WJEC EDUQAS A-LEVEL CHEMISTRY · COMPONENT 2

CHEMISTRY



EXAM QUESTION PACK

OA2.2 ALDEHYDES AND KETONES

SCORE	PERCENTAGE
/91	%

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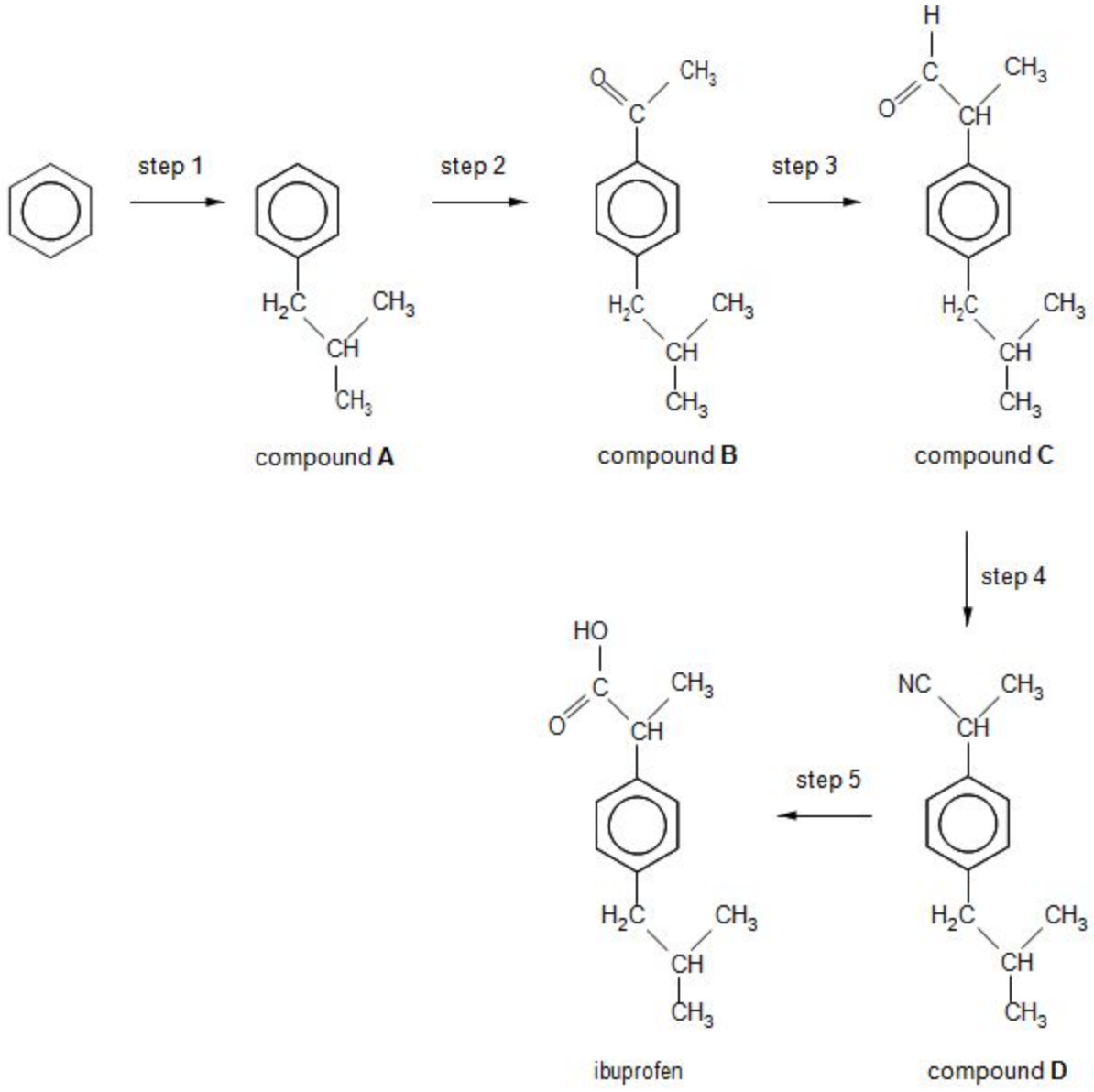
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1. Ibuprofen is a common drug taken as an analgesic and anti-inflammatory treatment.

A possible route to the synthesis of ibuprofen is shown below.



(a) Step 1 is a Friedel-Crafts alkylation reaction. Give the reagent(s) and condition(s) required for this step.

[3]

(b) Compounds **B** and **C** can be analysed using chemical tests.

(i) Give a chemical test that would give a positive result for **both** compound **B** and compound **C**. Include reagent(s) and the observation(s) expected for a positive result.

[2]

(ii) Give a chemical test that would give a positive result for compound **C** but **not** for compound **B**. Include reagent(s) and the observation(s) for both compounds.

[2]

(c) Compound **C** shows optical isomerism. Discuss this statement. Your answer should include:

- What is meant by optical isomerism.
- What feature of compound **C** allows it to exhibit optical isomerism.
- Diagrams to show the two optical isomers of compound **C**.
- How the two optical isomers of compound **C** can be distinguished.

[4] QWC [1]

(d) Give the reagent(s) and condition(s) required for step 5 and classify the reaction that occurs.

[3]

(e) A student investigating alternative methods of producing ibuprofen suggests that it would be better to convert compound **C** into ibuprofen in a one-step process. Discuss whether this is correct.

Your answer should include:

- The reagent(s) and condition(s) for a reaction expected to convert compound **C** directly into ibuprofen.
- Why it is generally better to use one step rather than two or more steps when producing a desired compound.
- A suggestion of why a two-step process is chosen for the synthesis of ibuprofen from compound **C** rather than a one-step process.

[4] QWC [1]

(Total 20)

2. Mauveine is a purple dye that was developed by Perkin in 1856 and was one of the first organic compounds to be synthesised on a large scale. He is credited with launching the synthetic chemical industry.

(a) Give the name for the part of a molecule that causes it to be coloured.

[1]

(b) The dye mauveine often contains a mixture of impurities. Iwan and Georgia wanted to confirm that a sample of the dye was impure.

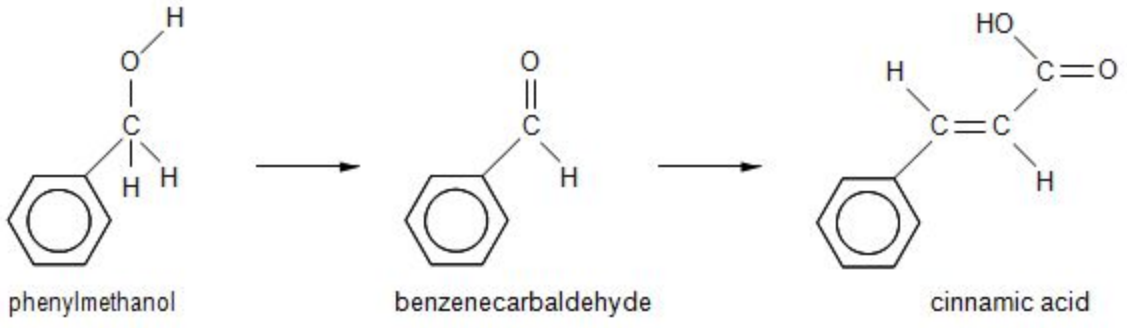
(i) Iwan used the melting temperature of the sample to confirm that the sample was impure. Give **one** way that the melting temperature would show this.

[1]

(ii) Georgia used gas chromatography to confirm that the sample was impure. State what information she obtained using this method that Iwan could not obtain from the melting temperature.

[2]

(c) Another compound synthesised by Perkin was cinnamic acid. Cinnamic acid can be produced in two steps from phenylmethanol as shown below.



(i) Give the reagent(s) and condition(s) required to obtain a sample of benzenecarbaldehyde from phenylmethanol.

[2]

Reagent(s) . . . . . .

Condition(s) . . . . . .

(ii) The conversion of phenylmethanol to benzenecarbaldehyde has a yield of 86 %. Calculate the mass of benzenecarbaldehyde that could be produced from 10.0 g of phenylmethanol.

[3]

(iii) The ^1H NMR high resolution spectrum of cinnamic acid contains peaks in the area 7.0-7.5 with an area of 5 due to the benzene ring. Describe what other features you would expect to see in the spectrum. [4]

Total [13]

3. (a) From the information given, draw the displayed formula of each compound.In parts (i)-(iii) the compounds consist of molecules that have **three** carbon In part (iv) the compound has **four** carbon atoms.

(i) A compound that is oxidised to a ketone

[1]

(ii) A neutral sweet-smelling compound

[1]

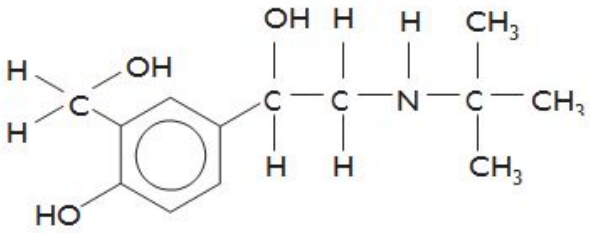
(iii) An α-amino acid

[1]

(iv) A hydrocarbon that exhibits E-Z isomerism

[1]

(b) The active compound in Ventolin® inhalers used by asthma sufferers is salbutamol, which shows optical isomerism.



salbutamol

(i) Indicate a chiral centre in this molecule by labelling it with an asterisk (*). [1]

(ii) State how the optical isomers of salbutamol could be distinguished from each other. [1]

(iii) Suggest a reason why only one optical isomer of salbutamol is used as a pharmaceutical. [1]

(iv) Draw the displayed formula of the likely organic product formed when salbutamol is refluxed with acidified $K_2Cr_2O_7$. [2]

(c)(i) Arrange the following molecules in order of **increasing** acidity

[1]

ethanoic acid *ethanol* *ethylamine* *phenol*

least acidic..... most acidic

(ii) Explain the difference in acid-base properties of ethylamine and phenol.

[4]

(Total 14)

4. (a) 1-Chloropentane can be made by the free radical chlorination of pentane, in a similar way to the reaction of methane with chlorine.

(i) Give the equation for the reaction of pentane with chlorine, showing the displayed formula of 1-chloropentane as part of your answer.

[1]

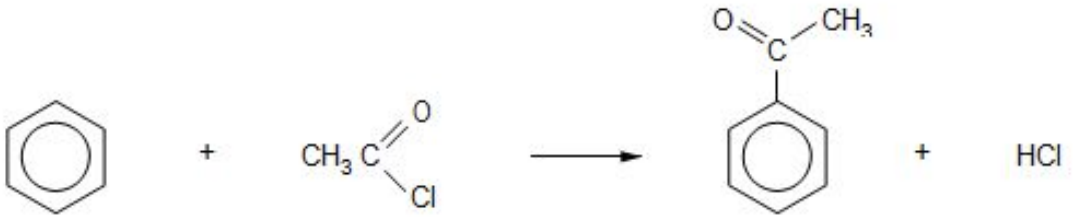
(ii) The free radical reaction of pentane with chlorine gives other chlorinated organic products. Give the structural formula of the carbon-containing free radical that leads to the formation of 2-chloropentane.

[1]

(b) Pentylbenzene can be produced by the reaction of 1-chloropentane and benzene in a Friedel-Crafts reaction. State the name of a catalyst that can be used in this reaction.

[1]

(c) A Friedel-Crafts reaction can be carried out with ethanoyl chloride in place of 1-chloropentane. This reaction gives phenylethanone as the main organic product.



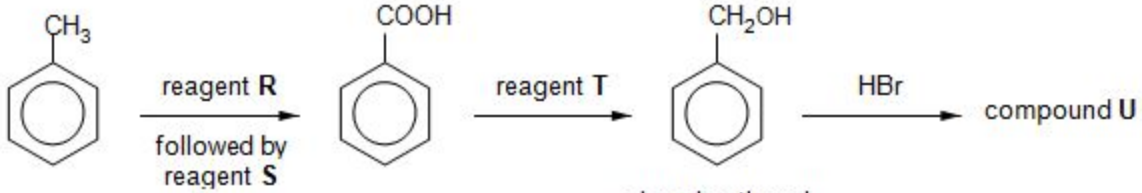
phenylethanone

(i) State what is seen when a few drops of phenylethanone are added to a solution of 2,4-dinitrophenylhydrazine.

[1]

(ii) This preparation of phenylethanone also gives small traces of an impurity. This impurity has a molecular formula $C_{10}H_{10}O_2$ and reacts in a similar way to phenylethanone when it is treated with 2,4-dinitrophenylhydrazine. It does not react with Tollens' reagent. Suggest a displayed formula for this impurity, giving a reason for your choice. [2]

(d) Methylbenzene can be oxidised to benzoic acid by heating it strongly with an alkaline solution of reagent **R** followed by treatment with reagent **S**. The benzoic acid can then be used to produce a number of other compounds. A reaction sequence is shown below.



phenylmethanol

(i) State the name of reagent **R**

[1]

(ii) State the name of reagent **S**

[1]

(iii) State the name of reagent **T**.

[1]

(iv) Give the displayed formula of the organic compound **U**.

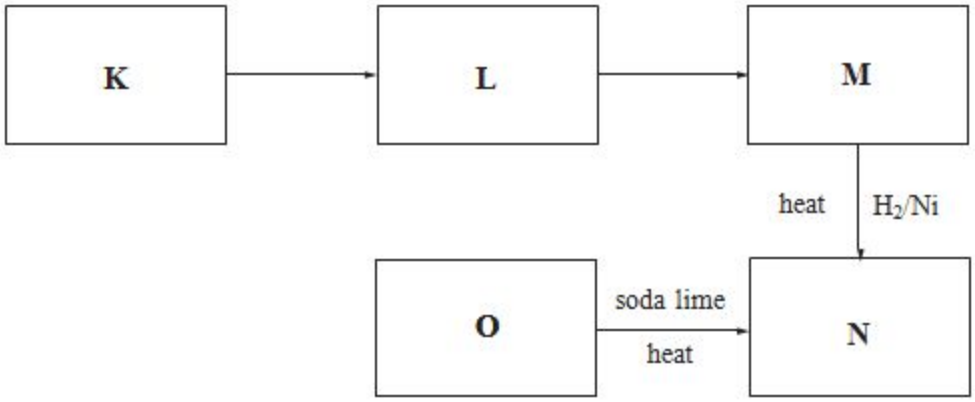
[1]

(e) State and explain how the infrared spectrum of benzoic acid would differ from that of phenylmethanol.

[2]

(Total 12)

5. *(a)* Study the reaction scheme shown below and the other information about compounds **K–O** that follows:



Compound **K** has a relative molecular mass of 58.06. It gives an orange-yellow solid with 2, 4-dinitrophenylhydrazine and gives a positive triiodomethane (iodoform) test.

0.500 g of compound **O** in aqueous solution requires 56.75 cm^3 of sodium hydroxide solution of concentration 0.100 mol dm^{-3} for complete neutralisation.
Compound **O** reacts with sodium hydroxide in a 1:1 molar ratio.

Compound **L** cannot be oxidised to compound **O**.

(i) Calculate the relative molecular mass of compound **O**. [2]

(ii) Identify compounds **K** and **O**, giving your full reasoning. [5]

(iii) Identify compounds **L**, **M** and **N**. [3]

(iv) State the reagent(s) needed for the conversion of **L** to **M**. [1]

(b) Rhodri prepared benzenecarboxylic acid, C_6H_5COOH, by hydrolysing ethyl benzenecarboxylate, $C_6H_5COOC_2H_5$.

The overall equation for this hydrolysis is:

$$C_6H_5COOC_2H_5 + H_2O \longrightarrow C_6H_5COOH + C_2H_5OH$$

He used the following method.

- Dissolve 3.20 g of sodium hydroxide in water and make up to 40.0 cm^3.
- Add the aqueous sodium hydroxide to 2.90 cm^3 of ethyl benzenecarboxylate in a round bottomed flask and reflux for 30 minutes.
- Transfer the mixture into a beaker and add dilute sulfuric acid until the solution is acidic.
- Filter the crystals obtained and recrystallise the benzenecarboxylic acid by dissolving in the minimum amount of hot water.

At the end of the experiment Rhodri's yield of benzenecarboxylic acid was 1.45 g.

(i) Suggest why Rhodri had to add sulfuric acid before recrystallising.

[1]

(ii) State why water is a suitable solvent for the recrystallisation.

[1]

(iii) Calculate the concentration, in mol dm^{-3}, of the aqueous sodium hydroxide used.

[2]

(iv) The density of ethyl benzenecarboxylate is 1.06 g cm-3. Calculate how many moles of ethyl benzenecarboxylate were used.

[2]

(v) Calculate the percentage yield obtained by Rhodri.

[2]

(vi) Give a reason why the percentage yield was substantially lower than 100 %.

[1]

(Total 20)

6.

(a) 2,4-Dinitrophenylhydrazine reagent (2,4-DNP), Tollens' reagent and iodine in sodium hydroxide solution can all be used in the laboratory to identify unknown compounds. Complete the table below by giving any observations made (or writing 'no reaction' as appropriate) when these reagents are added to the compounds listed. [4]

	butan-2-ol	ethanal	ethanol	propanone
2,4-DNP	no reaction			
Tollens' reagent			no reaction	
I_2/NaOH				

(b) Under certain conditions ethanol can be formed from ethene and water. A possible mechanism for this reaction is shown below.

$$CH_2{=}CH_2 + H^+ \longrightarrow CH_3CH_2^+ \xrightarrow{H_2O} C_2H_5OH + H^+$$

(i) Classify this type of mechanism. [1]

.....

(ii) State the name given to species such as the intermediate ion $CH_3CH_2^+$. [1]

.....

(iii) Give another reaction of ethene that follows this type of mechanism.

[1]

(iv) Give a reason why the main product of the reaction between propene and water under similar conditions is propan-2-ol.

[1]

(c) Propanone can react with hydrogen cyanide.

(i) Classify the type of reaction taking place when propanone reacts in this way.

[1]

(ii) Draw the mechanism for this reaction

[3]

(Total 12)

2 (a) Chromophore [1]

(b) (i) Melting temperature **lower** than literature value / melting occurs over a temperature range [1]

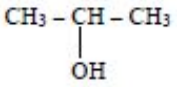
(ii) Identify percentage or amount of impurities (1)
Identify the number of compounds present or number of impurities (1) [2]

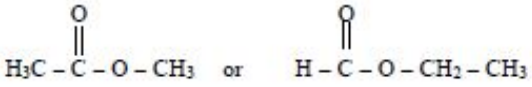
(c) (i) Acidified potassium dichromate (1)
Heat and distil (1) do not accept 'reflux' [2]

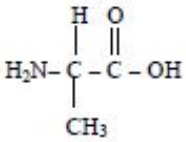
(ii) M_r of phenylmethanol = 108.08 M_r of benzenecarbaldehyde = 106.06 (1)
100% conversion would be 10.0 ÷ 108.08 × 106.06 = 9.815g (1)
86% yield = 9.815 × 86 ÷ 100 = 8.44g (1) [3]

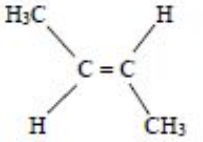
(iii) Two resonances in the range 5.8-7.0 ppm (1)
These are doublets (1)
One **singlet** at around 11.0 ppm (1)
All resonances have the same area (1) [4]

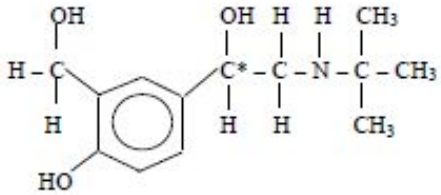
Total [13]

3 (a)(i)  [1]

(ii)  [1]

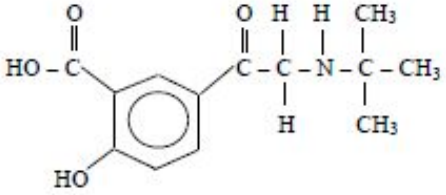
(iii)  [1]

(iv)  (or Z form) [1]

(b)(i)  [1]

(ii) The isomers rotate the plane of polarised light in opposite directions [1]

(iii) Side effects from other optical isomer / lower dose needed / improved pharmacological activity / only one isomer has correct orientation to bind with biological molecule [1]

(iv)  [2]

(1 mark for acid (accept aldehyde), 1 mark for ketone)

(c)(i) Ethylamine, ethanol, phenol, ethanoic acid [1]

(ii) Ethylamine is basic because it accepts a proton readily (1) due to the lone pair of electrons on the nitrogen. (1)
Phenol is acidic because it loses a proton / the anion formed is stabilised (1) by delocalisation of the negative charge over the benzene ring. (1)
(Accept description e.g. in phenoxide ion lone pairs of electrons on oxygen become delocalised with electrons in benzene ring.) [4]

Total [14]

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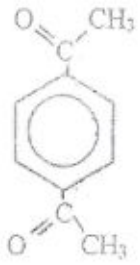
4 (a) (i) $CH_3CH_2CH_2CH_2CH_3 + Cl_2 \rightarrow CH_3CH_2CH_2CH_2CH_2Cl + HCl$ [1]

(ii) $CH_3CH_2CH_2\dot{C}HCH_3$ [1]

(b) (Anhydrous) aluminium chloride / iron(III) chloride allow $AlCl_3$ / $FeCl_3$ [1]

(c) (i) orange / red precipitate [1]

(ii)



(1) —$COCH_3$ groups in any positions

It must contain a C=O group but it is not an aldehyde as it does not react with Tollens' reagent (1) [2]

(d) (i) (Alkaline) potassium manganate(VII) (solution) allow $KMnO_4$ / MnO_4^- [1]

(ii) Dilute acid allow HCl / H^+ [1]

(iii) Lithium tetrahydridoaluminate(III) / lithium aluminium hydride
allow $LiAlH_4$ [1]

(iv)



(e) Only the infrared spectrum of benzoic acid would have a peak at 1650–1750 cm^{-1} (1)
This is due to the carbonyl group present in the benzoic acid (1) [2]

Total [12]

5 (a) (i) Moles NaOH = 5.675×10^{-3} (1)

M_r O = $\frac{0.50}{0.005675}$ = 88.1 (1) [2]

(ii) **K** contains C=O due to 2, 4-dinitrophenylhydrazine reaction (1)

Contains CH_3CO due to positive iodoform test (1)

From M_r **K** must be CH_3COCH_3 (1)

O contains COOH due to neutralisation / decarboxylation reaction (1)

From M_r O must be $CH_3CH_2CH_2COOH$ / $(CH_3)_2CHCOOH$ (1) [5]

(iii) L is $CH_3CH(OH)CH_3$ (1)

M is C_3H_6 (1)

N is C_3H_8 (1) [3]

(iv) Concentrated H_2SO_4 / Al_2O_3 / concentrated H_3PO_4 [1]

(b) (i) To form the acid from the salt / to precipitate the acid / the salt is water soluble [1]

(ii) The acid is soluble in hot water but insoluble in cold water [1]

(iii) Moles = 3.2/40 = 0.08 (1)

Concentration = 0.08/0.04 = 2 mol dm^{-3} (1) [2]

(iv) Mass = 2.90 x 1.06 = 3.074 g (1)

Moles = 3.074/150.1 = 0.0205 (1) [2]

(v) Maximum mass = 0.0205 x 122 = 2.50 g (1)

% yield = 1.45/2.50 = 58.0% (1) [2]

(vi) Hydrolysis not complete / equilibrium forms / C_6H_5COOH slightly soluble in water / two stages so some loss at both / mass lost during recrystallisation [1]

Total [20]

6 (a)

	Butan-2-ol	Ethanal	Ethanol	Propanone
2,4-DNP	No reaction	Yellow-orange precipitate	No reaction	Yellow-orange precipitate
Tollens' reagent	No reaction	Silver mirror	No reaction	No reaction
I_2/NaOH	Yellow precipitate	Yellow precipitate	Yellow precipitate	Yellow precipitate

(1 mark for each column) [4]

(b)(i) Electrophilic addition [1]

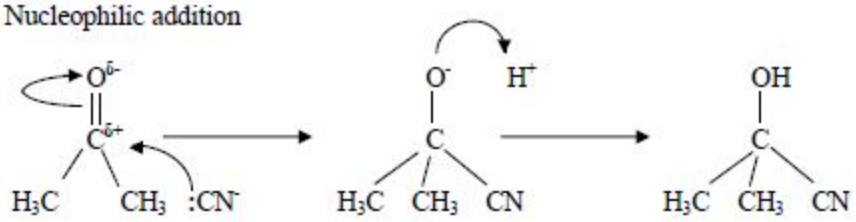
(ii) Carbonium ion / carbocation / electrophile [1]

(iii) Bromination / HBr addition / hydrogenation[1]

(iv) Secondary carbocation more stable than primary carbocation [1]

(c)(i) Nucleophilic addition [1]

(ii)



[3]

1 mark electron movement
1 mark charges

1 mark intermediate
and electron movement

(Accept $CN^{\delta-} - H^{\delta+}$ for CN^-)

Total [12]