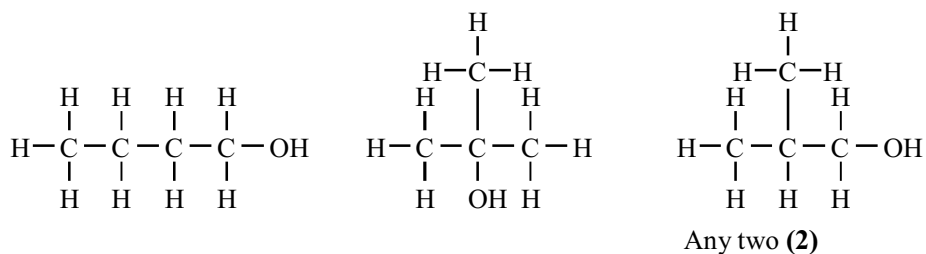


1. (a) (i)  $\text{Mr}(\text{C}_6\text{H}_{11}\text{OH}) = 100$  (1)  
 $6.0 \div 100 = 0.06$  (1) 2
- (ii)  $\text{Mr}(\text{C}_6\text{H}_{10}) = 82$  (1)  
 Answer to (a)(i)  $\times 82$  (1) =  $0.06 \times 82 = 4.92$  g 2
- (iii)  $\frac{1.8}{\text{Answer to (a)(ii)}} \times 100\% = 36.6\%$  (1)  
*Consequential* 1
- (b) BP of cyclohexene is lower / BP of cyclohexanol is higher(1) so it distils off as it forms / comes over first / vaporises first / boils first / or details of method as to how the product could be distilled off first / cyclohexanol left behind (1) 2
- (c) Carbon must come from cyclohexanol so using it up / comes from competing reaction / idea of breakdown of reactants so that not all reactants converted to desired product (1) 1
- (d) Reference to taking care when adding water / add mixture to water (1)  
 Wearing gloves / safety goggles / safety spectacles (1) 2
- (e) Reagent: bromine (solution) / bromine water /  $\text{Br}_2$   
 or potassium manganate(VII) + sulphuric acid / sodium carbonate / sodium hydroxide (or correct formulae) (1)  
 Result:  
 **$\text{Br}_2$**  yellow/red-brown/orange/orange-red/brown to colourless/decolourised/goes colourless *but not goes clear*  
 **$\text{KMnO}_4$**  purple to colourless/decolourised/goes colourless *not goes clear*  
 or if alkaline conditions brown ppt/solid (1) 2

[12]

2. (a) Diagrams:



Names:

Butan-1-ol, (2)-methylpropan-1-ol,  
 (2)-methylpropan-2-ol any two (2)

4

- (b) (i) From **orange to (blue-)green (1)** 1
- (ii) butan-(2)-one **(1)**  
Oxidation/redox **(1)** 2
- [7]**
3. (a) Mr 2-bromobutane = **137 (1)**  
**moles** =  $13.7/137 = 0.10$  **(1)** allow 0.1  
**moles** KOH =  $9.0156 = 0.16$  **(0.1607 or 0.161) (1)**  
KOH present in excess consequential **(1)** 4
- (b) Mr butan-2-ol = **74 (1)**  
max **moles** butan-2-ol obtainable = **0.10 (1)**  
*consequential on (a)*  
max mass =  $0.10 \times 74 = 7.4$  **g (1)** answer **with units**  
*If candidate has calculated that the 2-bromobutane is in excess the calculation is based on 9 g of KOH, this gives 0.16 mol of KOH and 11.9 g of product* 3
- (c) lone pair donor / electron pair donor / lone or electron pair can form co-ordinate / dative bond **(1)**  
hydroxide ion /  $\text{OH}^-$  **(1)** 2
- (d) rate increased **(1)**  
C-I bond weaker (than C-Br bond) / lower bond energy **(1)** 2
- [11]**
4. (a) diagram 1 (heating under) reflux **(1)**  
diagram 2 distillation **(1)** 2
- (b) (i) reaction is slow / time needed for reaction to reach completion **(1)** 1
- (ii) condenses vapours and returns liquid to flask / vapour turns to liquid and returns to flask **(1)**  
(it allows reaction at boiling point of reactants) without loss / escape of material/reactants  
prevents loss/escape of materials/reactants/products **(1)** 2

- (c) heat the mixture (slowly) **(1)**  
 collect only fraction/distillate **(1)**  
 produced at 102 °C / around 102 °C / between 100-104 °C / at  
 the boiling temperature of the 1-bromobutane **(1)**  
*Need to make clear that only distillate at this temperature is  
 collected for second mark* 3
- (d) (i)  $\frac{3.1}{7.2} \times 100 = 43.1\%$  **(1)** Allow 2-4 significant figures 2
- (ii) two reasons from:  
 side reactions **(1)**  
 reaction incomplete **(1)** Max  
 product lost in purification / transfers **(1)** 2
- [12]**
5. (a) (i) 

c	H	O	
68.2/12	13.6/1	18.2/16	÷ by A, <b>(1)</b>
5.68	13.6	1.14	÷ by smaller <b>(1)</b>
5	12	1	

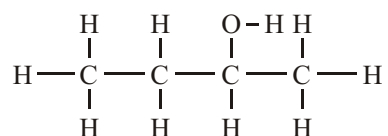
  
 formula  $C_5H_{12}O$  **(1)**
- (ii) Empirical formula mass = 88 = Molar mass **(1)**  
 Thus  $C_5H_{12}O$  **(1)** 2
- (b) (i)  $ROH + PCl_5 \rightarrow RCl + HCl + POCl_3$  2  
**(1)** for HCl, **(1)** for the rest
- (ii) Steamy / misty / fumes **(1)** 1
- (c) (i) Any of  
 2-methylbutan-1-ol,  
 3-methylbutan-1-ol,  
 2,2-dimethylpropan-1-ol. **(2)** 2
- (ii) Structure of the aldehyde consequent on the alcohol in (i) **(1)**  
*Mark CQ on the structure of the compound in (i), so if a 2° alcohol  
 appears it must be a ketone, if a 3° alcohol no product or distils  
 over. Carboxylic acid scores zero.* 1

	(iii)	Potassium (or sodium or ammonium) dichromate(VI) (1) and sulphuric acid (1) Potassium manganate(VII) (1) <u>dilute</u> sulphuric acid (1)	2	
	(iv)	Carboxylic acid (1) <i>Consequential</i>	1	
(d)	(i)	C=C (1) or Correct structure from Z with double bond shown (1)	1	
	(ii)	Carbon skeleton derivable from the structure of the alcohol used in (c)(i) (1) two bromine in correct places from that alkene (1) <i>Note:</i> <i>if 2, 2-dimethylpropan-1-ol given in c (ii) can have 2 marks for any sensible chemistry based on this</i>	2	[17]
6.	(a)	(i) Free radical (1)	1	
		(ii) Ethane single bonds / $\sigma$ only (1) • C-H must be broken (1) could be awarded for explained reference to difficult to break Ethene <b>also</b> has $\pi$ bond / $\sigma$ and $\pi$ bonds (1) where electrons are more accessible/ $\pi$ bond is weaker (and breaks) (1)	4	
	(b)	(i) 1-bromopropane (1)	1	
		(ii) CH <sub>3</sub> CH=CH <sub>2</sub> (1)	1	
		(iii) CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> OH (1).	1	
		(iv) Nucleophile (1).	1	
	(v)	• C-Cl bond is stronger than C-Br (1) • so activation energy for reaction is higher /more kinetically stable (1) (in the case of the chloro- compound).	2	[11]

7. (a) • Apparatus to show round or pear shaped flask **(1)** not conical  
 • Reflux condenser - *must have inner tube and inlet and outlet for water* **(1)**  
 Controlled source of heating e.g. electric heater/ hot plate **(1)**  
 Reasonable drawing **(1)** of an apparatus that would work. 4  
*Eg not sealed apparatus, water must flow correctly through condenser, joint shown between flask and condenser (no obvious gaps), no extras*  
*Show as ✓ Q on the script for this mark*
- (b) (i) (Fractional) distillation
- (ii) The mixture may be separated because the boiling temperatures are different / 1-bromobutane has lower boiling temperature (than butan-1-ol) **(1)**  
 The 1-bromobutane will distil over / vaporise first (and can be collected) **(1)**  
*allow butan-1-ol is left in the flask* 2
- (c) (i) Mr = 74 **(1)**  
 11.1/Mr = correct answer **(1)** [0.150 mol] 2
- (ii) Mr = 137 **(1)**  
 Answer to (i) × Mr = correct answer **(1)** [20.55 g] 2
- (iii)  $\frac{12.4 \times 100}{\text{answer to (ii)}} = \text{correct answer [60.3 or 60.2]}$  **(1)** 1
- (iv) Any **one** of:  
 • competing reactions  
 • side reactions  
 • incomplete reaction  
 • product lost in purification  
 • product lost in transfers. 1

**[13]**

8. (a)

OH on second carbon atom **(1)**All of molecule displayed **(1)**Butan-2-ol **(1)**

3

- (b) (i)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$  OR  $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$  OR  $\begin{array}{c} \text{CH}_3\text{CHCH}_2\text{OH} \\ | \\ \text{CH}_3 \end{array}$   
*NOT displayed*  
*NOT C<sub>4</sub>H<sub>9</sub>OH* 1
- (ii) Butanone (1)  
 Butanal and butanoic acid OR  
 2-methylpropanal and 2-methylpropanoic acid (2)  
*IF Ketone, Aldehyde + Carboxylic acid 1 (out of 3)* 3
- (c) (i) Suitable flask with contents and heat (1)  
 Vertical Liebig condenser (1)  
 Water flow correct (1) 3  
*IF distillation and correctly drawn 1 max ie for flask and heat*  
 Penalties  
 Poor diagram -1  
 Sealed apparatus -1
- (ii) (Fractional) distillation 1
- (d) (i)  $\text{CH}_3\text{CH}=\text{CHCH}_3$  or  $\text{CH}_3\text{CHCHCH}_3$  (1)  
*ALLOW cis and trans forms for 2 marks*  
*ALLOW displayed*  
 $\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2$  (1)  
 But-2-ene and but-1-ene or cis-but-2-ene and trans-but-2-ene (1) 3
- (ii) purple/(pale) pink to colourless/brown 1
- (iii) Bromine (water) *NOT* bromine gas 1

[16]

9. (a) It is a mixture / not a single compound 1
- (b) (i) 2,4-dimethylpentane 1
- (ii)  $C_7H_{16}$  1
- (iii) More volatile / lower boiling point / vaporises more readily / branched so doesn't knock / higher octane number 1
- (iv) Heat / high temperature /  $\geq 200\text{ }^\circ\text{C}$  (1)  
Silica / alumina (catalyst) / zeolites (1) 2
- (v) *Diagram should show:*  
Test tube containing paraffin absorbed on suitable absorbent – (1)  
**absorbent can be just shown in the diagram**  
Aluminium oxide catalyst (1)  
Heat catalyst (1)  
Recognition of collection of gas over water / gas syringe (1) 4
- Penalties*  
–1 for poor diagram
- (c) (i)  $(CH_3)_2C=CH_2$   
*ACCEPT*  $(CH_3)_2CCH_2$  1
- (ii) Elimination 1
- (iii) Potassium hydroxide / KOH / NAQH (1)  
Ethanollic / alcoholic solution + heat / reflux (1) 2
- [14]
10. (a) • A species with a lone pair / pair of electrons (1)  
**NOT** “negative ion” alone or as an alternative  
• which it uses / donates to form a (dative) covalent bond (1) 2
- (b) (i) • Ammonia /  $NH_3$  (in ethanol) (1)  
• heat (1) **NOT** heat under reflux *UNLESS* in a sealed tube  
*If a temperature is quoted it must be greater than 100°C*  
• in sealed tube / under pressure / concentrated (1)  
*If a pressure is quoted it must be greater than 1 atm*  
Conditions are dependent on correct reagent.  
If ammonia and an additional reagent **max (1)** for two correct conditions. 3
- (ii) Carbon-bromine bond stronger / higher bond enthalpy than carbon – iodine /  $E_a$  for C-Br is higher than C-I  
**IGNORE** any extra explanations involving the alkyl groups 1
- (c) Identify bonds broken **and** made (1)  
e.g. Energy in + 464 or + 3340

**AND** Energy out (-) 656 or (-) 3532 **(1)**

Energy needed to break bonds – energy released to make bonds = 36 **(1)**

e.g. C-I + 464 – 656 = + 36

or C-I + 3340 – 3532 = + 36 **(1)**

Correct evaluation dependent on use of 36 **(1)**

i.e. C-I = 228 kJ mol<sup>-1</sup> **(1)**

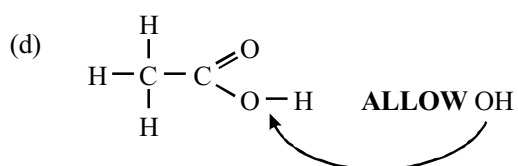
Correct answer with some correct working **(3)**

If final answer is negative max **(2)**

If 36 is on the wrong side, then 156 max 2 (-156 **(1)**)

If miss out 36, then ±192 **max 1**

3

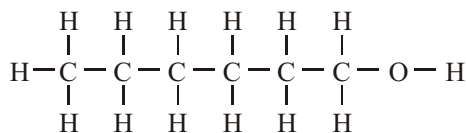
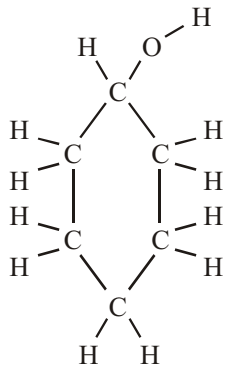


1

**[10]**

**11.** (a) (i) All bonds and atoms shown for each alcohol

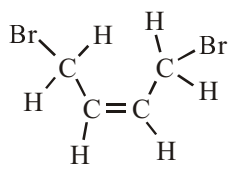
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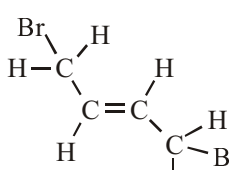


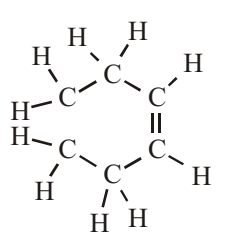
(ii)	Molecular formulae are different / different number of hydrogen atoms in each	1
(iii)	cyclohexanol secondary <b>(1)</b> hexan-1-ol primary <b>(1)</b>	2
(iv)	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CHO <b>(1)</b> Hexanal <b>(1)</b>	2
(v)	Warm with Benedict's / Fehling's solution <b>(1)</b> Hexan-1-ol: blue solution goes brown / red-brown / red / orange / yellow/ green (ppt) <b>(1)</b> Cyclohexanol: no change/ stays blue <b>(1)</b> Use of bromine to test for an alkene <b>(0)</b> Use of sodium carbonate to distinguish hexanoic acid from cyclohexanone, described correctly <b>(3)</b> OR test with suitable acidified dichromate OR manganate(VII) Product of hexan-1-ol: orange → green with dichromate purple → colourless with permanganate Product of cyclohexanol: no change	3
(b)	(i) Elimination/ dehydration	1
	(ii) Labelling not required if apparatus recognisable Round-bottom / pear-shaped flask + heat <b>(1)</b> cyclohexanol + conc sulphuric acid / phosphoric acid <b>(1)</b> condenser with correct water flow <b>(1)</b> receiving vessel OR closed flask + vent <b>(1)</b> OR tube containing mineral wool + heat (heat left hand side of tube) <b>(1)</b> Cyclohexanol in wool + aluminium oxide / Al <sub>2</sub> O <sub>3</sub> <b>(1)</b> Penalties Apparatus would not work e.g. no stopper above flask –1 Poor diagram –1 Completely sealed apparatus –1	4
	(iii) Add anhydrous/fused calcium chloride or anhydrous sodium / magnesium sulphate Accept formula Decant / filter off drying agent <b>(1)</b> For (re-)distilling without mentioning drying agent Accept fractional distillation <b>(1)</b>	2

[17]

12. (a) (i) Two reactants form **one product** 1
- (ii) **Substitution** reactions occur under these conditions 1
- (iii) The electrons of the double /  $\pi$  bond polarise the Br – Br molecule (**1**)  
and Br  $\delta^+$  is the electrophile (**1**)  
*OR show Br  $\delta^+$  – Br  $\delta^-$  attacking in the correct orientation* 2
- (b) (i)
- 

(1)

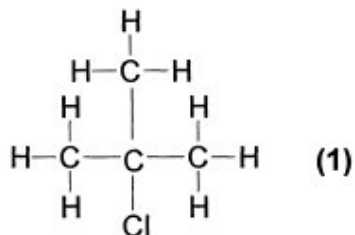


(1)
- 2
- (ii) No rotation about a C = C double bond  
*OR only single bonds can rotate* 1
- (c) (i)
- 
- 1
- (ii) Low temperature because exothermic reaction (**1**)  
High pressure because fewer molecules of product than of reactants gases are being converted into liquids (**1**) 2
- [10]**
13. (a) (i) 1,2-dichloroethane 1
- (ii) CH<sub>2</sub> = CHCl / CH<sub>2</sub>CHCl 1
- (iii) e.g. dissolve / bubble HCl in water / absorb in an alkali / condense the HCl(g) 1
- (b) (i) Species having unpaired electron 1
- (ii) Action of UV radiation/sunlight / named initiator / photoflood 1

(c)	(i)	Water / OH <sup>-</sup>	1	
	(ii)	Unshared / lone pair of electrons on a legitimate nucleophile based on (c)(i) <b>(1)</b>		
		(c)(i) "nucleophile" attacks / forms bond with C of C – Cl <b>(1)</b>	2	
	(iii)	Chloride ion / Cl <sup>-</sup>	1	
	(iv)	Add silver nitrate solution <b>(1)</b> <b>white ppt (1)</b>	2	<b>[11]</b>
<b>14.</b>	(a)	(i) Electron pair/ lone pair acceptor Or accepts electrons to form a (dative) covalent bond	1	
		(ii) Particle with an unpaired electron	1	
		(iii) Electron pair/ lone pair donor Or donates electrons to form a (dative) covalent bond	1	
	(b)	(i) Nucleophilic <b>(1)</b> Substitution <b>(1)</b>	2	
		(ii) (Free) radical <b>(1)</b> Substitution <b>(1)</b>	2	
		(iii) Electrophilic <b>(1)</b> Addition <b>(1)</b>	2	<b>[9]</b>
<b>15.</b>	(a)	(Heating under) reflux <b>(1)</b> Distillation/simple distillation <b>(1)</b> <i>NOT</i> fractional distillation	2	
	(b)	(i) $\frac{137}{74} \times 3.70$ <b>(1)</b> = 6.9/6.85(g) <b>(1)</b>	2	
		(ii) $\frac{4.60}{\text{answer to(i)}} \times 100 = 67 / 66.67 / 66.7 \%$	1	
		(iii) Slow/reaction takes a long time / high activation energy.	1	
		(iv) Measure boiling temperature/point <b>(1)</b> Compare with data book/literature/known value <b>(1)</b>	2	
	(c)	(i) Orange to green	1	

- (ii) **Oxidation continues (1)**  
 carboxylic acid formed (1) 2
- (iii) Aldehyde/first product distilled off as it forms/removed from  
 reaction mixture 1
- [12]**
16. (a)  $C_4H_{10}O + Na \rightarrow C_4H_9O^{(-)}Na^{(+)} + \frac{1}{2} H_2$   
 entities (1)  
 balancing, ignoring charges in organic product (1) 2
- (b) (i)  $Cr^{3+}$  1
- (ii) Heat and round-bottom (suitable i.e. not a beaker) flask (1)  
 condenser above (1)  
 water jacket and water direction  
*ALLOW arrows for water direction (1)*  
 -1 poor diagram e.g. flask and condenser integrated  
 -1 sealed apparatus 3
- (iii)
- $$\begin{array}{ccccccc}
 & H & & H & H & & \\
 & | & & | & | & & \\
 H & -C & - & C & - & C & -C & -H \\
 & | & & || & | & & | \\
 & H & & O & H & & H & & (1) & (1)
 \end{array}$$
- Butanone / butan-2-one (1) 2
- (iv)  $CH_3CHOHCH_2CH_3$   
*ALLOW TE from (iii) for butanal / butanoic acid* 1
- [9]**

17. (a)



2-chloro-2-methylpropane (1)

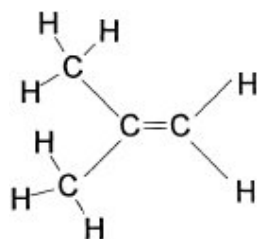
*No marks for primary or secondary halogenoalkane even if both formula and name are consistent*

*Must be displayed*

2

- (b) (i) Hydrogen chloride  
 OR HCl  
 OR (concentrated) hydrochloric acid *NOT dilute* hydrochloric acid  
 OR sodium / potassium chloride and concentrated sulphuric acid/  
 phosphoric acid 1
- (ii) Substitution (1)  
 Nucleophilic (1) 2

(c) (i)



2-methylprop-1-ene

2

- (ii) No because each carbon atom joined by the double bond has the same two groups attached to it/ OWTTE 1

- (d) Reduction / addition hydrogenation (1)  
Oxidation / addition (1) 2
- (e)
- 
- Must be consistent with (c)(i)*  
*Must be displayed* 1 [11]
18. (i) nucleophilic substitution (1) 2  
aqueous (1) Ignore heat under reflux here  
Allow aqueous ethanol
- (ii) elimination (1) 3  
ethanolic / alcoholic (1)  
**heat** (under reflux) (1) not h.u.r. , not warm [5]
19. (a) Potassium / sodium dichromate(VI)/K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>/Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> 1  
Allow potassium manganate(VII)/permanganate/KMnO<sub>4</sub>/potassium chromate  
/K<sub>2</sub>CrO<sub>4</sub>
- (b) (i) Exothermic 1  
(ii) (Cold) **water moving** through the condenser/water cools the vapour 1  
(iii) To prevent **ethanal** vaporising / **ethanal** is volatile 1  
(iv) (Remove ethanal) because fumes/vapour/gas 1  
flammable/irritant/harmful, **not toxic** 1
- (c)  $\frac{44}{46} \times 5.0$  (1) = 4.8 g  
 $4.8 \times \frac{40}{100} = 1.9$  g (1)  
The second mark can be scored if candidates make use of 2 M<sub>r</sub> values, 5.0g  
and 40% and the answer is less than 5.0g. 2 [7]

20. (a) (i) Solvent/to allow mixing/dissolving 1
- (ii)  $\text{Ag}^+(\text{aq}) + \text{X}^-(\text{aq}) \rightarrow \text{AgX}(\text{s})$  allow  $\text{Cl}^-$ ,  $\text{Br}^-$  or  $\text{I}^-$   
formulae (1)  
state symbols (1) allow state symbols if  $\text{NO}_3^-$  is in the equation. 2
- (iii) Ethanol/halogenoalkanes flammable / constant temperature/controlled temperature. 1
- QWC** (b) Equal volumes/amounts/quantities of ethanol / silver nitrate (1) (1) V  
Equal moles/amounts (not volumes) of halogenoalkanes (1) (1) A  
Test tubes reach temperature of water bath before mixing. (1) (1) E  
Mix reagents simultaneously / start timing on addition of reagents (1) (1) T  
Any two of white, cream, yellow (precipitates) (1) (1) C  
Iodide forms first then bromide then chloride / shortest time **not** rate (1) (1) O  
If any additional reagents are added. **Max 4** MAX 5

[9]

21. (a) (i)
- $$\begin{array}{ccccccc} & \text{H} & \text{H} & \text{H} & & & \\ & | & | & | & & & \\ \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{O} & - \text{H} & \\ & | & | & | & & & \\ & \text{H} & \text{H} & \text{H} & & & \end{array}$$
- 1
- (ii) Diagram should show  
Test tube containing propan-1-ol absorbed on suitable named absorbent (1)  
Aluminium oxide/porous pot catalyst named (1)  
Heat source **below** catalyst (1)  
Collection of propene gas over water / gas syringe (1) 4  
Penalise -1 for poor diagram/wouldn't work
- (b) (i) Sodium propoxide 1
- (ii)  $0.002 \text{ mol} / 2 \times 10^{-3} \text{ mol}$  1
- (c) (i)  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$  OR
- $$\begin{array}{c} \text{OH} \\ | \\ \text{CH}_3\text{CHCH}_3 \end{array} \text{ (1)}$$
- Propan-2-ol (1) 2
- (ii) Propanal - from blue to red/green/orange/brown ppt (1)  
Propanone - no change/stays blue (1)  
'blue' must be mentioned as the initial colour at least once. 2

[11]

22. (a) (i)  $\text{C}_2\text{H}_6(\text{g})/(\text{l}) \rightarrow \text{C}_2\text{H}_4(\text{g}) + \text{H}_2(\text{g})$   
If a state symbol is missing (0)

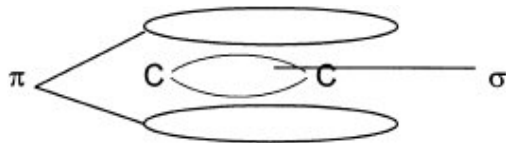
If (aq) (0)

1

- (ii) At high pressure reaction goes in direction to reduce pressure/to oppose change by Le Chatelier's principle (1)  
towards side with fewer molecules/moles (1)

2

- (b) Shapes of orbitals between and above carbon



*If p orbitals drawn must show overlapping*

Shapes (1) ACCEPT crescents for  $\pi$  bonds NOT lines for  $\sigma$  bond  
Labels (1)

2

- (c) Addition of bromine **water/solution** (1)  
from yellow/brown/orange to **colourless** (1)  
*OR*  
**acidified** potassium manganate(VII) (1)  
from pink/purple to **colourless** (1)

2

- (d) Addition (1)  
Electrophilic/electrophile *OR* appropriate *explanation* (1)

2

[9]

23. (a) (i)  $\text{CH}_3\text{CHICH}_2\text{CH}_3 / \text{CH}_3\text{CHIC}_2\text{H}_5$  (1)  
(allow full structural formula)

1

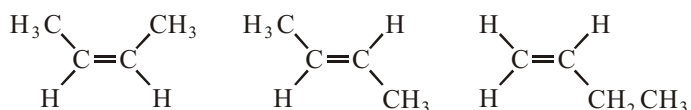
- (ii) Reagent: sodium hydroxide/potassium hydroxide (1)  
Condition: aqueous (ethanolic) solution (1)  
*dependent on correct reagent*

2

- (iii) (Heat) in ethanolic solution /ethanol/ alcohol (1)

1

- (iv)



(1)

(1)

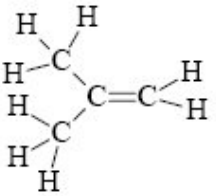
(1)

3

$\text{CH}_3\text{CH}=\text{CHCH}_3$  and  $\text{CH}_2=\text{CHCH}_2\text{CH}_3$  **max 2**



- (b) Rate bromo would be slower **(1)** (or reverse argument)  
 as C–Br bond is stronger (than C–I) **(1)**  
*consequential on correct 1<sup>st</sup> point*  
 and so activation energy would be greater **(1)**  
*consequential on their answer to 1<sup>st</sup> point* 3 **[10]**
24. (a) (i)  $\frac{137}{74} \times 4.0 = 7.4 / 7.41$  g 7.40 g is an s.f. error  
 2 or 3 SF 1
- (ii)  $5.9 \times 100 = 80\%$   
 ALLOW 79.7 / 79.6  
 conseq on (a) (i)  
 2 or 3 SF 1
- (b) (i) (Turns hot) vapour into liquid / condenses **(1)**  
*NOT* just ‘cooled’  
*NOT* just ‘product vapour’  
 Which returns to reaction mixture / allows reaction to go to  
 completion / minimises loss of reactants or products **(1)** 2
- (ii) Two layers shown and upper layer is water 1
- (iii) To dry (1-bromobutane) / as a drying agent  
*NOT* ‘to prevent reaction with 1-bromobutane’ 1
- (iv) • Heated flask (round or pear shaped **ONLY**) **(1)**  
 • Condenser **(1)**  
 • Thermometer in correct position **(1)**  
 • Quality – workable and safe **(1)<sup>Q</sup> (1)**  
 (NOT scored if:  
 wrong direction of water flow in condenser  
 gaps in apparatus  
 sealed apparatus  
 delivery tube in product  
 no joints whatsoever  
 condenser not sloping downwards  
 water bath used for heating 4
- (c) Wear gloves, 1-bromobutane harmful (by skin absorption)  
*NOT* ‘corrosive’ *NOT* ‘irritant’  
 H<sub>2</sub>SO<sub>4</sub> is corrosive *NOT* ‘irritant’  
 Electrical heater / heating mantle, 1-bromobutane flammable  
 Fume cupboard, 1-bromobutane harmful (vapour) *NOT* ‘irritant’ 1 **[11]**

25. (a) Isomer(s) 1  
 (b) B and C 1  
 (c) A 1  
 (d) 2-methylpropan-2-ol 1  
 (e) D and E 2
- (f) (i) Removal of water 1  
 (ii) Alkene / C=C / carbon carbon double bond 1  
 (iii)
- 

(1)

(1)

2-methylprop-1-ene (1)
- [10]
26. (a) Van der Waals/induced dipole-dipole 1  
 (b) (i) Hydrogen/dipole-dipole in **propan-1-ol**, (but no hydrogen/dipole-dipole in butane) 1  
 (ii) Van der Waals forces in propan-1-ol are stronger  
*OR* reverse argument (1)  
 because chain is not branched/so more surface contact between molecules)  
*OR* reverse argument (1) 2
- [4]
27. (a) (Sweat is a dilute aqueous) solution of sodium chloride and urea, (and also other metabolic waste products, such as the lactates produced in muscles)  
*OR*  
 Is a mixture of water, sodium chloride, urea 1
- (b) (Sweat is produced by the eccrine glands) via emotional, thermal and sensory stimuli 1
- (c)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{COOH}$   
*correct answer (2)*  
 correct structure, except  $\text{CH}_3$  branch in wrong place (1)  
 structure for a methylheptanoic acid (1) 2
- (d) Antiperspirants were too acidic and irritated the skin/rotted clothes 1
- (e)  $\text{Al}_2(\text{OH})_2\text{Cl}_4$  1

- (f) e.g. more wasted using aerosol  
 application more precise with roll-on/ consequences for atmospheric  
 pollution using aerosols/any other feasible alternative  
*ACCEPT* environmental pollution + *qualification*

1

[7]

### **Word total/penalty**

Candidates should have recorded their word total at the end of their answer, and this should be checked.

up to 105 words: no penalty

106 – 115 words: –1

116 – 125 words: –2

126 – 135 words: –3

and at a rate of –1 penalty for every 5 words excess thereafter, up to a maximum penalty equal to the number of key points included by the answer.

Note that words appearing in the title to the summary do not count in the word total. Normally hyphenated words (such as odour-causing, roll-ons, mid-1970s, zinc-based), numbers and chemical formulae count as one word. The question does not ask for equations in the summary, but if included they should be counted in the word total.

99 % = 2 words

RCOOH = 2 words

BO = 2 words

$\text{Al}_2(\text{OH})_m\text{Cl}_n$  = 2 words

ACH = 2 words

1947 = 2 words

$\text{C}_4 - \text{C}_{10}$  = 3 words

$m+n = 6$  = 3 words

### **Marking for key points (6 marks)**

One mark should be awarded for every key point clearly identified in an answer, up to a maximum of 6 marks.

A tick should be made in the script. Examiners should show the key point being awarded, i.e. ✓<sup>3</sup> shows key point 3 given.

List of key points: these may be in a different order, and need not be expressed in the wording below provided that the sense of each point is conveyed.

Key pt

### Distinction

- ✓<sup>1</sup> Deodorants act (solely) to reduce BO by **killing / eradicating / destroying** the (odour-causing) bacteria. **(1)**
- ✓<sup>2</sup> Antiperspirants reduce both odour **and** wetness  
*OR*  
In addition antiperspirants reduce wetness - *dependent on key pt 1* **(1)**
- ✓<sup>3</sup> Ethanol is the **principal** antibacterial agent **(1)**
- ✓<sup>4</sup> with **further activity** [OWTTE] derived from some of the added perfume oils.**(1)**
- ✓<sup>5</sup> Aluminium **salts** are (commonly) used in antiperspirants (nowadays).....  
*NOT* aluminium chlorohydrates **(1)**
- ✓<sup>6</sup> ..... and these **physically** block the eccrine/sweat glands -  
*must follow on from "aluminium"* **(1)**

4

### Formulation

- ✓<sup>7</sup> Deodorants and antiperspirants can be sold as a solution, a suspension or emulsion **(1)**

### Application

- ✓<sup>8</sup> and can be applied in )  
**pump** sprays )  
roll-ons ) *Any two* **(1)**  
sticks )  
aerosols )  
gels )

2

### **Quality of Written Communication (2 marks)**

These should *be impression* marked on a scale 2-1-0, and the mark out of 2 should be recorded in the body of the script at the end of the answer. This mark can not be lost as a result of a word penalty.

Candidates are expected to:

- show clarity of expression;
- construct and present coherent argument;
- demonstrate effective use of grammar punctuation and spelling.

The aspects to be considered are:

- use of technical terms; the answer should convey a correct understanding by the writer of the technical terms used in the passage which are involved in the key points.

- articulate expression; the answer should be well-organised in clear, concise English, without ambiguity. It should read fluently, with the links between key points in the original maintained.
- legible handwriting; the reader should be able to read the answer without difficulty at normal reading pace, with only the occasional difficulty with a word.
- points must be in a logical order.

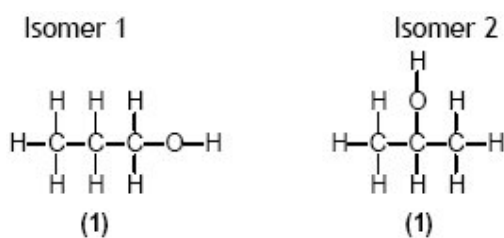
Good style and use of English, with only infrequent minor faults, no use of formulae **(2)**

Frequent minor or a few major faults in style and use of English **(1)**

Very poor style and use of English **(0)**

[15]

28. (a) (i)



propan-1-ol / 1-propanol **(1)**    propan-2-ol / 2-propanol **(1)**

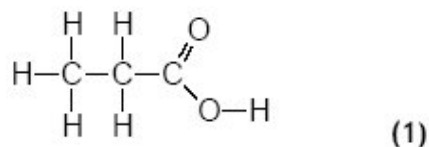
NOT propanol

ALLOW -OH

Penalise sticks once : penalise CH<sub>3</sub> once

4

(ii)



ALLOW CH<sub>3</sub>CH<sub>2</sub> and C<sub>2</sub>H<sub>5</sub> but not COOH

Colour change orange to green / blue / brown **(1)**

2

- (b) (i) PBr<sub>5</sub> / PBr<sub>3</sub> / red phosphorus + Br<sub>2</sub>  
or  
sodium/potassium bromide and (conc) H<sub>2</sub>SO<sub>4</sub> / 50% sulphuric acid /  
(conc) phosphoric acid / KBr + H<sub>2</sub>SO<sub>4</sub>

NOT dilute

1

- (ii) 2-bromopropane /  $\text{CH}_3\text{CHBrCH}_3$  *NOT* Bromo-2-propane 1
- (iii)  **$\text{CH}_3\text{CH(OH)CH}_3$**  (1)  
 $\text{CH}_3\text{CH}=\text{CH}_2$  must show double bond (1)  
*ACCEPT full structural formulae* (1)  
*ALLOW T.E. based on X* If 1-bromopropane 2
- [10]**
29. (a) (i) 1-chloropropane has more electrons than chloroethane (1)  
 So van der Waals' forces (between molecules) stronger/greater  
*OR*  
 More/greater van der Waals' forces (1)  
*OR reverse argument*  
*If dipoles are mentioned they must be temporary /induced /*  
*transient / fluctuating / flickering* 2
- (ii) Molecules in 2-chloropropane make less contact / pack less well /  
 can get closer together OWTTE  
*ACCEPT annotated diagram*  
*If the explanation about van der Waals' forces is given here*  
*allow it in (i) UNLESS incorrect intermolecular force mentioned*  
*in (i)* 1
- (b) (i) Reagent with a lone pair of electrons  
*OR*  
 Pair of electrons which it can use to make a bond  
*OR*  
 Reagent which attacks species with a  $(\delta)^+$  charge  
*NOT* "attacks nucleus" *on its own*  
*NOT* "species with a negative charge" 1
- (ii) C-I bond is weaker than C-Cl  
*Must say which bond is weaker* 1
- (c) (i) Use ethanolic KOH/KOH in alcohol/KOH in ethanol/  
 ethanol as solvent (and raise temperature) 1
- (ii) Elimination (1)  
 IGNORE comment on what is eliminated  
 IGNORE qualification eg electrophilic 1
- [7]**

30. (a) (i) Reaction takes time  
 OR reaction is slow / activation energy is high  
 OR to speed up the reaction / supplies activation energy  
*Answer could be covered in (ii) allow mark provided the answer in (i) is sensible.* 1
- (ii) (Without a reflux condenser the volatile) substances / the ester could be boiled off. 1
- (b) Any flask and any source of heat **(1)**  
 ALLOW "Heat"  
*Flask must be connected to the rest of the apparatus*  
 ALLOW flask & condenser as one piece of apparatus  
 vertical condenser **(1)**  
 water flow **(1)** consequential on a vertical condenser  
 apparatus not closed **(1)** consequential on a vertical condenser 4
- (c) (i) To convert it into benzoic acid  
 OR to liberate the acid (from the salt)  
 OR a description of the chemistry 1
- (ii) Because the acid is soluble in hot water  
 OR the acid is insoluble in cold water  
 OR to crystallise out the acid 1
- (d) (i) Amount of ester =  $4.5 \div 150 = 0.03$  (mol) **(1)**  
 Amount of product =  $2.93 \div 122 = 0.024$  (mol) **(1)**  
 $\% \text{ yield} = \frac{0.024 \times 100}{0.03} = 80\%$  **(1)**  
 OR  
 $150 \text{ g ester} \Rightarrow 122 \text{ g acid (1) } 4.5 \text{ g} \Rightarrow \frac{4.5 \times 1.27}{150} = 3.66 \text{ g (1)}$   
 $\frac{2.93 \times 100}{3.66} = 80 \% \text{ (1)}$   
 $\frac{2.93}{4.5} \times 100 \text{ (0)}$  3
- (ii) Lowered because more stays in solution  
 OR Lowered because some stays in solution 1

(e)  $\text{PCl}_5$  reacts with water 1

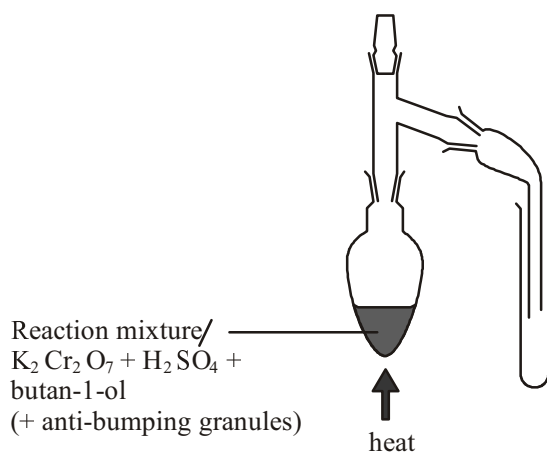
[13]

31. (a) (i) Redox  
 ALLOW oxidation / partial oxidation  
 NOT reduction / complete oxidation 1

(ii) Sodium or potassium dichromate ((VI)) /  $\text{Na}_2\text{Cr}_2\text{O}_7$  /  $\text{K}_2\text{Cr}_2\text{O}_7$  (1)  
 Sulphuric acid /  $\text{H}_2\text{SO}_4$  dilute or concentrated (1)  
 IGNORE any Roman numerals  
 ALLOW  $\text{H}^+$  and  $\text{Cr}_2\text{O}_7^{2-}$  / acidified dichromate 1 (out of 2)  
 $\text{H}_2\text{SO}_4$  mark not allowed if mixed with an alkali/carbonate 2

(iii) Orange to green / blue / blue green  
 ALLOW TE of purple to colourless / brown if  $\text{MnO}_4^-$  used in ii 1

(iv)



Arrow is enough to show heat

Pear-shaped/round bottomed flask/tube with side arm +  
 reagents/reaction mixture + heat (1)

Side-arm from adaptor/delivery tube from side-arm  
 tube/condenser + collecting vessel (1)

-1 for poor drawing eg line not tube, sealed apparatus, open at top,  
 collecting under water, large gaps in equipment, one-piece equipment  
 (ie flask must be separate from rest)

IF condenser used ignore water direction

No marks if refluxed/apparatus would not work 2



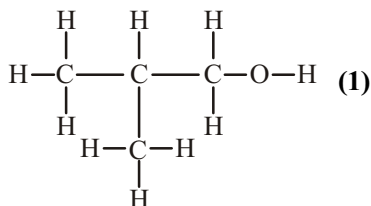
Watch for  $\begin{array}{c} \text{OH} \\ | \\ -\text{C} \\ // \\ \text{O} \end{array}$  (0)



- (vi) Benedict's solution (+ heat + NaOH) **(1)**  
 Red/brick-red (precipitate) **(1)**  
 ALLOW green/yellow/brown/red-brown/orange  
 Stays blue (solution) **(1)**  
 ALLOW nothing happens / no change if Benedicts colour given earlier  
 OR  
 potassium/sodium dichromate + acid **(1)**  
 goes green **(1)** ALLOW goes blue  
 stays orange solution **(1)**  
 ALLOW correct results with Fehlings solution or Tollens reagent

3

(b)



- (2-)methylpropan-1-ol **(1)**  
 Do not penalise if OH and CH<sub>3</sub>'s not fully displayed. ONLY ALLOW T.E.  
 for name if (2-)methylpropan-2-ol is drawn.

2

**[12]**

32. (a)  $\Delta H_{\text{at}} = (2 \times 347) + 612 + (8 \times 413) = + 4610 \text{ (kJ mol}^{-1}\text{)}$

Method **(2)**Answer (arithmetic and sign) **(1)**+ 4610 with no working **(3)**one multiple wrong/omitted (eg +4263/+1719) **2 max**two multiples wrong/omitted (eg +1372) **1 max**

3

- (b) (i) axes suitably labelled **with units** : “(Number of) carbon atoms” on **x-axis** and “ $\Delta H_{\text{at}}$  (l)  $\text{kJ mol}^{-1}$ ” on **y-axis (1)**  
 Linear and sensible scales **(1)**  
*ALLOW one big square per 1000 kJ. Must be one big square per carbon atom*  
 All points correctly plotted and joined with **straight** line or dot-to-dot **(1)**  
*only penalise if points clearly off line*  
 Graph of  $\Delta H_{\text{at}}$  vs. Boiling point **(0)**  
 Graph of Boiling point vs. number of carbon atoms **(0)** 3
- (ii) *1<sup>st</sup> mark: bond breaking increasing*  
*2<sup>nd</sup> mark: quantitative treatment*  
 e.g.  
 (From one alkene to the next) involves the **atomisation/breaking of an extra C–C bond** and two extra **C–H bonds (2)**  
 OR  
 a need to break more bonds as chain length increases (1)  
 molecules increase by  $-\text{CH}_2-$  as chain length increases (1) 2
- (iii) (+)  $4620 - 30 (\text{kJ mol}^{-1})$  1
- (c) (i) Van der Waals *OR* fluctuating/induced dipoles *OR* London/dispersion forces  
*NOT* vdw 1
- (ii) Number of electrons increases **(1)**  
 so the strength of the van der Waals / **intermolecular** forces also increases  
 OR  
 so there are more van der Waals forces **(1)**  
*Mark independently* 2
- (iii) Two **geometric** isomers [*can be shown in diagram instead*]/ a cis and trans form exist  
 OR  
 Valid argument based on no free rotation about C=C bond  $\rightarrow$  two isomers 1

- (iv) Pent-1-ene because unbranched/straight chain **(1)**  
 Greater area (of contact)/more contact between molecules/molecules  
 can align more easily **(1)**  
*IGNORE* argument based on stacking/packing  
*IGNORE* molecules can get closer together 2
- (d) There is hydrogen bonding in water **(1)**  
 Alkenes cannot form hydrogen bonds (with water molecules)/alkene-  
 water interactions too weak **(1)**  
*Mark independently* 2
33. (a) N<sub>2</sub>O 1
- (b) Refrigerants/heat transfer agents and anaesthetics /  
 they share similar properties  
*OR* properties exemplified  
 eg non flammable/non toxic/volatile - any **two** of these  
*OR*  
 Refrigeration technology resulted in the production of CFCs  
 which were then found to have properties of anaesthetics  
*OR*  
 Refrigerants/heat transfer agents were found to be anaesthetics 1
- (c) Inertness of **fluorine in the C-F bond**  
 Inertness of fluorine in the CF<sub>2</sub> / CF<sub>3</sub> groups  
 CF/CF<sub>2</sub>/CF<sub>3</sub> group conferred stability on **adjacent/neighbouring** C—Hal bonds  
*NOT* inertness of C-F bond/fluorine alone 1
- (d) (i) There is a greater difference between the electronegativities of fluorine  
 and hydrogen than between fluorine and chlorine / chlorine is more  
 electronegative than hydrogen  
*Answer in terms of relevant relative shifts in electron densities  
 are acceptable.*  
*ACCEPT* answers based on relative symmetries, e.g. electron cloud in  
 CF<sub>3</sub>CCl<sub>3</sub> is more symmetric than with CF<sub>3</sub>CH<sub>2</sub>Cl  
*ACCEPT* argument in terms of electropositivities 1
- (ii) CF<sub>3</sub>CH<sub>2</sub>Cl  
 because it possesses C—H bonds  
*OR* enables (electrostatic) interactions with “brain molecules”  
*OR* because a lower dose can be used 1

[17]

- (e) (2) - bromo - (2) - chloro - 1,1,1 - trifluoroethane }  
 OR } *IGNORE punctuation*  
 (1) - bromo - (1) - chloro - 2,2,2 - trifluoroethane }  
*ACCEPT non alphabetic versions*  
*NOT bromochlorotrifluoroethane* 1
- (f) 100-106.5 °  
*Any value or range of values within this range* 1

### Marking for key points

One mark should be awarded for **every** key point clearly identified in an answer.

#### Key points minus word penalty = maximum 6 marks

To gain the mark for a key point the wording used by the candidate must make clear the essential chemistry of the point.

### Key points

#### Advantages of using halothane: Any 5 (max) of these key points

- 1 Halothane is non/less flammable/ non explosive/toxic.  
*ALLOW inverse argument with reference to CHCl<sub>3</sub>, ether or 'earlier anaesthetics'* (1)
- 2 It does not cause gastric irritation / post operative vomiting.  
*ALLOW inverse argument with reference to CHCl<sub>3</sub>, ether or 'earlier anaesthetics'* (1)
- 3 It is not thought to cause **irreversible** liver damage **with repeated dosage**.  
*ALLOW inverse argument* (1)
- 4 Halothane contains a C–Br /bromine / **C–H** bond, so is **safer** (to use than other CFCs).  
*ALLOW inverse argument* (1)
- 5 Halothane produces narcosis /anaesthesia/deep sleep at low(er) doses/concentrations (than other CFCs)  
 OR halothane does not need high dose which lead to breathing paralysis. (1)
- 6 Halothane (was a potent inhalation agent) with a **smooth, pleasant induction** (period for the patient). (1)

#### Why halothane's use declined:

- 7 Halothane is associated with **post-operative liver dysfunction**. (1)
- 8 **Safer** and **cheaper** anaesthetics/agents (such as enflurane and isoflurane) were discovered. (1) 6

### Quality of Written Communication

These should *be impression* marked on a scale 2-1-0, and the mark out of 2 should be recorded in the body of the script at the end of the answer. This mark can not be lost as a result of a word penalty.

Candidates are expected to:

- show clarity of expression;
- construct and present coherent argument;
- demonstrate effective use of grammar punctuation and spelling.

The aspects to be considered are:

- use of technical terms; the answer should convey a correct understanding by the writer of the technical terms used in the passage which are involved in the key points.
- articulate expression; the answer should be well-organised in clear, concise English, without ambiguity. It should read fluently, with the links between key points in the original maintained.
- legible handwriting; the reader should be able to read the answer without difficulty at normal reading pace, with only the occasional difficulty with a word.
- points must be in a logical order.

Good style and use of English, with only infrequent minor faults, no use of formulae **(2)**

Frequent minor or a few major faults in style and use of English **(1)**

Very poor style and use of English **(0)**

NB: The quality of written communication mark cannot be lost through word penalties.

2

[7]

34. (a)

	Isomer	Complete oxidation
Primary	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ (1) OR $\text{C}_2\text{H}_5\text{CH}_2\text{CH}_2\text{OH}$ OR $(\text{CH}_3)_2\text{CHCH}_2\text{OH}$ (1) NOT $\text{C}_3\text{H}_7\text{CH}_2\text{OH}$ etc NOT $\text{OHCH}_2\text{CH}_2\text{CH}_2\text{CH}_3$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$ (1) $(\text{CH}_3)_2\text{CHCOOH}$ (1) $\text{CH}_3\text{CH}_2\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH}$ (1) ALLOW $\text{C}_2\text{H}_5\text{CH}_2\text{COOH}$ OR $(\text{CH}_3)_2\text{CH}-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH}$ ALLOW $(\text{CH}_3)_2\text{CHCOOH}$ $-\text{CO}_2\text{H}$ allowable for $\text{COOH}$ $\text{C}_2\text{H}_5$ allowable for $\text{CH}_3\text{CH}_2-$
Secondary	$\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$ (1)	$\text{CH}_3\text{CH}_2\overset{\text{O}}{\parallel}{\text{C}}\text{CH}_3$ (1) ALLOW $\text{CH}_3\text{CH}_2\text{COCH}_3$
Tertiary	$(\text{CH}_3)_3\text{COH}$ (1)	None (1)  MUST be stated eg n/a OR no product OR repeat the test alcohol formula ie $(\text{CH}_3)_3\text{COH}$ NOT just a line <b>Stand alone mark</b>
<i>Incorrect alcohol repeated 0 (out of 2)</i>		

The oxidation products are stand alone marks

If three carbon alcohols shown, correct oxidation products only score

6

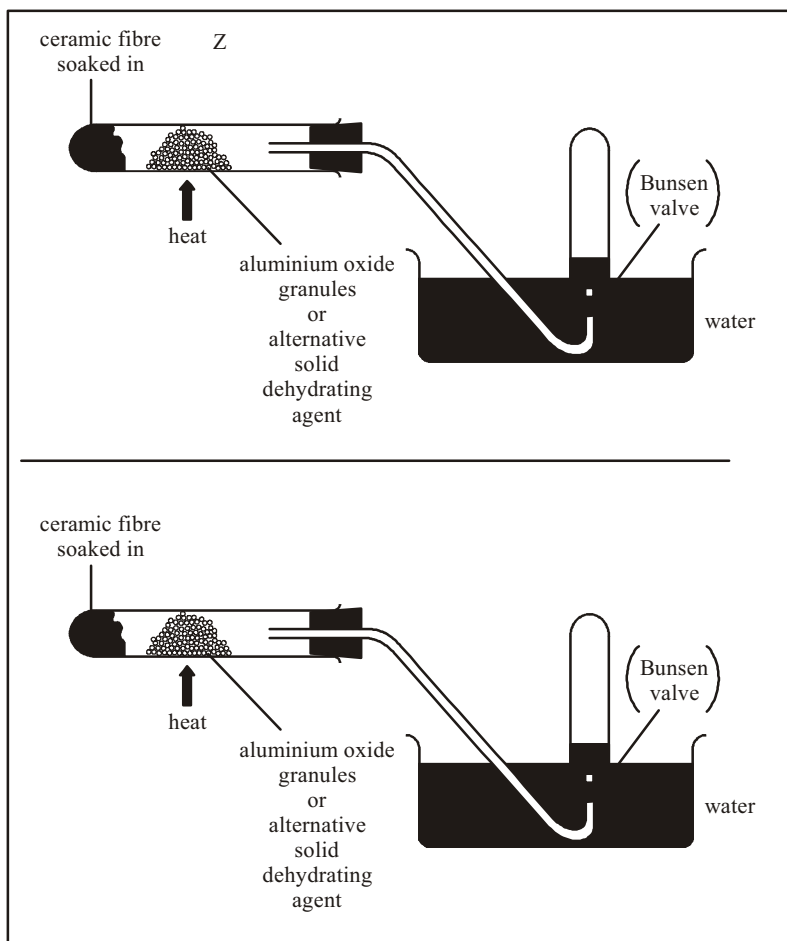
- (b) (i) 1(-)iodopropane 1
- (ii) Moist/wet/damp/aqueous/aq 1  
IGNORE any reference to heat
- (iii)  $\text{PI}_3$  1  
ALLOW  $\text{PI}_5$   
NOT names

- (c) (i) Ethanol/propanone/aqueous ethanol/alcohol **(1)**  
 heat **(1)**  
*OR* warm (under reflux)  
*OR* boil under reflux  
 ALLOW 'reflux' 2  
*If a temperature is stated must be between 30 ° and 80 °C*
- (ii)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CN}$   
 ALLOW  $\text{C}_2\text{H}_5\text{CH}_2\text{CN}$   
 NOT  $\text{C}_3\text{H}_7\text{CN}$  1  
*Cyanide group can be  $-\text{C}\equiv\text{N}$  but not  $-\text{N}\equiv\text{C}$  - if bond shown it must be correct*
- (iii) nucleophilic substitution 1
- [13]**
35. (a) Propan-2-ol  
 NOT prop-2-ol/ 2-propanol 1
- (b) Contains  $\text{>CHOH}$  or fully displayed  
*OR* carbon carrying OH/ hydroxyl/ "hydroxide" group attached to two other carbons/ two other methyl groups/ one other hydrogen  
 ALLOW contains  $\text{CHOH/CH(OH)}$   
 NOT references to hydroxide ion/  $\text{OH}^-$  in explanation 1
- (c)  $\text{C}_3\text{H}_8\text{O} + \frac{1}{2}\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$   
*OR*  
 $2\text{C}_3\text{H}_8\text{O} + 9\text{O}_2 \rightarrow 6\text{CO}_2 + 8\text{H}_2\text{O}$   
 products **(1)**  
 balancing of equation based on correct products **(1)**  
 ALLOW 4.5,  $4\frac{1}{2}$  for  $\frac{1}{2}$   
 IGNORE state symbols  
 No penalty if structural formulae used 2

- Bubbles/ effervescence/ fizzing (1)  
 Gets hotter/ heat produced/ temperature rises (1)  
 (d) NOT exothermic  
 Sodium dissolves/ disappears/ gets smaller (1)  
**White** solid produced (1)  
 Hissing sound (1)  
 NOT white precipitate  
 NOT floats/moves around and goes on fire 2
- } any two
- (e) (i) Orange to green/blue 1
- (ii)
- $$\begin{array}{ccccccc}
 & & \text{H} & & & \text{H} & \\
 & & | & & & | & \\
 \text{H} & - & \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\
 & & | & & || & & | & \\
 & & \text{H} & & \text{O} & & \text{H} & \quad \text{(1)}
 \end{array}$$
- MUST be fully displayed*  
 Propanone/ propan(e)-2-one (1)  
 ALLOW acetone  
 No TE from incorrect formula 2
- (iii) Blue / light blue  
 NOT mention of any other modified colour of blue  
 ie NOT blue-green 1



(f)



3

Tube + contents (1)

*ALLOW* glass wool/ mineral wool/ Rocksil wool

*NOT* wire wool/ cotton wool

Heat under some solid (1)

Gas collected by displacement of water – *water does not need to be labelled*

*OR* collect in syringe (1)

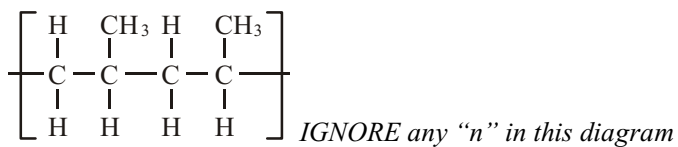
*IGNORE* open tube following Bunsen valve, providing gas can be collected

–1 for each error

eg single line tube; gap between bung and tube; delivery tube through side of trough, delivery tube not under collecting tube

[13]

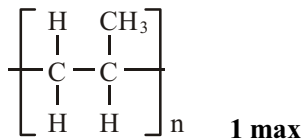
36. (a) (i) 2(-)chloropropane
- $$\begin{array}{c}
 \text{H} \quad \text{Cl} \quad \text{H} \\
 | \quad | \quad | \\
 \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\
 | \quad | \quad | \\
 \text{H} \quad \text{H} \quad \text{H}
 \end{array}$$
- No internal TE from name to structure*  
*MUST be fully displayed* 2
- (ii)
- IGNORE* rest of molecule
- $$\begin{array}{c}
 \text{(1)} \\
 | \delta^+ (\delta^-) \\
 -\text{C}-\text{Cl} \\
 | \\
 \text{(1)} \\
 \text{:OH}^-
 \end{array}$$
- Mark independently  
 Must attack the carbon  
 ALLOW attack by oxygen or negative charge or lone pair 2
- ACCEPT*  $\text{OH}^-$  *NOT*  $\text{OH}^-$   
*NOT*  $\text{C}^+$
- (b) (i) Elimination  
*NOT in conjunction with additional incorrect information*  
 eg “nucleophile” 1
- (ii) Sodium hydroxide / NaOH/potassium hydroxide / KOH (1)  
*Any additional incorrect reagent (0)*  
*NOT alkali on its own for 1<sup>st</sup> mark*  
 Alcoholic solution / ethanolic solution **and** heat / warm / reflux (1)  
 2<sup>nd</sup> mark is dependent on mention of correct reagent or “alkali”  
 “aqueous” negates 2<sup>nd</sup> mark eg KOH(aq) + heat (1) – ie reagent mark  
 NaOH(alc) + heat (2) 2
- (c) (i) Hydrogen/H bonding 1
- (ii)
- $$\begin{array}{c}
 \text{CH}_3 \quad \quad \quad \text{CH}_3 \\
 | \quad \quad \quad | \\
 \text{CH}_3\text{C}-\text{O}-\text{H} \cdots \text{O}-\text{CHCH}_3 \\
 | \quad \quad \quad | \\
 \text{H} \quad \quad \quad \text{H}
 \end{array}$$
- H-bond and rest of molecule (1)*  
*angle must be between 3 atoms for a correct H bond (1)*  
 ALLOW HOH 106-108° 2
- (d) (i)



Brackets optional but continuation must be shown

4 carbon chain with 6Cs overall in structure (1)

methyl groups can be on C<sub>1</sub> and C<sub>3</sub>, C<sub>1</sub> and C<sub>4</sub>, C<sub>2</sub> and C<sub>4</sub>, C<sub>2</sub> and C<sub>3</sub> (1)



2

- (ii) (big molecule) so large number of electrons (1)

Hence **large/strong van der Waals'** forces

(to be overcome to change state)(1)

2

**[14]**

37. (a) (i) (2-methylbut-1,3-diene)  
~~M P H m P P H N M P m P N~~  
 (1) (1)

IGNORE punctuation

ALLOW 1 max if correct answer is pre-fixed by cis / trans

2

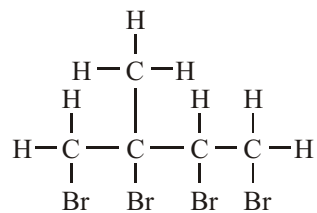
- (ii) From orange/yellow/brown to colourless (1)  
 NOT red NOT clear

1

- (iii) addition (1)  
 electrophilic (1)  
 in either order

2

- (iv)



Methyl group need not be displayed

1

- (b) (i) Van der Waals' (forces)  
 ACCEPT Van der Walls  
 NOT vdw

1

- (ii) Q because (unbranched) so greater area of **contact / closer packing**  
 (between molecules) (1)

hence greater Van der Waals/vdw forces (1)

2<sup>nd</sup> mark dependent on 1<sup>st</sup>

Incorrect isomer chosen (0)

Fully correct reverse argument (2)

2

[9]

38. (a) (i) **How it works**

(Liquid boils and) gas/vapour **is condensed** (in condenser and runs back) (1)

**Why it is used**

Reaction slow /reaction has high activation energy /increase rate / for more time/to enable reactants to be heated for a prolonged period (1)

When using volatile liquids/ to prevent loss of materials / to prevent escape of reactants (and products)/ to minimise loss of reactants (and products)(1)

3

(ii) **Apparatus**

Flask properly drawn and thermometer and heat (1)

Condenser properly drawn with water jacket with correct water flow(1)

**Set up**

Top of still head closed and collection end open

Thermometer at correct point in neck (still head)

Condenser at angle (1) **ALL THREE for 1 mark**

**Ignore any attempts to draw a fractionation column and a dropping funnel in a side arm.**

3

(b) Use a water bath/electric heater/electric hot plate/sand bath/ oil bath

Ignore

Keep away from naked flame / use a fume cupboard

1

*Reject do not use a Bunsen (unless qualified with what should be used)*

[7]

39. (a) A round-bottom(ed)/distillation flask (1)
- Accept Pear-shaped flask*  
*Accept Flask*  
*Accept long neck flask*
- Reject Liebig flask*  
*Reject conical flask*  
*Reject bottle ended flask*  
*Reject volumetric flask*
- B (Liebig) condenser (1)
- Accept condenser*  
*Reject cooling water jacket*  
*Reject condensing tube*
- C anti-bumping beads/granules (1) 3
- Accept porcelain/ silica*  
*Accept correct names in any order*
- (b) No stopper in top of flask (1)
- Reject "side arm on conical flask not needed"*
- No jacket on condenser (1)
- Water direction wrong way round (1)
- Reject i.e. implying sealed apparatus*
- Ignore:/ neutral
- "flask sealed off from rest of apparatus"*  
*"water bath not needed"*  
*"cork in conical flask not needed"*  
*"gap between top of condenser & still head"*  
*"air condenser sufficient"*  
*"fume cupboard not needed"*
- Reject thermometer should be in liquid*  
*Reject no need for anti bumping beads*
- If they give 4 or more errors : loses 1 mark for each "reject"  
 but neutral ones are ignored e.g.  
 3 correct + sealed apparatus = 3-1=2  
 3 correct+ water bath not needed = 3-0 = 3
- [if this part is completely blank send to review under out of clip category] 3
- (c) (concentrated) sulphuric/sulfuric acid 1
- Accept dilute*

- (d) Oxidation **(1)** partial oxidation  
hydrogen atoms lost (as organic reactant changes to product) **(1)** 2  
*Allow oxidation number of carbon increases (from -2 to -1)*  
*Accept redox if the rest of the answer makes clear that the ethanol has been oxidised*  
*Reject reduction*  
*Reject redox*
- (e) (i)  $\text{Cr}_2\text{O}_7^{2-}$  1
- (ii) Orange to green 1  
*Accept blue*
- (f) Ethanoic acid **(1)**  
 $\text{CH}_3\text{CO}_2\text{H}$  /  $\text{CH}_3\text{COOH}$  **(1)**  
Mark independently 2  
*Accept correct structural or displayed formula*  
*Accept molecular formula  $\text{C}_2\text{H}_4\text{O}_2$  correct if name is correct*  
*Reject empirical formula*  
*Reject  $\text{C}_2\text{H}_3\text{OOH}$ ,  $\text{CH}_3\text{CHO}_2$*
- [13]**
40. (a) (i)  $(18 \times 1.35) = 24.3 / 24.30$  (kJ) **(1)** 1
- (ii)  $\text{kJ from 1 mole} = \frac{24.3 \times 44}{0.5} / \frac{24.3}{0.0114} / 24.3 \times 88$  **(1)**  
 $\Delta H = -2140$  (3SF) (kJ mol<sup>-1</sup>) **(1)**  
Second mark must have negative sign and 3SF  
Allow TE from incorrect value in (i) 2  
*Accept  $\Delta H = -2138.4 / -2138 / +2138$  (kJ mol<sup>-1</sup>) for 1 mark*
- (iii) Incomplete combustion / combustion to C or CO. Not complete combustion **(1)** 1  
*Reject not all of the propane burns.*  
*Reject comments on accuracy of equipment.*

(b) (i)



$$\begin{array}{r}
 +6490 \text{ kJ mol}^{-1} \\
 \diagdown \quad \diagup \\
 3\text{C}(\text{g}) + 8\text{H}(\text{g}) + 10\text{O}(\text{g}) \\
 \diagup \quad \diagdown \\
 6 \times 805 + 8 \times 464
 \end{array}$$

$$\begin{aligned}
 +6490 &= \Delta H_c + (6 \times 805 + 8 \times 464) \\
 \Delta H_c &= +6490 - 4830 - 3712 \\
 &= -2052 \text{ kJ mol}^{-1}
 \end{aligned}$$

*Accept -2050 (kJ mol<sup>-1</sup>)*

Balancing cycle with **5O<sub>2</sub>** and **10 O(g)** (1)

$$\Delta H_1 = (6 \times 805 + 8 \times 464) = (+) 8542 \text{ (kJ mol}^{-1}\text{)} \text{ (1)}$$

Final value -2052 (kJ mol<sup>-1</sup>) (1)

*IGNORE SF*

*Allow TE from an incorrectly calculated  $\Delta H_1$  if method clear.*

3

- (ii) H<sub>2</sub>O is gas in equation/ not standard state  
 OR mean bond energies differ from bond energies in these  
 compounds / Environment in these compounds changes bond  
 energies from the mean.

1

*Accept H<sub>2</sub>O is liquid in  $\Delta H$  combustion calculation but gas in  
 bond energy calculation.*

*Reject "mean bond energies are used" without qualification*

*Reject all the substances are in the gaseous state*

(c) (i) Free radical (1) substitution (1)

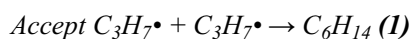
2

*Accept reverse order*

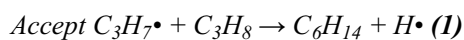
(ii)  $2\text{C}_3\text{H}_7\cdot \rightarrow \text{C}_6\text{H}_{14}$  (1)

Two (propyl) radicals may combine / a radical and a  
 molecule may produce C<sub>6</sub>H<sub>14</sub> (in a propagation step) (1)

2



*Accept multiples*



*Full mechanisms may be shown*

- (d) (i) 2-chloropropane: white precipitate/ solid /cloudiness **(1)**  
*Reject white colour*  
*Reject creamy*  
 2-iodopropane: yellow precipitate / solid **(1)** 2  
*Accept ppt appears slowly with chloropropane and quickly with iodopropane (1)*  
*Accept pale yellow precipitate*  
*Accept white colour and yellow colour – 1 out of 2*
- (ii)  $\text{Ag}^+(\text{aq}) + \text{I}^-(\text{aq}) \rightarrow \text{AgI}(\text{s})$   
 Formulae **(1)**  
 State symbols **(1)**  
 Minor error in formula with correct state symbols max 1 2  
*Accept max 1 out of 2 for wrong halide*
- (iii) Propan-2-ol/  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$  **(1)** 1  
*Accept displayed formula*  

$$\begin{array}{c} \text{CH}_3-\text{CH}-\text{CH}_3 \\ | \\ \text{OH} \end{array}$$
  
*Reject molecular formula  $\text{C}_3\text{H}_7\text{OH}$*
- 41.** (a) (i) 2,2,4-trimethylpentane  
 Ignore punctuation (Commas and hyphens may be interchanged) 1  
*Accept 2,4,4 - trimethylpentane*  
*Reject pentan for pentane*  
*2-dimethyl-4 methylpentane*  
*2,2-dimethyl-4-methyl pentane*  
*2-methyl-4,4-dimethyl pentane*  
*2,4-trimethylpentane*
- (ii)  $\text{C}_4\text{H}_9$  1  
*Accept  $\text{C}_8\text{H}_{18} \rightarrow \text{C}_4\text{H}_9$*
- (iii)  $\text{C}_2\text{H}_4$  1  
*Reject  $\text{CH}_2\text{CH}_2$*
- (iv) Positive because energy is required to break (C–C) bonds  
 (and not completely replaced (from new bonds made))

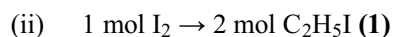
[17]



- OR Positive because cracking requires (continuous) supply of heat so must be endothermic 1
- Accept two C–C bonds are broken and one C=C made*
- Reject positive because it only occurs at high temperature*
- (v)  $C_8H_{18} + 17/2 O_2 \rightarrow 8CO + 9H_2O$
- OR  $2C_8H_{18} + 17 O_2 \rightarrow 16CO + 18H_2O$
- OR  $C_8H_{18} + 9/2 O_2 \rightarrow 8C + 9H_2O$  (or doubled)
- Oxygen on left and correct formulae of products (1)
- balancing (1)
- Second mark depends on first and a sensible hydrocarbon formula must be used. 2
- Accept balanced equations including CO and/or C with CO<sub>2</sub>*
- 17/2 can be written 8.5 or 8½*
- Allow balanced equations based on C<sub>8</sub>H<sub>18</sub> with a smaller alkane in the products for 1 mark eg*
- C<sub>8</sub>H<sub>18</sub> + O<sub>2</sub> → CO + C<sub>7</sub>H<sub>16</sub> + H<sub>2</sub>O (1)*
- (b) (i) Increase in pressure: No effect as number of moles/molecules (of gas) doesn't change during reaction (1)
- Increase in temperature: **more NO** as forward reaction endothermic OWTTE (1)
- One mark for two correct predictions with incorrect explanations 2
- Reject increase in temperature moves equilibrium to the right*
- (ii) Rate increases as converter gets hotter (as reaction is exothermic) 1
- (iii) N<sub>2</sub> / nitrogen is (major) part of air/ N<sub>2</sub> unreactive/ not poisonous/ not a greenhouse gas / not acidic 1
- Accept correct harmful properties of other 3 gases*
- (iv) Line from level of reactants to maximum labelled E<sub>A</sub> (1)
- Curve of similar shape above existing curve, starting and finishing at same levels, with maximum above original maximum (1) 2

[12]

42. (a) (i) Apparatus I (heating under) reflux (1)  
 Apparatus II distillation (1) 2  
*Reject fractional distillation*
- (ii) (expansion of vapour will) build up pressure 1  
*Accept prevent explosion*  
*Reject dangerous*  
*OR to prevent vapour escaping*
- (b) (i) Reaction is vigorous  
 OR exothermic  
 OR (very) fast or violent 1  
*Reject dangerous*
- (ii) (One or both of) the **liquids** flammable  
 OR ethanol is flammable  
 OR iodoethane is flammable  
 OR ethanol and iodoethane are flammable 1  
*Reject Substances or Reactants are flammable*
- (iii) To allow reaction to reach completion  
 OR reaction is slow  
 OR reaction has high activation energy. 1  
*Accept to maximise yield*
- (iv) The lower range is 70 to 71  
 The upper range is 73 to 74  
 e.g.  
 70 to 74 °C  
 OR  
 71 to 73 °C  
 OR  
 70 to 73 °C 1
- (c) In (i), (ii) and (iii) penalise 1SF on the first occasion only.  
 ALLOW ≥ 2SF
- (i)  $\frac{20.0}{254} = 0.0787$  (moles) 1  
*Accept 0.079 / 0.07874*



Answer to (i)  $\times 2 \times 156 = 24.6 / 24.55 / 24.57$  (g) (1)

Correct answer with some working scores (2)

If answer to c (i) not multiplied by 2 the 2nd mark only accessible if there is some attempt to work out a mole ratio or state a mole ratio in first part of calculation

N.B.  $156 \times \frac{20}{127}$  will give the correct final value (0) 2

*Accept mole ratio implied in method*

*OR*

*Mass method e.g.*

*127g I forms 156g C<sub>2</sub>H<sub>5</sub>I*

$$20\text{g I forms } 20 \times \frac{156}{127}$$

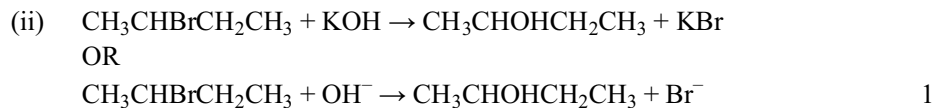
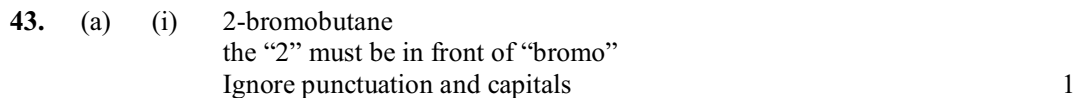
$$= 24.6 \text{ (g) (2)}$$

(iii)  $\frac{16.7}{24.6} \times 100 = 67.9 / 67.98 / 68.0$  (%) 1

*Accept CQ on (ii)*

*Reject yield > 100 %*

[11]



*Accept C<sub>2</sub>H<sub>5</sub> instead of CH<sub>2</sub>CH<sub>3</sub>*

*Allow K<sup>+</sup> as spectator ion*

*Reject eqns with NaOH*



*Accept C<sub>2</sub>H<sub>5</sub>OH (aq) / aqueous alcohol/KOH(aq)/aqueous*

*Do not penalise use of NaOH(aq) again*

*Reject just "ethanol / ethanolic / alcoholic (KOH)"*

- (iv) nucleophilic substitution (both needed) 1  
*Accept reasonable phonetic spelling*
- (b) (i)  $\text{CH}_3\text{CHBrCH}_2\text{CH}_3 + \text{OH}^- \rightarrow \text{CH}_3\text{CH}=\text{CHCH}_3 + \text{H}_2\text{O} + \text{Br}^-$   
 OR  
 $\text{CH}_3\text{CHBrCH}_2\text{CH}_3 + \text{OH}^- \rightarrow \text{CH}_2=\text{CHCH}_2\text{CH}_3 + \text{H}_2\text{O} + \text{Br}^-$   
 Double bond need not be shown 1  
*Accept C<sub>2</sub>H<sub>5</sub> instead of CH<sub>2</sub>CH<sub>3</sub>*  
*Ignore spectator ions*
- (ii) Ethanol / C<sub>2</sub>H<sub>5</sub>OH / CH<sub>3</sub>CH<sub>2</sub>OH /  

$$\begin{array}{c} \text{H} \quad \text{H} \\ | \quad | \\ \text{H}-\text{C}-\text{C}-\text{OH} \\ | \quad | \\ \text{H} \quad \text{H} \end{array}$$
 1  
*Accept alcohol OR Ethanolic/alcoholic*  
*Accept KOH/NaOH*  
*Reject C<sub>2</sub>H<sub>6</sub>O*  
*Reject any mention of water/aqueous*
- (iii) elimination 1  
 ignore “nucleophilic”  
*Reject electrophilic elimination*
- (c) (i) 1  

$$\begin{array}{c} \text{CH}_3 \quad \quad \text{CH}_3 \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \quad \text{H} \end{array} \quad \begin{array}{c} \text{CH}_3 \quad \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \quad \text{CH}_3 \end{array}$$
  
*bond to H of CH<sub>3</sub> on left carbon*  
*structure with 90° bond angles*
- (c) (ii) no / restricted rotation around double  
 bond / C=C / π – bond (1)  
 has two different groups joined to  
**each** C (of double bond) OR each (carbon of C=C) has a CH<sub>3</sub>  
 and a H (1) 2  
*limited rotation*  
*on the carbon*

- (d) (i) nickel / Ni  
OR platinum / Pt  
OR palladium / Pd 1
- (d) (ii) butane /  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$  1  
*C<sub>2</sub>H<sub>5</sub> for CH<sub>3</sub>CH<sub>2</sub>*  
*JUST "C<sub>4</sub>H<sub>10</sub>"*
- [12]**
44. (i)
- $$\begin{array}{c} \text{H} \\ | \\ \text{H}-\text{C}-\text{C}-\text{H} \\ | \quad \quad \quad \diagdown \\ \text{H} \quad \quad \quad \text{O} \end{array}$$

(1)

$$\begin{array}{c} \text{H} \\ | \\ \text{H}-\text{C}-\text{C} \\ | \quad \quad \quad \diagup \quad \diagdown \\ \text{H} \quad \quad \quad \text{O} \quad \quad \text{O}-\text{H} \end{array}$$

(1)
- Accept -OH for -O - H*
- 2
- (ii) structural formula of any tertiary alcohol (1)  
and its name (1) – must not contradict the formula and conditional  
on tertiary alcohol 2
- Accept 2<sup>nd</sup> mark can be awarded if minor slip in formula or no  
formula given*
- [4]**
45. (a) (i) Reaction exothermic or Reactants might evaporate 1
- Accept prevent oxidation of HBr or Br<sup>-</sup> (to bromine or Br<sub>2</sub>)*  
*Reject vigorous or violent or*  
*Side reactions occur*
- (ii) Heated round or pear-shaped flask (1)  
Correct vertical condenser inc. water direction (1)  
Gas-tight joint & open apparatus (1) 3
- ↑  
*Accept Heat*  
*Accept horizontal lines on flask (at joint)*  
*Accept just arrows to indicate water direction*  
*Reject just ↑ or just 'heat' or direct heating with a Bunsen or  
conical flask*  
*Reject horizontal lines at the top of condenser*  
*Reject distillation*

- (iii) Immiscible (with water) or do not mix 1  
*Accept immiscible with aqueous solution*  
*Accept insoluble in water*  
*Reject "Different densities" on its own*
- (iv) Drying agent or to dry product 1  
*Accept to remove water*  
*Reject Dehydrate or Dehydrating agent*
- (v) **Either**  
 Use electrical heater or sand bath (1)  
 1-bromopropane is flammable (1)  
*Accept water bath*  
*Accept flammable mixture OR propan-1-ol flammable*  
*Reject keep away from naked flame as 1-bromopropane is flammable*
- Or**  
 wear gloves (1)  
 1-bromopropane harmful by skin absorption (1) 2  
*Accept sulphuric acid corrosive (1)*  
*Reject organic liquids flammable*  
*Reject 1-bromopropane is harmful to skin*
- 2<sup>nd</sup> mark conditional on 1<sup>st</sup>
- (b) (i) Moles propan-1-ol =  $\frac{7.55}{60.0}$  (1)
- Mass 1-bromopropane =  $\left(123 \times \frac{7.55}{60.0}\right)$   
 = 15.5 g (1)
- IGNORE SF 2
- $7.55 \times \frac{123}{60.0} = 15.5 \text{ g scores full marks}$   
*Accept correct answer with some working*  
*Reject 15.4 (from 7.5/60 or truncated)*

- (ii)  $100 \times 8.3 \div 123 \times \frac{7.55}{60.0} = 53.6\%$   
 IGNORE SF 1
- Accept*  $100 \times \frac{8.3}{15.5} = 53.5\%$   
*Accept ECF*  
*Reject yield > 100%*
- (iii) Transfer losses or other products formed  
 or side reactions or (reaction) not complete 1  
*Reject experimental error or spillages*  
*Reject evaporation (from reflux)*
- [12]**
46. (a) (i) Iodine has more electrons/ 1-iodobutane has more electrons **(1)**  
 stronger/greater/larger/more Van der Waals forces **(1)** 2  
*Accept recognisable spellings*  
*Accept London/dispersion/ induced dipole-induced dipole/instantaneous dipole/fluctuating dipole/flickering dipole*  
*Reject vdw*
- (ii) 1-chlorobutane as less branched/unbranched **(1)**  
 ...so molecules can align/greater surface (area of contact)**(1)**  
 second mark conditional on 1-chlorobutane 2  
*Accept ...greater surface contact/many points of contact*  
*Reject closer packing (but ignore if rest is correct)*
- (iii) **G** 1
- (b) (i) **H** 1
- (ii) **E/1-chlorobutane (1)**  
**C–Cl is strongest/stronger (1)**  
 conditional on first mark 2  
*Accept it is the primary chloroalkane*  
*Accept highest activation energy*

- (iii) Alcohol/hydroxy(l) 1  
 Accept OH  
 Reject OH /hydroxide
- (iv)  $\text{Ag}^+(\text{aq}) + \text{X}^-(\text{aq}) \rightarrow \text{AgX}(\text{s})$  1  
 Accept  $\text{Ag}^+(\text{aq}) + \text{Cl}^-/\text{I}^-(\text{aq}) \rightarrow \text{AgCl}/\text{I}(\text{s})$
- (c) (i) High temperature/heat and pressure (1)  
 Ethanol (solvent) (1) 2  
 Accept conc  $\text{NH}_3$  for a period of time (1)
- (ii)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$  (1)  
 $+ \text{NH}_4\text{I}$  (1) 2  
 Accept  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_3^+\text{I}^-$  (1)  
 If balancing for  $\text{NH}_3$  gets second mark  
 $\text{INH}_4$  or  $\text{NH}_4^+ + \text{I}^-$  for second mark
- (iii) (1-)Butylamine / (1-)aminobutane 1  
 Accept butylammonium iodide  
 Reject butanamine
- [15]**
47. (a) (i)  $\text{KMnO}_4$  /potassium manganate(VII) /  
 potassium permanganate  
 Accept sodium analogues  
 Reject just "Potassium manganate"  
 IGNORE any acid or alkali 1  
 Or  
 $\text{O}_2$  **followed** by aqueous acid
- (ii) 1,2(-)dibromoethane 1



- (iii) EITHER:  
sodium bromide/NaBr /potassium bromide/KBr **(1)**  
*Accept HBr with concentrated/50 % sulphuric (1 only)*  
(50 %) sulphuric acid/H<sub>2</sub>SO<sub>4</sub>/ phosphoric acid/H<sub>3</sub>PO<sub>4</sub> **(1)**  
*Accept concentrated H<sub>2</sub>SO<sub>4</sub>*  
*Reject dilute/aqueous sulphuric acid/H<sub>2</sub>SO<sub>4</sub>*

OR:  
(Moist) red phosphorus/P **(1)**  
Bromine/Br<sub>2</sub> **(1)**  
*Accept PBr<sub>3</sub> alone (1 only)*  
*Reject PBr<sub>3</sub> plus any other reagent (0)*

2<sup>nd</sup> mark is conditional on the 1<sup>st</sup>

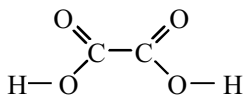
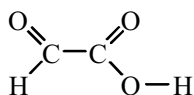
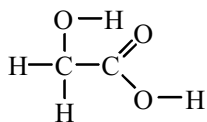
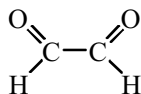
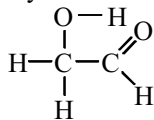
2

(iv) Colour change

from orange to green/blue (1)

*Reject ...to brown*Oxidation products (2)

any 2 of:

Bonding from C must be to O of OH groups –  
penalise once only

IGNORE any names

3

*Accept OH instead of O-H**If any **two** of the following given (1 out 2)**Accept CH<sub>2</sub>OHCHO**Reject CH<sub>2</sub>OHCOH**Accept CH<sub>2</sub>OHCOOH**Accept CHOCHO Or OHCCHO**Reject CHOCOH Or OHCCOH**Accept CHOCOOH Or OHCCOOH**Accept COHCOOH Or (COOH)<sub>2</sub> Or HOCCOOH**Allow CO<sub>2</sub>H for COOH in the above*

- (v)  $C_2H_2/CH\equiv CH$ /ethyne  
 Or  
 $CH_2=CHBr /CH_2CHBr$ /bromoethene 1  
*Accept 1-bromoethene*  
*Accept 2-bromoethene*  
*Reject  $CH_2BrCH$*   
*Reject  $C_2H_3Br$*
- (b) (i)  $C_2H_5Br$ /bromoethane (1)  
*Reject side reactions*  
 (only) monosubstitution occurs (1)  
*Reject reaction reaches equilibrium*  
 Or  
 1,1-dibromoethane/ $CH_3CHBr_2$  (1)  
 isomer of **B** / substitutes onto same carbon/Br (radical)  
 can remove H from either carbon (1)  
 Or  
 1,1,2-tribromoethane etc. (1)  
 substitution continues/ polysubstitution/reaction continues (1)  
 Or  
 Butane/ $C_4H_{10}$  (1)  
 Combination of two  $C_2H_5$  radicals (1)  
 The 1<sup>st</sup> mark is stand alone in each case. 2
- (ii)  $C_2H_6 + 3\frac{1}{2} O_2 \rightarrow 2CO_2 + 3H_2O$   
*Accept multiples*  
 Species (1)  
 Balancing (1)  
 IGNORE state symbols 2  
*Accept  $CH_3CH_3$  instead of  $C_2H_6$*   
*If incorrect hydrocarbon e.g. ethene scores zero*
- (iii) simplest (whole number) ratio of the different **atoms**  
 in a compound/molecule 1  
*Accept .....ratio of moles of **atoms**....*  
*Reject "elements" for "atoms"*
- (iv)  $CH_3$  1

- (v) Any alkane formula with odd no. of C atoms other than CH<sub>4</sub>  
 This can be a structural, full structural or molecular formula  
 IGNORE names even if incorrect 1 **[15]**
48. (a) (i) D and F **(1)**  
 2,2-dimethylbutan(e)-1-ol **(1)**  
 conditional on the first mark  
 IGNORE punctuation 2  
*Reject but-1-ol and buta-1-ol*
- (ii) B / 2-methylpentan-2-ol **(1)**  
 carbon atom joined to hydroxyl group is attached to three  
 other carbon atoms **(1)**  
 mark independently 2  
*Accept carbon atom joined to hydroxyl group has no hydrogens  
 attached*  
*Reject more than one given loses first mark*
- (iii) same molecular formula/same number and type of atoms **(1)**  
 different structural formula /different displayed formula/ different  
 arrangement of atoms **(1)** 2  
*Reject same chemical formula*  
*Reject different structure (alone)*
- (b) (i) D, F and C **(1)** 1  
*Accept D and C*  
*or*  
*F and C*
- (ii) (complete)oxidation **(1)** 1  
*Accept redox*  
*Reject reduction. partial*
- (iii) orange to green/blue **(1)** 1

- (c) (i) round-bottomed or pear-shaped flask + heat (1)  
 condenser with correct water flow (1)  
 collection vessel (1)  
 Apparatus with no joints max 2 3  
*Accept 2 max for non working apparatus*  
*Accept e.g. sealed*
- (ii) moles of cyclohexanol =  $15 / 100 = 0.15$   
 AND moles of cyclohexene =  $9.84 / 82 = 0.12$  (1)  
 $\% \text{ yield} = \frac{0.12}{0.15} \times 100 = 80\%$  (1)  
 Correct answer alone (2) 2  
*Accept moles of cyclohexanol =  $15 / 100 = 0.15$  and mass of cyclohexene =  $0.15 \times 82 = 12.3$  (1)*  
 $\% \text{ yield} = \frac{9.84}{12.3} \times 100 = 80\%$  (1)
- [14]
49. (a) (i) AgI  
 Or AgI(s)/(ppt) 1  
*Accept  $Ag^+I^-$*   
*ie any correct answers with **both** charges*  
*Reject Silver Iodide*  
*Reject  $Ag^+I$ ,  $AgI^+$ ,  $AgI^-$*
- (ii)  $Ag^+(aq) + I^-(aq) \rightarrow AgI(s)$   
*Accept TE of Cl, Br, X from (i)*  
*Reject TE from  $AgI_3$ ,  $Ag_2I$  etc*  
 Mark independently of (i), unless acceptable answer  
 TE 1  
*Accept TE  $Ag^{2+}(aq) + 2I^-(aq) \rightarrow AgI_2(s)$  from  $AgI_2$  in (i)*  
*Reject  $Ag^+(aq) + I^-(aq) \rightarrow AgI(\text{ppt})$*

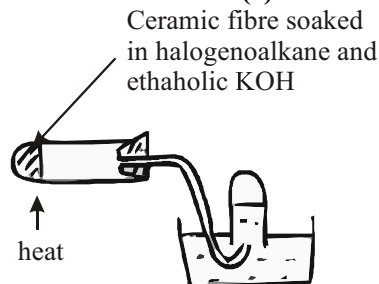
- (b) (i)  $\text{C}_4\text{H}_9\text{I} + \text{H}_2\text{O} \rightarrow \text{C}_4\text{H}_9\text{OH}/\text{C}_4\text{H}_{10}\text{O} + \text{HI}/\text{H}$   
 IGNORE states 1  
*Accept "H<sup>+</sup> + I<sup>-</sup>" for "HI"*  
*Accept Cl, Br, or X instead of I*  
*Allow combination of X on the left with I, Br, or Cl on the right*  
*or X on the right with I, Br, or Cl on the left*
- (ii) Substitution  
 IGNORE nucleophilic (but note this may get 1<sup>st</sup> mark for (iii)) 1  
*Accept hydrolysis*  
*Reject displacement/replacement/electrophilic/free radical substitution*
- (iii) Nucleophile – can be awarded from (ii) **(1)**  
 Because of nonbonding/unbonded /lone/unshared **pair**  
 of **electrons** (on oxygen/water) **(1)** 2  
*Reject just "pair of electrons"*  
*Reject 'spare' pair of electrons*  
*Reject unshared pair of electrons on the hydroxide ion/OH<sup>-</sup>*

(c) (i) **ceramic fibre in horizontal tube (1)***Accept mineral/glass/cotton wool**Reject steel wool*

soaked in reagents /reactants/halogenoalkane and (alcoholic) KOH with heat/Bunsen (1)

*Accept vertical flask/side arm test tube/boiling tube and reagents with heat for 2<sup>nd</sup> mark**Accept heat indicated anywhere along the test tube**Reject arrow without heat*

collection over water (1)

*Accept syringe (with three-way tap)**IGNORE diagram and position of Bunsen valve*Penalties (cumulative)

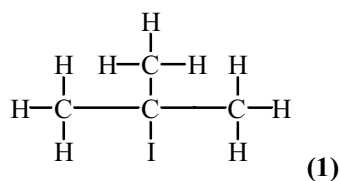
poor diagram –1

e.g. delivery tube through side of trough/no water in trough.

Use of pumice/aluminium oxide/ $\text{Al}_2\text{O}_3$  in test tube –1

3

## (ii)



Must be fully displayed

*Accept X, Cl or Br for 1<sup>st</sup> mark**Reject all other structures for 1<sup>st</sup> mark*

2-iodo(-2-)methylpropane / (2-)methyl-2-iodopropane (1)

2

*Accept chloro/bromo compounds if TE from diagram**Accept fully correct formula for 2-methyl-1-iodopropane with correct name gains 1 max again allow Br/Cl**Reject all other names for 2<sup>nd</sup> mark*

- (d) Three attached methyl groups /tertiary (1)

*Accept two attached methyl groups /secondary (1)*

Weaken/weaker/weak C-I/C-X/C-halogen/ C-Cl/C-Br bond

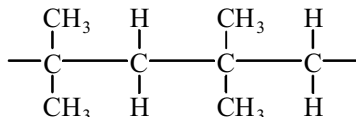
Or

Carbocation stabilised (1)

2

*Accept the iodine /halogen/chlorine/ bromine/X bond is weak*

- (e) (i)

CH<sub>3</sub> groups on positions 1,1,3,3, or 2,2,4,4 or 1,1,4,4 or 2,2,3,3

Ignore brackets and n's

1

*Accept part/fully displayed**Accept part/fully structural**Allow -CH<sub>2</sub>-**Allow CH<sub>3</sub>*

|

*Allow more than two units**Reject skeletal formulae (missing out hydrogens)*

- (ii) Reaction goes to favour lowest number of/no
- gaseous/gas**
- molecules
- 
- OR
- gas**
- to solid

1

*Reject just "by Le Chatelier's Principle"*

- (iii) A catalyst provides an alternative route/mechanism for a reaction... (1)
- 
- ...with a
- lower activation energy**
- (1)

Mark independently

2

*Additional totally incorrect comment negates 2<sup>nd</sup> mark e.g.  
"...and provides energy for the reaction"*

[17]

50. A

[1]

51. (a) A

1

(b) C

1

(c) D

1



	(d)	D	1	<b>[4]</b>
<b>52.</b>	(a)	D	1	
	(b)	C	1	
	(c)	A	1	<b>[3]</b>
<b>53.</b>	(a)	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> OH <b>(1)</b> Propan-1-ol <b>(1)</b> CH <sub>3</sub> CH(OH)CH <sub>3</sub> <b>(1)</b> Propan-2-ol <b>(1)</b>	4	
	(b)	(i) Propanoic acid <b>(1)</b> CH <sub>3</sub> CH <sub>2</sub> CO <sub>2</sub> H <b>(1)</b>	2	
		(ii) Either sodium dichromate ((VI)) or potassium manganate(VII) <b>(1)</b>  Sulfuric acid <b>(1)</b> dependent on 1 <sup>st</sup> mark Ignore concentrated/dilute	2	<b>[8]</b>
<b>54.</b>	(a)	(i) Make halogenoalkanes miscible with silver nitrate/AgNO <sub>3</sub> solution OR to dissolve halogenoalkanes/acts as solvent <b>(1)</b>	1	

- (ii) Feature of water molecule:  
 The oxygen atom has a lone pair of electrons **(1)**  
 Either an S<sub>N</sub>2 mechanism  
 Arrow from O of water towards C atom **(1)**  
 and arrow from C–I σ bond to I atom **(1)**  
 transition state with no charge **(1)**  
 Ignore final loss of H<sup>+</sup> and formation of I<sup>−</sup>  
 Or an S<sub>N</sub>1 mechanism  
 Arrow from C–I σ bond to I **(1)**  
 intermediate with + charge and I<sup>−</sup> ion **(1)**  
 arrow from O of water to C<sup>+</sup> of intermediate **(1)**  
 Ignore final loss of H<sup>+</sup> 4
- (iii) C 1
- (iv) Silver(I) chloride **(1)**  
 Ignore capitals 1
- (v) Precipitate dissolves/disappears/clears **(1)** 1  
*Reject precipitate changes colour*
- (vi) QWC  
 Must be given in a logical sequence  
 C–I bond is weakest (and break more easily) **(1)**  
 Because the iodine atom is the largest / greatest bond length **(1)**  
 So lowest activation energy **(1)**  
 Or reverse argument: e.g. C–Cl bond strongest 3  
*Reject Cl is more electronegative than I*  
*OR*  
*Cl forms a carbocation more readily than C–I*
- (b) QWC  
 Any two from three:  
 100 % atom economy **(1)**  
 higher cost of halogenoalkanes/halogenoalkanes are made from alcohols **(1)**  
 alkenes readily available from oil **(1)** 2
- (c) (i) suck back **(1)** 1

(ii) remove delivery tube from water/add Bunsen valve (1)

1

**[15]**