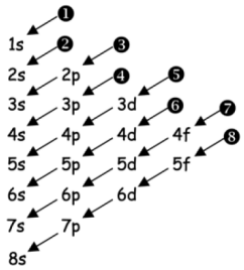
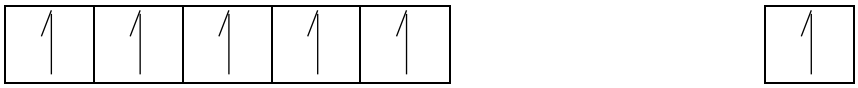
Past Papers Advanced Higher Chemistry

2020 Marking Scheme

Grade Obtained	A	B	C	D	N/A
2020	42.9%	28.4%	21.5%	5.3%	2.0%
2021	45.3%	24.1%	16.6%	7.5%	6.3%

This marking scheme is for the intended Advanced 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 by SQA in 2020 and 2021 are in the table above.

2020 Adv Higher Chemistry Marking Scheme

MC Qu	Answer	Reasoning
1	C	<u>Aufbau Principle</u>: Electrons fill up in order of increasing energy 1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p 6s 4f 5d 6p 7s 5f 6d 7p 8s 
2	A	☑A l=0 ∴ s-subshell and not an outer electron in 2p ☒B l=1 ∴ p-subshell and an outer electron in 2p ☒C m_l=0 ∴ named p-subshell in 2p ☒D m_l=1 ∴ named p-subshell in 2p <u>Oxygen</u> electron arrangement = 2,6 electronic configuration = $1s^2\ 2s^2\ 2p^4$
3	D	Electronic configuration of chromium atom: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$ ∴ $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$ shells are full and have no unpaired electrons. $3d^5$ $4s^1$ 
4	C	☒A X has smaller pK_a than Y so X is a weaker acid than Z ∴X is less acidic/more basic than Z ☒B X has smaller pK_a than Z so X is a weaker acid than Z ∴X is less acidic than Z ☑C Y has smaller pK_a than Z so Y is a weaker acid than Z ∴Y is less acidic/more basic than Z ☒D Y has smaller pK_a than X so Y is a weaker acid than X ∴Y is less acidic than X
5	A	❶ $2C + O_2 \longrightarrow 2CO$ ΔG^o = -475 kJ mol^{-1} ❷ $2Zn + O_2 \longrightarrow 2ZnO$ ΔG^o = -340 kJ mol^{-1} ❶x½ $C + \frac{1}{2}O_2 \longrightarrow CO$ ΔG^o = -237.5 kJ mol^{-1} ❷x-½ $ZnO \longrightarrow Zn + \frac{1}{2}O_2$ ΔG^o = +170.0 kJ mol^{-1} ❶'+❷' $C + ZnO \longrightarrow Zn + CO$ ΔG^o = -67.5 kJ mol^{-1}
6	C	☒A Enthalpy of formation requires 1 mole of a substances to be formed ☒B Enthalpy of formation requires 1 mole of a substances to be formed ☑C Formation of 1mol of a substance from its elements in their natural state ☒D Br_2 is a liquid at room temperature not a gas
7	B	<table><tr><th>Experiment</th><th>Change</th><th>Effect on Rate</th><th>Order of reactant</th></tr><tr><td>1+2</td><td>[BrO_3^-] x2</td><td>x2</td><td>[BrO_3^-]^1</td></tr><tr><td>2+3</td><td>[Br^-] x2</td><td>x2</td><td>[Br^-]^1</td></tr><tr><td>1+4</td><td>[H^+] x2</td><td>x4</td><td>[H^+]^2</td></tr></table>
8	D	☒A as X is zero order, increasing concentration of X will not increase the rate of reaction ☒B as X is zero order, increasing concentration of X has no effect on the rate of reaction ☒C concentration of X would decrease as time increases ☑D concentration of X would decrease as time increases. X is used up as reaction proceeds
9	B	Rate = k[P]^2[Q] ∴ 2xP and 1xQ react in the slow (rate determining) step ☒A 1xP and 2xQ react in the slow step ∴ rate = k[P]^1[Q]^2 = k[P][Q]^2 ☑B 2xP and 1xQ reacting in slow step ∴ rate = k[P]^2[Q]^1 = k[P]^2[Q] ☒C 1xX and 1xP react in the slow step ∴ rate = k[X]^1[P]^1 = k[X][P] ☒D 1xX and 1xQ react in the slow step ∴ rate = k[X]^1[Q]^1 = k[X][Q]
10	A	☑A OH^- is a nucleophile and propan-2-ol $CH_3CH(OH)CH_3$ is a secondary alcohol ☒B OH^- is attracted to centres of positive charge and is a nucleophile ☒C propan-2-ol $CH_3CH(OH)CH_3$ is a secondary alcohol not a tertiary alcohol ☒D propan-2-ol $CH_3CH(OH)CH_3$ is a secondary alcohol not a tertiary alcohol

11 **B**

☒A This reaction is electrophilic addition. No free radicals formed by homolytic fission involved.
☑B Free radial chain reaction substitution. Radicals in initiation step are formed by homolytic fission.
☒C This reaction is nucleophilic addition. No free radicals formed by homolytic fission involved.
☒D This reaction is electrophilic substitution. No free radicals formed by homolytic fission involved.

12 **C**

A. hexane		
Bond	Sigma σ bonds	Pi π bonds
5x C-C	5 x σ	0 x π
14x C-H	14 x σ	0 x π
Total	**19 x σ**	**0 x π**

B. hex-1-ene		
Bond	Sigma σ bonds	Pi π bonds
4x C-C	4 x σ	0 x π
1x C=C	1 x σ	1 x π
12x C-H	12 x σ	0 x π
Total	**17 v σ**	**1 x π**

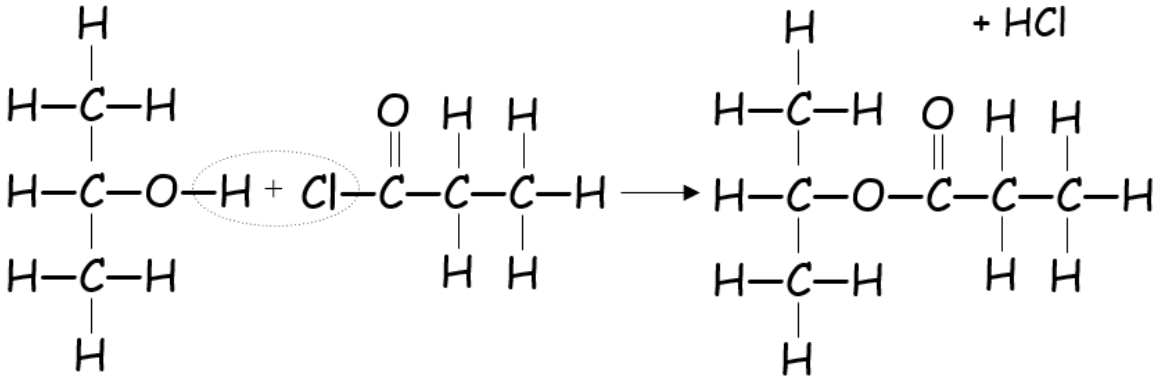
C. hex-1-yne		
Bond	Sigma σ bonds	Pi π bonds
4x C-C	4 x σ	0 x π
1x C≡C	1 x σ	2 x π
10x C-H	10 x σ	0 x π
Total	**15 x σ**	**2 x π**

D. Cyclohexane		
Bond	Sigma σ bonds	Pi π bonds
6x C-C	6 x σ	0 x π
12x C-H	12 x σ	0 x π
Total	**18 x σ**	**0 x π**

13 **D**

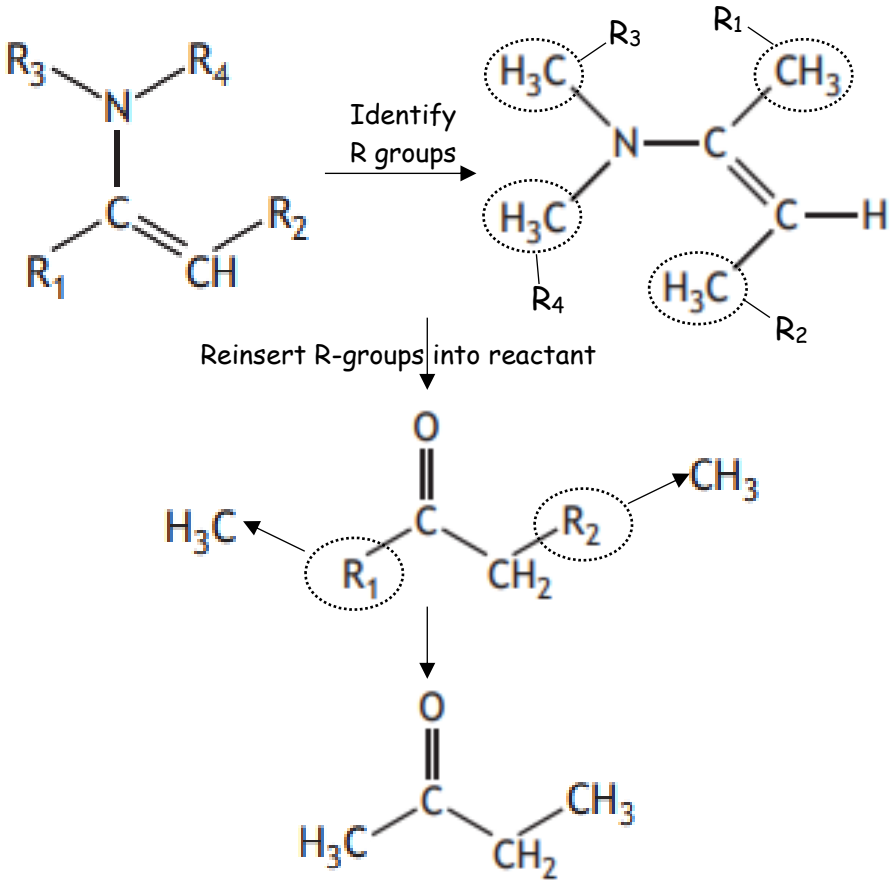
☒A 1-chloropropane would be formed by the addition of HCl across C=C bond in propene
☒B 2-chloropropane would be formed by the addition of HCl across C=C bond in propene
☒C H in HCl goes onto carbon in C≡C bond with the highest number of H already attached
☑D H in HCl goes onto carbon in C≡C bond with the highest number of H already attached
∴H attaches to C_1 and Cl then attaches to C_2 forming 2-chloropropene

14 **C**

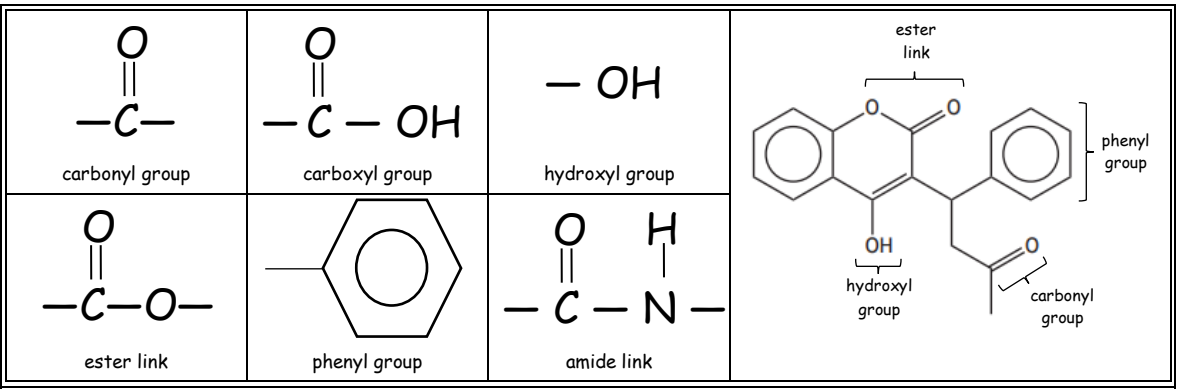


$CH_3CH(OH)CH_3 + CH_3CH_2COCl \rightarrow (CH_3)_2CHOOCCH_2CH_3 + HCl$

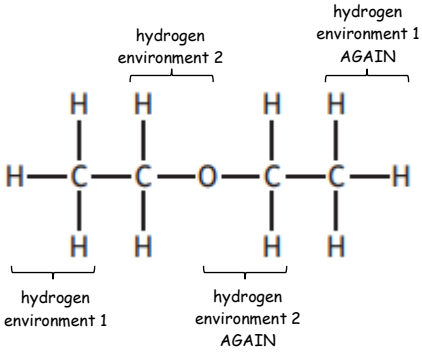
15 **D**



16 B



17 A



Hydrogen environment 1: RCH_3
- Chemical Shift at 1.5-0.9
- 3xH atoms in group
  ∴ height of peak taller than other peak
- 2 Hydrogen atoms on neighbouring groups
  ∴ **TRIPLET** under high resolution

Hydrogen environment 2: RCH_2–O–
- Chemical Shift at 3.9-3.5
- 2xH atoms in group
  ∴ height of peak lower than other peak
- 3 Hydrogen atoms on neighbouring groups
  ∴ **QUADRUPLET** under high resolution

18 D

☒A $C_4H_9NH_2$ is a primary amine ∴ hydrogen bonding raises boiling point
☒B $C_3H_7NHCH_3$ is a secondary amine ∴ hydrogen bonding raises boiling point
☒C $C_2H_5NHC_2H_5$ is a secondary amine ∴ hydrogen bonding raises boiling point
☑D $C_2H_5N(CH_3)_2$ is a tertiary amine ∴ no hydrogen bonding and a lower boiling point

19 C

Reactant 1	Reactant 2	Product
Iodomethane CH_3I	iodomethane CH_3I	Ethane CH_3CH_3
Iodomethane CH_3I	Iodoethane C_2H_5I	Propane $CH_3CH_2CH_3$
Iodoethane C_2H_5I	Iodoethane C_2H_5I	Butane $CH_3CH_2CH_2CH_3$

20 A

☑A Ketones do not react with Tollen's Reagent but will react with lithium aluminium hydride
☒B Aldehydes would react with Tollen's Reagent *and* lithium aluminium hydride
☒C Ethers do not react with Tollen's Reagent or lithium aluminium hydride
☒D Primary alcohols do not react with Tollen's Reagent or lithium aluminium hydride

21 D

☒A Having the same empirical formula does not guarantee the same chemical formula
☒B Same empirical formula does not mean they have same formula and same mass
☒C Two families can have same empirical formula e.g. alcohols and ethers
☑D Same empirical formula will give same percentage mass of each element in the compound

22 B

$$\frac{1}{\lambda} = R\left(\frac{1}{(n_1)^2} - \frac{1}{(n_2)^2}\right)$$

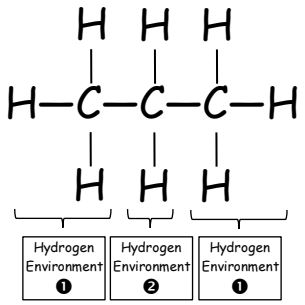
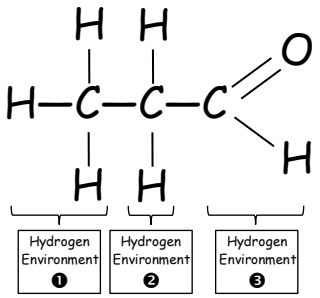
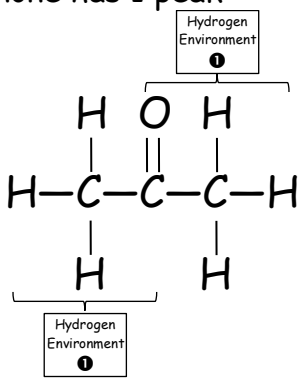
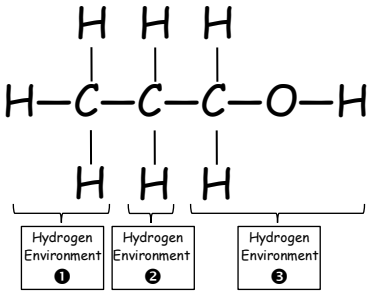
$$\frac{1}{\lambda} = 1.1\times10^{7}\left(\frac{1}{(2)^2} - \frac{1}{(9)^2}\right)$$

$$\frac{1}{\lambda} = 1.1\times10^{7}\left(\frac{1}{4} - \frac{1}{81}\right)$$

$$\frac{1}{\lambda} = 1.1\times10^{7} \times (0.238)$$

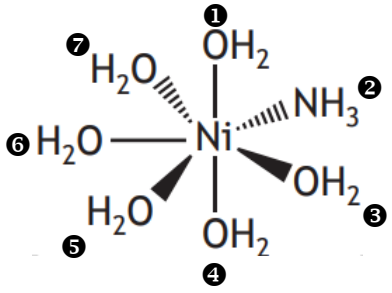
$$= 2614198$$

$$\lambda = 3.83\times10^{-7}\text{m}$$

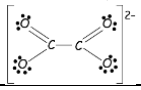
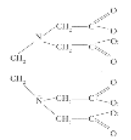
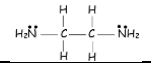
<table>
<tr><td rowspan="2">23</td><td rowspan="2">C</td><td>A. Propane has 2 peaks
 
</td><td>B. Propanal has 3 peaks
 
</td></tr>
<tr><td>C. Propanone has 1 peak
 
</td><td>D. Propan-1-ol has 3 peaks
 
</td></tr>
<tr><td>24</td><td>A</td><td colspan="2">☑A n $Zn^{2+}(NO_3^-)_2$ = v x c = 0.4 x 0.1 = 0.04mol $Zn(NO_3)_2$ f.u. ∴ 0.08mol NO_3^- ions
☒B n $(Na^+)_2SO_4^{2-}$ = v x c = 0.5 x 0.1 = 0.05mol Na_2SO_4 f.u. ∴ 0.05mol SO_3^{2-} ions
☒C n $Ba^{2+}(Cl^-)_2$ = v x c = 0.25 x 0.12 = 0.03mol $BaCl_2$ f.u. ∴ 0.06mol Cl^- ions
☒D n K^+I^- = v x c = 0.3 x 0.15 = 0.045mol KI f.u. ∴ 0.045mol NO_3^- ions</td></tr>
<tr><td>25</td><td>C</td><td colspan="2">bond enthalpy = Energy to break individual bond x Avogardo's number (L)
= 3.22×10^{-22} kJ x $6.02 \times 10^{23} mol^{-1}$
= 193.844 kJ mol^{-1}

<table>
<tr><td>Bond</td><td>F – F</td><td>Cl – Cl</td><td>Br – Br</td><td>I – I</td></tr>
<tr><td>Bond Enthalpy (kJ mol^{-1})</td><td>159</td><td>243</td><td>194</td><td>152</td></tr>
</table></td></tr>
</table>

2020 Adv Higher Chemistry Marking Scheme

Long Qu	Answer	Reasoning
1a	Electrons drop to lower energy level	Energy is released when a firework explodes and some of the energy is absorbed in promoting electrons to a higher energy level. When those excited electrons fall back to the lower level, specific quantities of energy are released corresponding to the differences in energy levels. These specific quantities of energy correspond to specific wavelengths of light.
1b(i)	620	$E = \frac{L \times h \times c}{\lambda}$ $\therefore \lambda = \frac{L \times h \times c}{E}$ $\lambda = \frac{L \times h \times c}{E} = \frac{6.02\times10^{23}\,mol^{-1} \times 6.63\times10^{-34}\,J\,s \times 3\times10^{8}\,m\,s^{-1}}{193 \times 1000\,J}$ $= 6.20\times10^{-7}$ m $= 620\times10^{-9}$ m = 620 nm
1b(ii)	Calcium	Metal: barium, calcium, copper, lithium, potassium, sodium, strontium Wavelength: 554nm, 620nm, 522nm, 671nm, 405nmn, 589nm, 650nm Colour: green, orange-red, blue-green, crimson, lilac, orange-yellow, red
1c(i)	entropy of a reaction and its surroundings always increases	The total entropy of a reaction system and its surroundings always increases for a spontaneous process.
1c(ii)	491	$\Delta G^o = \Delta H^o - T\Delta S^o = 0 \;\therefore\; T = \frac{\Delta H^o}{\Delta S^o} = \frac{+250 \times 1000\ J\ mol^{-1}}{+509\ J\ K^{-1}\ mol^{-1}} = 491K$
2a	octahedral	Octahedral shape is caused by six pair of electrons arranged around a central atom 2 electron pairs: F — Be — F, Linear 3 electron pairs: Trigonal Planar 4 electron pairs: Tetrahedral 5 electron pairs: Trigonal Pyramidal 6 electron pairs: Octahedral
2b	7	Seven different ligands donate a pair of electrons to the central Ni^{2+} ion. This gives a co-ordination number of 7 on this complex ion. 
2c(i)	amminepentaaquanickel(II)	amminepentaaquanickel(II) ammine NH_3 ligand; no. of ligands = 5; H_2O ligand; metal name; Charge on metal ion Neutral ligands include: Ligand / Name: OH_2 aqua; NH_3 ammine; CO carbonyl Negative Ligands include: Ligand / Name: Chloride Cl^- chlorido; Cyanide CN^- cyanido; Nitrite NO_2^- nitrito Central Ion: Positive Complex: metals keep their name. Negative Complex: Metals end in ATE e.g. Cuprate, Ferrate, Cobaltate Charge: Charge of central ion is converted into roman numerals and put in brackets

2c(ii) — Donates one pair of electrons to metal

Type of Ligand	Monodentate		Bidentate	Hexadentate
Examples	Neutral Ligands	Charged Ligands	Oxalic acid $O_4C_2^{2-}$ 	E.D.T.A. 
	Water OH_2	Chloride Cl^-	1,2-diaminoethane $N_2C_2H_8$ 	
	Ammonia NH_3	Cyanide CN^-		
	Carbon Monoxide CO	Nitrite NO_2^-		
		Hydroxide OH^-		

2d(i) — Second

$[Ni(OH_2)_6]^{2+}$ has 1st order kinetics as index on square brackets has value = 1
NH_3 has 1st order kinetics as index on square brackets has value = 1
Overall order = order of $[Ni(OH_2)_6]^{2+}$ + order of $[NH_3]$ = 1 + 1 = 2

2d(ii) — 5200 l mol^{-1} s^{-1}

$$k = \frac{\text{rate}}{[\,[Ni(OH_2)_6]^{2+}]\,[NH_3]} = \frac{1.3\times10^{2}\ \text{mol l}^{-1}\ \text{s}^{-1}}{0.10\ \text{mol l}^{-1} \times 0.25\ \text{mol l}^{-1}} = 5200\ \text{l mol}^{-1}\ \text{s}^{-1}$$

3a(i) — sp^2

Benzene has a ring of 6 carbons joined by sigma σ bonded sp^2 hybridised orbitals.
Each carbon in the ring has an unhybridised p-orbital which side on merges into rings of delocalised electrons above and below the ring of carbons.(π bonds)

3a(ii) — side on overlap of orbitals

π bonds are formed from the side on overlap of unhybridised p orbitals perpendicular to the axis of the covalent bond.
Sigma bonds are formed by end-on overlap of orbitals along the axis of the bond

3a(iii) — Answer to include:

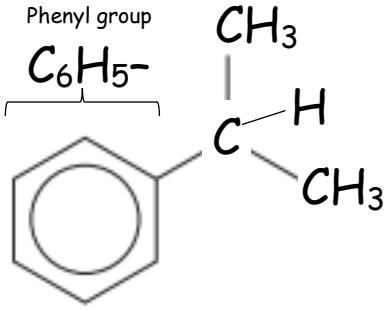
1st Mark One from:	Short conjugated system	few atoms in the conjugated system	delocalised electrons over a small number of carbon atoms	molecular orbital over a small number of carbon atoms

2nd Mark One from:	A large amount of energy is required to promote an electron from HOMO to LUMO	Large energy gap between HOMO and LUMO	the energy gap between HOMO and LUMO is not small enough to absorb visible light

3b(i) — (electrophilic) substitution

Substitution reaction as one group joins the ring as another leaves.
Electrophilic as the benzene ring is an electron dense molecule and electrophiles will attack the benzene ring.

3b(ii) — C_9H_{12}



3b(iii) — More stable carbocation formed

Re-arrangment of unstable arrangements into more stable arrangements is quite common in chemistry.

4a — Calcium carbonate/ limestone is insoluble

The calcium carbonate in limestone is insoluble and the reaction between limestone and hydrochloric acid is slow. A direct titration would not give accurate results so a back titration is used.
The limestone is left to react with a known excess hydrochloric acid until the reaction is finished and no limestone is left. The hydrochloric acid left over is then calculated by titration with sodium hydroxide and subtracted from the total hydrochloric acid to work out the no of moles of hydrochloric acid which reacted with the limestone.

4b(i) — 0.0253

Total **n**o. of mol of HCl = **v**olume x **c**oncentration = $0.025_{\text{litres}} \times 1.50_{\text{mol l}^{-1}} = 0.0375\text{mol}$

$$\text{Average volume NaOH (ignoring rogue result 10.7)} = \frac{10.1 + 10.2}{2} = 10.15\text{cm}^3$$

no. of mol NaOH = **v**olume x **c**oncentration = $0.01015_{\text{litres}} \times 0.300_{\text{mol l}^{-1}} = 0.003045\text{mol}$

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

1mol 1mol
0.003045mol 0.003045mol

25cm³ sample reacted with 0.003045mol HCl
100cm³ total flask reacted with 0.01218mol HCl
No. of moles reacted with limestone = total no. of mol – leftover HCl
= 0.0375 mol – 0.01218 mol
= 0.02532 mol

4b(ii) — 97.4% and yes

$$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$$

1mol : 2mol

0.01266mol : 0.02532mol

gfm $CaCO_3$ = (1x40.1) + (1x12) + (3x16) = 40.1+12+48 = 100.1g

mass = **n**o. of mol x **gfm** = 0.01266mol x 100.1g mol^{-1} = 1.266g

$$\% \text{ purity} = \frac{\text{Mass of pure calcium carbonate}}{\text{Mass of limestone}} \times 100 = \frac{1.266g}{1.30g} \times 100 = 97.4\%$$

Purity is greater than 95% so limestone can be used.

4c — Open Question 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.

5a(i) — $1s^2\ 2s^2\ 2p^6\ 3s^2 3p^6\ 3d^7$

Electronic configuration of cobalt atom: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7\ 4s^2$

Electronic configuration of Co^{2+} ion: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7$

5a(ii) — +2

As there are 2 Cl^- chloride ions per Co ion, it can be concluded that the cobalt ion must be Co^{2+} ions to balance the total of 2- charge between the two chloride ions.

5b(i) — Answer to include:

1st Mark:	Heating substance		
All three required for 2nd Mark:	Cool/leave in a desiccator (to prevent absorption of water)	Weigh	Repeat (the steps of heating, cooling and weighing) to constant mass

5b(ii) — 6

Gfm $CoCl_2$ = (1x58.9) + (2x35.5) = 58.9+71 = 129.9g

$$\textbf{n}\text{o. of mol} = \frac{\textbf{mass}}{\textbf{gfm}} = \frac{0.204}{129.9}\ 0.00157\text{mol}$$

mass of H_2O removed on heating = 0.372g – 0.204g = 0.168g

gfm H_2O = (2x1) + (1x16) = 2+16 = 18g

$$\textbf{n}\text{o. of mol} = \frac{\textbf{mass}}{\textbf{gfm}} = \frac{0.168}{18} = 0.00933\text{mol}$$

ratio of no. of mol $CoCl_2$: no. of mol H_2O

0.00157 : 0.00933mol

1 : 5.94

Must be Whole Number 1 : 6

5c(i) — EDTA

EDTA is a complexometric reagent that will form a complex ion with Co^{2+} ions in a 1mol : 1mol ratio allowing the no of moles of Co^{2+} ions to be calculated from the no. of moles of EDTA which it reacts with.

5c(ii) — One answer from:

Colorimetry	Spectrophotometry	Atomic emission/absorption spectroscopy	Precipitation

6a — Working to include moles for each element

C 3·33

H 6·70

O 3·33

Percentage Oxygen = 100% - 40.0% - 6.70% = 53.30%

Element	C	H	O
%	40.0	6.70	53.30
No. of moles (divide % by gfm)	$\frac{40.0}{12}$ = 3.33	$\frac{6.70}{1}$ = 6.70	$\frac{53.30}{16}$ = 3.33
Mole ratio (divide through by smallest value)	$\frac{3.33}{3.33}$ = 1.00	$\frac{6.70}{3.33}$ 2.01	$\frac{3.33}{3.33}$ 1.00
Round to Whole Number	1	2	1

6b(i) — $C_3H_6O_3$

Peak with highest m/z ratio is the gfm of the substance = 90

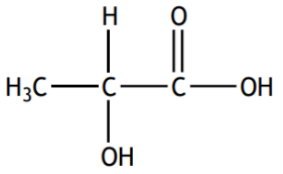
gfm of empirical formula = (3x12)+(6x1)+(3x16) = 36+6+48 = 90

∴ empirical formula is same as formula of substance as both have mass of 90

6b(ii) — One answer from:

Fragment	$[COOH]^+$	$[CH_3CHOH]^+$	$[C_2H_5O]^+$	$[CH_3CH_2O]^+$
Mass	(1x12)+(1x1)+(2x16) = 45	(2x12)+(5x1)+(1x16) = 45	(2x12)+(5x1)+(1x16) = 45	(2x12)+(5x1)+(1x16) = 45

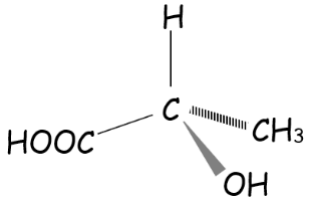
6c



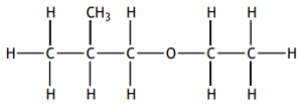
or $CH_3CH(OH)COOH$

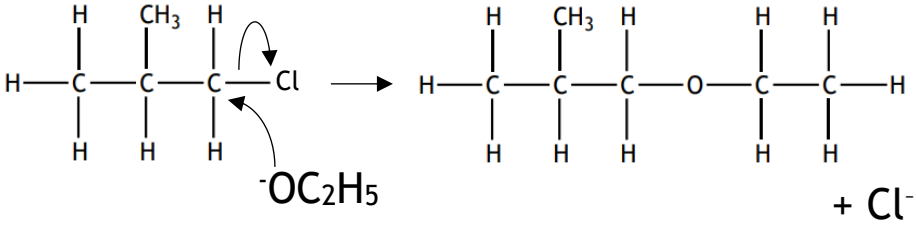
If Compound X rotates plane polarised light then it must contain a chiral carbon

- Chiral carbons have four different groups attached to them

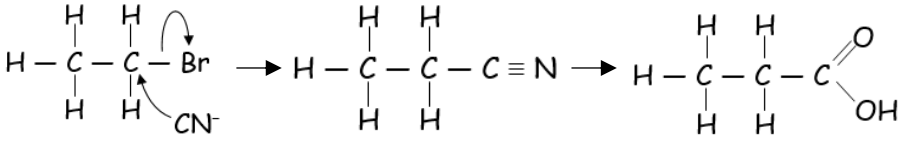


7a





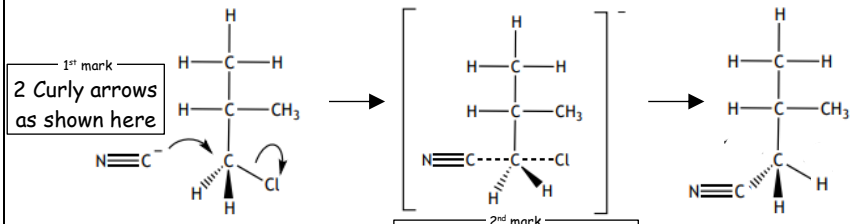
7b Carboxylic acids



Halogenalkane — Nitrile — Carboxylic acid

Step 1 is nucleophilic substitution and Step 2 is a hydrolysis.

7c Diagram showing



7d(i) Ethanol or alcohol

KOH dissolved in water undergoes nucleophilic substitution reactions
KOH dissolved in ethanol undergoes elimination reactions

7d(ii) 278cm^3 or 0.278l

gfm C_4H_9Cl = (4x12)+(9x1)+(1x35.5) = 48+9+35.5 = 92.5g

$$\text{no. of mol} = \frac{\text{mass}}{\text{gfm}} = \frac{1.85}{92.5} = 0.02\text{mol}$$

$$C_4H_9Cl \rightarrow C_4H_8 + HCl$$

1mol 1mol
0.02mol 0.02mol

100% yield methyl propene = 0.02mol

$\therefore$ 60.4% yield methyl propene = 0.02mol x $^{60.4}/_{100}$ = 0.02308 mol

volume = no. of mol x molar volume = 0.02308 mol x 23.0 l mol = 0.278litres = 278cm^3

8a CH_3COO^-

CH_3COOH + H_2O $\rightleftharpoons$ H_3O^+ + CH_3COO^-

Acid (Donates H^+) — Base (Accepts H^+) — Conjugate Acid (Formed when Base accepts H^+) — Conjugate Base (Formed when Acid loses H^+)

8b(i) 4.36

gfm CH_3COONa = (2x12)+(3x1)+(2x16)+(1x23) = 24+3+32+23 = 82g mol^{-1}

$$\text{no. of mol} = \frac{\text{mass}}{\text{gfm}} = \frac{4.10}{82} = 0.05\text{ mol}$$

$$\text{concentration} = \frac{\text{no. of mol}}{\text{volume}} = \frac{0.05\text{ mol}}{0.25\text{ litres}} = 0.2\text{ mol l}^{-1}$$

$$pH = pK_a - \log_{10}\frac{[acid]}{[salt]} = 4.76 - \log_{10}\frac{0.5}{0.2} = 4.76 - \log_{10}(2.5)$$

$$= 4.76 - (0.398)$$

$$= 4.362$$

8b(ii) One answer from:

The concentration of the acid and salt will change by the same amount	the acid and the salt are diluted by the same amount	(the concentration) ratio of the acid and salt is unchanged

8c Answer to include:

1st Mark:	Use the same volume of each buffer solution		
2nd Mark Any one from list:	measure the (rise/change in) pH after the same volume/moles of alkali has been added	measure the volume of alkali required to raise the pH by the same value/from pH=5 to pH=6.	the solution which shows the smallest change in pH when the same volume/moles of alkali has been added has the larger buffer capacity

9a

Substance which alters the biochemical processes in the body

A drug is a chemical which alters the normal biochemical processes in the body.
An agonist is a chemical which binds to a receptor protein and produced the biochemical response.
An antagonist is a chemical which binds to a receptor but does not produce the biochemical response.

9b

inhibitor

Inhibitors bind to proteins in body to block their activity.
Antagonists bind to receptor proteins to block the biochemical response of receptor

9c

2483

1kg bodyweight ⟷ 0.68mg
8.4kg bodyweight ⟷ 0.68mg x $^{8.4}/_{1}$ = 5.712mg
2.3cm^3 dose ⟷ 5.712mg
1000cm^3 dose ⟷ 5.712mg x $^{1000}/_{2.3}$ = 2483mg

$\therefore$ 2483 mg per litre = 2483ppm

9d

Open Question 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)

58.1

$$PV = nRT \quad \therefore n = \frac{PV}{RT} = \frac{101 \times 0.259}{8.31 \times 353} = 0.00892\text{mol}$$

$$\textbf{gfm} = \frac{\textbf{m}ass}{\textbf{n}o\ of\ mol} = \frac{0.518}{0.00892} = 58.1$$

10a(ii)

One answer from:

Propanone or propanal	C_3H_6O	a correct structural formula for propanone/propanal	any other carbonyl compound that fits the GFM calculated in (a)(i)

10b

One answer from:

The boiling point (of butanoic acid) is above 100 °C	The boiling point (of butanoic acid) is above boiling point of water	the water (bath) cannot reach a high enough temperature.

11a(i)

$$K = \frac{[I_3^-]}{[I_2]\,[I^-]}$$

For the equation: $aA + bB \rightleftharpoons cC + dD$

$$K = \frac{[C]^c\,[D]^d}{[A]^a\,[B]^b}$$

11a(ii)

779

Assuming a 1 litre container:
$[I_2]$ 1.21×10^{-3} = 0.00121 mol l^{-1} (in question) $[I_3^-]$ = 0.116 mol l^{-1} (in question)
[KI] = 0.239 mol l^{-1} $\therefore$ $[I^-]$ = 0.239 mol l^{-1} (at start)

$$I_2 + I^- \rightleftharpoons I_3^-$$

1mol	1mol	1mol
0.116mol	0.116mol	0.116mol
(used up)	(used up)	(formed)

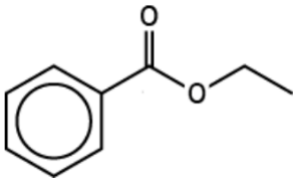
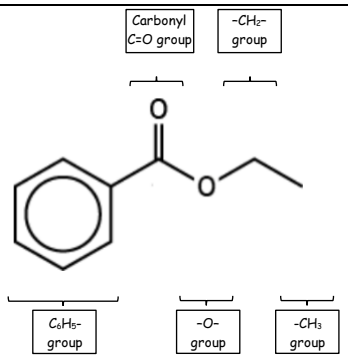
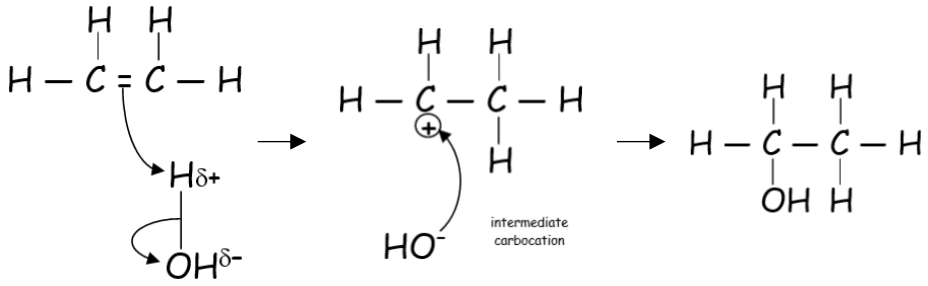
but 0.116mol I^- used up in reaction so 0.123mol I^- remaining at equilibrium.
Assuming 1 litre container, $[I^-]$ at equilibrium is 0.123mol l^{-1}

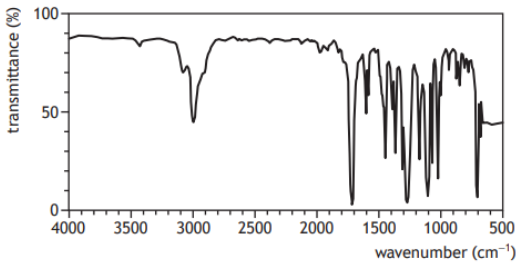
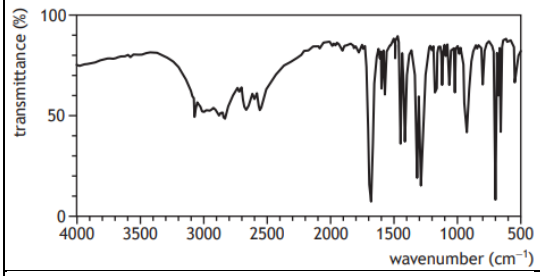
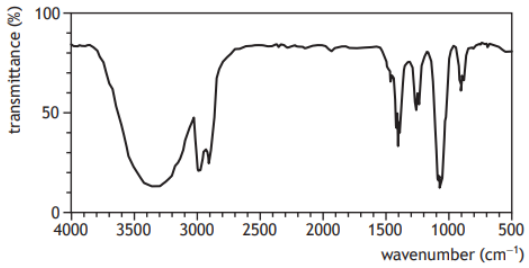
$$K = \frac{[I_3^-]}{[I_2]\,[I^-]} = \frac{0.116}{0.00121 \times 0.123} = 779.4$$

11b

Answer to include:

One from list for 1st Mark	Structure depends on VSEPR/ minimising repulsion/minimising repulsion between lone/non-bonding pairs		repulsion is greatest between lone/non-bonding pairs	
One from list for 2nd Mark	(In B) the lone/non-bonding pairs are 120° from one another	in A the lone/non-bonding pairs are 90° from one another	the angle is greater between non-bonding/lone pairs (in B)	the lone/non-bonding pairs are further away from each other (in B)

<table>
<tr><td>12a</td><td>  </td><td> 
</td></tr>
<tr><td>12b</td><td>To prevent reactant/product/vapour from escaping</td><td>The vapour created by evaporation of substances in the round bottom flask is condensed in the condenser unit and the chemicals returned to the round bottom flask.
The condenser unit has cold water going in at the bottom and water leaving at the top.</td></tr>
<tr><td>12c</td><td>Distillation</td><td>Distillation separates substances with different boiling points with the substance with the lower boiling point leaving as a vapour then condensed and collected.
In this reaction the ethanol CH_3CH_2OH will evaporate and the sodium benzoate $C_6H_5COO^-Na^+$ remains dissolved in the flask of the distillation apparatus.</td></tr>
<tr><td>12d</td><td>Elimination</td><td>Elimination reactions remove small molecules and leave C=C double bonds behind (and sometimes C≡C triple bonds).
Dehydration is the same reaction but the small molecule removed is water.</td></tr>
<tr><td>12e</td><td>Positively charged hydrogen in HBr</td><td> 
</td></tr>
<tr><td>12f(i)</td><td>Answer to include:</td><td>
<table>
<tr><td>1st Mark (one required)</td><td colspan="2">The (benzoate) ion from the salt removes/reacts with H+ from the water</td><td>the conjugate base of the weak acid, removes/reacts with H + ions from the water</td></tr>
<tr><td>2nd Mark (one required)</td><td>This results in the water equilibrium shifting to the right hand side</td><td>Shifting to the left hand side if candidate has written an equilibrium reaction with ions on the left hand side</td><td>this results in excess OH^- ions from the water equilibrium</td></tr>
</table>
</td></tr>
<tr><td>12f(ii)</td><td>Filtration</td><td>Insoluble solids are removed from liquids by filtration. Vacuum filtration can be used to speed up the movement of solution through the filter paper.</td></tr>
<tr><td>12g</td><td>Recrystallisation</td><td>Recrystallisation is used to increase the purity of a substance because that substance is highly soluble in a solvent at high temperature but less soluble at lower temperature. The substances crashes out of the solution on cooling but the impurities stay dissolved in the solvent.</td></tr>
<tr><td>12h(i)</td><td>Pure benzoic acid</td><td>When pure benzoic acid is added to the benzoic acid collected from process Y, the melting point will be unchanged if the benzoic acid collected in process Y is pure.
Impurities in the benzoic acid collected in process Y will change the melting point of the mixture if they are present when mixed with pure benzoic acid.</td></tr>
<tr><td>12h(ii)</td><td>Answer to include:</td><td>
<table>
<tr><td>1st Mark:</td><td>Any mention of measuring or looking up the melting point of pure benzoic acid</td></tr>
<tr><td>2nd Mark:</td><td>Correctly linking the mixed melting point value to the purity</td></tr>
</table>
</td></tr>
</table>

		Spectrum	Deductions
12i	1st Mark: Spectrum C 2nd Mark: No C=O peak at 1700 cm^{-1} in spectrum C or spectra A and B have a C=O peak at 1700 cm^{-1}	Spectrum A  	Contains peak 1730–1717cm^{-1} ∴ C=O stretch in aromatic ester Contains peak 3100-3000cm^{-1} ∴Benzene ring Conclusion: Ethyl Benzoate
		Spectrum B  	Contains peak around 1700cm^{-1} ∴ carbonyl C=O peak Contains peak 3000-2500cm^{-1} ∴ hydrogen bonded -OH group in -COOH group Conclusion: Benzoic Acid
		Spectrum C  	Contains peal 3600–3200cm^{-1} ∴ hydrogen bonded O–H stretch in alcohol No Peak around 1700cm^{-1} ∴C=O Carbonyl stretch Conclusion: Ethanol