Exampro GCSE Chemistry

C3 Chapter 3 Higher

Name:

Class:

Author:

Date:

Time: 78

Marks: 78

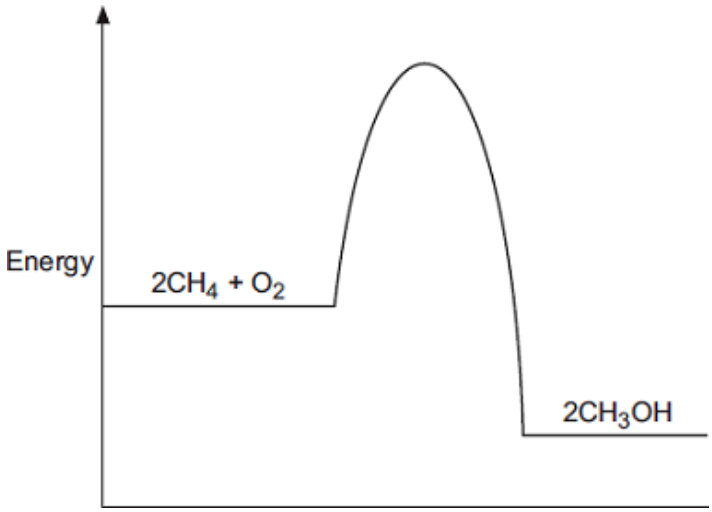
Comments:

Q1. Methanol (CH_3OH) can be made by reacting methane (CH_4) and oxygen (O_2). The reaction is exothermic.

The equation for the reaction is:

$$2\,CH_4 + O_2 \longrightarrow 2\,CH_3OH$$

(a) The energy level diagram for this reaction is given below.



(i) How does the diagram show that this reaction is exothermic?

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(1)

(ii) A platinum catalyst can be used to increase the rate of this reaction.

What effect does adding a catalyst have on the energy level diagram?

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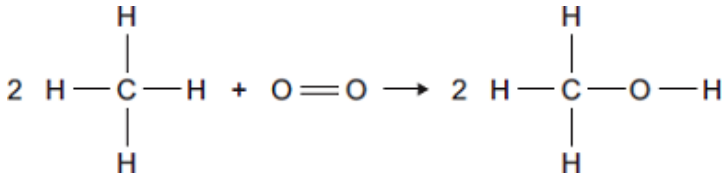
(1)

(b) The equation can also be written showing the structural formulae of the reactants and the product.



(i) Use the bond energies given in the table to help you to calculate the energy change for this reaction.

Bond	Bond energy in kJ
C — H	435
O ═ O	497
C — O	336
O — H	464

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Energy change = ... kJ

(3)

(iii) In terms of the bond energies, why is this an exothermic reaction?

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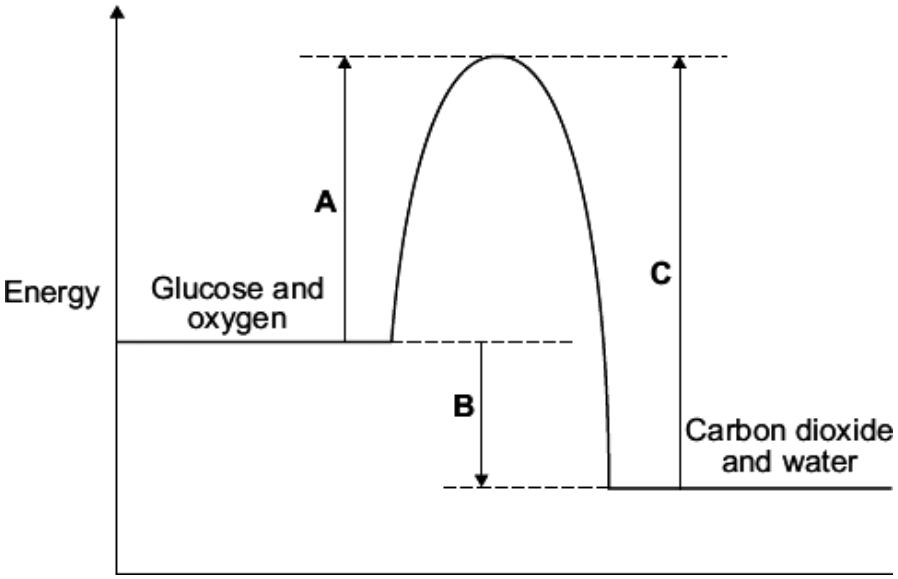
(1)

(Total 6 marks)

Q2. Food provides chemicals and energy to keep your body working. In your body, energy is released by respiration when glucose, $C_6H_{12}O_6$, reacts with oxygen.

$$C_6H_{12}O_6 + 6\,O_2 \rightarrow 6\,CO_2 + 6\,H_2O$$

(a) The energy level diagram for the reaction of glucose with oxygen is shown.



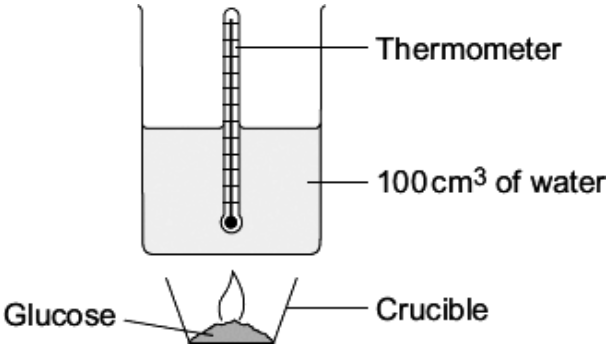
(i) Which energy change, **A**, **B** or **C**, represents the activation energy?

(1)

(ii) Which energy change, **A**, **B** or **C**, shows that the reaction is exothermic?

(1)

(b) A student did an investigation to find the amount of energy released when 1 g of glucose burns in air.



The student:

- recorded the room temperature
- placed 1 g of glucose into the crucible
- set up the equipment as shown in the diagram
- lit the glucose
- recorded the highest temperature of the water.

(i) One of the main errors in this experiment is energy loss to the surroundings.

Suggest **one** way that the equipment could be changed to reduce this energy loss.

.....

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(1)

(ii) The room temperature was 20 °C and the highest temperature recorded was 42 °C.
Use these temperature readings to calculate how much energy is released when 1 g of glucose burns.
The equation that you need to use is:

Energy released in joules = 100 × 4.2 × temperature change

Show clearly how you work out your answer.

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Burning 1 g of glucose releases ..... joules

(2)

(iii) The amount of energy released by 1 g of glucose should be 16 000 J.

Apart from energy loss to the surroundings, suggest **two** other reasons why the student's value was less than expected.

1 .....

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2 .....

.....

(2)

(c) Suggest **one** reason why food labels provide information about the energy released by the food.

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(1)

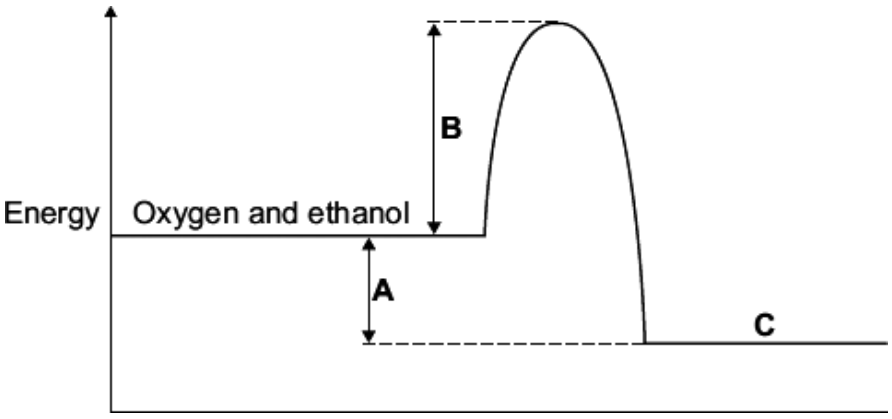
(Total 8 marks)

Q3. V2 rockets were used during the Second World War.

By aronsson [CC BY-SA 2.0], via Flickr

V2 rockets were powered by liquid oxygen and ethanol. Oxygen and ethanol react to produce carbon dioxide and water.

The energy level diagram represents the energy changes during this reaction.



(a) On the energy level diagram what is represented by the letter:

A .....

B .....

C .....

(3)

(b) What type of reaction is represented by this energy level diagram?

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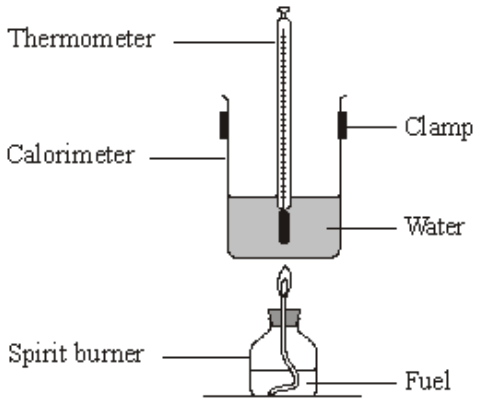
(1)
(Total 4 marks)

Q4. A student burned four fuels and compared the amounts of energy they produced.

The student set up the apparatus as shown in the diagram.



The heat produced when each fuel was burned was used to raise the temperature of 100 g of water. The student noted the mass of fuel burned, the increase in temperature and whether the flame was smoky.

The results are shown in the table.

Fuel	Mass of fuel burned (g)	Temperature increase (°C)	Type of flame
Ethanol	4	24	Not smoky
Methanol	3	9	Not smoky
Peanut oil	2	20	Smoky
Vegetable oil	1	15	Smoky

(a) The student suggested that the vegetable oil was the best fuel for producing heat.

Explain why.

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(2)

(b) Suggest an environmental problem that could be caused when large amounts of vegetable oil are burned. Suggest how the problem could be overcome.

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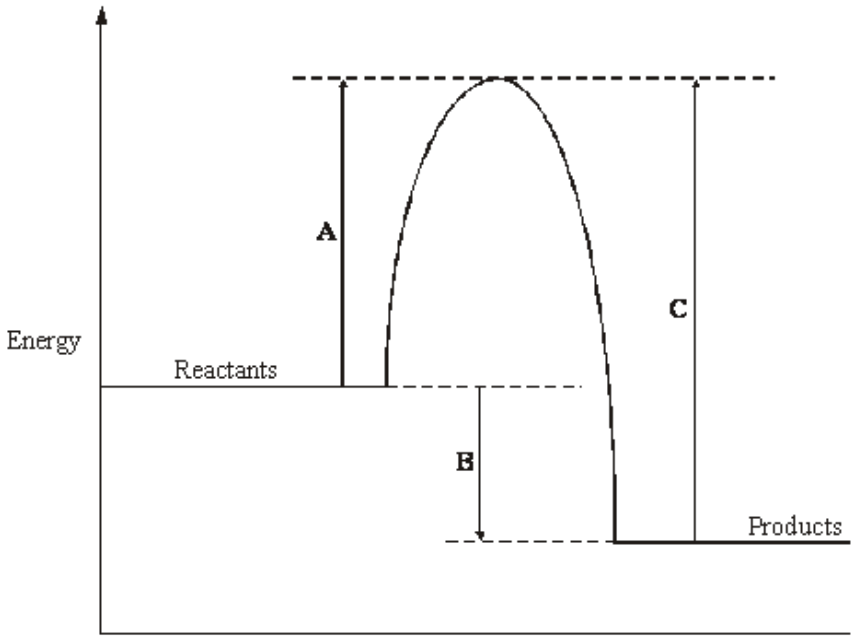
(2)

(c) An energy level diagram for the burning of vegetable oil is shown below.



Which of the energy changes **A**, **B** or **C:**

(i) represents the activation energy

.....

(1)

(ii) shows the amount of energy given out during the reaction?

.....

(1)

(Total 6 marks)

Q5. HYDROGEN FUEL OF THE FUTURE

It has been suggested that hydrogen could be used as a fuel instead of the fossil fuels that are used at present. The equation below shows how hydrogen burns in air.

$$2H_2 + O_2 \rightarrow 2H_2O + \text{heat}$$

The hydrogen would be made from water using energy obtained from renewable sources such as wind or solar power. The water splitting reaction requires a lot of energy.

(a) Hydrogen was successfully used as a fuel for a Soviet airliner in 1988.
Why would hydrogen be a good fuel for use in an aeroplane?

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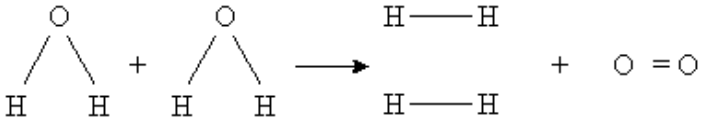
(2)

(b) The water splitting reaction is shown in the equation below.

$$2H_2O \rightarrow 2H_2 + O_2$$



Calculate the energy needed to split the water molecules in the equation into H and O atoms.

$$2H_2O \rightarrow 4H + 2O$$

.....

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(2)

(c) On the Periodic Table, hydrogen is placed on its own at the top and in the middle. It is difficult to position it because it has the properties of metals and non-metals.

(i) Where would you expect hydrogen to be placed on the periodic table on the basis of the arrangement of electrons in hydrogen atoms?

.....

.....

(1)

Explain your answer.

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.....

(1)

(ii) Give **one** way in which hydrogen behaves like a metal.

.....

.....

(1)

(iii) Give **one** way in which hydrogen behaves like a non-metal.

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(1)

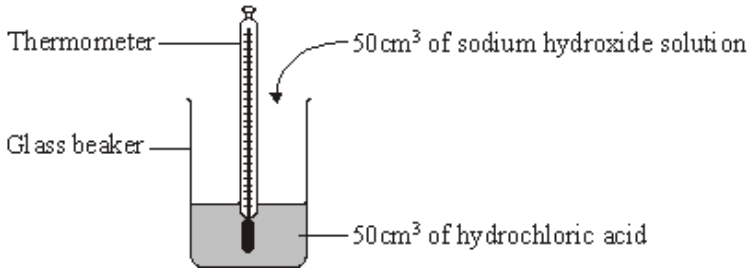
(Total 8 marks)

Q6. Read the information about energy changes and then answer the questions.

A student did an experiment to find the energy change when hydrochloric acid reacts with sodium hydroxide. The equation which represents the reaction is:

$HCl + NaOH \rightarrow NaCl + H_2O$

The student used the apparatus shown in the diagram.



The student placed 50 cm^3 of hydrochloric acid in a glass beaker and measured the temperature.

The student then quickly added 50 cm3 of sodium hydroxide solution and stirred the mixture with the thermometer. The highest temperature was recorded.

The student repeated the experiment, and calculated the temperature change each time.

	Experiment 1	**Experiment 2**	**Experiment 3**	**Experiment 4**
Initial temperature in °C	19.0	22.0	19.2	19.0
Highest temperature in °C	26.2	29.0	26.0	23.5
Temperature change in °C	7.2	7.0	6.8	4.5

(a) The biggest error in this experiment is heat loss.

Suggest how the apparatus could be modified to reduce heat loss.

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(1)

(b) Suggest why it is important to stir the chemicals thoroughly.

.....

(1)

(c) Which **one** of these experiments was probably carried out on a different day to the others?

Explain your answer.

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(1)

(d) Suggest why experiment 4 should **not** be used to calculate the average temperature change.

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(1)

(e) Calculate the average temperature change from the first three experiments.

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Answer = ... °C

(1)

(f) Use the following equation to calculate the energy change for this reaction.

energy change in joules = 100 × 4.2 × average temperature change

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Answer = ... J

(1)

(g) Which **one** of these energy level diagrams, **A** or **B**, represents the energy change for this reaction?

Explain why.

Diagram A

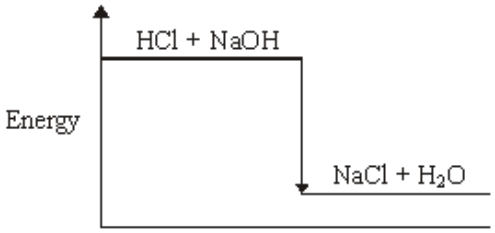
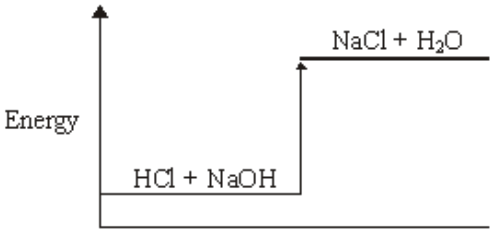


Diagram B



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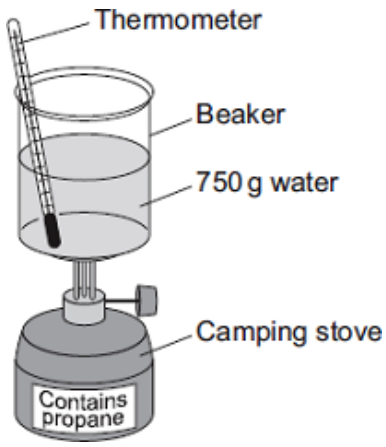
(1)

(Total 7 marks)

Q7. A camping stove uses propane gas.



(a) A student did an experiment to find the energy released when propane is burned.

The student:

- put 750 g water into a beaker
- measured the temperature of the water, which was 17 °C
- heated the water by burning propane
- measured the temperature of the water again, which was then 64 °C.

The student calculated the energy released using the equation

$$Q = m \times 4.2 \times \Delta T$$

Where:

Q = energy released (J)

m = mass of water (g)

ΔT = temperature change (°C)

(i) Use the student's results to calculate the energy released in joules (J).

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Energy released = ...

(3)

(ii) To find how much propane had been used the student weighed the camping stove before and after the experiment. The mass of the camping stove decreased by 6.0 g.

Using this information and your answer to part (a)(i), calculate the energy in kJ released when 1 mole of propane burns.

(If you have no answer for part (a)(i), assume the energy released during the experiment is 144 000 J. This is not the answer to part (a)(i).)

Relative formula mass (M_r) of propane = 44.

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Energy released = ... kJ

(2)

(iii) Suggest **two** things the student could do to make his results more accurate.

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(2)

(iv) The student's method does **not** give accurate results.

However, this method is suitable for comparing the energy released by different fuels.

Suggest why.

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(1)

(b) The student used bond energies to calculate the energy released when propane is burned.

The equation for the combustion of propane is:

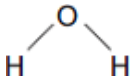
$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$

Some bond energies are given in the table

Bond	Bond Energy in kJ per mole
C ═ O	830
O — H	464

The displayed structures of the products are:

carbon dioxide 

water 

(i) Calculate the energy released by bond making when the products are formed.

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Energy released = ... kJ per mole

(3)

(ii) The energy used for bond breaking of the reactants in the equation is 6481 kJ per mole.

Calculate the overall energy change of this reaction.

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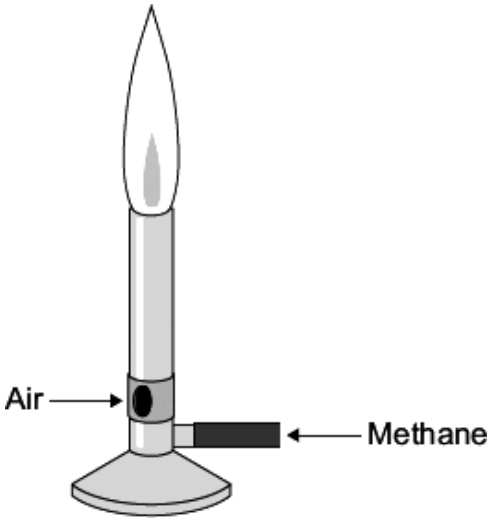
Overall energy change = ... kJ per mole

(1)

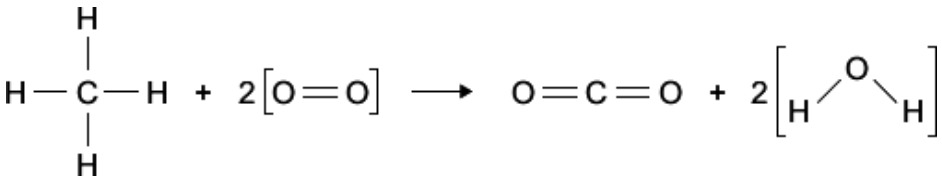
(Total 12 marks)

Q8. A Bunsen burner releases heat energy by burning methane in air.



(a) Methane (CH_4) reacts with oxygen from the air to produce carbon dioxide and water.

(i) Use the equation and the bond energies to calculate a value for the energy change in this reaction.



Bond	Bond energy in kJ per mole
C — H	414
O = O	498
C = O	803
O–H	464

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Energy change = ... kJ per mole

(3)

(ii) This reaction releases heat energy.

Explain why, in terms of bond energies.

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(2)

(b) If the gas tap to the Bunsen burner is turned on, the methane does not start burning until it is lit with a match.

Why is heat from the match needed to start the methane burning?

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(1)
(Total 6 marks)

Q9. Hydrogen peroxide is often used to bleach or lighten hair.

Hydrogen peroxide slowly decomposes to produce water and oxygen.

(a) The equation for the reaction can be represented using structural formulae.

$$2\ H-O-O-H \longrightarrow 2\ H-O-H + O=O$$

Use the bond energies in the table to help you to calculate the energy change for this reaction.

Bond	Bond energy in kJ per mole
H – O	464
O – O	146
O = O	498

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.....

Energy change = ... kJ

(3)

(b) Explain, in terms of bond making and bond breaking, why the reaction is exothermic.

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(1)

(Total 4 marks)

Q10. When a known mass of a hydrocarbon was completely burned in oxygen, 17.6 g of carbon dioxide and 7.2 g of water were the only products.

Relative formula masses (M_r): CO_2 = 44; H_2O = 18.

Use this information to calculate the number of moles of carbon dioxide and of water produced in this reaction. Use your answers to calculate the empirical formula of this hydrocarbon.

You must show your working to gain full marks.

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The empirical formula of this hydrocarbon is .....

(3)
(Total 3 marks)

Q11. Some cars are powered by hydrogen fuel cells.

Figure 1

(a) What type of energy is released by hydrogen fuel cells?

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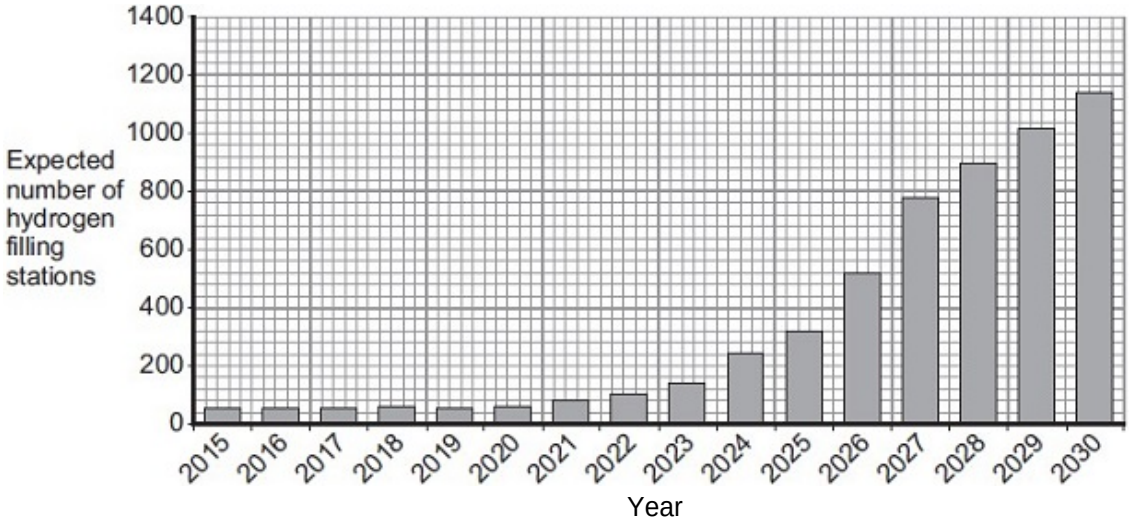
(1)

(b) Owners of cars powered by fuel cells buy hydrogen from hydrogen filling stations.

Figure 2 shows how the number of hydrogen filling stations in the UK is expected to increase up to the year 2030.

Figure 2



Use the information in **Figure 2** and your own knowledge to answer this question.

Suggest **two** reasons why the UK government might encourage the building of more hydrogen filling stations.

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.....

(2)

(c) The equation for the reaction of hydrogen with oxygen is:

$$2\,H_2 + O_2 \longrightarrow 2\,H_2O$$

During the reaction, energy is used to break the bonds of the reactants.

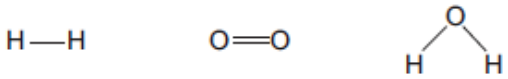
Energy is released when new bonds are made to form the product.

Bond energies for the reaction are given in the table below.

Bond	Bond energy in kJ
H—H	436
O=O	498
O—H	464

The structures of the reactants and product are shown in **Figure 3**.

Figure 3



hydrogen oxygen water

(i) Calculate the energy change for the reaction:

$$2\,H_2 + O_2 \longrightarrow 2\,H_2O$$

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Energy change = ... kJ

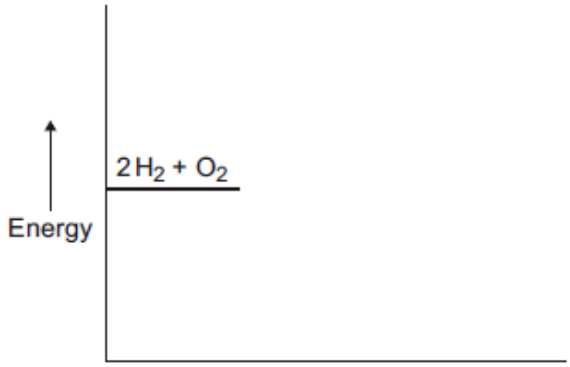
(3)

(ii) The reaction of hydrogen with oxygen is exothermic.

Complete the energy level diagram for this reaction on **Figure 4**.

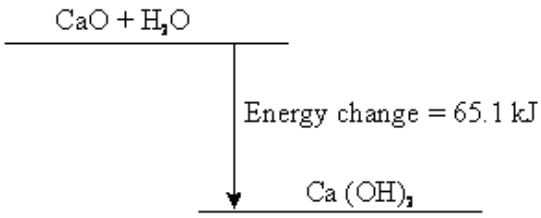
Clearly label the activation energy.

Figure 4



(3)
(Total 9 marks)

Q12. An energy diagram is shown below for the slaking of calcium oxide.



(i) Explain what the diagram tells you about the energy change which takes place in this reaction.

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(2)

(ii) Explain fully what the diagram tells you about the relative amount of energy required to break bonds and form new bonds in this reaction.

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(3)
(Total 5 marks)

M1. (a) (i) energy / heat of products less than energy of reactants

allow converse

allow products are lower than reactants

allow more energy / heat given out than taken in

allow methanol is lower

allow energy / heat is given out / lost

allow ΔH is negative

1

(ii) lowers / less activation energy

allow lowers energy needed for reaction
or *it lowers the peak/ maximum*

do ***not*** *allow just 'lowers the energy'*

1

(b) (i) (8 × 435) + 497 = 3977

accept: bonds broken: (2 × 435) + 497 = 1367

1

(6 × 435) + (2 × 336) + (2 × 464) = 4210

bonds made: (2 × 336) + (2 × 464) = 1600

1

3977 – 4210 = (–) 233

energy change:

1367 – 1600 = (–) 233

ignore sign

allow ecf

correct answer (233) = ***3*** *marks with or without working*

1

(ii) energy released forming (new) bonds is greater than energy needed to break (existing) bonds

allow converse

do ***not*** *accept energy needed to form (new) bonds greater than energy needed to break (existing) bonds*

1

[6]

M2. (a) (i) A

1

(ii) B

1

(b) (i) put a lid on (beaker)

any addition to the equipment that would prevent energy loss

or

insulate (top or sides of) beaker

or

use screens to prevent draughts

allow bomb calorimeter

*do **not** allow polystyrene cup*

ignore 'move the crucible'

1

(ii) (temperature change =) 22°C

*correct answer is **2** marks with or without working*

1

(100 × 4.2 × 22 =) 9240

allow ecf from their 22

1

(iii) any **two** from:

- a specified human/measurement error

  ignore 1g of glucose insufficient

  ignore 100cm^3 of water too much

  ignore calculation error

  ignore not repeated / anomalous results

- water should be stirred

  allow thermometer in fixed position

- not all of the glucose burns

  allow glucose was impure

- energy used to heat the beaker / container

  ignore light energy / evaporation

- recorded the room temperature (at the beginning)

  allow room temperature was higher/different to the temperature of the (cold) water

  allow did not measure the water temperature at the beginning

2

(c) any **one** from:

- for dietary information
  allow consequences of diet
  allow for nutritional information
  allow eat healthily
  ignore balanced diet
  ignore to know how much energy is taken in
- different foods produce different amounts of energy
- legal requirement

1

[8]

M3. (a) A = energy / enthalpy change / difference
*allow heat change **or** ∆H*
allow energy released

1

B = activation energy / EA
allow definition of activation energy

1

C = carbon dioxide and water
accept products

1

(b) exothermic
allow combustion / redox / oxidation
ignore reduction / burning

1

[4]

M4. (a) either:
calculations: all correct (ethanol = 6, methanol = 3, peanut oil = 10, vegetable oil = 15)
ignore repetition of data from table unqualified

or

implication of correct calculation

(vegetable oil) gives largest temperature / heat increase per gram (owtte)
*allow 'produced most heat in proportion to the fuel used' owtte for **1** mark*

2

(b) any **one** from:

owtte

- smoke

  ignore references to crops/food
- soot
- carbon
- carbon monoxide
- carbon dioxide
- global warming / climate change / greenhouse gases
- (air) pollution
- harmful/poisonous

1

scrub / wash the gases owtte

filter / remove (gases / fumes / appropriate named substance) owtte

(add extra oxygen) can burn more efficiently owtte

use a cleaner fuel owtte

plant more trees or similar linked to CO_2

any sensible answer

'don't burn so much fuel' insufficient alone

ignore extractor fans / air conditioning

1

(c) (i) A

1

(ii) B

1

[6]

M5. (a) low density;
gives out light energy when burnt;
combustion product is not harmful;

any two for 1 mark each

2

(b) attempt to add bond energies;
e.g. adding O-H bond energies
answer = 4 × 464 = 1856

for 1 mark each

2

(c) (i) Group 1:
elements in a group have the same number of electrons in outer shell
first because only one electron
or Group 7:
because needs one electron to complete outer shell

for 1 mark each

2

(ii) forms H^+ ion

for 1 mark

1

(iii) forms molecules;
low melting point (gases);
or form covalent bonds forms H^- ion

for 1 mark

1

[8]

M6. (a) eg plastic (beaker) / insulation / lid / cover **or** any mention of enclosed

any sensible modification to reduce heat loss
ignore prevent draughts
ignore references to gas loss

1

(b) all the substances react **or** all (the substances) react fully / completely **or** heat evolved quickly **or** distribute heat

accept to mix them
'so they react' is insufficient for the mark
accept increase chances of (successful) collisions / collision rate increase
*do **not** accept rate of reaction increase / make reaction faster*

1

(c) experiment 2 **and** different / higher / initial / starting temperature

*accept experiment 2 **and** the room is hotter / at higher temperature*
*do **not** accept temperature change / results higher*

1

(d) temperature change does not fit pattern

*accept anomalous / odd **or** it is the lowest **or** it is lower than the others **or** it is different to the others*
'results are different' is insufficient

1

(e) 7 / 7.0

1

(f) (100 × 4.2 × 7) = 2940

ecf from (e)

1

(g) diagram A **and** reaction exothermic / heat evolved / Δ H is negative / temperature rises

accept energy is lost (to the surroundings)

1

[7]

M7. (a) (i) ΔT = (64 – 17) = 47 °C

1

750 x 4.2 x 47

allow ecf using their ΔT

1

148 050

*correct answer gains **3 marks** with **or** without working*

ignore sign

allow 148.05 kJ

allow 148 kJ

1

(ii) 1085.7

*correct answer gains **2** marks with or without working.*

*allow answer in range 1080 – 1089 for **2 marks***

*allow answer in range 1080000 – 1089000 for **1 mark***

*if answer is incorrect allow 6/44 = 0.136 mol for **1 mark***

*allow (44 x their (a)(i))/(6 x 1000) correctly calculated for **2 marks***

*allow (44 x their (a)(i))/6 correctly calculated for **1 mark***

If they have used the given value of 144 000:

*Allow any answer in range 1051 - 1059 for **2 marks** with or without working.*

*allow any answer in range 1051000 – 1059000 for **1 mark***

2

(iii) repeat the experiment and then calculate the mean

1

any **one** from:

- use a lid
- insulate the beaker
  *do **not** allow flammable insulation*
- stir
- prevent draughts

1

(iv) inaccuracies likely to have similar effects
allow systematic errors

1

(b) (i) 8530
correct answer gains 3 marks with or without working.
If answer is incorrect;
(6 x 803) = 4818 gains 1 mark
(8 x 464) = 3712 gains 1 mark
correct addition of their calculated values gains 1 mark (ecf)

3

(ii) 6481 – 8530) = (-) 2049
ignore sign
allow ecf from (b)(i)

1

[12]

M8. (a) (i) (-)810
ignore sign
*correct answer gains **3** marks with or without working*
*if the answer is incorrect look at the working up to a maximum of **two***
- *bonds broken = (4 × 414) + (2×498) = 2652 kJ*
- *bonds formed = (2x803) + (4x464) = 3462 kJ*
- *correct subtraction of their bonds formed from their bonds broken*

3

(ii) because energy needed to break the bonds

1

is less than the energy released when bonds are formed

1

(b) to provide activation energy

or

to break bonds

1

[6]

M9. (a) *correct answer with or without working = **3** marks*

M1: (bonds broken) = 2148 (kJ)

1

M2: (bonds made) = 2354 (kJ)

1

M3: change in energy
= (-) 206 (kJ)
ecf
ignore sign

1

(b) energy released from forming new bonds is greater than energy needed to break existing bonds
allow the energy needed to break bonds is less than the energy released in forming bonds
*do **not** accept energy needed to form bonds*

1

[4]

M10. $\frac{17.6}{44}$ (moles) **or** 0.4 (moles) CO_2

1

$\frac{7.2}{18}$ (moles) **or** 0.4 (moles) H_2O

1

empirical formula = CH_2
allow 1C:2H
***or** correct simplest ratio related to elements*
***or** ecf from previous stage*
allow this mark for correct formula alone

1

[3]

M11. (a) electrical

1

(b) using hydrogen saves petrol / diesel / *crude oil*

allow crude oil is non-renewable

ignore hydrogen is renewable

1

using hydrogen (in fuel cells) does not cause pollution

accept no carbon dioxide produced

allow less carbon dioxide produced

allow hydrogen produces <u>only</u> water

1

(c) (i) (–)486

*correct answer with or without working gains **3** marks*

if answer is incorrect:

*(2 × 436) + 498 **or** 1370 gains **1** mark*

*4 × 464 **or** 1856 gains **1** mark*

*correct subtraction of ecf gains **1** mark*

3

(ii) products lower than reactants

1

reaction curve correctly drawn

1

activation energy labelled

1

[9]

M12. exothermic

65.1 kJ of energy given out more energy given out in forming new bonds than taken in in breaking bonds

each for1 mark

[5]