JABchem

Past Papers Higher Chemistry

2020

Marking Scheme

Grade Obtained	A	B	C	D	N/A
2020	40.7%	25.5%	22.1%	7.8%	3.9%
2021	43.4%	19.9%	18.2%	10.4%	8.1%

This marking scheme is for the intended Higher Chemistry Exam in 2020 which was cancelled due to the Covid-19 pandemic. This paper was widely used in schools in 2021 to predict grades for students when the 2021 exams were cancelled. Some refer to this paper as the 2021 paper for this reason.
Whether this paper would have been the exact same paper presented to students had the exams gone ahead in 2020 is unknown but it fair to conclude that it would have been very close if not the same.
The grades awarded in 2020 and 2021 are in the table above.

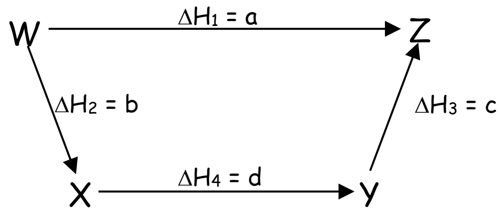
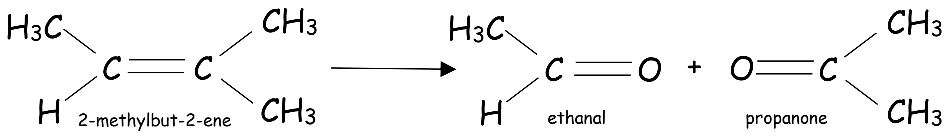
2020 Higher Chemistry Marking Scheme

<table>
<tr><th>MC Qu</th><th>Answer</th><th>Reasoning</th></tr>
<tr><td>1</td><td>A</td><td>☑A Filtration is the process to separate an insoluble substance from a liquid.
☒B Distillation is the process where chemicals are separated due to different boiling points
☒C Evaporation is the process to separate a substance from the solvent it is dissolved in
☒D Collection over water is the process to collect insoluble gases using a delivery tube</td></tr>
<tr><td>2</td><td>D</td><td>The size of atoms decreases across a period e.g. sodium to chlorine due to the increased number of protons/increased nuclear charge. The increased nuclear charge has a greater attraction for the outer shell of electrons and it moves closer to the nucleus.</td></tr>
<tr><td>3</td><td>B</td><td>☒A CO_2 is non-polar due to the spatial arrangement of the atoms within the molecule
☑B London dispersion forces are broken as solid CO_2 is changed into gaseous CO_2
☒C No covalent bonds are broken as it is still CO_2 at the end of the change of state
☒D CO_2 is non-polar due to the spatial arrangement of atoms and has no permanent dipoles</td></tr>
<tr><td>4</td><td>A</td><td>☑A Elements with high electronegativities tend to gain electrons and are reduced
☒B Elements with high electronegativities tend to reduce so are oxidising agents
☒C Elements with low electronegativities e.g. metals tend to lose electrons
☒D Elements with low electronegativities tend to oxidise themselves so are reducing agents</td></tr>
<tr><td>5</td><td>C</td><td>☒A X must be less viscous as the metal ball is falling through it faster
☒B Y must have the strongest van der Waals forces as the ball bearing is travelling slower
☑C X is less viscous and Y must have the stronger van der Waals forces
☒D X must be less viscous as the metal ball is falling through it faster</td></tr>
<tr><td>6</td><td>C</td><td>1st ionisation energy $Be(g) \longrightarrow Be^{+}(g) + e^{-}$ $\Delta H = 900kJ\ mol^{-1}$
2nd ionisation energy $Be^{+}(g) \longrightarrow Be^{2+}(g) + e^{-}$ $\Delta H = 1757kJ\ mol^{-1}$
total $Be(g) \longrightarrow Be^{2+}(g) + 2e^{-}$ $\Delta H = 2657kJ\ mol^{-1}$</td></tr>
<tr><td>7</td><td>D</td><td>☒A 2-methylpropanoic acid $C_4H_8O_2$ is not an isomer of pentanoic acid $C_5H_{10}O_2$
☒B propyl methanoate $C_4H_8O_2$ is not an isomer of pentanoic acid $C_5H_{10}O_2$
☒C 2-ethylbutanoic acid $C_6H_{12}O_2$ is not an isomer of pentanoic acid $C_5H_{10}O_2$
☑D ethyl propanoate $C_5H_{10}O_2$ is an isomer of pentanoic acid $C_5H_{10}O_2$</td></tr>
<tr><td>8</td><td>B</td><td><table>
<tr><td>— OH</td><td>—C(=O)— OH</td><td>—C(=O)—O—</td><td>—C(=O)—N(H)—</td></tr>
<tr><td>hydroxyl group</td><td>carboxyl group</td><td>ester link</td><td>amide link</td></tr>
</table></td></tr>
<tr><td>9</td><td>B</td><td><table>
<tr><td>Alcohol Number</td><td>❶</td><td>❷</td><td>❸</td><td>❹</td></tr>
<tr><td>Number of carbons attached to carbon with -OH group</td><td>1</td><td>2</td><td>1</td><td>1</td></tr>
<tr><td>Type of Alcohol</td><td>Primary</td><td>Secondary</td><td>Tertiary</td><td>Primary</td></tr>
<tr><td>Product of oxidation with acidified potassium dichromate</td><td>Carboxylic acid</td><td>Ketone</td><td>[No Oxidation]</td><td>Carboxylic Acid</td></tr>
</table></td></tr>
<tr><td>10</td><td>C</td><td>2-methylbutanal is an aldehyde which would reduce to the primary alcohol 2-methylbutan-1-ol.
2-methylbutanal ⟶ 2-methylbutan-1-ol
$C_5H_{10}O \longrightarrow C_5H_{11}OH$
gfm = (5x12)+(10x1)+(1x16) = 60+10+16 = 86g   gfm = (5x12)+(12x1)+(1x16) = 60+12+16 = 88g</td></tr>
<tr><td>11</td><td>C</td><td>☒A ethyl methanoate would hydrolyse and form the salt sodium methanoate (and ethanol)
☒B methyl ethanoate would hydrolyse and form the salt sodium ethanoate (and methanol)
☑C propanoic acid C_2H_5COOH would react to form the salt sodium propanoate
☒D butanoic acid C_3H_7COOH would react to form the salt sodium butanoate</td></tr>
</table>

12	B	☒A proteins are not hydrolysed into amino acids during denaturing ☑B hydrogen bonds are broken in the denaturing step as the protein changes shape ☒C proteins are not hydrolysed into amino acids during denaturing ☒D water is removed in the condensation reaction to turn amino acids into proteins
13	C	☒A fats are more saturated than oils as oils have more C=C double bonds than fats ☒B fats are more saturated than oils as oils have more C=C double bonds than fats ☑C fats are more saturated than oils and hsve higher melting points than oils ☒D fats have higher melting points than oil as fats are solid at room temperature
14	B	☒A antioxidants are easily oxidised themselves so act as electron donors ☑B antioxidants are easily oxidised to stop oxidation of food so do not act as oxidising agent ☒C antioxidants are easily oxidised themselves so act as reducing agents ☒D antioxidants act as free radical scavengers and react with free radicals
15	D	☒A Termination Step with free radicals before the arrow only ☒B Initiation Step with free radicals after the arrow only ☒C Termination Step with free radicals before the arrow only ☑D Propagation Step with free radicals on both sides of the arrow.
16	A	☑A small rise in temperature decreases the time and gives a large increase in reaction rate ☒B activation Energy does not change with a change in temperature ☒C Kelvin temperature scale must be used to investigate doubling the temperature ☒D Increase in temperature is decreasing the time for reaction ∴ increasing the rate
17	D	rate = $\frac{1}{\text{time}} = \frac{1}{5s} = 0.2\ s^{-1}$ relative rate $=0.20s^{-1}$ gives concentration = 0.96 mol l^{-1}
18	B	☒A high activation energy barrier too high for the reaction to take place at room temp ☑B low activation energy barrier and the reaction more likely to happen at room temp ☒C this enthalpy diagram is endothermic as the products are higher than the reactants ☒D this enthalpy diagram is endothermic as the products are higher than the reactants
19	C	☒A 3 volumes of gas reactants becomes 2 volumes of gas products ∴ not halving of reactants ☒B 1 volume of gas reactants becomes 1 volume of gas products ∴ not halving of reactants ☑C 4 volumes of gas reactants becomes 2 volumes of gas products ∴ halving of reactant vol ☒D 1 volume of gas reactants becomes 2 volumes of gas products ∴ not halving of reactants
20	D	If 80% Yield produces 0.8mol of ester product then 100% Yield would be 1.0mol of ester $CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$ 1.0mol 1.0mol 1.0mol 1.0mol
21	A	☑A decrease in temperature increases the yield by more forward reaction and decrease in temperature favours the exothermic reaction ∴ forward reaction is exothermic ☒B Equilibrium is achieved at 250°C and 300 atm but reverse reaction is still happening ☒C The 500°C line is always below the 250°C line so increasing temperature lowers yield ☒D There is increase in product yield when the pressure increased after 200 atmospheres
22	B	**n**o. of mol H_2SO_4 = **v**olume x **c**oncentration = 0.05litres x 0.2mol l^{-1} = 0.01mol $2KOH + H_2SO_4 \longrightarrow K_2SO_4 + 2H_2O$ 2mol 1mol 0.02mol 0.01mol
23	C	☒A P is closer to base line than S ∴ P must be more polar than S ☒B Q is further from the base line than P ∴ Q must be smaller than P ☑C R is closer to base line than P ∴ R must be more polar than P ☒D S is closer to base line than Q ∴ S must be larger than Q
24	A	Sample 1 is ignored as rough titre Sample 3 is ignored as beyond $0.2cm^3$ limit for concordance Average = $\frac{20.3 + 20.4}{2} = 20.35cm^3$
25	A	Increasing the pressure favours the forward pressure-reducing reaction. The mixture becomes paler as NO_2 turns into N_2O_4 ∴**NO_2 is brown**. Increasing the temperature makes mixture darker brown (i.e. more NO_2). The reverse reaction must be endothermic if it is favoured by an increase in temperature. ∴ **Forward reaction is exothermic**

	B		☒A CCl_4 is non-polar due to 3D arrangement of Cl atoms around central C atom ☑B $NH_3$is a polar molecule due to the electronegativity difference between atoms ☒C CO_2 is non-polar due to linear arrangement of O atoms around central C atom ☒D CH_4 is non-polar as it is a hydrocarbon. All hydrocarbons are non-polar.
	A		☑A CO reduces metal ores to metals. CO acting as Reducing Agent ☒B $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ is reduction ∴ MnO_4^- acting as oxidising agent ☒C $H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$ is reduction ∴ H_2O_2 acting as oxidising agent ☒D $Cr_2O_7^{2-}+14H^++5e^- \rightarrow 2Cr^{3+}+7H_2O$ is reduction ∴ $Cr_2O_7^{2-}$ acting as oxidising agent
	C		❶ $NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O$ ❷ $Zn \rightarrow Zn^{2+} + 2e^-$ ❶x2 $2NO_3^- + 8H^+ + \cancel{6e^-} \rightarrow 2NO + 4H_2O$ ❷x3 $3Zn \rightarrow 3Zn^{2+} + \cancel{6e^-}$ ❶'+❷' $2NO_3^- + 8H^+ + 3Zn \rightarrow 2NO + 3Zn^{2+}$ 2mol 3mol 1mol 1.5mol
	B		☒A Primary Alcohol: 1 carbon directly attached to carbon with the -OH group ☑B Tertiary Alcohol: 3 carbons directly attached to carbon with the -OH group ☒C Secondary Alcohol: 2 carbons directly attached to carbon with the -OH group ☒D Secondary Alcohol: 2 carbons directly attached to carbon with the -OH group
	A		☑A Amino acid with $-CH_3$ side group has been removed during partial hydrolysis ☒B $CH-CH_3$ group should be on left of $-CH_2-$ group in hydrolysis fragment ☒C $-CH_2-$ group has been removed but two groups are rejoined ☒D $CH-CH(CH_3)_2$ group should be on right of $-CH_2-$ group in hydrolysis fragment
	D		☒A pentyl ethanoate has a total of 7 carbons ∴ cannot have formula $C_6H_{12}O_2$ ☒B hexan-2-one has formula $C_6H_{12}O$ so only has 1 oxygen atom not 2 oxygen atoms. ☒C 3-methylpentan-2-ol has formula $C_6H_{13}OH$ so only has 1 oxygen atom not 2. ☑D hexanoic acid has formula $C_6H_{12}O_2$
	B		Primary Alcohols → Aldehydes → Carboxylic acids (Hot copper(II) oxide, Acidified dichromate solution; Hot copper(II) oxide, Acidified dichromate solution) Secondary Alcohol → Ketone (Hot copper(II) oxide, Acidified dichromate solution, Benedict's or Fehling's solution, Tollen's Reagent) ☒A pentan-1-ol is a primary alcohol would oxidise with hot copper(II) oxide to pentanal which would further oxidise with Fehling's solution to form pentanoic acid ☑B pentan-2-ol is a secondary alcohol would oxidise with hot copper(II) oxide to form pentan-2-one which does not react with Fehling's solution. ☒C pentan-3-one is a ketone and does not oxidise with hot copper(II) oxide. ☒D pentanoic acid is a carboxylic acid and does not oxidise with hot copper(II) oxide.
	D		☒A molecule has five carbons but not in one continuous chain of five carbons ☒B longest chain containing functional group has three carbons ∴ ends in propanoic acid ☒C two separate methyl $-CH_3$ groups attached to C_2 so is dimethyl not a ethyl $-C_2H_5$ group. ☑D 2x methyl $-CH_3$ groups attached to C_2 of three carbon main chain with -COOH group
	D		☒A Molecule A has 10 carbons and is derived from two C_5 isoprene units joining together ☒B Molecule B has 10 carbons and is derived from two C_5 isoprene units joining together ☒C Molecule C has 10 carbons and is derived from two C_5 isoprene units joining together ☑D Molecule D has 9 carbons so cannot be made by two C_5 isoprene units joining together.

	C		☒A methanol (primary alcohol) oxidises to methanoic acid (carboxylic acid) ☒B propanal (aldehyde) oxidises to propanoic acid (carboxylic acid) ☑C butan-2-one (ketone) reduces to become butan-2-ol (secondary alcohol) ☒D propan-2-ol (secondary alcohol) oxidises to propanone (ketone)
	B		☒A Primary Amine: 1 carbon directly bonded to nitrogen atom ☑B Secondary Amine: 2 carbons directly bonded to nitrogen atom ☒C Tertiary Amine: 3 carbons directly bonded to nitrogen atom ☒D Primary Amine: 1 carbon directly bonded to nitrogen atom
	D		Formula of Calcium Phosphate = $Ca_3(PO_4)_2$ 1mol of $Ca_3(PO_4)_2$ contains 3mol of Ca^{2+}ions and 2 mol of PO_4^{3-}ions.
	A		**gfm** CH_4 = 16g ∴ **no.** of mol = $^{mass}/_{gfm}$ = $^{4}/_{16}$ = 0.25mol ☑A **gfm** He = 4g ∴ **no.** of mol = $^{mass}/_{gfm}$ = $^{1}/_{4}$ = 0.25mol ☒B **gfm** H_2 = 2g ∴ **no.** of mol = $^{mass}/_{gfm}$ = $^{1}/_{2}$ = 0.5mol ☒C **gfm** N_2 = 28g ∴ **no.** of mol = $^{mass}/_{gfm}$ = $^{3.5}/_{28}$ = 0.125mol ☒D **gfm** Cl_2 = 71g ∴ **no.** of mol = $^{mass}/_{gfm}$ = $^{35.5}/_{71}$ = 0.5mol
	C		$MgCO_3 + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2O + CO_2$ 1mol 2mol 1mol 1mol 1mol 0.05mol 0.1mol 0.05mol 0.05mol 0.05mol Only 0.06mol of nitric acid available but 0.1mol nitric acid needed to react with all 0.05mol $MgCO_3$ ∴ Nitric acid HNO_3 is the limiting factor. 0.03mol 0.06mol 0.03mol 0.03mol 0.03mol ☒A 0.03mol of CO_2 gas produced ☒B 0.03mol of $MgCO_3$ produced ☑C 0.03mol of $MgCO_3$ reacted ∴ 0.02mol of $MgCO_3$ remaining ☒D nitric acid HNO_3 is the limiting factor so all 0.06mol are used up.
	D		☒A O atom in C=O bonds have δ– charges so will not be attracted to each other ☒B C-H bond is non-polar due to similar electronegativity so no dipole ☒C C-H bonds are non-polar due to similar electronegativity so no dipoles ☑D C in C=O bond has δ+ charge and is attracted to δ- charge on other C=O bond
	B		atom economy = $\frac{\text{mass of useful products}}{\text{total mass of reactants}} \times 100 = \frac{(4 \times 55.8)}{(2 \times 159.6)+(3 \times 12)} \times 100 = \frac{223.2}{319.2+36} \times 100 = 62.8\%$
	B		$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(l)}$ 1mol 5mol 3mol 4mol 1vol 5vol 3vol negligible volume $100cm^3$ $500cm^3$ $300cm^3$ - (+$100cm^3$ O_2 leftover) Total Volume at end of reaction = $300cm^3$ CO_2 + $100cm^3$ leftover O_2 = $400cm^3$
	B		Step 1: 60% of 100% = $\frac{60}{100}$ x 100% = 60% Step 2: 90% of 60% = $\frac{90}{100}$ x 60% = 54%
20	C		☒A Volume of gas must be reduced as volume of acid is reduced (zinc in excess) ☒B Initial Rate of reaction must be increased as lumps replaced by powder ☑C Initial rate must be greater and final volume of gas must be reduced ☒D Initial Rate of reaction must be increased as lumps replaced by powder
21	A		

			$\Delta H_1 = \Delta H_2 + \Delta H_3 + \Delta H_4$ $\Delta H_2 = \Delta H_1 - \Delta H_3 - \Delta H_4$ $b = a - c - d$ 
22	D		☒A Higher Activation Energy will make a successful collision less likely to happen. ☒B The higher the kinetic energy of reactants the more like the collision will have sufficient energy to react. ☒C Higher the concentration the higher the likelihood of a successful collision ☑D Whether a reaction is exothermic or endothermic has no bearing on the reaction rate.
23	C		☒A no change in pressure from reactants to products ∴ lowering pressure has no effect ☒B lowering pressure favours pressure increasing reaction (reverse reaction) ☑C lowering pressure favours pressure increasing reaction (forward reaction) ☒D lowering pressure favours pressure increasing reaction (reverse reaction)
24	A		☑A Increasing the temperature moves the curve to the right. ☒B Increasing the temperature moves the curve to the right not the left. ☒C E_a does not change when temperature is changed ☒D Area under curve should be same as same number of particles.
25	D		

2020 Higher Chemistry Marking Scheme

<table>
<tr><th>Long Qu</th><th>Answer</th><th>Reasoning</th></tr>
<tr><td>1a(i)</td><td>Increase in atomic number gives increase in electronegativity</td><td>As you go across a period, the electronegativity increases as the electrons within a bond are more attracted to the nuclei at either end of the bond. The bonded electrons are closer to each nucleus as size of atoms decrease as you cross a period.</td></tr>
<tr><td>1a(ii)</td><td>They don't form covalent bonds</td><td>The noble gases in group 0 are unreactive as they already have a full outer shell. This means noble gases don't need to form bonds to achieve a full outer shell.</td></tr>
<tr><td>1a(iii)</td><td>One answer from:</td><td><table><tr><td>Screening effect increases so less attraction for shared electrons</td><td>Covalent radius increases so less attraction of nucleus for shared electrons</td></tr></table></td></tr>
<tr><td>1b(i)</td><td>2.8 ±0.05</td><td>Problem Solving: Selecting information</td></tr>
<tr><td>1b(ii)</td><td>Cross at (2.1,1.8)</td><td>Problem Solving: Selecting information</td></tr>
<tr><td>1b(iii)A</td><td>$(Li^+)_2S^{2-}$</td><td><table><tr><td>Write down Symbols and valency below</td><td>Cross-Over arrows to work out formula</td><td>Work out chemical formula (Cancel down if necessary)</td><td>Insert charges to each ion and multiple ions required brackets</td></tr><tr><td>Li S
1 2</td><td>Li S
1 2</td><td>Li_2S</td><td>$(Li^+)_2S^{2-}$</td></tr></table></td></tr>
<tr><td>1b(iii)B</td><td>Due to changes to the data booklet in 2021, the answers to this question no longer come to 1.5</td><td><table><tr><td>Answer</td><td colspan="2">1</td><td colspan="2">2</td><td colspan="2">3</td></tr><tr><td>Elements</td><td>Carbon</td><td>Fluorine</td><td>Sulfur</td><td>Fluorine</td><td>Boron</td><td>Oxygen</td></tr><tr><td>Electronegativity</td><td>Electronegativity = 2.6</td><td>Electronegativity = 4.0</td><td>Electronegativity = 2.6</td><td>Electronegativity = 4.0</td><td>Electronegativity = 2.0</td><td>Electronegativity = 3.4</td></tr><tr><td>Difference</td><td colspan="2">1.4</td><td colspan="2">1.4</td><td colspan="2">1.4</td></tr></table></td></tr>
<tr><td>1c</td><td>Polar (covalent)</td><td>The covalent bond in hydrogen fluoride is a polar bond due to the electronegativity difference within the bond is 1.8. The polar bond is a permanent dipole and is so polar it takes part in hydrogen bonding between molecules.</td></tr>
<tr><td>2a(i)</td><td>graphite</td><td>There are three forms of the element carbon.
• Carbon in the form of fullerene is a molecular form with formula C_{60}.
• There are two forms of carbon which are covalent network; diamond and graphite.</td></tr>
<tr><td>2a(ii)</td><td><table><tr><td>Covalent bond</td></tr><tr><td>London dispersion forces</td></tr></table></td><td>Diamond is a covalent network so covalent bonds are broken when diamond undergoes sublimation into a gas.
Fullerene is a non-polar molecule and London dispersion forces are broken when fullerene undergoes sublimation into a gas.</td></tr>
<tr><td>2a(iii)</td><td>12</td><td>$C_{60} + 12Br_2 \longrightarrow C_{60}Br_{24}$
1mol 12mol 1mol
1 Br_2 molecule will add across each C=C double bond.</td></tr>
<tr><td>2b</td><td>45.8</td><td>$\text{atom economy} = \frac{\text{mass of useful products}}{\text{total mass of reactants}} \times 100 = \frac{(2\times55.8)}{(1\times159.6)+(3\times28.0)} \times 100 = 45.8\%$</td></tr>
<tr><td>2c</td><td>+250 kJ mol^{-1}</td><td>❶ $CO + \frac{1}{2}O_2 \rightarrow CO_2$ $\Delta H = -283$ kJ mol^{-1}
❷ $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$ $\Delta H = -286$ kJ mol^{-1}
❸ $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ $\Delta H = -891$ kJ mol^{-1}

❶x-1 $CO_2 \rightarrow CO + \frac{1}{2}O_2$ $\Delta H = +283$ kJ mol^{-1}
❷X-3 $3H_2O \rightarrow 3H_2 + 1\frac{1}{2}O_2$ $\Delta H = +858$ kJ mol^{-1}
❸ $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ $\Delta H = -891$ kJ mol^{-1}

Add ❶'+❷+❸ $CH_4 + H_2O \rightarrow CO + 3H_2$ $\Delta H = +250$ kJ mol^{-1}</td></tr>
</table>

3	Open Question Answer to Include:	**3 mark answer** Demonstrates a **<u>good</u> understanding** of the chemistry involved. A good comprehension of the chemistry has provided in a logically correct, including a statement of the principles involved and the application of these to respond to the problem.	**2 mark answer** Demonstrates a **<u>reasonable</u> understanding** of the chemistry involved, making some statement(s) which are relevant to the situation, showing that the problem is understood.	**1 mark answer** Demonstrates a **<u>limited</u> understanding** of the chemistry involved. The candidate has made some statement(s) which are relevant to the situation, showing that at least a little of the chemistry within the problem is understood.
4a				
4b				
4c(i)				
4c(ii)				
4c(iii)				
4d(i)				
4d(ii)				
4d(iii)A				
4d(iii)B				
4e(i)				
4e(ii)A				
4e(ii)B				
5a				
5b(i)				
5b(ii)				
5c(i)				
5c(ii)				
6a				
6b(i)				
6b(ii)				
6b(iii)				
6b(iv)A				
6b(iv)B				
6c(i)				
6c(ii)				
7a				
7b				
7c(i)				
7c(ii)				
7d				
7e(i)				
7e(ii)				
8a(i)				
8a(ii)				
8b(i)				
8b(ii)				
8c(i)A				
8c(i)B				

<table>
<tr><td>8c(ii)</td><td></td><td></td></tr>
<tr><td>8c(iii)</td><td></td><td></td></tr>
<tr><td>9a(i)</td><td></td><td></td></tr>
<tr><td>9a(ii)</td><td></td><td></td></tr>
<tr><td>9a(iii)</td><td></td><td></td></tr>
<tr><td>9b</td><td></td><td></td></tr>
<tr><td>9c(i)</td><td></td><td></td></tr>
<tr><td>9c(ii)</td><td></td><td></td></tr>
<tr><td>9d(i)</td><td></td><td></td></tr>
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<tr><td>9d(iii)</td><td></td><td></td></tr>
<tr><td>10</td><td>Open Question Answer to Include:</td><td><table>
<tr><th>3 mark answer</th><th>2 mark answer</th><th>1 mark answer</th></tr>
<tr><td>Demonstrates a <u>good</u> understanding of the chemistry involved. A good comprehension of the chemistry has provided in a logically correct, including a statement of the principles involved and the application of these to respond to the problem.</td><td>Demonstrates a <u>reasonable</u> understanding of the chemistry involved, making some statement(s) which are relevant to the situation, showing that the problem is understood.</td><td>Demonstrates a <u>limited</u> understanding of the chemistry involved. The candidate has made some statement(s) which are relevant to the situation, showing that at least a little of the chemistry within the problem is understood.</td></tr>
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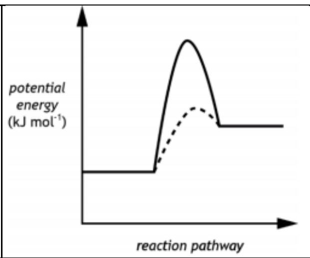
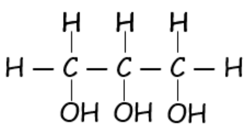
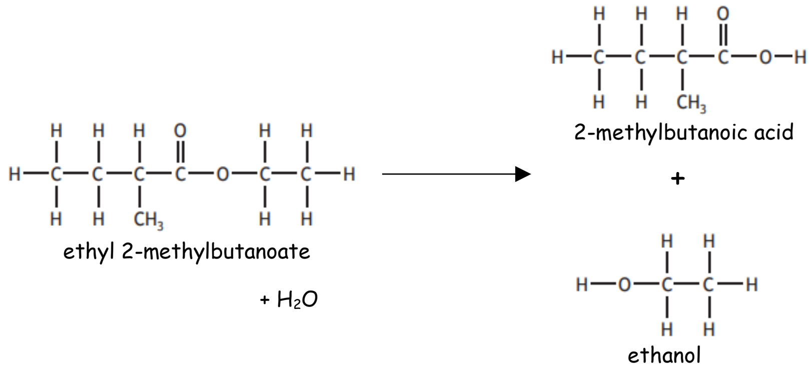
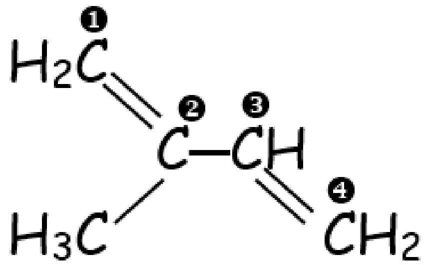
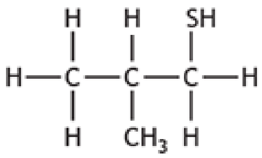
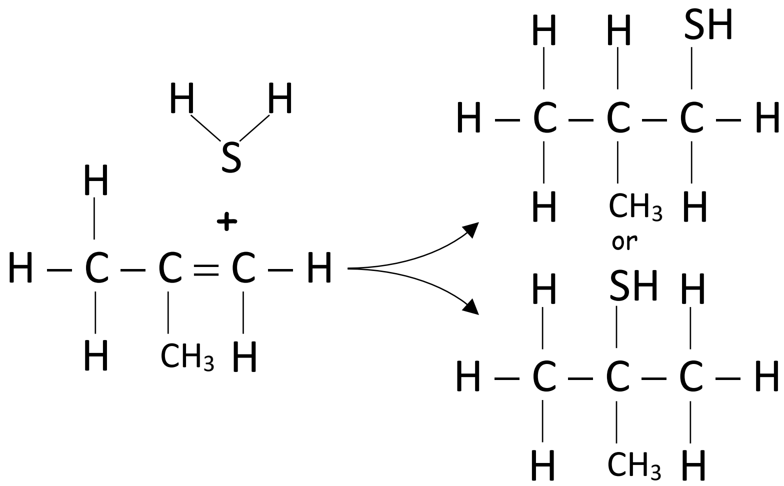
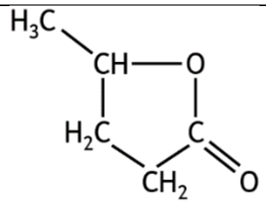
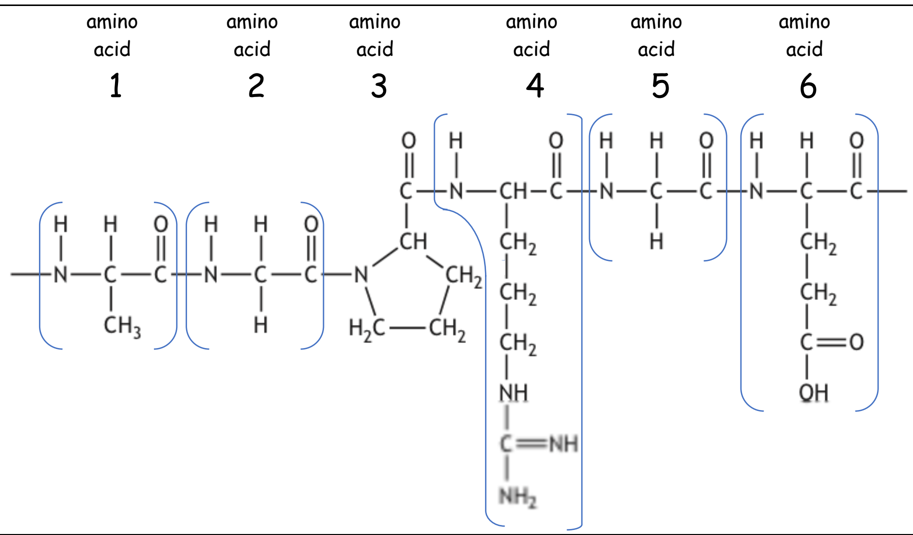
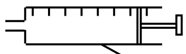
<tr><td>11a(i)</td><td></td><td></td></tr>
<tr><td>11a(ii)</td><td></td><td></td></tr>
<tr><td>11b(i)</td><td></td><td></td></tr>
<tr><td>11b(ii)</td><td></td><td></td></tr>
<tr><td>11b(iii)</td><td></td><td></td></tr>
<tr><td>12a</td><td></td><td></td></tr>
<tr><td>12b</td><td></td><td></td></tr>
<tr><td>12c</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>1a(ii) Part A</td><td><table>
<tr><td>A</td><td>0</td></tr>
<tr><td>B</td><td>10</td></tr>
<tr><td>C</td><td>20</td></tr>
<tr><td>D</td><td>30</td></tr>
<tr><td>E</td><td>40</td></tr>
</table></td><td>For the concentration of thiosulphate to be varied, the total volume of the solution must be kept constant. The total volume of sodium thiosulphate solution and water is 50 cm^3 in each experiment.</td></tr>
<tr><td>1a(ii) Part B</td><td>35.1</td><td>$\text{Rate} = \frac{1}{\text{Time}} \quad \therefore \text{time} = \frac{1}{\text{Rate}} = \frac{1}{0.0285} = 35.1\text{s}$</td></tr>
<tr><td>1a(iii)</td><td>12±1</td><td>For doubling of rate from $0.02s^{-1}$ to $0.04s^{-1}$
Temperature at $0.02s^{-1}$ = 44°C
Temperature at $0.04s^{-1}$ = 56°C
Change in temperature = 12°C</td></tr>
<tr><td>1b</td><td>Sufficient Energy to React
And
Correct Geometry</td><td><table>
<tr><td>1st Mark:</td><td>sufficient or enough energy</td><td>energy equal to or greater than the activation energy</td><td>minimum/ enough energy to form an activated complex</td></tr>
<tr><td>2nd Mark:</td><td colspan="3">(Collision must occur with) suitable/correct/geometry/orientation</td></tr>
</table></td></tr>
<tr><td>1c(i)</td><td>X at peak on curve</td><td>The top of the hill (peak on the curve) is the activated complex where the bonds of the reactants are half broken and the bonds of the products are half formed.</td></tr>
</table>

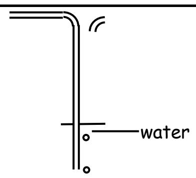
1c(ii)		A catalyst lowers the activation energy without changing the position of the reactants or products. This means that the top of the hill is lowered. The enthalpy change is the same as the positions of the reactants and products are unchanged.
2a(i)	Increasing number of protons or increasing nuclear charge	Going across a period does not increase the size of an atom as it is the same outer shell which is being filled up. The increased positive charge in the nucleus attracts the outer shell into more as you go across a period.
2a(ii)	One answer from:	Increased screening/shielding | Covalent radius increases | Atom size increases | More shells so less attraction of nucleus for outer electron decreases
2b(i)	$N^{+}(g) \rightarrow N^{2+}(g) + e^{-}$	1st Ionisation Energy: The removal of one mole of electrons from one mole of atoms in the gaseous state. 2nd Ionisation Energy: The removal of one mole of electrons from one mole of 1+ ions in the gaseous state.
2b(ii)	Answer to Include:	1st Mark: The 6th ionisation energy involves removing an electron from the shell which is full/stable/closer to the nucleus **or** the 6th electron is removed from the electron shell which is inner/full/stable/closer to the nucleus 2nd Mark: The 6th electron is less shielded **or** the 6th electron is more strongly attracted to/pulled towards the nucleus.
2c	<u>1st Mark</u>: Al forms Al^{3+} ion P forms P^{3-} ion <u>2nd Mark</u>: P^{3-} ion has one more electron shell than Al^{3+} ion	Phosphorus atoms have electron arrangement of 2,8,5 and form P^{3-} ions which have electron arrangement of 2,8,8 Aluminium atoms have electron arrangement of 2,8,3 and form Al^{3+} ions which have electron arrangement of 2,8 Phosphide P^{3-} ion has one more electron shell than aluminium Al^{3+} ion.
2d	Radius Ratio = 0.96 Caesium Chloride Structure	$\text{Radius ratio} = \frac{\text{Radius of positive ion}}{\text{Radius of negative ion}} = \frac{135}{140} = 0.96$
3	Open Question Answer to Include:	**3 mark answer**: Demonstrates a **<u>good</u> understanding** of the chemistry involved. A good comprehension of the chemistry has provided in a logically correct, including a statement of the principles involved and the application of these to respond to the problem. **2 mark answer**: Demonstrates a **<u>reasonable</u> understanding** of the chemistry involved, making some statement(s) which are relevant to the situation, showing that the problem is understood. **1 mark answer**: Demonstrates a **<u>limited</u> understanding** of the chemistry involved. The candidate has made some statement(s) which are relevant to the situation, showing that at least a little of the chemistry within the problem is understood.
4a(i)	Biological catalyst	An enzyme is a protein which acts as a catalyst for the chemical reactions inside living things.
4a(ii)	4.5	Mass of cider = $1.36 g/cm^3 \times 50 cm^3 = 68 g$ $\%\text{mass of alcohol} = \frac{\text{Mass of alcohol}}{\text{Mass of cider}} \times 100 = \frac{3.05}{68} \times 100 = 4.48\%$
4b(i)	Carbon dioxide	Malic acid → Lactic Acid + X $C_4H_6O_5 \rightarrow C_3H_6O_3 + CO_2$
4b(ii) Part A	0.25	$R_f = \frac{\text{Distance moved by substance}}{\text{Distance moved by solvent}} = \frac{4.1}{16.4} = 0.25$
4b(ii) Part B	Sample 4 or Cider B	Problem Solving: Cider B/Sample 4 is the only cider that has no malic acid spot at 4.1 indicating all the malic acid has turned into lactic acid
4c	Propane-1,2,3-triol	 glycerol **Propane-1,2,3-triol** Prop: 3 carbons; ane: Single bonds between carbons; 1,2,3: Functional groups on Carbons 1,2,3; triol: 3 hydroxyl –OH groups

4d(i)	Answer to include:	1st Mark: Molecule is polar due to hydroxyl groups **or** Can form hydrogen bonds due to hydroxyl groups 2nd Mark: Solubility increases as more polar hydroxyl groups are added (and increases hydrogen bonding)
4d(ii)	2-methylbutanoic acid	
4d(iii)	2-methylbuta-1,3-diene or isoprene	 2-methylbuta-1,3-diene
4e(i)	Carbonyl	
4e(ii)	Ethanoic acid	**Primary Alcohol** → **Aldehyde** → **Carboxylic acid** Ethanol → Ethanal → Ethanoic acid
5a(i)	-694	Bond Breaking Steps: 4xC-H bonds 4x 412kJ = 1648kJ; 2xO=O bond 2x 498kJ = 996kJ; Total bond breaking = 2644kJ Bond Forming Steps: 2xC=O bonds 2x 743kJ = 1486kJ; 4xO-H bonds 4x 463kJ = 1852kJ; Total bond Forming = 3338kJ Enthalpy change = +2644 - 3338 = $-694kJ\ mol^{-1}$ ΔH = ΣBond enthalpies for bonds broken - ΣBond enthalpies for bonds formed ΔH = 2644 - 3338 ΔH = $-694\ kJ\ mol^{-1}$
5a(ii)	Answer to include:	Mean bond enthalpy is an average energy from a number of compounds. Bond enthalpy relates to only one particular compound or molecule.
5a(iii)	0.367	no. of moles = $\frac{\text{Volume}}{\text{Molar Volume}} = \frac{0.200\text{litres}}{24\text{ litres mol}^{-1}}$ = 0.00833mol $CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(l)}$ 1mol 2mol 1mol 2mol 0.00833mol 0.00833mol **mass** = **no.** of mol x **gfm** = 0.00833 x 44 = 0.367g
5b(i)	Record the mass of burner before and after heating	The before and after masses of the spirit burner (including lid) are needed to calculate the change in mass of the spirit burner and this change in mass is the mass of heptane burned.
5b(ii)	-3496	Heat Energy = Specific Heat Capacity x Mass x Change In Temperature $E_h = c \times m \times \Delta T$ $E_h = 4.18\ kJ\ kg^{-1}\ °C^{-1} \times 0.4kg \times 23°C$ E_h = 38.456 kJ gfm Heptane C_7H_{16} = (7x12) + (16x1) = 84 + 16 = 100g

<table>
<tr><td></td><td></td><td>1.1g heptane ⟷ 38.456kJ
1mol heptane = 100g heptane ⟷ 38.456kJ x $^{100}/_{1.1}$
= -3496kJ mol^{-1}</td></tr>
<tr><td>5b(iii)</td><td>One answer from:</td><td><table><tr><td>Loss of heat to surroundings</td><td>Incomplete combustion</td><td>Loss by evaporation</td></tr><tr><td>Absorption of heat by glass/beaker/can</td><td>No stirring</td><td>No lid on container</td></tr></table></td></tr>
<tr><td>6a(i)
Part A</td><td>Same number of electrons or Same strength of LDF</td><td>Both molecules have identical number of electrons (34) so have the same ability to form London Dispersion Forces between molecules (due to formation of temporary dipoles in their electron clouds). The difference between the molecules mist be caused by other intermolecular forces.</td></tr>
<tr><td>6a(i)
Part B</td><td>Answer to include:</td><td><table><tr><td>1st mark:</td><td>Propan-1-ol has stronger intermolecular forces than ethanethiol</td><td>Intermolecular forces in propan-1-ol take more energy to break than those in ethanethiol</td></tr><tr><td>2nd mark:</td><td colspan="2">Intermolecular bonds in propan-1-ol are hydrogen bonds and intermolecular bonds in ethanethiol are permanent dipole to permanent dipole attractions</td></tr></table></td></tr>
<tr><td>6a(ii)</td><td>methanethiol</td><td><table><tr><td>Alkane:</td><td>Methane CH_4</td><td>Ethane C_2H_6</td><td>Propane C_3H_8</td></tr><tr><td>Thiol:</td><td>Mathanethiol CH_3SH</td><td>Ethanethiol C_2H_5SH</td><td>Propanethiol C_3H_7SH</td></tr></table></td></tr>
<tr><td>6a(iii)</td><td>11.853mg</td><td>1cm^3 air ⟷ 2.7x10^{-7}mg
1 litre air ⟷ 2.7x10^{-4}mg
43900 litres air ⟷ 2.7x10^{-4}mg x $^{43900}/_1$ = 11.853mg or 0.0118g</td></tr>
<tr><td>6b(i)</td><td>-SH group is attached to carbon which is attached to 3 other carbons</td><td><table><tr><td>Primary Thiol</td><td>Secondary Thiol</td><td>Tertiary Thiol</td></tr><tr><td>-SH group attached to carbon which is attached to 0 or 1 other carbons atoms</td><td>-SH group attached to carbon which is attached to 2 other carbon atoms.</td><td>-SH group attached to carbon which is attached to 3 other carbon atoms.</td></tr><tr><td>-SH group attached to carbon which is attached to 2 hydrogen atoms.</td><td>-SH group attached to carbon which is attached to 1 hydrogen atom.</td><td>-SH group attached to carbon which is attached to no hydrogen atoms.</td></tr></table></td></tr>
<tr><td>6b(ii)
Part A</td><td></td><td></td></tr>
<tr><td>6b(ii)
Part B</td><td>41.2</td><td>2-methylpropene + hydrogen sulphide ⟶ 2-methyl-2-propanethiol
1mol ... 1mol
56.0g ... 90.1g
30.5g ... 90.1g x $^{30.5}/_{56.0}$
= 49.07g
$\%Yield = \frac{Actual}{Theoretical} \times 100 \quad \therefore Actual = \frac{\%\ Yield \times Theoretical}{100} = \frac{84 \times 49.07}{100} = 41.2g$</td></tr>
<tr><td>7a(i)</td><td>Propagation</td><td><table><tr><td>Step</td><td>Reactants
(before Arrow)</td><td>⟶</td><td>Products
(after Arrow)</td></tr><tr><td>Initiation</td><td>No free radicals on Reactant Side</td><td>⟶</td><td>Free radicals on Product Side</td></tr><tr><td>Propagation</td><td colspan="3">Free Radicals found on both sides of arrow</td></tr><tr><td>Termination</td><td>Free radicals on Reactant Side</td><td>⟶</td><td>No free radicals on Product Side</td></tr></table></td></tr>
<tr><td>7a(ii)</td><td>uv/ultraviolet</td><td>Ultraviolet light can cause the formation of free radicals as energy in the uv light can cause bonds to split and the two electrons in the bond separate one to each</td></tr>
</table>

<table>
<tr><td></td><td></td><td>side. This means there are unpaired electrons which are called free radical. This breaks the plastic down in to smaller chunks that can be digested by bacteria.</td></tr>
<tr><td>7a(iii)</td><td>Anti-oxidant or
Free Radical Scavenger</td><td>Free Radical Scavengers and anti-oxidants quickly react with any free radical particles going and prevent future propagation steps which would prolong the breakdown of the plastics.</td></tr>
<tr><td>7b(i)</td><td>Water/H_2O</td><td>5-hydroxypentanoic acid = $C_5H_{10}O_3$
lactone = $C_5H_8O_2$ Difference = H_2O</td></tr>
<tr><td>7b(ii)</td><td>
</td><td>One less carbon between Carboxyl -COOH group and Hydroxyl group
∴One less carbon in lactone ring i.e. ring has 4 carbons plus 1 oxygen in ring
Carbon with hydroxyl -OH group has methyl $-CH_3$ group sticking off it
∴Methyl $-CH_3$ group sticking off C on other side of -O-C=O ester group</td></tr>
<tr><td>7b(iii)</td><td>3-hydroxybutanoic acid</td><td>3-hydroxybutanoic acid
-OH on C_3 | -OH side group | Four carbon main chain | Carboxyl -COOH functional group</td></tr>
<tr><td>8a(i)</td><td>6</td><td>
</td></tr>
<tr><td>8a(ii)</td><td>London Dispersion Forces</td><td>There are three forms of van der Waals' Attraction. London Dispersion forces are found in all substances but are the weakest form of intermolecular attraction. Permanent dipole to permanent dipole attractions are stronger than London Dispersion Forces and Hydrogen Bonding is the strongest form of van der Waals' attraction.</td></tr>
<tr><td>8b(i)</td><td>Answer to include:</td><td><table>
<tr><td>1st Mark:</td><td>Dissolve gelatin (in small volume of deionised water)</td></tr>
<tr><td>2nd Mark:</td><td>Transfer quantitatively/with rinsings/with washings</td></tr>
<tr><td>3rd Mark:</td><td>Fill to the mark/line (on volumetric/standard flask)</td></tr>
</table></td></tr>
<tr><td>8b(ii)</td><td>11.0</td><td><table>
<tr><td>Concentration (%)</td><td>2.0</td><td>4.0</td><td>6.0</td><td>8.0</td><td>10.0</td></tr>
<tr><td>Viscosity (units)</td><td>1.0</td><td>2.0</td><td>4.0</td><td>7.0</td><td>(-)</td></tr>
<tr><td>Difference</td><td></td><td>1.0</td><td>2.0</td><td>3.0</td><td>(4.0)</td></tr>
<tr><td>Prediction (units)</td><td>(-)</td><td>(-)</td><td>(-)</td><td>(-)</td><td>11.0</td></tr>
</table></td></tr>
<tr><td>8c(i)</td><td>Enzyme Changes shape or denatured</td><td>Enzymes are specifically shaped globular proteins which denature when heated. Denaturing is caused by the 3D structure of the protein in the enzyme changing. This 3D structure is held by various types of bonding e.g. hydrogen bonding. Once the enzyme has changed shape, the substrate molecule no longer fits the enzyme active sire and the enzyme no longer catalyses the reaction.</td></tr>
<tr><td>8c(ii)</td><td>37.88</td><td>13.2mg bromelain ⟷ 1g pineapple
500mg bromelain ⟷ 1g x $^{500}/_{13.2}$
= 37.88g</td></tr>
<tr><td>9a(i)</td><td>+220±2</td><td>Activation Energy (forward reaction) is measure from:
R to Activated Complex = 220 – 0 - +220kJ mol^{-1}
NB: Activation energy are always endothermic with a positive value.</td></tr>
</table>

9a(ii)	One Answer from:	Favours the endothermic/ reverse reaction	(Forward) reaction is exothermic	Reverse reaction is endothermic
9b	Diagram showing:	workable method for removal of HCl but allowing Cl_2 to pass through water (1mark)	workable method to collect gas (1mark)  	


water

9c	-391	❶ $C + 2H_2 \rightarrow CH_4$ ΔH=-75 kJ mol^{-1} ❷ $C + 2Cl_2 \rightarrow CCl_4$ ΔH=-98 kJ mol^{-1} ❸ $\frac{1}{2}H_2 + \frac{1}{2}Cl_2 \rightarrow HCl$ ΔH=-92 kJ mol^{-1} ❶x-1 $CH_4 \rightarrow C + 2H_2$ ΔH=+75 kJ mol^{-1} ❷ $C + 2Cl_2 \rightarrow CCl_4$ ΔH=-98 kJ mol^{-1} ❸x4 $2H_2 + 2Cl_2 \rightarrow 4HCl$ ΔH=-368 kJ mol^{-1} Add ❶'+❷+❸' $CH_4 + 4Cl_2 \rightarrow CCl_4 + 4HCl$ ΔH=-391 kJ mol^{-1}
10a	Tap water contains metal ions/salts which are not found in deionised water	The tap water used might contained chloride ions or magnesium ions which would alter the concentration of either ions in the final solution. Deionised water or distilled water are free from ions.
10b(i)	☐ Pipette ☐ Measuring cylinder	Pipettes are the most accurate method of transferring accurate volumes of solutions. Measuring cylinders do not provide an accurate measurement of volume, only approximate volumes.
10b(ii)	E (1st Step), C (2nd Step), B (3rd Step), D (4th Step), A (5th Step)	E: Weigh the filter paper C: Filter the precipitate B: Wash the precipitate with water to remove any impurities D: Dry the precipitate in an oven A: Weigh the precipitate and the filter paper
10b(iii)	0.463	no. of mol = $\frac{mass}{gfm} = \frac{1.393}{143.3}$ = 0.00972mol $MgCl_{2(aq)} + 2AgNO_{3(aq)} \rightarrow 2AgCl_{(s)} + Mg(NO_3)_{2(aq)}$ 1mol → 2mol 0.00486mol → 0.00972mol **mass** = **no.** of mol x **gfm** = 0.00486 x 95.3 = 0.463g
10c	96.0	% purity = $\frac{\text{mass of pure sample}}{\text{mass of impure sample}}$ x100 = $\frac{2.403}{2.503}$ x100 = 96.0%
11	Open Question Answer to Include:	**3 mark answer**: Demonstrates a **good understanding** of the chemistry involved. A good comprehension of the chemistry has provided in a logically correct, including a statement of the principles involved and the application of these to respond to the problem. **2 mark answer**: Demonstrates a **reasonable understanding** of the chemistry involved, making some statement(s) which are relevant to the situation, showing that the problem is understood. **1 mark answer**: Demonstrates a **limited understanding** of the chemistry involved. The candidate has made some statement(s) which are relevant to the situation, showing that at least a little of the chemistry within the problem is understood.
12a(i)	Ionic / Positively charged	Compound A has polar bonds which have permanent dipoles to allow interaction with water molecules. Compounds B+C have ionic charges which allow these compounds to interact with water.
12a(ii) Part A	Alkaline hydrolysis or saponification	Alkali will hydrolyse fats/oils into glycerol and three fatty acids. The alkali will then neutralise the fatty acids to form salts which act as soaps.
12a(ii) Part B	Answer to Include:	1st Mark: ionic/hydrophilic part **and** a non-polar/hydrophobic part to molecule 2nd Mark: Head/COO^- part of the molecules dissolves in water (hydrophilic) Tail/hydrocarbon chain part of molecule dissolves in oil (hydrophobic) 3rd Mark: One from: Agitation cause small oil droplets to form; The (negatively-charged) ball-like structures repel each other; Soap/compound C allow emulsions to form or break oil into micelles.
12a(iii)	React edible oil with glycerol	Edible oils can form an ester link with the hydroxyl -OH group on a glycerol (propane-1,2,3-triol). The emulsifier has a hydrophobic tail from the edible oil that has just joined on and has hydrophilic hydroxyl -OH groups.
12b(i)	One answer from:	Both nuclei have the same attraction for the bonding electrons / Both atoms have same electronegativity / Bonding electrons shared evenly
12b(ii)	One answer from:	

		To ensure all chlorine is used up/to prevent chlorine being released / NaOH is the cheaper/less expensive reactant / To ensure that the bleach cleaner contains sodium hydroxide / Excess NaOH would neutralise any acid added to cleaner / Excess NaOH helps break up oil/grease
12c	Answer to include:	1st Mark: Adding acid increases in the number of H^+ ions 2nd Mark: Rate of Forward Reaction increases (to reduce concentration of H^+ ions by turning them into products)
12d(i)	$OCl^- + 2H^+ + 2e^-$ ↓ $Cl^- + H_2O$	redox: $OCl^- + 2H^+ + 2I^- \longrightarrow I_2 + Cl^- + H_2O$ oxidation: $2I^- \longrightarrow I_2 + 2e^-$ reduction: $OCl^- + 2H^+ + 2e^- \longrightarrow Cl^- + H_2O$
12d(ii)	1.76×10^{-2} or 0.0176	**n**o. of mol = **v**olume x **c**oncentration = 0.0090 litres x 0.098 mol l^{-1} = 8.82×10^{-4} mol $I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_2O_6$ I_2: 1mol, 4.41×10^{-4}mol; $2Na_2S_2O_3$: 2mol, 8.82×10^{-4}mol $OCl^- + 2I^- + 2H^+ \longrightarrow I_2 + Cl^- + H_2O$ OCl^-: 1mol, 4.41×10^{-4}mol; I_2: 1mol, 4.41×10^{-4}mol $\text{concentration} = \frac{\text{no. of mol}}{\text{volume}} = \frac{4.41\times10^{-4}\text{mol}}{0.025 \text{ litres}} = 1.76\times10^{-2} \text{ mol } l^{-1}$