

Mark Scheme - 2.8 Instrumental Analysis

1. (a) (i) % H = 14.3 (1)

$$\text{C} : \text{H} = \frac{85.7}{12.0} : \frac{14.3}{1.01} = 7.14 : 14.16 \text{ (1)}$$

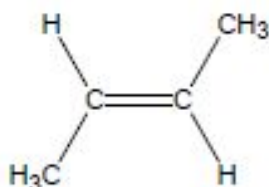
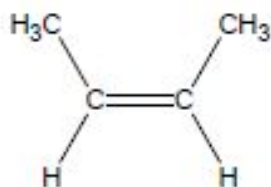
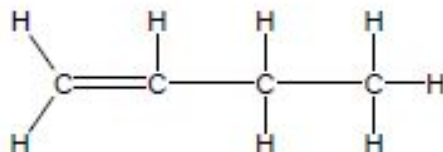
empirical formula = CH₂ (1) [3]

(ii) M_r = 42/ largest fragment has mass 42 (1)

(CH₂ = 14) therefore molecular formula = C₃H₆ (1) [2]

(iii) CH₃ is present [1]

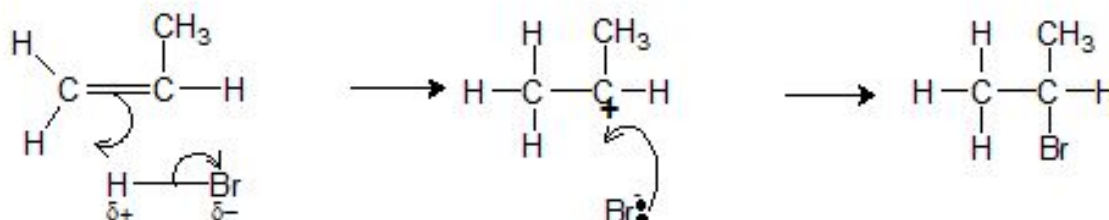
(b) 1 mark for each [3]



Total [9]

2.

- (a) (i) 1 mark for arrows in first diagram; 1 mark for arrow in second diagram;
1 mark for all charges



2 max if incorrect isomer given [3]

- (ii) 2-bromopropane formed from a secondary carbocation (1)
Secondary carbocations are more stable than primary carbocations (1)
[2]

- (b) Empirical formula = C_3H_5Br (1)

Molecular formula = C_3H_5Br

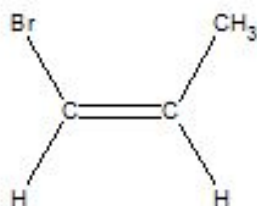
(must show use of mass spectrum to gain this mark) (1)

Two molecular ion peaks as there are two isotopes of bromine (1)

Peaks at 15 = CH_3^+ and 41 = $C_3H_5^+$ (1)

550 cm^{-1} = C-Br 1630 cm^{-1} = C=C 3030 cm^{-1} = C-H (1)

Molecule is:



(1) [6]

QWC: legibility of text, accuracy of spelling, punctuation and grammar, clarity of meaning [1]

Total [12]

3.

(a) (i) Mass C = $1.79 \times 12/44 = 0.488$ (g) [1]

(ii) Mass O = 0.65 (g) ecf from part (i) [1]

(iii) C : H : O = $0.488/12 : 0.061/1 : 0.65/16 = 0.0407 : 0.061 : 0.0406$ (1)
= 2:3:2 empirical formula is $C_2H_3O_2$ (1)

No ecf from incorrect ratios [2]

(iv) Mr of empirical formula = 59 so molecular formula is $C_4H_6O_4$ so F is acid 2/ molecular formula acid 1 is $C_5H_8O_2$ so empirical formula is not $C_2H_3O_2$ molecular formula acid 2 is $C_4H_6O_4$ so empirical formula is $C_2H_3O_2$ [1]

(v) Bromine turns from brown/red-brown to colourless for Acid 1 [1]

(vi)
$$\begin{array}{cccc} & H & H & H & H \\ & | & | & | & | \\ HO & -C & -C & -C & -C- OH \\ & | & | & | & | \\ & H & H & H & H \end{array}$$
 [1]

(b) (i) Mr / molecular ion (is 46) [1]

(ii) CH_3 (present) [1]

(iii) OH (present) [1]

(c) Ethene to ethanol: steam (1)

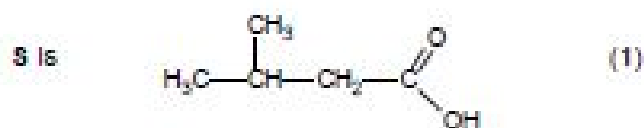
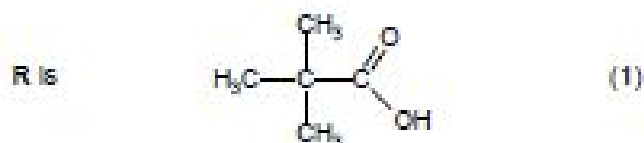
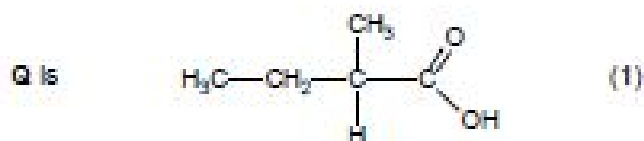
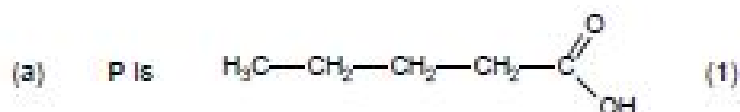
H_3PO_4 (catalyst) (1)

Ethanol to ethene: conc H_2SO_4 / Al_2O_3 / pumice (1)

High temperature > $150^\circ C$ for H_2SO_4
> $300^\circ C$ for Al_2O_3 / pumice (1) [4]

Total [14]

4.



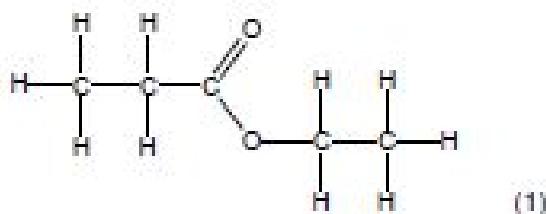
[4]

(b) (i) T neutral and sweet-smelling therefore an ester (1)
 Infrared spectrum at 1750 cm^{-1} shows C=O and at 3000 cm^{-1} shows O-H therefore X is an acid (1)

Y is an alcohol, formed from ethanal must be ethanol (1)

5 carbons in ester therefore X must be propanoic acid (1)

Structure of T is



(Maximum 4 marks)

[4]

QWC Legibility of text; accuracy of spelling, punctuation and grammar, clarity of meaning (1)

Selection of a form and style of writing appropriate to purpose and to complexity of subject matter (1) [2]

(ii) i Reagent to form Y is NaBH_4 / LiAlH_4 [1]

ii Sulfuric acid acts as a catalyst / removes water so pushes equilibrium to right [1]

(c)	$\text{CH}_3(\text{CH}_2)$	0.1 to 2.0 ppm triplet (1)	
	$(\text{CH}_2)\text{CH}_2\text{O}$	3.5 to 4.0 ppm quadruplet (1)	
	CH_2CO	2.5 to 3.0 ppm singlet (1)	
	CH_3CO	2.0 to 2.5 ppm singlet (1)	[4]

(d)	Isomer P (1)		
	Only P can form hydrogen bonds between molecules (1)		
	Hydrogen bonds are the strongest intermolecular bonds / need more energy to break hydrogen bonds (1)		[3]

QWC The information is organised clearly and coherently, using specialist vocabulary where appropriate [1]

Total [20]