Name: _____

Class: _____

Date: _____

Organic Chemistry part 4 AQA Triple Chemistry

Time: **70 minutes**

Marks: **68 marks**

Comments:

1. This question is about alkenes and crude oil.

(a) Pentene is an alkene molecule containing five carbon atoms.

Complete the formula for pentene.

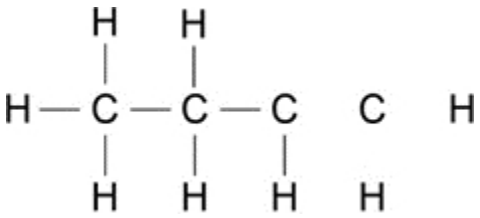
C _____ H _____

(1)

(b) Butene is an alkene molecule containing four carbon atoms.

The diagram shows all of the atoms and some of the bonds in the displayed formula for butene.

Complete the displayed formula by adding the remaining bonds.



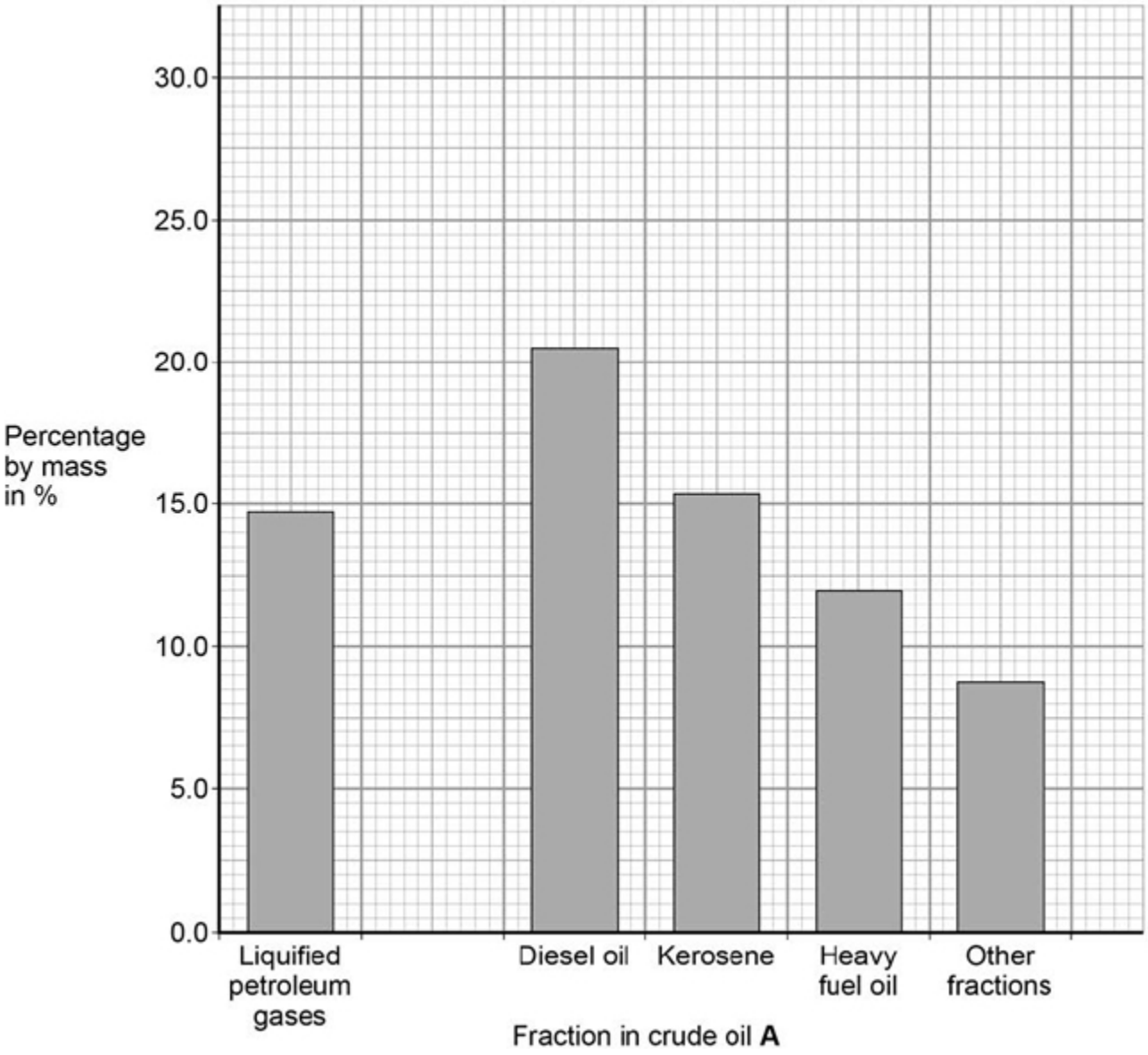
(1)

Pentene and butene are produced from crude oil.

The table shows the percentages of different fractions in two samples of crude oil.

Fraction	**Percentages by mass in %**	
	Crude oil A	**Crude oil B**
Liquefied petroleum gases	14.7	7.1
Petrol	28.6	11.1
Diesel oil	20.5	17.2
Kerosene	15.4	38.5
Heavy fuel oil	12.0	16.0
Other fractions	8.8	10.1

The graph shows the percentages of different fractions in crude oil **A**.



(c) Plot the data for petrol in the table above on the graph.

(1)

(d) What mass of crude oil **A** is needed to obtain 12 tonnes of heavy fuel oil?

Use the table above.

10 tonnes ☐

100 tonnes ☐

1000 tonnes ☐

10 000 tonnes ☐

(1)

(e) Calculate the total mass of car fuel that can be produced from 2000 kg of crude oil **B**.

Use the table above.

_____

_____

_____

_____

Mass of car fuel = _____ kg

(3)

(f) Crude oil **B** is a better source of hydrocarbons for cracking than crude oil **A**.

Suggest why.

Use the table above.

_____

_____

(1)

(g) Alkenes are obtained from crude oil using fractional distillation followed by cracking.

Explain how alkenes are produced using fractional distillation followed by cracking.

(6)

(Total 14 marks)

2. The table below gives information about four alcohols.

Alcohol	Formula	Melting point in °C	Boiling point in °C
Methanol	CH_3OH	−94	65
Ethanol	CH_3CH_2OH	−118	78
Propanol	$CH_3CH_2CH_2OH$	−129	97
Butanol	$CH_3CH_2CH_2CH_2OH$	−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 ☐

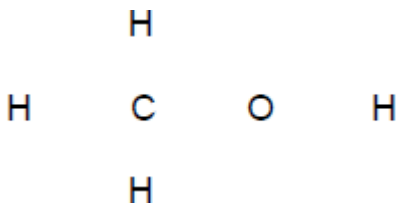
Propanol has the highest melting point ☐

(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.

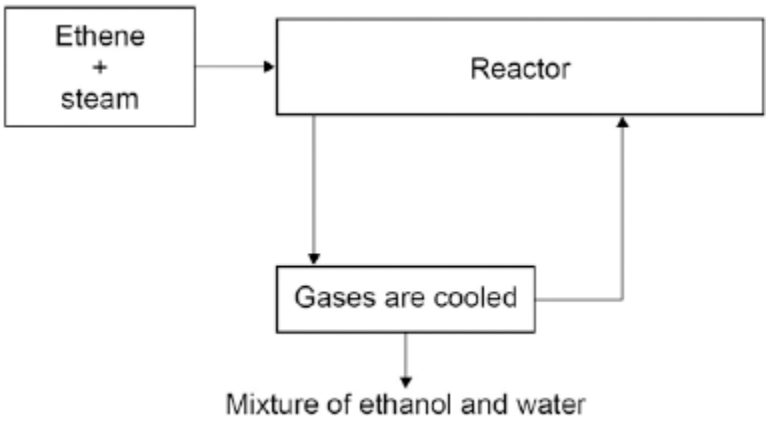
Figure 1



(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)

3. This question is about hydrocarbons.

(a) The names and formulae of three hydrocarbons in the same homologous series are:

Ethane	C_2H_6
Propane	C_3H_8
Butane	C_4H_{10}

The next member in the series is pentane.

What is the formula of pentane?

_____

(1)

(b) Which homologous series contains ethane, propane and butane?

Tick **one** box.

Alcohols ☐

Alkanes ☐

Alkenes ☐

Carboxylic acids ☐

(1)

(c) Propane (C_3H_8) is used as a fuel.

Complete the equation for the complete combustion of propane.

$C_3H_8 + 5O_2 \rightarrow 3$ _____ + 4 _____

(2)

(d) Octane (C_8H_{18}) is a hydrocarbon found in petrol.

Explain why octane is a hydrocarbon.

_____

_____

(2)

(e) The table below gives information about the pollutants produced by cars using diesel or petrol as a fuel.

Fuel	Relative amounts of pollutants		
	Oxides of Nitrogen	Particulate matter	Carbon dioxide
Diesel	31	100	85
Petrol	23	0	100

Compare the pollutants from cars using diesel with those from cars using petrol.

(3)

(f) Pollutants cause environmental impacts.

Draw **one** line from each pollutant to the environmental impact caused by the pollutant.

Pollutant	**Environmental impact caused by the pollutant**
	Acid rain
Oxides of nitrogen	Flooding
	Global dimming
Particulate matter	Global warming
	Photosynthesis

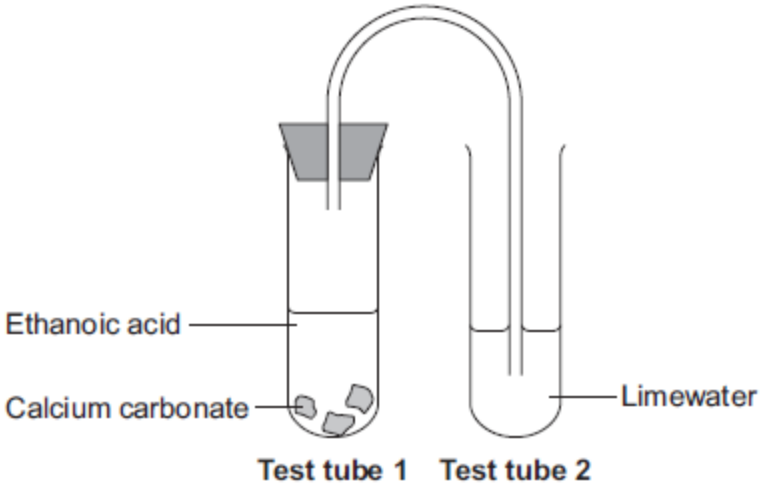
(2)

(Total 11 marks)

4. 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 _____

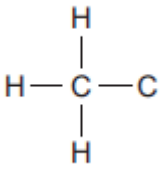
_____

_____

_____

(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

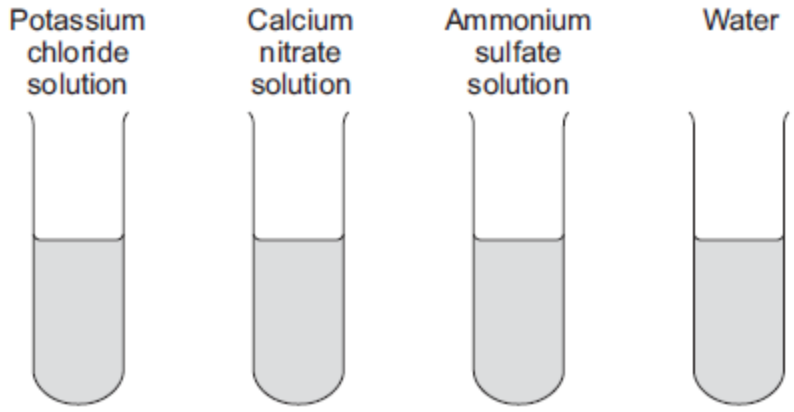
_____ catalyst to produce pleasant-smelling compounds

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 presence of dilute nitric acid			no change	no change
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.

_____

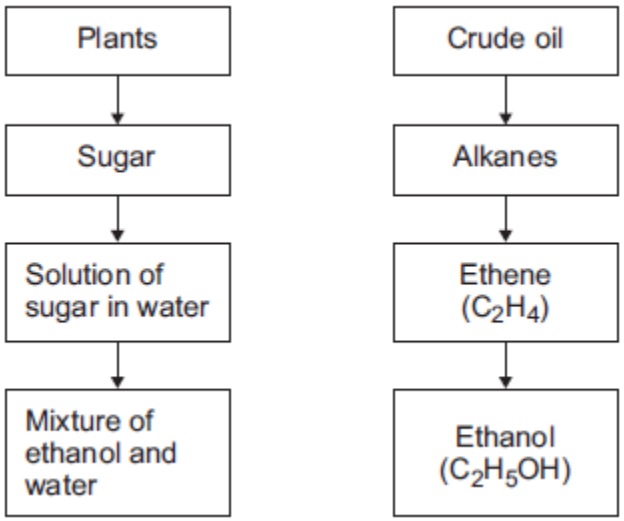
_____

_____

(1)

(Total 12 marks)

5. Ethanol can be made from plants and from crude oil as shown in the diagram below.



(a) Describe how the solution of sugar in water is used to produce the mixture of ethanol and water.

_____

_____

_____

_____

(2)

(b) Ethanol has a boiling point of 78 °C.
Water has a boiling point of 100 °C.

Describe how distillation is used to separate a mixture of ethanol and water.

_____

_____

_____

_____

_____

(3)

(Total 5 marks)

6. This question is about hydrocarbons.

(a) Most of the hydrocarbons in crude oil are alkanes.

(i) Large alkane molecules can be cracked to produce more useful molecules.

The equation shows the cracking of dodecane.

$$\underset{\text{dodecane}}{C_{12}H_{26}} \longrightarrow \underset{\text{butane}}{C_4H_{10}} + \underset{\text{hexene}}{C_6H_{12}} + \underset{\text{ethene}}{C_2H_4}$$

Give **two** conditions used to crack large alkane molecules.

1. _____

2. _____

(2)

(ii) The products hexene and ethene are alkenes.

Complete the sentence.

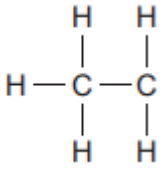
When alkenes react with bromine water the colour changes

from orange to _____ .

(1)

(iii) Butane (C_4H_{10}) is an alkane.

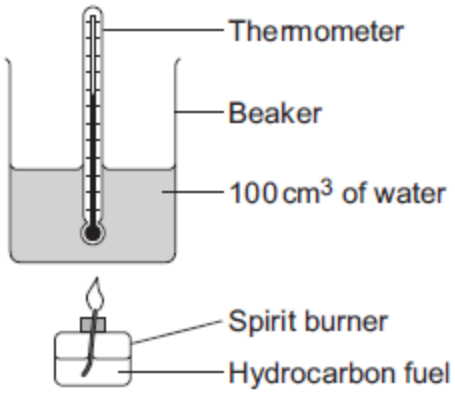
Complete the displayed structure of butane.



(1)

(b) A group of students investigated the energy released by the combustion of four hydrocarbon fuels.

The diagram below shows the apparatus used.



Each hydrocarbon fuel was burned for two minutes.

Table 1 shows the students' results.

Table 1

	After two minutes				
Name and formula of hydrocarbon fuel	**Mass of fuel used in g**	**Temperature increase of water in °C**	**Energy released by fuel in kJ**	**Energy released by 1.0 g of fuel in kJ**	**Relative amount of smoke in the flame**
Hexane, C_6H_{14}	0.81	40	16.80	20.74	very little smoke
Octane, C_8H_{18}	1.10	54	22.68	20.62	some smoke
Decane, $C_{10}H_{22}$	1.20	58	24.36		smoky
Dodecane, $C_{12}H_{26}$	1.41	67	28.14	19.96	very smoky

(i) Calculate the energy released by 1.0 g of decane in kJ.

_____

_____

Energy released = _____ kJ

(2)

(ii) Suggest **one** improvement to the apparatus, or the use of the apparatus, that would make the temperature increase of the water for each fuel more accurate.

Give a reason why this is an improvement.

_____

_____

_____

(2)

(iii) The students noticed that the bottom of the beaker became covered in a black substance when burning these fuels.

Name this black substance.

Suggest why it is produced.

_____

_____

_____

_____

(2)

(iv) A student concluded that hexane is the best of the four fuels.

Give **two** reasons why the results in **Table 2** support this conclusion.

1. _____

_____

2. _____

_____

(2)

(c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Most car engines use petrol as a fuel.

- Petrol is produced from the fractional distillation of crude oil.
- Crude oil is a mixture of hydrocarbons.
- Sulfur is an impurity in crude oil.

Car engines could be developed to burn hydrogen as a fuel.

- Hydrogen is produced from natural gas.
- Natural gas is mainly methane.

Table 2 shows information about petrol and hydrogen.

Table 2

	Petrol	**Hydrogen**
State of fuel at room temperature	Liquid	Gas
Word equation for combustion of the fuel	petrol + oxygen ⟶ carbon dioxide + water	hydrogen + oxygen ⟶ water
Energy released from combustion of 1 g of the fuel	47 kJ	142 kJ

Describe the **advantages** and **disadvantages** of using hydrogen instead of petrol in car engines.

Use the information given and your knowledge and understanding to answer this question.

(6)

(Total 18 marks)

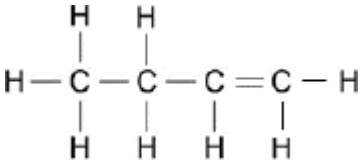
Mark schemes

1.

(a) C_5H_{10}

1

(b)



1

(c) bar labelled petrol to 28.6 (%)

allow a tolerance of $\pm \frac{1}{2}$ *a square*

1

(d) 100 tonnes

1

(e) 7.1 + 11.1 + 17.2 = 35.4

1

$$\frac{2000 \times 35.4}{100}$$

allow ecf from step 1

1

= 708 (kg)

*an answer of 1276 (kg) gains **2** marks*

1

(f) higher percentage (by mass) of heavier fractions
or
higher percentage of larger molecules

1

(g) **Level 3 (5-6 marks):**
Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.

Level 2 (3-4 marks):
Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.

Level 1 (1-2 marks):
Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

Level 0
No relevant content.

Indicative content

fractional distillation
- oil heated / boiled / vaporised
- fractionating column used
- fractions have different boiling ranges / temperatures
- column hotter at bottom

or

column cooler at top
- fractions condense at different levels
- heavy fractions collect at bottom

or

light fractions collect at top

cracking
- high temperature
- catalyst or steam
- large molecules split into small molecules
- mixture of alkanes and alkenes produced

6

[14]

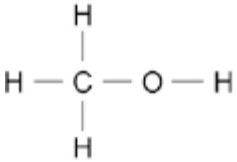
2. (a) Propanol

1

(b) Butanol has the highest boiling point

1

(c)



1

(d) ethene + water (→ ethanol)

allow answers in either order

allow steam for water

1

(e) goes back to reactor

allow is recycled

1

(f) air contains oxygen

1

which oxidises ethanol

allow ethanol reacted with oxygen

1

to produce ethanoic acid

1

[8]

3. (a) C_5H_{12}

1

(b) Alkanes

1

(c) (3) CO_2

1

(4) H_2O

1

*allow for **1** mark*

4 CO_2 + 3 H_2O

(d) contains hydrogen and carbon

1

(hydrogen and carbon) <u>only</u>

1

(e) *(diesel)*

produces more oxides of nitrogen

allow converse answers in terms of petrol

1

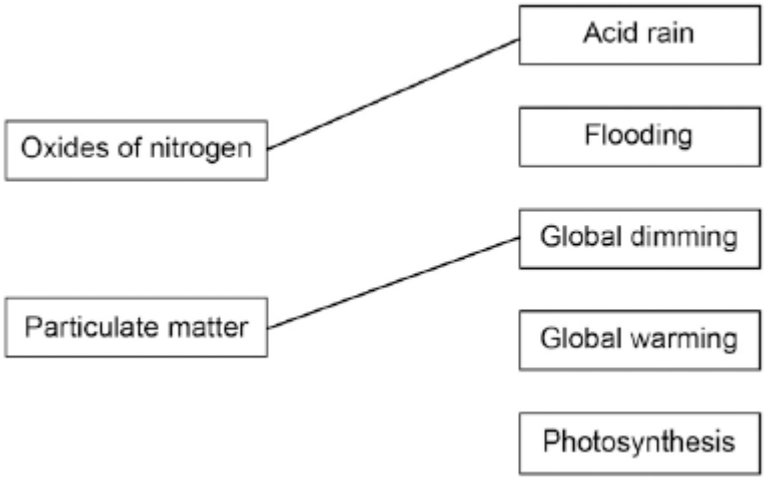
produces (more) particulate matter

1

produces less carbon dioxide

1

(f)



2

[11]

4. (a) (i) fizz / effervescence / bubbles

allow calcium carbonate decreases in size or dissolves

1

because carbon dioxide produced / released

allow because gas produced / released

1

limewater turns cloudy / milky / white

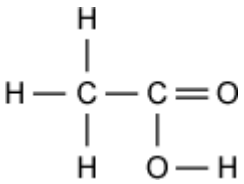
1

because (a precipitate of or solid) calcium carbonate forms

allow because of carbon dioxide if not already credited

1

(ii)



allow -OH

do not allow lower case 'h'

1

(iii) acid

must be in this order

ignore any name of an acid

1

ester(s)

1

(b) white (precipitate) no change

no change no change

all four correct 2 marks

any two correct 1 mark

2

(c) (i) lilac

allow purple

1

red

1

must be in this order

(ii) colours are masked / changed by each flame colour

1

[12]

5. (a) add yeast

1

and ferment **or** by fermentation

*allow in a warm place **or** temperatures within the range 20-45^{o}C **or** with an airlock / absence of air*

1

(b) heat (the mixture)

1

ethanol has a lower boiling point than water **or** more ethanol than water vaporises **or** ethanol evaporates first or when the temperature reaches 78^{o}C

allow ethanol and water boil at different temperatures

1

condense (the vapour)

allow condense at different temperatures for the last two marking points

if no other mark is awarded, allow repeat distillation or use fractional distillation apparatus for 1 mark

1

[5]

6. (a) (i) high temperature

allow heating / hot / 250-900 °C

1

catalyst or steam

allow named catalyst eg zeolite, Al_2O_3, silica, ceramic

allow in the absence of air / oxygen

1

ignore any references to pressure

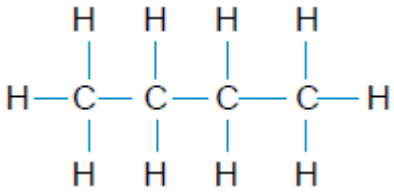
(ii) colourless

allow decolourised

ignore clear / discoloured

1

(iii)



1

(b) (i) 20.3(0) (kJ)

*if answer incorrect allow **1** mark for 24.36/1.2*

2

(ii) use a lid

allow insulate beaker or use draught shield

1

reduce energy / heat loss

ignore references to thermometer or repeats or distance of flame or loss of water vapour

allow stir (1) to distribute energy / heat (1)

allow use a metal can (1) as it's a better conductor (1)

1

(iii) carbon/soot

ignore tar, smoke

1

(produced by) incomplete combustion

allow from a limited supply of oxygen/air

1

(iv) hexane gives out the greatest energy (per 1.0 g)

ignore more energy

1

hexane produces the least smoke / carbon / soot

allow has the cleanest flame

ignore less smoke / carbon / soot

1

(c) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also apply a 'best-fit' approach to the marking.

Level 3 (5 – 6 marks):
Descriptions of advantages **and** disadvantages that are linked to their own knowledge.

Level 2 (3 – 4 marks):
Descriptions of an advantage **and** a disadvantage with some use of their knowledge to add value.

Level 1 (1 – 2 marks):
Statements made from the information that indicate whether at least one statement is an advantage **or** a disadvantage
or a linked advantage or disadvantage

0 marks:
No relevant content

Examples of the added value statements and links made in the response could include:
Note that link words are in bold; links can be either way round.
Accept reverse arguments and ignore cost throughout.

Advantages of using hydrogen:
- Combustion only produces water **so** causes no pollution
- Combustion does not produce carbon dioxide **so** this does not contribute to global warming or climate change
- Combustion does not produce sulfur dioxide **so** this does not contribute to acid rain
- Incomplete combustion of petrol produces carbon monoxide **that is** toxic
- Incomplete combustion of petrol produces particulates **that** contribute to global dimming
- Petrol comes from a non-renewable resource **but** there are renewable/other methods of producing hydrogen
- Hydrogen releases more energy **so** less fuel needed or more efficient

Disadvantages of using hydrogen:
- Hydrogen is a gas **so** is difficult to store or transfer to vehicles
- Hydrogen gas is very flammable **so** leaks cause a greater risk of explosion
- Most hydrogen is produced from fossil fuels **which** are running out
- Cannot be used in existing car engines **so** modification / development or replacement is needed
- Lack of filling stations **so** difficult to refuel your vehicle

6

[18]