Chapter 17: Alcohols, esters and carboxylic acids

Homework marking scheme

1 a i excess [1]
of acidified dichromate [1]
under reflux. [1]

ii $C_4H_{10}O + 2[O] \rightarrow C_4H_8O_2 + H_2O$ [1]

b In this question the changes from alcohol to aldehyde to carboxylic acid should be explained along with the accompanying infrared spectra.
At the start there will be a strong absorption at 3200–3600 cm^{-1} [1]
due the O–H group in the alcohol. This will disappear. [1]
A strong absorption will then appear at 1670–1750 cm^{-1} [1]
due to the >C=O group in an aldehyde. This will remain. [1]
A strong, broad absorption will then appear at 2500–3500 cm^{-1} [1]
due to the carboxylic acid. [1]

c X is $CH_3CH(CH_3)CH_2OH$. [1]
It must be a primary alcohol because it is oxidised to a carboxylic acid (not a ketone). [1]
It must have a branched carbon chain, because when dehydrated it gives a branched alkene. [1]

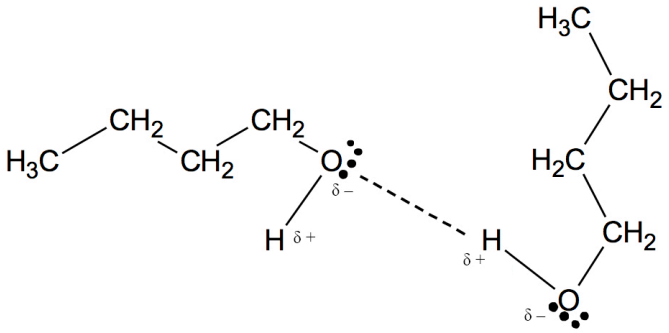
d Y is $CH_3CH_2CH_2CH_2OH$ [1]
It must be a primary alcohol because it is oxidised to a carboxylic acid (not a ketone). [1]
It gives a straight-chain alkene when it is dehydrated. [1]

e i $CH_3CH(CH_3)COOH$ [1]

ii $CH_3CH(CH_3)COOCH_2CH_2CH_2CH_3$ [1]

iii $CH_3CH(CH_3)COOH + CH_3CH_2CH_2CH_2OH \rightleftharpoons CH_3CH(CH_3)COOCH_2CH_2CH_2CH_3 + H_2O$ [1]
heat and acid (H^+) catalyst [1]

f



dipoles [1]
lone pairs on O [1]
hydrogen bond (shown as dashed line) between molecules [1]

2 a

A: pentan-1-ol B: pentan-2-ol C: pentan-3-ol
D: 2-methylbutan-1-ol E: 3-methylbutan-1-ol F: 2-methylbutan-2-ol
G: 3-methylbutan-2-ol H: 2,2-dimethylpropan-1-ol

1 mark per name [8]

b i A, D, E and H
1 mark for two correct and 2 marks for all four correct. [2]

ii B, C and G [1]

iii F [1]

iv H cannot be dehydrated [1]
because there is no hydrogen atom on the carbon adjacent to the carbon with O–H. [1]

v A and B [1]

vi B [1]
C also gives these *cis–trans* isomers but does not give the third product, pent-1-ene [1]
B gives all three. [1]

3 a i P is $CH_3COOCH_2CH_3$ (molecular formula $C_4H_8O_2$) [1]
P is an ester because it has a sweet smell and can be prepared using ethanol and a carboxylic acid. [1]
Q is therefore ethanoic acid. [1]

ii $CH_3CH_2OH + CH_3COOH \rightleftharpoons CH_3COOCH_2CH_3 + H_2O$ [1]

b i R is $CH_3CH_2COOCH_3$ (molecular formula $C_4H_8O_2$) [1]
R is an ester because it has a sweet smell and can be prepared using methanol and a carboxylic acid. [1]
S is therefore propanoic acid. [1]

ii $CH_3CH_2COOH + CH_3OH \rightleftharpoons CH_3CH_2COOCH_3 + H_2O$ [1]

c i $K_c = \dfrac{[CH_3CH_2COOCH_3][H_2O]}{[CH_3CH_2COOH][CH_3OH]}$ [1]

ii $CH_3CH_2COOH + CH_3OH \rightleftharpoons CH_3CH_2COOCH_3 + H_2O$

Number of moles	CH_3CH_2COOH	CH_3OH	$CH_3CH_2COOCH_3$	H_2O
At start	0.02	0.01	0	0
At equilibrium	0.02 − 0.005 = 0.015	0.01 − 0.005 = 0.005	0.005	0.005

[1]

Therefore, $K_c = \dfrac{0.005 \times 0.005}{0.015 \times 0.005} 0.005^2/0.015 \times 0.005 = 0.33$ [1]

No units [1]

iii no effect [1]
Only temperature affects the value of the equilibrium constant. [1]

d T has to be a carboxylic acid because its solution has a pH below 7 (acidic). [1]
It must be $CH_3CH_2CH_2COOH$ (molecular formula $C_4H_8O_2$) and because it has an unbranched chain. [1]
The only other carboxylic acid with this formula has a branched chain. [1]

e In P the intermolecular forces are dipole–dipole forces because of the δ+ C=O δ− dipole. [1]
In T the intermolecular forces are hydrogen bonds formed because of O–H groups present. [1]
Hydrogen bonds are stronger than dipole–dipole forces. [1]