# Past Papers Higher Chemistry

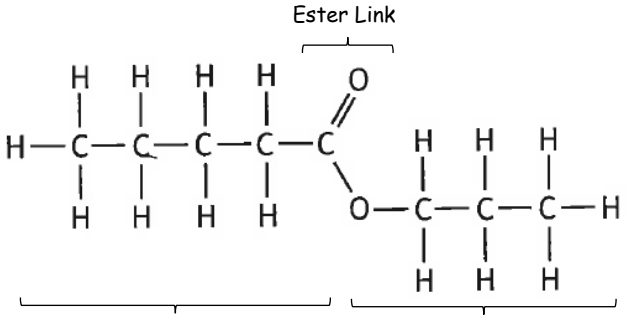
# 2022

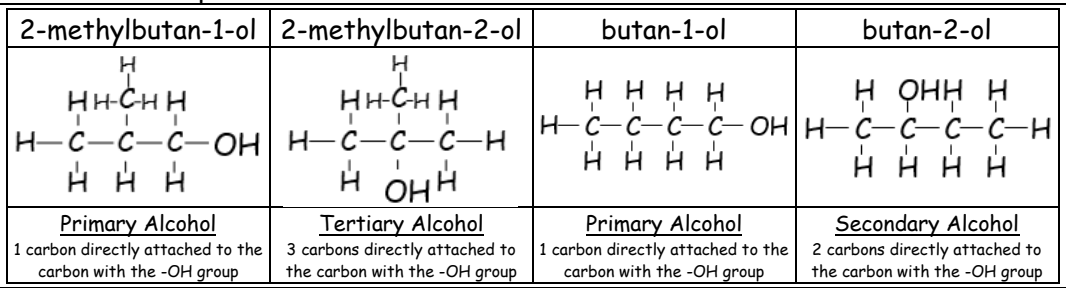
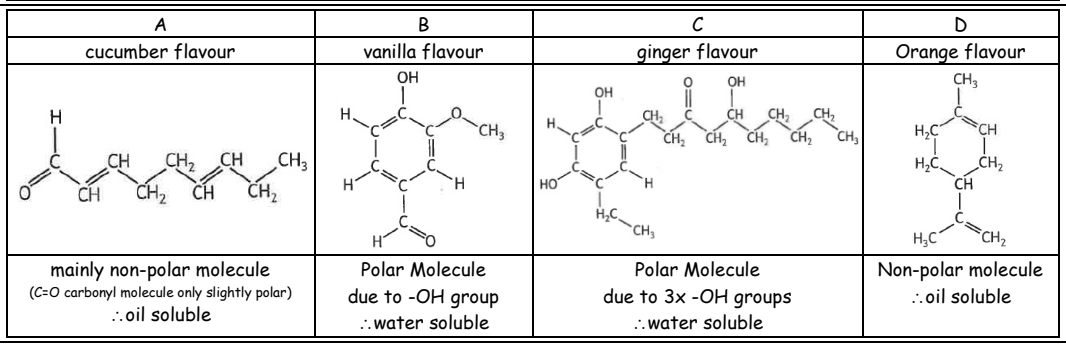
# Marking Scheme

| Grade Awarded | Mark Required | | % candidates achieving grade |
|---|---|---|---|
| | (/120) | % | |
| A | 84+ | 70.0% | 34.9% |
| B | 68+ | 56.7% | 24.1% |
| C | 53+ | 44.2% | 19.3% |
| D | 37+ | 30.1% | 12.9% |
| No award | <37 | <30.1% | 8.8% |

| Section: | Multiple Choice | Extended Answer | Assignment |
|---|---|---|---|
| Average Mark: | 16.4 /25 | 55.1 /95 | No Assignment in 2022 |

# 2022 Higher Chemistry Marking Scheme

| MC Qu | Answer | % Correct | Reasoning |
|---|---|---|---|
| 1 | D | 74 | ☒A Boron is a covalent network due to its high melting point<br>☒B Neon is monatomic in Group 0 due to its full pouter shell<br>☒C Sodium is a metal and contains metallic bonding<br>☑D Sulphur has a covalent $S_8$ structure and has LdF between molecules |
| 2 | A | 67 | ☑A Forming a 2+ ion creates a full outer shell and a low 2nd ionisation energy<br>☒B Forming a 3+ ion creates a full outer shell and a low 3rd ionisation energy<br>☒C ionisation energy removes electrons and forms positive ions<br>☒D ionisation energy removes electrons and forms positive ions |
| 3 | C | 48 | ☒A Intermolecular forces decide the boiling point not the covalent bonds inside<br>☒B Intermolecular forces decide the boiling point not the covalent bonds inside<br>☑C Permanent dipole to permanent dipole attractions between polar covalent HCl molecules are stronger than London dispersion forces between $H_2$ molecules<br>☒D Van der Waals' forces are never stronger than covalent bonds |
| 4 | B | 63 | **Agent** / **Reducing Agent** / **Oxidising Agent**<br>Action of Agent on Another Species: reduces another species / oxidises another species<br>Action on Agent Itself: agent is oxidised / agent is reduced<br>Effect on Electrons in Agent: loss of electrons / gain of electrons<br>Likely Electronegativity of Agent: low / high<br>Position in Electrochemical series: top right / bottom Left |
| 5 | D | 45 | Redox: $Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 6Fe^{3+}$<br>Oxidation: $6Fe^{2+} \rightarrow 6e^- + 6Fe^{3+}$<br>Reduction: $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$ |
| 6 | A | 49 | Formula: / $MgBr_2$ / $MgSO_4$<br>Mole ratio: / 1mol : 2mol / 1mol : 1mol<br>4mol $Br^-$ ions / 2mol : 4mol /<br>3mol $Mg^{2+}$ ions / 2mol / 1mol<br>1mol $SO_4^{2-}$ ions / / 1mol : 1mol |
| 7 | D | 84 |  <br>$C_5$ carboxyl side ∴Ends in Pentanoate<br>$C_3$ alcohol side ∴Starts with Propyl |
| 8 | C | 52 | Structure shown has formula $C_8H_{16}O$<br>☒A octan-4-one has formula $C_8H_{16}O$<br>☒B 2-ethylhexanal has formula $C_8H_{16}O$<br>☑C 2-ethylhexan-1-ol has formula $C_8H_{18}O$<br>☒D 5-methylheptan-3-one has formula $C_8H_{16}O$ |
| 9 | A | 82 | Name / Hydroxyl / Carboxyl / Amine / Carbonyl<br>Functional Group / $-OH$ / $-C(=O)-OH$ / $H-N-$ / $-C(=O)-$ |

| | | | |
|---|---|---|---|
| 10 | C | 73 | ☒A C=C double bond in prenol molecule would decolourise bromine solution quickly<br>☒B C=C double bond in prenol molecule would decolourise bromine solution quickly<br>☑C Prenol would decolourise bromine solution and react with hot copper (II) oxide<br>☒D Prenol is a primary alcohol and would react with hot copper (II) oxide |
| 11 | B | 48 | Palm oil has iodine number of 48 ∴ 48g of Iodine reacts with 100g of palm oil<br>Olive oil has iodine number of 84 ∴ 84g of Iodine reacts with 100g of olive oil<br>• palm oil must contain less C=C double bonds than olive oil as less iodine is required by palm oil to saturate the molecules completely.<br>• palm oil must be more saturated than olive oil if it contains less C=C bonds<br>• more saturated palm oil molecules fit together better would meaning palm oil molecules are closer together and raises melting point of palm oil. |
| 12 | B | 86 | ☒A head section is polar making it hydrophilic.<br>☑B hydrophilic head dissolves in water and hydrophobic tail dissolves in oil<br>☒C head section is polar would dissolve in water making it hydrophilic.<br>☒D head section is polar would dissolve in water. |
| 13 | D | 87 |  |
| 14 | C | 77 |  |
| 15 | B | 76 | ☒A Carbonyl group would be numbered $C_2$ to give functional group lowest numbering system<br>☑B Secondary alcohol 4-methylpentan2-ol oxidises to form the ketone 4-methylpentan-2-one<br>☒C Molecule is secondary alcohol and would oxidise to form a ketone not aldehyde<br>☒D Molecule is secondary alcohol and would oxidise to form a ketone not aldehyde |
| 16 | C | 54 | ☒A the bottom of the meniscus should be used to measure the volumes in a burette<br>☒B rinsing the burette with deionised water will result in the dilution of the next solution in burette<br>☑C small volume of the reactant in the burette should be used to rinse the burette before use, the bottom of the meniscus should be used to measure volumes and draining a small volume of acid will remove any air bubble below the tap in the burette.<br>☒D the bottom of the meniscus should be used to measure the volumes in a burette |
| 17 | B | 58 | ☒A polar ethanol would not be a solvent to dissolve non-polar lycopene & beta-carotene<br>☑B pentane is non-polar and would be a good solvent for non-polar lycopene & beta-carotene<br>☒C polar propanoic acid would not be a solvent to dissolve non-polar lycopene & beta-carotene<br>☒D polar water would not be a solvent to dissolve non-polar lycopene & beta-carotene |
| 18 | D | 86 | $\text{rate} = \frac{1}{\text{time}} = \frac{1}{0.004} = 250\text{s}$ |
| 19 | A | 63 | $C_4H_{8(g)} + 6O_{2(g)} \rightarrow 4CO_{2(g)} + 4H_2O_{(g)}$<br>1mol, 1vol, 100cm³ + 6mol, 6vol, 600cm³ → 4mol, 4vol, 400cm³ + 4mol, 4vol, 400cm³<br>700cm³ used up → 800cm³ produced |

**20 C 58**

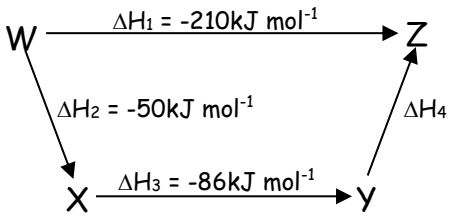
☒A No effect as neither $Na^+$ or $Cl^-$ ions is a reactant or product and don't react with a reactant/product
☒B $H^+$ ions in $HCl_{(aq)}$ increases concentration of a product ∴equilibrium shifts to left
☑C $OH^-$ ions in $NaOH_{(aq)}$ neutralises $H^+$ in products ∴equilibrium shifts to right to replace $H^+$ ions
☒D $CH_3COO^-$ ions in $CH_3COONa_{(aq)}$ increases concentration of product ∴equilibrium shifts to left

**21 D 75**

| Quantity | Measured | A | B | C | D |
|---|---|---|---|---|---|
| Enthalpy of Reactants ($kJ\ mol^{-1}$) | Where R starts on y-axis | 30 | 30 | 30 | 30 |
| Activation Energy of Forward Reaction ($kJ\ mol^{-1}$) | Difference between R and top of hill | 80-30 = 50 | 110-30 = 80 | 110-30 = 80 | 140-30 = 110 |
| Activation Energy of Reverse Reaction ($kJ\ mol^{-1}$) | Difference between P and top of hill | 80-40 = 40 | 110-40 = 70 | 110-70 = 40 | 140-70 = 70 |

**22 B 78**

$\Delta H_1 = \Delta H_2 + \Delta H_3 + \Delta H_4$
$\Delta H_4 = \Delta H_1 - \Delta H_2 - \Delta H_3$
$\Delta H_4 = -210 - (-50) - (-86)$
$\Delta H_4 = -74kJ\ mol^{-1}$
But $\Delta H$ for Z to Y = $+74kJ\ mol^{-1}$




**23 A 62**

$50cm^3$ diluted in a $250cm^3$ standard/volumetric flask gives 1 in 5 dilution.
$0.100mol\ l^{-1}$ given 1 in 5 dilution results in solution becoming $0.02mol\ l^{-1}$ (or $2.0 \times 10^{-2}\ mol\ l^{-1}$)

**24 B 48**

☒A gfm AgF = 107.9 ∴ $n = {}^{m}/_{gfm} = {}^{2.868}/_{107.9} = 0.0266mol$
☑B gfm AgCl = 143.4 ∴ $n = {}^{m}/_{gfm} = {}^{2.868}/_{143.4} = 0.0200mol$
☒C gfm AgBr = 187.8 ∴ $n = {}^{m}/_{gfm} = {}^{2.868}/_{187.8} = 0.0153mol$
☒D gfm AgI = 234.8 ∴ $n = {}^{m}/_{gfm} = {}^{2.868}/_{234.8} = 0.0122mol$

**25 A 47**

☑A $10cm^3$ of water is better measured in a measuring cylinder and titration carried out in conical flask
☒B beakers are not as accurate as measuring cylinders for measuring volumes
☒C Volumetric/standard flasks are used to make up solutions of accurately known concentration
☒D Volumetric/standard flasks are used to make up solutions of accurately known concentration

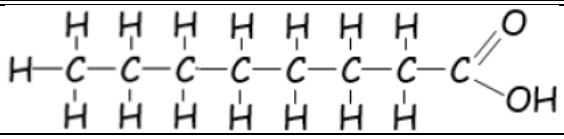
# 2022 Higher Chemistry Marking Scheme

| Long Qu | Answer | Reasoning |
|---|---|---|
| 1a(i) | one answer from: | atoms/nuclei have the same attraction for the bonding electrons / same electronegativity/ electronegativity values given / Bonding electrons shared equally (between the atoms). |
| 1a(ii) | greater nuclear charge | Across a period, **the number of protons increases** giving a **greater nuclear charge**. The greater nuclear charge pulls the outer electron shell further which reduces the size of the atom. |
| 1b(i) | Answer to include: | The energy required to remove 1 mole of electrons from one mole of atoms in the gaseous state. |
| 1b(ii) | One answer from: | More shells so increased screening/shielding<br>covalent radius increases / atom size increases / more shells } so attraction of { nucleus / protons } for outer electrons **decreases** |
| 1c(i) | Answer to include: | Hydrogen bonding (1 mark)<br>1 mark for either:<br>Hydrogen bonding occurs between hydrogen bonded to N, O or F *(all 3 elements needed)* / The attraction between δ+ end on a permanent dipole is strongly attracted to the δ− end of a neighbouring permanent dipole in molecules with hydrogen and a atom with high electronegativity |
| 1c(ii) | Answer to include: | 1st Mark: London dispersion forces become stronger (moving from HCl to HI)<br>2nd Mark: Number of electrons increases (moving from HCl to HI) |
| 2a | $3KClO_4 + 8Al \rightarrow 3KCl + 4Al_2O_3$ | $3KClO_4 + 8Al \longrightarrow 3KCl + 4Al_2O_3$ |
| 2b(i) | 1.35 | **gfm** $KClO_4$ = 122.6g<br>no. of mol = $\frac{\text{mass}}{\text{gfm}} = \frac{4.6}{122.6} = 0.0375\text{mol}$<br>$2KClO_3 \longrightarrow 3O_2 + 2KCl$<br>2mol 0.0375mol : 3mol 0.0563mol<br>Volume = no. of mol x Molar Volume = $0.0563_{mol} \times 24_{litres\ mol^{-1}} = 1.35_{litres}$ |
| 2b(ii) | no effect | Catalysts speed up chemical reaction but do not get used up in that chemical reaction. The enthalpy change is the same for the catalysed and the non-catalysed route due to Hess's Law. |
| 2b(iii) | 2595.6 | 5.5g ↔ 103kJ<br>1mol = 138.6g ↔ 103kJ x $^{138.6}/_{5.5}$<br>= 2595.6kJ |
| 2b(iv) | Answer to include: | 1st Mark: Increases the number of particles with energy 2 equal to or greater than the activation energy / Increases the number of particles with (sufficient) energy to form an activated complex/to react<br>2nd Mark: More successful collisions |
| 2c | Sodium | Peak B at 590nm. Sodium gives a flame colour at 589nm. |
| 3 | Open Question<br>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.<br>**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.<br>**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. |

**4a(i)** Ester link

| hydroxyl group | carboxyl group | ester link | carbonyl group |
|---|---|---|---|
|  |  |  |  |

**4a(ii)** Diagram showing:



**4a(iii)** Structure of Heptan-1-ol or other $C_7$ alcohol listed:

Propyl octanoate has a total of 11 carbons. For the isomer of propyl octanoate to be an ester with butanoic acid being released during hydrolysis, the alcohol released by this hydrolysis must have seven carbons. There are 38 possible seven carbon alcohols. (I think!)

| | | | |
|---|---|---|---|
| heptan-1-ol | heptan-2-ol | heptan-3-ol | heptan-4-ol |
| 2-methylhexan-1-ol | 3-methylhexan-1-ol | 4-methylhexan-1-ol | 5-methylhexan-1-ol |
| 2-methylhexan-2-ol | 3-methylhexan-2-ol | 4-methylhexan-2-ol | 5-methyl-hexan-2-ol |
| 2-methylhexan-3-ol | 3-methylhexan-3-ol | 4-methylhexan-3-ol | 5-methylhexan-3-ol |
| 2,2-dimethylpentan-1-ol | 2,3-dimethylpentan-1-ol | 2,4-dimethylpentan-1-ol | 3,3-dimethylpentan-1-ol |
| 3,4-dimethylpentan-1-ol | 4,4-dimethylpentan-1-ol | 2,3-dimethylpentan-2-ol | 2,4-dimethylpentan-2-ol |
| 3,3-dimethylpentan-2-ol | 3,4-dimethylpentan-2-ol | 4,4-dimethylpentan-2-ol | 2,2-dimethylpentan-3-ol |
| 2,3-dimethylpentan-3-ol | 2,4-dimethylpentan-3-ol | 2,2,3-trimethylbutan-1-ol | 2,3,3-trimethylbutan-1-ol |
| 2,3,3-trimethylbutan-2-ol | 3-ethylpentan-1-ol | 3-ethylpentan-2-ol | 3-ethylpentan-3-ol |
| 2-ethyl-2-methylbutan-1-ol | 2-ethyl-3-methylbutan-1-ol | | |

**4b(i)** 35-45

| Triglyceride | Glyceryl trilinoleate | Glyceryl tricaprate | Difference |
|---|---|---|---|
| Number of Carbons | 57 carbons | 33 carbons | 24 carbons |
| Absorbance Units | 19.3 | 16.1 | 3.2 |

3.2 difference in absorbance units = 24 carbons

Glyceryl trilaurate = 17.5 absorbance units (1.4 units above Glyceryl tricaprate)

1.4 difference in absorbance units = $24 \times {}^{1.4}/_{3.2} = 10.5$ carbons

$\therefore$ Estimate of number of carbons in glyceryl trilaurate = 24 + 11 = 35

**4b(ii)** glyceryl trilinoleate

The lower the melting point, the higher the number of C=C double bonds in molecule.
Oil molecules do not fit as close together due to the change of direction in the carbon chain after a C=C double bond. The further apart the molecules are, the lower the melting point as less energy is needed to separate the molecules into a liquid as there are weaker van der Waals' between oil molecules.

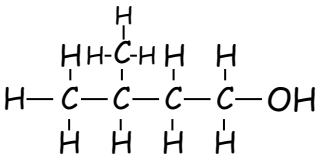
**4c(i)** by react with glycerol

Fatty acids from edible oils react with glycerol by condensation reaction. One or two fatty acids react with glycerol to form an emulsifier. This will leave at least one polar -OH group on the glycerol part of the molecule needed to form the hydrophilic head on the emulsifier.

**4c(ii)** Answer to include:

| | |
|---|---|
| 1st Mark: | Correctly identifying that the 2 emulsifier has two parts with different polarities or two parts that are hydrophobic/hydrophilic. |
| 2nd Mark: | Hydrophobic part / hydrocarbon chain / fatty acid chain / non-polar part — dissolves in non-polar liquids; hydrophilic part / hydroxyl groups / polar part — dissolves in polar liquids |

**5a** 3-methylbutan-1-ol



3-methylbutan-1-ol

3-methylbutan-1-ol

methyl $-CH_3$ on $C_3$ of main chain | four carbons on main chain | $-OH$ group on $C_1$

**5b(i)**

$C_3H_7OH \downarrow C_3H_6O + 2H^+ + 2e^-$

Step 1: Write down main species in reaction

$C_3H_7OH \rightarrow C_3H_6O$

Step 2: Balance all atoms other than O or H (no change in this example)

$C_3H_7OH \rightarrow C_3H_6O$

Step 3: Balance O atoms by adding $H_2O$ to the other side (no change in this example)

$C_3H_7OH \rightarrow C_3H_6O$

Step 4: Balance H atoms by adding $H^+$ to the other side

$C_3H_7OH \rightarrow C_3H_6O + 2H^+$

Step 5: Balance charge by adding electrons to the most positive side

$C_3H_7OH \rightarrow C_3H_6O + 2H^+ + 2e^-$

**5b(ii)** To provide $H^+$ ions

$H^+$ ions are a reactant on the left hand side of the equation. If the reactants are not acidified than one of the reactants will be absent and the chemical reaction will not proceed.

**5b(iii)** orange → green

| Oxidising Agent | Start Colour | End Colour |
|---|---|---|
| Acidified Dichromate | Orange | Green |
| Fehling's Solution | Blue | Brick Red (orange) |
| Hot copper (II) oxide | Black | Brown |
| Tollen's Reagent | (Colourless) | Silver mirror produced |

**5b(iv)** Tollen's Reagent

| Oxidising Agent | Reactant(s) | | Product(s) |
|---|---|---|---|
| Acidified Dichromate | $Cr_2O_7^{2-} + 14H^+ + 6e^-$ | → | $2Cr^{3+} + 7H_2O$ |
| Fehling's Solution | $Cu^{2+} + e^-$ | → | $Cu^+$ |
| Hot copper (II) oxide | $Cu^{2+} + 2e^-$ | → | $Cu$ |
| Tollen's Reagent | $Ag^+ + e^-$ | → | $Ag$ |

**5b(v)** tertiary alcohols (do not oxidise)

| Oxidation of Alcohols | | | | |
|---|---|---|---|---|
| | Primary alcohol | → | Aldehyde | → Carboxylic acid |
| | Secondary alcohol | → | Ketone | ✗ [No oxidation] |
| | Tertiary alcohol | ✗ | [No oxidation] | |

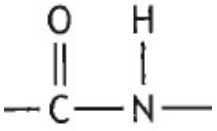
**5b(vi)** 1 : 10 / 1 : 8

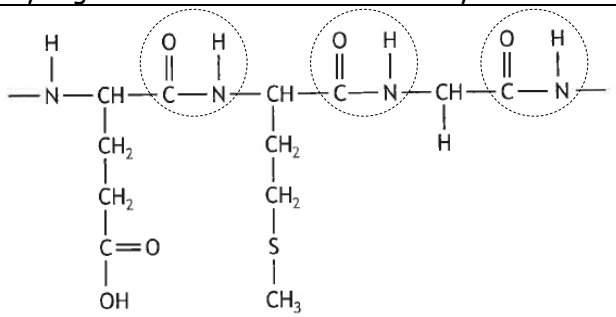
| Chemical | Formula | No. of O | No. of H | Oxygen : Hydrogen ratio |
|---|---|---|---|---|
| butan-1-ol | $C_4H_9OH$ | 1 | 10 | 1:10 |
| butanal | $C_4H_8O$ | 1 | 8 | 1:8 |

**6a(i)** biological catalyst

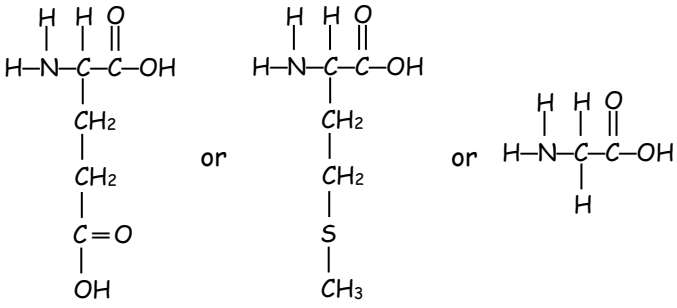
An enzyme is a specially-shaped protein which acts as a biological catalyst, catalysing chemical reactions in the body at 37°C.

**6a(ii)A** one peptide link circled:





**6a(ii)B** one amino acid structure from:



**6a(ii)C** amino acid which must be obtained through diet

Essential amino acids are amino acids which must be obtained from your diet for a healthy diet to be obtained. These amino acids cannot be made by the body.

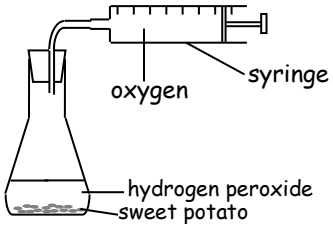
**6a(ii)D** condensation

A condensation reaction occurs when two molecules join together to form a bigger molecule and water is removed at the join.
Other small molecules can also be removed instead of water.

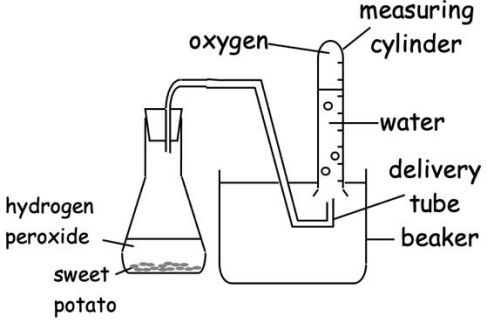
**6a(iii)** Answer to include:

| | |
|---|---|
| 1st Mark: | enzyme becomes denatured/enzyme changes shape |
| 2nd Mark: | Intermolecular/hydrogen bonds are broken |

**6a(iv)** Answer to include one of:




or



## 6b(i)

one answer from:

| | | |
|---|---|---|
| To prevent unwanted oxidation | to oxidise in place of the compounds they have been added to protect | to stop (oxidation of edible oils) food acquiring a rancid flavour. |

## 6b(ii)

answer to include:

| | | | |
|---|---|---|---|
| 1st Mark: | Vitamin C molecule is polar due to its hydroxyl groups | or | Vitamin C can form hydrogen bonds due to its hydroxyl groups |
| 2nd Mark: | Vitamin C is soluble in water because of interactions of polar -OH groups in Vitamin C with polar -OH groups in water. | | |

## 6c

975g

2 marks for mass
1 mark for units

1kg body weight ↔ 3mg solanine
65kg body weight ↔ 3mg solanine x $^{65}/_{1}$
=195g solanine

0.2mg solanine ↔ 1g of potato
195mg solanine ↔ 1g of potato x $^{195}/_{0.2}$
= 975g of potato

## 7a

0.203g

Heat Energy = Specific Heat Capacity x Mass x Change In Temperature

$E_h = c \times m \times \Delta T$

$E_h = 4.18\ kJ\ kg^{-1}\ ^oC^{-1} \times 0.1kg \times 27^oC$

$E_h = 11.3\ kJ$

gfm Heptane $CH_4$ = (1x12) + (4x1) = 12 + 4 = 16g

1 mol $CH_4$ = 891 kJ ⟷ 16g

11.3 kJ ⟷ 16g x $^{11.3}/_{891}$

= 0.203g

## 7b

-816

| Bond Breaking Steps (endothermic) | | Bond Forming Steps (exothermic) | |
|---|---|---|---|
| 4xC-H bonds | 4x 412kJ = 1648kJ | 2xC=O bonds | 2x 804kJ = 1608kJ |
| 2xO=O bond | 2x 498kJ = 996kJ | 4xO-H bonds | 4x 463kJ = 1852kJ |
| Total bond breaking | = 2644kJ | Total bond Forming | = 3460kJ |

Enthalpy change = ∑Bond Breaking Steps – ∑Bond forming steps = 2644 - 3460 = -816kJ $mol^{-1}$

## 7c

17.6%

$$\text{atom economy} = \frac{\text{mass of useful products}}{\text{total mass of reactants}} \times 100 = \frac{(3x2)}{(1x16)+(1x18)} \times 100 = 17.6\%$$

## 7d

High
Low

| Change in Temperature | Change In Pressure |
|---|---|
| Maximising Yield of $NO_2$ = more reverse reaction<br>• reverse reaction is endothermic<br>• Increasing temperature favours the endothermic reaction<br>• HIGH temperature increases reverse reaction<br>• HIGH temperature increases yield of $NO_2$ | Maximising Yield of $NO_2$ = more reverse reaction<br>• reverse reaction increases pressure (1vol→2vol)<br>• Decreasing pressure favours the pressure-increasing reaction<br>• LOW pressure increases reverse reaction<br>• LOW pressure increases yield of $NO_2$ |

## 7e(i)

-4632

❶ $C_{(s)} + 3H_{2(g)} + N_{2(g)} \rightarrow CH_3NHNH_{2(l)}$ $\Delta H$=+54 kJ $mol^{-1}$

❷ $N_{2(g)} + 2O_{2(g)} \rightarrow N_2O_{4(g)}$ $\Delta H$=-20 kJ $mol^{-1}$

❸ $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\Delta H$=-394 kJ $mol^{-1}$

❹ $H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$ $\Delta H$=-286 kJ $mol^{-1}$

❺ $H_2O_{(l)} \rightarrow H_2O_{(g)}$ $\Delta H$=+41 kJ $mol^{-1}$

❶x-4 $4CH_3NHNH_{2(l)} \rightarrow \cancel{4C_{(s)}} + \cancel{12H_{2(g)}} + 4N_{2(g)}$ $\Delta H$=-216 kJ $mol^{-1}$

❷x-5 $5N_2O_{4(g)} \rightarrow 5N_{2(g)} + \cancel{10O_{2(g)}}$ $\Delta H$=+100 kJ $mol^{-1}$

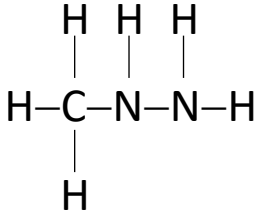
❸x4 $\cancel{4C_{(s)}} + \cancel{4O_{2(g)}} \rightarrow 4CO_{2(g)}$ $\Delta H$=-1576 kJ $mol^{-1}$

❹x12 $\cancel{12H_{2(g)}} + \cancel{6O_{2(g)}} \rightarrow 12H_2O_{(l)}$ $\Delta H$=-3432 kJ $mol^{-1}$

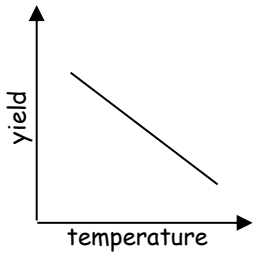
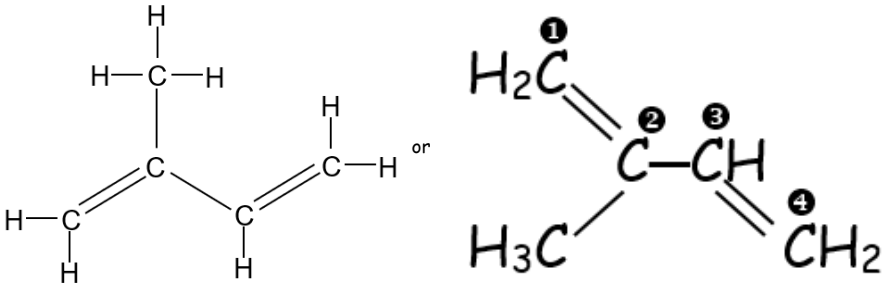
❺x12 $\cancel{12H_2O_{(l)}} \rightarrow 12H_2O_{(g)}$ $\Delta H$=+492 kJ $mol^{-1}$

add $5N_2O_{4(g)} + 4CH_3NHNH_{2(l)} \rightarrow 4CO_{2(g)} + 12H_2O_{(g)} + 9N_{2(g)}$ $\Delta H$=-4632 kJ $mol^{-1}$

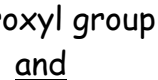
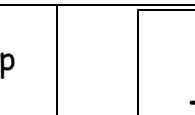
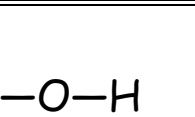
## 7e(ii)



| Element | Valency | No of Bonds made by element |
|---|---|---|
| C | 4 | 4 |
| N | 3 | 3 |
| H | 1 | 1 |

<table>
<tr><td>8a(i)</td><td>increase<br>increase<br>no effect</td><td>A catalyst increases the rate of both the forward and reverse reactions by lowering the activation energies of both the forward and reverse reactions. The position of equilibrium is not changed but the time to get to equilibrium is shortened.</td></tr>
<tr><td>8a(ii)</td><td> 
</td><td>The forward reaction in the water-gas shift reaction is exothermic.<br>• Increasing the temperature favours the endothermic reaction<br>• Reverse reaction is endothermic<br>• Reverse reaction is favoured by increasing the temperature<br>• Less products formed as temperature increase<br>• Graph has decreasing slope as yield decreases as temperature increases</td></tr>
<tr><td>8b</td><td>Calculation showing:</td><td>gfm sorbic acid $C_6H_8O_2$ = (6x12)+(8x1)+(2x16) = 72 + 8 + 32 = 112<br>$\text{no. of mol} = \frac{\textbf{mass}}{\textbf{gfm}} = \frac{7}{112} = 0.0625\text{mol}$ (available)<br>n KOH = volume x concentration = $0.25_{\text{litres}} \times 0.5_{\text{mol l}^{-1}} = 0.125\text{mol}$<br>$C_6H_8O_2 + KOH \longrightarrow H_2O + C_6H_7O_2$<br>1mol<br>0.125mol<br>(required)<br>Less no. of mol of sorbic acid available than is required<br>∴ Sorbic acid is limiting reactant and KOH is in excess</td></tr>
<tr><td>8c</td><td>$2.52\text{x}10^{-5}$<br>or<br>0.0000252</td><td>1% = 1g per $100\text{cm}^3$<br>0.002% = 0.002g per $100\text{cm}^3$<br>$100\text{cm}^3 = 0.002\text{g}$<br>$330\text{cm}^3 = 0.002\text{g} \times {}^{330}/_{100} = 0.0066\text{g}$<br>gfm = 261.8g<br>$\text{no. of mol} = \frac{\textbf{mass}}{\textbf{gfm}} = \frac{0.0066}{261.8} = 2.52\text{x}10^{-5}\text{ mol}$</td></tr>
<tr><td>8d(i)A</td><td>non-water soluble<br>or<br>volatile<br>or<br>aroma</td><td>Essential oils are concentrated extracts of volatile, non-water soluble aroma compounds from plants<br>• mixtures of many different compounds.<br>• widely used in<br><table><tr><td>perfumes</td><td>cosmetic products</td><td>cleaning products</td><td>flavourings in foods</td></tr></table></td></tr>
<tr><td>8d(i)B<br>Part I</td><td>terpene</td><td>Terpenes are key components in most essential oils.<br>Terpenes are unsaturated compounds formed by joining together isoprene (2-methylbuta-1,3-diene) units.</td></tr>
<tr><td>8d(i)B<br>Part II</td><td>correct structure drawn of<br>2-methylbut-1,3-diene</td><td> 
</td></tr>
<tr><td>8d(i)B<br>Part III</td><td>3</td><td>Formula of zingiberene: $C_{15}H_{24}$<br>Formula of isoprene: $C_5H_8$<br>∴ 3 isoprene units join together</td></tr>
<tr><td>8d(ii)A</td><td>water or $H_2O$</td><td>The difference between the two molecules is the a C=C double bond is formed in the product and an H atom was removed on one side where the C=C double bond formed and a OH group was removed from the other side of where the C=C double bond formed.</td></tr>
</table>

**8d(ii)B** — Hydroxyl group and Carbonyl Group

|  |  |  |
|---|---|---|
| hydroxyl group | carboxyl group | carbonyl group |

**9** — Open Question Answer to Include:

| 3 mark answer | 2 mark answer | 1 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. | Demonstrates a **reasonable understanding** of the chemistry involved, making some statement(s) which are relevant to the situation, showing that the problem is understood. | 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. |

**10a(i)** — One from:

| | |
|---|---|
| Higher the number of chlorine atoms the higher the ODP | Lower the number of chlorine atoms the lower the ODP |
| Lower the number of fluorine atoms the higher the ODP | Higher the number of fluorine atoms the lower the ODP |

**10a(ii)** — 1+5

Refrigerant Compound 1 has 2 carbons, 4 fluorines and 2 bromines
Refrigerant Compound 1 has 2 carbons, 4 fluorines and 2 chlorines

**10a(iii)** — Carbon dioxide and ammonia do not contain halogens or Carbon dioxide and ammonia do not damage the ozone layer

$CO_2$ and $NH_3$ lack group 7 elements (halogen) atoms in their structure.
All refrigerant compounds in table have halogen atoms in their structure.

**10b(i)** — Species (atoms/molecules/particles) with unpaired electron

Free radicals are atoms or molecules that are highly reactive due to the presence of an unpaired electron.

**10b(ii)A** — Initiation

| Step | Reactants (before Arrow) → Products (after Arrow) |
|---|---|
| Initiation | No free radicals on Reactant Side → Free radicals on Product Side |
| Propagation | Free Radicals found on both sides of arrow |
| Termination | Free radicals on Reactant Side → No free radicals on Product Side |

**10b(ii)B** — One from:

$$CH_3F + F^\bullet \longrightarrow {}^\bullet CH_2F + HF$$

$$^\bullet CH_2F + F_2 \longrightarrow CH_2F_2 + F^\bullet$$

$$F_2 + {}^\bullet CH_3 \longrightarrow CH_3F + F^\bullet$$

$$^\bullet CH_2F + HF \longrightarrow CH_2F_2 + H^\bullet$$

**10c** — 0.208

0.05kg → 0.025kg difluoromethane
0.05kg → 0.025kg pentafluoroethane

$$\text{no. of mol} = \frac{\textbf{mass}}{\textbf{gfm}} = \frac{25g}{120\ g\ mol^{-1}} = 0.208\ \text{mol}$$

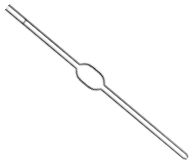
**11a(i)** — water and carbon dioxide

copper (II) carbonate + ethanoic acid → copper (II) ethanoate + water + carbon dioxide

metal carbonate + acid → salt + water + carbon dioxide

**11a(ii)** — $Cu^{2+}(CH_3COO^-)_2$

Copper (II) has a valency of 2 and forms $Cu^{2+}$ ions
Ethanoate ions has a formula of $CH_3COO^-$ and valency of 1.
Formula of copper (II) ethanoate is $Cu(CH_3COO)$.
Ionic formula of copper (II) ethanoate is $Cu^{2+}(CH_3COO^-)_2$

<table>
<tr><td>11b</td><td>Answer to include:</td><td>
<table>
<tr><td>1 mark</td><td>1mark</td><td>1mark</td></tr>
<tr><td>Dissolve oxalic acid (in a small volume of deionised water)</td><td>Transfer quantitatively oxalic acid solution to standard/volumetric flask including rinsings/washings</td><td>Fill volumetric/standard flask up to mark (with deionised water)</td></tr>
</table>
</td></tr>
<tr><td>11c(i)</td><td>  </td><td>Volumetric bulb pipette to be drawn showing:<br>• volumetric mark/line<br>• end of pipette must narrow to a point<br>A graduated pipette would also be acceptable.</td></tr>
<tr><td>11c(ii)</td><td>pink → colourless</td><td>Colour in conical flask at start: <u>pink</u> as sodium hydroxide solution is in conical flask at start and phenolphthalein is pink in alkaline conditions<br>Colour in conical flask at end: <u>colourless</u> as sodium hydroxide in conical flask has been neutralised by the addition of oxalic acid from the burette. Phenolphthalein is colourless in acidic/neutral conditions</td></tr>
<tr><td>11c(iii)</td><td>concordant</td><td>Results in a titration are described as concordant when the individual titres are within 0.2cm$^3$ of each other. This ignores the rough titre and any rogue results.</td></tr>
<tr><td>11d</td><td>0.27</td><td>Oxalic acid no. of mol = volume x concentration = $0.02675_{litres} \times 0.126_{mol\ l^{-1}} = 0.00337$mol<br>$H_2C_2O_4 + 2NaOH \longrightarrow Na_2C_2O_4 + 2H_2O$<br>1mol 2mol<br>0.00337mol 0.00674mol<br>concentration = $\frac{\textbf{n}\text{o. of mol}}{\textbf{v}\text{olume}} = \frac{0.00674_{mol}}{0.025_{litres}} = 0.270\ \text{mol}\ l^{-1}$</td></tr>
</table>