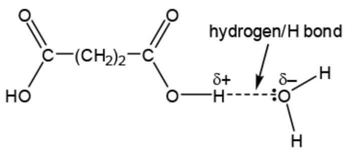
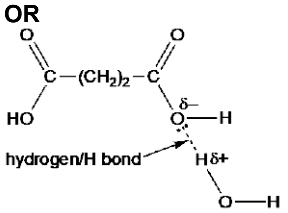
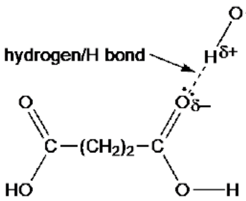
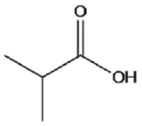
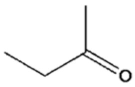
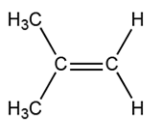
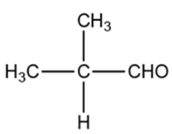
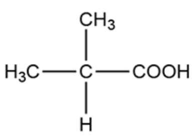
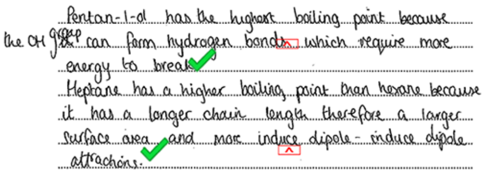
Mark scheme – Alcohols

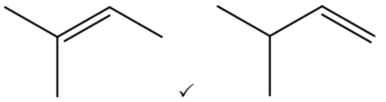
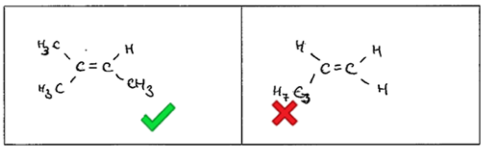
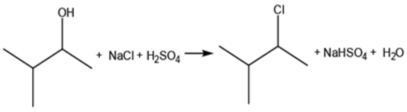
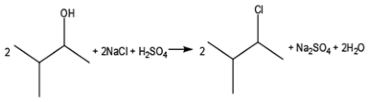
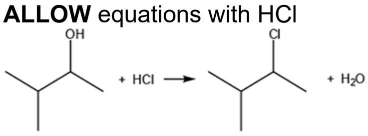
Question			Answer/Indicative content	Marks	Guidance
1		i	**Reagents** $K_2Cr_2O_7$ **AND** acid **AND** reflux ✓ **Equation** $HO(CH_2)_4OH + 4[O] \rightarrow$ $HOOC(CH_2)_2COOH + 2H_2O$ [O] **AND** H_2O ✓ Correctly balanced equation ✓	3 (AO1.1) (AO2.5) (AO2.6)	**ALLOW** $Na_2Cr_2O_7$ **OR** $Cr_2O_7^{2-}$ **ALLOW** H_2SO_4 **OR** HCl **OR** H^+ **ALLOW** words. e.g. 'acidified dichromate' **ALLOW** a small slip in formula for dichromate e.g KCr_2O_7, **<u>Examiner's Comments</u>** Many candidates did not correctly balance this equation or missed water as a product entirely.
		ii	 **OR**  Diagram showing correct dipole charges on each end of one hydrogen bond between a water molecule and a diacid ✓ Hydrogen bond between one lone pair on O atom in one of the molecules and the H atom of another **AND** Hydrogen bonding stated or labelled on diagram	2 (AO2.1×2)	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **DO NOT ALLOW** δ+ on H atoms of CH_2 group **ALLOW** H-bond for hydrogen bond **ALLOW** H bond between C=O and H_2O, i.e.  **IF** diagram is not labelled, **ALLOW** hydrogen bond/H bond from text **<u>Examiner's Comments</u>** Candidates who answered this question well had clear, labelled diagrams. Too often, labels, dipoles and lone pairs were missing.
			Total	**5**	
2			**C, E AND F** ✓✓ Three correct alcohols → 2 marks Two correct alcohols → 1 mark	2 (AO1.1×1) (AO2.1×1)	**If >2 alcohols are shown lose 1 mark for each incorrect response** **<u>Examiner's Comments</u>** Generally this was well answered. However, some candidates only gave two responses where three were required, presumably because it was worth two marks.
			Total	**2**	

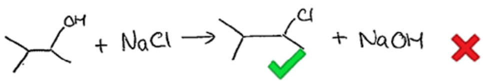
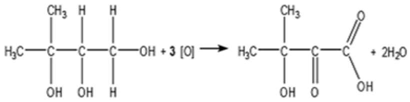
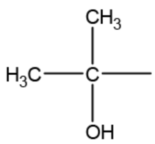
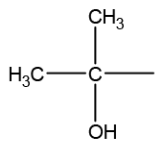
3		i	A →  ✓ B → NONE ✓ C →  ✓	3 (AO2.5) (AO1.2) (AO2.5)	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **DO NOT ALLOW STICKS IN STRUCTURES** **Examiner's Comments** Part 25(a)(i) discriminated extremely well and rewarded well-prepared candidates. Most candidates recognised that B is a tertiary alcohol and will not react with acidified dichromate. The structure from A was often shown as an aldehyde rather than a carboxylic acid. It was also common for candidates to replace the OH group of A with the carboxyl COOH group, gaining a carbon atom in the chain in the process. The ketone oxidation product from C proved to be easier. Part 25(a)(ii) proved to be difficult. Candidates need to be careful in identifying the longest carbon chain to derive the stem of an organic name. Many candidates thought that alcohol C was a branched propanol, with 1-methylpropan-1-ol being seen very often instead of the correct name of butan-2-ol. In part 25(a)(iii), less than half the candidates wrote a correctly-balanced equation for this reaction. Although $4CO_2$ and $5H_2O$ were usually seen for the products, oxygen was usually seen as $6\frac{1}{2}O_2$, rather than $6O_2$. Candidates need to look very closely at the formula of the organic compound so that the O in $C_4H_{10}O$ is accounted for in the balancing.
		ii	butan-2-ol ✓	1 (AO1.2)	**IGNORE** lack of hyphens, or addition of commas **ALLOW** butane-2-ol **DO NOT ALLOW** butan-3-ol **OR** but-2-ol **Examiner's Comments** Part 25(a)(i) discriminated extremely well and rewarded well-prepared candidates. Most candidates recognised that B is a tertiary alcohol and will not react with acidified dichromate. The structure from A was often shown as an aldehyde rather than a carboxylic acid. It was also common for candidates to replace the OH group of A with the carboxyl COOH group, gaining a carbon atom in the chain in the process. The ketone oxidation product from C proved to be easier. Part 25(a)(ii) proved to be difficult. Candidates need to be careful in identifying the longest carbon chain to derive the stem of an organic name. Many candidates thought that alcohol C was a branched propanol, with 1-methylpropan-1-ol being seen very often instead of the

					correct name of butan-2-ol. In part 25(a)(iii), less than half the candidates wrote a correctly-balanced equation for this reaction. Although $4CO_2$ and $5H_2O$ were usually seen for the products, oxygen was usually seen as $6½O_2$, rather than $6O_2$. Candidates need to look very closely at the formula of the organic compound so that the O in $C_4H_{10}O$ is accounted for in the balancing.
		iii	$C_4H_{10}O + 6O_2 \rightarrow 4CO_2 + 5H_2O$ ✓	1 (AO2.6)	**Examiner's Comments** Part 25(a)(i) discriminated extremely well and rewarded well-prepared candidates. Most candidates recognised that B is a tertiary alcohol and will not react with acidified dichromate. The structure from A was often shown as an aldehyde rather than a carboxylic acid. It was also common for candidates to replace the OH group of A with the carboxyl COOH group, gaining a carbon atom in the chain in the process. The ketone oxidation product from C proved to be easier. Part 25(a)(ii) proved to be difficult. Candidates need to be careful in identifying the longest carbon chain to derive the stem of an organic name. Many candidates thought that alcohol C was a branched propanol, with 1-methylpropan-1-ol being seen very often instead of the correct name of butan-2-ol. In part 25(a)(iii), less than half the candidates wrote a correctly-balanced equation for this reaction. Although $4CO_2$ and $5H_2O$ were usually seen for the products, oxygen was usually seen as $6½O_2$, rather than $6O_2$. Candidates need to look very closely at the formula of the organic compound so that the O in $C_4H_{10}O$ is accounted for in the balancing.
			Total	**5**	
4		i	 **F** ✓  **G** ✓  **H** ✓	**3**	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** mixture of the above (as long as unambiguous) **IGNORE** molecular formula **ALLOW** CH_3– **ALLOW** 1 mark for **G AND H** combined is structures are correct but in wrong boxes **Examiner's Comments** Part (i) discriminated extremely well and rewarded the well-prepared candidate. Compound F proved to be the most difficult option, with a large variety of responses, many appearing to be guesses. Candidates were much

					more successful with compounds **G** and **H**, although these were sometimes shown in reverse order. A significant number of candidates drew structures containing C=C or C=O bonds in which the carbon atom had five bonds. Candidates should check drawing of organic structures carefully to ensure that all carbon atoms have four bonds. There were some good responses for part (ii), with many clearly shown and correct systematic names.
		ii	2-methylpropan−1−ol ✓ *Both numbers required*	**1**	**IGNORE** absence of hyphen or use of dots or commas as separators **DO NOT ALLOW** 2−methylprop−1−ol **OR** 2−methpropan−1−ol **OR** 2−methypropan−1−ol
			Total	**4**	
5			**Heptane compared to hexane** heptane (has a longer chain so) has more points of contact / more surface interaction (between molecules) ✓ heptane has stronger/more induced dipole(–dipole) interactions ✓ **Pentan-1-ol compared to heptane and/or hexane** pentan-1-ol has hydrogen bonds that are strong(er than induced dipole–dipole interactions) **OR** (alcohols have) hydrogen bonds and induced dipole(-dipole) interactions/London forces ✓ **Energy required to break forces** More energy is required to break induced dipole(–dipole) interactions in heptane than hexane **OR** More energy is required to break hydrogen bonds ✓	**4**	**ANNOTATE WITH TICKS AND CROSSES** **ALLOW ORA** throughout **ALLOW** heptane has more electrons **IGNORE** IDID **ALLOW** stronger/more London forces **IGNORE** van der Waals' forces/VDW for induced dipole–dipole interactions *(ambiguous as this term refers to both permanent dipole–dipole interactions and induced dipole–dipole interactions)* **IGNORE** 'pentan-1-ol can form hydrogen bonds with water' **ALLOW** 'more energy to break intermolecular forces' if intermolecular forces are not stated. **IGNORE** it is harder to break the intermolecular forces *no reference to energy)* **IGNORE** more energy needed to separate molecules **IGNORE** more energy is needed to break bonds **<u>Examiner's Comments</u>** This question was answered well with most candidates scoring three or four marks. Examiners were impressed by the number of responses that accurately referred to induced dipole-dipole interactions or London forces rather than van der Waals' forces, which is ambiguous. Some responses lacked detail, as demonstrated in Exemplar 10. **Exemplar 10**

					 Pentan-1-ol has the highest boiling point because the OH group can form hydrogen bonds which require more energy to break. Heptane has a higher boiling point than hexane because it has a longer chain length therefore a larger surface area and more induce dipole - induce dipole attractions. This response attributes the higher boiling point of pentan-1-ol to the amount energy required to break hydrogen bonds. However, it does not refer the relative strength of this type of interaction. Consequently, the first paragraph only scores marking point four and not marking point three. The higher boiling point of heptane compared to hexane is explained by a correct comparison of the induced dipole-dipole interactions present in these compounds, so marking point two was achieved. However, the justification for the difference in intermolecular forces lacks precision. Candidates should be encouraged to focus on surface contact or surface interaction between molecules rather than referring to surface area alone.
			Total	**4**	
6	a	i	3-methylbutan-2-ol ✓	**1**	**IGNORE** lack of hyphens or addition of commas **ALLOW** 3-methylbutane-2-ol **DO NOT ALLOW** 2-methylbutan-3-ol **OR** 3-methylbut-2-ol **OR** 3-methbutan-2-ol **OR** 3-methybutan-2-ol **OR** 3-methlybutan-2-ol **<u>Examiner's Comments</u>** The majority of candidates were able to correctly name alcohol A as 3-methylbutan-2-ol. A significant number of responses used incorrect numbering and suggested 2-methylbutan-3-ol as the name.
		ii	$(CH_3)_2CHCHOHCH_3$ ✓	**1**	**ALLOW** brackets around OH e.g. $(CH_3)_2CHCH(OH)CH_3$ **ALLOW** any unambiguous structural formula e.g. $CH_3CH(CH_3)CHOHCH_3$ $CH_3CH(CH_3)CH(CH_3)OH$ **<u>Examiner's Comments</u>** Most candidates were able to show a correct structural formula of alcohol A.

		iii	One mark for each correct structure.  ✓ ✓	**2**	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW** in either order **<u>Examiner's Comments</u>** Many candidates correctly identified the two alkenes formed as 2-methylbut-2-ene and 3-methybut-1-ene. Stronger responses used skeletal formula to show the structures clearly. Some candidates preferred to use chemical symbols to represent the atoms present and although this approach is valid, lower ability responses did not show sufficient detail as demonstrated in Exemplar 1. **Exemplar 1**  In this response the alkene 2-methylbut-2-ene has been correctly identified and one mark credited. However, the attempt to show 3-methylbut-1-ene does not score. This is because C_3H_7 has been used instead of $CH(CH_3)_2$. Candidates should be encouraged to show every carbon atom when drawing a structure as the use of ambiguous formulae is not sufficient to gain credit.
		iv	 Correct haloalkane ✓ Correctly balanced equation ✓	**2**	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW** H^+ for H_2SO_4 **ALLOW** equations forming Na_2SO_4  **ALLOW** equations with HCl  **DO NOT ALLOW** equations that form NaOH **<u>Examiner's Comments</u>** This question proved difficult for candidates. Although many candidates were able to identify the correct organic product, only the higher ability candidates were able to construct an appropriate balanced equation. A common error was to omit the role of the acid; this is shown in Exemplar 2 below. Lower ability candidates appeared not to recognise this reaction and suggested an alkoxide salt, rather than a haloalkane as the organic product. **Exemplar 2**

					 This type of response was seen frequently by examiners. The candidate has drawn the correct structure of the haloalkane formed and scores the first mark. However, the response fails to recognise that the reaction occurs under acidic conditions and omits the sulfuric acid from the equation.
	b		 Correct organic product ✓ Rest of equation ✓	**2**	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW** any vertical bond to the tertiary OH group e.g. **ALLOW**  **OR**  **<u>Examiner's Comments</u>** This question required candidates to apply their knowledge of the oxidation of alcohols to complete the equation for the complete oxidation of compound B. This question discriminated well. Many candidates correctly identified the organic product but only the higher ability candidates could complete the equation. A common error was to omit water as a product of the reaction.
			Total	**8**	
7		i	*Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Correctly labelled diagram of reflux apparatus that works, with no safety problems **AND** An appreciation of most of the purification steps required to gain a pure sample *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Labelled diagram of apparatus (either reflux or distillation) but with safety/procedural problems **OR** clear diagram of reflux apparatus without labelling **AND** Some details of further purification steps	6	**Indicative scientific points may include:** **Apparatus set up for reflux:** • round-bottom/pear shaped flask • heat source • condenser *Detail: water flow in condenser bottom to top; open system.* **Purification** • Use of a **separating funnel** to separate organic and aqueous layers *Detail: Collect lower organic layer density greater* • **Drying** with an anhydrous salt, *Detail: e.g. $MgSO_4$, $CaCl_2$, etc.* • **Redistillation** *Detail: Collect fraction distilling at 102°C.*

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)
Diagram of apparatus (**reflux OR separation OR distillation**) drawn with no labelling **OR** labelled diagram with significant safety/procedural
AND / OR
Few or imprecise details about further purification stages

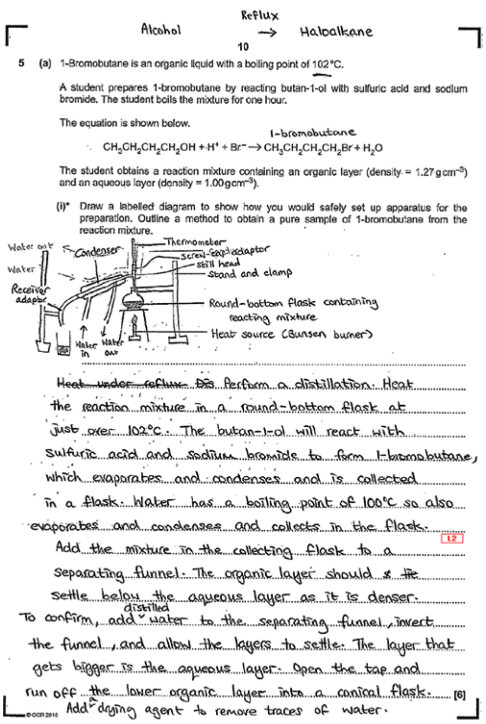
There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks
No response or no response worthy of credit.

<u>Examiner's Comments</u>

Candidates were not prepared to answer this type of question and the diagrams were hard to give credit to. Many had significant safety implications such as open beakers of butan-1-ol being heated by a Bunsen burner. Most mis-read the question and just outlined the method for purification and struggled to recall the practical details. Very few candidates mentioned the use of anhydrous salts, referring instead to 'boiling off' the water.

Exemplar 4


Alcohol $\xrightarrow{\text{Reflux}}$ Haloalkane

10

5 (a) 1-Bromobutane is an organic liquid with a boiling point of 102 °C.

A student prepares 1-bromobutane by reacting butan-1-ol with sulfuric acid and sodium bromide. The student boils the mixture for one hour.

The equation is shown below.

$$CH_3CH_2CH_2CH_2OH + H^+ + Br^- \rightarrow CH_3CH_2CH_2CH_2Br + H_2O$$ (1-bromobutane)

The student obtains a reaction mixture containing an organic layer (density = 1.27 g cm^{-3}) and an aqueous layer (density = 1.00 g cm^{-3}).

(i)* Draw a labelled diagram to show how you would safely set up apparatus for the preparation. Outline a method to obtain a pure sample of 1-bromobutane from the reaction mixture.

~~Heat under reflux. Dis~~ Perform a distillation. Heat the reaction mixture in a round-bottom flask at just over 102°C. The butan-1-ol will react with sulfuric acid and sodium bromide to form 1-bromobutane, which evaporates and condenses and is collected in a flask. Water has a boiling point of 100°C so also evaporates and condenses and collects in the flask. Add the mixture in the collecting flask to a separating funnel. The organic layer should ~~s the~~ settle below the aqueous layer as it is denser. To confirm, add distilled water to the separating funnel, invert the funnel, and allow the layers to settle. The layer that gets bigger is the aqueous layer. Open the tap and run off the lower organic layer into a conical flask. Add a drying agent to remove traces of water. [6]

L2

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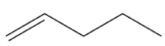
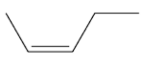
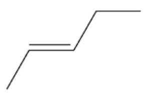
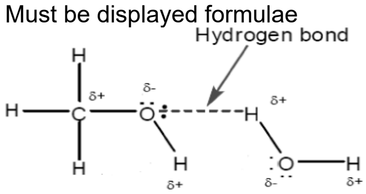
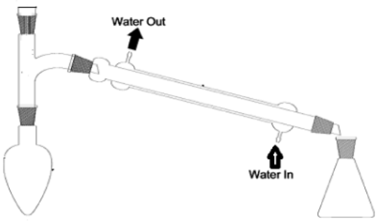
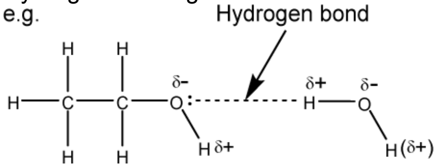
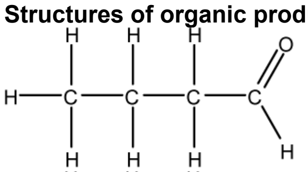
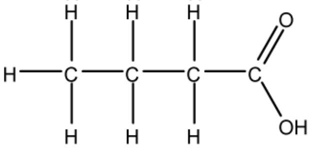
This candidate was credited 4 marks for this level 2 answer. Although they have drawn distillation apparatus instead of reflux, they have considered the boiling point of the product, detailed using a separating funnel, a

					drying agent and that the lower organic layer would be drawn off first.
		ii	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = 12.6 (g) award 2 marks** • n(1-bromobutane) = $0.150 \times \frac{61.4}{100} = 0.0921$ (mol) ✓ • **Mass 1-bromobutane = 0.0921 × 136.9 = 12.6 (g) ✓** **3 SF required**	2	**Common errors:** 33.4 (0.150 × 100/61.4 = 0.244 × 136.9) 1 mark **ALLOW ECF** for incorrect moles or incorrect M_r **of 1-bromobutane** (provided answer is to 3 SF) **DO NOT ALLOW** 6.82 (using M_r of butan-1-ol) **ALLOW** calculation using masses, e.g. • **Theoretical = 0.150 × 136.9 = 20.535 (g) ✓** ***(ALLOW 20.535 rounded back to 20.5)*** • Actual mass = $20.535 \times \frac{61.4}{100} = 12.6$ (g) ✓ *(20.5 also gives 12.6)* **<u>Examiner's Comments</u>** This question was well answered, but a significant number of candidates incorrectly used the Mr of butan-1-ol when calculating the mass of 1-bromobutane.
			Total	**8**	
8			** Please refer to the marking instruction point 10 for guidance on how to mark this question.* **(Level 3)** Applies knowledge of elimination reactions to provide the correct names and structures of all three alkenes. **AND** Full, detailed explanation of formation of both types of isomers linked to the reaction, with clear understanding of both types of isomerism. *The explanations show a well-developed line of reasoning which is clear and logically structured. The information presented is relevant to the compounds drawn / named.* (5–6 marks) **(Level 2)** Applies knowledge of elimination reactions to provide the correct name and structure for pent-1-ene. **AND** Correct structures of stereoisomers of pent-2-ene but full names missing or incorrect. **AND** Explanation of formation of at least one type of	6	**Indicative scientific points may include:** • the elimination can produce a double bond in either the 1- or the 2- position (through combination of the hydroxyl group with a hydrogen from either the 1st or the 3rd carbon) • this leads to the formation of structural isomers (pent-1-ene and pent-2-ene) • pent-2-ene exhibits stereoisomerism / *E/Z* isomerism / *cis–trans* isomerism because it has two different groups attached to each carbon atom • there are two possible isomers of pent-2-ene and three in total. **Names and structures of alkenes**  pent-1-ene  *Z* or *cis*-pent-2-ene  *E* or *trans*-pent-2-ene

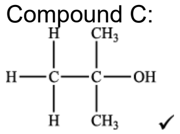
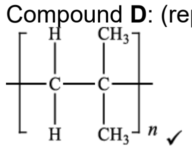
			isomers in some detail. *The explanations show a line of reasoning presented with some structure. The information presented is in the most-part relevant to the compounds drawn / named.* (3–4 marks) **(Level 1)** Applies knowledge of elimination reactions to name and draw the structures of organic products. Either name **OR** structure should be correct for two compounds. **AND** Attempts to explain formation of one type of isomer. *The information about isomerism is basic and communicated in an unstructured way. The relationship to the compounds drawn / named may not be clear.* (1–2 marks) **(0 marks)** No response or no response worthy of credit.		
			Total	**6**	
9	a		Displayed formulae of CH_3OH and H_2O **AND** C–O **AND** O–H polar bonds shown on CH_3OH molecule with δ+ and δ- **AND** Both O–H polar bonds shown on H_2O molecule with δ+ and δ- ✓ **Two** lone pairs shown on both oxygen atoms **AND** Hydrogen bond / H-bond labelled and in the correct position between the H on water and the oxygen lone pair on methanol ✓	**2**	Must be displayed formulae  **IGNORE** δ+ shown on other H atoms **ALLOW** hydrogen bond between the H on methanol (OH) and the oxygen lone pair on water **Examiner's Comment:** Candidates did not cope well with the requirement to produce a hydrogen bonding diagram that was expected to match the content of all four of the bullet points listed in the question. Perhaps candidates did not read the question carefully enough but some diagrams did not include displayed formulae, dipoles were often missing from the methanol molecule, lone pairs were absent from oxygen atoms and the hydrogen bond was marked in an incorrect position. This resulted in a low scoring question for a diagram that had produced much higher scores when asked on papers from the legacy specification.
	b		*Please refer to the marking instructions on page 5 of the mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)**	**6**	**Indicative scientific points** **<u>1. Oxidation reaction forming aldehyde</u>**

			A comprehensive explanation with all three scientific points covered thoroughly. *There is a well-developed description with a logical structure including correct chemical equations and an explanation with a clear line of reasoning including a fully labelled diagram.* **Level 2 (3–4 marks)** The candidate attempts all three scientific points but explanations are incomplete. **OR** Explains two scientific points thoroughly with no omissions. *The description has a line of reasoning presented with some structure and includes correct structural formulae and an accurate diagram of a distillation apparatus.* **Level 1 (1–2 marks)** A simple explanation based on at least two of the main scientific points **OR** The candidate explains one scientific point thoroughly with few omissions. *The description may be communicated in an unstructured way but it includes the correct reagents and conditions for the formation of the aldehyde.* *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks–***No response or no response worthy of credit.*		• acid / H+ **AND** dichromate / $Cr_2O_7^{2-}$ • heat **AND** distillation • organic product is butanal / $CH_3CH_2CH_2CHO$ • $CH_3CH_2CH_2CH_2OH + [O] \rightarrow CH_3CH_2CH_2CHO + H2O$ **<u>2. Oxidation reaction forming carboxylic acid</u>** • acid / H+ **AND** dichromate / $Cr_2O_7^{2-}$ • heat under reflux • organic product is butanoic acid / $CH_3CH_2CH_2COOH$ • $CH_3CH_2CH_2CH_2OH + 2[O] \rightarrow CH_3CH_2CH_2COOH + H_2O$ **<u>3. Distillation</u>** • diagram of apparatus with condenser • condenser has water flow • collection of organic product • product is separated to prevent further oxidation (to carboxylic acid)  **Examiner's Comment:** A very wide range of responses was seen in the second question marked using a level of response mark scheme and a greater proportion of candidates were able to access the highest level in this question. Diagrams of a distillation apparatus were often disappointing and many poor answers failed to identify the oxidation products. A Level 1 response usually named the oxidising agent and included a crude diagram of a distillation apparatus. Diagrams in Level two responses often included more detail with a condenser cooled by water flow and an indication of where butanal can be collected. A Level three response was expected to include balanced equations for the oxidation reactions.
			Total	**8**	
10	a		$C_5H_{10}O + 7O_2 \longrightarrow 5CO_2 + 5H_2O$ ✓	**1**	**ALLOW** multiples e.g. $2C_5H_{10}O + 14O_2 \longrightarrow 10CO_2 + 10H_2O$ **ALLOW** any equation involving an unsaturated alcohol

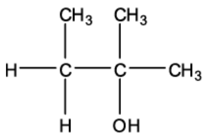
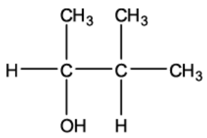
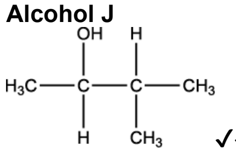
					with correct balancing **e.g.** $C_5H_8O + 6.5O_2 \longrightarrow 5CO_2 + 4H_2O$ $C_5H_6O + 6O_2 \longrightarrow 5CO_2 + 3H_2O$ $C_5H_4O + 5.5O_2 \longrightarrow 5CO_2 + 2H_2O$ $C_5H_2O + 5O_2 \longrightarrow 5CO_2 + H_2O$ **IGNORE** state symbols **Examiner Comments** The more able candidates were able to balance this combustion equation. Those who failed to be awarded the mark either used the molecular formula of a saturated alcohol or did not consider the presence of the oxygen atom in the alcohol when balancing the equation.
	b	i	Diagram showing a water molecule and an ethanol molecule with at least one $H^{\delta+}$ and one $O^{\delta-}$ on **BOTH** molecules ✓ Hydrogen bond between one lone pair on O atom in one of the molecules and the H atom of another. **AND** Hydrogen bonding stated or labelled on diagram ✓ e.g. 	2	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **DO NOT ALLOW** δ+ on H atoms of alkyl group **DO NOT ALLOW** any marks for a diagram containing O_2H If more than one hydrogen bond is shown they must **all** be correct to award the mark. **Examiner Comments** The examiners were surprised that more of the candidates did not achieve both marks on a question that many would have experienced before from legacy past papers. Candidates often failed to include dipoles and lone pairs even though this was indicated in the stem of the question. Candidates should recognise the involvement of the lone pair in any hydrogen bonds drawn. Where candidates gave more than one hydrogen bond in their diagrams they had to be correct for a mark to be awarded.
		ii	Hexane-1,6-diol has more OH groups (than hexan-1-ol) **AND** (hexane-1,6-diol) forms more hydrogen bonds **with water** ✓	1	Statements **MUST** be comparative e.g. hexane-1,6-diol has two –OH groups and hexan-1-ol has one −OH group **ALLOW** hydroxyl or hydroxy **DO NOT ALLOW** hydroxide/OH^- **ALLOW ORA** **Examiner Comments** The best answers here stated that that hexane-1,6-diol had more OH groups than hexan-1-ol and so more hydrogen bonds could be formed with water molecules. Weaker answers did not compare the two compounds simply stating that hexan-1,6-diol had two OH groups or that it formed two hydrogen bonds with water. Candidates who did include a comparison frequently failed to state that solubility was due to hydrogen bonds being formed with water.

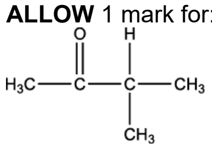
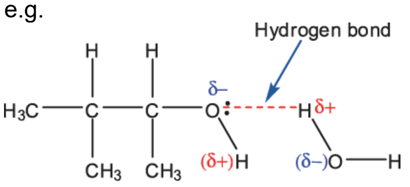
	c		**Structures of organic products**  ✓  ✓ **Equations** $CH_3CH_2CH_2CH_2OH + [O] \longrightarrow CH_3CH_2CH_2CHO + H_2O$ ✓ $CH_3CH_2CH_2CH_2OH + 2[O] \longrightarrow CH_3CH_2CH_2COOH + H_2O$ ✓ **Reaction conditions** Distillation to produce aldehyde/$CH_3CH_2CH_2CHO$ **AND** Reflux to produce carboxylic acid/$CH_3CH_2CH_2COOH$ ✓	**5**	**ANNOTATE WITH TICKS AND CROSSES** Use of any primary alcohol containing 3, 5 or more carbons can be awarded up to 4 marks. **ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **IGNORE** names **DO NOT ALLOW** $CH_3CH_2CH_2COH$ for the structure of the aldehyde. **ALLOW** $CH_3CH_2CH_2CO_2H$ for the structure of the carboxylic acid. **ALLOW** marks for structures from equations as long as unambiguous. **ALLOW** molecular formulae in equations e.g. $C_4H_{10}O + [O] \longrightarrow C_4H_8O + H_2O$ $C_4H_{10}O + 2[O] \longrightarrow C_4H_8O_2 + H_2O$ $C_4H_9OH + [O] \longrightarrow C_3H_7CHO + H_2O$ $C_4H_9OH + 2[O] \longrightarrow C_3H_7CO_2H + H_2O$ **IGNORE** incorrect structures in equations i.e. $C_4H_{10}O + [O] \longrightarrow C_3H_7COH + H_2O$ scores equation mark Conditions **must** be linked to aldehyde/carboxylic acid or correct products. Conditions may be written above arrow of equation. **Examiner Comments** A very well answered question. Candidates had obviously been well prepared as even the weakest candidates gained a number of marks here. The most common mark lost was a failure to include H_2O in the balanced equations. In the preparation of the carboxylic acid, a number of Candidates balanced the equation with $2H_2O$.
			Total	**9**	
11	a		Alcohols have hydrogen bonds (and van der Waals' forces) ✓ Hydrogen bonds are stronger than van der Waals' forces (in alkanes) ✓	2	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **ALLOW** reference to specific compounds e.g. comparing methane and methanol Second marking point requires **BOTH** types of intermolecular forces in response i.e comparison of hydrogen bonds **AND** van der Waals is **essential** **DO NOT ALLOW** the second mark for a comparison of van der Waals' and hydrogen bonds between alcohols and water **ALLOW** more energy required to break hydrogen bonds than van der Waals' forces **ALLOW** it is harder to overcome the hydrogen bonds

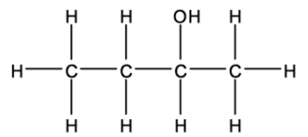
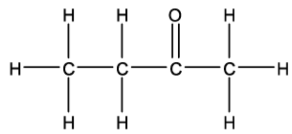
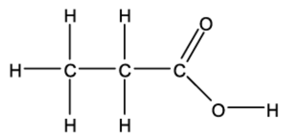
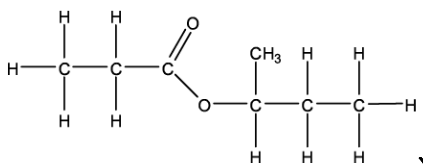
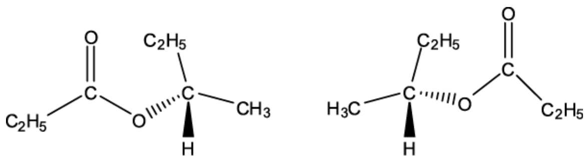
					than van der Waals' forces **IGNORE** more energy is needed to break bonds **Examiner's Comments** Many candidates attributed the difference in boiling point between alkanes and alcohols to the relative strength of hydrogen bonds compared with van der Waals' forces. Weaker responses simply identified alcohols as being able to form hydrogen bonds, but failed to compare these with van der Waals' forces.
	b		2-methylpropan-1-ol has less surface (area of) contact **OR** fewer points of contact ✓ 2-methylpropan-1-ol has fewer / weaker van der Waals' forces **OR** less energy required to break van der Waals' forces in 2-methylpropan-1-ol ✓	2	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **Both answers need to be comparisons** **ALLOW ORA** throughout Reference to just surface area / closeness of molecules is **not** sufficient **IGNORE** reference to H bonds **IGNORE** less energy is needed to break bonds **Examiner's Comments** Most candidates recognised that 2-methylpropan-1-ol is branched and communicated both marking points succinctly. Weaker responses identified that 2-methypropan-1-ol would have weaker intermolecular forces, but failed to specify these as van der Waals' forces.
	c	i	Elimination **OR** dehydration ✓	1	**Examiner's Comments** Many candidates correctly named the type of reaction. There were a significant number of incorrect responses, the most common of which included hydrolysis, dehydrogenation and condensation.
		ii	**IF answer = 14.0 OR 14.1 g award 3 marks** **…………………………………………………………** . **actual** $n(C_5H_8)$ produced = $\frac{5.00}{68.0}$ = 0.0735 (mol) ✓ **theoretical** $n(C_5H_9OH) = n(C_5H_8) = 0.0735 \times \frac{100}{45.0}$ = 0.163 (mol) ✓	3	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **ALLOW ECF** at each stage **ALLOW 3 SF** up to calculator value correctly rounded for intermediate values **ALLOW** expected mass $C_5H_8 = 5.00 \times \frac{100}{45.0}$ = 11.111 (g) **ALLOW** Mass C_5H_9OH reacted = 0.0735 × 86.0 = 6.321 (g)

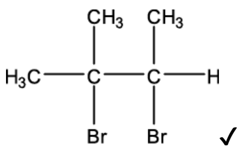
			Mass of C_5H_9OH = 0.163 × 86.0 = 14.0 (g) **OR** 14 g **OR** 14.1 g ✓ (*use of unrounded values in calculator throughout*)		**ALLOW** Mass of C_5H_9OH used = $6.321 \times \frac{100}{45.0}$ = 14.0 **OR** 14 (g) **ALLOW 2 SF** up to calculator value correctly rounded for mass of C_5H_9OH **Note:** 2.84 **OR** 2.85 g would get 2 marks *(use of 45.0/100 instead of 100/45.0)* 13.76 **OR** 13.8 would get 2 marks *(use of 0.16 for moles C_5H_9OH)* **Examiner's Comments** Candidates coped well with this calculation based on percentage yield. Most were able to calculate the moles of cyclopentene produced and the strongest scaled this correctly to give the moles of cyclopentanol required. A common mistake was to scale by a factor of 45/100, rather than 100/45. However, error carried forward marks were awarded and the majority of candidates scored two or three marks. Answer: 14.1 g
			Total	**8**	
12			Compound C:  ✓ **CARE**: Tertiary alcohol Compound **D**: (repeat unit)  ✓	2	**For structures:** **ALLOW** correct structural **OR** skeletal **OR** displayed formula **OR** mixture of the above *Connectivity* **IGNORE** connectivity of bonds to CH_3 e.g. **ALLOW** CH_3– **ALLOW any** vertical bond to OH, e.g. **ALLOW** OH **OR** OH | | **DO NOT ALLOW** OH– **DO NOT ALLOW** more than one repeat unit **REQUIRED:** Side links (dotted lines fine) **NOT REQUIRED:** Brackets and '*n*' **Examiner's Comments** This part was answered well. If a mark was lost, it was almost always due to compound C, especially at the low

					scoring end of the range. Many struggled with the structure of a tertiary alcohol or omitted H atoms from the structure. Compound D was generally drawn correctly by candidates of all abilities. If the mark was not credited, it was usually due to not removing the double bond, or drawing more than one repeat unit.
			Total	**2**	
13	a	i	**Equation** $CH_3CH(OH)CH_2CH_3$ + [O] → $CH_3COCH_2CH_3$ + H_2O ✓ **Structure of product could be allowed from equation** $CH_3COCH_2CH_3$ ✓	2	**ALLOW** molecular formulae: $C_4H_{10}O$ and C_4H_8O **ALLOW** C_4H_9OH **ALLOW** C_2H_5 for CH_3CH_2 **ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous **Examiner's Comments** The majority of candidates were able to identify the structure of the ketone formed in the oxidation of butan-2-ol but many were not able to construct a suitable equation. Water was often omitted from the equation on the right hand side whilst sometimes the equation was incorrectly balanced with a 2 being placed in front of the [O]. The most able candidates normally scored both marks.
		ii	Butan-2-ol/butanone is flammable **OR** Butan-2-ol / butanone is volatile / low boiling point **OR**		**IGNORE** vague answers about health and safety **ALLOW** alcohol for butan-2-ol **ALLOW** ketone for butanone
		ii	Butan-2-ol / butanone will evaporate / boil away ✓	1	**DO NOT ALLOW** the product or reactant. **DO NOT ALLOW** distillation
		ii	(Heat under) reflux **OR** a description of reflux with vertical condenser and a round bottomed or pear shaped flask with source of heat. ✓	1	**DO NOT ALLOW** any reference to closed system. **Examiner's Comments** Another question requiring candidates to evaluate a practical activity where responses were on the whole disappointing. Very few candidates were able to access both of the marks with the harder of the two marks being for suggesting why the apparatus was not suitable for the experiment. Clearly many candidates were able to suggest a better method of carrying out the experiment with reflux being often quoted.
	b		The –OH group is attached to a carbon that is attached to one hydrogen atom **OR** The –OH group is attached to a carbon that is attached to two C atoms / alkyl groups/R groups ✓	1	**ALLOW** alcohol / hydroxyl / functional group for –OH **Examiner's Comments** The definition of a secondary alcohol was well known

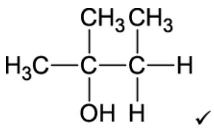
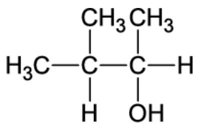
					with most candidates being to express this to gain the mark available.
			Total	**5**	
14			 ✓  ✓	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous **ALLOW any** vertical bond to OH, e.g. **ALLOW** OH | **OR** OH | **DO NOT ALLOW** OH– **Examiner's Comments** Many candidates found it difficult to draw the structures for the two alcohols that could be dehydrated to produce compound A. This was surprising as it was a simple task to add water across the double bond of compound "A" resulting in two branched chained isomers. The most common incorrect answers were pentan-1-ol and pentan-2-ol, although some candidates shortened the chain length resulting in compounds containing only four carbon atoms.
			Total	**2**	
15	a		**QWC**: Evidence of the **IR** absorption at 1720 (cm^{-1}) for presence of C=O / carbonyl group ✓ **QWC**: No carboxylic acid OH absorption in IR **OR** no peak between 2500–3300 cm^{-1} **AND** so **J** is a secondary alcohol **OR** so **K** is a ketone ✓	6	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **LOOK ON THE SPECTRUM** for labelled peaks which can be given credit **BOTH IR** at ~ 1720 (cm^{-1}) **AND** C=O required **ALLOW** ranges from *Data Sheet*, i.e. C=O within range 1640–1750 cm^{-1}; **IGNORE** any reference to C-O absorption For structures of **J** and **K**, **ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above **IGNORE** any names given for **J** and **K** **ALLOW** 1 mark for the structure of an alcohol with the molecular formula $C_5H_{12}O$ **DO NOT ALLOW** pentan-1-ol (*primary and unbranched*) or 2-methylbutan-2-ol (*branched but tertiary*) **DO NOT ALLOW** any marks for **J** and **K** if more than one structure is given for **J** **Note:** 'sticks' in either **J** and / or **K** will lose only 1 mark
			Alcohol J  ✓✓		
			Compound K Structure of a carbonyl compound that could be obtained from alcohol **J** ✓		

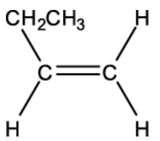
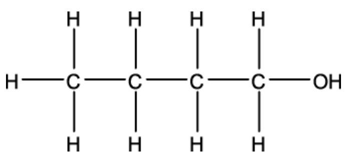
			Equation Balanced equation for conversion of **J** to **K** ✓ e.g. $CH_3CHOHCH(CH_3)_2 + [O] \rightarrow CH_3COCH(CH_3)_2 + H_2O$		**ALLOW** 1 mark for:  **IF** a structure is not given for **J** **NOTE:** structures for **J** and **K** could be awarded from the equation, even if not labelled. **ALLOW** molecular formulae in equation i.e. $C_5H_{12}O + [O] \rightarrow C_5H_{10}O + H_2O$ **DO NOT ALLOW** equations that form a carboxylic acid **Examiner's Comments** This question discriminated well and most candidates were able to score at least one mark, by identifying the C=O peak in the IR spectrum provided. The most able candidates gave succinct responses that included both the correct structures of **J** and **K** as well as a balanced equation. In addition, they included reference to the absence of a carboxylic acid O-H peak in the IR spectrum concluding that **K** must be a ketone. This marking point was missed by a large proportion of the cohort and often a branched primary alcohol for **J** and corresponding aldehyde for **K** were suggested. Some candidates incorrectly identified the C—H peak in the spectrum as an O—H and suggested that **K** was a carboxylic acid.
	b		**Labelled** diagram showing at least one H-bond between alcohol molecule and water ✓ e.g. 	1	**IF** diagram is not labelled **ALLOW** Hydrogen bonds / H bonds from text Diagram should include role of an O lone pair and dipole charges on each end of H bond. **IGNORE** alcohol R group, even if wrong **ALLOW** structural **OR** displayed **OR** skeletal formula **OR** mixture of the above **Examiner's Comments** The majority of candidates were able to draw a diagram to show the hydrogen bond between an alcohol and water. However, a significant proportion lacked the accuracy required at this level and failed to show the role of the lone pair. It was also common to see responses that omitted the relevant dipoles. The question asked for the inclusion of relevant dipoles and lone pairs and candidates are advised to double check diagrams to ensure these key features are not neglected.
			Total	**7**	

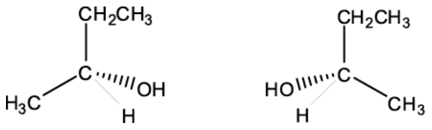
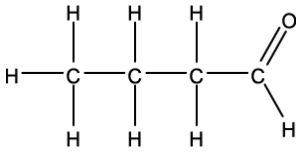
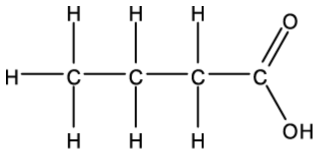
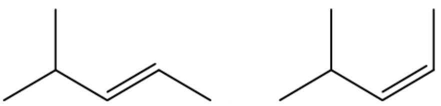
16			Molar mass of **B** = 74 ✓ **B-F** clearly identified **B/alcohol:**  ✓ **C/ketone:**  ✓ **D/carboxylic acid:**  ✓ **E and F:**  ✓ H_2O/water ✓	6	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **Check and annotate page 19 below this response** Molar mass = $\frac{2.59}{0.035}$ = 74 For structure of **B**, **C**, **D** or **E / F ALLOW** correct displayed **OR** correct structural formula **OR** correct skeletal formula **OR** mixture of the above as long as unambiguous. **DO NOT ALLOW** missing H atom(s) in a displayed formula for one structure but **ALLOW** missing H atoms in subsequent structures. **IGNORE** names of organic compounds **E** and **F** can be identified either way round **ALLOW** H_2O or displayed formula for mark For **E** and **F** – **ALLOW** the two optical isomers  **Examiner's Comments** Candidate were required to apply their knowledge of the reactions of alcohols to suggest the structures of the five compound **B–F**. Generally this question was answered well and most candidates scored three or more marks. The majority of candidates chose to use displayed formula. Other candidates opted to use skeletal formula and only a small proportion showed structural formulae. Almost all of the candidates were able to correctly calculate the molar mass of **B** as 74 g mol^{-1} which allowed most to suggest a structure for the compound. Many candidates used the information that **B** forms a ketone and provided the correct structure of butan-2-ol, although a significant proportion of candidates suggested **B** was butan-1-ol. The more able candidates identified the structure of **C** as butanone, but a large proportion of the cohort did not suggest a structure. Some candidates who used displayed formula for **C** often included an extra hydrogen atom on the carbonyl group.

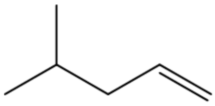
					Most candidates were able to suggest a correct structure of carboxylic acid **D** and therefore deduced that the reaction between **B** and **D** was an esterification reaction. The most difficult part of this question was identifying **E** and **F**. The most able candidates provided a correct structure for the ester, however some candidates often missed of one of the hydrogen atoms from their displayed formula. The most common incorrect response was to the structure of butyl propanoaoate. Some candidates identified the other compound formed in the reaction of **B** and **D** as water but a large proportion gave a second ester. In general the structures given by candidates were accurately drawn but candidates should be reminded to check their work carefully to ensure the correct number of atoms and bonds are present if using displayed formula.
			Total	**6**	
17	a		 ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above **DO NOT ALLOW** molecular formula **ALLOW** dichloro or diiodo compound instead of the dibromo compound as the **only** alternatives. **Examiner's Comments** This question required candidates to interpret the reaction scheme and suggest an intermediate compound that could be formed from 2-methylbut-2-ene that could be also hydrolysed to give the diol shown. The most able candidates demonstrated their understanding of this scheme and often suggested the correct dihalo compound. Most candidate favoured the dibromo compound however some chose to show the dichloro or diiodo compound. All of these responses received credit. A large proportion of structures suggested were obtainable from 2-methylbut-2-ene but could not be hydrolysed. These included the products of hydrogenation e.g. 2-methylbutane, or hydration e.g. 2-methylbutan-2-ol. Consequently only the most able candidates achieved a mark in part (b), as this was essentially dependant on part (a).
	b		Reagent **A**: correct halogen✓ e.g. Br_2 / bromine	1	**ALLOW** Cl_2 if dichloro compound drawn **ALLOW** I_2 if diiodo compound drawn **IGNORE** state symbols Answer must match box from **(a)** to score

					Examiner's Comments This question required candidates to interpret the reaction scheme and suggest an intermediate compound that could be formed from 2-methylbut-2-ene that could be also hydrolysed to give the diol shown. The most able candidates demonstrated their understanding of this scheme and often suggested the correct dihalo compound. Most candidate favoured the dibromo compound however some chose to show the dichloro or diiodo compound. All of these responses received credit. A large proportion of structures suggested were obtainable from 2-methylbut-2-ene but could not be hydrolysed. These included the products of hydrogenation e.g. 2-methylbutane, or hydration e.g. 2-methylbutan-2-ol. Consequently only the most able candidates achieved a mark in part (b), as this was essentially dependant on part (a).
	c	i	Steam **AND** acid catalyst ✓	1	**ALLOW** H^+ / named acid / H_2SO_4 / H_3PO_4 **ALLOW** $H_2O(g)$ **ALLOW** water only if a temperature of 100 °C or above is quoted. **IGNORE** any temperature given with steam **IGNORE** pressure **Examiner's Comments** One would expect the majority of candidates to do well in a question which required them to state the reagents and conditions required for the hydration of alkenes; however this was not the case. The most able candidates provided accurate responses which referred to both steam and the acid catalyst, which was often shown to be H_3PO_4. Other candidates stated only one of the two required responses and it was common to see the acid catalyst stated alongside a temperature and pressure but with no reference to steam. Some candidates stated the reagent as H_2O instead of steam and this was allowed if accompanied by a temperature of over 100 °C. Candidates should be encouraged to learn reagents and conditions required for organic reactions.
		ii	(compounds or molecules) having the same molecular formula but different structural formulae ✓	1	**ALLOW** different structure **OR** different displayed formula **OR** different skeletal formula for structure Same formula is **not** sufficient Different arrangement of atoms is **not** sufficient **Examiner's Comments**

					The majority of candidates were able to explain the term structural isomers.
		iii	 ✓  ✓	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above **ALLOW** any vertical bond to OH **DO NOT ALLOW** OH− **Examiner's Comments** Many candidates found this question difficult and a large number of candidates showed structures of alcohols with the molecular formula $C_5H_{12}O$, but that could not be formed from 2- methylbut-2-ene. Examples of these incorrect responses included 2-methylbutan-1-ol, pentan-1- ol, pentan-2-ol and pentan-3-ol. Only the most able could show the structures of both alcohols produced by the hydration of 2-methlybut-2-ene. Candidates should be reminded to check that any structures they suggest are consistent with the context of the question.
		iv	Does not contain OH group(s) **OR** does not contain hydroxyl group(s) **OR** is not an alcohol ✓ Does not form hydrogen bonds with water ✓	2	**ALLOW ORA** throughout **DO NOT ALLOW** OH^- (ions) / hydroxide (ions) 'Does not form hydrogen bonds' is **not** sufficient **Examiner's Comments** The majority of candidates were able to recognise that the key to the solubility of the isomers in water is that they contain the OH group whereas 2-methylbut-2-ene does not. Most candidates scored the second mark by accurately explaining that the OH group could form hydrogen bonds with water.
	d		Reagents: Acid / H^+ and (potassium or sodium) dichromate / $Cr_2O_7^{2-}$ seen **once**✓ Observations: Orange to Green **OR** Orange to Blue✓ Distillation / Distil produces aldehyde / CH_3CH_2CHO: ✓ $CH_3CH_2CH_2OH + [O] \rightarrow CH_3CH_2CHO + H_2O$ ✓ Reflux (of propan-1-ol) produces carboxylic acid / CH_3CH_2COOH✓	6	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **ALLOW** H_2SO_4 and $K_2Cr_2O_7$ **ALLOW** correct displayed formula **OR** correct structural formula **OR** skeletal formula **OR** a mixture of the above **DO NOT ALLOW** molecular formulae **ALLOW** C_3H_7OH for propan-1-ol in equations **DO NOT ALLOW** CH_3CH_2COH for aldehyde **IGNORE** further oxidation of aldehyde **ALLOW** $CH_3CH_2CO_2H$ for carboxylic acid **Examiner's Comments**

			$CH_3CH_2CH_2OH + 2[O] \rightarrow CH_3CH_2COOH + H_2O$ ✓		This question differentiated well with some very good answers but also some weak responses. The most able candidates provided succinct and well-structured responses which demonstrated a good understanding of the oxidation of primary alcohols. Frequently, good candidates picked up five or six marks. The most common approach was to state the oxidising agent first and whilst most candidates were able recall that potassium dichromate was required, a significant proportion failed to state that an acid was also needed. Many candidates were able to give the colour change but a large number did not mention this. Candidates often referred to the production of the aldehyde and then the carboxylic acid and the majority of candidates were able to provide the correct conditions for these processes. Providing balanced equations for each reaction proved to be the most challenging aspect of this question. A large proportion of candidates included hydrogen as the by-product rather than water, or specified no by-product at all. Another common error was the incorrect balancing of the complete oxidation equation. A significant proportion of responses did not use the correct amount of the oxidising agent when converting propan-1-ol to propanoic acid. The examiners were encouraged by the candidates' ability to provide correct structural formulae, however some candidates showed the aldehyde group as –COH. Candidates should be reminded that an aldehyde group is expected to be represented as –CHO in this type of formula.
			Total	**14**	
18	a		**F–K** clearly identified	6	**ANNOTATE ANSWER WITH TICKS AND CROSSES**
			Compound F:		**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous
					**IGNORE** names
			Compound G:		
					
			Compounds H and I:		**H** and **I** can be identified either way round

			 **Compound J:**  **Compound K:** 		
	b		(Add) 2,4-dinitrophenylhydrazine **AND** orange/yellow/red precipitate Take melting point of crystals Compare to known values	3	**NOTE: (b)** is marked completely independently of **(a)** ALLOW errors in spelling **ALLOW** 2,4(−)DNP **OR** 2,4(−)DNPH **ALLOW** Brady's reagent or Brady's Test **ALLOW** solid **OR** crystals **OR** ppt as alternatives for precipitate **Mark second and third points independently of response for first marking point** **DO NOT ALLOW** 2nd and 3rd marks for taking and comparing boiling points **OR** chromatograms
			Total	**9**	
19		i	Elimination	1	**ALLOW** Dehydration
		ii	Same structural formula **AND** Different arrangement (of atoms) in **space OR** different **spatial** arrangement 	3	**ALLOW** have the same structure / displayed formula / skeletal formula **DO NOT ALLOW** same empirical formula **OR** same general formula Stereoisomers have the same formula or molecular formula is **not** sufficient Reference to *E/Z* isomerism or optical isomerism is **not** sufficient **IGNORE** names **IF** skeletal formula is not used **ALLOW** one mark if both stereoisomers of alkene **B** are shown clearly.

		iii		1	**ALLOW** correct structural **OR** skeletal **OR** displayed formula **OR** mixture of the above **IGNORE** names
		iv	** Please refer to the marking instruction point 10 for guidance on how to mark this question.* **Level 3 (5–6 marks)** Outlines full details of how a pure sample of **B** is obtained from the reaction mixture. **AND** Correctly calculates mass of **B** • *Purification steps are clear, in the correct order, using appropriate scientific terms.* • *Calculation shows all relevant steps and mass given to 3 significant figures.* **Level 2 (3–4 marks)** Some details of how a sample of **B** is obtained from the reaction mixture. **AND** Attempts a calculation which is mostly correct. • *Purification steps lack detail, e.g. no drying agent or no explanation of separation, or only some scientific terms used.* • *Calculation can be followed but unclear.* **Level 1 (1–2 marks)** Few or imprecise details of how a sample of **B** is obtained from the reaction mixture. **AND** Attempts to calculate the mass of B using mole approach but makes little progress with only 1 step correct. • *Purification step is unclear with few scientific terms and little detail, e.g. just 'separate the layers and dry'.* • *Calculation is difficult to follow and lacking clarity* **0 marks** No response or no response worthy of credit.	6	**Indicative scientific points, with bulleted elements, may include:** **1. Purification** • Use of a **separating funnel** to separate organic and aqueous layers • **Drying** with an anhydrous salt, e.g. $MgSO_4$, $CaCl_2$, etc. • **Redistillation** Incorrect purification method is **NOT** worthy of credit. **2. Mass of B obtained** • $n(\mathbf{A})$ used = $\frac{9.26}{102}$ = 0.0908 (mol) = theoretical $n(\mathbf{B})$ • **Actual** $n(\mathbf{B})$ obtained = $n(0.908) \times \frac{75}{100}$ = 0.0681 (mol) • mass **B** = 84 × 0.0681 = **5.72 g** **CHECK** for extent of errors by **ECF** Alternative correct calculation may calculate the mass of **B** as 0.0908 × 84 = 7.63 g, followed by 7.63 × $\frac{75}{100}$ = 5.72 g Calculation must attempt to calculate $n(\mathbf{A})$ in mol. Simply finding 75% of the initial mass of alcohol A, 9.26, is **NOT** worthy of credit.
			Total	**11**	
20			** Please refer to the marking instruction point 10 for guidance on how to mark this question.* **(Level 3)** Candidate provides a method for identifying the alcohols **AND** provides all supporting evidence from IR	6	**Indicative scientific points may include** **Identification of alcohols** Based on recognition of alcohols as primary, secondary and tertiary (stated or implied by method). Basic procedure involves reflux followed by use of IR to identify different oxidation products.

			spectrum **AND** gives details of reagents and conditions and correct equations. *The explanation is detailed and well structured. The information is clearly supported by details of reactions and evidence of oxidation product.* (5–6 marks) **(Level 2)** Candidate provides a basic method **AND** provides some supporting evidence from IR spectrum **AND** gives details of reagents and conditions with some attempt at equations. *The explanation has some structure. The information is supported by some details of reactions and evidence from IR spectrum.* (3–4 marks) **(Level 1)** Candidate attempts to describe a basic method **AND** gives some supporting evidence from IR spectrum **OR** details of reagents and conditions with some attempt at equations. *The explanation is basic and lacks structure. The information is supported by limited evidence from the reactions and oxidation products and would not lead to identification.* (1–2 marks) No response or no response worthy of credit. (0 marks)		**Reactions** • stated reagents ($H^+/Cr_2O_7^{2-}$ and conditions (reflux)) • equations using [O] including structural formulae $CH_3CH_2CHOHCH_3$ + [o] → $CH_3CH_2COCH_3$ + H_20 $CH_3CH_2CH_2CH_2OH$ + 2[o] → $CH_3CH_2CH_2COOH$ + H_2o **Identification of oxidation product** • IR: carboxylic acid from broad OH absorption and C=O • IR: carbonyl / ketone from C=O and no OH • tertiary alcohol from lack of C=O and OH peak in IR **OR** no colour change in reflux.
			Total	**6**	