A-Level Chemistry

Carbon NMR

Mark Scheme

Time available: 40 minutes
Marks available: 35 marks

1. (a)

1

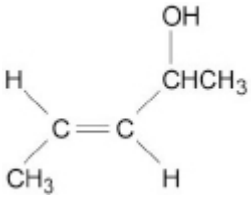
(b) Use Plane polarised light

M1

rotates (the plane of) in opposite directions

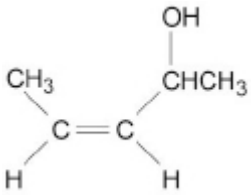
M2

(c)



Must be E isomer

M1

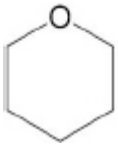


Must be Z isomer

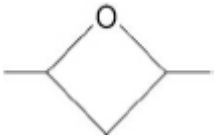
Allow 1 mark out of 2 for 2 correct structures but shown in the wrong boxes

M2

(d)



M1



M2

[7]

2. (a) **M1** Amount $CO_2 = {}^{1.89}/_{44} = 0.043$ = mol C

1

M2 Amount $H_2O = {}^{0.643}/_{18} = 0.0357$ mol

1

M3 Amount H = 0.036 x 2 = 0.0714 mol

1

M4 Amount O = $^{0.913}/_{16}$ = 0.057 mol

1

	C	H	O
	0.043	0.0714	0.057
M5	1	1.66	1.33
	3	5	4

1

Alternate method

M1 *mass C = 1.89 – (1.89 x* $\frac{32}{44}$*) = 0.515 g*

M2 *mass H = 1.5 – (0.515 + 0.913)*

M3 *= 0.0715 g*

OR mass ***M2*** *H = 0.643 – (0.643 x* $\frac{16}{18}$*)*

M3 *= 0.0714 g C H O*

	C	H	O
M4	$\frac{0.515}{12}$ = 0.043	$\frac{0.0715}{1}$ = 0.0715	$\frac{0.913}{16}$ = 0.057
M5	1	1.66	1.33
	3	5	4

(b) **M1** Amount H_2O = $^{0.26}/_{18}$ = 0.014 mol

1

M2 Amount $H_3Y.xH_2O$ = $^{3}/_{210}$ = 0.014 mol
or
Amount of H_3Y = 2.74/192 = 0.014 mol
(hence ratio 1:1)

1

Common alternate method

M1 *Amount* H_3Y *.x*H_2O = $^{3}/_{210}$ *= 0.0143 mol*

M2 M_r *x*H_3Y = $\frac{2.74}{0.0143}$ *= 192*

M_r H_2O *= 210 -192 = 18*

(hence x= 1)

(c) 2(-) Hydroxy

1

(d) Number of peaks = 4

Allow Four

1

[9]

3. (a) 4 peaks

1

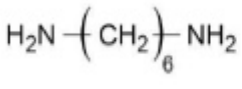
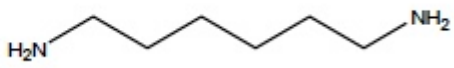
Triplet

1

Two H on adjacent C

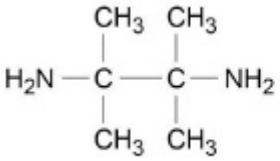
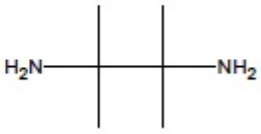
M3 dependent on correct M2

1

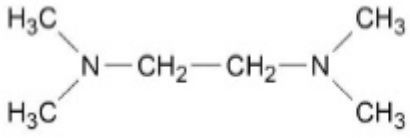
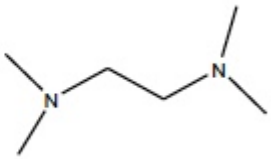
(b)  or 

Not $-C_6H_{12}-$

1

(c)  or 

1

(d)  or 

Not $-C_2H_4-$

1

[6]

4. 6 / six

[1]

5. (a) (i) There are three pairs of equivalent carbon atoms

1

(ii) 75ppm

1

(b) (i) 4

1

(ii) 2

1

(c) Each structure can represent a pair of cis/Z and trans/E isomers
OR
Optical isomers

1

[5]

6.

(a) Cyclopentanone

Allow cyclopentan -1-one but no other numbers

Ignore spaces, commas and hyphens

1

(b)

This question is marked using Levels of Response. Refer to the Mark Scheme Instructions for Examiners for guidance.	
Level 3 **5-6 marks**	**All stages are covered and each stage is generally correct and virtually complete.** Answer is well structured with no repetition or irrelevant points. 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.** Answer shows some attempt at structure Ideas are expressed with reasonable clarity with, perhaps, some repetition or some irrelevant points. Some 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.** Answer includes isolated statements and these are presented in a logical order. Answer may contain valid points which are not clearly linked. Errors in the use of technical terms.
0 marks	Insufficient correct chemistry to gain a mark.

Indicative Chemistry content

Stage 1: boiling points
1a) **Y** has a higher bp
1b) **Y** has H-bonds between molecules and **X** has dip-dip imf
1c) More energy required to overcome H-bonds

Mention of covalent bond breaking loses 1c

Stage 2: ^{13}C NMR
2a) Both have 3 peaks/absorptions in their ^{13}C NMR
2b) **X** has peaks at 20-50 **OR** 190-220ppm
2c) **Y** has peaks at 50-90 **OR** 90-150ppm

(Ignore peaks at 5-40ppm - present in both)

Stage 3: ir

3a) **X** has a peak (for C=O) at 1680-1750 cm^{-1}

3b) **Y** has peak (for O−H) at 3230-3550 cm^{-1}

OR peak (for C=C) at 1620-1680 cm^{-1}

3c) They would have different fingerprint regions (below 1500 cm^{-1})

6

[7]