WJEC EDUQAS A-LEVEL CHEMISTRY · COMPONENT 2

CHEMISTRY



EXAM QUESTION PACK

OA1.1 STEREOISOMERISM

SCORE	PERCENTAGE
/73	%

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1. (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]

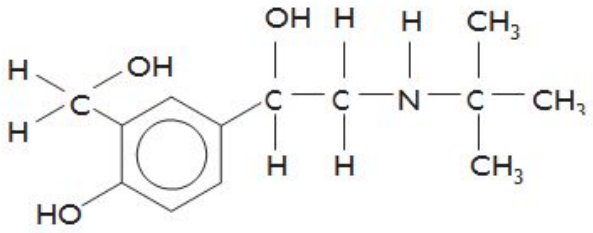
(iii) An α-amino acid

[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)

2. During 2010 a serious leak of petroleum (crude oil) occurred in the Gulf of Mexico. This loss of millions of litres of petroleum caused an environmental and ecological disaster.

(a) Petroleum consists largely of a mixture of alkanes that do not dissolve in seawater but form a surface layer. The main reason that these alkanes cannot dissolve in water is because they are unable to hydrogen bond with water. Explain what is meant by *hydrogen bonding* and use this to explain why alkanes do not dissolve in water.

[4] QWC [1]

(b)(i) Some of the leaking oil was collected by tankers and taken to oil refineries. The petroleum was then separated into fractions by the process of fractional distillation. Describe what is meant by ***fractional distillation***.

[2]

(ii) One of the fractions was then further refined into fuel for vehicles.
During refining, most of the sulfur compounds present in the fuel are removed in order to reduce the amount of oxides of sulfur released in exhaust gases.
One stage in the process is to convert unpleasant-smelling thioalcohols (R—SH) into disulfides (R—S—S—R) using copper chloride, $CuCl_2$.

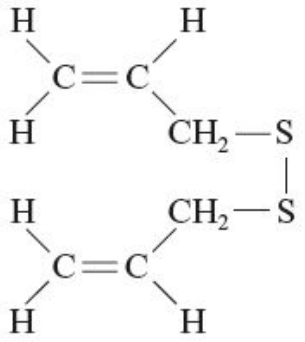
$$2R{-}SH + 2CuCl_2 \longrightarrow R{-}S{-}S{-}R + 2CuCl + 2HCl$$

Explain, using the oxidation states (numbers) of copper, why copper chloride, $CuCl_2$, is reduced in this reaction. You should assume that the oxidation state of chlorine is –1. [2]

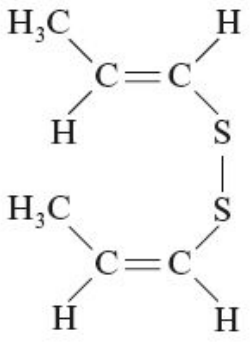
.....

.....

(c) Compounds **A** and **B** are organic compounds of sulfur found naturally in some foods.



compound **A**
found in garlic



compound **B**
produced on cooking onions

(i) These two compounds are structural isomers. State what is meant by the term *structural isomer*.

[1]

(ii) Explain why only compound **B** can exist as E-Z isomers.Your answer should comment on the atoms/groups involved and the reason why these give rise to E-Z isomerism.

[2]

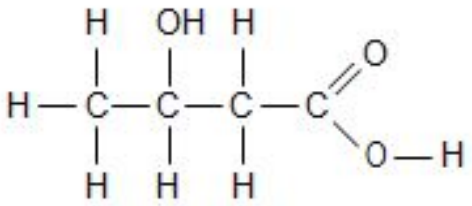
(iii) Compound **A** is sold by the chemical suppliers at £48.00 for 100 g. The material sold is only 73% pure but this is satisfactory for the purposes needed.
Calculate the cost of 1 mol of compound **A**, which has a molecular formula $C_6H_{10}S_2$. [2]

(Total 14)

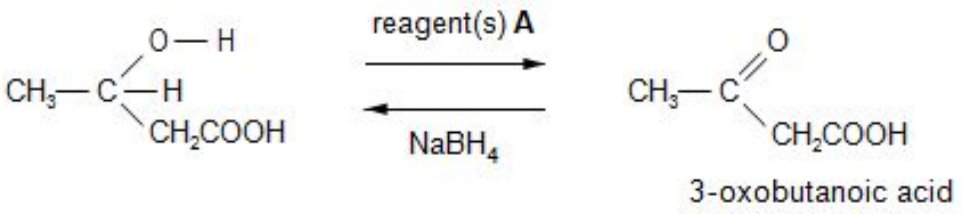
3. 3-Hydroxybutanoic acid is a white solid that can react as a carboxylic acid and an alcohol.

(a) Indicate the position of any chiral centre in the formula of 3-hydroxybutanoic acid by use of an asterisk (*).

[1]



(b) The acid can be oxidised to an oxoacid by using reagent(s) **A**. This oxoacid can then be reduced back to the hydroxyacid by sodium tetrahydridoborate(III), $NaBH_4$.



3-oxobutanoic acid

(i) State the name(s) of reagent(s) **A**.

[1]

(ii) The reduction of the oxoacid gives 3-hydroxybutanoic acid, which is present as a racemic mixture.

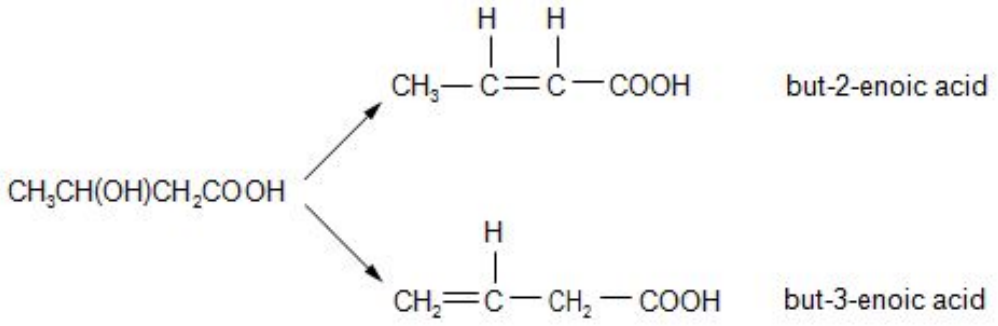
I. State what is meant by the term ***racemic mixture***.

[1]

II. State the effect (if any) that a racemic mixture has on the plane of polarised light.

[1]

(c) 3-Hydroxybutanoic acid readily undergoes an elimination reaction to form a mixture of unsaturated acids.



(i) State which of these unsaturated acids exists as *E-Z* isomers, giving a reason for your answer.

[1]

(ii) A scientist reported that the yield of the products was: but-2-enoic acid 89%, but-3-enoic acid 4%

together with unreacted 3-hydroxybutanoic acid 7%

State any additional information that another scientist would have to know so that the experiment could be repeated to confirm these yields.

[2]

1

2

(d) Both 3-hydroxybutanoic acid and 3-oxobutanoic acid will undergo the triiodomethane (iodoform) reaction. State the reagent(s) used for this reaction and the observation made.

[2]

Reagent(s). . . . . .

Observation. . . . . .

(e) Describe the NMR spectrum of this chloro-compound.

In your answer you should include the following points, **giving an explanation for each**.

• the number of peaks (and their approximate position in ppm)

• the relative peak areas

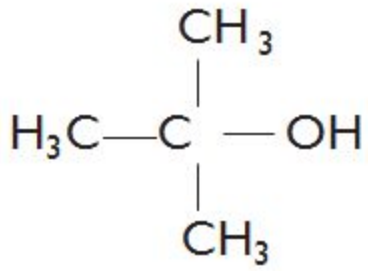
• any splitting pattern

[3] QWC [1]

(Total 13)

4. (a) In 2012 an off-licence in Derby was prosecuted for selling fake vodka

(i) A report in the local paper stated that this 'vodka' was contaminated by 'tertiary butanol', the formula of which is shown below.



State the **systematic** name of this compound.

[1]

(ii) Analysis showed that the total alcohol content of a bottle of the fake vodka was 35 %.

A gas-liquid chromatogram showed a mixture of alcohols to be present in the following proportions:

- tertiary butanol 6 parts
- methanol 8 parts
- ethanol 86 parts

Calculate the percentage of ethanol by volume in the fake vodka.

[1]

..... %

(iii) Tertiary butanol can be dehydrated in an elimination reaction to produce 2-methylpropene. Suggest a suitable dehydrating agent for this reaction.

[1]

(iv) 2-Methylpropene can be polymerised to give poly(2-methylpropene).Draw the repeating unit of the polymer.

[1]

(v) Write the displayed formula of any isomer of tertiary butanol that contains a chiral centre. Identify the chiral centre by an asterisk (*).

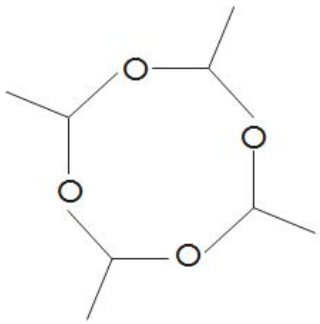
[2]

(vi) The main alcoholic compound of the fake vodka is ethanol. This can be oxidised to give ethanal.

I. State the reagent(s) used to oxidise ethanol to ethanal in the laboratory.

[1]

II Ethanal can be polymerised to 'metaldehyde', $(CH_3CHO)_4$, which is used to kill slugs.



Use the Data Sheet to describe how the infrared spectrum of 'metaldehyde' will differ from the infrared spectrum of its monomer, ethanal, giving the absorption values and the bonds involved. Reference to C —H bonds is not required. [2]

(b) The oxidation of tertiary alcohols is different from those of primary and secondary alcohols. 'Tertiary butanol' is oxidised to propanone and methanoic acid.

(i) State a test that will give a positive result for propanone but not methanoic acid.

[2]

Reagent

Observation

(ii) State a test, other than the use of an acid-base indicator, that will give a positive result for methanoic acid but not propanone.

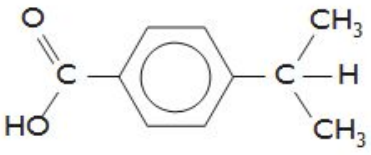
[2]

Reagent

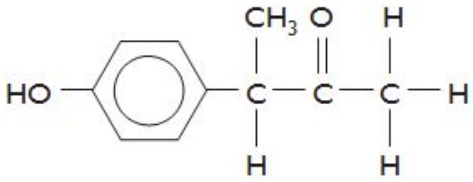
Observation

(Total 13)

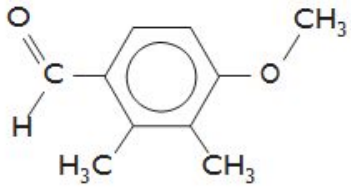
5. This question focuses on the chemistry of some of the many compounds which share the molecular formula $C_{10}H_{12}O_2$. Four compounds with this formula are shown below.



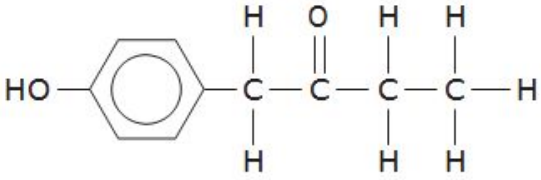
compound **W**



compound **x**



compound **y**



compound **Z**

(a) Draw an **ester** which is an isomer of the compounds above.

[1]

(b) Only one of the compounds shown can exhibit optical isomerism

(i) Identify which compound can exhibit optical isomerism.

[1]

.....

(ii) Indicate the chiral centre in this molecule by labelling it with an asterisk (*).

[1]

(iii) State how the two enantiomers of this compound can be distinguished.

[1]

(Total 19)

(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]

2 (a) Hydrogen bonding occurs between (1) oxygen, nitrogen or fluorine (1) of one molecule and hydrogen, which is bonded to oxygen / nitrogen / fluorine of another molecule (1)
Alkanes do not contain an O-H, N-H or F-H bond and cannot therefore hydrogen bond to water molecules (1) [4]

QWC *Candidates should have use 'a selection and form of writing appropriate to purpose and to complexity of subject matter'* [1]

(b) (i) The (purified) petroleum is separated by heating (1) due to the different boiling temperatures of different fractions (1)

OR the mixture is vaporised (1) and then condensed according to boiling temperatures (1) (as at the oil refinery) [2]

(ii) $CuCl_2$ Cu +2 CuCl Cu +1 (1)

(reduction occurs when) the oxidation number becomes less positive (1) [2]

(c) (i) Same molecular formula but a different structural formula / structure [1]

(ii) Both of the carbon atoms of the double bond have different atoms / groups bonded to them (1)
There is no free rotation about the double bond (1) [2]

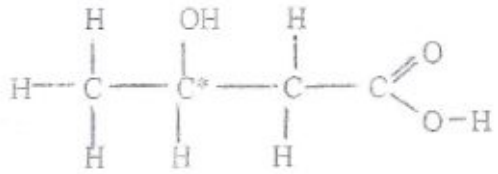
(iii) M_r of compound **A** is 146.3 / 146 (1)

Cost per mole is $\frac{146.3 \times 48 \times 100}{100 \times 73}$ = £96.20 (1)

(Accept £96.00 per mole if M_r of 146 has been used) [2]

Total [14]

3 (a)



[1]

(b) (i) Acidified potassium dichromate allow H^+, $Cr_2O_7^{2-}$ [1]

(ii) I An equimolar mixture of two enantiomers / optical isomers
do not accept 'equal mixture' [1]

II It has no (apparent) effect on the plane of polarised light [1]

(c) (i) But-2-enoic acid; this is because each of the carbon atoms of the double bond has two different groups / atoms
allow reason based on the other isomer [1]

(ii) Any TWO from the following for (1) each
reagent used / temperature / quantities / time of reaction / catalyst / solvent [2]

(d) Reagent(s) KOH / I_2 or NaOCl / KI (1) allow names
Observation Yellow precipitate (1) [2]

(e) The NMR spectrum will consist of two peaks, as there are two discrete 'areas' of protons; these will be seen at between 2.0 to 2.5 (CH_3) and between 2.5 to 3.0 (CH_2) (1)
The peak area ratio will be 3:2 for the CH_3 and CH_2 protons respectively (1)
There will be no splitting of either signal as the protons causing these signals are not bonded directly to other carbon atoms that also have protons (1)

1 max if only one peak described correctly [3]

QWC *Legibility of text; accuracy of spelling, punctuation and grammar; clarity of meaning.* [1]

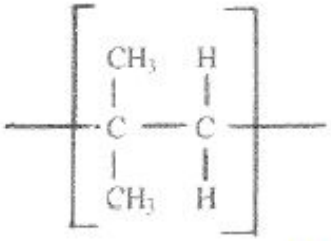
Total [13]

4 (a) (i) (2-)Methylpropan-2-ol [1]

(ii) 30.1 / 30 [1]

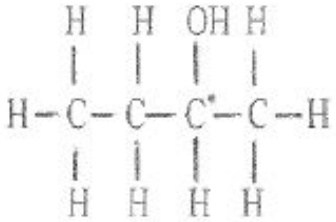
(iii) (Concentrated) sulfuric acid / phosphoric acid / aluminium oxide / pumice [1]

(iv)



(with or without n) [1]

(v)



(1) for structure, (1) for asterisk [2]

(vi) I acidified potassium dichromate / H^+, $Cr_2O_7^{2-}$(aq) [1]

II ethanal has a C = O bond at 1650-1750 cm^{-1}
(metaldehyde does not have this bond) (1)

metaldehyde has a C – O bond at 1000-1300 cm^{-1}
(ethanal does not have this bond) (1) [2]

(b) (i) **Reagent** 2,4-dinitrophenylhydrazine / 2,4-DNP OR iodine / NaOH or KI / NaOCl (1)

Observation yellow / orange / red precipitate OR yellow precipitate (1) [2]

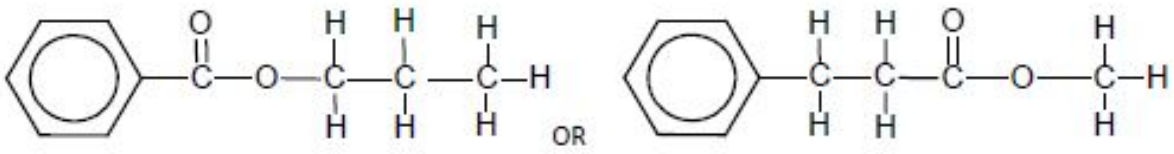
(ii) **Reagent** ethanol / sulfuric acid OR $NaHCO_3$ OR Ag^+/NH_3 / Tollens' (1)

Observation sweet smelling liquid OR effervescence OR silver mirror (1) [2]

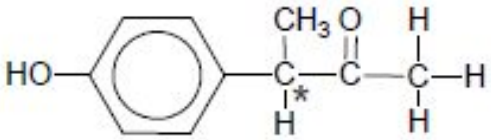
Total [13]

5 (a) Any valid ester structure with formula $C_{10}H_{12}O_2$ [1]

Examples:



(b) (i) Compound X [1]

(ii)  [1]

(iii) Rotate the plane of polarised light in opposite directions [1]