

Answers to exam-style questions

Topic 10

- 1 A
2 C
3 B
4 C
5 C
6 D
7 C
8 A
9 C
10 B

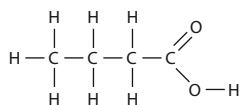
11 a Alcohols contain the -OH functional group.

$\begin{array}{cccc} \text{OH} & \text{H} & \text{H} & \text{H} \\ & & & \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array}$	butan-1-ol
$\begin{array}{cccc} \text{H} & \text{OH} & \text{H} & \text{H} \\ & & & \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array}$	butan-2-ol
$\begin{array}{ccc} \text{H} & \text{OH} & \text{H} \\ & & \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ & & \\ \text{H} & \text{CH}_3 & \text{H} \end{array}$	2-methylpropan-2-ol
$\begin{array}{ccc} \text{H} & \text{H} & \text{OH} \\ & & \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ & & \\ \text{H} & \text{CH}_3 & \text{H} \end{array}$	2-methylpropan-1-ol

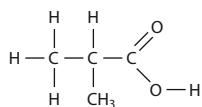
[4]

b Only primary alcohols can be oxidised to a carboxylic acid. Primary alcohols have only one C attached to the carbon with the OH group on it. Butan-1-ol and 2-methylpropan-1-ol are primary alcohols. The only change that occurs is that the $\text{-CH}_2\text{OH}$ group of the primary alcohol becomes a -COOH group in the carboxylic acid – the rest of the carbon skeleton remains unchanged.

butan-1-ol becomes:



2-methylpropan-1-ol becomes:



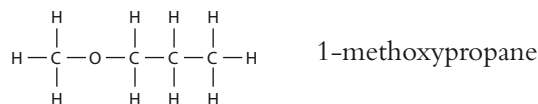
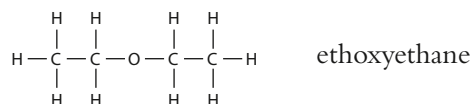
Suitable oxidising agents are: acidified potassium dichromate(VI), $\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$ or just $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$
colour change: orange to green

or

acidified potassium manganate(VII), KMnO_4/H^+
or $\text{MnO}_4^-/\text{H}^+$ colour change: purple to colourless

[6]

c The isomer must have the same molecular formula but no -OH group. Possible isomers are:

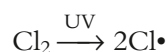


[2]

12 a $\text{C}_2\text{H}_6 + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{HCl}$ [1]

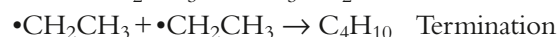
b i free radical substitution [1]

ii *Homolytic fission* occurs in the initiation step. In the presence of ultraviolet light the Cl-Cl bond breaks so that one electron goes to each Cl atom:



A *free radical* is an atom/group of atoms with an unpaired electron. In this case, $\text{Cl}\cdot$ is a free radical. A $\text{CH}_3\text{CH}_2\cdot$ free radical is also formed in this reaction.

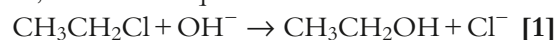
A *termination step* occurs when two free radicals react together – this ends a chain reaction. There are three possible termination steps in this mechanism:



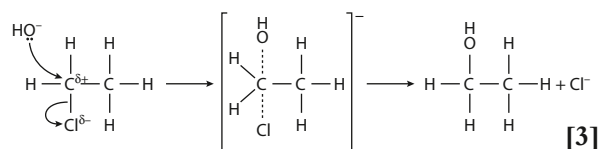
[4]

c i $\text{CH}_3\text{CH}_2\text{Cl} + \text{NaOH} \rightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{NaCl}$

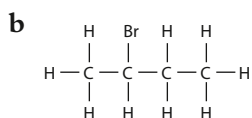
or, as an ionic equation:



ii Chloroethane is a primary halogenoalkane and therefore reacts by an $\text{S}_{\text{N}}2$ mechanism:

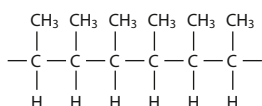


13 a Both compounds must be shaken with bromine water. But-2-ene decolorises the bromine water (orange to colourless), but there is no change with butane. [3]



[1]

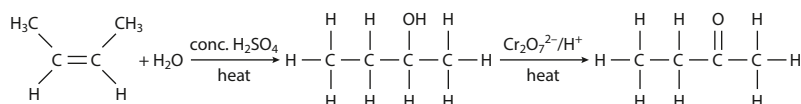
c Only the C=C part of the molecule reacts – all other groups remain unchanged:



[2]

d Butanone can be obtained by oxidation of a secondary alcohol, butan-2-ol.

To convert but-2-ene to an alcohol we must add water across the double bond:



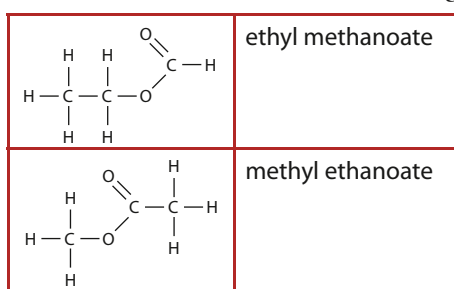
[5]

14 a

	C	H	O
Percentage	48.6	8.2	43.2
Divide by A_r	48.6/12.01	8.2/1.01	43.2/16.00
Moles	4.05	8.12	2.7
Divide by smallest	4.05/2.7	8.12/2.7	2.7/2.7
Ratio	1.5	3.01	1

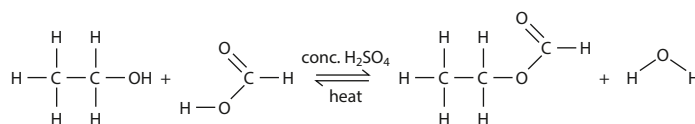
Multiplying by 2 to get whole numbers we get $\text{C}_3\text{H}_6\text{O}_2$, which is the empirical formula. The empirical formula mass is $(3 \times 12.01 + 6 \times 1.01 + 2 \times 16) = 74.09$. The empirical formula mass is the same as the relative molecular mass, so the molecular formula is the same as the empirical formula. The molecular formula is $\text{C}_3\text{H}_6\text{O}_2$. [3]

b i Esters contain the COOC functional group:

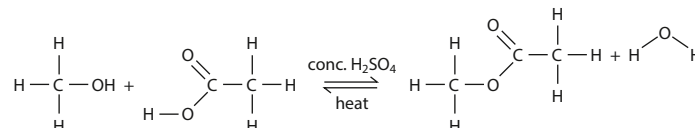


[4]

ii

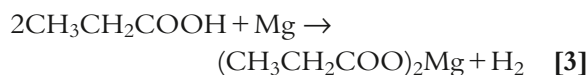
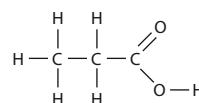


or

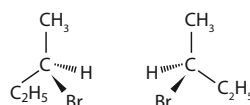


[2]

c Acids react with magnesium to form hydrogen, so this isomer must be a carboxylic acid:



15 a 2-bromobutane has a chiral centre, i.e. a C atom with four different groups attached.



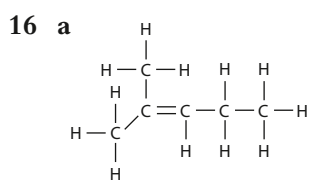
[3]

b i 'N' stands for 'nucleophilic'. A nucleophile is a molecule/negatively charged ion, possessing a lone pair of electrons, which is attracted to a more positively charged region in a molecule (region with lower electron density) and donates a lone pair of electrons to form a covalent bond. [1]

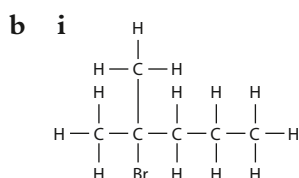
ii The $\text{S}_{\text{N}}2$ mechanism occurs with inversion of configuration at the carbon attached to the halogen. Which enantiomer of the product is formed can be predicted from knowing the configuration of the enantiomer you started with. [2]

iii 1-bromobutane will react more quickly than 2-bromobutane via an $\text{S}_{\text{N}}2$ mechanism. There is less steric hindrance around the C with the Br in 1-bromobutane, because there is only one alkyl group attached to this C. It is therefore easier for the nucleophile to get in to attack the C in 1-bromobutane. An alternative explanation is in terms of the transition state. The transition state will be more crowded in 2-bromobutane, because there are two alkyl groups around the five

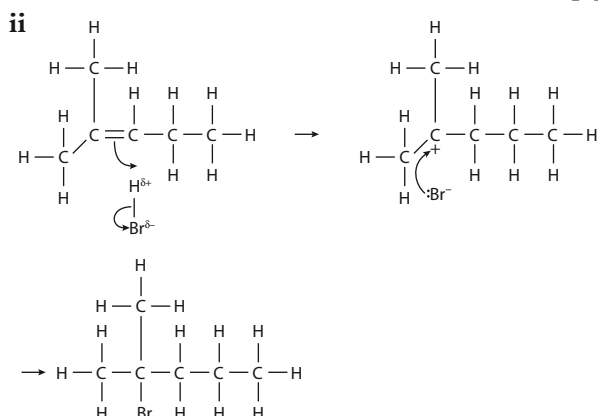
co-ordinate C. This makes the transition state less stable for 2-bromobutane, and so the activation energy is higher. This means that this reaction will occur more slowly. [2]



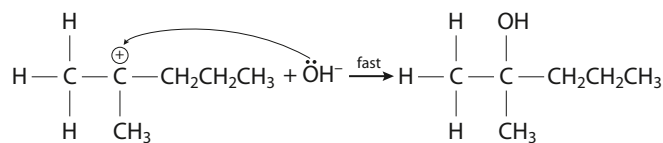
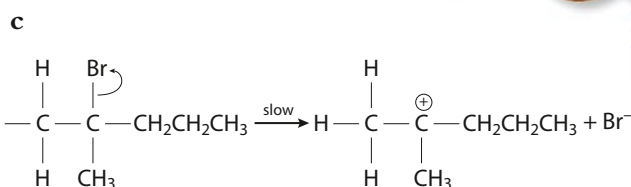
[1]



This is an addition reaction and H-Br will add across the C=C. The alkene is unsymmetrical so we can use Markovnikov's rule to predict the major product. The H of the H-Br will become attached to the C which has more Hs already attached; that is, carbon 3. [2]



The major product is formed because when the H joins to the C atom with more H atoms attached a tertiary carbocation is formed. This is more stable than the secondary carbocation that would be formed if the bond broke the other way. The tertiary carbocation is more stable because there are more electron-releasing alkyl groups attached to the C with the positive charge. [5]



[3]

d X cannot be oxidised because it is a tertiary alcohol. [1]