A-Level Chemistry

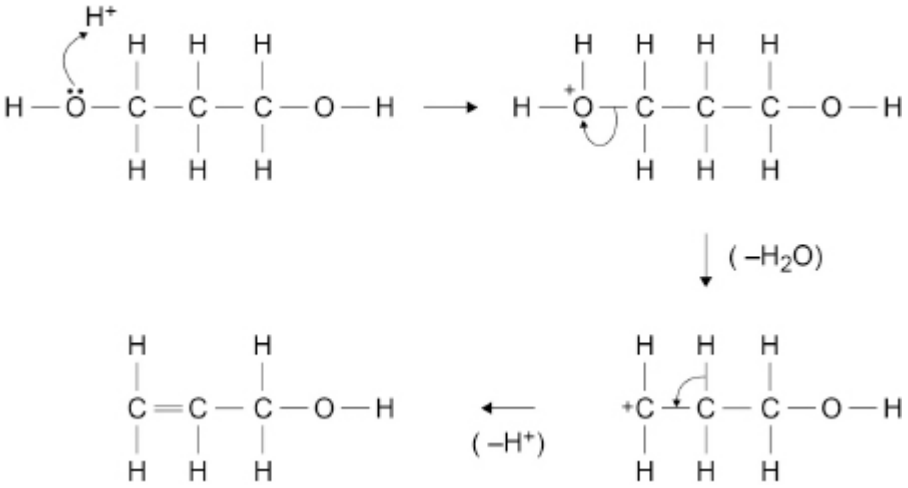
Elimination of Alcohols

Mark Scheme

Time available: 54 minutes
Marks available: 50 marks

1. (a) nucleophilic substitution **1**

(b) **M1** elimination



1

M2 arrow from lone pair on O to H^+ **1**

M3 1st intermediate **and** arrow from C–O^+H_2 bond to O **1**

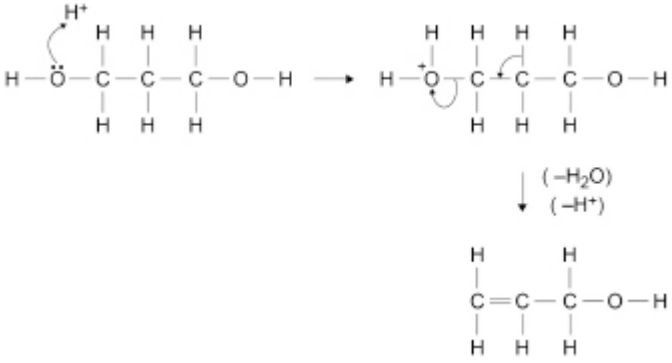
M4 2nd intermediate (carbocation) **and** arrow from a correct C–H bond to correct C–C to form C=C

Max 2 of 3 marks (M2-4) *for wrong organic reactant (ignore structure of product)*

M3 *and* ***M4*** *can be scored in one concurrent step:*

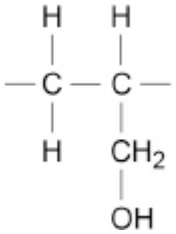
M3 for correct intermediate and arrow from C–O^+H_2 bond to O

M4 *for arrow from a correct C–H bond to correct C–C to form C=C 1*



1

(c)

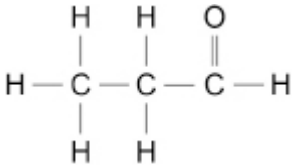


Any correct structural representation

Ignore any brackets and/or n

1

(d)



Structure in any form

1

[7]

2. (a) **M1** idea that pentan-2-ol has stronger intermolecular forces

***M1** idea that hydrogen bonds are stronger than van der Waals' forces*

*Penalise **M1** for any reference to idea of breaking covalent bonds*

1

M2 pent-1-ene has van der Waals' forces (only)

***M2** allow London forces or temporary/induced dipole forces or vdW forces for van der Waals' forces*

1

M3 pentan-2-ol (also) has hydrogen bonds

***M3** Ignore reference to dipole-dipole forces in pentan-2-ol*

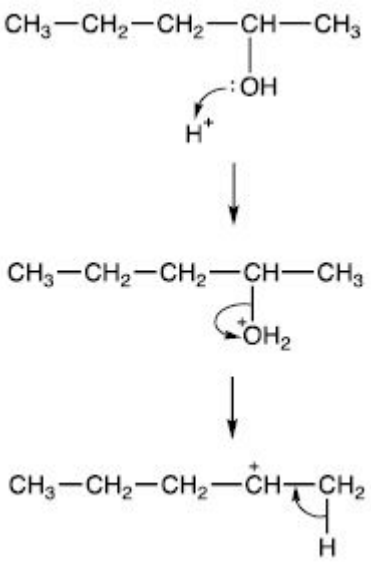
1

(b) **M1** reagent = conc sulfuric acid or conc phosphoric acid

***M1** penalise incorrect name or formula (even if both name and formula are given)*

1

M2 condition = hot / temperature in range 150-200°(C)



***M2** allow high temperature*

***M2** reagent must indicate an acid in some way in order for **M2** to be awarded*

***M1/2** allow 1 mark if H_2SO_4/H_3PO_4 given as reagent and conc(entrated) given as condition*

1

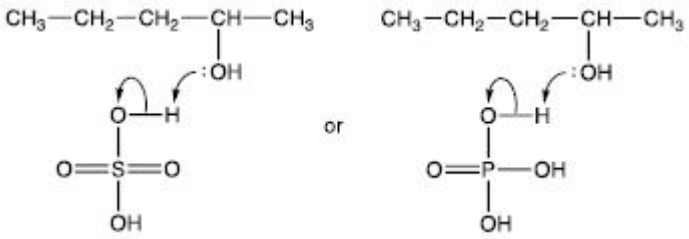
M3 curly arrow from lone pair on alcohol O to H^+

M3-5

*penalise **M3/4/5** for any additional arrow(s) in addition to the correct one at each stage*

*If incorrect reactant (or product if shown), maximum 2 marks of **M3-5***

Alternatives for M3



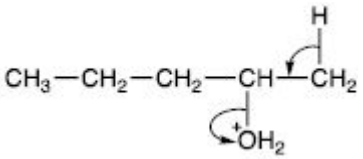
1

M4 curly arrow from C-O bond to O on correct intermediate

1

M5 arrow from C-H bond on C1 to C-C bond between C1 and C2 on correct carbocation

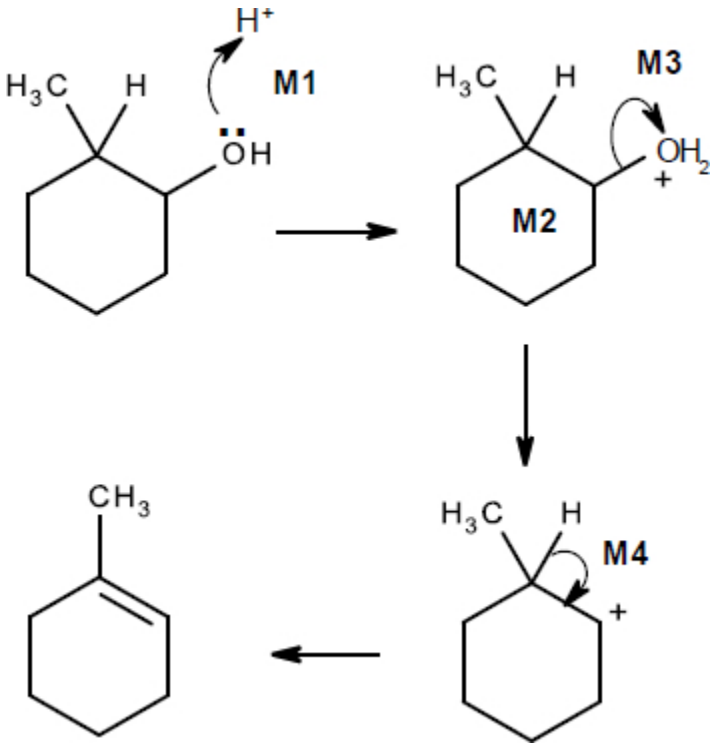
*allow **M4** and **M5** concurrent:*



1

[8]

3. (a)



M1 curly arrow from lone pair on O to H^+ **1**

M2 correct structure of intermediate with + on O **1**

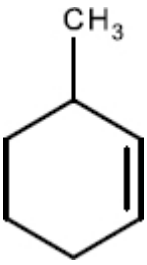
M3 curly arrow from C-O bond to O **1**

M4 curly arrow from correct C-H bond towards correct C-C <u>bond</u> **1**

*Ignore other species that are drawn, but penalise any curly arrows to/from other species for **M1/3/4** as relevant (but allow attack by an anion of phosphoric acid on the H that is lost in **M4** in addition to the arrow specified)*

*for **M2**, the O of the $^+OH_2$ group must be bonded to the ring*

(b)



Any correct structural representation **1**

(c) **M1** more stable (carbocation formed)

*For **M1** penalise more stable product*

1

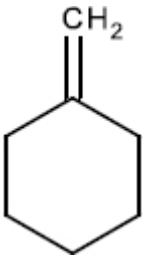
M2 changes from secondary to tertiary (carbocation)

*For **M2** allow explanation via inductive effect with more alkyl / C groups attached or inductive effect from methyl group as alternatives*

Allow 2^o or 2^y for secondary and 3^o or 3^y for tertiary

1

(d)



Any correct structural representation

1

(e) **M1** cyclohexene : van der Waals' <u>forces</u> (between molecules)

1

M2 cyclohexanol : hydrogen bonds (between molecules)

1

M3 phosphoric acid: hydrogen bonds (between molecules)

1

M4 idea that cyclohexene has weakest forces

1

M5 separated by (simple / fractional) <u>distillation</u>

1

M6 cyclohexene has lowest boiling point / boils off first

Extended response

Maximum of 5 marks for answers which do not refer to the van der Waals forces or hydrogen bonds being between molecules in some way

***M1** penalise reference to presence of other intermolecular forces*

***M1** allow vdW forces (on this occasion)*

***M1/2/3** penalise reference to breaking covalent bonds*

***M2 & M3** ignore reference to van der Waals and/or (permanent) dipole-dipole forces*

***M2** allow use of term H bonds (on this occasion)*

***M4** allow converse argument*

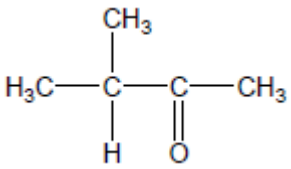
***M4 & M6** – allow correct comparison of cyclohexene forces and boiling point to one of the other two compounds if only one of cyclohexanol or phosphoric acid discussed*

[14]

4. (a) 3-methylbutan-2-ol

1

(b)



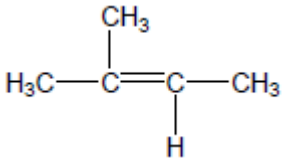
Allow $(CH_3)_2CHCOCH_3$

1

(c) Elimination

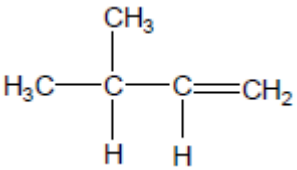
1

(d)



Allow $(CH_3)_2C=CHCH_3$

1



Allow $(CH_3)_2CHCH=CH_2$

1

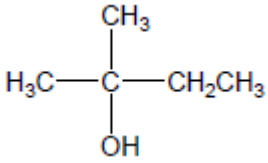
(e) Position

1

(f) C B A

1

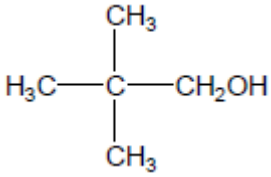
(g)



Allow $(CH_3)_2C(OH)CH_2CH_3$

1

(h)



Allow $(CH_3)_3CCH_2OH$

1

[9]

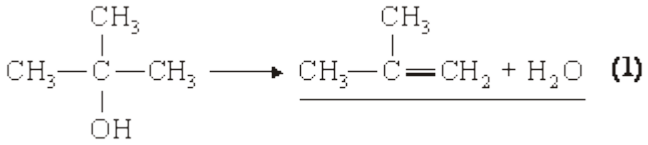
5.

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

ignore additional (aq)

(ii) *Dehydrating agent*: conc H_2SO_4 OR conc H_3PO_4 OR Al_2O_3 **(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)

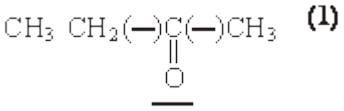
3

(b) (i) *Isomer*: butan-2-ol OR the fourth one

[look at name in table]

wrong isomer = CE

Structure of the ketone:



(1)

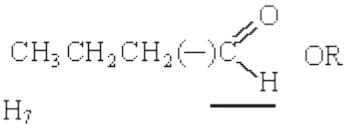
(ii) *Isomer*: butan-1-ol OR the first one
OR 2-methylpropan-1-ol OR the third one

[look at name in table]

Wrong isomer = CE

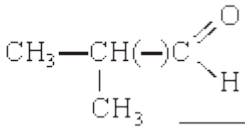
Structure of the aldehyde:

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]