

1. From the evidence, candidates may have identified compound **F** as propanone, propanal or propanoic acid

If **F** is propanone or propanoic acid, then maximum score = 7; **but** if **F** is propanal then maximum score = 6

The mark scheme for **F** = propanone and propanal is shown below.

mass spec of E– Remember to check the spectrum

Quality of Written Communication – mass spec gives M^+ or molecular ion of 60 **OR** mass spec gives parent ion of 60 **OR** highest m/z (**ALLOW** m/e) value is 60 ✓

$m/z = 45$ indicates loss of CH_3

OR $m/z = 45$ indicates presence of CH_3CHOH

OR CH_2CH_2OH **OR** C_2H_5O ✓

IR of F – Remember to check the spectrum

IR shows no broad absorption between 2500 to 3300 cm^{-1} so no O—H bond

OR no broad absorption between 2500 to 3300 cm^{-1} so not a carboxylic acid ✓

IR shows absorption at 1700 cm^{-1} due to a C=O bond

OR absorption at 1700 cm^{-1} indicates a ketone **OR** aldehyde present

Identification and equation

F is CH_3COCH_3 **OR** propanone ✓

E is $CH_3CHOHCH_3$ **OR** propan-2-ol ✓

$CH_3CHOHCH_3 + [O] \rightarrow CH_3COCH_3 + H_2O$ ✓

If **F** has been incorrectly identified as propanal, mark identification and equation as ECF, so max = 2

ALLOW **E** is $CH_3CH_2CH_2OH$ ✓

ALLOW: $CH_3CH_2CH_2OH + [O] \rightarrow CH_3CH_2CHO + H_2O$ ✓

The mark scheme for **F** = propanoic acid is shown below.

mass spec of E– Remember to check the spectrum

QWC – mass spec gives M^+ or molecular ion of 60

OR mass spec gives parent ion of 60

OR highest m/z (**OR** m/e) value is 60 ✓

$m/z = 45$ indicates loss of CH_3

OR $m/z = 45$ indicates presence of CH_3CHOH

OR CH_2CH_2OH **OR** C_2H_5O ✓

IR of F– Remember to check the spectrum

IR shows (broad) absorption somewhere between 3500 and 2500 cm^{-1} suggests carboxylic acid
OR O–H bond ✓

IR shows absorption at 1700 cm^{-1} due to C=O

OR absorption at 1700 cm^{-1} indicates a carboxylic acid ✓

Identification and equation

F is $\text{CH}_3\text{CH}_2\text{COOH}$ **OR** propanoic acid ✓

E is $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ **OR** propan-1-ol ✓

$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH} + 2[\text{O}] \rightarrow \text{CH}_3\text{CH}_2\text{COOH} + \text{H}_2\text{O}$ ✓

Extra guidance for marking of question

If E has **not** been identified **OR** if F has been identified as a **ketone or aldehyde**, use the **first** mark scheme

If F has been identified as a **carboxylic acid**, use the **second** mark scheme

Mass spec

These two marking points stand as **independent** marks whichever compounds have been identified.

The positive sign for fragment ions is not required. **IGNORE** negative charge.

The mass spec may well be on the actual spectrum.

IR mark

These stand as **independent** marks whichever compounds have been identified.

The IR analysis may well be on the actual spectrum.

Identification marks

If both structure and name are given they must **both** be correct but allow ‘propanol’ drawn with the correct structure because the position number of the –OH has been clearly identified

ALLOW ECF for identification of F e.g. if E is pentan-2-ol ✗ then an answer of pentan-2-one for F will be given a mark ✓ as ECF

ALLOW identification marks for E and F from equation

Equation mark

ALLOW ECF for any correct equation showing the oxidation of **any** alcohol to the appropriate product.

ALLOW molecular formulae in equations,

i.e. $\text{C}_3\text{H}_7\text{OH} + [\text{O}] \rightarrow \text{C}_2\text{H}_5\text{CHO} + \text{H}_2\text{O} \checkmark$; $\text{C}_3\text{H}_8\text{O} + [\text{O}] \rightarrow \text{C}_3\text{H}_6\text{O} + \text{H}_2\text{O} \checkmark$;

$\text{C}_3\text{H}_7\text{OH} + [\text{O}] \rightarrow \text{C}_2\text{H}_5\text{COH} + \text{H}_2\text{O} \checkmark$

[7]

2. (a) **method 1:**
fermentation of sugars or carbohydrates **OR** reaction with yeast with sugar or carbohydrates $\checkmark$
 $\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2 \checkmark$

method 2:

hydration of ethene **OR** reaction of ethene with water **OR** reaction of steam with ethene $\checkmark$

$\text{C}_2\text{H}_4 + \text{H}_2\text{O} \rightarrow \text{C}_2\text{H}_5\text{OH} \checkmark$

***ALLOW** sugar from equation*

***ALLOW** $\text{C}_2\text{H}_6\text{O}$ in equation*

***ALLOW** correct multiples*

***IGNORE** state symbols*

***ALLOW** ethene from the equation*

***IGNORE** mention of any catalyst*

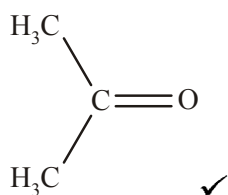
***ALLOW** $\text{C}_2\text{H}_6\text{O}$ in equation **OR** H_2O over the arrow*

***ALLOW** correct multiples*

***IGNORE** state symbols*

4

- (b) (i) $(\text{CH}_3)_2\text{CO}$ **OR**



$(\text{CH}_3)_2\text{CHOH} + [\text{O}] \rightarrow (\text{CH}_3)_2\text{CO} + \text{H}_2\text{O} \checkmark$

If name and formula given both need to be correct

***ALLOW** propanone **OR** acetone*

***IGNORE** propone*

***NOT** incorrect named compound*

***ALLOW** $\text{C}_3\text{H}_8\text{O} + [\text{O}] \rightarrow \text{C}_3\text{H}_6\text{O} + \text{H}_2\text{O}$*

***ALLOW** O instead of [O]*

***ALLOW** correct multiples*

***IGNORE** state symbols*

2

- (ii) $\text{CH}_3\text{CH}_2\text{COOH}$ **OR** propanoic acid ✓

Any number or range of numbers between 1750–1640 (cm^{-1})
for C=O ✓

Any number or range of numbers between 2500–3300 (cm^{-1})
for O–H ✓

ALLOW C=O and O–H marks independent of compound
identified **i.e. stand alone marks**

ALLOW correct bonds shown by the appropriate absorption on
the IR spectrum

IGNORE reference to C–O bond

3

- (c) (i) 2-methylpropan-2-ol ✓

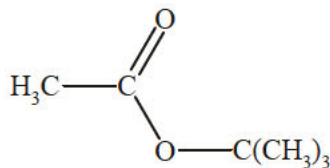
ALLOW methylpropan-2-ol **OR** tertiarybutanol

1

- (ii) ester ✓

1

- (iii) $\text{CH}_3\text{CO}_2\text{C}(\text{CH}_3)_3$ **OR** $\text{CH}_3\text{COOC}(\text{CH}_3)_3$
OR



ester group shown ✓

rest of molecule ✓

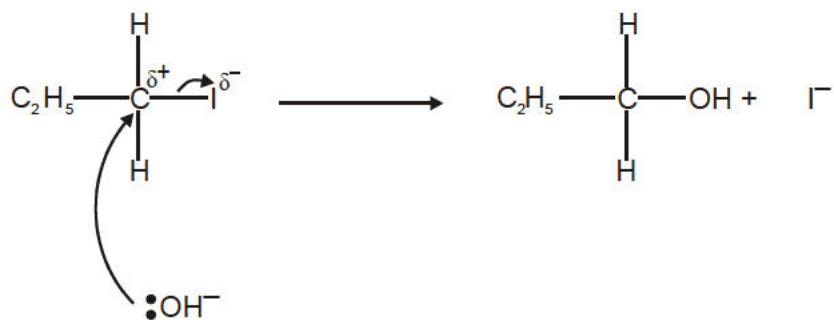
ALLOW skeletal formula **OR** displayed formula

ALLOW ester linkage even if rest of structure is wrong

2

[13]

3. (a) (i)



C-I curly arrow from the bond not from carbon atom ✓

curly arrow from the OH⁻ ✓

correct partial charges on C—I ✓

no need to show any lone pairs on oxygen but must have a clear negative sign rather than partial negative charge

IGNORE lone pairs

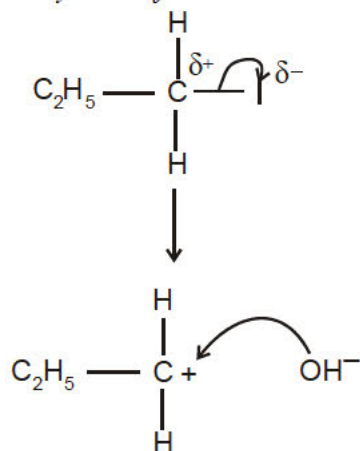
IGNORE products of this reaction

ALLOW curly arrow from a negative charge or from any part of hydroxide ion

If S_N1 mechanism is given then use the mark scheme below
correct partial charges on C—I ✓

C—I curly arrow from the bond not from carbon atom ✓

curly arrow from the OH⁻ to the **correct** carbocation ✓



3

(ii) nucleophilic substitution ✓

1

- (b) C–I bonds broken more easily ✓
 C–I bonds are weaker **OR** have less bond enthalpy **OR** C–I bonds are longer ✓
ALLOW ora e.g. C–Br bonds are stronger **OR** broken less easily

2

[6]

4. from IR absorption, **J** contains O–H **OR** from IR **J** is an alcohol ✓

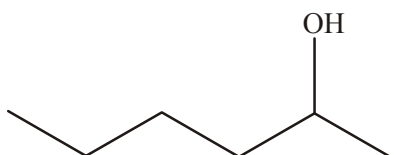
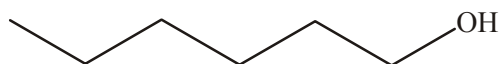
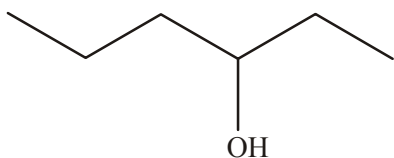
$$\text{C} : \text{H} : \text{O} = \frac{70.59}{12.0} : \frac{13.72}{1.0} : \frac{15.69}{16.0}$$

OR 5.8825 : 13.72 : 0.9806 ✓

empirical formula = C₆H₁₄O ✓

(from mass spectrum), *M*_r = 102 ✓

evidence that it has been shown that the empirical formula is the molecular formulae e.g. *Mr* of C₆H₁₄O = 102 so empirical formula is molecular formula ✓



One mark for each correct structure ✓ ✓ ✓

This is a QWC mark

ALLOW two marks for correct empirical formula with no working out

This is a QWC mark

ALLOW structural or displayed formulae

IGNORE incorrect names

ALLOW one minor slip in drawing structures e.g. one missing hydrogen but **ALLOW** ecf for bigger slips such as showing just sticks and no hydrogen atoms

ALLOW bond to H in OH

ALLOW one mark for three isomers of $C_6H_{13}OH$ whether branched or unbranched as a catch mark if no other mark has been awarded for the structures

If more than three isomers of $C_6H_{13}OH$ drawn

- 1 branched and 3 unbranched award **two** marks
- any other combination award **one** mark

ALLOW one mark for hexan-1-ol, hexan-2-ol and hexan-3-ol if structures not drawn

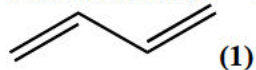
[8]

5. (i) Any two realistic fragments,
e.g. CH_3^+ : 15; $C_2H_5^+$: 29; $C_3H_7^+$: 43; $C_4H_9^+$: 57; OH^+ : 17, etc. (1) (1) 2
Do not penalise missing charge.
- (ii) breathalysers/monitoring of air pollution, MOT emission testing, etc. (1) 1

[3]

6. mole ratio = $88.89/12 : 11.1/1 = 7.41 : 11.1$ (1)
empirical formula = C_2H_3 (1)
relative mass of $C_2H_3 = 27$.
 $M_r = 2 \times 29$ so molecular formula = C_4H_6 (1)
X reacts with 2 mol H_2 so there are 2 double bonds (1)

Possible structure = 1,3-butadiene /



[5]

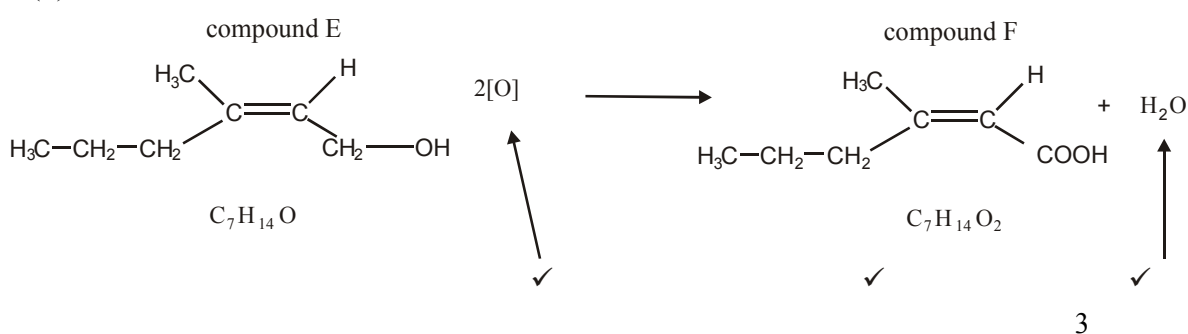
7. (a) (i) H^+ 1
 $Cr_2O_7^{2-}$ 1
(ii) Orange to green/black/blue 1
- (b) (i) contains a $C=O$ /aldehyde, ketone, carboxylic acid and ester/ 1

carbonyl/carbonyl in an aldehyde

- (ii) does **not** contain a O–H/ (hydrogen bonded in a) carboxylic acid 1
- (iii) distillation (no mark) **because** distillation allows loss of volatile components /removes butanal from oxidising mixture 1
prevents formation of RCOOH/ partial oxidation would be achieved 1
or reverse argument for reflux not being used
in that reflux prevents loss of volatile components
hence complete oxidation would be achieved/RCOOH would be formed
✓

[7]

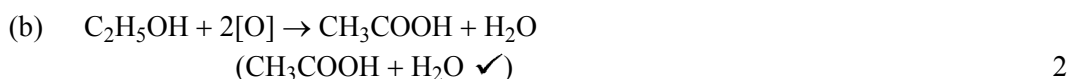
8. (i) H^+ ✓ $\text{Cr}_2\text{O}_7^{2-}$ 2
- (ii)



- (iii) carboxylic acid would have an absorption between $1680 - 1750 \text{ cm}^{-1}$ / 1700 cm^{-1} or $2500 - 3300 \text{ cm}^{-1}$. 1

[6]

9. (a) (i) (volatile components) can escape/distil out 1
ethanal is most volatile/b pt less than 60°C /partial oxidation 1
- (ii) (volatile components) cannot escape/ refluxed 1
complete oxidation will be achieved/oxidised to the acid 1



- (c) spectrum C 1
spectrum C only shows absorption at 1700 cm^{-1} for the C=O 1
the other two spectra contain the OH group absorption at approx 3000 cm^{-1} 1

[9]

10. acrylic acid 1
approx 1700 cm^{-1} (range $1650 - 1750$) indicates C=O 1

approx 3000 cm^{-1} (range $2500\text{--}3300$) indicates O-H
 not $3230\text{--}3550\text{ cm}^{-1}$

1

[3]

11. (a) (i) alkene ✓
 alcohol/hydroxy/hydroxyl ✓

1

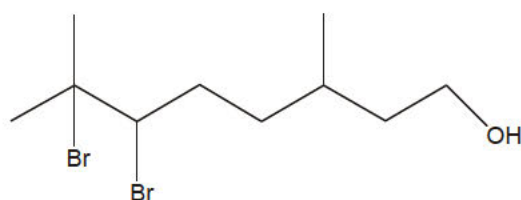
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- (b) (i) I = alkene & II = alcohol... both are needed ✓
 (ii) decolourised / colourless ✓
 (iii) ✓

1

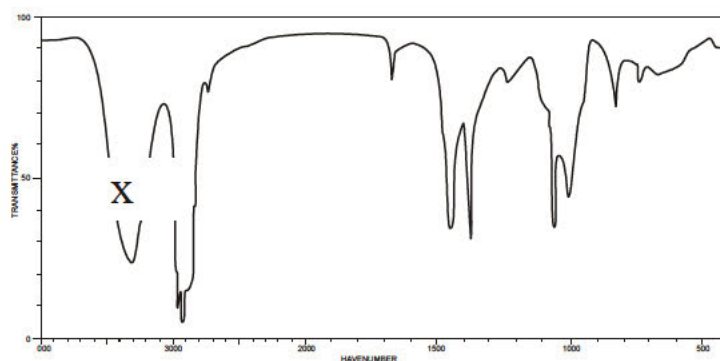
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1



- (iv) X as shown below ✓

1



- (c) (i) Ni/Pt/Rh/Pd ✓
 (ii) compound B is $\text{C}_{10}\text{H}_{22}\text{O}$ ✓
 (iii) $\text{C}_{10}\text{H}_{20}\text{O} + \text{H}_2 \rightarrow \text{C}_{10}\text{H}_{22}\text{O}$ ✓

1

1

1

[9]

12. (a) (i) Alkene/ $\text{C}=\text{C}$ ✓
 Alcohol/ROH/hydroxy/hydroxyl/OH (not OH^- or hydroxide) ✓
 (ii) One of the C in both $\text{C}=\text{C}$ is joined to two atoms or groups that are the same ✓

1

1

1

(b)	Observation	decolourisation (of Br ₂) ✓	1
	Molecular formula	C ₁₀ H ₁₈ OBr ₄ ✓✓ C ₁₀ H ₁₈ OBr ₂ gets 1 mark	2
(c)	reagent	CH ₃ COOH ✓	1
	catalyst	H ₂ SO ₄ /H ⁺ /HCl (aq) <i>or dilute loses the mark</i> ✓	1
(d)	(i)	C ₁₀ H ₁₈ O + 2[O] → C ₁₀ H ₁₆ O ₂ + H ₂ O ✓✓ 1 mark for H ₂ O and 1 mark for 2[O]	2
	(ii)	The infra-red spectrum was of compound Y because absorption between 1680 – 1750 cm ⁻¹ indicates a C=O ✓ and the absence of a peak between 2500 – 3300 cm ⁻¹ shows the absence of the OH hydrogen bonded in a carboxylic acid ✓	1 1

[12]