

# **WJEC Chemistry A-level**

## 4.1: Stereoisomerism

### Practice Questions

Wales Specification

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 atoms. In part (iv) the compound has **four** carbon atoms.

(i) A compound that is oxidised to a ketone

[1]

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(ii) A neutral sweet-smelling compound

[1]

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(iii) An  $\alpha$ -amino acid

[1]

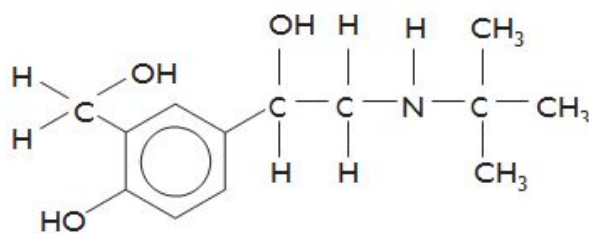
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(iv) A hydrocarbon that exhibits E-Z isomerism

[1]

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(b) The active compound in Ventolin<sup>®</sup> 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]

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

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(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]

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**(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]

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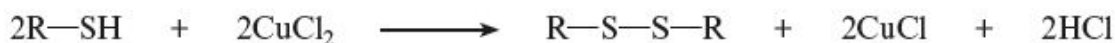
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(b)(i) Some of the leaking oil was collected by tankers and taken to oil refineries. The petroleum was then separated into fractions by the process of fractional distillation. Describe what is meant by **fractional distillation**.

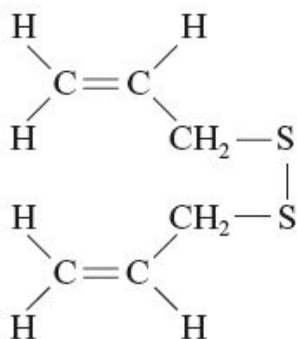
[2]

- (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<sub>2</sub>.

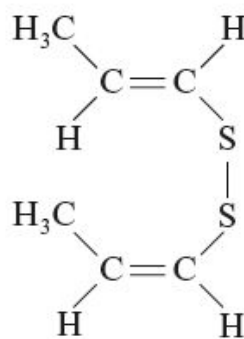


Explain, using the oxidation states (numbers) of copper, why copper chloride, CuCl<sub>2</sub>, is reduced in this reaction. You should assume that the oxidation state of chlorine is -1. [2]

- (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]

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(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]

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(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]

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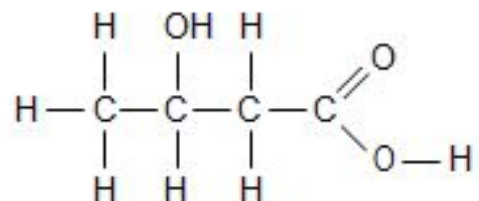
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(Total 14)

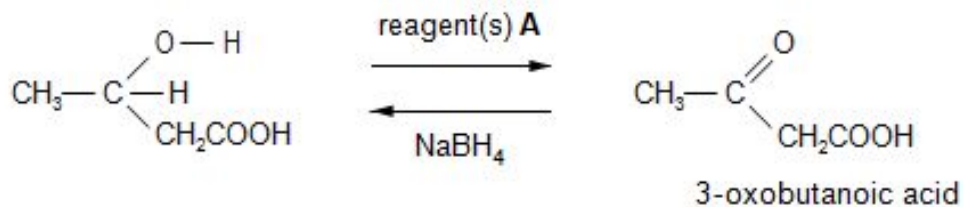
3. 3-Hydroxybutanoic acid is a white solid that can react as a carboxylic acid and an alcohol.

(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),  $\text{NaBH}_4$ .



- (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.

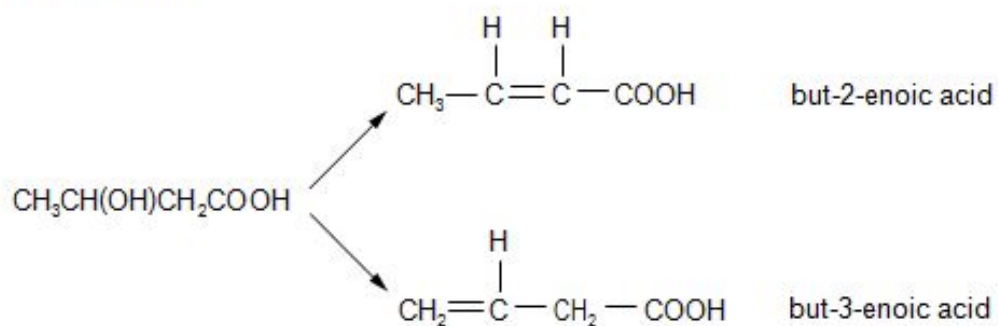
- I. State what is meant by the term *racemic mixture*.

[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]

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- (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

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2

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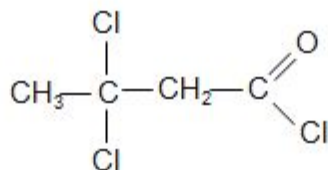
(d) Both 3-hydroxybutanoic acid and 3-oxobutanoic acid will undergo the triiodomethane (iodoform) reaction. State the reagent(s) used for this reaction and the observation made.

[2]

Reagent(s).....

Observation.....

(e) 3-Oxobutanoic acid reacts with phosphorus(V) chloride to give 3,3-dichlorobutanoyl chloride.



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]

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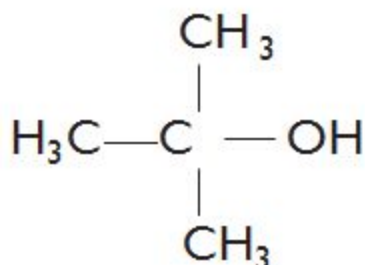
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(Total 13)



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]

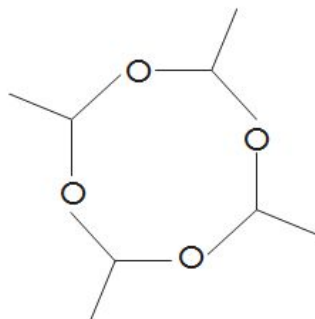
(vi) The main alcoholic compound of the fake vodka is ethanol. This can be oxidised to give ethanal.

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

[1]

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II Ethanal can be polymerised to ‘metaldehyde’,  $(\text{CH}_3\text{CHO})_4$ , 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]

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(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*

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*Observation*

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(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*

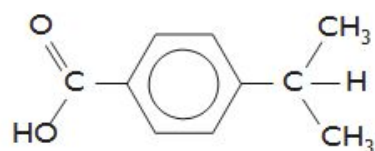
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*Observation*

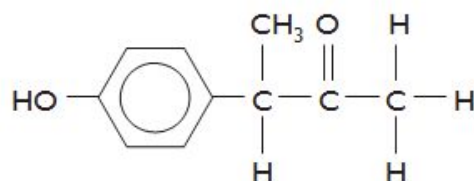
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**(Total 13)**

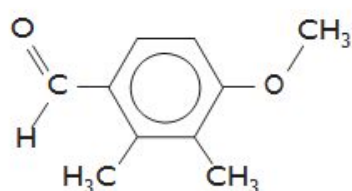
5. This question focuses on the chemistry of some of the many compounds which share the molecular formula  $C_{10}H_{12}O_7$ . Four compounds with this formula are shown below.



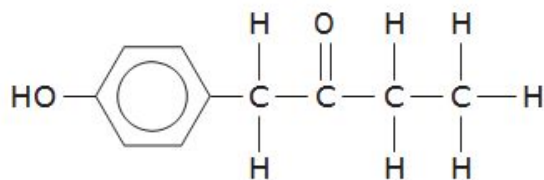
compound W



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]

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(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]

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**(Total 19)**