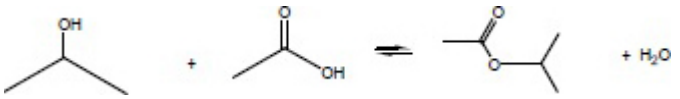
Mark schemes

## Q1.

(a) **M1** $CH_3CH(OH)CH_3 + CH_3COOH \rightleftharpoons CH_3COOCH(CH_3)_2 + H_2O$

**M2** Methyl ethyl ethanoate.




*Allow ECF from incorrect 5 carbon ester*

*Allow other valid names*
*1-methylethyl ethanoate*
*Isopropyl ethanoate*
*2-propyl ethanoate*
*Propan-2-yl ethanoate*

**2**

(b)

| This question is marked using Levels of Response. Refer to the Mark Scheme Instructions for Examiners for guidance. | |
|---|---|
| **Level 3**<br>5-6 marks | All stages are virtually complete (virtually complete means one from stage 1 and two from stages 2 and 3).<br>Answer communicates the whole explanation, including equations, coherently and shows a logical progression through all three stages. |
| **Level 2**<br>3-4 marks | All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies (covered means one from a stage)<br>**OR** two stages virtually complete (virtually complete means one from stage 1 or two from stages 2 and 3).<br>Answer is coherent and shows some progression through all three stages. Some steps in each stage may be incomplete. |
| **Level 1**<br>1-2 marks | Two stages are covered (covered means one from a stage) but the explanation of each stage may be incomplete or may contain inaccuracies<br>**OR** only one stage is virtually complete (virtually complete means one from stage 1 or two from stages 2 and 3).<br>Answer shows some progression between two stages. |
| **0 mark** | Insufficient correct chemistry to gain a mark. |

Indicative Chemistry Content

**Stage 1**
1a Measuring cylinder(s) for the propan-2-ol and ethanoic acid (size not required but if specified should be between 10 - 100 $cm^3$)
Allow $10cm^3$ / graduated pipette or burette

1b (Dropping/teat) pipette for sulfuric acid (NOT graduated or other qualification for pipette)

**Stage 2 Diagram e.g. below to include**
2a Labelled condenser shown vertical and open at top and bottom i.e. in cross section

2b Labelled water in at the bottom and water out at the top of the vertical condenser

2c Labelled reaction flask recognisable as either pear shaped or round bottomed

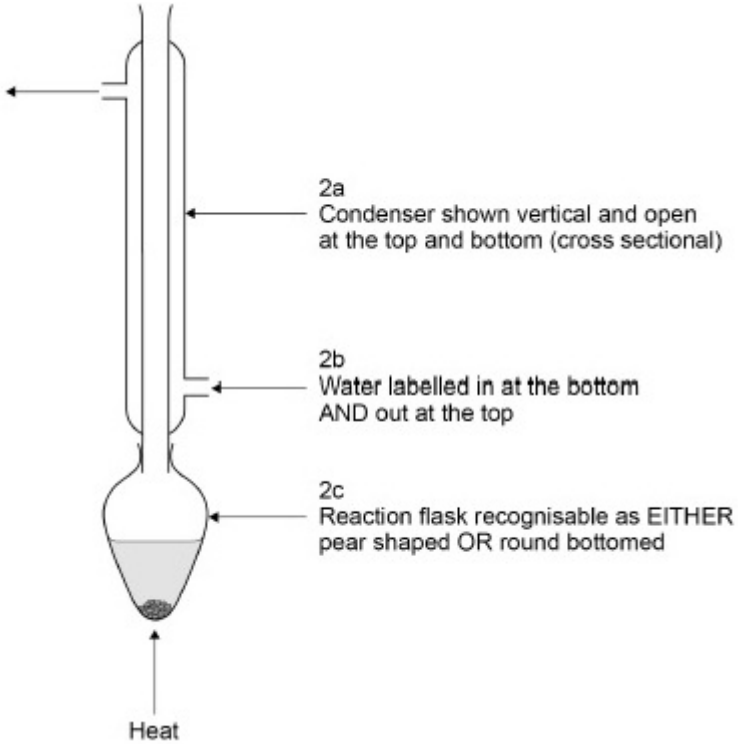
**Stage 3 Safety**
Needs precaution AND reason for each suggestion

3a Use a fume cupboard/fume hood/well-ventilated lab space
AND to avoid breathing in harmful/toxic/corrosive compounds

3b Wear gloves
AND as compounds are corrosive

3c Add glass beads/chips (to the mixture before heating)/labelled as anti-bumping granules/chips
AND to ensure smooth boiling/reduce size of bubbles

3d Use an electric heater/water bath
AND as compounds are flammable



(c) **M1** To neutralise/remove/react with (excess) acid

**M2** Remove stopper/bung OR tip the funnel upside down and open the tap

**M3** There will be a build up of pressure/gas/carbon dioxide

*M3 must be linked to their precaution in M2*

OR

**M2** Allow add stopper

**M3** To prevent spillage

**3**

(d) Drying agent/To remove water

*Not dehydrating agent*

**1**

(e) Compare boiling point to a data book/known value

*Boils at sharp boiling point/over a narrow temp range*

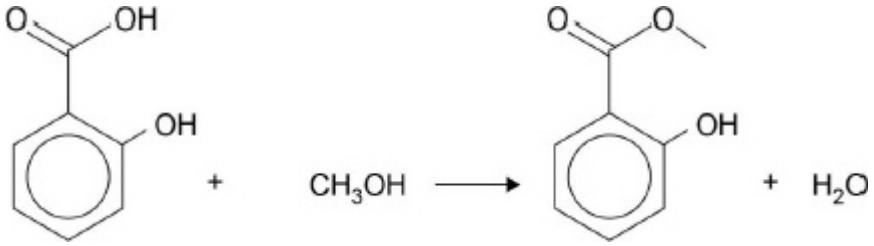
**1**

**[13]**

## Q2.

(a) **M1** Skeletal formula of organic product

**M2** Rest of equation




*M1 Need H on alcohol OH*

*M1 Allow O-H for alcohol OH*

*M2 for correct formulae for 2-hydroxybenzenecarboxylic acid and methanol on left and $H_2O$ on right*

*M2 Allow $C_7H_6O_3$/$HOC_6H_4COOH$ and $CH_4O$*

*Ignore additional non-skeletal structures for ester (assume it is working out)*

*Allow Kekulé structures for rings*

**2**

(b) Ethanoic anhydride/It is less/not corrosive
OR
Ethanoic anhydride/It does not form strong acid/HCl /(only) forms weak/ethanoic/carboxylic acid
OR
Ethanoic anhydride/It is less/not vulnerable to hydrolysis

*Allow reverse argument for ethanoyl chloride e.g. ethanoyl chloride is (more) corrosive*

*Ignore cost/less volatile/products are less harmful/safer/toxic/produces toxic fumes*

*Ignore references to less/more exothermic/violent/vigorous*

**1**

(c) (Nucleophilic) addition-elimination

*Ignore esterification/acylation*

**1**

(d) Catalyst

*Ignore proton donor/heterogeneous/homogeneous*

*Allow speeds up reaction/lowers activation energy*

**1**

(e) Boiling points are above 85 °C

*Allow product(s) or reactant(s) or named product(s) or reactant(s) boiling points are above 85 °C*

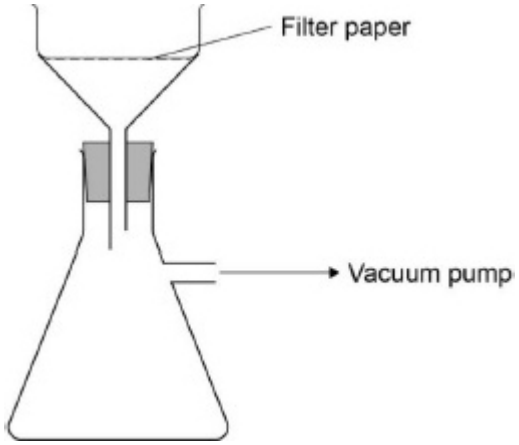
*Allow none of them would boil/mixture would not boil/do not need to boil the mixture*

*Allow no volatile reagent(s)/product(s)/reactant(s)*

*Ignore reference to mixture/substances not evaporating/vaporising*

**1**

(f)




**M1**

- Cross sectional (i.e. funnel top and bottom shown open)
- Bung or collar drawn (with funnel spout visible through)
- (Buchner/Hirsch) Funnel - approximate shape
- Horizontal filter paper - allow solid or dashed line

**M2**

Labels must include filter paper and indication of vacuum/water pump/reduced pressure/suction

**2**

(g) Any 2 of:

- Ethanoic acid
- Phosphoric acid
- 2-hydroxybenzenecarboxylic acid
- Ethanoic anhydride
- Water

*Ignore catalyst/unreacted reactants*

*Allow names or correct formulae*

*Allow salicylic acid/2-hydroxybenzoic acid*

**2**

(h) **M1** Dissolve crude product in <u>hot</u> solvent (water and ethanol)

*Ignore initial filtration*

*M1 not wrong solvent if named*

**M2** of minimum volume

*M2 Allow reference to saturated solution as alternative to minimum volume*

**M3** Filter (hot to remove insoluble impurities)

*M3 Ignore method of filtration*

*Allow decant*

**M4** Cool (to recrystallise)

**M5** Filter under reduced pressure / with Buchner/Hirsch apparatus

**M6** Wash (with cold solvent) **and** dry

*M6 Allow water and/or ethanol*

*Apply list principle for each additional process (e.g. drying agent added, base to neutralise acid added, distillation, solvent extraction) in an incorrect method*

*Ignore reference to melting point determination*

**6**

(i) **M1** Melting point

*M1 Ignore boiling point*

**M2** Lower (than data book value)

*M2/3 In either order*

*M2 Ignore 'different'*

*M2 ECF for 'higher' if b.pt in M1*

*M2If b.pt in M1 NOT 'lower'*

**M3** Melts over a (wide) range of temperature (rather than sharp/narrow range if pure)

*M3 ECF from b.pt*

**3**

**[19]**

## Q3.

(a) M1 3 $CH_3(CH_2)_{14}COOH$

M2 $CH_2(OH)CH(OH)CH_2OH$

*Penalise additional product(s) once*

**2**

(b) M1 $M_r = 256$

M2 $n(CH_3(CH_2)_{14}COOH) = \frac{0.387}{M1} = 1.51 \times 10^{-3}$

M3 $Q = 150 \times 4.18 \times 13.6 = 8527.2$ (J)

M4 $\Delta H = \frac{M3}{M2} \div 1000 = (-)5641$

M5 $\Delta H = -5640$ kJ $mol^{-1}$

*Must be negative and 3sf (allow ecf on M4)*

**5**

(c) M1 Less exothermic

*Allow Less negative (value) / Lower*

M2 Incomplete combustion

*Allow products of incomplete combustion*

**2**

(d)

| | | C<br>37.08 | H<br>5.15 | O<br>24.72 | S<br>M1 = 33.05 |
|---|---|---|---|---|---|
| M2 | ÷ $A_r$ | = 3.09 | = 5.15 | = 1.55 | = 1.030 |
| | ÷ smallest | = 3 | = 5 | = 1.50 | = 1 |
| M3 | Empirical formula = $C_6H_{10}O_3S_2$ | | | | |

*M1 % S = 33.05*

*M2 Calculation of moles*

*M3 Ratio of moles AND Empirical Formula*

*If no Sulfur used ecf for M2 and M3*

*M2 3.09 : 5.15 : 1.55*

*M3 $C_6H_{10}O_3$*

**3**

(e) M1 Acid rain

*Allow smog*

M2 $SO_2$

*Allow $NO_x$*

**2**

(f) M1 Bonds broken = 9459 kJ $mol^{-1}$

(5C-C + 7C-O + 7C-H + 5O-H)

*Allow if they cancel the common bonds*

*M1 4233*

M2 Bonds formed = 9682 kJ $mol^{-1}$

(2C-C + 10C-H + 2C-O + 2O-H + 4C=O)

*M2 4456*

M3 $\Delta H$ = M1 - M2 = -223 kJ $mol^{-1}$

*M3 can be awarded as ecf from their M1 and M2*

**3**

(g) M1 $\Delta H$ = -235 - (2 × -394) - (3 × -242)

M2 = +1279 kJ $mol^{-1}$

*If no sign assume positive*

**2**

**[19]**

## Q4.

(a) catalyst

***ALLOW*** *reduces* $E_a$

***IGNORE*** *speeds up reaction*

***IGNORE*** *provides alternative path*

***IGNORE*** *proton donor*

***IGNORE*** *dehydrating agent*

**1**

(b) electric heater/heat mantle or (hot) water bath

***IGNORE*** *not with a Bunsen/naked flame / gently*

***ALLOW*** *hot water*

***ALLOW*** *heating/hot plate/ sand bath / oil bath*

***ALLOW*** *reference to flame/Bunsen if in context of heating a water bath*

***NOT*** *any indication of direct heat from Bunsen*

**1**

(c) **M1** there is a bung/stopper (in the end of the condenser)

**M2** idea of pressure build up

***owtte***

***M2*** *stopper could be forced out*

***IGNORE*** *glass shatters / explodes*

**M3** water goes the wrong way through the condenser

**M4** water does not fill the condenser / condenser is not cool enough

*water in at top / out at bottom*

***IGNORE*** *condenser is wrong way round*

***ALLOW*** *less condensing / vapour/gas/reactants/products will not condense / not as effective at cooling/condensing vapour/reactants/products escapes*

***IGNORE*** *uneven cooling*

***NOT*** *mixture in flask not cooled*

***ALLOW M1/M3*** *neck of flask not sealed owtte*

***M2/M4*** *vapour/reactants/products can escape*

***IGNORE*** *references to clamps*

**4**

(d) **M1** to neutralise/react with/remove the acid

***ALLOW*** *carboxylic/ethanoic and/or sulfuric*

***IGNORE*** *react with/neutralise the distillate/mixture*

***IGNORE*** *to act as a base*

***NOT*** *if incorrect acid named*

**M2** carbon dioxide / gas is produced

***ALLOW*** *effervescence / bubbles / fizzes*

***IGNORE*** *water vapour produced*

***NOT*** *if incorrect gas named*

***IGNORE*** *pressure build up (as in Q)*

**2**

(e) **M1** ethyl ethanoate/it is immiscible with / insoluble in water

***ALLOW*** *water/solution and ethyl ethanoate/it do not mix,*

***OR*** *aqueous and organic layers do not mix*

***ALLOW*** *ethyl ethanoate/it is hydrophobic*

***IGNORE*** *references to polarity / intermolecular forces*

**M2** ethyl ethanoate/it is less dense / has lower density (than water)

***IGNORE*** *different/low density*

***NOT*** *lighter*

***ALLOW*** *answers for either mark from either part*

**2**

(f) to remove/absorb water / as a drying agent

***ALLOW*** *reacts with water*

***ALLOW*** *to dry the product/it*

***IGNORE*** *dehydrates*

***NOT*** *reference to crystals forming*

***NOT*** *to dry the reactants*

***NOT*** *to remove soluble impurities*

**1**

(g) **M1** mass of ethanol = 10 x 0.790 (= 7.90 g)

**M2** amount of ethanol = $\frac{7.90}{46.0}$ (= 0.172 mol) **AND**

amount of ethanoic acid = $\frac{5.25}{60.0}$ (= 0.0875 mol)

**M3** (limiting reagent is) ethanoic acid

**M4** (max amount of ethyl ethanoate = 0.0875 mol)

max mass of ethyl ethanoate = 88.0 x 0.0875 (= 7.70 g)

**M5** % yield = $\frac{5.47}{\text{M4}}$ x 100 = 71.0% (70.6 to 71.1 to min 2sf)

*Allow ECF at each stage*

***M1** scores from 0.172 mol of ethanol*

***M2** need to see numbers or sums for both substances*

***M2** 10/46 can only be ECF if 10 is identified as a mass*

***M3** ECF from **M2** if both amounts clearly shown and $n_{ethanol} < n_{ethanoic\ acid}$*

***M4** independent of **M3***

*Alternative **M4 & 5***

***M4** Amount of ethyl ethanoate formed*

$= \frac{5.47}{88.0}$ *(=0.0622)*

***M5** % yield =* $\frac{\text{M4}}{0.0875}$ *x 100 = 71.0%*

***Correct answer scores M4 and M5 but mark M1/2/3 separately***

***M5** must show an attempt at mass or moles of ester formed divided by mass or moles of ester expected*

**5**

(h) reaction is an equilibrium/reversible

***ALLOW** losses during distillation/isolation/purification/transfer / incomplete distillation / side reactions / byproducts*

***ALLOW** incomplete reaction*

***ALLOW** impurities/contamination/water present / not dry*

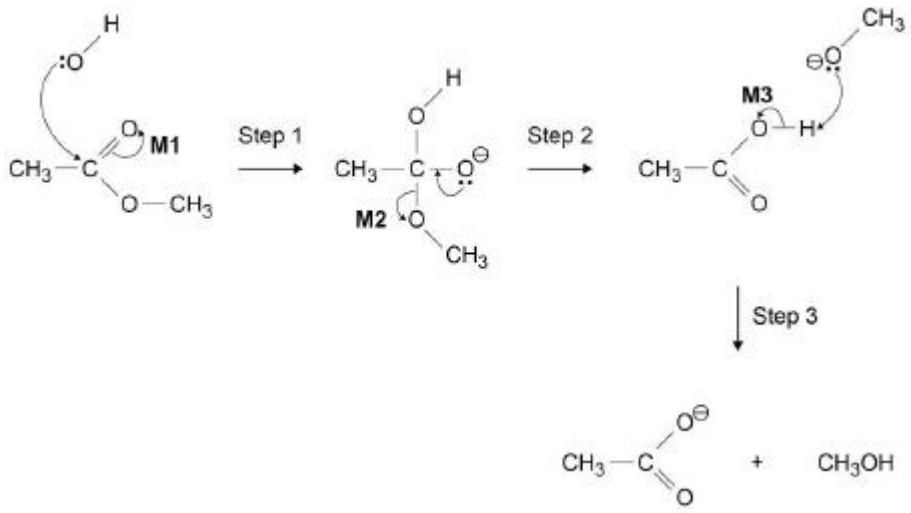
***IGNORE** water is also produced (during the reaction)*

**1**

**[17]**

## Q5.

(a)




*M1: Arrow from C=O bond to O*
*M2: Arrow from correct C-O bond to O*
*M3: Arrow from O-H bond to O*

**3**

(b) (Alkaline/base) hydrolysis

**1**

(c) Base

*Allow proton acceptor*
*Ignore ref to Bronsted Lowry*

**1**

(d) Soap only

**1**

**[6]**