Mark Scheme

Question	Key	Marks	Guidance
1	B	**1**	
2	B	**1**	

OCR (A) Chemistry A-Level - Carboxylic Acids and Esters

Mark Scheme

Question	Key	Marks	Guidance
3	D	1	
4	A	1	

Mark Scheme

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th></th><th>Guidance</th></tr>
<tr><td>5</td><td>(a)</td><td>(i)</td><td>

Burette readings

<table>
<tr><td>Final (reading)/cm^3</td><td>23.15</td><td>45.95</td><td>32.45</td><td rowspan="2">✓</td></tr>
<tr><td>Initial (reading)/cm^3</td><td>0.60</td><td>23.15</td><td>10.00</td></tr>
</table>

- Correct titration results recorded with initial and final readings, clearly labeled
AND all readings recorded to two decimal places with last figure either 0 or 5

Titres

<table>
<tr><td>Titre/cm^3</td><td>22.55</td><td>22.80</td><td>22.45</td><td>✓</td></tr>
</table>

- Correct subtractions to obtain final titres to 2 DP

Units

- Units of cm^3 for initial, final and titres ✓

Mean titre

- mean titre = $\frac{22.55 + 22.45}{2}$ = 22.50 **OR** 22.5 cm^3 ✓
i.e. using concordant (consistent) titres

</td><td>4</td><td></td><td>

Table **not** required

ALLOW initial reading before final reading

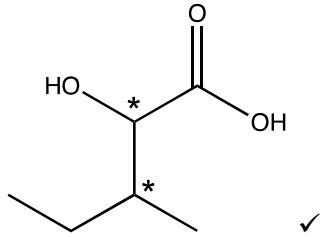
ALLOW ECF

ALLOW units with each value
ALLOW brackets for units, i.e. (cm^3)

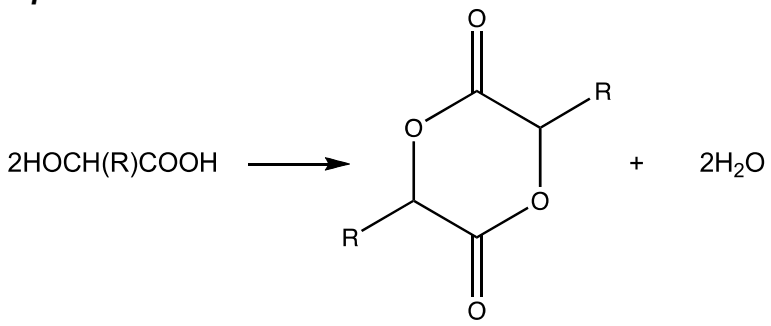
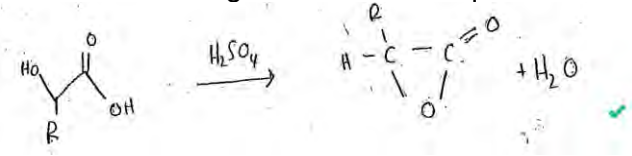
ALLOW ECF from incorrect concordant titres

</td></tr>
</table>

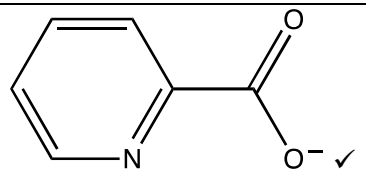
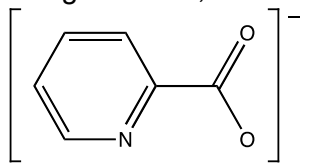
Mark Scheme

Question	Answer	Marks		Guidance
(a) (ii)	**ALLOW 3SF** or more throughout **IGNORE** trailing zeroes, e.g. **ALLOW** 0.084 for 0.0840 --- $n(\text{NaOH}) = 0.0840 \times \frac{22.50}{1000} = 1.89 \times 10^{-3}$ (mol) ✓ n(**A**) in 250 $cm^3 = 10 \times 1.89 \times 10^{-3} = 1.89 \times 10^{-2}$ (mol) ✓ $M(\text{A}) = \frac{2.495}{1.89 \times 10^{-2}} = 132$ (g mol^{-1}) ✓ M(alkyl group) (= 132 – 75) = 57 ✓ R = C_4H_9 ✓ **ALLOW** alkyl group in drawn structure with straight chain or branch(es) in wrong position, e.g. for R = C_4H_9, $CH_3CH_2CH_2CH_2$ **OR** $(CH_3)_3C$ Structure with chiral carbon atoms identified (see * below)  ✓	6		**ALLOW ECF** from incorrect mean titre in **4a(i)** e.g. From 22.60 cm^3 (mean of all 3 titres in **(i)**, $n(\text{NaOH}) = 1.8984 \times 10^{-3}$ (mol) **ALLOW ECF** from incorrect n(NaOH) **ALLOW ECF** from incorrect n(**A**) **ALLOW ECF** from incorrect M(**A**) – 75 **ALLOW ECF** for alkyl group closest to calculated M(alkyl group), e.g. for M = 45, **ALLOW** C_3H_7 (43) **ALLOW** correct structural **OR** skeletal **OR** displayed formula **OR** mixture of the above as long as non-ambiguous **IGNORE** poor connectivity to OH groups *Given in question* --- **Common error for 4 marks max** *25.00 instead of 22.50 and scaling by × 10* 2.10×10^{-3} × → 2.10×10^{-2} ✓ → 118.81 ✓ → 43.81 ✓ → C_3H_7 ✓ *25.00 instead of 22.50 and scaling by* $\times \frac{250}{22.50}$ 2.10×10^{-3} × → 2.33×10^{-2} ✓ → 106.93 ✓ → 31.93 ✓ → C_2H_5 ✓ No structure with 2 chiral centres possible ×

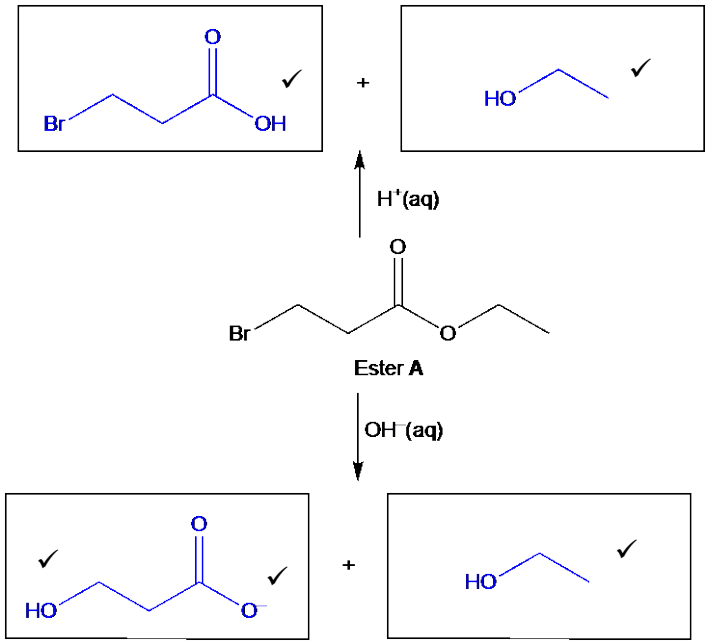
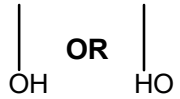
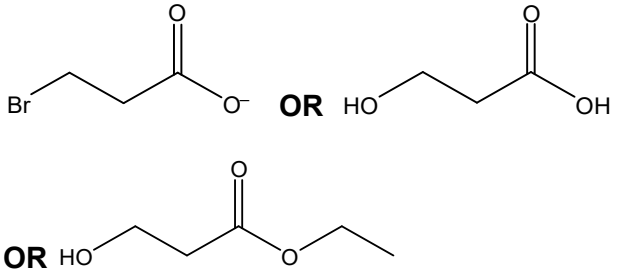
Mark Scheme

Question			Answer	Marks		Guidance
	(b)	(i)	***Equation*** $2HOCH(R)COOH + Mg \rightarrow (HOCH(R)COO)_2Mg + H_2$ Organic product ✓ Balance ✓ ***Type of reaction*** Redox ✓	3		**ALLOW** correct structural **OR** skeletal **OR** displayed formula **OR** mixture of the above as long as non-ambiguous **ALLOW** $2HOCH(R)COOH + Mg \rightarrow 2HOCH(R)COO^- + Mg^{2+} + H_2$ **ALLOW** multiples **IGNORE** poor connectivity to OH groups *Given in question*
	(b)	(ii)	***Equation***  Organic product ✓ Balance ✓ ***Type of reaction*** Condensation **OR** esterification ✓	3		**ALLOW** correct structural **OR** skeletal **OR** displayed formula **OR** mixture of the above as long as non-ambiguous **ALLOW** 1 mark of the 2 equation marks for formation of '3 ring' with balanced equation:  **ALLOW** condensation polymerisation **ALLOW** addition–elimination **IGNORE** elimination **IGNORE** dehydration

Mark Scheme

Question			Answer	Marks		Guidance
	(c)	(i)	 ✓	1		**ALLOW** brackets around structure with negative charge outside, i.e.  **ALLOW** ring (Kekulé structure)
	(c)	(ii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 1.61×10^{-3} award 2 marks** M = 418(.0) (g mol^{-1}) **OR** n(Cr) = 3.85×10^{-6} (mol) ✓ Mass = 3.85×10^{-6} × 418.0 = 1.61×10^{-3} g ✓	2		**Note**: $\frac{200 \times 10^{-6}}{52.0} = 3.85 \times 10^{-6}$ (at least 3 SF) **ALLOW ECF** from incorrect M **OR** n(Cr) **ALLOW 3 SF** up to calculator value correctly rounded
			Total	**19**		

Mark Scheme

Question			Answer	Marks	AO element	Guidance
6	(a)	(i)	ethyl 3-bromopropanoate ✓	1	AO1.2	**ALLOW** one word: ethyl3-bromopropanoate **OR** more words, e.g. ethyl 3-bromo propanoate **IGNORE** lack of hyphens, or addition of commas
		(ii)		5	AO2.5 ×5	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW** in either order **ALLOW** any vertical bond to the OH group e.g. **ALLOW**  **DO NOT ALLOW** OH– **ALLOW** in either order For reaction with OH^-, **ALLOW** one mark for 

Mark Scheme

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AO element</th><th>Guidance</th></tr>
<tr><td></td><td></td><td>(iii)</td><td>hydrolysis ✓</td><td>1</td><td>AO1.1</td><td>IGNORE ‘acid’ and ‘alkaline’’
IGNORE nucleophilic substitution</td></tr>
<tr><td></td><td>(b)</td><td></td><td>
<table>
<tr><th>Proton environment</th><th>Chemical shift</th><th>Splitting pattern</th></tr>
<tr><td>1</td><td>3.0–4.3</td><td>Triplet</td></tr>
<tr><td>2</td><td>2.0–3.0</td><td>Triplet</td></tr>
<tr><td>3</td><td>3.0–4.3</td><td>Quartet</td></tr>
<tr><td>4</td><td>0.5–1.9</td><td>Triplet</td></tr>
</table>
Mark by column
Chemical shift: all 4 correct ✓✓
3 correct ✓

Splitting pattern: all 4 correct ✓✓
3 correct ✓</td><td>4</td><td>AO3.1
× 4</td><td>ALLOW δ values ± 0.2 ppm, as a range or a value within the range

ALLOW integers for δ values
e.g. 2 is equivalent to 2.0

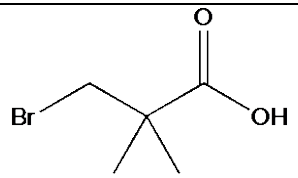
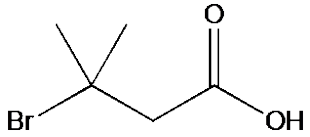
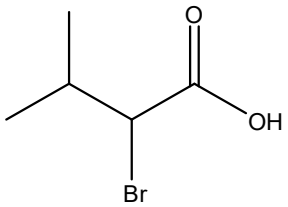
ALLOW quadruplet for quartet

ALLOW diagrams to show splitting pattern
e.g.
  for triplet

  for quartet

ALLOW splitting patterns shown as numbers
i.e. ‘3’ for triplet, ‘4’ for quartet</td></tr>
</table>

Mark Scheme

Question			Answer	Marks	AO element	Guidance
	(c)		 **OR**  **OR**  ✓	**1**	AO3.1	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous
	(d)		**IF** answer on answer line = 24018, **AWARD** 2 marks **IF** answer on answer line = 27600, **AWARD** 1 mark --- Relative mass of 200 molecules = 200 × 138 = 27600 ✓ M_r of polyester = 27600 – 199 × 18 = 24018 ✓	**2**	AO2.2 ×2	**ALLOW ECF** from incorrect M_r Alternative method based on repeat unit: M_r of 200 repeat units = 200 x 120 = 24000 ✓ M_r of polymer = 24000 + 1 + 17 = 24018 ✓
	(e)	(i)*	*Refer to marking instructions on page 4 of mark scheme*	**6**	AO3.3	**Indicative scientific points may include:**

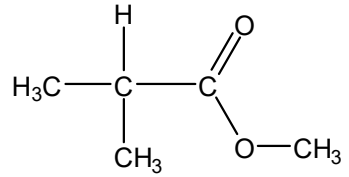
Mark Scheme

Question	Answer	Marks	AO element	Guidance
	for guidance on marking this question. **Level 3 (5-6 marks**) Correct calculation of the mass of $(CH_3)_2CHCHO$. **AND** Planned synthesis includes oxidation of aldehyde and formation of ester **C** with most of the reagents and conditions identified and equations are mostly correct. *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)** Calculation of the mass of $(CH_3)_2CHCHO$ is partly correct **AND** Planned synthesis includes oxidation of aldehyde and formation of ester **C** with some of the reagents and conditions identified **OR** Attempts to calculate mass of $(CH_3)_2CHCHO$ but makes little progress **AND** Planned synthesis includes oxidation of aldehyde and formation of ester **C** with most of the reagents and conditions identified and equations for each step are mostly correct *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.*		×6	**<u>Calculation of mass of $(CH_3)_2CHCHO$</u>** **Using moles** • $n(\text{ester}) = \frac{12.75}{102.0}$ = 0.125 (mol) • $n((CH_3)_2CHCHO) = 0.125 \times \frac{100}{40}$ = 0.3125 (mol) • Mass of $(CH_3)_2CHCHO = 72.0 \times 0.3125$ = 22.5 g **Using mass** • Theoretical mass of ester = $12.75 \times \frac{100}{40}$ = 31.875 (g) • Theoretical $n((CH_3)_2CHCHO) = \frac{31.875}{102}$ = 0.3125 (mol) • Mass of $(CH_3)_2CHCHO = 72.0 \times 0.3125$ = 22.5 g **ALLOW** small slip/rounding errors such as errors in *Mr* e.g. use of 71 instead of 72 for $(CH_3)_2CHCHO$ **----------** ***Examples of partly correct calculations*** Mass = 3.60 g from $0.125 \times \frac{40}{100} \times 72$ (*% yield inverted*) Mass = 9.00 g from 0.125×72 (*% yield omitted*)

Mark Scheme

Question			Answer	Marks	AO element	Guidance
			Level 1 (1-2 marks) Calculation of the mass of $(CH_3)_2CHCHO$ is partly correct **OR** Planned synthesis includes both steps with some of the reagents and conditions identified **OR** Attempts equations for both steps but these may contain errors **OR** Describes one step of the synthesis with reagents, conditions and equation mostly correct *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>Synthesis: reagents and conditions</u>** ***Step 1:*** Oxidation of aldehyde $(CH_3)_2CHCHO$ • Reagents: $Cr_2O_7^{2-}/H^+$ • Conditions: reflux • Equation: $(CH_3)_2CHCHO + [O] \rightarrow (CH_3)_2CHCOOH$ ***Step 2:*** Formation of ester C • Reagents**:** methylpropanoic acid/$(CH_3)_2CHCOOH$ and methanol/CH_3OH • Conditions: acid (catalyst) reflux/heat • Equation: $(CH_3)_2CHCOOH + CH_3OH \rightarrow (CH_3)_2CHCOOCH_3 + H_2O$ **IGNORE** attempts to form methanol in synthesis
	(e)	**(ii)**		**2**	AO2.7 × 2	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous

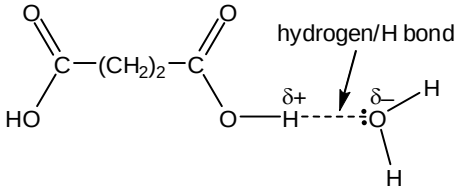
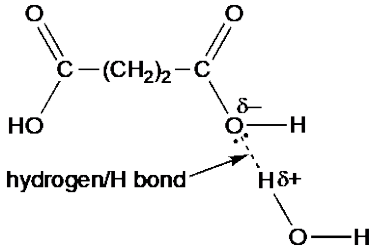
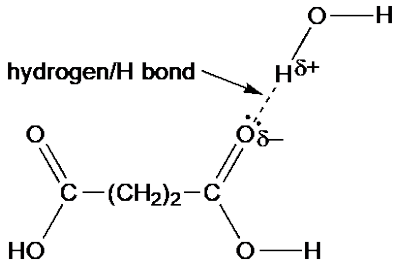
Mark Scheme

Question			Answer	Marks	AO element	Guidance
			Y (43) = $(CH_3)_2CH^+$ ✓ **Z** (71) $(CH_3)_2CHCO^+$ ✓ *If '+' charge is missing/incorrect but the structures of **both** fragments are correct, award one mark*			**ALLOW** positive charge to be anywhere on the structure For **Y** and **Z**, **ALLOW** structure of a feasible fragment ion formed from ester **C**  **Ester C** e.g. **Y** (43) = CH_3OC^+ **Z** (71) = $^+CCOOCH_3$ **ALLOW** 1 mark if both correct **ions** are shown but in the incorrect columns **ALLOW** 1 mark for both correct **ions** if one or both have an 'end bond' **ALLOW** 1 mark if both **ions** are shown using correct molecular formulae
			Total	**22**		

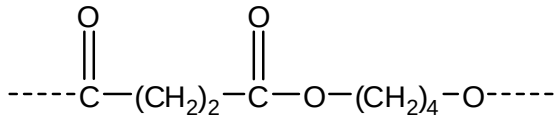
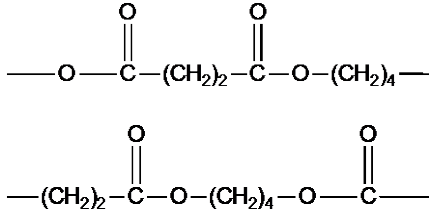
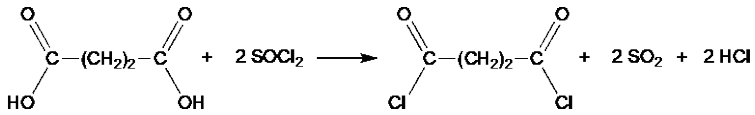
Mark Scheme

Question	Answer	Marks	AO element	Guidance
7	A	1	1.1	
8	A	1	1.1	
9	D	1	1.2	

Mark Scheme

Question			Answer	Marks	AO element	Guidance
10	(a)	(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**	**1.1** **2.5** **2.6**	**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,
		(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**	**2.1×2**	**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

Mark Scheme

Question			Answer	Marks	AO element	Guidance
	(b)	(i)	 Ester link (must be displayed) ✓ Rest of structure ✓	2	1.2 2.5	**ALLOW** the 'O' or C=O at either end, e.g.  **IGNORE** brackets **IGNORE** *n* End bonds' **MUST** be shown (solid or dotted) **DO NOT ALLOW** more than one repeat unit
		(ii)	the ester/ ester bond/ ester group /polyester can be broken down ✓ **OR** It can be hydrolysed ✓	1	3.2	**IGNORE** references to photodegradable 'Bond breaks' is not sufficient – no reference to ester bond
		(iii)	 $SOCl_2$ in equation ✓ Structure of diacyl dichloride ✓ Complete balanced equation ✓	3	1.1 1.2 2.6	**ALLOW** alternative approach using PCl_5 or PCl_3

Mark Scheme

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AO element</th><th>Guidance</th></tr>
<tr><td>11</td><td>(a)</td><td></td><td>
<table>
<tr><th>Bond angle</th><th>Name of shape</th></tr>
<tr><td>120(°)</td><td>Trigonal planar</td></tr>
<tr><td>104–105(°)</td><td>Non-linear</td></tr>
</table>
Mark by row OR by column to give higher mark

i.e. 2 bond angles correct ✓
2 shapes correct ✓
OR
i.e. bond angle AND shape correct in 1st row ✓
bond angle AND shape correct in 2nd row ✓
</td><td>2</td><td>1.2×2</td><td>For non-linear,
ALLOW bent, v-shaped, angular
IGNORE planar, ‘not straight’</td></tr>
<tr><td></td><td>(b)</td><td></td><td>
$CH_3SO_2OH + H_2O \rightleftharpoons CH_3SO_2O^- + H_3O^+$ ✓

A1 B2 B1 A2 ✓

For an equilibrium shown using CH_3COOH instead of H_2O, mark acid–base pairs by ECF, i.e.
$CH_3SO_2OH + CH_3COOH \rightleftharpoons CH_3SO_2O^- + CH_3COOH_2^+$ ☒
A1 B2 B1 A2 ECF ✓

CH_3SO_2OH dissociates more (than CH_3COOH)
OR CH_3SO_2OH is a stronger acid ✓

ORA in terms of CH_3COOH being a weaker acid

Student is correct
AND
(sulfonic acid has) lower pK_a/higher K_a OR greater $[H^+]$
ORA ✓
</td><td>4</td><td>2.1×2

3.1

3.2</td><td>ALLOW → for ⇌

ALLOW acid–base pairs labelled other way round.
i.e. $CH_3SO_2OH + H_2O \rightleftharpoons CH_3SO_2O^- + H_3O^+$
A2 B1 B2 A1
ALLOW ~~small slip~~

If ONE charge is missing from equilibrium.
ALLOW ECF for acid–base pairs mark

IGNORE ‘more acidic’
Response needs strength/dissociation

ALLOW maths explanation for final 2 marks, e.g.
$K_a(CH_3COOH) = 10^{-(4.76)} = 1.74 \times 10^{-5}$
$[H^+] = \sqrt{(1.74 \times 10^{-5}) \times 1} = 4.17 \times 10^{-3}$
$pH = -\log 4.17 \times 10^{-3} = 2.38$ ✓

$K_a(CH_3SO_2OH) = 10^{-(-1.90)} = 79.4$
$[H^+] = \sqrt{(79.4) \times 1} = 8.91$
$pH = -\log 8.91 = -0.95$ ✓
BOTH pH calcs subsumes ‘Student is correct’</td></tr>
</table>

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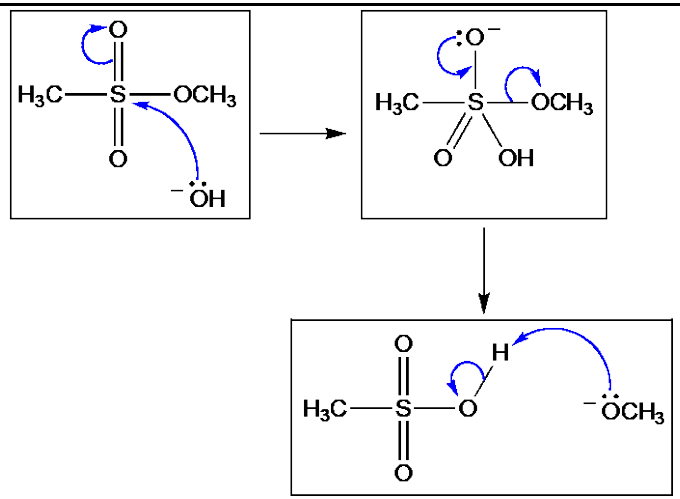
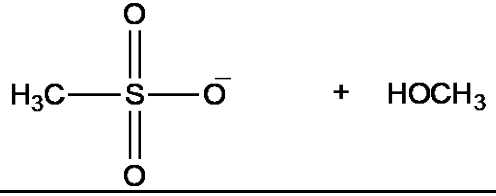
	(c)		 6 curly arrows correct ✓✓✓✓ 5 curly arrows correct ✓✓✓ 4 curly arrows correct ✓✓ 3 curly arrows correct ✓	4	3.1×4	**IGNORE** any added charges **OR** dipoles. *Marks solely for curly arrows* **IGNORE** any curly arrows on bottom structures (not in boxes): 
			Total	**10**		