Mark schemes

Q1.

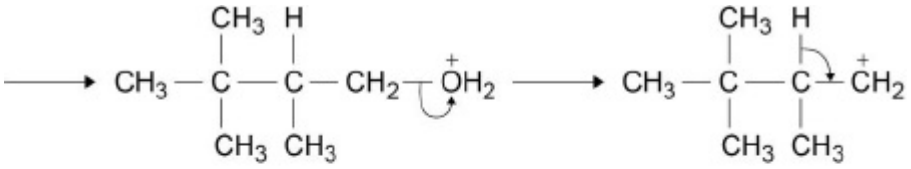
(a) **M1** idea of ensuring condenser fills with water

M2 idea that condenser is cool(er) **or**

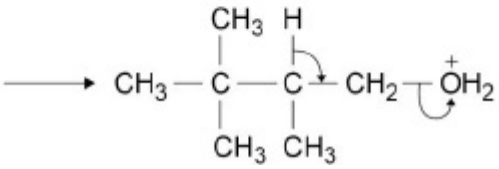
ensuring (more) vapour condenses

2

(b) **M1** elimination



OR



M1 *ignore dehydration; ignore reference to acid-catalysed*

M2 correct protonated intermediate with OH_2^+

M3 loss of H_2O: correct arrow from middle of C-O bond to the O

M4 loss of H^+: correct arrow from middle of correct C-H bond to correct C-C bond

M2 *+ charge anywhere on* OH_2 *group*

M3 *and* ***M4*** *can be two separate steps or all in one step - if two steps shown then the correct carbocation is part of* ***M4***

Ignore structure of product

For ***M3/4****, penalise extra arrows on the original structure (or elsewhere) that contradict "correct" ones*

4

(c) Correct answer scores 5

M1 mass of alcohol = 12 × 0.818 (= 9.816 g)

M2 amount of alcohol = $\frac{\text{M1}}{116(.0)}$ (= 0.0846 mol)

M3 M_r of alkene = 98(.0)

M4 mass of alkene expected = **M2** × **M3** (= 8.29 g)

M5 % yield = $\frac{6.12}{\text{M4}}$ × 100 = 73.8% (at least 2sf)

Alternative

M4 *mol of alkene formed* = $\frac{6.12}{\text{M3}}$ *(= 0.0624 mol)*

M5 *% yield* = $\frac{\text{M4}}{\text{M2}}$ *× 100 = 73.8% (at least 2sf)*

Allow ECF at each stage

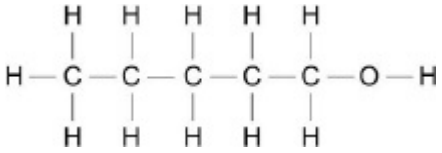
M5 *should be an attempt at (their) mass (or moles) of alkene achieved divided by their mass (or moles) of alkene expected x 100*

5

[11]

Q2.

(a) Displayed formula of pentan-1-ol

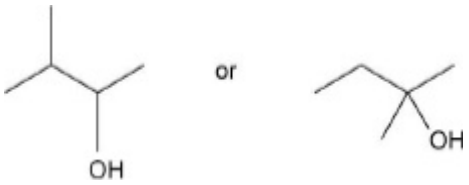


NOT *pentan-3-ol*

NOT *-OH*

1

(b) Skeletal formula of 3-methylbutan-2-ol or 2-methylbutan-2-ol



IGNORE *numbers on C atoms*

IGNORE *'dots' at junctions*

IGNORE *other non-skeletal structures*

IGNORE *skeletal structure of pentan-2-ol*

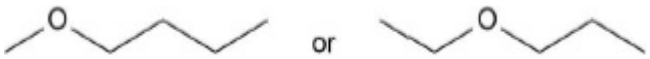
NOT *other incorrect skeletal structures*

NOT *O-H*

NOT *if bond clearly to H of OH*

1

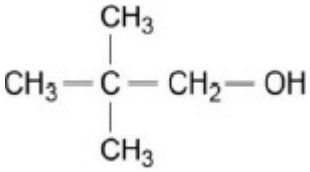
(c) one of these compounds



Any structural representation of correct compound

1

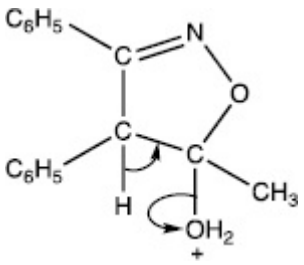
(d)



Any structural representation of correct compound

1

(e)



M1 loss of H_2O: arrow from C-O bond to O

M2 loss of H^+: arrow from correct C-H bond to correct C-C bond

M3 elimination

M1/M2 *list principle for additional arrows on any structure*

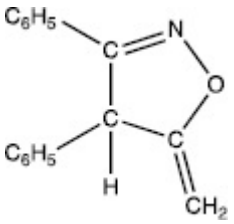
M1 NOT *if arrow to +*

M3 IGNORE *acid-catalysed / dehydration*

NOT *nucleophilic / addition / electrophilic*

3

(f)



Any structural representation of correct compound

If skeletal CH_2 not needed

Allow rings in place of C_6H_5

1

[8]

Q3.

(a) **M1** $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

1

M2 $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

Allow C_2H_6O for ethanol formula

1

M3 $2C_2H_5OH + 6O_2 \rightarrow 4CO_2 + 6H_2O$

***M1/2/3** allow multiples*

***M3** $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$*

1

M4 explains with reference to relevant equations that formation of $C_6H_{12}O_6$ takes in $6CO_2$ and fermentation and combustion of ethanol gives out $6CO_2$

***M4** depends on having appropriate equations in **M1/2/3** showing 6 CO_2 in and out*

1

(b) transport (from South America to Europe) produces CO_2 / has C emissions / has larger C footprint

Process to separate ethanol from propanone and butan-1-ol produces CO_2 / has C emissions / has larger C footprint

1

(c) **M1** 685.5 (686), 668(.25), 595(.33…) in third column of table

***M1** ignore any minus sign on values*

1

M2 depends on their answer to **M1** − must be the compound giving most energy per mole of CO_2 released (correct **M1** would give ethanol)

***M2** need evidence of attempt to calculate energy released per C atom (i.e. per mole of CO_2 formed)*

1

(d) **M1** amount propanone = $\frac{1.18}{58.0}$ (= 0.0203 mol)

1

M2 q = **M1** × 1786 (= 36.3 kJ = 36300 J)

1

M3 $\Delta T \left(= \frac{q}{mc} = \frac{\text{M2 (in J)}}{260 \times 4.18}\right)$ = 33.4 (°C) (allow 32.8-33.4)

***M3** ignore sign*

1

M4 final temperature = (22.3 + **M3**) = 55.7 (°C) (allow 55-596)

***M4** must show a temperature rise*

1

Correct answer scores 4 marks

Allow ECF at each stage

(e) **M1** correctly showing how many of which types of bonds are broken / made

(broken) 3(C-C) + 9(C-H) + (C-O) + (O-H) + 6(O=O)
(made) 8(C=O) + 10(O-H)

***M1** could show broken as:*
3(C-C) + 9(412) + (360) + (463) + 6(496)
or 7507 + 3(C-C)
and, could show made as
8(805) + 10(463)
or 11070

1

M2 (bonds broken) − (bonds made) = −2504
7507 + 3(C-C) − 11070 = −2504
3(C–C) = 1059

*Allow ECF from **M1** to **M2***

*Ignore incorrect number of C-C bonds in **M1/2**, but should be 3 for **M3***

1

M3 (C–C) = $\frac{\text{M2}}{3}$ = 353 (kJ mol^{-1})

*Allow ECF from **M2** to **M3** (if **M2** is negative value, then ignore sign for **M3**)*

1

Correct answer scores 3 marks;

265 scores 2 marks if from 4(C-C) bonds

1188 scores 2 marks (not included −2504)

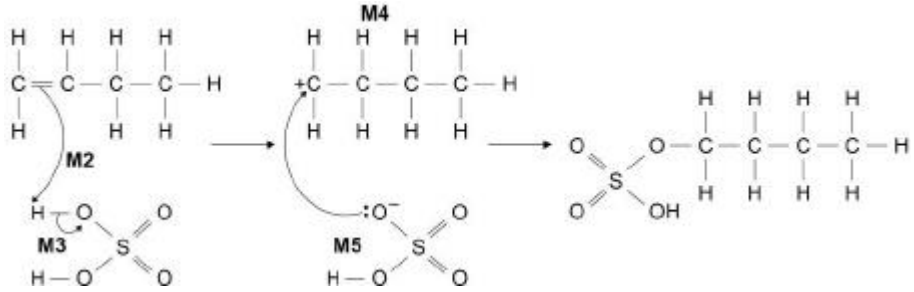
2022 scores 2 marks (using (made − broken))

−353 scores 2 marks

±834 scores 2 marks (use of C-O in CO_2)

±836 scores 1 marks (use of C-O in CO_2 and using (made − broken))

(f) **M1** electrophilic addition



1

M2 must show an arrow from the double bond towards the H atom of the H_2SO_4 molecule

__M2__ ignore partial negative charges on the double bond

1

M3 must show the breaking of the H-O bond in H_2SO_4

__M3__ penalise incorrect partial charges on the H–O bond and penalise formal charges

1

M4 is for the structure of the correct carbocation

Penalise __M4__ if there is a bond drawn to the positive charge

1

M5 must show an arrow from the lone pair of electrons on the correct oxygen of HSO_4^- towards the positively charged atom of <u>their</u> carbocation drawn

1

All arrows are double-headed. Penalise one mark from the total for __2-5__ if half headed arrows are used

Do not penalise the "correct" use of "sticks"

Penalise only once in any part of the mechanism for a line and two dots to show a bond

For __M2 / 3__, the full structure of H_2SO_4 does not need to be shown, but the key features for the mechanism should be shown and the formula must be correct. Penalise only once in __M2 / 3__ an incorrect but genuine attempt at the structure of sulfuric acid

***Max 3 of 4 marks (M2-5)** for wrong organic reactant or wrong carbocation (ignore structure of product)*

If attack is shown from C=C to H^+ rather than H_2SO_4, then allow __M2__ but not __M3__

For __M5__, credit attack on a partially positively charged carbocation structure, but penalise __M4__ for the structure of the carbocation

For __M5__, the full structure of HSO_4^- is not essential, but attack must come from a lone pair on an

individual oxygen on HSO_4^-, but the – sign could by anywhere on the ion (eg :OSO_3H^-)

(g) **M1** formed from less stable carbocation

***M1** must be clear that it is the stability of the carbocation that matters rather than the stability of the alcohol*

1

M2 formed from primary rather than secondary carbocation

***M2** allow 1 mark for primary carbocation is less stable than secondary carbocation even if not clear that product is formed from a carbocation (but must be clear that the alcohols are not the carbocations)*

1

[21]

Q4.

(a) Wear gloves

1

Conc phosphoric acid is corrosive

1

Allow wash spillages with lots of water

OR

Use a fume cupboard
Volatile organic compounds are harmful / toxic

Allow work in a well-ventilated lab space

OR

Keep away from naked flames
Organic compounds are flammable

Other valid suggestions eg heating mantle or electric heater

Not water bath

OR

Periodically release pressure inside separating funnel
Prevent build-up of pressure

(b) To remove (water) soluble impurities

Allow to remove (excess) acid

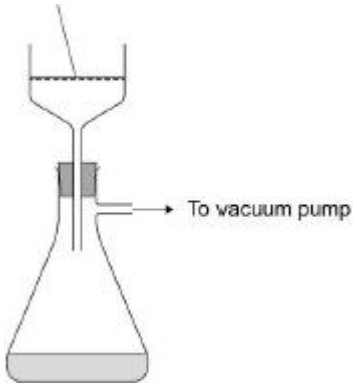
1

(c) To remove water / absorb water / dry the liquid

Allow drying agent

1

(d)



Deduct a mark(s) for error(s) / omission(s)

Minimum

- *Cross sectional (ie funnel top and end shown open)*
- *Bung or collar drawn*
- *(Buchner) Funnel − approximate shape WITH label*
- *Filter paper − WITH label*

2

(e) Impurity: hexan-1-ol

If hexan-3-ol allow ecf for M2

M1

Reason: It is likely to have a similar boiling point

M2

(f) Mass hex-1-ene = 11.0 × 0.678 (or = 7.46 g)

Allow consequential marks for M2,M3,M4

M1

n hex-1-ene = $\frac{7.46}{84.0}$ (or = 0.0888)

M2

Mass of product = 0.0888 × 0.31 × 102

M3

Mass product = 2.8 g

Allow answers 2.8 or 2.9 only

M4

[12]