A-Level Chemistry

Oxidation of Alcohols

Mark Scheme

Time available: 88 minutes
Marks available: 73 marks

1. (a)

This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.	
Level 3 **5-6 marks**	**All stages are covered and each stage is generally correct and virtually complete** (6 v 5) Answer is well structured, with no repetition or irrelevant points, and covers all aspects of the question. Accurate and clear expression of ideas with no errors in use of technical terms.
Level 2 **3-4 marks**	**All stages are covered but stage(s) may be incomplete or may contain inaccuracies OR two stages are covered and are generally correct and virtually complete** (4 v 3) Answer has some structure and covers most aspects of the question. Ideas are expressed with reasonable clarity with, perhaps, some repetition or some irrelevant points. If any, only minor errors in use of technical terms.
Level 1 **1-2 marks**	**Two stages are covered but stage(s) may be incomplete or may contain inaccuracies OR only one stage is covered but is generally correct and virtually complete** (2 v 1) Answer includes statements which are presented in a logical order and/or linked.
Level 0	Insufficient correct chemistry to gain a mark.

Stage 1
Anti-bumping granules
1a no anti-bumping granules / add anti-bumping granules
1b to create smaller bubbles / to prevent large bubbles / to prevent mixture jumping into condenser

Stage 2
Open system with no thermometer
2a system should be closed (above flask) to prevent gases escaping
2b should be closed with (bung +) thermometer
2c to allow collection of propanone (only) / to prevent distillation of other components / to stay in suitable temperature range

Stage 3
The water direction in the condenser
3a water flows in wrong direction through condenser / change water direction
3b condenser not cool enough / not full of water
3c product may not condense / comes through as gas

6

(b) **M1** mass of propan-2-ol = 2.0 x 0.786 (= 1.572 g to at least 2sf)

M2 amount of propan-2-ol = $\frac{1.572}{60.0}$ (= 0.0262 to at least 2 sf) mol

M3 mass of propanone expected = 0.0262 x 58.0 (= 1.52 g to at least 2sf)

M4 % yield = $\left(\frac{0.954}{1.52} \times 100\right)$ = 63% (2sf only)

Alternative for M3/4

M3 *amount of propanone formed =* $\frac{0.954}{58.0}$ *(= 0.0164) mol*

M4 *% yield =* $\left(\frac{0.0164}{0.0262} \times 100\right)$ *= 63% (2sf only)*

Allow ECF at each step

4

(c) **M1** propan-2-ol: tetrahedral and 109.5°

M1 *allow 104–110°*

1

M2 propanone: trigonal planar and 120°

M2 *allow 115–123°*

Any two correct boxes scores one mark

1

(d) **M1** propan-2-ol has stronger intermolecular forces

*Penalise **M1** and **M2** for any reference to breaking covalent bonds, (but **M3** could score)*

1

M2 propan-2-ol has hydrogen bonds between molecules

*For **M2** ignore reference to dipole-dipole forces in propan-2-ol*

1

M3 propanone has dipole-dipole forces and/or van der Waals' forces

1

[15]

2. (a) **M1** flask not clamped

allow *<u>only</u> the condenser is clamped*

1

M2 sealed system / bung in condenser

allow *explanation of effect of bung being there e.g. pressure build up*

not *reference to incorrect water direction*

1

(b) sulfuric acid needs adding

allow *hydrochloric / nitric / phosphoric*

ignore *conc/dil*

not *just acid/H^+*

1

(c) **M1** direction of water flow through condenser

allow *reference to water direction from answer to (a)*

1

M2 thermometer not needed

allow *references to safety issue(s) if* ***not*** *given in (a)*

ignore *reference to position of thermometer*

1

(d) to prevent 'bumping'

allow *prevent large bubbles / ensure small bubbles*

not *increases rate*

1

(e) **M1** (fractional) distillation

1

M2 $\frac{6.5}{60}$ mol propan-1-ol (= max $\frac{6.5}{60}$ mol propanoic acid) (0.108)

M2 $\frac{6.5}{60}$ *mol propan-1-ol (= max* $\frac{6.5}{60}$ *mol propanoic acid)*

1

M3 $\frac{6.5 \times 74}{60}$ = 8.02 g (i.e. M2 x 74)

M3 $\frac{3.25}{74}$ *mol propanoic acid formed*

1

M4 $\frac{3.25 \times 100}{8.02}$ = 40.5 %

M4 $\frac{3.25/74}{6.5/60} \times 100$ *= 40.5 %*

1

(f) **M1** add sodium carbonate/hydrogencarbonate

1

M2 effervescence / bubbles

not *gives off* (CO_2) *gas*

1

M3 no (visible) change/reaction

not *nothing / no observation*

allow *acidified sodium/potassium dichromate*

no visible change / stays orange

orange to green

allow *named alcohol + sulfuric acid plus sweet smell and no change/reaction*

allow *named carboxylic acid + sulfuric acid plus no change/reaction and sweet smell*

not *pH measurement*

incorrect reagent = 0/3

incomplete reagent – mark on

1

[13]

3.

(a) A mixture of liquids is heated to boiling point for a prolonged time

1

Vapour is formed which escapes from the liquid mixture, is changed back into liquid and returned to the liquid mixture

1

Any ethanal and ethanol that initially evaporates can then be oxidised

1

(b) $CH_3CH_2OH + H_2O \longrightarrow CH_3COOH + 4H^+ + 4e^-$

1

(c) Mixture heated in a suitable flask / container

A labelled sketch illustrating these points scores the marks

1

With still head containing a thermometer

1

Water cooled condenser connected to the still head and suitable cooled collecting vessel

1

Collect sample at the boiling point of ethanal

1

Cooled collection vessel necessary to reduce evaporation of ethanal

1

(d) Hydrogen bonding in ethanol and ethanoic acid or no hydrogen bonding in ethanal

1

Intermolecular forces / dipole-dipole are weaker than hydrogen bonding

1

(e) Reagent to confirm the presence of ethanal:

Add Tollens' reagent / ammoniacal silver nitrate / aqueous silver nitrate followed by 1 drop of aqueous sodium hydroxide, then enough aqueous ammonia to dissolve the precipitate formed

OR

Add Fehling's solution

1

Warm

M2 and M3 can only be awarded if M1 is given correctly

1

Result with Tollen's reagent:

Silver mirror / black precipitate

OR

Result with Fehling's solution:

Red precipitate / orange-red precipitate

1

Reagent to confirm the absence of ethanoic acid

Add sodium hydrogencarbonate or sodium carbonate

1

Result; no effervescence observed; hence no acid present

1

M5 can only be awarded if M4 is given correctly

OR

Reagent; add ethanol and concentrated sulfuric acid and warm

Result; no sweet smell / no oily drops on the surface of the liquid,

hence no acid present

[16]

4. (a) H_2SO_4

Allow H_3PO_4 or HCl

1

(b) Dichromate / Cr(VI) reduced or Cr(III) formed.

Allow Cr^{6+} and Cr^{3+}

1

(c) The alcohol is flammable

Allow enables temperature to be controlled

1

(d) Tollens'

1

Silver mirror
OR Fehling's
Red precipitate
OR Benedict's
Red precipitate

1

[5]

5. (a) Compounds with the same molecular formula

1

but different structures due to different positions of the same functional group on the same carbon skeleton/chain

1

(b) Compound A is butan-1-ol only

1

Compound C is butanone or butan-2-one

(penalise but-1-ol, but allow repeat error for but-2-one)
(credit butane-1-ol)

1

(c) (i) oxidation or redox

1

(ii) $K_2Cr_2O_7$ or potassium dichromate(VI)

(penalise the dichromate ion or incorrect oxidation state, but mark on)

1

acidified or H_2SO_4 (or other identified strong acid)

(penalise H^+)

(do not credit the acid unless M1 has been correctly attempted)

1

(iii) (heat under) reflux

OR use excess oxidising agent

1

(iv) correctly drawn structure of 2-methylpropan-2-ol

(insist on clearly drawn C-C and C-0 bonds)

1

(v) correctly drawn structure of methanoic acid

(insist on C-0 and C=O displayed in the formula)

1

(d) (i) Tollens' reagent or this whole reagent specified (ammoniacal silver nitrate)
OR Fehling's solution
OR acidified potassium dichromate(VI)

1

(ii) correctly drawn structure of methylpropanal

(insist on C-H and C=O of aldehyde displayed in the formula)

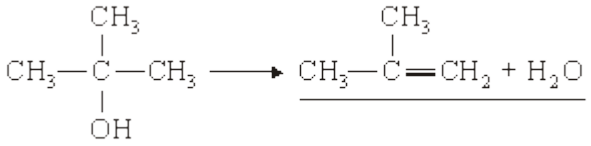
1

[12]

6. (a) (i) 2-methylpropan-2-ol **(1)** OR the second one

(ii) *Dehydrating agent*: conc H_2SO_4 OR conc H_3PO_4 OR Al_2O_3 ignore additional (aq) **(1)**

Equation:



(1)

Allow C_4H_9OH in equation provided RHS is correct

if b(i) is blank, b(ii) equation must be full for credit
i.e. NOT C_4H_9OH

Mark consequential on b(i)

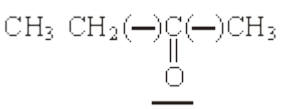
3

(b) (i) *Isomer*: butan-2-ol OR <u>the fourth one</u>

[look at name in table]

wrong isomer = CE

Structure of the ketone:



(1)

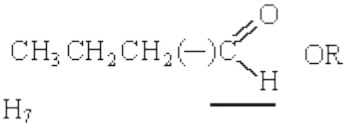
(ii) *Isomer*: butan-1-ol OR <u>the first one</u>
OR 2-methylpropan-1-ol OR <u>the third one</u>

[look at name in table]

Wrong isomer = CE

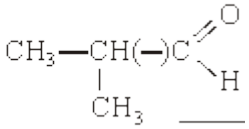
Structure of the aldehyde:

Either



NOT C_3H_7

OR



(iii)

Reagent	M1	Tollen's ($AgNO_3/NH_3$)	Fehling's
Observation with ketone	M2	Stays colourless no change	stays blue no change
Observation with aldehyde	M3	Silver mirror black ppt	red solid orange/red brown/ red ppt/solid

Other include(*)
$K_2Cr_2O_7$ / H_2SO_4
$KMnO_4/H_2SO_4$
Schiff's
Benedict's
Wrong reagent R
No reagent = CE
Penalise $AgNO_3$ $[Ag(NH_3)_2]$ but allow M2 and M3 sequentially.

(*)	$K_2Cr_2O_7$ / H_2SO_4 acidified	ketone	aldehyde
		orange no change	green
	$KMnO_4/H_2SO_4$ acidified	purple no change	colourless (v. Pale pink)

Benedict's ≡ *Fehling's* ; *Schiff's colouless* → *pink with CHO violet*

7

(c) *Equation*: $CH_3CH_2CH_2CH_2OH$ (or C_4H_9OH) + 2[O] → $CH_3CH_2CH_2COOH$ (or C_3H_7COOH) + H_2O **(1)**

Name of product: butanoic acid **(1)**

Accept butaneoic acid

2

[12]