C3 Revision – Energy Changes

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:

(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
		435
		497
		336
		464

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Energy change = ... kJ **(3)**

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

.....

.....**(1)(Total 6 marks)**

Q2. Hydrogen could be the fuel used in all cars. One advantage is that when hydrogen reacts with oxygen only water is produced.

The chemical equation for this reaction is:

$2\ H_2 \quad + \quad O_2 \quad 2H_2O$

This equation can be written showing the structural formulae.

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

(a) Use the bond energies in the table to calculate the energy change for this reaction.

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

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Energy change = ... kJ **(3)**

(b) Suggest why the bond energy of O = O is higher than the bond energies of both H – H and O – H.

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..... **(1)**

(c) In terms of bond energies, explain why hydrogen can be used as a fuel

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.....

.....**(2)(Total 6 marks)**

Q3. 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.

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

(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.

.....

.....**(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 .....

.....

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)**

Q4. During a thunderstorm lightning strikes the Eiffel Tower.

In lightning the temperature can reach 30 000 °C. This causes nitrogen and oxygen in the air to react, producing nitrogen oxide. This reaction has a high *activation energy* and is *endothermic*.

An equation that represents this endothermic reaction is:

N_2	+	O_2	→	2NO

The energy level diagram for this reaction is given below.

(a) The energy level diagram shows that this reaction is *endothermic*.

Explain how.

.....

.....**(1)**

(b) What is meant by the term *activation energy*?

.....

.....**(1)**

(c) The equation showing the structural formulae of the reactants and products is

N ≡ N	+	O = O	→	2 N = O

Bond	**Bond energy in kJ**
N ≡ N	945
O = O	498

N = O	630

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

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Energy change = ... kJ

(3)

(ii) In terms of bond energies, explain why this reaction is endothermic.

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.....**(1)(Total 6 marks)**

Q5. 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		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)**

Q6. V2 rockets were used during the Second World War.

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?

.....

.....**(1) (Total 4 marks)**

Q7. 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)**

Q8. Methanol can be made when methane reacts with oxygen.

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

(i) What is the energy change represented by **A**?

..... **(1)**

(ii) Use the energy level diagram to explain how it shows that this reaction is exothermic.

.....

.....

.....

.....**(2)**

(b) A student did an experiment to find the energy released when methanol burns in air.

The student:

- weighed a spirit burner containing methanol
- set up the equipment as shown in the diagram
- recorded the initial temperature

- lit the spirit burner
- put out the flame when the temperature of the water had risen by about 20 °C
- stirred the water and recorded the highest temperature of the water
- reweighed the spirit burner containing the methanol.

The student repeated the experiment and recorded his results.

	Experiment 1	Experiment 2	Experiment 3
Initial mass of spirit burner and methanol in g	299.3	298.3	296.9
Final mass of spirit burner and methanol in g	298.3	297.1	295.9
Initial temperature in °C	23	22	23
Highest temperature in °C	45	50	43
Temperature change in °C	22	28	20

Use the diagram and the information in the table to answer the questions.

(i) The main error in this experiment is energy loss.

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

.....

(1)

(ii) The temperature change in Experiment 2 is greater than the temperature change in Experiment 1 **and** Experiment 3.

Explain why.

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..... **(2)**

(iii) Suggest **one** reason why the student repeated the experiment.

.....

..... **(1)**

(iv) Use the temperature change in Experiments 1 **and** 3 to calculate how much energy is released when 1g of methanol burns. The equation that you need to use is:

Energy released in joules = 100 x 4.2 x mean temperature change

Show clearly how you work out your answer.

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.....

.....

Burning 1g of methanol releases ..... J

(2)

(Total 9 marks)

Q9. # 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.

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

.....

.....**(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?

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.....**(1)**

Explain your answer.

.....

.....**(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.

....

....**(1)(Total 8 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) reactants–

2 × H-H + 1 × O = O
= 1370 (kJ)

1

products–
4 × O-H = 1856 (kJ)

1

energy change = 486(kJ)

1

(b) O=O has a double (covalent) bond

or

O-H and H-H only have single (covalent) bonds

1

(c) hydrogen can be used as a fuel because when it reacts with oxygen more energy is released in bond making than used in bond breaking

1

therefore the reaction releases energy **or** the reaction is exothermic

1

[6]

M3. (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 100cm³ 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]

M4. (a) energy of product greater than energy of reactants

allow converse
allow energy = heat
*do **not** accept temperature for energy*
allow product / nitrogen oxide is higher than reactants
allow less energy / heat given out than taken in
allow energy / heat is taken in / gained
allow ∆ H is positive

1

(b) (minimum) energy needed to start the reaction / overcome energy barrier

accept (minimum) energy needed for a collision to be successful

1

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

bonds broken = 945 + 498 = 1443 (kJ)

1

bonds made = 2 × 630 = 1260 (kJ)

1

energy change = 1443 - 1260 = (+) 183

ignore sign
allow ecf

1

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

allow converse
accept energy change (∆H) is + / positive
*do **not** accept energy <u>needed to form new bonds</u> is less than energy needed to break existing bonds*

1

[6]

M5. (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]

M6. *(a)* *A = <u>energy</u> / <u>enthalpy</u> 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]

M7. *(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 <u>activation</u> energy

or

to break bonds

1

[6]

M8. *(a) (i) activation energy **or** energy needed to start the reaction*

1

(ii) the reaction is exothermic because the energy level / value of products is less than the energy level / value of reactants

*allow the reaction is exothermic because arrow **B** goes down*
or methanol is below methane and oxygen
or arrow **C** is bigger than arrow **A** for **1** mark

allow energy level of products is lower unqualified
***or** the energy level of reactants is higher unqualified for **1** mark*

2

(b) (i) use a lid / cover over the calorimeter

or any mention of how the calorimeter could be safely enclosed / insulated

1

(ii) a greater mass of methanol was burned in Experiment 2

1

therefore the temperature change was greater because more energy was transferred / released

1

(iii) any **one** from:

- to improve or check repeatability / quality of results
- to make it easier to spot an anomalous measurement
- to be able to calculate an average mean value

1

(iv) 8820 (J)

for correct answer

if answer is incorrect allow one mark for 21 used as the mean temperature change

2

[9]

M9. (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]