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>O
‖
— C — OH</td><td>O
‖
—C—O—</td><td>O H
‖ |
— C — N —</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
$C_5H_{10}O$ ⟶ $C_5H_{11}OH$
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>

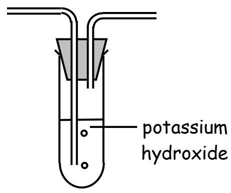
12	B	☒A proteins are not hydrolysed into amino acids during denaturing ☑B hydrogen bonds are broken in the denaturing step as the protein changes shape ☒C proteins are not hydrolysed into amino acids during denaturing ☒D water is removed in the condensation reaction to turn amino acids into proteins
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 have 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	no. of mol H_2SO_4 = volume x concentration = 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**

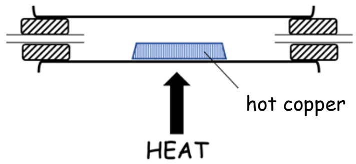
2020 Higher Chemistry Marking Scheme

<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
shielding</td><td>increases so less attraction of</td><td>nucleus
protons</td><td>for</td><td>bonding electrons
outer electrons
shared electrons</td></tr>
<tr><td>covalent radius
atomic size
number of shells</td><td>increases so less attraction of</td><td>nucleus
protons</td><td>for</td><td>bonding electrons
outer electrons
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><th>Write down Symbols and valency below</th><th>Cross-Over arrows to work out formula</th><th>Work out chemical formula (Cancel down if necessary)</th><th>Insert charges to each ion and multiple ions required brackets</th></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>Sulphur</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>$\text{atom economy} = \frac{\text{mass of useful products}}{\text{total mass of reactants}} \times 100 = \frac{(2 \times 55.8)}{(1 \times 159.6) + (3 \times 28.0)} \times 100 = 45.8\%$</td></tr>
<tr><td>2c</td><td>+250 kJ mol^{-1}</td><td>❶ $CO + \frac{1}{2}O_2 \rightarrow CO_2$ ΔH=-283 kJ mol^{-1}
❷ $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$ ΔH=-286 kJ mol^{-1}
❸ $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ ΔH=-891 kJ mol^{-1}

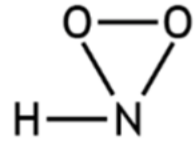
❶x-1 $CO_2 \rightarrow CO + \frac{1}{2}O_2$ ΔH=+283 kJ mol^{-1}
❷X-3 $3H_2O \rightarrow 3H_2 + 1\frac{1}{2}O_2$ ΔH=+858 kJ mol^{-1}
❸ $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ ΔH=-891 kJ mol^{-1}

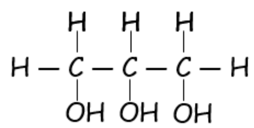
Add ❶'+❷+❸ $CH_4 + H_2O \rightarrow CO + 3H_2$ ΔH=+250 kJ mol^{-1}</td></tr>
</table>

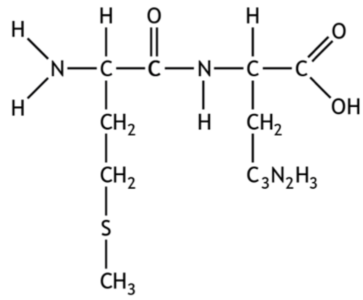
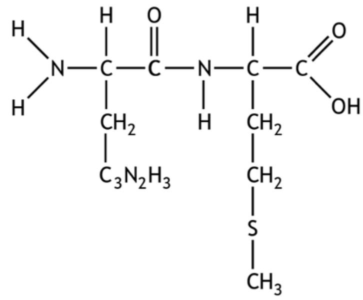
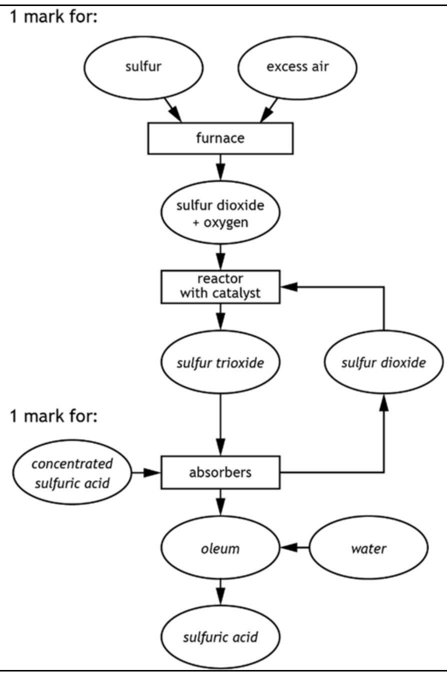
<table>
<tr><td>3</td><td>Open Question Answer to Include:</td><td>
<table>
<tr><th>3 mark answer</th><th>2 mark answer</th><th>1 mark answer</th></tr>
<tr><td>Demonstrates a <u>good</u> understanding of the chemistry involved. A good comprehension of the chemistry has provided in a logically correct, 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>
</table>
</td></tr>
<tr><td>4a</td><td>Bond enthalpy is high</td><td>The bond enthalpy of nitrogen is 945kJmol^{-1} and is the highest in data booklet. To become reactive, the N≡N triple bond has to be broken before the free nitrogen atoms can then combine with other elements.</td></tr>
<tr><td>4b</td><td>1 mark for each workable diagram</td><td>
1st mark


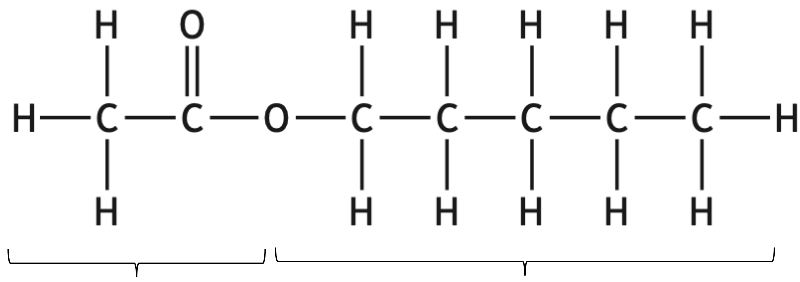
(potassium hydroxide must be labelled)
and
2nd mark


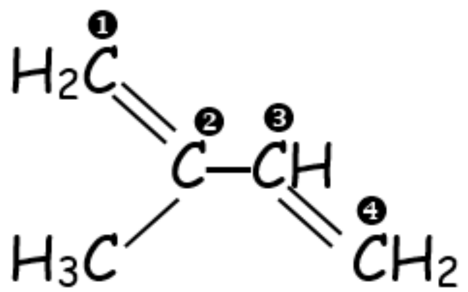
(Heated copper must be labelled)
</td></tr>
<tr><td>4c(i)</td><td>Working showing:</td><td>
$$\text{no. of mol Li} = \frac{\text{mass}}{\text{gfm}} = \frac{0.5}{6.9} = 0.0725\text{mol}$$
$$\text{no. of moles } N_2 = \frac{\text{Volume}}{\text{Molar Volume}} = \frac{0.9\text{ litres}}{24\text{ litres mol}^{-1}} = 0.0375\text{mol (available)}$$
$$6Li_{(s)} + N_{2(g)} \longrightarrow 2Li_3N_{(s)}$$
6mol   1mol   2mol
0.0725mol   0.0242mol (required)
There is more N_2 available (0.0375mol) than is required (0.00242mol) to react all Li present   ∴ N_2 is in excess   ∴Li is the limiting reactant
</td></tr>
<tr><td>4c(ii)</td><td>$Cu^{+}_{(aq)} + e^{-} \rightarrow Cu_{(s)}$</td><td>Reduction is the gain of electrons so electrons appear before arrow. State symbols are not required.</td></tr>
<tr><td>4c(iii)</td><td>(ionic) lattice/network</td><td>Ionic compounds form ionic lattices with alternating positive and negative ions in all directions. Ionic lattices are also called ionic networks.</td></tr>
<tr><td>4d(i)</td><td>atoms/molecules with an unpaired electron</td><td>A free radical has an unpaired electron which makes the free radical reactive as it seeks to pair up its unpaired electron with another species. Free radicals can be formed by exposure to uv light.</td></tr>
<tr><td>4d(ii)</td><td>676</td><td>
<table>
<tr><th colspan="2">Bond Breaking Steps</th><th colspan="2">Bond Forming Steps</th></tr>
<tr><td>1xN≡N bond
1xO=O bond</td><td>1x 945kJ = 945kJ
1x 498kJ = 498kJ</td><td>2xN=O bonds</td><td>2x X kJ = 2X kJ</td></tr>
<tr><td>Total bond breaking</td><td>=1443kJ</td><td>Total bond Forming</td><td>= 2X kJ</td></tr>
</table>
ΔH = ΣBond enthalpies for bonds broken - ΣBond enthalpies for bonds formed
91 kJ mol^{-1} = 1443 kJ mol^{-1} - 2X
∴ 2X = 1443 kJ mol^{-1} - 91 kJ mol^{-1}
= 1352 kJ mol^{-1}
∴ X = 676 kJ mol^{-1}
</td></tr>
<tr><td>4d(iii)A</td><td>termination</td><td>
<table>
<tr><th>Step</th><th>Reactants (before Arrow) ⟶ Products (after Arrow)</th></tr>
<tr><td>Initiation</td><td>No free radicals on Reactant Side ⟶ Free radicals on Product Side</td></tr>
<tr><td>Propagation</td><td>Free Radicals found on both sides of arrow</td></tr>
<tr><td>Termination</td><td>Free radicals on Reactant Side ⟶ No free radicals on Product Side</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td>4d(iii)B</td><td>one diagram from:</td><td>H—O—N=O or </td></tr>
<tr><td>4e(i)</td><td>Answer to include:</td><td><table><tr><td>1st Mark</td><td>decreasing temperature favours exothermic reaction
or increasing temperature favours endothermic reaction</td></tr><tr><td>2nd Mark</td><td>Increases the yield of ammonia</td></tr></table></td></tr>
<tr><td>4e(ii)A</td><td>Equation showing:</td><td>$C_3H_5N_3O_9 \longrightarrow 3CO_2 + 2\frac{1}{2}H_2O + 1\frac{1}{2}N_2 + \frac{1}{4}O_2$</td></tr>
<tr><td>4e(ii)B</td><td>One answer from:</td><td><table><tr><td>the shock/bump provides the activation energy/E_A</td><td>the shock/bump provides sufficient/enough energy to start the reaction</td><td>the reaction has a low activation energy/E_A</td></tr></table></td></tr>
<tr><td>5a</td><td>One answer from:</td><td><table><tr><td>Contains oxygen to ensure complete combustion</td><td>Sample is surrounded by water so all energy transferred/reduce heat loss to surroundings</td><td>Sealed container prevents/reduces heat loss to the surroundings</td><td>Stirring to ensure accurate temperature (measurement)</td></tr></table></td></tr>
<tr><td>5b(i)</td><td>-34 078</td><td>Heat Energy = Specific Heat Capacity × Mass × Change In Temperature
$E_h = c \times m \times \Delta T$
$E_h = 4.18\ kJ\ kg^{-1}\ {}^{\circ}C^{-1} \times 0.775kg \times 11.9^{\circ}C$
$E_h = 38.55\ kJ$
gfm triolein = 884g (in question)
no. of mol triolein = $\frac{mass}{gfm} = \frac{1.00}{884}$ = 0.00113mol

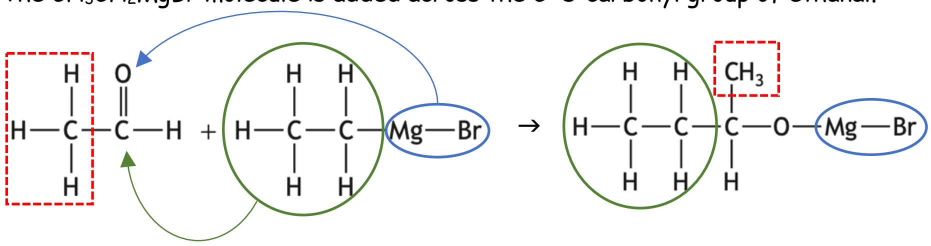
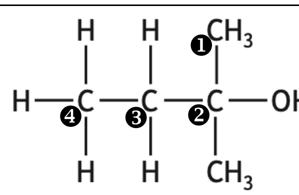
0.00113mol triolein ⟷ 38.55 kJ
1mol triolein ⟷ 38.55 kJ x $^{1}/_{0.00113}$
= -341078kJ mol^{-1}</td></tr>
<tr><td>5b(ii)</td><td>0.7125</td><td>$C_{57}H_{104}O_6 + 80\ O_2 \longrightarrow 57CO_2 + 52H_2O$
80mol 57mol
Because 1 mole of a gas has the same volume at same conditions of temperature and pressure:
80vol 57vol
Respiratory Quotient = $\frac{CO_2\ produced}{O_2\ consumed} = \frac{57vol}{80vol}$ = 0.7125</td></tr>
<tr><td>5c(i)</td><td>23·3</td><td><table>
<tr><td>Formula</td><td>$C_{15}H_{26}O_6$</td><td>$C_{21}H_{38}O_6$</td><td>$C_{27}H_{50}O_6$</td><td>$C_{33}H_{62}O_6$</td><td>$C_{39}H_{74}O_6$</td><td>$C_{45}H_{86}O_6$</td><td>$C_{51}H_{98}O_6$</td><td>$C_{56}H_{110}O_6$</td></tr>
<tr><td>Number of Carbons</td><td>C_{15}</td><td>C_{21}</td><td>C_{27}</td><td>C_{33}</td><td>C_{39}</td><td>C_{45}</td><td>C_{51}</td><td>C_{56}</td></tr>
<tr><td>Viscosity (units)</td><td>3.0</td><td>5.9</td><td>8.8</td><td>11.7</td><td>14.6</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Difference</td><td></td><td>2.9</td><td>2.9</td><td>2.9</td><td>2.9</td><td>(2.9)</td><td>(2.9)</td><td>(2.9)</td></tr>
<tr><td>Prediction</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>17.5</td><td>20.4</td><td>23.3</td></tr>
</table></td></tr>
<tr><td>5c(ii)</td><td>Glycerol has 3 hydroxyl groups</td><td>Glycerol has three hydroxyl -OH groups. Each hydroxyl group reacts with a fatty acid any condensation reaction where a water molecule is removed.

glycerol</td></tr>
<tr><td>6a</td><td><table><tr><td>1st Mark (for mass)</td><td>2nd Mark (for units)</td></tr><tr><td>0·00113</td><td>kg</td></tr><tr><td>1·13</td><td>g</td></tr><tr><td>1130</td><td>mg</td></tr></table></td><td>0.133g iodine obtained from 1000g seaweed
0.15mg iodine = 0.00015g iodine
0.00015g iodine obtained from 1000g x $^{0.00015g}/_{0.133g}$
= 1.13g seaweed</td></tr>
</table>

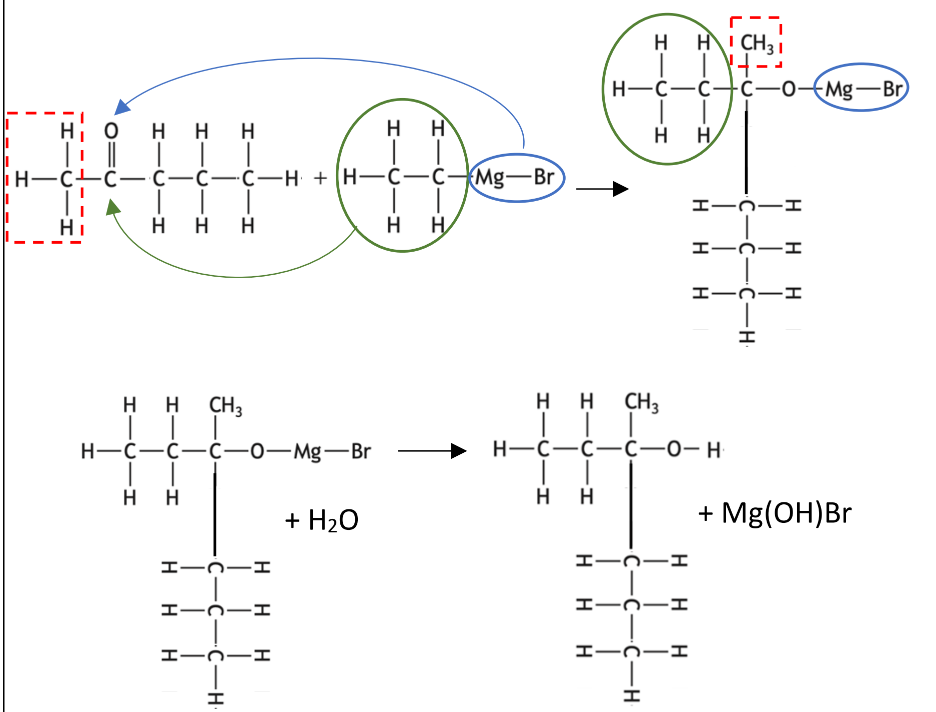
6b(i)	Answer to include:	Measuring the mass of container + seaweed/sample then subtract the mass of the container
6b(ii)	I^- ions or Iodide ions	Reducing agents reduce another species while being oxidised themselves (losing electrons in the process) $H_2O_2 + 2I^- + 2H^+ \longrightarrow 2H_2O + I_2$ $2I^- \longrightarrow I_2 + 2e^-$
6b(iii)	Answer to include:	A solution of accurately/exactly/precisely known concentration
6b(iv)A	0·00013	$I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$ 1mol. 2mol 0.00013mol 0.00026mol
6b(iv)B	0·033	**gfm** I_2 = (2x126.9) = 253.8g **m**ass = **n**o. of mol x **gfm** = 0.00013 x 253.8 = 0.03299g
6c(i)	Amino acid that must be acquired/obtained from the diet	Essential amino acids must be obtained from the diet if they are going to be joined together to form all the different proteins needed in the body.
6c(ii)	One from:	 or 
7a	2 marks awarded top half (1 mark) bottom half (1 mark)	
7b	Requires heat to be removed	Highly exothermic reactions need the excess heat energy removed safely from the reaction system. Excess heat could lead to the evaporation of liquid reactants/products and the resultant large increase in gas pressure could lead to an explosion.
7c(i)	Answer to include:	1st mark: description of LDFs as forces of attraction between temporary dipoles (and induced dipoles) 2nd mark: explanation of the cause of temporary dipoles in terms of uneven distribution of electrons/electron wobble/movement of electrons in the molecule

<table>
<tr><td>7c(ii)</td><td><u>1st Mark</u>
Sulphur has more electrons than oxygen
<u>2nd Mark</u>
forces are stronger due to sulphur structure being S_8 whereas oxygen is O_2</td><td>London dispersion forces are formed when a temporary dipole is formed. This is the result of an temporary imbalance of electrons on one side of an atom causing the atom. To have a δ+ side and a δ– side.
The greater number of electrons in the atom, the greater the likelihood of the temporary dipole happening.
This temporary dipole induces neighbouring atoms to form a dipole.
The dipoles between atoms are attracted to each other and this leads to the atoms being closer together and this increases the boiling point.</td></tr>
<tr><td>7d</td><td><table><tr><td>Effect of catalyst on enthalpy change</td><td>Effect of catalyst on activation energy</td></tr><tr><td></td><td></td></tr><tr><td>stay the same</td><td></td></tr><tr><td></td><td>decrease</td></tr></table></td><td>A catalyst lowers the activation energy by providing an alternative route to the products. The activation energy is the minimum energy required for an activated complex to be formed and the new substance(s) formed.
A catalyst has no effect on the enthalpy change for a reaction as the energy of the reactants and products are not changed by the catalyst.</td></tr>
<tr><td>7e(i)</td><td>Do not form scum</td><td>Scum is formed as a precipitate between ions in hard water (usually Ca^{2+} ions) and the negative ion found in soaps/detergents. Soft water lacks Ca^{2+} ions so no precipitate/scum is formed when soap is used with soft water.
Soapless detergents are designed to not form a precipitate with Ca^{2+} and no precipitate/scum formed with hard or soft water.</td></tr>
<tr><td>7e(ii)</td><td>Answer to include:</td><td><table><tr><td>One word from below to describe the
HEAD</td><td>One word from below to describe the
TAIL</td></tr><tr><td>Hydrophilic</td><td>Hydrophobic</td></tr><tr><td>Polar</td><td>Non-polar</td></tr><tr><td>Ionic</td><td>Non-polar</td></tr><tr><td>Water soluble</td><td>Fat soluble</td></tr></table></td></tr>
<tr><td>8a(i)</td><td>pentyl ethanoate</td><td>
carboxylic acid side
Second Name of Ester
-ethanoate
alcohol side
First Name of Ester
pentyl-</td></tr>
<tr><td>8a(ii)</td><td>Condensation or esterification</td><td><table><tr><td>Condensation</td><td>A condensation reaction happens when two molecules join together and a small molecule (usually water) is removed where they joined. Condensation reactions where an ester is formed are also known as esterification reactions.</td></tr><tr><td>Hydrolysis</td><td>A hydrolysis reaction happens when a molecule splits into two molecules and a small molecule (usually water) is added across the break point.</td></tr></table></td></tr>
<tr><td>8b(i)</td><td>Carbon dioxide is (relatively) insoluble
Or
has very low solubility</td><td>Although carbon dioxide is soluble it is only sparingly soluble in water. The majority of carbon dioxide does not dissolve in the water as it makes its way through the water to the upside down measuring cylinder filled with water.
NO_2 and NH_3 are much more soluble in water than CO_2.
Best way to collect any gas which is soluble is in a gas syringe</td></tr>
</table>

<table>
<tr><td>8b(ii)</td><td>0·029</td><td>no. of moles $CO_2 = \frac{\text{Volume}}{\text{Molar Volume}} = \frac{0.055 \text{ litres}}{24 \text{ litres mol}^{-1}} = 0.00229\text{mol}$
$C_6H_8O_7 + 3NaHCO_3 \longrightarrow 3CO_2 + 3H_2O + C_6H_5O_7Na_3$
1mol 3mol
0.000764mol 0.00229mol
gfm citric acid = 192g
mass citric acid in 5 sweets = no. of mol x gfm = 0.000764 x 192 = 0.147g
mass citric acid in 1 sweet = $^{0.147g}/_{5}$ = 0.0293g</td></tr>
<tr><td>8c(i)A</td><td>orange to green</td><td rowspan="2"><table>
<tr><th>Oxidising Agent</th><th>Colour Change</th><th>Primary alcohol ↓ Aldehyde</th><th>Secondary Alcohol ↓ Ketone</th><th>Aldehyde ↓ Carboxylic Acid</th></tr>
<tr><td>Hot copper(II) oxide</td><td>Brown to black</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Acidified dichromate</td><td>Orange to green</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Fehling's solution</td><td>Blue to brick red</td><td>×</td><td>×</td><td>✓</td></tr>
<tr><td>Tollen's Reagent</td><td>Silver mirror</td><td>×</td><td>×</td><td>✓</td></tr>
</table></td></tr>
<tr><td>8c(i)B</td><td>Tollens' reagent or Fehling's solution</td></tr>
<tr><td>8c(ii)</td><td>2</td><td>Formula of isoprene = C_5H_8
Formula of limonene = $C_{10}H_{16}$
2 isoprene units join together to form limonene</td></tr>
<tr><td>8c(iii)</td><td>1 pence
or
£0·01</td><td>$100cm^3$ solution contains 0.184g vanillin
$5cm^3$ solution contains 0.184g x $^{5}/_{100}$ = 0.0092g vanillin
1000g vanillin costs £1050.00
0.0092g vanillin costs £1050.00 x $^{0.0092}/_{1000}$
= £0.00966
= 0.966p
≈ 1p</td></tr>
<tr><td>9a(i)</td><td>1·575</td><td>$100cm^3$ mouthwash contains 1.5g of 35% hydrogen peroxide solution
$300cm^3$ mouthwash contains 4.5g of 35% hydrogen peroxide solution
35% of 4.5g = $\frac{35}{100}$ x4.5g =1.575g</td></tr>
<tr><td>9a(ii)</td><td>Protein(s)</td><td>Proteins are polymers made by the condensation polymerisation of amino acids. Enzymes are biological catalysts which are specially shaped proteins and catalyse chemical reactions at body temperatures.</td></tr>
<tr><td>9a(iii)</td><td>pipette and burette</td><td>Pipettes and burette are more accurate methods of measuring volumes of liquids than measuring cylinders and beakers.</td></tr>
<tr><td>9b</td><td>essential oils</td><td>Essential oils are concentrated extracts of the volatile, non-water soluble aroma compounds from plants. They are mixtures of many different compounds. They are widely used in perfumes, cosmetic products, cleaning products and as flavourings in foods.</td></tr>
<tr><td>9c(i)</td><td>2-methylbuta-1,3-diene</td><td>

2-methylbuta-1,3-diene</td></tr>
<tr><td>9c(ii)</td><td>ketone</td><td>Menthol is a secondary alcohol as its hydroxyl -OH group has two carbons attached to the carbon with the -OH group.
Secondary alcohols oxidise to ketones.</td></tr>
</table>

9d(i)	methanol	salicylic acid + X → methyl salicylate + water $C_7H_6O_3$ + $C_xH_yO_z$ → $C_8H_8O_3$ + H_2O For C: 7+x = 8+0 ∴ x = 8+0-7 = 1 For H: 6+y = 8+2 ∴ y = 8+2-6 = 4 For O: 3+z = 3+1 ∴ z = 3+1-3 = 1 ∴ $C_1H_4O_1 = CH_4O$ Methanol has formula CH_4O
9d(ii)	79·24	**gfm** salicylic acid = 138g no. of mol = $\frac{\text{mass}}{\text{gfm}} = \frac{28.3}{138}$ = 0.205mol salicylic acid + methanol(X) → methyl salicylate + water 1mol → 1mol 0.205mol → 0.205mol (theoretical) **gfm** methyl salicylate = 152g no. of mol = $\frac{\text{mass}}{\text{gfm}} = \frac{24.7}{152}$ = 0.163mol (actual) %Yield = $\frac{\text{Actual}}{\text{Theoretical}}$ x100 = $\frac{0.163\text{mol}}{0.205\text{mol}}$ x 100 = 79.24%
9d(iii)	6·5	1kg body mass has toxicity at 0.14g methyl salicylate 65kg body mass has toxicity at 0.14g x $^{65}/_{1}$ = 9.1g methyl salicylate 7.0g methyl salicylate found in 5.0cm^3 oil of wintergreen 9.1g methyl salicylate found in 5.0cm^3 x $^{9.1}/_{7.0}$ = 6.5cm^3 oil of wintergreen
10	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.
11a(i)	Reactants/solvent is flammable/catches fire with a flame	The reactants and the solvent are often flammable in reflux so an open flame could cause any escaping vapours to catch fire. A water bath solves this issue, If a temperature above 100°C is required then a heating mantle should be used instead.
11a(ii)	condenser	The condenser is fitted to the flask to give a cold surface for the vapours escaping the flask to condense back to liquids and return to then flask. In reflux techniques the water should enter the condenser at the bottom and leave at the top of the condenser.
11b(i)	addition	The CH_3CH_2MgBr molecule is added across the C=O carbonyl group of ethanal. 
11b(ii)	2-methylbutan-2-ol	 2-methylbutan-2-ol methyl $-CH_3$ group on C_2 / 4 carbons on main chain / Hydroxyl -OH functional group on C_2

11b(iii)	A correct structural formula for 3-methylhexan-3-ol	
12a	Poly(phenylethene)	The yoghurt pot has a spectrum which is most similar to the spectrum for poly(phenylethane) as it has both peaks which are both smaller than the other spectra show.
12b	C=O circled	From p15 of data booklet: 1720cm^{-1} peak caused by C=O stretch in various chemical groupings; aldehydes & ketones, aromatic esters and carboxylic acids. The C=O in the structure is part of an ester group (the 6 carbon hexagonal group is described as aromatic at Advanced Higher)
12c	2 single absorptions (peaks) required <u>1st Mark</u> peak for C-H within the range 2700-3300 cm^{-1} <u>2nd Mark</u> peak for C≡N within the range 2260-2215cm^{-1}