JABchem

Past Papers Higher Chemistry

2011

Marking Scheme

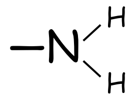
Grade Awarded	Mark Required (/100)	% candidates achieving grade
A	69+	28.7%
B	56+	23.6%
C	43+	24.4%
D	36+	10.1%
No award	<36	13.2%

Section:	Multiple Choice	Extended Answer
Average Mark:	25.4 /40	31.4 /60

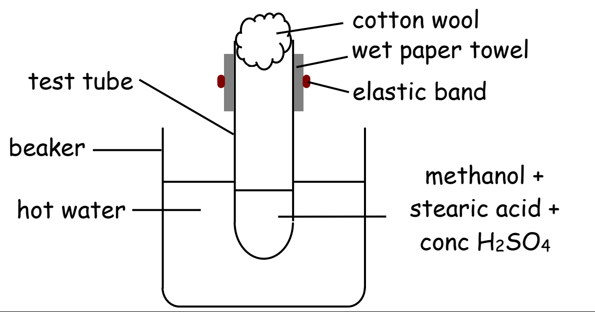
2011 Higher Chemistry Marking Scheme

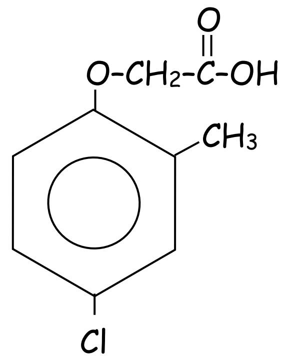
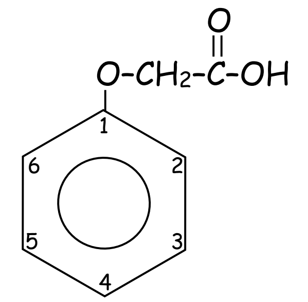
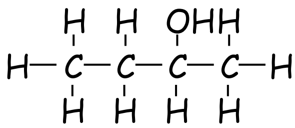
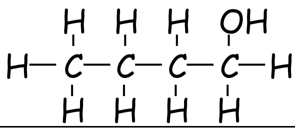
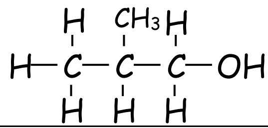
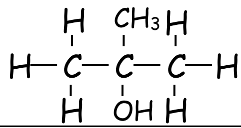
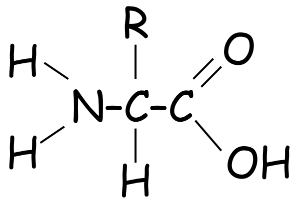
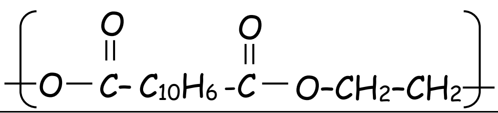
<table>
<tr><th>MC Qu</th><th>Answer</th><th>% Pupils Correct</th><th>Reasoning</th></tr>
<tr><td>1</td><td>D</td><td>86</td><td>☒A Bromine has the formula Br_2 and has diatomic molecules
☒B Methane has the formula CH_4 and has pentatomic molecules
☒C Hydrogen has the formula H_2 and has diatomic molecules
☑D Helium is monatomic as it is a Noble Gas in group 0 and has the formula He</td></tr>
<tr><td>2</td><td>A</td><td>56</td><td>☑A Isotopes have same number of electrons so have same electron arrangement
☒B Isotopes have different numbers of neutrons ∴ have different nuclei
☒C Isotopes have different numbers of neutrons
☒D Isotopes have different numbers of neutrons ∴ have different mass numbers</td></tr>
<tr><td>3</td><td>A</td><td>62</td><td>☑A No precipitate: copper (II) sulphate and lithium chloride are both soluble
☒B Insoluble zinc carbonate precipitate formed
☒C Insoluble silver nitrate precipitate formed
☒D Insoluble magnesium phosphate precipitate formed</td></tr>
<tr><td>4</td><td>D</td><td>44</td><td><table>
<tr><td>Carbohydrate</td><td>Glucose</td><td>Fructose</td><td>Maltose</td><td>Sucrose</td><td>Starch</td></tr>
<tr><td>Formula</td><td>$C_6H_{12}O_6$</td><td>$C_6H_{12}O_6$</td><td>$C_{12}H_{22}O_{11}$</td><td>$C_{12}H_{22}O_{11}$</td><td>$(C_6H_{10}O_5)_n$</td></tr>
<tr><td>Reaction with Benedict's</td><td>Turns brick red</td><td>Turns brick red</td><td>Turns brick red</td><td>No reaction</td><td>No reaction</td></tr>
</table></td></tr>
<tr><td>5</td><td>B</td><td>77</td><td>☒A 1mol F_2 = 38g ∴ no. of mol = $^{mass}/_{gfm}$ = $^{100}/_{38}$ = 2.63mol ∴ least molecules
☑B 1mol H_2 = 2g ∴ no. of mol = $^{mass}/_{gfm}$ = $^{100g}/_{2}$ = 50.0mol ∴ most molecules
☒C 1mol N_2 = 28g ∴ no. of mol = $^{mass}/_{gfm}$ = $^{100g}/_{28}$ = 3.57mol
☒D 1mol O_2 = 32g ∴ no. of mol = $^{mass}/_{gfm}$ = $^{100g}/_{32}$ = 3.13mol</td></tr>
<tr><td>6</td><td>D</td><td>70</td><td>☒A E_a stays the same and number of successful collisions decreases at lower temperatures
☒B Activation Energy (E_a) does not change as temperature increases
☒C Activation Energy (E_a) does not change as temperature increases
☑D E_a stays the same and number of successful collisions decreases at lower temperatures</td></tr>
<tr><td>7</td><td>B</td><td>53</td><td>$Zn + 2AgNO_3 \longrightarrow Zn(NO_3)_2 + 2Ag$
1mol 2mol 2mol
0.025mol 0.05mol 0.05mol
☒A Only 0.025mol of Zn will react with 0.05mol of silver nitrate solution
☑B 0.05mol of silver is displaced in the reaction above
☒C All silver nitrate solution is reacted and 0.075mol of Zn left in excess
☒D Only 0.025mol of the 1mol of Zn reacts with 0.05mol of silver nitrate solution</td></tr>
<tr><td>8</td><td>C</td><td>52</td><td>☒A $S_2O_8^{2-}$ ions are used up (reactant) and become SO_4^{2-} ions (product)
☒B I^- ions are used up (reactant) and become I_2 molecules (product)
☑C Fe^{2+} ions act as catalyst as they are not used up in the overall reaction
☒D $S_2O_8^{2-}$ ions are used up (reactant) and become SO_4^{2-} ions (product)</td></tr>
<tr><td>9</td><td>C</td><td>62</td><td>ΔH for forward reaction= 130-210kJ mol^{-1} = -80kJ mol^{-1}
E_a forward reaction (catalysed) = E_a reverse reaction (catalysed) + ΔH (forward reaction)
= 180 – 80 kJ mol^{-1}
= 100kJ mol^{-1}</td></tr>
<tr><td>10</td><td>A</td><td>72</td><td>☑A enthalpy of combustion is the energy released from the complete combustion of 1 mol
☒B ethanoic acid CH_3COOH is not a product of complete combustion
☒C ethanoic acid CH_3COOH is not a product of complete combustion
☒D carbon monoxide formed but complete combustion required for enthalpy of combustion</td></tr>
<tr><td>11</td><td>C</td><td>87</td><td>☒A potassium atom is larger than sodium atom as K has more occupied electron shells
☒B potassium atom is larger than sodium atom as K has more occupied electron shells
☑C potassium atom is larger than sodium atom as K has more occupied electron shells
☒D ionisation energy is dependent on atom size not the other way around.</td></tr>
<tr><td>12</td><td>C</td><td>80</td><td>Hydrogen has an electronegativity of 2.2 and will form a non-polar covalent bond with an element with the same electronegativity as itself.</td></tr>
</table>

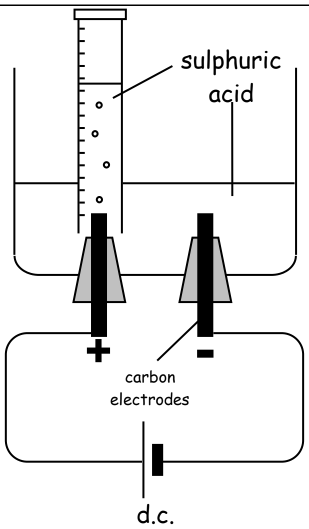
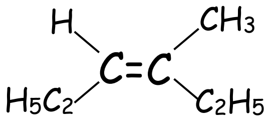
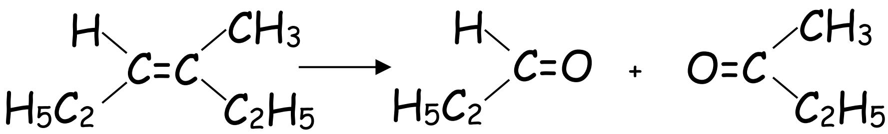
13	A	75	☑A ionic substances conduct electricity when molten (but not when solid) ☒B ionic substances and polar covalent substances can both dissolve in polar solvents ☒C ionic, most metallic and some covalent substances are solid at room temperature ☒D ionic and covalent network substances have high boiling points
14	D	58	0.1mol Cl^- ∴ 0.1mol K^+ in K^+Cl^- 0.1mol CO_3^{2-} ∴ 0.2mol K^+ in $(K^+)_2CO_3^{2-}$ = 0.3mol of K^+
15	C	61	☒A 1mol H_2 = 2g ∴ no. of mol = $^{mass}/_{gfm}$ = $^{1g}/_{2}$ = 0.5mol H_2 ☒B 1mol N_2 = 28g ∴ no. of mol = $^{mass}/_{gfm}$ = $^{14g}/_{28}$ = 0.5mol N_2 ☑C 1mol Ne = 20.2g ∴ no. of mol = $^{mass}/_{gfm}$ = $^{20.2g}/_{20.2}$ = 1mol Ne ∴ most volume ☒D 1mol Cl_2 = 71g ∴ no. of mol = $^{mass}/_{gfm}$ = $^{35.5g}/_{71}$ = 0.5mol Cl_2
16	D	49	$C_4H_{10}(g) + 6\frac{1}{2}O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(g)$ 1mol 6.5mol 4mol 5mol 1vol 6.5vol 4vol 5vol $20cm^3$ $130cm^3$ $80cm^3$ $100cm^3$ (+$20cm^3$ O_2 leftover) Final Volume = $80cm^3$ CO_2 + $20cm^3$ leftover O_2 + $100cm^3$ $H_2O_{(g)}$ = $200cm^3$
17	D	87	☒A cyclo-ring structures help prevent knocking by keeping hydrocarbon molecules apart ☒B aromatic ring structures help prevent knocking by keeping hydrocarbon molecules apart ☒C branched structures help prevent knocking by keeping hydrocarbon molecules apart ☑D straight chain structures can lead to knocking as the molecules get too close together
18	A	96	☑A hydrogen does not produced carbon dioxide when burned ∴ no effect on global warming ☒B natural gas CH_4 burns to form carbon dioxide ∴ contributes to global warming ☒C petrol burns to form carbon dioxide ∴ contributes to global warming ☒D coal burns to form carbon dioxide ∴ contributes to global warming
19	C	61	☒A Possible products include: 1-chlorohexane, 2-chlorohexane and 3-chlorohexane ☒B Possible products include: 1-chlorohex-1-ene, 2-chlorohex-1-ene, 3-chlorohex-1-ene, etc ☑C Whichever carbon the chlorine joins on to, it will be numbered carbon number 1 ☒D Possible products include: 1-chlorocyclohexene and 3-chlorocyclohexene, 4-chlorocyclohexene
20	B	71	☒A Methanol contains the hydroxyl –OH group ☑B Methanal contains the aldehyde –CHO group ☒C Methanoic Acid contains the carboxyl –COOH group ☒D Methanone does not exist as ketones have a minimum of three carbons
21	B	59	☒A Pentan-2-one has the formula $C_5H_{10}O$ ∴ not an isomer of ethyl propanoate $C_5H_{10}O_2$ ☑B Pentanoic acid has the formula $C_5H_{10}O_2$ ∴ isomer of ethyl propanoate $C_5H_{10}O_2$ ☒C methyl propanoate has the formula $C_4H_8O_2$ ∴ not an isomer of ethyl propanoate $C_5H_{10}O_2$ ☒D Pentane-1,2-diol has the formula $C_5H_{12}O_2$ ∴ not an isomer of ethyl propanoate $C_5H_{10}O_2$
22	A	62	Step 1 – Cracking – Creation of C=C double bond as molecule get (slightly) smaller Step 2 – Hydration – Adding water across a C=C double bond
23	C	47	☒A propanone is a ketone and cannot not oxidised by hot copper (II) oxide ☒B paraffin is an hydrocarbon and cannot oxidised by hot copper (II) oxide ☑C Propan-1-ol oxidises to form propanoic acid, which turns pH indicator red ☒D Propan-2-ol oxidises to form propanone, which does not turn pH indicator red
24	B	44	☒A ketones do not hydrolyse with sodium hydroxide solution ☑B methyl propanoate (an ester) is hydrolysed by sodium hydroxide ☒C secondary alcohols do not hydrolyse with sodium hydroxide solution ☒D aldehydes do not hydrolyse with sodium hydroxide solution
25	D	79	☒A aldehydes are not used as flavourings ☒B carboxylic acids are not used as flavourings ☒C secondary alcohols are not used as flavourings ☑D esters are used as flavourings, solvents and perfumes
26	D	57	Question – Answer – Reasoning Process X – Steam Reforming – Coal and natural gas turn into synthesis gas ($CO+H_2$) by steam reforming Substance Y – Methanal – Methanol is a primary alcohol and is oxidised to methanal

27	B	49	Functional Group for Amine: 
28	B	55	☒A –OH group at *8 o'clock* in benzene is not needed for blood pressure increase ☑B structure contains all common groups between noradrenaline and phenylephrine ☒C no other groups beyond -NH group necessary for blood pressure increase ☒D molecule is missing –OH group at bottom of benzene ring
29	D	82	☒A kevlar is a very strong polymer and used in bullet-proof vests ☒B biopol is a biodegradable polymer ☒C poly(ethenol) is soluble in water ☑D poly(vinylcarbazole) is a photoconductive polymer used in photocopiers
30	C	65	☒A Fats are triesters made when glycerol and fatty acids join together ☒B Oils are triesters made when glycerol and fatty acids join together ☑C Enzymes are specifically-shaped proteins which catalyse reactions in living things ☒D Amino acids join together to make proteins
31	B	89	☒A Glycol is a product of the reaction (feedstocks are reactants) ☑B Ethene and Ethanol are reactants and feedstocks in this reaction ☒C Glycol and poly(ethene) are products of the reaction (feedstocks are reactants) ☒D Glycol and poly(ethene) are products of the reaction (feedstocks are reactants)
32	D	51	Evaporation of $K_{(s)}$: $K_{(s)} \rightarrow K_{(g)}$ = 88kJ mol^{-1} 1st Ionisation Energy: $K_{(g)} \rightarrow K^{+}_{(g)} + e^{-}$ = 425kJ mol^{-1} 2nd Ionisation Energy: $K^{+}_{(g)} \rightarrow K^{2+}_{(g)} + e^{-}$ = 3060kJ mol^{-1} Overall Reaction: $K_{(s)} \rightarrow K^{2+}_{(g)} + 2e^{-}$ = 88+425+3060 = 3573 kJ mol^{-1}
33	D	40	☒A ester and water (flask B) break down as reverse reaction proceeds ☒B ester and water (flask B) break down as reverse reaction proceeds ☒C Flask A contains both reactants and products as reaction is not 100% ☑D Both flasks contain reactants and products as the reaction is reversible
34	A	48	Increased solubility of ammonia in water is caused by more forward reaction: Change to: Pressure — Effect: Increase in pressure favours forward reaction which decreases pressure Change to: Temperature — Effect: Decrease in temperature favours exothermic forward reaction
35	B	64	Acid: 0.1mol l^{-1} acid with pH=4 ∴ **weak acid** (NB a strong acid at 0.1mol l^{-1} would have pH=1) Alkali: pH=11 ∴ $[H^+] = 10^{-11}$ mol l^{-1} ∴ $[OH^-]=10^{-3}$ mol l^{-1} (= 0.001mol l^{-1}) ∴ **strong alkali**
36	C	45	☒A NH_4Cl is acidic ∴ concentrations of $H^+_{(aq)}$ and $OH^-_{(aq)}$ are not equal ☒B Na_2CO_3 is alkaline ∴ concentrations of $H^+_{(aq)}$ and $OH^-_{(aq)}$ are not equal ☑C KNO_3 is neutral ∴ concentrations of $H^+_{(aq)}$ and $OH^-_{(aq)}$ are equal ☒D $CH_3COO^-K^+$ is alkaline ∴ concentrations of $H^+_{(aq)}$ and $OH^-_{(aq)}$ are not equal
37	C	74	Write down the main species involved in the reaction: $IO_3^- \rightarrow I_2$ Balance all atoms except O and H: $2IO_3^- \rightarrow I_2$ Add H_2O to other side to balance O atoms: $2IO_3^- \rightarrow I_2 + 6H_2O$ Add H^+ ions to other side to balance H atoms: $2IO_3^- + 12H^+ \rightarrow I_2 + 6H_2O$ Add e^- to most positive side to balance charge: $2IO_3^- + 12H^+ + 10e^- \rightarrow I_2 + 6H_2O$
38	A	56	❶x2 $2NO_3^- + 8H^+ + 6e^- \rightarrow 2NO + 4H_2O$ ❷x3 $3Zn \rightarrow 3Zn^{2+} + 6e^-$ Add ❶'+❷' $2NO_3^- + 8H^+ + 3Zn \rightarrow 2NO + 4H_2O + 3Zn^{2+}$ 2mol 3mol $^2/_3$mol 1mol
39	B	54	☒A equal no. of moles of each metal are produced but metals have different gfm ☑B equal no. of moles of each metal are produced ∴ equal number of metal atoms ☒C metals are positive ions which are deposited on the negative electrode ☒D equal number of moles of each metal are produced
40	A	65	☑A Alpha radiation stopped by smoke particles and long half-life for device long life ☒B Gamma radiation would not be stopped by smoke particles and cannot be used ☒C A short half-life would mean the smoke-detector would not work for long ☒D Gamma radiation would not be stopped by smoke particles and cannot be used

2011 Higher Chemistry Marking Scheme

Long Qu	Answer	Reasoning
1a	homogeneous	Homogeneous: Catalyst in *same* state as the reactants Heterogeneous: Catalyst in *different* state from the reactants
1b(i)	0.0015	Rate = $\frac{\Delta quantity}{\Delta time} = \frac{1.80 - 1.20}{400 - 0} = \frac{0.6 \text{ mol l}^{-1}}{400 \text{ s}}$ = 0.0015 mol l^{-1} min^{-1}
1b(ii)	Line drawn showing:	Steeper gradient going down | Curving off to finish at similar concentration
2a(i)	Electrons are closer to nucleus and harder to remove	Across a period, atoms are smaller due to increased nuclear charge • Electrons harder to remove if they are closer to nucleus • Increase in 1st ionisation energy
2a(ii)	$Cl(g) \longrightarrow Cl^{+}(g) + e^{-}$	1st Ionisation energy is the removal of 1 mole of electrons from 1 mol of atoms in the gaseous state.
2b	Noble gas already have full outer shell	Noble gases already have full outer shell and do not have to form bonds to achieve a full outer shell. Electronegativity is a measure of the attraction for electrons so noble gases have no measurable attraction for electrons.
3a	Covalent networks have high melting points	Ionic bonding always has a high melting point but covalent bonding has two subtypes: • Covalent molecular (sometimes called discrete covalent) have low melting points as there are only weak bonds between the molecules. • Covalent networks have high melting points as covalent in network bonds must be broken to melt the substance.
3b	Ionic bonding is a lattice of ions with no bonds between ions	Ionic bonding is held together due to the electrostatic attraction between positive and negative ions. The formula $MgCl_2$ is the simplest ratio of Mg^{2+} ion to Cl^{-} ions and does not represent $MgCl_2$ molecules within substance.
4a	2,2,4-trimethylpentane	**2,2,4-trimethylpentane** 2,2,4: Three side groups on C_2, C_2 and C_4 trimethyl: Three $-CH_3$ methyl side groups pent: Five carbons on main chain ane: Single Bonds on main chain
4b	Smaller molecules used in winter	In the colder months of winter, hydrocarbons are less volatile and harder to catch fire. Smaller, more volatile hydrocarbons are added to petrol in winter to increase the volatility of the petrol.
4c	Explanation detailing:	 After 10 minutes, contents poured into beaker containing sodium hydrogencarbonate solution. Ester floats on top
5a	0.286g	no. of mol = $\frac{\text{Volume}}{\text{Molar Volume}} = \frac{0.096\text{litres}}{24\text{litres mol}^{-1}}$ = 0.004mol $Ca(OCl)_2 + 2HCl \longrightarrow Ca(OH)_2 + 2Cl_2$ 1mol → 2mol 0.002mol → 0.004mol 1mol $Ca(OCl)_2$ = (1x40)+(2x16)+(2x35.5) = 40+32+71 = 143g **m**ass = **n**o. of mol x **gfm** = 0.002mol x 143 g mol^{-1} = 0.286g

5b		phenoxyethanoic acid part of the molecule is the same:  2,4-dichloro sidegroups becomes 4-chloro and 2-methyl i.e. chlorine atom on carbon 4 is the same but chlorine atom on carbon 2 becomes a $-CH_3$ methyl group.
6a		Butan-2-ol is a secondary alcohol as it has 2 carbons directly attached to the carbon with the –OH group. There are three alcohol isomers of butan-2-ol: butan-1-ol  Primary Alkanol: 1 carbon directly attached to the carbon with the –OH group 2-methylpropan-1-ol  Primary Alkanol: 1 carbon directly attached to the carbon with the –OH group 2-methylpropan-2-ol  Tertiary Alkanol: 3 carbons directly attached to the carbon with the –OH group
6b	Answer to include:	Triethanol amine has 3 hydroxyl –OH groups which means there are three sets of hydrogen bonds to neighbouring molecules. Hydrogen bonding brings molecules closer together and raises the boiling point. Triisopropylamine has a similar mass but no hydroxyl –OH groups and has no sites for hydrogen bonding and has a lower boiling point as the molecules are further apart naturally.
7a	$C_8H_9NO_2$	Benzene has a formula of C_6H_6 but this molecule has two groups substituted onto the ring in place of two of the hydrogens: $HO\text{-}C_6H_4\text{-}NH\text{-}CO\text{-}CH_3 \longrightarrow C_8H_9NO_2$
7b	Amino Acid	Amino acids have a similar structure where each individual amino acid has a different R group. Methionine has an R group of: $-CH_2\text{-}CH_2\text{-}S\text{-}CH_3$ 
7c	0.0225	Absorbance 1.6 ⟷ concentration 0.040g l^{-1} Absorbance 0.9 ⟷ concentration 0.040g $l^{-1} \times {}^{0.9}/_{1.6}$ = 0.0225 g l^{-1}
8a	Diagram showing:	
8b	72.0%	1mol glycerol $C_3H_8O_3$ = (3x12)+(8x1)+(3x16) = 36+8+48 = 92g 1mol ethane-1,2-diol $C_2H_6O_2$ = (2x12)+(6x1)+(2x16) = 24+6+32 = 62g glycerol + hydrogen ⟶ ethane-1,2-diol + methanol 1mol 1mol 1mol 1mol 92g → 62g 92kg → 62kg 27.6kg → 62kgx${}^{27.6}/_{92}$ = 18.6kg (theoretical) $\%Yield = \frac{Actual}{Theoretical} \times 100 = \frac{13.4}{18.6} \times 100 = 72.0\%$
9a	Answer to include:	Palm oil has more saturated fats than olive oil. Saturated fats fit together more closely due to shape. Molecules are closer together and this raises the melting point as more energy is required to separate molecules.

<table>
<tr><td>9b</td><td>polyunsaturated</td><td>
<table>
<tr><td>Saturated fatty acid</td><td>Monounsaturated Fatty Acid</td><td>Diunsaturated Fatty Acid</td></tr>
<tr><td>$C_nH_{2n+1}COOH$
If n=17: $C_{17}H_{35}COOH$</td><td>$C_nH_{2n-1}COOH$
If n=17: $C_{17}H_{33}COOH$</td><td>$C_nH_{2n-3}COOH$
If n=17: $C_{17}H_{31}COOH$</td></tr>
<tr><td colspan="3">$C_{17}H_{31}COOH$ has 2xC=C double bonds and is a polyunsaturated fatty acid</td></tr>
</table>
</td></tr>
<tr><td>9c</td><td>Soap</td><td>Fatty acids can be neutralised by sodium hydroxide to form soap</td></tr>
<tr><td>10a(i)</td><td>$O_3 + 2KI + H_2O$
↓
$I_2 + O_2 + 2KOH$</td><td>ozone + potassium iodide + water → iodine + oxygen + potassium hydroxide
$O_3 + 2KI + H_2O \rightarrow I_2 + O_2 + 2KOH$</td></tr>
<tr><td>10a(ii)</td><td>paper turns blue/black</td><td>Iodine produced in reaction turns blue/black when starch in the paper is present.</td></tr>
<tr><td>10b</td><td>
</td><td>Oxygen gas and ozone gas are produced at positive electrode as both ion-electron equations are oxidation reactions and give electrons to the positive electrode.</td></tr>
<tr><td>10c(i)</td><td>Acidified dichromate solution</td><td>
<table>
<tr><td>Oxidising Agent</td><td>Acidified Dichromate solution</td><td>Benedict's/Fehling's Solution</td><td>Hot copper (II) oxide</td><td>Tollen's Reagent</td></tr>
<tr><td>Colour Change</td><td>orange ⟶ green</td><td>blue ⟶ brick red</td><td>black ⟶ brown</td><td>silver mirror produced</td></tr>
</table>
</td></tr>
<tr><td>10c(ii)</td><td>diagram of 3-methylhex-3-ene
</td><td>
3-methylhex-3-ene   propanal   butan-2-one</td></tr>
<tr><td>11a</td><td>acid which partially dissociates</td><td>
<table>
<tr><td>Strong Acid</td><td>Acid which fully dissociated into ions</td><td>e.g. hydrochloric acid</td></tr>
<tr><td>Weak Acid</td><td>Acid which partially dissociated into ions</td><td>e.g. ethanoic acid</td></tr>
</table>
</td></tr>
<tr><td>11b(i)</td><td>HCl is strong acid with full dissociation of H^+ ions to react with Mg</td><td>Hydrochloric acid is a strong acid and is fully dissociated. It has all its H^+ ions available to react with magnesium immediately. Sulphurous acid is a weak acid and it has less H^+ ions available to react with Magnesium at any particular time but equilibrium will replace those H^+ ions that are removed.</td></tr>
<tr><td>11b(ii)</td><td>Sulphurous acid releases two H^+ ions per molecule while HCl releases one H^+</td><td>Sulphurous acid H_2SO_3 is a weak acid with $2H^+$ ions potentially released per molecule. Only a small proportion of H^+ ions dissociate at any one time but as the H^+ ions are removed by neutralisation, equilibrium shifts to replace the H^+ ions. Ultimately, only 10cm^3 of sulphurous acid is required due to the double quantity of H^+ ions released compared to HCl.</td></tr>
<tr><td>11b(iii)</td><td>13</td><td>$[OH^-] = 0.1 \text{ mol } l^{-1} = 10^{-1} \text{ mol } l^{-1}$
$$[H^+] = \frac{10^{-14}}{[OH^-]} = \frac{10^{-14}}{10^{-1}} = 10^{-13} \text{ mol } l^{-1}$$
$[H^+] = 10^{-13} \text{ mol } l^{-1} \therefore pH = 13$</td></tr>
</table>

<table>
<tr><td>12a</td><td>Proton:neutron ratio is too high/low</td><td>There is a zone of stability in the proton:neutron ratio. Atoms which are outwith this zone are unstable and can breakdown by radioactive decay.</td></tr>
<tr><td>12b</td><td>Answer to include:</td><td>$^{131}_{53}I \rightarrow {}^{131}_{54}Xe + {}^{0}_{-1}e$</td></tr>
<tr><td>12c(i)</td><td>8 days</td><td><table><tr><td>mass of iodine = 100pg</td><td>time = 0 days</td></tr><tr><td>mass of iodine = 50pg</td><td>time = 8 days</td></tr></table></td></tr>
<tr><td>12c(ii)</td><td>3.22×10^{11}</td><td>From graph: 4 days = 70pg ^{131}I = $70 \times 10^{-12}g$ ^{131}I
1mol ^{131}I = 131g = 6.02×10^{23} ions
$70 \times 10^{-12}g$ = 6.02×10^{23} ions $\times \frac{70 \times 10^{-12}}{131}$
= 3.22×10^{11} ions</td></tr>
<tr><td>13a</td><td>Answer to include:</td><td>OH^- ions in sodium hydroxide neutralise reactant H^+ ions to form water
Reactant H^+ ions removed
Equilibrium shifts to LEFT to replace reactant H^+
More yellow colour and less orange colour due to equilibrium shift</td></tr>
<tr><td>13b(i)</td><td>Answer to include:</td><td>Add some deionised water from wash bottle to dissolve iron (II) sulphate
Rinse stirring rod with deionised water
Dissolved solution is transferred into standard flask through funnel
Beaker and funnel are rinsed in deionised water to ensure full transfer of solution
Flask is made up to the mark on the standard flask
bottom of meniscus on line in flask</td></tr>
<tr><td>13b(ii)</td><td>3.65×10^{-3}</td><td>no. of mol Fe^{2+} = volume x concentration = 0.0274litres x 0.02mol l^{-1} = 5.48×10^{-4} mol
$3Fe^{2+} + CrO_4^{2-} + 8H^+ \longrightarrow 3Fe^{3+} + Cr^{3+} + 4H_2O$
3mol   1mol
5.48×10^{-4}mol 1.83×10^{-4}mol
concentration = $\frac{\text{no. of mol}}{\text{volume}} = \frac{1.83 \times 10^{-4}\text{ mol}}{0.05\text{ litres}}$ = 3.65×10^{-3} mol l^{-1}</td></tr>
<tr><td>14a</td><td>-2660 to -2673</td><td><table><tr><td>Alkanol</td><td>Methanol</td><td>Ethanol</td><td>Propan-1-ol</td><td>Butan-1-ol</td></tr><tr><td>Enthalpy of Combustion</td><td>-727kJ mol^{-1}</td><td>-1367 kJ mol^{-1}</td><td>-2020 kJ mol^{-1}</td><td>-</td></tr><tr><td>Difference</td><td></td><td>640</td><td>653</td><td>(640-653)</td></tr><tr><td>Prediction</td><td>-</td><td>-</td><td>-</td><td>-2660 to -2673</td></tr></table></td></tr>
<tr><td>14b</td><td>-2474.6</td><td>1mol butan-2-ol C_4H_9OH = (4x12)+(10x1)+(1x16) = 48+10+16 = 74g
$\Delta H = cm\Delta T$ = 4.18 x 0.2 x 40 = 33.44kJ
1g ⟷ 33.44kJ
74g ⟷ 33.44kJ x $^{74}/_{1}$
= 2474.6kJ mol^{-1}
Exothermic ∴ = -2474.6kJ mol^{-1}</td></tr>
<tr><td>14c</td><td>-3332</td><td>❶ $5C + 6H_2 + \frac{1}{2}O_2 \rightarrow C_5H_{11}OH$ ΔH= -354 kJ
❷ $C + O_2 \rightarrow CO_2$ ΔH= -394 kJ
❸ $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$ ΔH= -286 kJ

❶x-1 $C_5H_{11}OH \rightarrow 5C + 6H_2 + \frac{1}{2}O_2$ ΔH= +354 kJ
❷x5 $5C + 5O_2 \rightarrow 5CO_2$ ΔH= -1970 kJ
❸x6 $6H_2 + 3O_2 \rightarrow 6H_2O$ ΔH= -1716 kJ

add $C_5H_{11}OH + 7\frac{1}{2}O_2 \rightarrow 5CO_2 + 6H_2O$ ΔH= -3332 kJ</td></tr>
<tr><td>15a</td><td>Precipitation</td><td>Chemical reactions where solids are formed from solutions are called precipitation. Precipitates are removed by filtration.</td></tr>
<tr><td>15b</td><td>Water</td><td>$2Ce(OH)_{3(s)} \rightarrow Ce_2O_{3(s)} + 3H_2O$
cerium (III) hydroxide   cerium (III) oxide   water</td></tr>
<tr><td>15c(i)</td><td>Chlorine is recycled at chlorination step</td><td>Chlorine is produced at positive electrode by electrolysis. It can be used in the chlorination step when $Ce_2O_3 \longrightarrow CeCl_3$.
Recycling of by-products reduces costs.</td></tr>
</table>

15c(ii)	1.16kg	Q = I x t = 4000 x (10x60) = 2 400 000 C $Ce^{3+} + 3e^- \longrightarrow Ce$ 3mol — 1mol 3x96500C — 140.1g =289500C — 140.1g 2400000C — 140.1g x $^{2400000}/_{289500}$ = 1161.5g = 1.16kg
16a	3	Formula: Na_2SO_4; Ionic formula: $(Na^+)_2SO_4^{2-}$; No of ions: $2xNa^+$, $1xSO_4^{2-}$, i = 3
16b	0.204°C	Formula: $(NH_4)_3\,PO_4$; Ionic formula: $(NH_4^+)_3\,PO_4^{3-}$; No of ions: $3xNH_4^+$, $1xPO_4^{3-}$, i = 4 ΔT_b = 0.51 x c x i 0.51 x 0.1 x 4 0.204°C