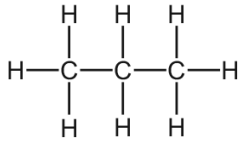
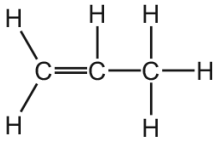
14.7 Carboxylic acids

01. 0620_m21_qp_42 Q: 5

The table shows the names or structures of organic compounds **P** to **U**.

P	Q	R
	propanoic acid	but-1-ene
S	**T**	**U**
propan-1-ol	methyl butanoate	

(a) Give the letters of the organic compounds, **P** to **U**, that are unsaturated hydrocarbons.

..... [2]

(b) Describe the test for an unsaturated hydrocarbon.

test .....

observations .....

[2]

(c) But-1-ene is an unbranched molecule.

(i) Name the unbranched isomer of but-1-ene.

..... [1]

(ii) Draw the structure of a branched isomer of but-1-ene. Show all of the atoms and all of the bonds.

[1]

(d) Dodecane is an alkane with 12 carbon atoms. Dodecane can be cracked.

(i) Write the formula of dodecane.

..... [1]

(ii) Give the letters of all the organic compounds, **P** to **U**, that can be formed when dodecane is cracked.

..... [2]

(e) Name the reagent and suggest the conditions needed to convert organic compound **U** into organic compound **S**.

reagent .....

conditions .....

[3]

(f) Organic compound **S** can be converted to organic compound **Q** by reaction with an acidified reagent.

(i) Name the type of chemical change that happens to organic compound **S**.

..... [1]

(ii) Name the acidified reagent added to organic compound **S**.

..... [1]

(g) Organic compound **T** is made by reacting two compounds together.

(i) Name the homologous series that organic compound **T** belongs to.

..... [1]

(ii) Name the **two** compounds which react together to make organic compound **T**.

Draw the structures of each compound you have named. Show all of the atoms and all of the bonds.

name .....

structure

name .....

structure

[4]

(iii) Deduce the molecular formula of organic compound **T**.

..... [1]

[Total: 20]

02. 0620_s21_qp_41 Q: 7

Many organic compounds contain carbon, hydrogen and oxygen only.

(a) An organic compound **V** has the following composition by mass.

C, 48.65%; H, 8.11%; O, 43.24%

Calculate the empirical formula of compound **V**.

empirical formula = ... [3]

(b) Compound **W** has the empirical formula CH_4O and a relative molecular mass of 32.

Calculate the molecular formula of compound **W**.

molecular formula = ... [1]

(c) Compounds **X** and **Y** have the same general formula.

X and **Y** are both carboxylic acids.

Compound **X** has the molecular formula $C_2H_4O_2$.

Compound **Y** has the molecular formula $C_4H_8O_2$.

(i) Deduce the general formula of compounds **X** and **Y**.

..... [1]

(ii) Draw the structure of compound **Y**. Show all of the atoms and all of the bonds.

Name compound **Y**.

name .....
[3]

(iii) Give the name used to describe a 'family' of similar compounds with the same general formula, similar chemical properties and the same functional group.

..... [1]

(d) Propene is an unsaturated hydrocarbon. The formula of propene is shown.

$CH_3CH=CH_2$

(i) State the colour change observed when propene is added to aqueous bromine.

from ..... to ..... [1]

(ii) Propene can be produced by cracking long chain alkanes.

Pentadecane, $C_{15}H_{32}$, is cracked to produce an alkane and propene in a 1 : 2 molar ratio.

Complete the chemical equation for this reaction.

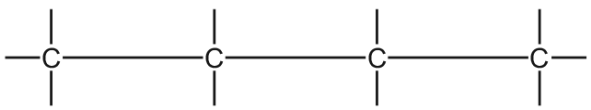
$C_{15}H_{32} \rightarrow$ ..... + ... [2]

(iii) Propene can be converted into poly(propene).

Name the type of polymerisation that occurs when propene is converted into poly(propene).

..... [1]

(iv) Complete the diagram to show a section of poly(propene).



[2]

[Total: 15]

03. 0620_s21_qp_43 Q: 7

Many organic compounds contain carbon, hydrogen and oxygen only.

(a) An organic compound **R** has the following composition by mass.

C, 69.77%; H, 11.63%; O, 18.60%

Calculate the empirical formula of compound **R**.

empirical formula = ... [2]

(b) Compound **S** has the empirical formula CH_2O and a relative molecular mass of 60.

Calculate the molecular formula of compound **S**.

molecular formula = ... [2]

(c) Compounds **T** and **V** have the same molecular formula, $C_3H_6O_2$.

- Compound **T** is an ester.
- Compound **V** contains a –COOH functional group.

(i) State the name given to compounds with the same molecular formula but different structures.

..... [1]

(ii) Name the homologous series that **V** is a member of.

..... [1]

(iii) Draw a structure of compound **T**. Show all of the atoms and all of the bonds.

Name compound **T**.

name .....
[3]

(iv) Draw the structure of compound **V**. Show all of the atoms and all of the bonds.

Name compound **V**.

name .....
[2]

(d) Ethanol can be produced from long chain alkanes such as decane, $C_{10}H_{22}$, in a two-step process.

$$\text{decane} \xrightarrow{\textbf{step 1}} \text{ethene} \xrightarrow{\textbf{step 2}} \text{ethanol}$$

For each of the two steps:
- name the type of chemical reaction that occurs
- write a chemical equation.

step 1: decane to ethene

type of reaction .....

chemical equation .....

step 2: ethene to ethanol

type of reaction .....

chemical equation .....
[4]

[Total: 15]

04. 0620_w21_qp_41 Q: 5

Alkenes and carboxylic acids are both families of similar compounds with similar chemical properties. Alkenes and carboxylic acids have different reactions.

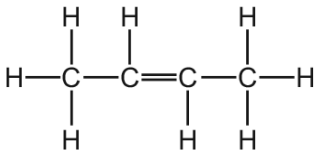
(a) State the term used for a 'family' of similar compounds.

..... [1]

(b) State the general formula of alkenes.

..... [1]

(c) The structure of but-2-ene is shown.



(i) But-2-ene reacts with aqueous bromine in an addition reaction.

Describe the colour change seen when but-2-ene is added to aqueous bromine.

from ..... to ..... [1]

(ii) State what is meant by the term *addition reaction*.

..... [1]

(iii) Write the chemical equation for the reaction between but-2-ene and bromine.

..... [2]

(iv) But-2-ene forms a polymer.

Suggest the name of the polymer formed from but-2-ene.

..... [1]

(v) Name and draw a structural isomer of but-2-ene.

Show all of the atoms and all of the bonds.

name .....

structure

[2]

(d) Butanoic acid, $CH_3CH_2CH_2COOH$, is a carboxylic acid.

(i) Deduce the empirical formula of butanoic acid.

..... [1]

(ii) Complete the chemical equation for the reaction of butanoic acid and sodium carbonate, Na_2CO_3.

$2CH_3CH_2CH_2COOH + Na_2CO_3 \rightarrow$ ..... + ... + ... [2]

(iii) Butanoic acid reacts with methanol to form an organic compound and water.

- Name the organic compound formed.

..... [1]

- Draw the structure of the organic compound formed.

Show all of the atoms and all of the bonds.

[2]

[Total: 15]

05. 0620_s20_qp_41 Q: 5

Ethanol is manufactured by two different processes.

(a) For each process, name the organic reactant and state the type of reaction.

organic reactant ..... type of reaction .....

organic reactant ..... type of reaction .....

[4]

(b) Alcohols can be oxidised to form carboxylic acids.

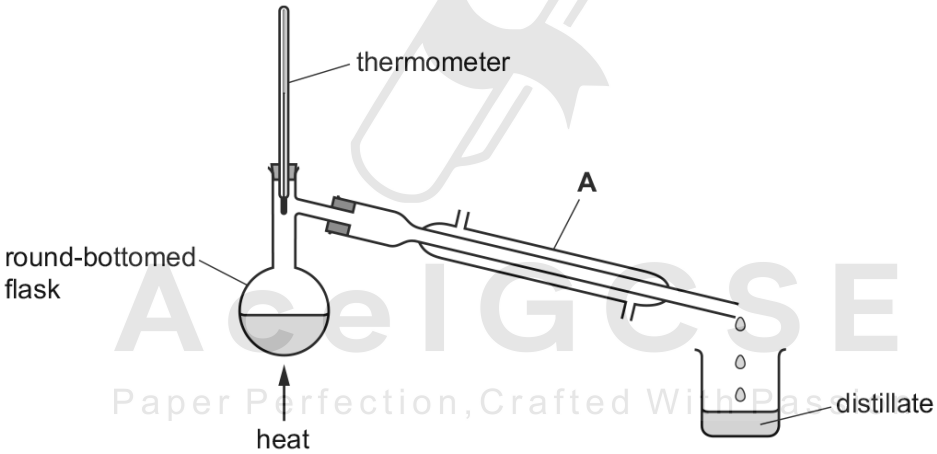
Name a suitable oxidising agent for this reaction.

..... [1]

(c) Alcohols can be partially oxidised to form aldehydes.

Aldehydes are a homologous series of organic compounds.

Partial oxidation is achieved by reacting an alcohol with the oxidising agent in distillation apparatus as shown.



(i) Name apparatus **A**.

..... [1]

(ii) On the diagram, use **one** arrow to show where water enters apparatus **A**. [1]

(d) The table shows some information about aldehydes.

(i) Complete the table.

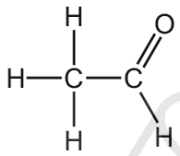
name	.....	ethanal	propanal	butanal
molecular formula	CH_2O	C_2H_4O	C_3H_6O	.....

[2]

(ii) Deduce the general formula of aldehydes.

..... [1]

(e) The structural formula of ethanal is shown.

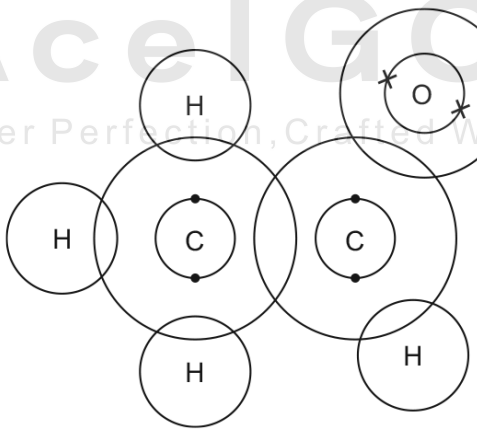


The C=O group in aldehydes is at the end of the carbon chain.
This is a reactive part of the molecule.

(i) What is the name given to the reactive part of any organic molecule?

..... [1]

(ii) Complete the dot-and-cross diagram to show the electron arrangement of a molecule of ethanal. Inner shells have been drawn.



[3]

(f) Propanone belongs to a homologous series called ketones. Ketones have the same C=O group as aldehydes but the C=O group is not at the end of the carbon chain. Propanone has the same molecular formula as propanal, C_3H_6O.

(i) What term is used to describe molecules with different structures but with the same molecular formula?

..... [1]

(ii) Suggest the structure of propanone, C_3H_6O. Show all of the atoms and all of the bonds.

[2]

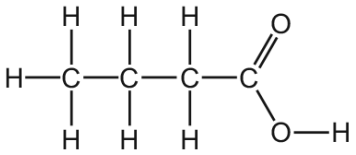
[Total: 17]

06. 0620_s20_qp_43 Q: 1

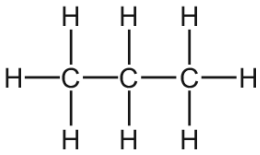
(a) The structures of five organic compounds, **A**, **B**, **C**, **D** and **E**, are shown.

Answer the questions that follow.
Each letter may be used once, more than once or not at all.

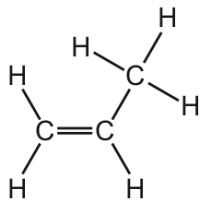
A



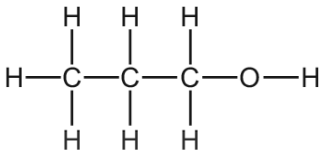
B



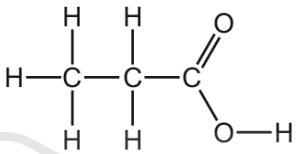
C



D



E



(i) Give the letter of the compound that is propan-1-ol.

..... [1]

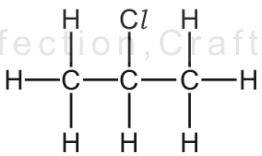
(ii) Give the letter of the compound that has the empirical formula CH_2.

..... [1]

(iii) Give the letter of **one** compound that reacts with bromine in an addition reaction.

..... [1]

(iv) Give the letter of **one** compound that reacts with chlorine to form the compound shown.



..... [1]

(v) Give the letters of **two** compounds that can react with each other to form an ester.

..... and ..... [1]

(vi) Give the letter of the compound that is in the same homologous series as hex-1-ene.

..... [1]

(vii) Give the letter of **one** compound that is an acid.

..... [1]

(viii) Draw a structural isomer of compound **D**.

Show all of the atoms and all of the bonds.

[1]

(b) Some acids are described as weak acids.

State the meaning of the term *weak acid*.

weak .....

acid .....

[2]

[Total: 10]

07. 0620_w20_qp_41 Q: 7

(a) Ethanol can be manufactured by two different methods.

Method 1: fermentation of a sugar, $C_6H_{12}O_6$

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

Method 2: reaction of ethene with steam

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

(i) Give **one** advantage of using fermentation compared with Method 2.

.....

..... [1]

(ii) Give **one** disadvantage of using fermentation compared with Method 2.

.....

..... [1]

(b) Ethanol reacts with acidified potassium manganate(VII) to form water and a product that turns litmus red.

(i) State the name of the product that turns the litmus red.

..... [1]

(ii) State the type of reaction that ethanol undergoes when it reacts with acidified potassium manganate(VII).

..... [1]

(c) Ethanol reacts with methanoic acid to form an ester.

(i) Name the ester formed in this reaction.

..... [1]

(ii) Draw the structure of the ester formed.
Show all of the atoms and all of the bonds.

[1]

(d) The table shows the melting points of ethanol and sodium chloride.

substance	melting point / °C
ethanol	–114
sodium chloride	801

The difference in melting points is due to differences in attractive forces between particles in these substances.

Name the type of attractive force in each substance, which is responsible for the difference in melting points.

ethanol .....

sodium chloride .....
[2]

[Total: 8]

---

08. 0620_m19_qp_42 Q: 4

This question is about ethanoic acid, CH_3COOH.

(a) Ethanoic acid is manufactured from methanol and carbon monoxide.

$$CH_3OH(g) + CO(g) \rightleftharpoons CH_3COOH(g)$$

The process is done at 200 °C and 30 atmospheres pressure.
The forward reaction is exothermic.

Complete the table using only the words *increases*, *decreases* or *no change*.

	effect on the rate of the forward reaction	effect on the equilibrium yield of $CH_3COOH(g)$
adding a catalyst		no change
increasing the temperature		
decreasing the pressure	decreases	

[4]

(b) How would you show that an aqueous solution of ethanoic acid is an acid **without** using an indicator or measuring the pH?

State the reagent you would use and give the expected observations. Write a chemical equation for the reaction that you describe.

- reagent

.....

- expected observations

.....

.....

- chemical equation

.....

[3]

(c) Ethanoic acid is a weak acid.

(i) What is meant by the term *acid*?

.....

..... [1]

(ii) Why is ethanoic acid described as *weak*?

.....

..... [1]

(d) Ethanoic acid reacts with methanol to form an ester.

(i) State **two** conditions required for this reaction.

1 .....

2 .....
[2]

(ii) Draw the structure of the ester formed when ethanoic acid reacts with methanol. Show all of the atoms and all of the bonds. Name the ester.

structure

name .....
[3]

(iii) Name an ester which is a structural isomer of the ester in **(d)(ii)**.

..... [1]

[Total: 15]

09. 0620_s19_qp_41 Q: 4

Ethanoic acid is a weak acid and hydrochloric acid is a strong acid.
Both ethanoic acid and hydrochloric acid dissociate in aqueous solution.

(a) (i) Define the term *acid*.

..... [1]

(ii) The chemical equation shows the changes which occur when the **strong** acid, hydrochloric acid, is added to water.

$$HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$$

Complete the chemical equation to show the changes which occur when the **weak** acid, ethanoic acid, is added to water.

$CH_3COOH(aq)$ ..... [2]

(b) A student does experiments to show that hydrochloric acid is a strong acid and ethanoic acid is a weak acid. The student adds an excess of hydrochloric acid and an excess of ethanoic acid to separate samples of lumps of calcium carbonate.

Only the identity of the acid is changed between the experiments. All other conditions are kept the same.

(i) State **two** observations which would show that hydrochloric acid is a stronger acid than ethanoic acid.

1 .....

2 .....
[2]

(ii) The student uses the same size container and checks that the pressure is the same for each experiment.

State **three** other conditions which must be kept the same to ensure fair testing.

1 .....

2 .....

3 .....
[3]

(c) Hydrochloric acid produces salts called chlorides.

Magnesium carbonate reacts with hydrochloric acid to produce magnesium chloride.

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + H_2O + CO_2$$

A student used 50.00 cm^3 of 2.00 mol/dm^3 hydrochloric acid in an experiment to produce magnesium chloride.

Calculate the mass, in g, of magnesium carbonate needed to react exactly with 50.00 cm^3 of 2.00 mol/dm^3 hydrochloric acid using the following steps.

- Calculate the number of moles of HCl present in 50.00 cm^3 of 2.00 mol/dm^3 HCl.

..... mol

- Determine the number of moles of $MgCO_3$ which would react with 50.00 cm^3 of 2.00 mol/dm^3 HCl.

..... mol

- Calculate the relative formula mass, M_r, of $MgCO_3$.

M_r of $MgCO_3$ = ...

- Calculate the mass of $MgCO_3$ needed to react exactly with 50.00 cm^3 of 2.00 mol/dm^3 HCl.

mass = ... g
[4]

(d) A student prepares crystals of magnesium chloride by adding an excess of magnesium carbonate to 50.00 cm^3 of 2.00 mol/dm^3 hydrochloric acid.

The student filters the mixture and rinses the residue.

(i) Why does the student add an **excess** of magnesium carbonate?

..... [1]

(ii) Why does the student rinse the residue?

..... [1]

(iii) Describe how the student would obtain pure crystals of magnesium chloride from the filtrate.

.....

.....

..... [3]

(e) Silver chloride, AgC*l*, is insoluble. It can be made by a precipitation reaction between aqueous barium chloride and a suitable aqueous silver salt.

(i) What is meant by the term *precipitate*?

.....

..... [2]

(ii) Name a suitable silver salt to use to prepare silver chloride.
Complete the chemical equation to show the formation of insoluble silver chloride from aqueous barium chloride and the silver salt you have named.

name of a suitable silver salt .....

$BaCl_2$ + ... → ..... + ...

[3]

[Total: 22]

10. 0620_s19_qp_42 Q: 4

Methanol is made industrially by reacting carbon monoxide with hydrogen. The gases react at a temperature of 250 °C and a pressure of 75 atmospheres.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

The forward reaction is exothermic.

(a) Suggest a source of hydrogen for this industrial process.

..... [1]

(b) Complete the table using only the words *increases*, *decreases* or *no change*.

	effect on the rate of the reverse reaction	effect on the equilibrium yield of $CH_3OH(g)$
adding a catalyst		no change
increasing the temperature	increases	
decreasing the pressure		

[4]

(c) Methanol is a member of the homologous series of alcohols.

(i) State **two** general characteristics of a homologous series.

1 .....

2 .....

[2]

(ii) Draw the structures of **two** different alcohols, each containing **three** carbon atoms. Show all of the atoms and all of the bonds.

Name these **two** alcohols.

name	name .....

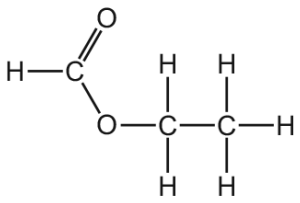
[4]

(iii) What term is used to describe compounds with the same molecular formula but different structural formulae?

..... [1]

(d) Alcohols react with carboxylic acids to produce esters.

(i) The structure of ester **X** is shown.



Name ester **X**.

..... [1]

(ii) Give the name of the carboxylic acid and the alcohol that react together to produce ester **X**.

carboxylic acid .....

alcohol .....

[2]

(iii) Ester **Y** is different from ester **X** but also has the formula $C_3H_6O_2$.

Draw the structure of ester **Y**. Show all of the atoms and all of the bonds.

.....

[2]

[Total: 17]

11. 0620_s19_qp_43 Q: 5

Carboxylic acids react with alcohols to form esters. The reaction is reversible.
The equation for the reaction between ethanoic acid and ethanol is shown.

$$CH_3COOH + CH_3CH_2OH \rightleftharpoons CH_3COOCH_2CH_3 + H_2O$$

(a) (i) What is the name of the ester formed in this reaction?

..... [1]

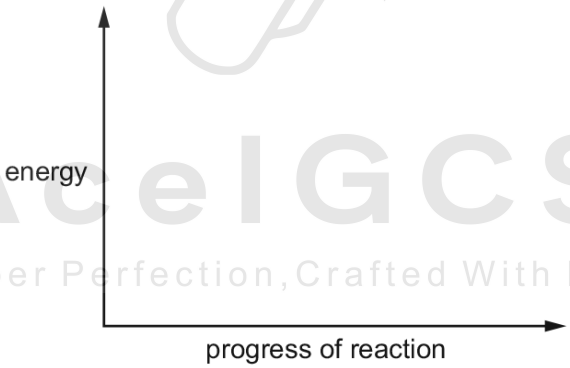
(ii) Draw the structure of the ester formed. Show all of the atoms and all of the bonds.

[1]

(b) The reaction between ethanoic acid and ethanol is exothermic.

Draw an energy level diagram for this reaction.

On your diagram label:
- the reactants and products
- the energy change of the reaction, ΔH.



[3]

(c) Concentrated sulfuric acid is a catalyst for this reaction.

What is meant by the term *catalyst*?

.....

..... [2]

(d) The rate of reaction can be increased by increasing the temperature.

Explain why increasing the temperature increases the rate of reaction.

.....

.....

.....

.....

.....

..... [4]

(e) The reaction between ethanoic acid and ethanol reaches equilibrium.

(i) The reaction between ethanoic acid and ethanol is exothermic.

State and explain the effect, if any, of increasing the temperature on the amount of ester at equilibrium.

.....

.....

..... [2]

(ii) State and explain the effect, if any, of removing water from the mixture on the amount of ester at equilibrium.

.....

.....

..... [2]

[Total: 15]

12. 0620_w19_qp_42 Q: 5

Methanol, CH_3OH, is a member of the homologous series of alcohols.

(a) Methanol can be made from methane in a two-step process.

step 1 Methane is reacted with chlorine gas to produce chloromethane, CH_3Cl.

step 2 CH_3Cl is reacted with sodium hydroxide to produce CH_3OH and one other product.

(i) What conditions are needed in **step 1**?

..... [1]

(ii) Write the chemical equation for the reaction which occurs in **step 1**.

..... [1]

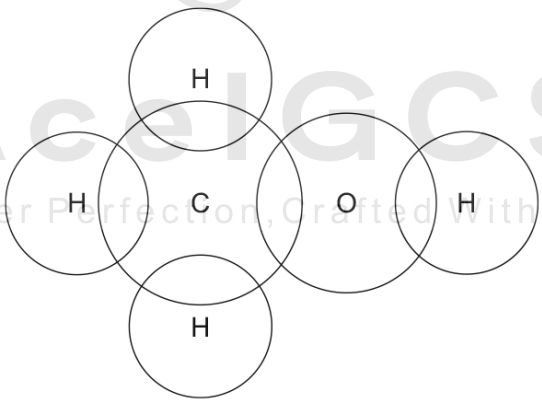
(iii) State the type of organic reaction occurring in **step 1**.

..... [1]

(iv) Complete the chemical equation for **step 2**.

$CH_3Cl + NaOH \rightarrow CH_3OH +$ ..... [1]

(b) Draw a dot-and-cross diagram to show the electron arrangement in a molecule of methanol. Show outer shell electrons only.



[2]

(c) Methanol reacts with propanoic acid to form an ester with a molecular formula $C_4H_8O_2$.

(i) Name the ester formed when methanol reacts with propanoic acid.

..... [1]

(ii) Name **one** other substance formed when methanol reacts with propanoic acid.

..... [1]

(iii) Draw the structure of an ester which is a structural isomer of the ester named in **(c)(i)**. Show all of the atoms and all of the bonds.

[3]

(iv) State the conditions needed to form an ester from a carboxylic acid and an alcohol.

..... [1]

[Total: 12]

13. 0620_s18_qp_42 Q: 7

Many organic compounds, such as alcohols, carboxylic acids and esters, contain the elements carbon, hydrogen and oxygen only.

(a) Compound **R** has the following composition by mass: C, 60.00%; H, 13.33%; O, 26.67%.

Calculate the empirical formula of compound **R**.

empirical formula = ... [2]

(b) Compound **S** has the empirical formula C_2H_4O and a relative molecular mass of 88.

Calculate the molecular formula of compound **S**.

molecular formula = ... [2]

(c) Compounds **T** and **V** both have the molecular formula $C_3H_6O_2$.

- Compound **T** produces bubbles of carbon dioxide gas when it is added to aqueous sodium carbonate.
- Compound **V** is an ester.

(i) What is the name given to compounds with the same molecular formula but different structures?

..... [1]

(ii) Draw the structures of compounds **T** and **V**. Show all of the atoms and all of the bonds.

compound **T**

compound **V**

[2]

(iii) All compounds with the molecular formula $C_3H_6O_2$ can undergo complete combustion in an excess of oxygen.

Complete the chemical equation for this reaction.

$C_3H_6O_2$ + ... → ..... + ...

[2]

(d) Compound **W** has the molecular formula C_2H_6O. Compound **W** reacts when heated with ethanoic acid and a catalyst to produce a sweet-smelling liquid.

(i) Give the name of the homologous series to which compound **W** belongs.

..... [1]

(ii) Draw the structure of compound **W**. Show all of the atoms and all of the bonds.

[1]

(e) Alkanes and alkenes are hydrocarbons.

(i) What is meant by the term *hydrocarbon*?

.....

..... [2]

(ii) State the general formula of:

alkanes .....

alkenes .....

[2]

(f) Ethanol can be produced from long-chain alkanes as shown.

long-chain alkane $\xrightarrow{\textbf{step 1}}$ ethene $\xrightarrow{\textbf{step 2}}$ ethanol

Describe the **two-stage** manufacture of ethanol from the long-chain alkane octane, C_8H_{18}.
Include:

- the names of the types of chemical reactions that occur
- reaction equations
- reaction conditions.

step 1 .....

.....

.....

.....

step 2 .....

.....

.....

..... [5]

[Total: 20]

14. 0620_s18_qp_43 Q: 4

Ethanol is a member of the homologous series of alcohols.

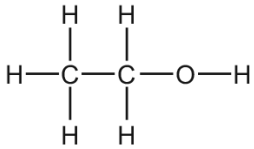
(a) Give **two** characteristics of members of a homologous series.

1 .....

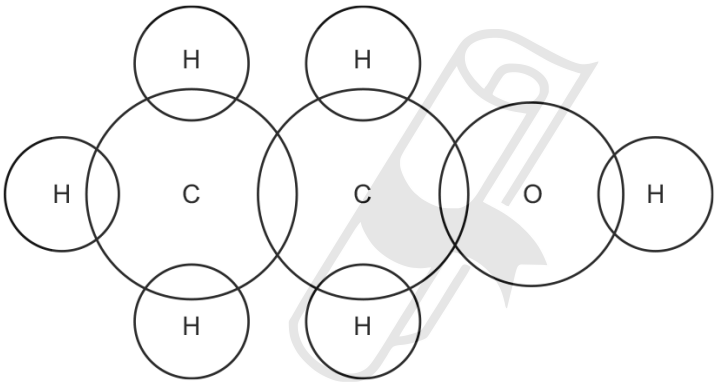
2 .....

[2]

(b) The structure of ethanol is shown.



Complete the dot-and-cross diagram to show the electron arrangement in a molecule of ethanol. Show outer shell electrons only.



[2]

(c) Ethanol can be produced by the catalytic addition of steam to ethene or by the fermentation of glucose.

(i) Write a chemical equation for the production of ethanol by the catalytic addition of steam to ethene.

..... [1]

(ii) Write a chemical equation for the production of ethanol by the fermentation of glucose, $C_6H_{12}O_6$.

..... [1]

(iii) State **one** advantage of producing ethanol by the catalytic addition of steam to ethene. Your answer must **not** refer to cost.

..... [1]

(iv) State **one** advantage of producing ethanol by the fermentation of glucose. Your answer must **not** refer to cost.

..... [1]

(d) Ethanol can be oxidised to ethanoic acid.

State the chemical reagent needed to oxidise ethanol to ethanoic acid.

..... [1]

(e) Ethanoic acid reacts with ethanol in the presence of an acid catalyst. The products are an organic compound and water.

(i) Draw the structure of the organic compound formed. Show all of the atoms and all of the bonds.

[2]

(ii) State the name of the organic compound formed.

..... [1]

(iii) Which homologous series does the organic compound formed belong to?

..... [1]

(f) Ethanoic acid, CH_3COOH, is a weak acid. It reacts with copper(II) carbonate to form the salt copper(II) ethanoate, $Cu(CH_3COO)_2$.

(i) What is meant by the term *weak* when applied to acids?

..... [1]

(ii) Describe how a crystalline sample of copper(II) ethanoate can be prepared starting with ethanoic acid and copper(II) carbonate.

.....

.....

.....

.....

.....

..... [3]

(iii) Write the word equation for the reaction between ethanoic acid and copper(II) carbonate.

..... [1]

[Total: 18]

15. 0620_s17_qp_41 Q: 6

The alkenes and alkanes are both examples of homologous series which are hydrocarbons.

(a) What is meant by the term *hydrocarbon*?

.....

..... [2]

(b) Give **three** characteristics of an homologous series.

1 .....

2 .....

3 .....

[3]

(c) Name and draw the structure of the second member of the alkene homologous series.
Show all of the atoms and all of the bonds.

name .....

structure

[2]

(d) Alcohols can be made from alkenes.

Name the reagent and conditions needed to convert an alkene into an alcohol.

.....

..... [2]

(e) The alcohol butanol, $CH_3CH_2CH_2CH_2OH$, can be converted into a carboxylic acid with four carbon atoms.

(i) Name the carboxylic acid formed from butanol and draw its structure. Show all of the atoms and all of the bonds.

name .....

structure

[2]

(ii) Ethanoic acid can be formed from ethanol by fermentation. It can also be formed by the addition of a suitable chemical reagent.

Name the reagent needed to convert ethanol into ethanoic acid.

..... [2]

(iii) State the type of chemical change which occurs when ethanol is converted into ethanoic acid.

..... [1]

(f) Describe how a student could prepare the ester methyl ethanoate in a school laboratory.
In your description give

- the names of the **two** starting organic chemicals,
- the essential reaction conditions needed,
- a chemical equation for the reaction.

.....

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 19]

16. 0620_w17_qp_41 Q: 4

(a) Ethanol, C_2H_5OH, can be made by fermentation.

(i) Complete the chemical equation for the formation of ethanol by fermentation.

$$C_6H_{12}O_6 \rightarrow \text{.....}C_2H_5OH + \text{.....}$$

[2]

(ii) State **two** conditions required for fermentation.

1 .....

2 .....

[2]

(b) Ethanol can also be made by the catalytic hydration of ethene. The equation for the reaction is shown.

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

(i) Name a suitable catalyst for this reaction.

..... [1]

(ii) Calculate the maximum mass of ethanol that can be made from 56 g of ethene.

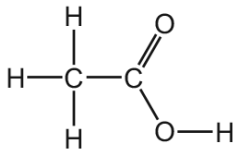
maximum mass of ethanol = ... g [2]

(c) Ethanol can be oxidised to form ethanoic acid.

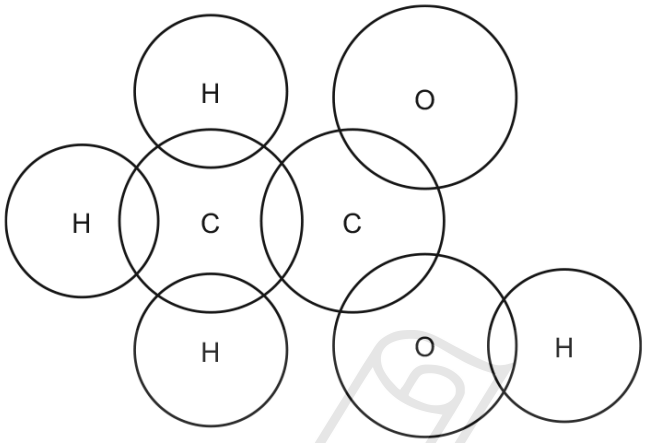
(i) Name a suitable oxidising agent for this reaction.

..... [1]

(ii) A molecule of ethanoic acid has the structure shown.



Complete the dot-and-cross diagram to show the electron arrangement in ethanoic acid. Show outer shell electrons only.



[3]

(d) Ethanoic acid is a weak acid.

(i) When referring to an acid, what is meant by the term *weak*?

.....

..... [1]

(ii) Describe how you could show that ethanoic acid is a weaker acid than hydrochloric acid.

.....

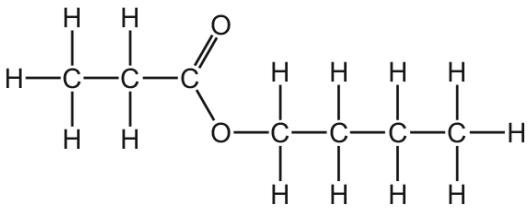
.....

.....

..... [3]

(e) Carboxylic acids react with alcohols to make esters.

The structure of an ester is shown.



Draw the structures of the carboxylic acid and alcohol from which this ester can be made.
Give the names of the carboxylic acid and alcohol.

structure of the carboxylic acid

name of the carboxylic acid .....

structure of the alcohol

name of the alcohol .....

[4]

[Total: 19]

17. 0620_w15_qp_31 Q: 5

(a) A compound, **X**, contains 55.85% carbon, 6.97% hydrogen and 37.18% oxygen.

(i) How does this prove that compound **X** contains only carbon, hydrogen and oxygen?

..... [1]

(ii) Use the above percentages to calculate the empirical formula of compound **X**.

..... [2]

(iii) The M_r of **X** is 86.

What is its molecular formula?

..... [2]

(b) **(i)** Bromine water changes from brown to colourless when added to **X**.

What does this tell you about the structure of **X**?

..... [1]

(ii) Magnesium powder reacts with an aqueous solution of **X**. Hydrogen is evolved.

What does this tell you about the structure of **X**?

..... [1]

(iii) **X** contains two different functional groups.

Draw a structural formula of **X**.

[1]

[Total: 8]

18. 0620_w14_qp_31 Q: 5

Three common pollutants in the air are carbon monoxide, the oxides of nitrogen, NO and NO_2, and unburnt hydrocarbons. They are all emitted by motor vehicles.

(a) Describe how the oxides of nitrogen are formed.

.....

..... [2]

(b) Describe how a catalytic converter reduces the emission of these three pollutants.

.....

.....

.....

.....

..... [4]

(c) Other atmospheric pollutants are lead compounds from leaded petrol.
Explain why lead compounds are harmful.

.....

..... [1]

[Total: 7]

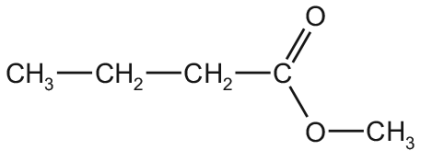
19. 0620_w14_qp_31 Q: 6

Esters, polyesters and fats all contain the ester linkage.

(a) Esters can be made from alcohols and carboxylic acids. For example, the ester ethyl ethanoate can be made by the following reaction.

$$CH_3COOH + CH_3CH_2OH \rightarrow CH_3COOCH_2CH_3 + H_2O$$

(i) Name the carboxylic acid and the alcohol from which the following ester could be made.



name of carboxylic acid .....

name of alcohol .....
[2]

(ii) 6.0 g of ethanoic acid, M_r = 60, was reacted with 5.5 g of ethanol, M_r = 46.
Determine which is the limiting reagent and the maximum yield of ethyl ethanoate, M_r = 88.

number of moles of ethanoic acid = ... [1]

number of moles of ethanol = ... [1]

the limiting reagent is ..... [1]

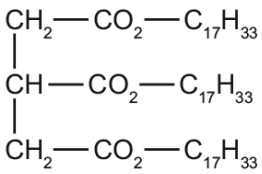
number of moles of ethyl ethanoate formed = ... [1]

maximum yield of ethyl ethanoate = ... [1]

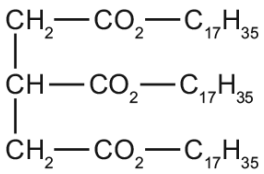
(b) The following two monomers can form a polyester.

Draw the structural formula of this polyester. Include two ester linkages.

(c) Fats and vegetable oils are esters. The formulae of two examples of natural esters are given below.



ester 1



ester 2

(i) One ester is saturated, the other is unsaturated.
Describe a test to distinguish between them.

test .....

result with unsaturated ester .....

.....

result with saturated ester .....

.....
[3]

(ii) Deduce which one of the above esters is unsaturated. Give a reason for your choice.

.....

.....

..... [2]

(iii) Both esters are hydrolysed by boiling with aqueous sodium hydroxide.
What types of compound are formed?

..... and ..... [2]

[Total: 17]

20. 0620_w14_qp_33 Q: 7

Butane is oxidised to a mixture of carboxylic acids by oxygen in the presence of a catalyst.
The acids formed are methanoic acid, ethanoic acid and propanoic acid – the first three members of the carboxylic acid homologous series.

(a) (i) Give the name and structural formula of the fourth member of this series.

name .....

structural formula showing all the atoms and bonds

[3]

(ii) State **three** characteristics of a homologous series.

.....

.....

..... [3]

(iii) All members of this series are weak acids.

What is meant by the term *weak acid*?

.....

.....

..... [3]

(b) Carboxylic acids react with alcohols to form esters. Ethanol reacts with ethanoic acid to form the ester ethyl ethanoate, $CH_3COOCH_2CH_3$.

(i) Give the name and formula of the ester which is formed from methanol and propanoic acid.

name .....

formula .....
[2]

(ii) What is the name of the ester which has the formula CH_3COOCH_3?

..... [1]

(c) (i) Complete the equation for the oxidation of butane to propanoic acid.

$$3C_4H_{10} + ...O_2 \rightarrow 4C_2H_5COOH + ...H_2O$$

[1]

(ii) Name **another** compound which can be oxidised to propanoic acid.

..... [1]

[Total: 14]

---

21. 0620_s13_qp_33 Q: 6

Sulfuric acid and malonic acid are both dibasic acids. One mole of a dibasic acid can form two moles of hydrogen ions.

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$$

Dibasic acids can form salts of the type Na_2X and CaX.

(a) Malonic acid is a white crystalline solid which is soluble in water. It melts at 135 °C. The structural formula of malonic acid is given below. It forms salts called malonates.

$$CH_2(COOH)_2 \text{ or } HOOC-CH_2-COOH$$

(i) How could you determine if a sample of malonic acid is pure?

technique used .....

result if pure ..... [2]

(ii) What is the molecular formula of malonic acid?

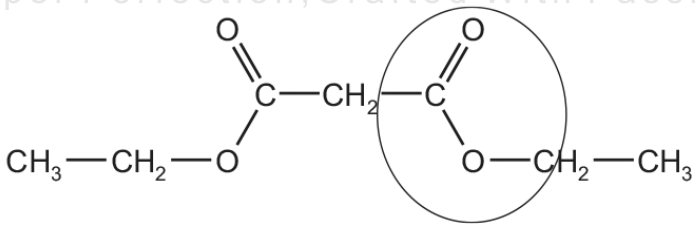
..... [1]

(iii) When malonic acid is heated there are two products, carbon dioxide and a simpler carboxylic acid. Deduce the name and molecular formula of this acid.

.....

..... [2]

(iv) Malonic acid reacts with ethanol to form a colourless liquid which has a 'fruity' smell. Its structural formula is given below.



What type of compound contains the group which is circled?

..... [1]

(b) (i) Suggest why a solution of malonic acid, concentration 0.2 mol / dm^3, has a higher pH than one of sulfuric acid of the same concentration.

..... [1]

(ii) Describe a test, other than measuring pH, which can be carried out on both acid solutions to confirm the explanation given in **(b)(i)** for the different pH values of the two acids.

.....

..... [2]

(c) Complete the following equations for reactions of these two acids.

(i) sodium hydroxide + malonic acid → ..... + ... [1]

.....

(ii) $CuO + H_2SO_4 \rightarrow$ ..... + ... [2]

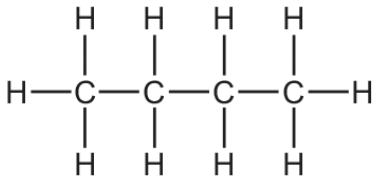
(iii) $Mg + CH_2(COOH)_2 \rightarrow$ ..... + ... [2]

(iv) $K_2CO_3 + H_2SO_4 \rightarrow$ ..... + ... + ... [2]

[Total: 16]

22. 0620_s12_qp_31 Q: 6

Butane is an alkane. It has the following structural formula.



(a) The equation for the complete combustion of butane is given below. Insert the two missing volumes.

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$$

.... 40 volume of gas / cm^3

[2]

(b) Butane reacts with chlorine to form two isomers of chlorobutane.

(i) What type of reaction is this?

..... [1]

(ii) Explain the term *isomer*.

.....

..... [2]

(iii) Draw the structural formulae of these two chlorobutanes.

[2]

(c) One of the chlorobutanes reacts with sodium hydroxide to form butan-1-ol. Butan-1-ol can be oxidised to a carboxylic acid.

(i) State a reagent, other than oxygen, which will oxidise butan-1-ol to a carboxylic acid.

..... [1]

(ii) Name the carboxylic acid formed.

..... [1]

(iii) Butan-1-ol reacts with ethanoic acid to form an ester. Name this ester and give its structural formula showing all the individual bonds.

name ..... [1]

structural formula

[2]

[Total: 12]

23. 0620_w12_qp_32 Q: 7

The alcohols form a homologous series. The first member of this series is methanol, CH_3OH.

(a) (i) Give the general formula of the alcohols.

..... [1]

(ii) The mass of one mole of an alcohol is 116 g. What is its formula?
Show your reasoning.

.....

..... [2]

(iii) Draw a diagram showing the arrangement of the outer (valency) electrons in one molecule of methanol.

Use x to represent an electron from a carbon atom.
Use o to represent an electron from a hydrogen atom.
Use ● to represent an electron from an oxygen atom.

[3]

(b) Methanol is manufactured using the following method.

$$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g) \quad \text{reaction 1}$$

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \quad \text{reaction 2}$$

The conditions for reaction 2 are:

pressure	100 atmospheres
catalyst	a mixture of copper, zinc oxide and aluminium oxide
temperature	250 °C

The forward reaction is exothermic.

(i) Why is high pressure used in reaction 2?

.....

..... [2]

(ii) Explain why using a catalyst at 250 °C is preferred to using a higher temperature of 350 °C and no catalyst.

.....

.....

..... [3]

(c) Methanol is oxidised by atmospheric oxygen. This reaction is catalysed by platinum.

(i) The products of this reaction include a carboxylic acid. Give its name and structural formula.

name .....

structural formula showing all bonds

[2]

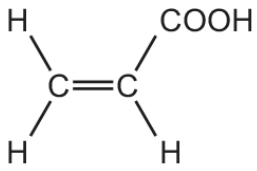
(ii) Deduce the name of the ester formed by the reaction of methanol with the carboxylic acid named in **(i)**.

..... [1]

[Total: 14]

24. 0620_w12_qp_33 Q: 5

Propenoic acid is an unsaturated carboxylic acid. The structural formula of propenoic acid is given below.



(a) (i) Describe how you could show that propenoic acid is an unsaturated compound.

test .....

result .....

..... [2]

(ii) Without using an indicator, describe how you could show that a compound is an acid.

test .....

result .....

..... [2]

(b) Propenoic acid reacts with ethanol to form an ester. Deduce the name of this ester. Draw its structural formula.

name of ester .....

structural formula showing all bonds

[3]

(c) An organic compound has a molecular formula $C_6H_8O_4$. It is an unsaturated carboxylic acid. One mole of the compound reacts with two moles of sodium hydroxide.

(i) Explain the phrase *molecular formula*.

.....

..... [2]

(ii) One mole of this carboxylic acid reacts with two moles of sodium hydroxide. How many moles of –COOH groups are there in one mole of this compound?

..... [1]

(iii) What is the formula of another functional group in this compound?

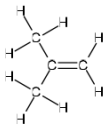
..... [1]

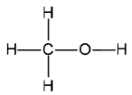
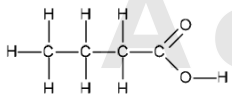
(iv) Deduce a structural formula of this compound.

[1]

[Total: 12]

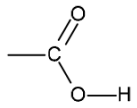
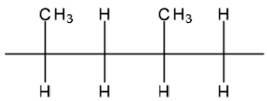
01. 0620_m21_ms_42 Q: 5

Question	Answer	Marks
(a)	R and U only	2
(b)	aqueous bromine (1) turns colourless / decolourises (1)	2
(c)(i)	but-2-ene	1
(c)(ii)	structure of methyl propene 	1
(d)(i)	$C_{12}H_{26}$	1
(d)(ii)	P, R and U	2
(e)	steam (1) catalyst (1) One other condition (1): either 60 atm **or** 300 °C	3
(f)(i)	oxidation	1
(f)(ii)	potassium manganate(VII)	1
(g)(i)	ester	1

Question	Answer	Marks
(g)(ii)	name = methanol structure =  name = butanoic acid structure = 	4
(g)(iii)	$C_5H_{10}O_2$	1

02. 0620_s21_ms_41 Q: 7

Question	Answer	Marks
(a)	48.65 / 12 8.11 / 1 43.24 / 16 (1) **OR evaluation** 4.05 8.11 2.7(0) divide all by smallest **OR** 1.5 : 3 : 1 **OR** 6 : 3 : 2 (1) $C_3H_6O_2$ (1) **ALLOW** symbols in any order	3
(b)	(M_r of CH_4O = 32) CH_4O (1)	1
(c)(i)	$C_nH_{2n}O_2$ **OR** C_nH_{2n+1} COOH	1

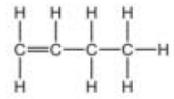
Question	Answer	Marks
(c)(ii)	butanoic acid (1) fully displayed carboxylic acid group (1)  correct structure of butanoic acid showing all atoms and bonds (1)	3
(c)(iii)	homologous series	1
(d)(i)	brown to colourless	1
(d)(ii)	C_9H_{20} (1) $2C_3H_6$ (1)	2
(d)(iii)	addition	1
(d)(iv)	 any one repeat unit (1) both repeat units fully correct (1)	2

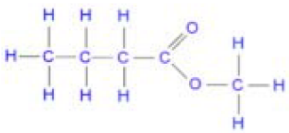
03. 0620_s21_ms_43 Q: 7

Question	Answer	Marks
(a)	11.63 / 1 69.77 / 12 18.6 /16 **Or evaluation** 11.63 5.81 1.16 **Or ratio** 10 : 5 : 1 (1) $C_5H_{10}O$ (1)	2
(b)	(M_r of CH_2O =) 30 (1) $C_2H_4O_2$ (1)	2
(c)(i)	structural isomers	1
(c)(ii)	carboxylic acids	1

Question	Answer	Marks
(c)(iii)	name of ester, corresponding to $C_3H_6O_2$: ethyl methanoate or methyl ethanoate (1) correctly displayed ester linkage (1) fully correct displayed formula corresponding to $C_3H_6O_2$ and matching named ester (1)	3
(c)(iv)	displayed formula of propanoic acid (1) propanoic acid (1)	2
(d)	**Step 1:** cracking (1) $C_{10}H_{22} \rightarrow C_2H_4 + C_8H_{18}$ (1) **Step 2:** (catalytic) addition (1) $C_2H_4 + H_2O \rightarrow C_2H_5OH$ (1)	4

04. 0620_w21_ms_41 Q: 5

Question	Answer	Marks
(a)	homologous series	1
(b)	C_nH_{2n}	1
(c)(i)	orange to colourless	1
(c)(ii)	(only) one product is formed	1
(c)(iii)	$C_4H_8 + Br_2 \rightarrow C_4H_8Br_2$ $C_4H_8Br_2$ (1) equation fully correct (1)	2
(c)(iv)	(poly) but-2-ene	1
(c)(v)	but-1-ene (1) structure of but-1-ene  (1)	2
(d)(i)	C_2H_4O	1
(d)(ii)	$2C_3H_7COOH + Na_2CO_3 \rightarrow 2C_3H_7COONa + H_2O + CO_2$ C_3H_7COONa (1) equation fully correct (1)	2

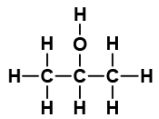
Question	Answer	Marks
(d)(iii)	methyl butanoate (1)  ester link (1) rest of structure (1)	3

05. 0620_s20_ms_41 Q: 5

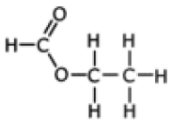
(a)	M1 sugar(s) M2 fermentation M3 ethene M4 hydration	4

(b)	(acidified) potassium manganate(VII)	1
(c)(i)	(Liebig) condenser	1
(c)(ii)	arrow at the lower inlet	1
(d)(i)	methanal	1
	C_4H_8O	1
(d)(ii)	$C_nH_{2n}O$	1
(e)(i)	functional group	1
(e)(ii)	M1 4 × C–H dot cross bonds and 1 C–C dot cross bond M2 1 × C=O dot cross bond M3 non-bonding electrons on O	3
(f)(i)	(structural) isomers	1
(f)(ii)	M1 any structure with correct valencies and formula of C_3H_6O M2 C=O bond on second carbon (of a chain of 3)	2

06. 0620_s20_ms_43 Q: 1

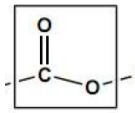
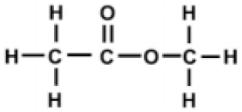
(a)(i)	**D**	**1**
(a)(ii)	**C**	**1**
(a)(iii)	**C**	**1**
(a)(iv)	**B**	**1**
(a)(v)	**D** AND **E** or **A**	**1**
(a)(vi)	**C**	**1**
(a)(vii)	**A** or **E**	**1**
(a)(viii)		**1**
(b)	donate or lose protons does not fully ionise / partially ionises / forms an equilibrium mixture	**2**

07. 0620_w20_ms_41 Q: 7

Question	Answer	Marks
(a)(i)	sugar or $C_6H_{12}O_6$, is renewable / sustainable	**1**
(a)(ii)	slow(er) process	**1**
(b)(i)	ethanoic acid	**1**
(b)(ii)	oxidation	**1**
(c)(i)	ethyl methanoate	**1**
(c)(ii)		**1**
(d)	ethanol: (forces of attraction) between molecules (1) sodium chloride: (force of attraction) between positive and negative ions/ionic bonding (1)	**2**

08. 0620_m19_ms_42 Q: 4

(a)	**M1** increases(1)	No change
	M2 increases(1)	**M3** decreases(1)
	decreases	**M4** decreases(1)
(b)	**M1** Suitable metal e.g. magnesium / any carbonate / any base(1) **M2** suitable observation e.g. insoluble base / insoluble carbonate / metal dissolve or disappear **or** metal / carbonate bubbles(1) **M3** balanced equation fully correct(1)	**3**
(c)(i)	proton donor	**1**
(c)(ii)	ionises / dissociates partially or incompletely	**1**
(d)(i)	**M1** heat(1) **M2** catalyst / concentrated sulfuric acid(1)	**2**

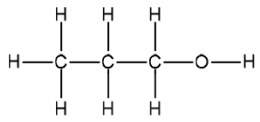
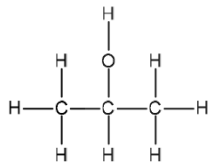
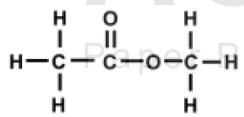
(d)(ii)	**M1** Correct ester linkage(1)  **M1** and **M2** whole molecule fully correct(2)  **M3** methyl ethanoate (1)	**3**
(d)(iii)	ethyl methanoate	**1**

09. 0620_s19_ms_41 Q: 4

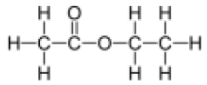
(a)(i)	proton donor	**1**
(a)(ii)	$(CH_3COOH) \rightleftharpoons CH_3COO^-$ (1) + H^+ (1)	**2**
(b)(i)	any **two** from: • faster rate of fizzing • solid dissolves quicker / disappears quicker / gets smaller quicker • fizzing stops quicker • dissolving stops quicker	**2**
(b)(ii)	any **three** from: • temperature • volume (of acid) • concentration (of acid) • mass / amount (of $CaCO_3$) • particle size / surface area (of $CaCO_3$)	**3**

(c)	**M1** mol of HC*l* = 2.00 × $\frac{50.0}{1000}$ = 0.1(00) mol (1) **M2** mol of $MgCO_3$ = $\frac{\text{M1}}{2}$ = 0.1(00) / 2 = 0.05(00) (1) **M3** M_r of $MgCO_3$ = 84 (1) **M4** mass of $MgCO_3$ = **M3** × **M2** = 84 × 0.05(00) = 4.2(0)g (1)	**4**
(d)(i)	to remove the acid / make sure all the acid is used up / no acid is left over	**1**
(d)(ii)	to make sure all the filtrate / $MgCl_2$ / salt goes through / no $MgCl_2$ left behind	**1**
(d)(iii)	evaporation mark (1) the starting of crystallisation mark (1) drying the crystals mark (1)	**3**
(e)(i)	a solid (1) which forms when two solutions are mixed / reacted / added (1)	**2**
(e)(ii)	(silver) nitrate (1) $BaCl_2 + 2AgNO_3 \rightarrow 2AgCl + Ba(NO_3)_2$ formulae (1) balance(1)	**3**

10. 0620_s19_ms_42 Q: 4

(a)	water / natural gas / hydrocarbons	1
(b)	<table><tr><td>effect on the rate of the reverse reaction</td><td>effect on the percentage of methanol in the equilibrium mixture</td></tr><tr><td>**M1 increases(1)**</td><td>no change</td></tr><tr><td>increases</td><td>**M3 decreases(1)**</td></tr><tr><td>**M2 decreases(1)**</td><td>**M4 decreases(1)**</td></tr></table>	4
(c)(i)	**any 2 from**: □ same or **similar** chemical properties or reactions (1) □ (same) general formula (1) □ (consecutive members) differ by CH_2 (1) □ same functional group (1) □ common (allow **similar)** methods of preparation (1) □ physical properties vary in predictable manner / show trends / gradually change **OR** example of a physical property variation i.e. melting point / boiling point / volatility (1)	2
(c)(ii)	**M1**  (1) **M2** propan-1-ol (1) **M3**  (1) **M4** propan-2-ol (1)	4
(c)(iii)	structural isomers / structural isomerism	1
(d)(i)	ethyl methanoate	1
(d)(ii)	**M1** methanoic acid (1) **M2** ethanol (1)	2
(d)(iii)	 **M1** correct displayed ester linkage (1) **M2** whole molecule fully correct (1)	2

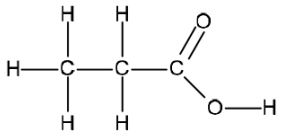
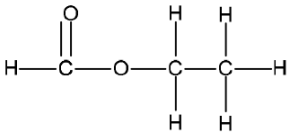
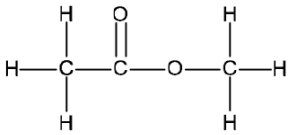
11. 0620_s19_ms_43 Q: 5

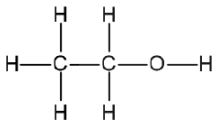
(a)(i)	ethyl ethanoate	1
(a)(ii)	correct structure of ethyl ethanoate showing all bonds 	1
(b)	**M1** right hand energy level lower than left hand side energy level **M2** reactants and product positions identified **M3** energy change shown as approximately vertical line indicating gap between reactants and products with arrow head pointing from reactant to products. Arrow needs to be labelled	3
(c)	**M1** (a substance which) increases the rate of a reaction **M2** without being used up (at the end) OR unchanged (chemically) at the end OR without changing mass	2
(d)	**M1** particles / molecules in explanation **M2** (particles) move faster / more energy **M3** more collisions per second or greater collision rate **M4** more of the (colliding) molecules / particles have sufficient energy (activation energy) to react / more of the collisions have sufficient energy (activation energy) to react	4
(e)(i)	**M1** less ester **M2** equilibrium moves left **and** because forward reaction is exothermic	2
(e)(ii)	**M1** more ester **M2** (equilibrium moves right) to replace water	2

12. 0620_w19_ms_42 Q: 5

(a)(i)	ultraviolet light	1
(a)(ii)	$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$	1
(a)(iii)	substitution	1
(a)(iv)	$NaCl$	1
(b)	all bonding pairs correct (1) H atoms have 2 electrons and C and O atoms have 8 electrons (1)	2
(c)(i)	methyl propanoate	1
(c)(ii)	water	1
(c)(iii)	molecular formula = $C_4H_8O_2$ (1) correct ester link showing all atoms and all bonds (1) rest of molecule (1)	3
(c)(iv)	(acid) catalyst	1

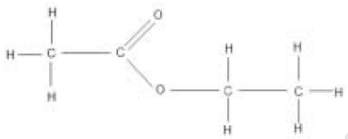
13. 0620_s18_ms_42 Q: 7

(a)	60 / 12 :13.33 / 1 : 26.67 / 16 or evaluation 5 : 13.33 : 1.67 or 3:8:1	1
	C_3H_8O	1
(b)	(C_2H_4O =) 44	1
	$C_4H_8O_2$	1
(c)(i)	structural isomers	1
(c)(ii)	**T**  **V**  **OR** 	2
(c)(iii)	$C_3H_6O_2$ + 3½ O_2 → $3CO_2$ + $3H_2O$ 1 mark for all formulae correct 1 mark for correct balancing	2

(d)(i)	alcohol / alkanol	1
(d)(ii)		1
(e)(i)	(they contain) carbon and hydrogen (atoms)	1
	only	1
(e)(ii)	alkane: C_nH_{2n+2}	1
	alkene: C_nH_{2n}	1
(f)	(step 1) crack / cracking (of octane)	1
	(step 1) equation with only C_8H_{18} on left hand side and C_2H_4 + other correct product(s) on right hand side e.g. C_8H_{18} → C_2H_4 + C_6H_{14}	1
	(step 2) hydration / addition	1
	(step 2) one correct condition for **either** process required (cracking): 450 (□) C to 800 (□) C / zeolites / aluminosilicates / silica / SiO_2 / aluminium oxide / Al_2O_3 / alumina / china / broken pot / chromium oxide / Cr_2O_3 / up to 70 atmospheres (hydration): phosphoric acid / H_3PO_4 / 300 (□)C / 60 atmospheres	1
	C_2H_4 + H_2O → C_2H_5OH / CH_3CH_2OH	1

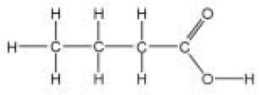
14. 0620_s18_ms_43 Q: 4

(a)	any **two** from: trend in physical properties same/similar chemical properties (same) general formula successive members differ by CH_2 same functional group	**2**
(b)	all bonding pairs correct and no extra incorrect non-bonding electrons	**1**
	4 non-bonding electrons on O completing oxygen octet	**1**
(c)(i)	$C_2H_4 + H_2O \rightarrow C_2H_5OH$	**1**
(c)(ii)	$C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH$	**1**
(c)(iii)	any **one** from: pure(r) product fast(er) reaction continuous process	**1**
(c)(iv)	any **one** from: renewable feedstock low**er** temperature low**er** pressure	**1**
(d)	(acidified) potassium manganate(VII)	**1**

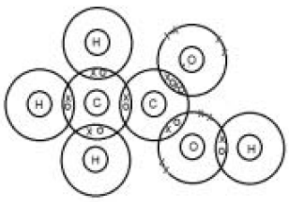
(e)(i)	ester linkage correct	**1**
	fully correct molecule 	**1**
(e)(ii)	ethyl ethanoate	**1**
(e)(iii)	ester	**1**
(f)(i)	partially dissociated / partially ionised	**1**
(f)(ii)	add excess copper(II) carbonate to ethanoic acid	**1**
	filter	**1**
	heat to point of crystallisation **AND** leave (to cool)	**1**
(f)(iii)	ethanoic acid + copper carbonate → copper ethanoate + carbon dioxide + water	**1**

15. 0620_s17_ms_41 Q: 6

(a)	(compound that) contains carbon and hydrogen	1
	and no other elements / only	1
(b)	any 3 from: • same / similar chemical properties • (same) general formula • (consecutive members) differ by CH_2 • same functional group • common (allow similar) methods of preparation • physical properties vary in predictable manner / show trends / gradually change / example of a physical property variation	3
(c)	propene	1
	structure correctly shown	1
(d)	steam	1
	catalyst	1

(e)(i)	butanoic acid	1
		1
(e)(ii)	acidified	1
	(potassium) manganate(VII)	1
(e)(iii)	oxidation	1
(f)	methanol	1
	ethanoic acid	1
	catalyst	1
	heat	1
	$CH_3COOH + CH_3OH \rightarrow CH_3COOCH_3 + H_2O$	1

16. 0620_w17_ms_41 Q: 4

(a)(i)	→ $2(C_2H_5OH)$ + $2CO_2$ **M1** carbon dioxide made as product **M2** balanced	**2**
(a)(ii)	any 2 from: □ 37 °C □ anaerobic □ glucose is aqueous □ yeast	**2**
(b)(i)	(concentrated) phosphoric acid	**1**
(b)(ii)	92 If full credit is not awarded, allow 1 mark for M_r of ethene = 28	**2**
(c)(i)	(acidified) potassium manganate(VII) **OR** potassium (di)chromate(VI)	**1**
(c)(ii)	 **M1** all shared pairs of electrons correct for single bonds **M2** 2 shared pairs of electrons for the C=O bond **M3** total of 8 electrons on each O including 4 non-bonding electrons and no additional non-bonding electrons	**3**
(d)(i)	partially ionised / dissociated	**1**

(d)(ii)	**M1** (acids) have same concentration	**1**
	M2: measure pH **OR** describe how to measure pH (such as use Universal Indicator) **M3**: lower pH corresponds to the stronger acid / hydrochloric acid **OR** **M2**: add calcium / magnesium / zinc / iron **M3**: faster rate of forming bubbles corresponds to the stronger acid / hydrochloric acid **OR** **M2**: rate of reaction with (metal) carbonate **M3**: faster rate of forming bubbles corresponds to the stronger acid / hydrochloric acid **OR** **M2**: rate of reaction with (named) metal oxide **M3**: dissolves faster means that reaction is with the stronger acid / hydrochloric acid **OR** **M2**: electrical conductivity **M3**: greater conductivity corresponds to the stronger acid / hydrochloric acid **OR** **M2**: add sodium hydroxide (or other named alkali) **M3**: greater temperature change corresponds to the stronger acid / hydrochloric acid	**2**
(e)	structure of propanoic acid	**1**
	propanoic acid	**1**
	structure of butan-1-ol	**1**
	butan-1-ol	**1**

17. 0620_w15_ms_31 Q: 5

(a)(i)	adds up to 100%;	**1**
(a)(ii)	**M1** 55.85/12 **and** 6.97(/1) **and** 37.2/16; **or** evaluation 4.650 6.970 2.325; **M2** C_2H_3O; correct answer with no working = [2]	**1** **1**
(a)(iii)	**M1** (86/)43; **M2** $C_4H_6O_2$; correct answer with no working = [2]	**1** **1**
(b)(i)	unsaturated / C=C double bond / alkene;	**1**
(b)(ii)	(organic / carboxylic) acid / contains or releases H^+ ions;	**1**
(b)(iii)	$CH_3CH=CHCOOH$ / $CH_2=CHCH_2COOH$ / $CH_2=CH(CH_3)COOH$;	**1**

18. 0620_w14_ms_31 Q: 5

(a) nitrogen and oxygen react [1]
at high temperatures (in engine) [1]

(b) M1 carbon monoxide (converted to) carbon dioxide **or** $2CO + O_2 \rightarrow 2CO_2$ [1]

M2 (by) oxides of nitrogen (which are reduced to) nitrogen
or $2NO \rightarrow N_2 + O_2$ **or** $2NO_2 \rightarrow N_2 + 2O_2$ [1]

M3 hydrocarbons (burn) making water [1]

M4 products: any **two** from:
carbon dioxide, water, nitrogen [1]

(c) lead compounds are toxic **or** brain damage **or** reduce IQ or nausea or kidney failure **or** anaemia [1]

[Total: 7]

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19. 0620_w14_ms_31 Q: 6

(a) (i) butanoic acid [1]
methanol [1]

(ii) number of moles of ethanoic acid = 0.1 [1]
number of moles of ethanol = 0.12(0) [1]
the limiting reagent is ethanoic acid [1]
number of moles of ethyl ethanoate formed = 0.1 [1]
maximum yield of ethyl ethanoate is 8.8 g [1]

(b) correct ester linkage [1]
two ester linkages (COND on M1) [1]
continuation (COND on M2) [1]

(c) (i) add bromine water/bromine [1]
turns colourless [1]
remains brown/orange/reddish brown/yellow [1]

ALLOW: potassium manganate(VII) (acidic or alkaline) [1]
correct colour colourless/green or brown ppt [1]
stays pink/purple [1]

(ii) ester 1 [1]
COND alkyl group is C_nH_{2n+1} which is NOT $C_{17}H_{33}$
or $C_{17}H_{35}$ is C_nH_{2n+1} **or** less hydrogen [1]

(iii) soap **or** (sodium) salt (of a carboxylic acid) **or** carboxylate [1]

alcohol [1]

[Total: 17]

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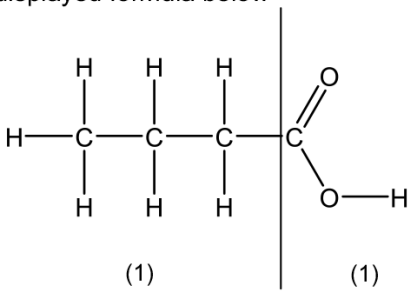
20. 0620_w14_ms_33 Q: 7

(a) (i) butanoic acid/butyric acid [1]

displayed formula below [2]



(ii) any **three** from:
same or similar chemical properties
(same) general (molecular) formula
(consecutive members) differ by CH_2
same functional group
common methods of preparation
physical properties vary in predictable manner/show trends/gradually change
or example of a physical property variation i.e. melting point/boiling point/volatility [3]

(iii) dissociates/ionises/splits up (into ions) [1]

partially/incompletely/slightly/not fully [1]

(donates) protons/(forms) H^+/H_3O^+(as the only positive ion) [1]

(b) (i) methyl propanoate [1]

$CH_3CH_2COOCH_3/CH_3CH_2CO_2CH_3/C_2H_5COOCH_3/C_2H_5CO_2CH_3$ [1]

(ii) methyl ethanoate [1]

(c) (i) $3C_4H_{10} + \mathbf{5}\,½\,O_2 \rightarrow 4C_2H_5COOH + \mathbf{3}\,H_2O$ [1]

(ii) propanol or propan-1-ol or propanal [1]

[Total: 14]

21. 0620_s13_ms_33 Q: 6

(a)	**(i)**	measure melting point	**NOT** just heating	[1]
		pure sample would melt at 135 °C **OR** impure would melt lower than 135 °C		[1]
	(ii)	$C_3H_4O_4$		[1]
	(iii)	$C_2H_4O_2$ **OR** CH_3COOH		[1]
		ethanoic **OR** acetic acid both marks are independent of each other		[1]
	(iv)	ester	**NOT** organic, covalent	[1]
(b)	**(i)**	malonic is a weaker acid/less dissociated **OR** sulfuric acid is a stronger acid/more dissociated **NOT** sulfuric acid is a strong acid		[1]
	(ii)	add piece of suitable metal, e.g. Mg **ALLOW** A*l*, Ca **NOT** K, Na, Cu		[1]
		sulfuric acid reacts fast**er OR** malonic reacts slow**er**		[1]
		OR as above add a piece of $CaCO_3$, if soluble carbonate then [1] only		
		OR measure electrical conductivity		[1]
		sulfuric acid is the bett**er** conductor **OR** malonic acid poor**er** conductor **NOT** sulfuric acid is a good conductor		[1]
(c)	**(i)**	sodium malonate **and** water		[1]
	(ii)	$CuSO_4$ H_2O		[2]
	(iii)	$CH_2(COO)_2Mg$ H_2		[2]
	(iv)	K_2SO_4 CO_2 **and** H_2O	**NOT** H_2CO_3	[2]

[Total: 16]

(a) $10\,cm^3$; [1]
$65\,cm^3$; [1]

(b) (i) chlorination / substitution / photochemical / exothermic / halogenation / free radical; [1]

(ii) (compounds) same molecular formula; different structural formulae; [2]

(iii) $CH_3–CH_2–CH_2–CH_2–Cl$ [1]
$CH_3–CH_2–CH(Cl)–CH_3$ [1]

(c) (i) potassium manganate(VII) / potassium dichromate(VI) / copper(II) oxide; [1]
note: do not insist on oxidation numbers but if given must be correct

(ii) butanoic acid; [1]

(iii) butyl ethanoate; [1]

correct formula all bonds shown = [2]
if alkyl groups incorrect then correct ester linkage showing bonds = [1] [2]

[Total: 12]

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(a) (i) $C_nH_{2n+1}OH$ [1]

(ii) 116-17 = 99, 2n+1 = 99, n = 7
for any evidence of working out [1]
$C_7H_{15}OH$ [1]

(iii) 4bps around C; [1]
1 bp on each hydrogen; [1]
2bps and 2nbps on oxygen; [1]

(b) (i) increases yield / moves equilibrium to RHS / favours forward reaction; [1]
high pressure favours side with smaller number of (gas) molecules; [1]

(ii) any two from:
higher temperature / catalyst causes faster reaction;
comment about compromise conditions to give best rate and yield;
at 250°C (lower temp) higher yield / forward reaction favoured;
at 350°C (higher temp) lower yield / back reaction favoured; [3]

(c) (i) methanoic acid; [1]
correct SF showing all bonds; [1]
accept: -OH

(ii) methyl methanoate; [1]

[Total: 14]

(a) (i) add bromine water / bromine / aqueous bromine; [1]
colourless; [1]

or add potassium manganate(VII) / permanganate; (ignore acid or alkali) [1]
colourless; [1]

(ii) add metal / carbonate / insoluble base / strong alkali **allow:** ammonia with an indicator / use pH meter; [1]
COND: on reagent

metal - hydrogen given off / metal dissolves / effervescence / gas given off / burning splint pops;

carbonate - carbon dioxide given off / effervescence / gas given off / limewater milky;

insoluble base - solution formed / dissolves;

alkali - use of indicator to show neutralisation / temperature increase;

pH meter - gives pH less than 7 [1]

(b) ethyl propenoate; [1]
correct SF all bonds shown;; [2]
allow: [1] for correct displayed ester linkage

(c) (i) number of atoms of each element; [1]
in one molecule; [1]

(ii) 2; [1]

(iii) C=C [1]

(iv) $HOOC(CH_3)C=C(CH_3)COOH$

[Total: 12]