**All questions are for separate science students only**

Q1.

This question is about organic compounds.

(a) Butane is an alkane with small molecules.

Complete the sentence.

Choose the answer from the box.

| fertiliser | formulation | fuel |
|---|---|---|

Butane can be used as a _____.

(1)

(b) Poly(propene) is a polymer.

What is the name of the monomer used to produce poly(propene)?

Tick (✓) one box.

| | |
|---|---|
| Propane | ☐ |
| Propanoic acid | ☐ |
| Propanol | ☐ |
| Propene | ☐ |

(1)

Ethene and steam react to produce ethanol.

The equation for the reversible reaction is:

$$\text{ethene} + \text{steam} \rightleftharpoons \text{ethanol}$$

(c) The reaction produces a maximum theoretical mass of 400 kg of ethanol from 243 kg of ethene and 157 kg of steam.
A company produces 380 kg of ethanol from 243 kg of ethene and 157 kg of steam.
The percentage yield of ethanol is less than 100%

Calculate the percentage yield of ethanol.

Use the equation:

$$\text{percentage yield of ethanol} = \frac{\text{mass of ethanol actually made}}{\text{maximum theoretical mass of ethanol}} \times 100$$

_____

_____

Percentage yield = _____ %

(2)

(d) What are two possible reasons why the percentage yield of ethanol is less than 100%?

Tick (✓) two boxes.

| | |
|---|---|
| Ethanol is the only product of the reaction. | ☐ |
| Ethanol is very unreactive. | ☐ |
| Some ethanol changes back into ethene and steam. | ☐ |
| Some ethanol escapes from the apparatus. | ☐ |
| Some ethanol reacts with steam. | ☐ |

(2)

(e) Ethanol burns in oxygen.

Balance the equation for the reaction.

$$C_2H_5OH + \_\_\_ O_2 \rightarrow 3 H_2O + 2 CO_2$$

(1)

(f) Two processes for producing ethanol are:

- fermentation
- hydration (reacting ethene with steam).

The table below shows information about the processes.

| Feature | Process | |
|---|---|---|
| | Fermentation | Hydration |
| Raw material | sugar | crude oil |
| Energy usage | low | high |

| | | |
|---|---|---|
| Rate of reaction | slow | fast |
| Purity of ethanol | 15% | 98% |

Give two advantages and two disadvantages of using fermentation to produce ethanol.

Advantage of fermentation 1 _____

_____

Advantage of fermentation 2 _____

_____

Disadvantage of fermentation 1 _____

_____

Disadvantage of fermentation 2 _____

_____

(4)

(Total 11 marks)

Q2.

This question is about cycloalkenes.

Cycloalkenes are ring-shaped hydrocarbon molecules containing a double carbon-carbon bond.

Cycloalkenes react in a similar way to alkenes.

(a) Describe a test for the double carbon-carbon bond in cycloalkene molecules.

Give the result of the test.

Test _____

_____

Result _____

_____

(2)

(b) The table below shows the name and formula of three cycloalkenes.

| Name | Formula |
|---|---|

| | |
|---|---|
| Cyclobutene | C4H6 |
| Cyclopentene | C5H8 |
| Cyclohexene | C6H10 |

Determine the general formula for cycloalkenes.

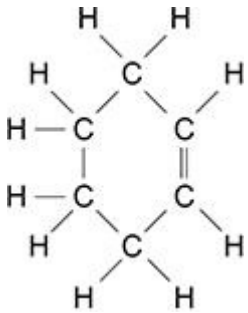
_____

General formula = _____

(1)

Figure 1 shows the displayed structural formula of cyclohexene, C6H10

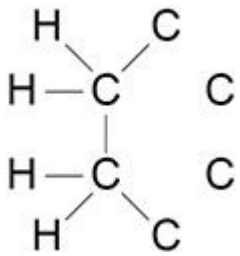
Figure 1



Chlorine reacts with cyclohexene to produce a compound with the formula C6H10Cl2

(c) Complete Figure 2 to show the displayed structural formula of C6H10Cl2

Figure 2



(2)

(d) Calculate the percentage by mass of chlorine in a molecule of C6H10Cl2

Relative atomic masses (*Ar*): H = 1 C = 12 Cl = 35.5

_____

_____

_____

_____

Percentage by mass = _____ %

(3)

(Total 8 marks)

Q3.

This question is about alkenes and alcohols.

Ethene is an alkene produced from large hydrocarbon molecules.

Large hydrocarbon molecules are obtained from crude oil by fractional distillation.

(a) Name the process used to produce ethene from large hydrocarbon molecules.

_____

(1)

(b) Describe the conditions used to produce ethene from large hydrocarbon molecules.

_____

_____

_____

_____

(2)

(c) Ethanol can be produced from ethene and steam.

The equation for the reaction is:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

The forward reaction is exothermic.

Explain how the conditions for this reaction should be chosen to produce ethanol as economically as possible.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(6)

(d) Ethanol can also be produced from sugar solution by adding yeast.

Name this process.

_____

(1)

(e) Butanol can be produced from sugar solution by adding bacteria.

Sugar solution is broken down in similar ways by bacteria and by yeast. Suggest the reaction conditions needed to produce butanol from sugar solution by adding bacteria.

_____

_____

_____

_____

(2)

Ethanol and butanol can be used as fuels for cars.

(f) A car needs an average of 1.95 kJ of energy to travel 1 m Ethanol has an energy content of 1300 kilojoules per mole (kJ/mol). Calculate the number of moles of ethanol needed by the car to travel 200 km

_____

_____

_____

_____

_____

Number of moles = _____ mol

(3)

(g) When butanol is burned in a car engine, complete combustion takes place.

Write a balanced equation for the complete combustion of butanol.

You do not need to include state symbols.

_____

(2)

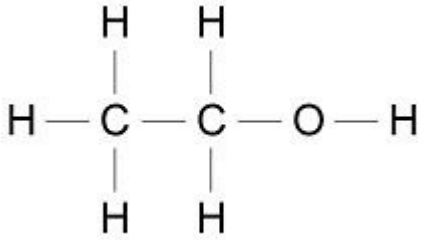
(Total 17 marks)

Q4.

This question is about ethanol and ethanoic acid.

Ethanol is an alcohol.

(a) The diagram below shows the displayed structural formula of ethanol.



Draw a circle on the diagram above around the alcohol functional group.

(1)

(b) An ethanol molecule contains atoms of three different elements.

Complete the table below to show:

- the name of each element
- the symbol for each element
- the number of atoms of each element in one molecule of ethanol.

Use the diagram above.

| Name of element | Symbol for element | Number of atoms in one molecule of ethanol |
|---|---|---|
| Carbon | C | |
| Hydrogen | | 6 |
| | O | 1 |

(3)

(c) Ethanol removes grass stains from clothes.

What type of substance is ethanol when used to remove grass stains?

Tick (✓) one box.

A solute ☐

A solution ☐

A solvent ☐

Wine contains ethanol.

Wine is produced from grape juice by fermentation.

(1)

(d) Complete the sentence.

Grape juice can be fermented to produce wine because

grape juice contains _____.

(1)

(e) What is added to grape juice to cause fermentation?

_____

(1)

(f) Ethanol reacts with ethanoic acid to produce an ester.

What is the name of the ester produced when ethanol reacts with ethanoic acid?
Tick (✓) one box.

Ethane ☐

Ethene ☐

Ethyl ethanoate ☐

(1)

(g) Ethanoic acid reacts with sodium carbonate.

The equation for the reaction is:

$2\ CH_3COOH(aq) + Na_2CO_3(s) \rightarrow 2\ CH_3COONa(aq) + H_2O(l) + CO_2(g)$

What is the name of the liquid produced by this reaction?

_____

(1)

(h) Vinegar is a solution that contains ethanoic acid.

400 cm3 of vinegar contains 20 g of ethanoic acid. Calculate the mass of ethanoic acid in 1.0 dm3 of vinegar.

_____

_____

_____

_____

_____

_____

Mass = _____g

(3)

(Total 12 marks)

Q5.

This question is about hydrocarbons.

Hexane and hexene are hydrocarbons containing six carbon atoms in each molecule.
Hexane is an alkane and hexene is an alkene.

(a) Draw one line from each hydrocarbon to the formula of that hydrocarbon.

| Hydrocarbon | Formula |
|---|---|
| | C6H8 |
| Hexane | C6H10 |
| | C6H12 |
| Hexene | C6H14 |
| | C6H16 |

(2)

(b) Bromine water is added to hexane and to hexene.

What would be observed when bromine water is added to hexane and to hexene?

Hexane _____

_____

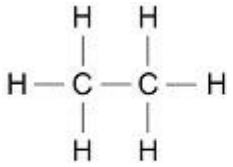
Hexene _____

_____

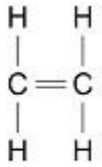
(2)

(c) Ethane is an alkane and ethene is an alkene.

The diagram below shows the displayed structural formulae of ethane and of ethene.



**Ethane**



**Ethene**

Compare ethane with ethene.

You should refer to:

- their structure and bonding
- their reactions.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(6)

(Total 10 marks)

## Q6.

This question is about carboxylic acids.

Carboxylic acids belong to a homologous series.

The table below shows information about the first three carboxylic acids in this homologous series.

| Name | Formula | pH of a 0.01 mol/dm3 solution |
|---|---|---|
| Methanoic acid | | 2.91 |
| Ethanoic acid | CH3COOH | 3.39 |
| | CH3CH2COOH | 3.44 |

(a) Complete the table above.

(2)

(b) Ethanoic acid ionises in water.

The equation for the reaction is:

$$CH3COOH(aq) \rightleftharpoons CH3COO–(aq) + H+(aq)$$

Explain how the equation shows that ethanoic acid is a weak acid.

_____

_____

_____

_____

(2)

(c) A student adds a solution of ethanoic acid to zinc carbonate in an open flask on a balance.

Explain what happens to the mass of the flask and its contents during the reaction.

_____

_____

_____

_____

_____

_____

(3)

(d) The student compares the rates of the reaction of zinc carbonate with:

- 0.01 mol/dm3 methanoic acid
- 0.01 mol/dm3 ethanoic acid.

The rate of the reaction with methanoic acid is greater than the rate of the reaction with ethanoic acid.
Explain why.

You should refer to ions in your answer.

Use the table above.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

Ethanoic acid reacts with ethanol to produce an ester.

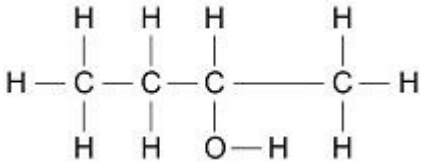
(e) Give the name of the ester produced when ethanoic acid reacts with ethanol.

_____

(1)

(f) Hexanedioic acid and ethanediol join together to produce a polyester.

Ethanoic acid and ethanol join together in the same way to produce an ester.
Which is the displayed structural formula of the ester produced when ethanoic acid reacts with ethanol?
Tick (✓) one box.



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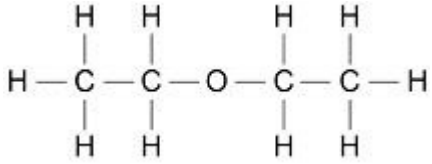

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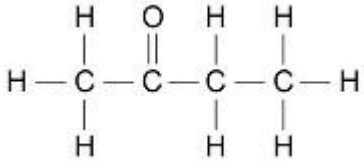

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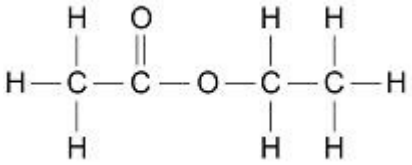


☐

(1)

(Total 12 marks)

Q7.

Methylated spirit is a useful product made from a mixture of substances.

The table below shows the mass of the substances in a sample of methylated spirit.

| Substance | Mass in grams |
|---|---|
| Ethanol | 265.5 |
| Methanol | 23.3 |
| Pyridine | 3.0 |
| Methyl violet | 1.5 |

(a) What name is given to a useful product such as methylated spirit?

_____

(1)

(b) Calculate the percentage by mass of methanol in methylated spirit.

Use the table above.

_____

_____

_____

_____

Percentage = _____ %

(2)

Methylated spirit contains ethanol and is available cheaply.

Methylated spirit also contains:

- pyridine which has a very unpleasant smell
- methyl violet which makes the mixture purple.

(c) Suggest why pyridine and methyl violet are added to ethanol to make methylated spirit.

_____

_____

(1)

(d) Suggest one use of methylated spirit.

_____

(1)

(e) Describe how ethanol is produced from sugar solution.

Give the name of this process.

_____

_____

_____

_____

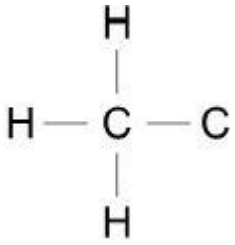
_____

_____

(3)

(f) The diagram below shows part of the displayed formula for ethanol.

Complete the diagram.



(1)

(g) Name the gas produced when sodium is added to ethanol.

_____

(1)

(h) Methanol is used to produce methanoic acid.

What type of substance reacts with methanol to produce methanoic acid?

_____

(1)

(Total 11 marks)

Q8.

The table below gives information about four alcohols.

| Alcohol | Formula | Melting point in °C | Boiling point in °C |
|---|---|---|---|
| Methanol | CH3OH | −94 | 65 |
| Ethanol | CH3CH2OH | −118 | 78 |
| Propanol | CH3CH2CH2OH | −129 | 97 |
| Butanol | CH3CH2CH2CH2OH | −89 | 118 |

(a) Which alcohol in the table is liquid over the greatest temperature range?

_____

(1)

(b) Which statement is correct?

Tick one box.

A molecule of ethanol has 5 hydrogen atoms ☐

Butanol has the highest boiling point ☐

Methanol has the largest molecules ☐

Propanol has the highest melting point ☐

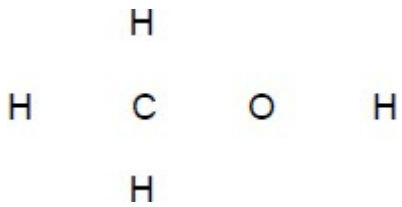
(1)

(c) A molecule of methanol has five single covalent bonds.

Draw the missing bonds in Figure 1 to complete the displayed formula for

methanol.

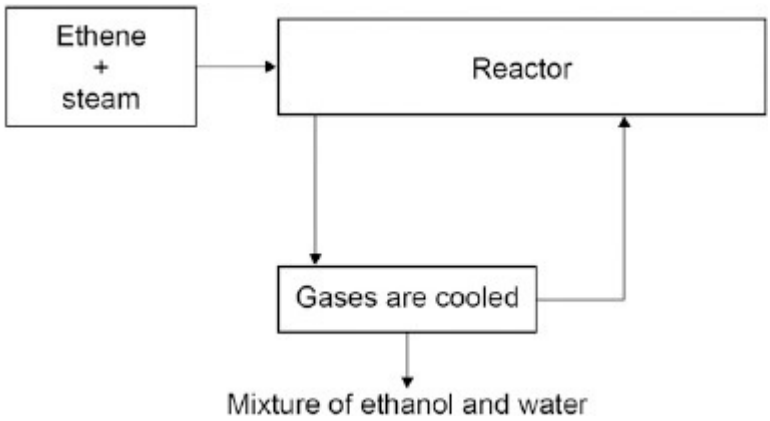
Figure 1




(1)

(d) Figure 2 shows a flow diagram of the process to produce ethanol.

Figure 2




Complete the word equation for the reaction to produce ethanol.

_____ + _____ → ethanol

(1)

(e) What happens to the unreacted ethene?

_____

_____

(1)

(f) Wine contains ethanol.
A bottle of wine was left open in air.
After a few days, the wine tasted of vinegar.
Vinegar is a solution of ethanoic acid in water.

Explain how oxidation causes the wine to taste of vinegar after a few days.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

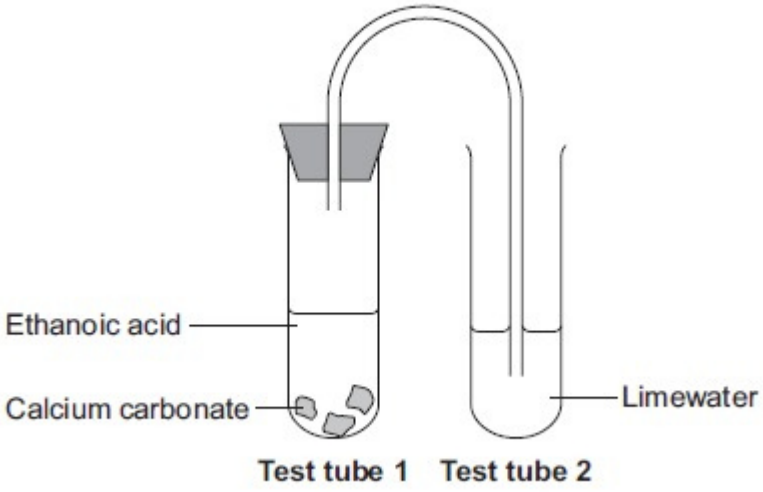
(Total 8 marks)

Q9.

This question is about reactions of ethanoic acid and the analysis of salts.

(a) Figure 1 shows the apparatus used to investigate the reaction of ethanoic acid with calcium carbonate.

**Figure 1**




(i) Describe a change that would be seen in each test tube. Give a reason for each change. Test tube 1 _____

_____

_____

_____ Test tube 2 _____

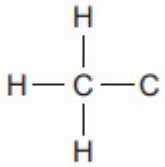
_____

_____

_____

(4)

(ii) Complete the displayed structure of ethanoic acid.



(1)

(iii) Ethanoic acid is a carboxylic acid.
Complete the sentence.

Carboxylic acids react with alcohols in the presence of an

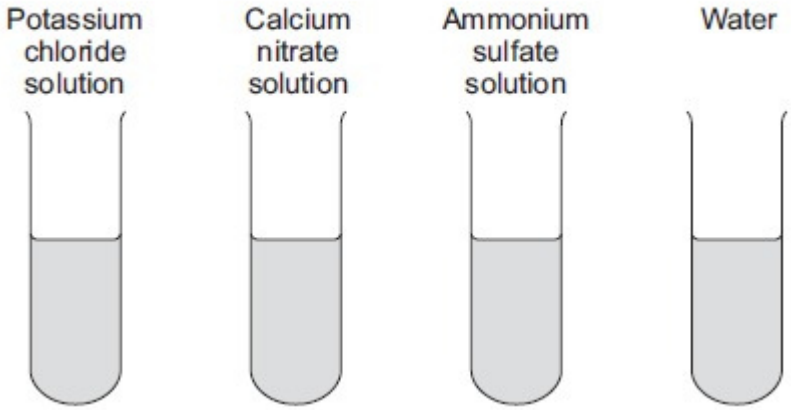
_____ catalyst to produce pleasant-smelling compounds

called _____ .

(2)

(b) Figure 2 shows four test tubes containing three different salt solutions and water.

**Figure 2**




Each solution and the water was tested with:

- silver nitrate in the presence of dilute nitric acid
- barium chloride in the presence of dilute hydrochloric acid.

Complete the table of results.

| | Potassium chloride solution | Calcium nitrate solution | Ammonium sulfate solution | Water |
|---|---|---|---|---|
| Test with silver nitrate in the | | | no change | no change |

| | | | | |
|---|---|---|---|---|
| presence of dilute nitric acid | | | | |
| Test with barium chloride in the presence of dilute hydrochloric acid | | no change | white precipitate | |

(2)

(c) Flame tests can be used to identify metal ions.

(i) Complete the following sentences.

The flame colour for potassium ions is _____ .

The flame colour for calcium ions is _____ .

(2)

(ii) Give one reason why a flame test would not show the presence of both potassium ions and calcium ions in a mixture.

_____

_____

_____

(1)

(Total 12 marks)

## Q10.

This question is about organic compounds.

Hydrocarbons can be cracked to produce smaller molecules.

The equation shows the reaction for a hydrocarbon, C18H38

$C_{18}H_{38} \rightarrow C_6H_{14} + C_4H_8 + 2\,C_3H_6 + C_2H_4$

(a) Which product of the reaction shown is an alkane?

Tick one box.

C2H4 ☐

C3H6 ☐

C4H8 ☐

C6H14 ☐

(1)

(b) The table below shows the boiling point, flammability and viscosity of C18H38 compared with the other hydrocarbons shown in the equation.

| | Boiling point | Flammability | Viscosity |
|---|---|---|---|
| A | highest | lowest | highest |
| B | highest | lowest | lowest |
| C | lowest | highest | highest |
| D | lowest | highest | lowest |

Which letter, A, B, C or D, shows how the properties of C18H38 compare with the properties of C2H4, C3H6, C4H8 and C6H14?

Tick one box.

A ☐

B ☐

C ☐

D ☐

(1)

(c) The hydrocarbon C4H8 was burnt in air.

Incomplete combustion occurred.

Which equation, A, B, C or D, correctly represents the incomplete combustion reaction?

A $C_4H_8 + 4O \rightarrow 4CO + 4H_2$

B $C_4H_8 + 4O_2 \rightarrow 4CO + 4H_2O$

C $C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$

D $C_4H_8 + 8O \rightarrow 4CO_2 + 4H_2$

Tick one box.

A ☐

B ☐

C ☐

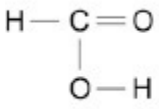
D ☐

(1)

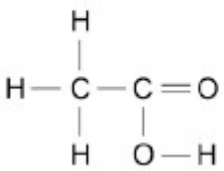
(d) Propanoic acid is a carboxylic acid.

Which structure, A, B, C or D, shows propanoic acid?

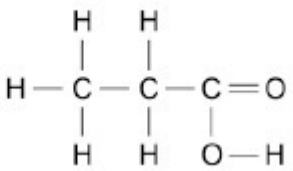
**A**



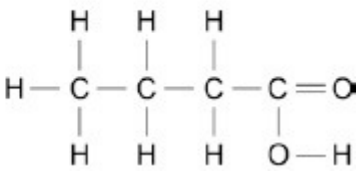
**B**



**C**



**D**



Tick one box.

A ☐

B ☐

C ☐

D ☐

(1)

(e) Propanoic acid is formed by the oxidation of which organic compound?

Tick one box.

Propane ☐

Propene ☐

Propanol ☐

Polyester ☐

(1)

(Total 5 marks)