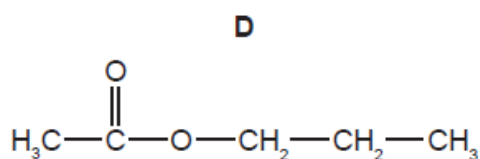
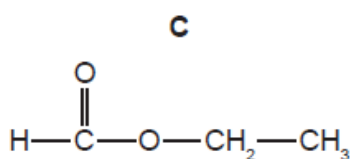
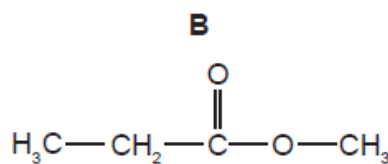
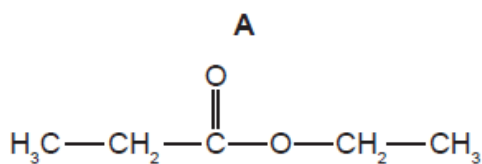


Section A

Q1 Which formula represents an ester which will form sodium ethanoate on hydrolysis with aqueous sodium hydroxide?



Q2 The ester $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{CH}_3$ is responsible for the aroma of apples. When this ester is hydrolysed by acid in the stomach, what is the empirical formula of the organic acid produced?

A CH_2O

B CH_4O

C $\text{C}_2\text{H}_4\text{O}$

D $\text{C}_3\text{H}_6\text{O}_2$

Q3 Which reaction would not give ethanoic acid as a product?

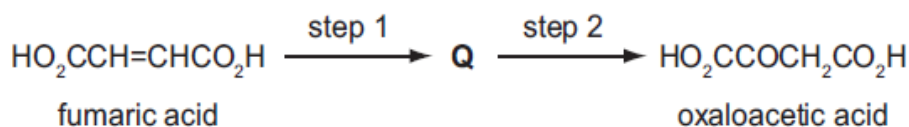
A heating ethanenitrile under reflux with dilute sodium hydroxide

B heating ethanenitrile under reflux with dilute sulfuric acid

C heating ethanal under reflux with acidified sodium dichromate(VI)

D heating ethanol under reflux with acidified sodium dichromate(VI)

Q4 Fumaric acid can be converted into oxaloacetic acid by a two-step process involving the intermediate Q.



Each of these steps can be achieved in the laboratory by a single reagent.

What could be the intermediate Q and the reagent for step 2?

	Q	reagent for step 2
A	$\text{HO}_2\text{CCHBrCH}_2\text{CO}_2\text{H}$	warm acidified KMnO_4
B	$\text{HO}_2\text{CCHBrCH(OH)CO}_2\text{H}$	warm NaOH(aq)
C	$\text{HO}_2\text{CCH(OH)CH}_2\text{CO}_2\text{H}$	Fehling's solution
D	$\text{HO}_2\text{CCH(OH)CH}_2\text{CO}_2\text{H}$	warm acidified $\text{K}_2\text{Cr}_2\text{O}_7$

Q5 Use of the Data Booklet is relevant to this question.

A sample of ethyl propanoate is hydrolysed by heating under reflux with aqueous sodium hydroxide. The two organic products of the hydrolysis are separated, purified and weighed. Out of the total mass of products obtained, what is the percentage by mass of each product?

A 32.4 % and 67.6 %

B 38.3 % and 61.7 %

C 42.3 % and 57.7 %

D 50.0 % and 50.0 %

Q6 Use of the Data Booklet is relevant to this question.

A sample of propyl ethanoate is hydrolysed by heating under reflux with aqueous sodium hydroxide. The two organic products of the hydrolysis are separated, purified and weighed. Out of the total mass of products obtained, what is the percentage by mass of each product?

- A 32.4 % and 67.6 % B 38.3 % and 61.7 %
C 42.3 % and 57.7 % D 50.0 % and 50.0 %

Q7 A compound Y has the following properties.

- It is a liquid at room temperature and atmospheric pressure.
- It does not mix completely with water.
- It does not give steamy fumes with PCl_5 .

What could Y be?

- A ethane B ethanoic acid
C ethanol D ethyl ethanoate

Q8 A common industrial solvent is a mixture of propanone, CH_3COCH_3 , and pentyl ethanoate $\text{CH}_3\text{CO}_2(\text{CH}_2)_4\text{CH}_3$.

Which reagent would have no reaction with this industrial solvent?

- A HCl (aq) B HCN (aq) with a little KCN
C Na (s) D NaBH_4

Q9 Lactic acid (2-hydroxypropanoic acid), $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}$, is found in sour milk.

Which reaction could occur with lactic acid?

- A $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H} + \text{CH}_3\text{OH} \rightarrow \text{CH}_3\text{CH}(\text{OCH}_3)\text{CO}_2\text{H} + \text{H}_2\text{O}$
B $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H} + \text{HCO}_2\text{H} \rightarrow \text{CH}_3\text{CH}(\text{O}_2\text{CH})\text{CO}_2\text{H} + \text{H}_2\text{O}$
C $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H} + \text{NaHCO}_3 \rightarrow \text{CH}_3\text{CH}(\text{ONa})\text{CO}_2\text{H} + \text{H}_2\text{O} + \text{CO}_2$
D $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H} + \text{Cl}_2 \rightarrow \text{CH}_3\text{CH}(\text{Cl})\text{CO}_2\text{H} + \text{HOCl}$

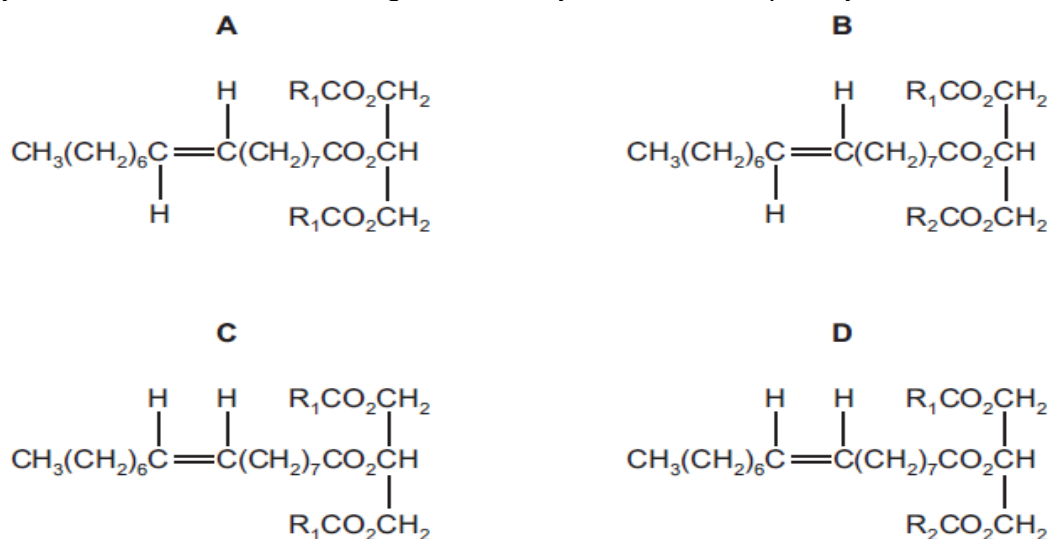
Q10 Use of the Data Booklet is relevant to this question.

2.30 g of ethanol were mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for one hour. The desired organic product was then collected by distillation. The yield of product was 60.0 %.

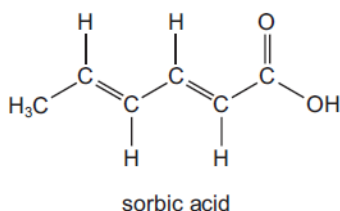
What mass of product was collected?

- A 1.32 g B 1.38 g C 1.80 g D 3.20 g

Q11 Some vegetable oils contain 'trans fats' that are associated with undesirable increases in the amount of cholesterol in the blood. In the diagrams below, R_1 and R_2 are different hydrocarbon chains. Which diagram correctly illustrates an optically active 'trans fat'?



Q12 Sorbic acid is used as a food preservative because it kills fungi and moulds.



Sorbic acid will react with

- hydrogen in the presence of a nickel catalyst,
- bromine in an organic solvent.

How many moles of hydrogen and of bromine will be incorporated into one mole of sorbic acid by these reactions?

	moles of hydrogen	moles of bromine
A	2	2
B	2	2½
C	3	2
D	3	2½

Q13 Compound Y has M_r of 88. It does not fizz when added to a solution of sodium hydrogencarbonate. It can be hydrolysed by dilute sulfuric acid to produce two organic products with M_r values of 46 and 60.

What is the identity of compound Y?

- A butanoic acid
C 3-hydroxybutanal

- B ethyl ethanoate
D butyl methanoate

Q14 How many isomeric esters, including structural isomers and stereoisomers, can be made with the molecular formula $C_5H_{10}O_2$, if methanoic acid is one of the two reactants used?

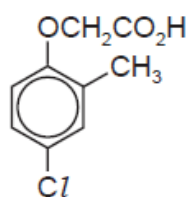
A 2

B 3

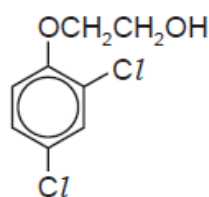
C 4

D 5

Q15 Y and Z are two widely-used selective weed killers.



Y



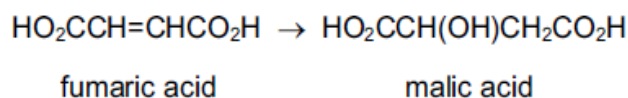
Z

Which reagent will distinguish Y from Z?

- A acidified $AgNO_3(aq)$
C Na

- B Fehling's solution
D $Na_2CO_3(aq)$

Q16 Energy is released in the human body by the oxidation of glucose in a complex sequence of reactions. Part of this sequence is the Krebs cycle. One reaction in the Krebs cycle is the conversion of fumaric acid into malic acid.



Which reagents could achieve this transformation in the laboratory?

A acidified KMnO_4

B $\text{Br}_2(\text{aq})$ followed by hot $\text{NaOH}(\text{aq})$

C H_2O with Pt catalyst

D steam with H_2SO_4

Q17 Which pair of substances could react to give the ester $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}_3$?

A ethanol and ethanoic acid

B methanol and ethanoic acid

C methanol and propanoic acid

D propan-1-ol and methanoic acid

Q18 Which reagent reacts with ethanol and also reacts with ethanoic acid?

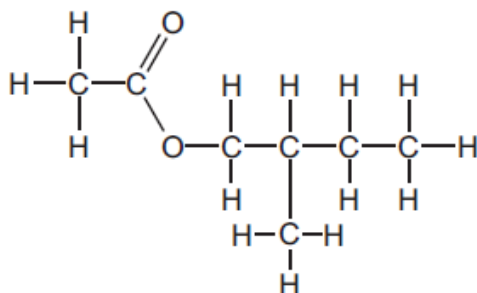
A acidified potassium dichromate(VI)

B sodium

C sodium carbonate

D sodium hydroxide

Q19 Bees use 2-methylbutyl ethanoate as an 'alarm' pheromone to alert other bees.



2-methylbutyl ethanoate

Which starting materials would be required to synthesise 2-methylbutyl ethanoate?

A $\text{CH}_3\text{CH}_2\text{OH}$ and $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CO}_2\text{H}$

B $\text{CH}_3\text{CO}_2\text{H}$ and $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$

C $\text{CH}_3\text{CH}_2\text{OH}$ and $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CO}_2\text{H}$

D $\text{CH}_3\text{CO}_2\text{H}$ and $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CO}_2\text{H}$

Section B

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

Q20 An organic compound, X, will react with an excess of calcium metal to produce a salt with the empirical formula $\text{CaC}_4\text{H}_6\text{O}_4$.

What could be the identity of X?

1 ethanoic acid

2 butanedioic acid

3 methylpropanedioic acid

Q21 A number of alcohols with the formula $\text{C}_4\text{H}_{10}\text{O}$ are separately oxidised. Using 70 g of the alcohols a 62 % yield of organic product is achieved.

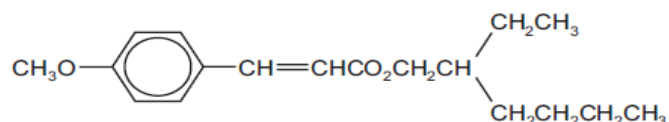
What mass of product could be obtained?

1 42.2 g of butanone

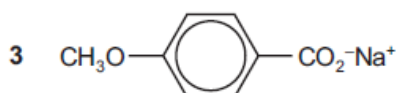
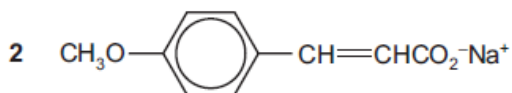
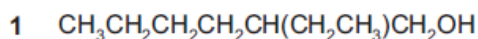
2 51.6 g of butanoic acid

3 51.6 g of 2-methyl propanoic acid

Q22 A sun protection cream contains the following ester as its active ingredient.



Which substances are present in the products of its hydrolysis by aqueous sodium hydroxide?



Q23 Which reagents, when used in an excess, can be used to make sodium lactate, $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{Na}$, from lactic acid, $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}$?

1 Na

2 NaHCO_3

3 NaOH

Q24 Ethanoic acid, $\text{CH}_3\text{CO}_2\text{H}$, is an important chemical which is used in the industrial manufacture of rayon and aspirin.

Which processes can be used to make ethanoic acid?

1 hydrolysis of ethanenitrile

2 oxidation of ethanol

3 oxidation of ethanal

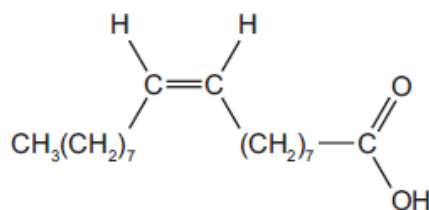
Q25 On acid hydrolysis, which compounds produce propanoic acid?

1 $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}_3$

2 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CN}$

3 $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$

Q26 Oleic acid is found in olive oil. It has the following formula.



Which reagents will give a positive result with oleic acid?

1 aqueous bromine

2 acidified potassium dichromate(VI)

3 Fehling's reagent

Q27 An organic compound, X, will react with calcium metal to produce a salt with the empirical formula $\text{CaC}_4\text{H}_4\text{O}_4$.

What could be the identity of X?

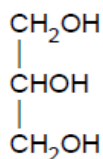
1 ethanoic acid

2 butanedioic acid

3 2-methylpropanedioic acid

1. D
2. C
3. A
4. D
5. A
6. C
7. D
8. C
9. B
10. C
11. B
12. A
13. B
14. D
15. D
16. D
17. C
18. B
19. B
20. D
21. A
22. B
23. C
24. A
25. D
26. D
27. C

Q1 Although there are many different types of food eaten around the world, animal fats and/or vegetable oils are commonly used in cooking. Animal fats and vegetable oils are usually glyceryl esters, that is esters of glycerol, propane-1,2,3-triol.



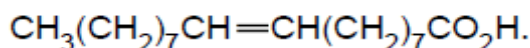
Many animal fats contain esters of stearic acid, $\text{CH}_3(\text{CH}_2)_{16}\text{CO}_2\text{H}$.

Vegetable oils often contain esters of oleic acid, $\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{CO}_2\text{H}$.

(a) Draw the structural formula of the glyceryl ester formed when one molecule of glycerol is completely esterified with stearic acid.

(b) What reagent(s) would you use, in a school or college laboratory, to obtain a small sample of oleic acid, $\text{C}_{17}\text{H}_{33}\text{CO}_2\text{H}$, from the glyceryl ester present in a vegetable oil?

.....
Oleic acid is the *cis* isomer and elaidic acid the *trans* isomer of



(c) By using this formula, draw the structural formula of elaidic acid, clearly showing the stereochemistry.

Oleic and elaidic acids are examples of mono-unsaturated acids. Many vegetable oils contain esters of polyunsaturated fatty acids. Such oils are often hydrogenated to form esters containing saturated or mono-unsaturated fatty acids.

(d) (i) Suggest the meaning of the term *polyunsaturated fatty acid*.

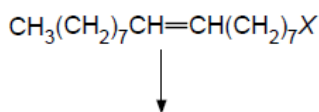
.....
(ii) What reagent and condition(s) are used for the hydrogenation of an unsaturated fatty acid?

reagent condition(s)

In cooking, unsaturated fats are often oxidised to give aldehydes or ketones.

(e) (i) Give the structural formulae of the two aldehydes formed by the partial oxidation of the unsaturated fat below.

In the structure, X, represents the rest of the fat molecule.



(ii) Name the reagent you would use to show that the product contained **either** an aldehyde **or** a ketone. What change would be seen?

reagentobservation

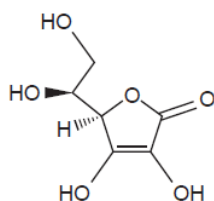
(iii) What reagent would you use to **confirm** the presence of an aldehyde? What change would be seen?

reagentobservation

Animal fats and vegetable oils can become rancid because of oxidation. The rancid fat or oil has an unpleasant smell and taste.

Antioxidants are used to prevent the spoilage of many foodstuffs by oxidation.

One antioxidant that is widely used is vitamin C, ascorbic acid.



ascorbic acid

(f) (i) How many chiral carbon atoms are present in one molecule of ascorbic acid?

If none, write 'none'

(ii) The ascorbic acid molecule contains three functional groups.

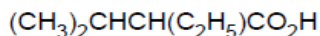
Two of these are alcohol (primary and secondary) and alkene.

What is the name of the third functional group?

(June 2011 P22)

Q2 Fermentation of sugars by bacteria or moulds produces many different organic compounds.

One compound present in fermented molasses is 2-ethyl-3-methylbutanoic acid which gives a distinctive aroma to rum.



2-ethyl-3-methylbutanoic acid

(a) (i) What is the molecular formula of 2-ethyl-3-methylbutanoic acid?

(ii) How many chiral carbon atoms are present in a molecule of 2-ethyl-3-methylbutanoic acid? If none write 'none'

A sample of 2-ethyl-3-methylbutanoic acid may be prepared in a school or college laboratory by the oxidation of 2-ethyl-3-methylbutan-1-ol, $(\text{CH}_3)_2\text{CHCH}(\text{C}_2\text{H}_5)\text{CH}_2\text{OH}$.

(b) (i) State the reagent(s) that would be used for this oxidation.

Describe what colour change would be seen.

reagent(s)

colour change from to

This reaction is carried out by heating the reacting chemicals together.

(ii) What could be the main organic impurity present in the sample of the acid?

Explain your answer.

.....

(iii) State whether a distillation apparatus or a reflux apparatus should be used. Explain your answer.

.....

.....

(c) A structural isomer of 2-ethyl-3-methylbutan-1-ol is 2-ethyl-3-methylbutan-2-ol, $(\text{CH}_3)_2\text{CHC}(\text{OH})(\text{C}_2\text{H}_5)\text{CH}_3$. What colour change would be seen if this were heated with the reagents you have given in (b)(i)? Explain your answer as clearly as you can.

.....

.....

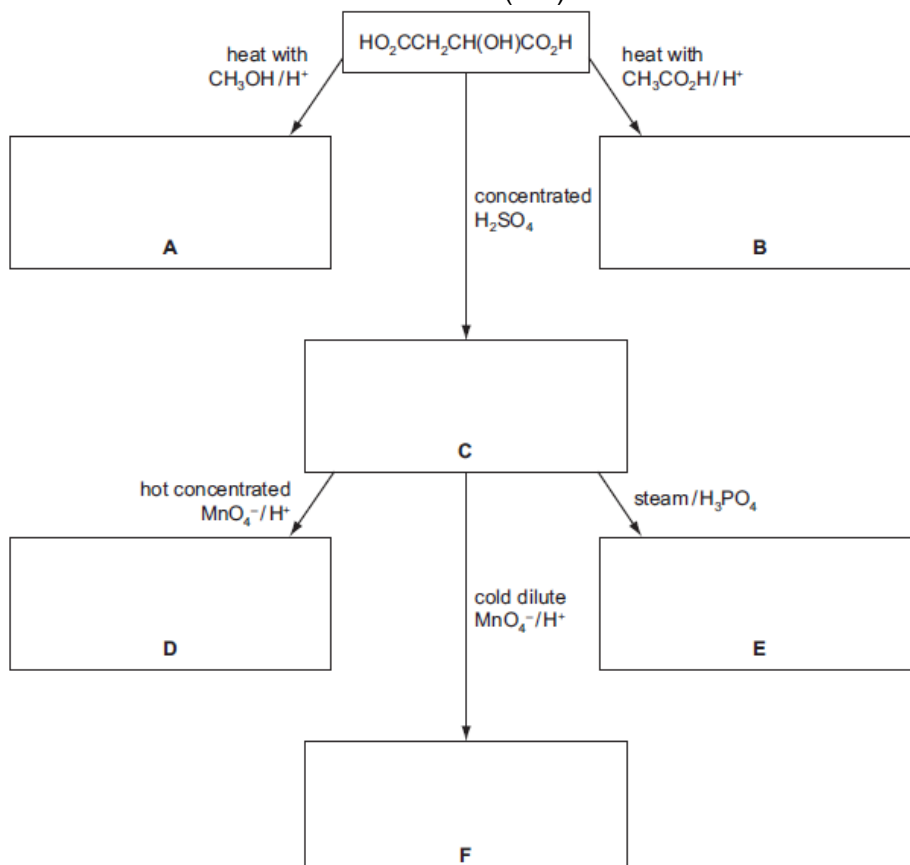
An isomer of 2-ethyl-3-methylbutanoic acid which is an ethyl ester is a very strong smelling compound which is found in some wines.

(d) This ethyl ester contains a branched hydrocarbon chain and is chiral. Draw the displayed formula of this ethyl ester. Identify the chiral carbon atom with an asterisk

(June 2011 P23)

Q3 Food additives are substances added to food to preserve the flavour or to improve its taste and appearance. European Union legislation requires most additives used in foods to be labelled clearly in the list of ingredients, either by name or by an 'E number'. E296 is malic acid which occurs in unripe fruit.

Malic acid has the structural formula $\text{HO}_2\text{CCH}_2\text{CH}(\text{OH})\text{CO}_2\text{H}$.



(b) What *type of reaction* is **each** of the following conversions?

malic acid into **C**

C into **D**

C into **E**

(c) Suggest **one** major commercial use of compounds such as **A** or **B**.

.....
(d) (i) Malic acid is chiral.

Draw fully displayed formulae of the two optical isomers of malic acid.

Indicate with an asterisk (*) the chiral carbon atom.

(ii) Compound **C** also shows stereoisomerism.

Draw the skeletal formulae of **each** of the stereoisomers of **C**. Label **each** isomer.

(e) The food additive E330 is another organic compound which occurs naturally in fruit.

E330 has the following composition by mass: C, 37.5 %; H, 4.17 %; O, 58.3 %.

Calculate the empirical formula of E330.

(June 2012 P22)

Q4 A student reacted together an alcohol and a carboxylic acid under appropriate conditions to produce an ester.

A sweet smelling organic liquid, **Q**, with the empirical formula C_2H_4O was produced.

The M_r of **Q** was found by experiment to be 87.5.

(a) What is the molecular formula of **Q**?

(b) In the boxes below, draw the structural formulae of **four** isomers with this formula that are esters.

W	X
Y	Z

A sample of **Q** was hydrolysed by heating with aqueous sulfuric acid.

The resulting mixture was heated under reflux with acidified potassium dichromate(VI) to give a **single** organic product, **R**.

The product, **R**, was collected and subjected to the following tests.

A sample of **R** gave no reaction with Tollens' reagent.

A second sample of **R** gave no reaction with 2,4-dinitrophenylhydrazine reagent.

A third sample of **R** gave an effervescence with sodium carbonate.

(c) (i) What does the result of the test with Tollens' reagent show about **R**?

.....
(ii) What does the result of the test with 2,4-dinitrophenylhydrazine reagent show about **R**?

.....
(iii) What functional group does the result of the test with sodium carbonate show to be present in **R**?

.....
(d) (i) What is the identity of the single organic compound, **R**?

.....
(ii) Which of your structures, **W**, **X**, **Y** or **Z**, represents the ester, **Q**?

.....
(e) Which, if any, of your esters, **W**, **X**, **Y** or **Z**, is chiral?

.....
 (June 2013 P22)

Q5 alcohol, aldehyde, carboxylic acid, ester or ketone functional groups. These functional groups may be identified by their reactions with specific reagents.

Compound **F** is a white solid which has the molecular formula $C_3H_6O_3$.

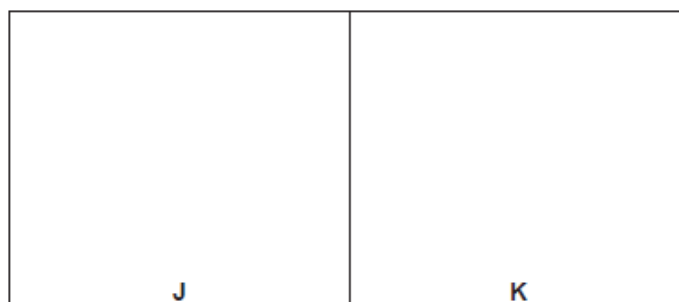
Compound **F** is soluble in water. Addition of $NaHCO_3$ to this solution produces a colourless gas, **G**, which turns lime water milky.

(a) (i) What is the identity of the gas **G**?.....

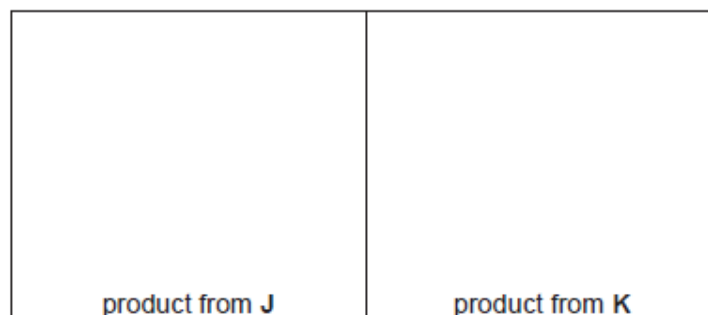
- (ii) What functional group does this test show to be present in **F**?.....
- (b) When **F** is heated with concentrated sulfuric acid, a colourless liquid **H** is produced. When cold dilute acidified KMnO_4 is shaken with **H**, the solution becomes colourless.
- (i) What *type of reaction* occurs when **H** is formed from **F**?.....
- (ii) Use your answers to (a)(ii) and (b)(i) to deduce the structural formula of the colourless liquid **H**.

(c) Compound **F** will react with sodium.
Calculate the volume of H_2 , measured at room temperature and pressure, which will be produced when 0.600 g of **F** is reacted with an excess of Na.

- (d) There are two structural isomers of **F** that give the reactions described in (a) and (b).
(i) Suggest two structural formulae for these isomers.



- (ii) Isomers **J** and **K** can both be oxidised.
What will be produced when **each** of the isomers **J** and **K** is heated under reflux with acidified $\text{K}_2\text{Cr}_2\text{O}_7$?



(June 2013 P22)