/reaction mixture (1)</p> <p>Ignore:</p> <p>any use of aluminium oxide/pumice reflux/distillation set up</p> <p>Gas collection over water (1)</p> <p>Ignore Bunsen valves</p> <p>Allow:</p> <p>Collection in a gas syringe</p>	<p>Sealed apparatus but ignore inadvertent closures owing to poor cross-sectional drawings (-1)</p> <p>Poor diagram e.g. clear air gaps at intermediate joints in the apparatus(-1)</p> <p>Solution/substances alone</p> <p>An arrow on its own</p> <p>Conical/flat bottomed flask</p> <p>N.B. contradiction between drawing and any label</p> <p>Solution/substances alone</p> <p>A poor diagram mark (which can be the second) should be deducted for the delivery tube through the side of trough and/or the delivery tube missing the collection tube.</p>	3
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13)

(a)(i)	<p>H H</p> <p>.x .x xx</p> <p>H.xC.xC.xSx.H</p> <p>.x .x xx</p> <p>H H</p> <p>All Bonding electrons (1)</p> <p>Ignore any circles/bonds with electrons</p> <p>Two lone pairs on sulfur</p> <p>Dependent on eight electrons around sulfur (1)</p> <p>Accept all dots/crosses</p> <p>Fully correct methanethiol 1max</p>	<p>missing Hs/Cs (-1)</p>	2
(a)(ii)	<p>104.5 (°) (accept 91 to 105)(1)</p> <p>(Four pairs/two bonding pairs and two non-bonding pairs of electrons in) minimum repulsion/maximum separation/as far apart as possible (tetrahedral arrangement)</p> <p>Ignore the number of pairs of electrons (1)</p> <p>And lone/non bonding pair(s) of electrons repel more (than bond pairs/CH bonds) (1)</p> <p>Mark independently</p>	<p>atoms...</p> <p>Linear shape (-1)</p> <p>...repel any sort of atoms</p>	3

(b)(i)	<p>Two pairs of electrons/two bonds (around the H atom)</p> <p>OR</p> <p>Can be shown on a diagram either with electrons or bonds (in approximate straight line) around the hydrogen (1)</p> <p>(Repel to) maximum separation/minimum repulsion/as far apart as possible (1)</p> <p>Dependent on first mark except:</p> <p>Allow: It has a linear shape due to maximum separation/minimum repulsion 1 max</p>	Linear shape on its own	2
(b)(ii)	<p>Sulfur is less electronegative (than oxygen)/not electronegative enough</p> <p>OR oxygen is more electronegative (than sulfur) / electronegative enough</p> <p>OR Hydrogen bonds can only occur between H and either N, O, or F due to the large difference in electronegativity</p>	<p>Bigger/higher rmm/atom/molecule alone</p> <p>Hydrogen not bonded to N, O, or F alone</p>	1
(c)(i)	<p>Temporary asymmetrical distribution/random arrangement of electrons/ charge (density)</p> <p>Ignore references to atoms/molecules</p> <p>OR instantaneous/temporary dipole (1)</p> <p>(these produce) induced dipoles</p> <p>OR description of induction (1)</p> <p>Mark independently</p> <p>Ignore references to atoms/molecules</p>	<p>Any mention of permanent dipoles = 0/2</p> <p>d+ and d- /$\delta+$ and $\delta-$ unless clearly temporary</p>	2
(c)(ii)	<p>Ethanethiol/sulfur has more electrons (so forces are stronger)</p> <p>Allow sulfur has an extra shell of electrons</p> <p>OR ethanol/oxygen has fewer/less electrons (so forces are weaker)</p> <p>Allow oxygen has one fewer shell of electrons</p>	<p>Larger charge cloud/larger electron cloud/more outer electrons on their own</p> <p>Any reference to size/radius/rmm unless with correct answer</p>	1

(d)(i)	Any one from: Bubbles (of gas) /fizzing /effervescence Sodium disappears/dissolves/gets smaller White solid forms Multiple answers: number correct minus number wrong to give a maximum of 1 and a minimum of 0 Ignore: sodium floats or sinks and/or heat given out and/or hydrogen produced	Sodium rushes about (i.e. any confusion with reaction of sodium with water) Flames Steam	1
(d)(ii)	$\text{Na} + \text{CH}_3\text{CH}_2\text{SH} \rightarrow \text{CH}_3\text{CH}_2\text{SNa} + \frac{1}{2}\text{H}_2$ Accept multiples Ignore charges on sodium salt/state symbols even if incorrect	H for hydrogen $\text{CH}_3\text{CH}_2\text{NaS}$	1
(e)(i)	$\text{C}_2\text{H}_5\text{Br} + \text{KOH} \rightarrow \text{C}_2\text{H}_5\text{OH} + \text{KBr} / \text{K}^+ + \text{Br}^-$ Accept ionic equation $\text{C}_2\text{H}_5\text{Br} + \text{OH}^- \rightarrow \text{C}_2\text{H}_5\text{OH} + \text{Br}^-$ Allow molecular formula of alcohol, $\text{C}_2\text{H}_6\text{O}$		1
(e)(ii)	Type – substitution (1) Mechanism – Nucleophilic (1) Accept words in either order. Both words may be given on either line. N.B. This is the only way to score 2 marks!		2
(e)(iii)	KSH /NaSH Allow KHS/NaHS or H_2S Ignore state symbols		1
(f)	Sulfur dioxide/ SO_2 (1) Causes acid rain (1) Allow effects of acid rain e.g. acid lakes/lake pollution/ crop or forest damage/ limestone building damage/ named metal which corrodes. [It is quite possible candidates will give details of oxidation of sulfur dioxide to sulfur trioxide and formation of sulfuric acid. Ignore any of this additional information.] Allow triggers asthma Ignore any reference to greenhouse gas/ global warming/any reference to sea pollution or sea creatures Second mark dependent on first mark except allow: If SO_2 not mentioned then, $\text{SO}_3/\text{H}_2\text{SO}_4$ causes acid rain for 1 mark	SO_3 CO_2 Attacks ozone layer CO_2 causes acid rain	2

14)

(a)(i)	An atom/ molecule (or ion)/species/entity with an unpaired electron Ignore any references to homolytic bond fission but penalise a reference to heterolytic bond fission	Lone/single/free electron with unpaired electrons A free radical is an unpaired electron	1
(a)(ii)	$\begin{array}{c} \times \times \quad \cdot \cdot \\ \times \text{N} \times : \text{O} : \\ \times \end{array}$ Double bond (1) Other electrons correct Dependent on double bond (1) Allow: all dots or all crosses or any combination	N single bond O Reject unpaired electron on oxygen	2
(b)(i)	<u>Wherever</u> it appears in the answer: Ag/silver (oxidized) 0 to +1/1+ (1) <u>Wherever</u> it appears in the answer: N/Nitrogen = +5/5+ (1) (Element reduced) N/nitrogen ... to +2/2+ (1) N.B. Some candidates give ...+2/2+ and +5/5+ which is correct for both nitrogen products Only penalise no positive charges once		3
(b)(ii)	* $3\text{Ag(s)} + 4\text{HNO}_3\text{(aq)} \rightarrow \text{NO(g)} + 3\text{AgNO}_3\text{(aq)} + 2\text{H}_2\text{O(l)}$ 3Ag reacting to form NO and 3AgNO ₃ (1) 4HNO ₃ and 2H ₂ O (1) mark independently of (b)(i) No TE from (b)(i)		2
(c)(i)	The reaction is endothermic (so goes to remove heat/lower the temperature) Allow ΔH is positive (so goes to remove heat/lower the temperature)	Reaction/equilibrium moves to the right/to oppose change without any other statement	1
(c)(ii)	The yield is not changed OR No change OR no effect on the equilibrium (1) as there is no change in the number of (moles of) (gaseous) molecules OR as there is no change in the number of (gaseous) moles/particles (1) Allow: cylinder surface acts as catalyst (1) And all sites are filled so pressure has no affect (1) Second mark dependent on first in both cases Ignore any comment on rate whether correct or not	Reference to atoms or ions instead of molecules	2

(c)(iii)	<p>Rate increases because (increase in pressure) means more particles per unit volume/less space for molecules/molecules closer together/greater or increased concentration (1)</p> <p>Comment: A correct statement of why the rate increases is needed with rate increases (somewhere in the answer) for the first mark</p> <p>which increases the frequency / increases the number of collisions/more chance of (successful) collisions (between molecules) (1)</p> <p>Ignore any references to (activation/kinetic) energy</p> <p>Mark independently</p>	<p>more particles per unit area Reference to atoms or ions instead of molecules</p>	2
<p>* (d)(i)</p>	<p>Jet aeroplanes fly (much) close(r)/near(er) to the ozone (layer)/stratosphere (so more NO to deplete ozone layer) (1)</p> <p>ALLOW: Jet aeroplanes fly in the ozone (layer)/stratosphere</p> <p>Some NO from cars reacts (e.g. with O₂ to give NO₂)</p> <p>OR NO from planes does not react before it can react with the ozone (1)</p>	<p>Anything else e.g. aeroplanes fly in the ionosphere</p> <p>NO absorbed by plants NO from cars dissociates/decomposes/break down NO from planes does not dissociate/decompose/break down NO from cars takes a long time to reach the ozone layer NO dissolves</p>	2

(d)(ii)	<p>Please underline Key Points with highlighter, or annotate with tick at Key Point, or annotate with Key Point number from mark scheme wherever mark awarded.</p> <p>This ensures that it is easy to count up marks for this part.</p> <p>KP1 $\text{NO}(\bullet) + \text{O}_3 \rightarrow (\bullet)\text{NO}_2 + \text{O}_2$ (1)</p> <p>Comment: Dots are not required for KP1</p> <p>KP2 $\bullet\text{NO}_2 + \text{O}_3 \rightarrow \text{NO}\bullet + 2\text{O}_2$ (1)</p> <p>Comment: Dots can be on either side of both free radicals</p> <p>ALLOW for KP2: $\text{O}_3 \rightarrow \text{O}\bullet + \text{O}_2$ $\bullet\text{NO}_2 + \text{O}\bullet \rightarrow \text{NO}\bullet + \text{O}_2$</p> <p>N.B. Both equations required here</p> <p>The overall equation is:</p> <p>KP3 $2\text{O}_3 \rightarrow 3\text{O}_2$ (1)</p> <p>ALLOW: equilibrium arrow</p> <p>This mark is independent of KP1 and KP2</p> <p>KP4 NO/the free radical (Allow Cl•) is regenerated/a catalyst or wtte (1)</p> <p>KP5 and one molecule can break down large numbers of ozone molecules</p> <p>OR NO (Allow Cl•) continues to react (with ozone)/reaction is continuous</p> <p>OR Mention of chain reaction (1)</p> <p>Ignore any reference to global warming as an additional problem</p>	<p>Overall equation with nothing cancelled</p> <p>If Cl• is referred to as the radical then neither KP4 nor KP5 can be gained</p> <p>If the candidate makes clear that any of these processes lead to global warming loses KP4 or 5 but not both.</p>	
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