Past Papers
Advanced Higher Chemistry

Revised

2013
Marking Scheme

Grade Awarded	Mark Required		% candidates achieving grade
	(/125)	%	
A	85+	68.0%	35.1%
B	72+	57.6%	30.6%
C	60+	48.0%	17.1%
D	54+	43.2%	6.3%
No award	<54	<43.2%	10.8%

Section:	Multiple Choice	Extended Answer	Investigation
Average Mark:	21.4 /30	39.0 /70	16.7 /25
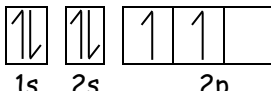
2013 Revised Adv H Chem Marking Scheme

MC Qu	Answer	% Pupils Correct	Reasoning

1 — **C** — **88** (oldAH=90)

- ☒ A Ionisation Energy remove one mole of electrons
- ☒ B Ionisation Energy remove one mole of electrons
- ☑ C Removal of one from of electrons from one mole of 1+ gaseous ions
- ☒ D Ionisation Energy remove one mole of electrons

2 — **B** — **75** (oldAH=77)

EM Radiation	Gamma	X-ray	UV	Visible	Infrared	Microwave	Radio & TV
Velocity	$3\times10^8 m\,s^{-1}$	$3\times10^8 m\,s^{-1}$	$3\times10^8 m\,s^{-1}$	$3\times10^8 m\,s^{-1}$	$3\times10^8 m\,s^{-1}$	$3\times10^8 m\,s^{-1}$	$3\times10^8 m\,s^{-1}$
Wavelength	short			$\longrightarrow$			Long
Frequency	high		$\longleftarrow$				Low

3 — **A** — **75** (oldAH=74)

- ☑ A Copper (II) Sulphate gives blue-green flame colour (λ=325nm) $\therefore$ highest frequency
- ☒ B Potassium Chloride gives lilac flame colour (λ=405nm)
- ☒ C Barium Chloride gives green flame colour (λ=554nm)
- ☒ D Lithium Sulphate gives crimson flame colour (λ=671nm) $\therefore$ lowest frequency

4 — **D** — **69** (oldAH=62)

Colour	Violet	Indigo	Blue	Green	Yellow	Orange	Red
Velocity	$3\times10^8 m\,s^{-1}$	$3\times10^8 m\,s^{-1}$	$3\times10^8 m\,s^{-1}$	$3\times10^8 m\,s^{-1}$	$3\times10^8 m\,s^{-1}$	$3\times10^8 m\,s^{-1}$	$3\times10^8 m\,s^{-1}$
Wavelength	450nm		$\longleftarrow$			$\longrightarrow$	700nm
Frequency	6.67×10^{14}Hz		$\longleftarrow$				4.28×10^{14}Hz
Indicator Colour	A in acid / C in alkali		B in alkali	B in acid	C in acid / D in alkali		A in alkali / D in acid

5 — **A** — **81** (oldAH=70)

- ☑ A Hund's Rule: orbitals fill up single rooms first to maximise the number of parallel spins
- ☒ B Aufbau principle: Orbitals fill up in order of lowest energy (1s,2s,2p,3s,3p,4s,3d,4p,5s,4d,5p,6s,4f, etc)
- ☒ C Pauli Exclusion Principle: No electron has the same 4 quantum numbers
- ☒ D Valence Shell Electron Pair Repulsion Theory: predicts geometry of molecules

6 — **A** — **56** (oldAH=62)

- ☑ A 3 electrons in 3rd shell $\therefore$ element is in group 3
- ☒ B 5 electrons in 3rd shell $\therefore$ element is in group 5
- ☒ C Incomplete d-shell $\therefore$ element is a transition metal
- ☒ D 5 electrons in 4th shell $\therefore$ element is in group 5

7 — **C** — **65** (oldAH=60)

- ☒ A Mass Spectroscopy: mass measured by the bending of charged particles in electric field
- ☒ B IR-spectroscopy: absorbed IR radiation of particular wavenumber vibrates particular bonds
- ☑ C Emission Spectroscopy: measuring wavelengths produced as excited electrons drop down energy levels
- ☒ D Proton NMR: flipping of spins in a hydrogen nuclei in a strong magnetic field

8 — **B** — **72** (oldAH=79)

- ☒ A 2 lone pairs (both on oxygen atom)
- ☑ B 3 lone pairs (all on chlorine atom)
- ☒ C 1 lone pair (on nitrogen atom)
- ☒ D 2 lone pairs (both on oxygen atom)

9 — **C** — **69** (oldAH=63)

- ☒ A SF_4 has 5 pairs (4 bonding and 1 non-bonding)
- ☒ B NH_4^+ has 4 pairs (4 bonding and 0 non-bonding) $\therefore$ tetrahedral
- ☑ C XeF_4 has 6 pairs (4 bonding and 2 non-bonding) $\therefore$ square planar
- ☒ D AlH_4^- has 4 pairs (4 bonding and 0 non-bonding) $\therefore$ tetrahedral

10 — **B** — **71** (oldAH=69)

- ☒ A Cu^{2+} ions $\rightarrow$ Cu metal (oxidation state: 2$\rightarrow$0)
- ☑ B Cu^{2+} ions $\rightarrow$ Cu^{2+} ions in a complex with NH_3 (oxidation state: 2$\rightarrow$2)
- ☒ C Cu^{2+} ions $\rightarrow$ Cu^+ ions (oxidation state: 2$\rightarrow$1)
- ☒ D Cu metal $\rightarrow$ Cu^{2+} ions (oxidation state: 0$\rightarrow$2)

11 — **A** — **50**

no. of mol = **volume** x **concentration** = 0.1litres x 0.5 mol l^{-1} = 0.05mol

1mol AgCl = (1x107.9)+(1x35.5) = 143.4g

$$2AgNO_3 + CaCl_2 \longrightarrow Ca(NO_3)_2 + 2AgCl_{(s)}$$

2mol	1mol		1mol	2mol
0.05mol				0.05mol

mass = **no.** of mol x **gfm** = 0.05 x 143.4 = 7.17g

12	B	58 oldAH=54	no. of mol K^+ ions = volume x concentration = 1 litre x 0.1 mol l^{-1} = 0.1 mol K^+ ions 1 mol K_2SO_4 contains 2 mol K^+ ions $\therefore$ 0.05 mol K_2SO_4 contains 0.1 mol K^+ ions volume = $\dfrac{\text{no. of mol}}{\text{concentration}}$ = $\dfrac{0.05 \text{ mol}}{0.2 \text{ mol } l^{-1}}$ = 0.25 litres = 250cm^3
13	C	83 oldAH=80	☒A Catalysts do not alter the position of equilibrium ☒B Adding acid will move equilibrium to left to remove the additional product (H^+) ☑C Alkali will neutralise H^+ ions and equilibrium will move to right to replace H^+ ions ☒D Adding dihydrogenphosphate ions ($H_2PO_4^-$) will move equilibrium to left
14	A	90 oldAH=91	☑A increasing temperature will alter the solubility of caffeine different rate ☒B adding more caffeine will not alter the proportion of caffeine in the solvents ☒C increasing the volume of a solvent does not alter the final concentration of caffeine ☒D increasing the volume of a solvent does not alter the final concentration of caffeine
15	D	83 oldAH=85	partition coefficient = $\dfrac{[X]_{hexane}}{[X]_{water}}$ = $\dfrac{13}{6}$ = 2.17
16	C	70 oldAH=72	☒A pH of ethanoic acid will increase towards pH=7 during dilution ☒B pK_a is a measure of the degree of dissociation and dilution does not alter pK_a ☑C [H^+] will decrease and pH increases towards pH=7 during dilution ☒D Dilution does not alter the degree of dissociation
17	D	74 oldAH=71	Ethanoate CH_3COO^- ions join up with H^+ ions and form molecules of ethanoic acid CH_3COOH as ethanoic acid is a weak acid. The removal of H^+ ions from the equilibrium will result in the equilibrium moving to left to replace these H^+ ions and this results in more reverse reaction and less products in the mixture ($\therefore$ less iodine)
18	A	71 oldAH=81	Potassium hydroxide and ethanoic acid will neutralise to form potassium ethanoate and will have an alkaline pH. The indicator chosen should have a pH range which changes colour in the alkaline region of the pH scale.
19	B	66	☒A increases in free energy would lead to ΔG>0 (stopping the spontaneous process) ☑B spontaneous processes always have an increase in disorder (entropy) ☒C the total enthalpy of a process should always be the same ☒D spontaneous endothermic reactions occur (with a large increase in disorder)
20	D	47 oldAH=57	☒A mpt NaCl = 801°C $\therefore$ NaCl is a solid at 750°C $\therefore$ solid have lower disorder/entropy ☒B mpt $CaCl_2$ = 775°C $\therefore$ $CaCl_2$ is a solid at 750°C $\therefore$ solid have lower disorder/entropy ☒C mpt KCl = 770°C $\therefore$ KCl is a solid at 750°C $\therefore$ solid have lower disorder/entropy ☑D mpt $MgCl_2$= 714°C $\therefore$ $MgCl_2$ is a liquid at 750°C $\therefore$ liquids have higher disorder/entropy
21	C	85	☒A refluxing condenses escaping vapours back into a reaction vessel ☒B distillation separates liquids with different boiling points ☑C recrystallisation is used to separate substances from impurities in a sample ☒D chromatography separates chemicals of different solubility and size
22	D	87 oldAH=82	Oxidation is one of the following reactions: primary alcohol ⟶ aldehyde ⟶ carboxylic acid secondary alcohol ⟶ ketone ⟶✗⟶ tertiary alcohol ⟶✗⟶ Butan-1-ol is a primary alcohol and butanoic acid is a carboxylic acid. Reduction is the reverse reaction of oxidation.
23	A	84 oldAH=87	❶ Substitution Reaction $\quad$ $CH_3CH_2CH_2OH$ (propan-1-ol) → $CH_3CH_2CH_2Cl$ (1-chloropropane) ❷ Elimination of HCl $\quad$ $CH_3CH_2CH_2Cl$ (1-chloropropane) → $CH_3CH{=}CH_2$ (propene) ❸ Substitution of CH_3O^- $\quad$ $CH_3CH_2CH_2Cl$ (1-chloropropane) → $CH_3OCH_2CH_2CH_3$ (methoxypropane)

24	D	73	
25	B	81 (oldAH=77)	☒A Pentanal C_4H_9CHO does not contain hydrogen bonding ∴ lower bpt ☑B Pentan-2-ol $CH_3CH(OH)C_3H_7$ contains hydrogen bonding ∴ highest bpt ☒C Pentan-2-one $CH_3COC_3H_7$ does not contain hydrogen bonding ∴ lower bpt ☒D Ethoxypropane $C_2H_5OC_3H_7$ does not contain hydrogen bonding ∴ lower bpt
26	D	62 (oldAH=61)	Propan-2-ol $CH_3CH(OH)CH_3$ ∴ R group = $CH_3CH(CH_3)$— 2-chlorobutane $CH_3CHClCH_2CH_3$ ∴ R' group = —$CH(CH_3)CH_2CH_3$ ∴ Ether R—O—R' = $CH_3CH(CH_3)$— O —$CH(CH_3)CH_2CH_3$
27	C	63 (oldAH=61)	
28	A	56 (oldAH=50)	☑A Addition: small molecules added across C=C bonds and other π-bonds ☒B Oxidation: increase in the oxygen : hydrogen ratio ☒C Elimination: small molecule removed (e.g. H_2O) and C=C bond left behind ☒D Substitution: swapping of atoms/groups on and off a molecule
29	D	94 (oldAH=93)	☒A Nucleophiles are species which are attracted to centres of positive charge ☒B Electrophiles are species which are attracted to centres of negative charge ☒C Free Radicals are species with unpaired electrons ☑D Receptors are proteins embedded in cell walls with specific shapes to fit molecules with the correct pharmacophore shape
30	D	50	

2013 Revised Adv H Chem Marking Scheme

Long Qu	Answer	Reasoning
1a	Equal in energy	Degenerate orbitals are equal in energy. The three 2p orbitals in the 2nd shell are equal in energy and the electrons will fill them up singly in any order as they are equal in energy to each other.
1b	$\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow$ $\uparrow$ 1s 2s 2p	According to the aufbau principle, electrons fill up in orbitals of lowest energy first ∴ 1s then 2s then 2p (then 3s then 3p then 4s then 3d ….) According to Hund's Riles, orbitals fill up single with parallel spins first.
1c	sp^3 hybridisation	One s orbital and three p orbitals in the 2nd shell of carbon atoms hybridise to form 4 sp^3 hybrid orbitals
2a	-220.3 J K^{-1} mol^{-1}	ΔS^o = $\Sigma S^o_{(products)}$ - $\Sigma S^o_{(reactants)}$ = (2x27.0) + (1x5.70) - ((2x33.0)+(1x214)) = 54.0 + 5.7 - (66.0 + 214) = 59.7 - 280 = -220.3 J K^{-1} mol^{-1}
2b	-526.4 kJ mol^{-1}	❶ $Mg_{(s)}$ + $\frac{1}{2}O_{2(g)}$ → $MgO_{(s)}$ ΔH=-493 kJ mol^{-1} ❷ $C_{(s)}$ + $O_{2(g)}$ → $CO_{2(g)}$ ΔH=-394 kJ mol^{-1} ❶x2 $2Mg_{(s)}$ + $O_{2(g)}$ → $2MgO_{(s)}$ ΔH=-986 kJ ❷x-1 $CO_{2(g)}$ → $C_{(s)}$ + $O_{2(g)}$ ΔH=+394 kJ ❶' + ❷' $2Mg_{(s)}$ + $CO_{2(g)}$ → $2MgO_{(s)}$ + $C_{(s)}$ ΔH=-592 kJ ΔG^o = ΔH^o - $T\Delta S^o$ = (-592) - 298 x $^{-220.3}/_{1000}$ = (-592) - (-65.6) = -526.4 kJ mol^{-1}

3	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.

Long Qu	Answer	Reasoning
4a	Answer to include:	A series of standard solutions of different known concentrations of potassium permanganate are made up and their absorbencies measured.
4b	Green or 500-560nm	The solutions appear purple as the green light is removed by atomic adsorption and the red and blue light is transmitted giving a purple colour.
4c	0.29%	From graph: Absorbance = 0.26 ∴ $[MnO_4^-]$ = $1.3x10^{-4}$ mol l^{-1} no. of mol = volume x concentration = 0.1litres x $1.3x10^{-4}$ mol l^{-1} = $1.3x10^{-5}$ mol mass of Mn = no. of mol x gfm = $1.3x10^{-5}$mol x 54.9g mol^{-1} = $7.137x10^{-4}$g %Mn = $\frac{mass\ of\ Mn}{mass\ of\ steel}$ x100 = $\frac{0.0007137g}{0.245g}$ x100 = 0.29%
4d	296 kJ mol^{-1}	$E = \frac{L \times h \times c}{\lambda}$ = $\frac{6.02x10^{23}\ mol^{-1} \times 6.63x10^{-34}\ J\ s \times 3x10^8\ m\ s^{-1}}{405 \times 10^{-9}m}$ = 295848.9 J mol^{-1} = 296 kJ mol^{-1}
5a	4	Each dimethylglyoxime molecule has two nitrogen atoms within its structure that have lone pairs of electrons which are donated to the central Ni^{2+} ion in the complex. This gives a co-ordination number of four between the two dimethylglyoxime molecules and the Ni^{2+} ion.

5b	19.8%	1 mol $Ni(C_4H_7O_2N_2)_2$ = $(1\times58.7)+(8\times12)+(14\times1)+(4\times16)+(4\times14)$ = 58.7+96+14+64+56 = 288.7g $\dfrac{\text{Mass of Ni}}{\text{in red precipitate}}$ = 0.942g $\times \dfrac{\text{mass of Ni}}{\text{mass of complex}}$ = 0.942g $\times \dfrac{58.7}{288.7}$ = 0.1915g %Ni in impure salt = $\dfrac{0.1915}{0.968} \times 100$ = 19.8%

5c(i)	Hexaaquanickel(II)	# Hexaaquanickel(II) Number of ligands = 6 ligand is water central metal ion charge on ion

5c(ii)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8$	Electrons are removed from 4s before 3d: Ni atom: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ 4s^2$ $\therefore$ Ni^{2+} ion: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8$

5d(i)	Red and blue light is absorbed Green light is transmitted	

Colour	Red	Orange	Yellow	Green	Blue	Violet
Wavelength (nm)	640-700	600-640	560-600	480-560	450-480	400-450

Peak 1	Peak 2	Peak 3
The graph show absorbance in the blue/violet region of the visible spectrum with a large peak around 400-450nm region	The graph show absorbance in the red region of the visible spectrum with a large peak around 640-700 region	The graph show absorbance in the infra-red region of the visible spectrum with a large peak around 800-900nm region
blue light is absorbed by complex	red light is absorbed by complex	no effect: outwith visible spectrum

Conclusion from Peak 1 and Peak 2:
red and blue light are absorbed and remaining green light is transmitted

5d(ii)	NH_3 splits d-orbitals more Shorter wavelength absorbed to supply more energy	NH_3 has a more powerful ligand field splitting effect from the spectrochemical series than H_2O and splits the 3d orbitals in the Ni^{2+} to a greater degree. The d$\rightarrow$d transitions require more energy and the lower wavelength is absorbed to supply the greater energy to make the d$\rightarrow$d transitions.

5d(iii)	green/blue	

Colour	Red	Orange	Yellow	Green	Blue	Violet
Wavelength (nm)	640-700	600-640	560-600	480-560	450-480	400-450

Major absorbance at 600nm $\therefore$ orange wavelengths are absorbed
$\therefore$ green/blue wavelengths are transmitted

6a	2.935	$$\begin{aligned} pH &= \tfrac{1}{2}pK_a - \tfrac{1}{2}\log_{10} c \\ &= (\tfrac{1}{2} \times 4.87) - \tfrac{1}{2} \times \log_{10}(0.1) \\ &= 2.435 - (-0.5) \\ &= 2.935 \end{aligned}$$

6b	6.17	C_2H_5COONa concentration = $\dfrac{\text{no. of mol}}{\text{volume}}$ = $\dfrac{0.20\ mol}{0.1\ litres}$ = 2 mol l⁻¹ pH = $pK_a - \log\dfrac{[acid]}{[salt]}$ = $4.87 - \log\dfrac{0.10\ mol\ l^{-1}}{2\ mol\ l^{-1}}$ = $4.87 - \log(0.05)$ = 4.87 − (−1.301) = 6.17

7a	$C_6H_8N_2$	

7b		

| 7c | Phenylethanal
3 peaks due to three different proton environments | Aldehyde | Phenylethanal | 2-methylbutanal | 3-methylbutanal |
|---|---|---|---|---|---|
| | | Structure | (aromatic ring structure with CH_2–CHO) | (branched chain aldehyde structure) | (branched chain aldehyde structure) |

Peak Chemical Shift (ppm)	Corresponding Structure	Description	Relative Height of Peak	No of Hydrogens in Group
3.2	$ArCH_2R$	CH_2 group with alkyl R group on one end and aromatic group on other	2	2 Hydrogens in $-CH_2-$ group
6.7	ArH	Aromatic Group attached to hydrogen	5	5 hydrogens in $-C_6H_5$ group
9.2	$RC\!\!\diagup^{O}_{H}$	Aldehyde group attached to alkyl group	1	1 hydrogen in -CHO group

7d	Agonist	Agonists	fit the binding site and cause a biological response inside the cell
		Antagonists	fit the binding site of the receptor but does not cause the biological response and prevents any other chemical doing so.

8a(i)	1 or 1st order

$[C_4H_9Br]$ /mol l^{-1}	$[NaOH]$ /mol l^{-1}	Initial Rate /mol l^{-1} s^{-1}
8.0×10^{-4}	0.10	0.15
1.6×10^{-3}	0.10	0.30

Doubling $[C_4H_9Br]$ doubles the rate $\therefore$ first order kinetics

8a(ii)	Zero or no order

$[C_4H_9Br]$ /mol l^{-1}	$[NaOH]$ /mol l^{-1}	Initial Rate /mol l^{-1} s^{-1}
1.6×10^{-3}	0.10	0.15
1.6×10^{-3}	0.20	0.30

Doubling $[NaOH]$ does not change the rate $\therefore$ zero order kinetics

8b	Rate=k[C$_4$H$_9$Br]	Rate = $k[C_4H_9Br]^1[NaOH]^0 = k[C_4H_9Br]$

8c	187.5 s^{-1}	rate = $k[C_4H_9Br]$ $\therefore$ $k = \dfrac{rate}{[C_4H_9Br]} = \dfrac{0.15 \text{ mol l}^{-1}\text{ s}^{-1}}{8 \times 10^{-4} \text{ mol l}^{-1}} = 187.5$ s^{-1}

| 8d | 2-bromo-2-methylpropane (2-bromomethylpropane) Or tertiary structure

Tertiary haloalkanes form more stable carbocation intermediates due to steric hindrance of the tertiary structure |
|---|---|

1-bromobutane	2-bromobutane	1-bromo-2-methylpropane	2-bromo-2-methylpropane
C_3H_7 structure	C_2H_5 structure	CH_3CHCH_3 structure	CH_3 structure
primary haloalkane	secondary haloalkane	primary haloalkane	tertiary haloalkane

Primary and secondary haloalkanes react with NaOH by S_N2 mechanism. 2 particles are involved in the rate determining step where the nucleophilic species (OH⁻ion) attacks the central carbon due to the lack of steric hindrance of primary/secondary structure.

Tertiary haloalkanes react by S_N1 mechanism. Carbocations are formed first in the RDS and then the nucleophilic species (OH⁻) attacks the planar carbocation intermediate to form alkanol

8e	Mechanism showing:

(Reaction mechanism diagram:)

$CH_3-\overset{CH_3}{\underset{CH_3}{C}}-Br$ 2-bromo-2-methylpropane $\xrightarrow{\text{Step 1}}$ $CH_3-\overset{CH_3}{\underset{CH_3}{C^+}}$ carbocation intermediate Br^-

$CH_3-\overset{CH_3}{\underset{CH_3}{C^+}}$ ^-OH $\xrightarrow{\text{Step 2}}$ $CH_3-\overset{CH_3}{\underset{CH_3}{C}}-OH$ 2-methylpropan-2-ol

S_N1 nucleophilic substitution will take place as only 2-bromo-2-methylpropane is involved in the Rate Determining Step (Step 1) as hydroxide ions are zero order.

9a	One answer from:	fairly high molecular mass	available in high purity	(thermodynamically) stable	Soluble in water (or named solvent)	soluble

9b	Answer to include:	Step 1	Accurately weigh required/correct mass of Na_2CO_3 and dissolve completely in small volume of deionised water
		Step 2	Transfer the solution to a standard flask, sensing the beaker with deionised water and transferring risings to the flask
		Step 3	Add deionised water up to the mark adding the last few drops with a dropper
		Step 4	Invert to mix once stoppered.

9c — Answer to include:

no. of mol = **volume** x **concentration** = 0.250 litres x 0.2 mol l^{-1} = 0.05mol

$$volume = \frac{no.\ of\ mol}{concentration} = \frac{0.05\ mol}{1\ mol\ l^{-1}} = 0.05\ litres = 50cm^3\ (1^{st}\ mark)$$

2nd mark:

Measure 50cm^3 of stock 1 mol l^{-1} Na_2CO_3 solution using a pipette and transfer to 250cm^3 standard flask Add deionised water up to the mark, stopper and invert.

10a — Electrophilic Substitution (or alkylation)

$$Cl-CH_2CH_3 \xrightarrow[\text{(heterolytic fission)}]{\text{aluminium chloride } AlCl_3} {}^+CH_2CH_3 + Cl^-$$

+ HCl

10b — Chlorine molecule splits to form chlorine free radicals with one electron going to each chlorine

Light/uv radiation is required in the initiation step of a free radical chain reaction: $Cl_2 \longrightarrow 2Cl^\bullet$ by homolytic fission.

$$Cl-Cl \xrightarrow{\text{u.v. light}} Cl^\bullet + Cl^\bullet$$

10c

(Intermediate)

10d — Elimination

KOH(aq) is used for nucleophilic substitution of –OH groups onto haloalkanes
KOH dissolved in ethanol is used for elimination reactions forming alkenes from haloalkanes

10e

11a — Phosphoric acid <u>or</u> aluminium oxide <u>or</u> sulphuric acid

Phosphoric acid (sometimes referred to as orthophosphoric acid), hot aluminium oxide and concentrated sulphuric acid perform dehydration reactions, a type of elimination reaction.

11b(i) — 87.8%

1mol $C_6H_{11}OH$ = (6x12)+(12x1)+(1x16) = 72+12+16 =100g   1mol C_6H_{10} = (6x12)+(10x1) = 72+10 =82g

$$C_6H_{11}OH \longrightarrow C_6H_{10} + H_2O$$

1mol	1mol
100g	82g
4.36g	82g x$^{4.36}/_{100}$
	= 3.5752g (Theoretical)

$$\% \ Yield = \frac{Actual}{Theoretical} \times 100 = \frac{3.14}{3.5752} \times 100 = 87.8\%$$

11b(ii)	One answer from:		Impure starting materials		Mechanical losses	Mass transfer losses
			Reaction may not go to completion		Side reactions	Equilibrium reaction

11c	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.

12a	$C_4H_{10}O$	Mass of carbon in CO_2 = $^{12}/_{44}$ × 11.89g = 3.243g Mass of hydrogen in H_2O = $^{2}/_{18}$ × 6.08g = 0.676g Mass of oxygen = total mass – (mass of carbon +hydrogen) = 5.00 – 3.243 – 0.676 = 1.081g

Elements	C	H	O
Mass or %	3.243g	0.676g	1.081g
Divide by RAM	$\frac{3.243g}{12g\ mol^{-1}}$ = 0.270 mol	$\frac{0.676g}{1g\ mol^{-1}}$ = 0.676 mol	$\frac{1.081g}{16g\ mol^{-1}}$ = 0.0676mol
Divide through by smallest number	$\frac{0.270mol}{0.0676mol}$ =3.99	$\frac{0.676mol}{0.0676mol}$ = 10	$\frac{0.0676mol}{0.0676mol}$ 1
Empirical Formula	4	10	1

12b	C—O stretch	Alkyl ethers C—O bonds stretch at wavenumber range 1070-1150cm^{-1}

12c	$C_4H_{10}O$	$C_4H_{10}O$ = (4x12)+(10x1)+(1x16) = 48 + 10 + 16 = 74

12d	Ethoxyethane Or $C_2H_5OC_2H_5$	Possible $C_4H_{10}O$ ether structures:

Ethoxyethane			methoxypropane		
$CH_3CH_2OCH_2CH_3$			$CH_3OCH_2CH_2CH_3$		
Chemical Shift	Group	Relative Intensity	Chemical Shift	Group	Relative Intensity
0.9-1.5	-CH₃	3	0.9-1.5	-CH₃	3
3.5-3.9	R-CH₂-O-	2	3.5-3.9	R-CH₂-O-	2