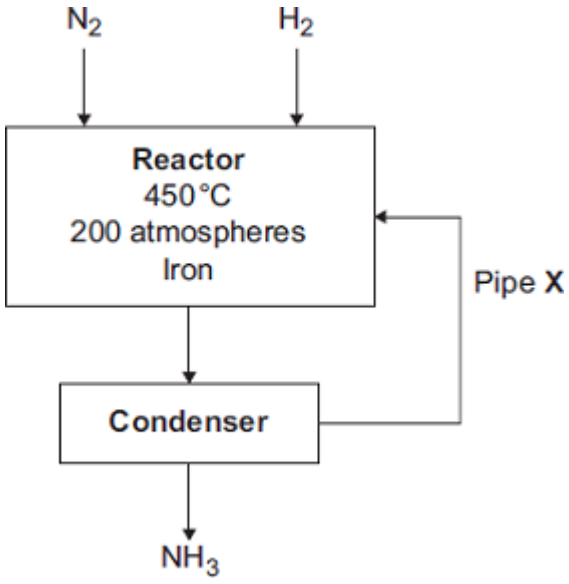
Energy changes part 2

Q1.

The flow diagram shows the Haber process. In the Haber process, ammonia (NH_3) is produced from nitrogen (N_2) and hydrogen (H_2).



(a) Which raw material is nitrogen obtained from?

_____

(1)

(b) What is the purpose of Pipe **X**?

_____

_____

_____

_____

(2)

(c) Balance the chemical equation below for the production of ammonia.

N_2 + _____H_2 ⇌ _____NH_3

(1)

(d) A temperature of 450°C is used in the reactor.
The reaction of nitrogen with hydrogen is reversible.
The forward reaction is exothermic.

Explain why a temperature of 450°C is the optimum temperature for the Haber process.

_____

_____

_____

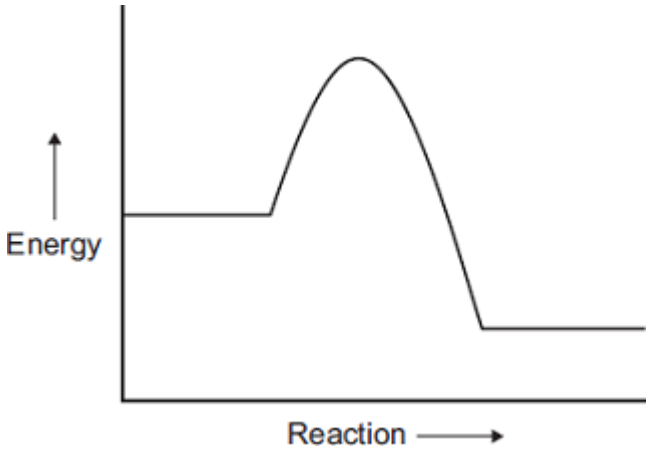
_____

_____

_____

(2)

(e) An energy level diagram for the reaction between nitrogen and hydrogen is shown below.



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

_____

_____

(1)

(ii) In the Haber process iron is used as a catalyst.

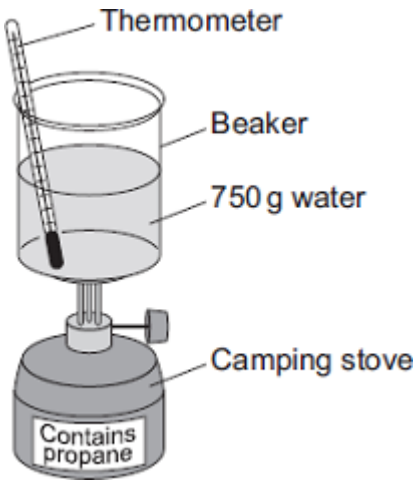
Draw a line on the energy level diagram to show the effect of adding a catalyst.

(1)

(Total 8 marks)

Q2.

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).

_____

_____

_____

_____

_____

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.

_____

_____

_____

_____

Energy released = _____ kJ

(2)

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

_____

_____

_____

_____

(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.

_____

_____

(1)

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

The equation for the combustion of propane is:

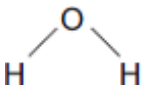
$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$

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.

_____

_____

_____

_____

_____

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.

_____

_____

Overall energy change = _____ kJ per mole

(1)

(Total 12 marks)

Q3.

Read the information.

Alumina is a white solid. In 1800, scientists thought that alumina contained an undiscovered metal. We now call this metal aluminium. At that time, scientists could not extract the aluminium from alumina.

In 1825, Christian Oersted, a Danish scientist, did experiments with alumina.

Step 1 He reacted a mixture of hot alumina and carbon with chlorine to form aluminium chloride. The reaction is very endothermic.

Step 2 The aluminium chloride was reacted with potassium. He was left with potassium chloride and tiny particles of aluminium metal.

Other scientists were **not** able to obtain the same results using his experiment and his work was not accepted at that time.

In 1827, Friedrich Wöhler, a German chemist, made some changes to Oersted's experiment. He obtained a lump of aluminium. He tested the aluminium and recorded its properties.

(a) Suggest why scientists in 1800 could not extract aluminium from alumina.

_____

_____

(1)

(b) Oersted's experiment in 1825 was **not** thought to be reliable.

Explain why

_____

_____

(1)

(c) Why must the reaction in **Step 1** be heated to make it work?

_____

_____

(1)

(d) Complete the word equation for the reaction in **Step 2**.

aluminium chloride + potassium → _____ + _____

(1)

(e) Suggest how Wöhler was able to prove that he had made a new metal.

_____

_____

_____

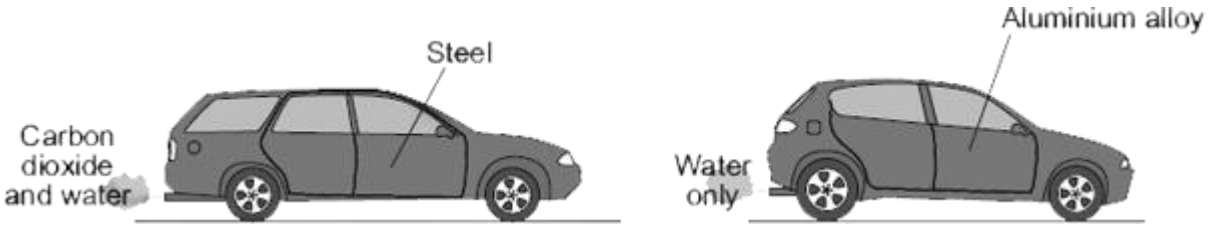
_____

(2)

(Total 6 marks)

Q4.

The picture shows two different cars.



(a) Some properties of aluminium are given below.

Tick (✓) **two** reasons why aluminium is better than steel for car bodies.

Reason	Tick (✓)
Aluminium is not a transition metal.	
Aluminium has a low density.	
Aluminium is expensive to extract.	
aluminium is resistant to corrosion.	

(2)

(b) Each car body is made from an *alloy*.

(i) What is an *alloy*?

_____

_____

(1)

(ii) An alloy is used to make a car body. A pure metal is **not** used to make a car body.

Suggest why.

_____

_____

(1)

(c) The car with a steel body uses petrol for fuel.

Draw a ring around the correct answer to complete each sentence.

(i) Petrol is made from

air.
crude oil.
metal ores.

(1)

(ii) Petrol is a mixture of

carbonates
hydrocarbons
polymers

including C_8H_{18}

(1)

(iii) In the car engine petrol reacts with

argon
nitrogen
oxygen

to produce carbon dioxide and water.

(1)

(d) Look at the substances coming out of each car's exhaust.

(i) Suggest the name of the fuel used in the car with the aluminium alloy body.

Name of fuel _____ .

(1)

(ii) Why is the fuel burned in the car with the aluminium alloy body better for the environment than petrol?

_____

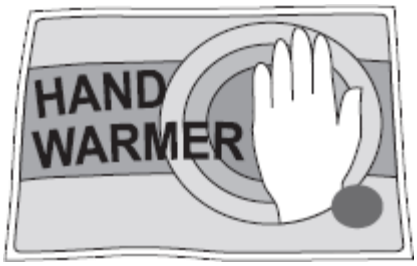
_____

(1)

(Total 9 marks)

Q5.

Hand warmers use chemical reactions.



(a) The table shows temperature changes for chemical reactions **A**, **B** and **C**.

Reaction	Starting temperature in °C	Final temperature in °C	Change in temperature in °C
A	18	25	+ 7
B	17	_____	+ 5
C	18	27	+ 9

What is the final temperature for reaction **B**? Write your answer in the table.

(1)

(b) (i) What name is given to reactions that heat the surroundings?

_____

(1)

(ii) Which reaction, **A**, **B** or **C**, would be best to use in a hand warmer?

Reaction ☐

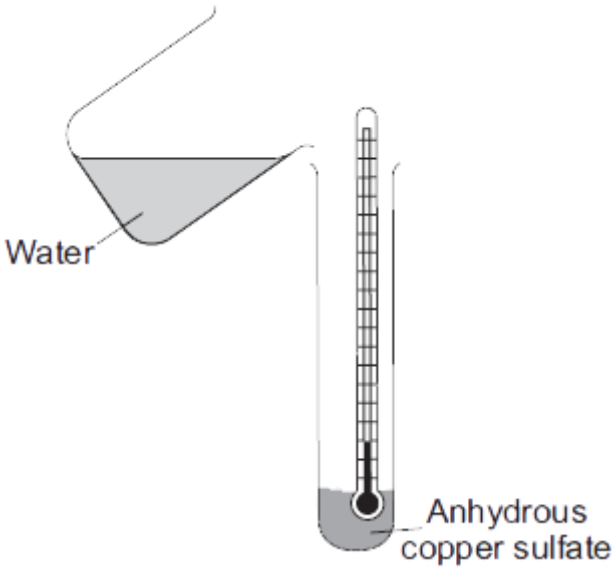
Give a reason why you chose this reaction.

_____

_____

(2)

(c) A student added water to some anhydrous copper sulfate.



The equation for the reaction is shown.

anhydrous copper sulfate + water ⇌ hydrated copper sulfate

$CuSO_4$ + 5 H_2O ⇌ $CuSO_4.5H_2O$

The student measured the temperature before and after the reaction.

(i) The measurements showed that this reaction can be used for a hand warmer.

Draw a ring around the correct answer to complete the sentence.

When water is added to anhydrous copper sulfate the temperature

of the mixture

increases.
decreases.
stays the same.

(1)

(ii) Anhydrous copper sulfate is white.

What colour is seen after water is added to the anhydrous copper sulfate?

_____

(1)

(iii) What does the symbol ⇌ mean?

_____

(1)

(iv) The student heated a tube containing hydrated copper sulfate.

Name the solid substance produced.

_____

(1)

(Total 8 marks)

Q6.

The symbol equation for the decomposition of hydrogen peroxide is:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

(a) This reaction is *exothermic*.

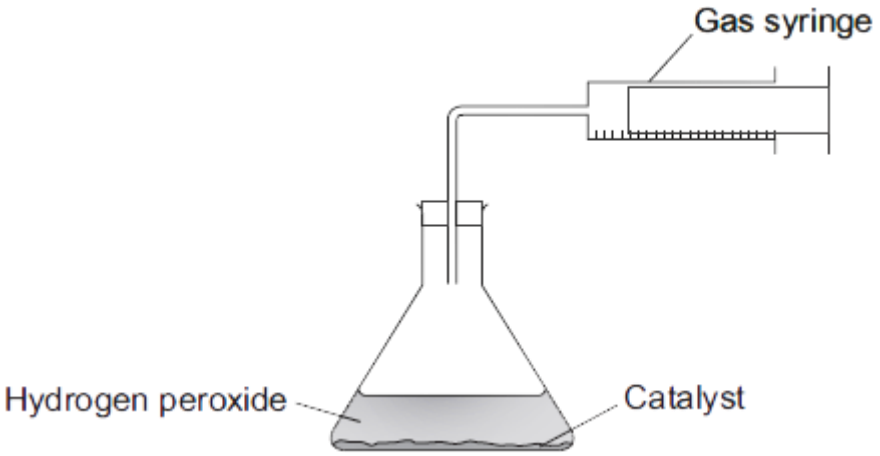
What is an *exothermic* reaction?

_____

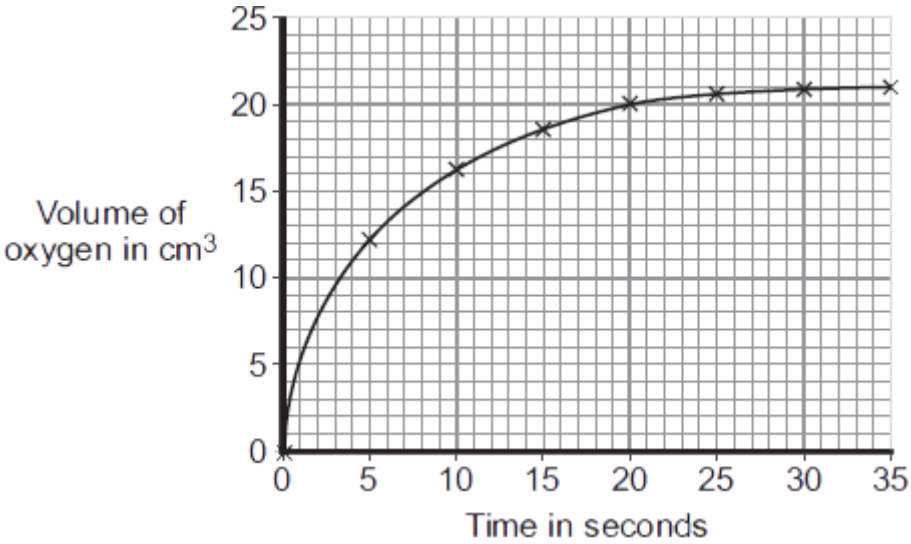
_____

(1)

(b) A student measured the volume of oxygen produced by 50 cm^3 of hydrogen peroxide.



The graph shows the results.



(i) Use the graph to describe the changes in the rate of the reaction from 0 to 35 seconds.

_____

_____

_____

_____

_____

_____

(3)

(ii) What was the total volume of oxygen gas collected?

_____ cm^3

(1)

(iii) The student had calculated that the hydrogen peroxide used should produce 25 cm^3 of oxygen.

Calculate the percentage yield of oxygen.

_____

_____

_____

Answer = _____ %

(2)

(c) An increase in the temperature of the hydrogen peroxide increases the rate of the reaction.

Use your knowledge of particles to explain why.

_____

_____

_____

_____

_____

_____

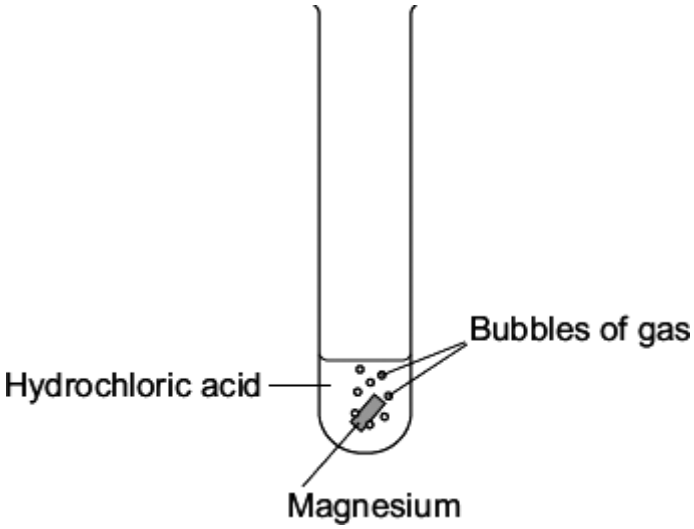
(3)

(Total 10 marks)

Q7.

A student investigated the reaction of magnesium with hydrochloric acid.

(a) A piece of magnesium was dropped into the hydrochloric acid.



Bubbles of gas were produced and the magnesium disappeared.

The reaction is exothermic.

(i) What measurements would the student make to show that the reaction is exothermic?

_____

_____

_____

_____

(2)

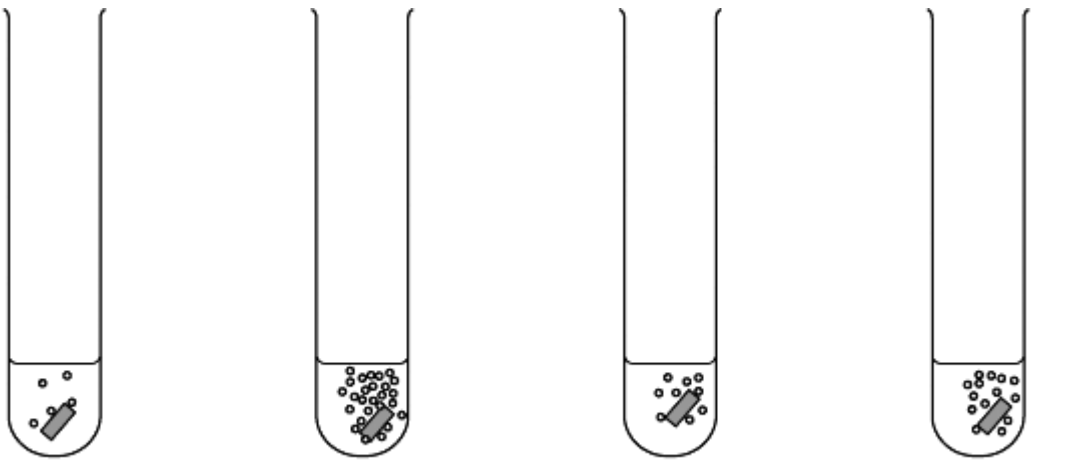
(ii) How would these measurements show that the reaction is exothermic?

_____

(1)

The student investigated how changing the concentration of the hydrochloric acid affects this reaction.

Each test tube contained a different concentration of hydrochloric acid.
The diagrams show the results of this experiment.



(b) Suggest **one** control variable in this investigation.

_____

_____

(1)

(c) (i) Which test tube, **A**, **B**, **C** or **D**, contained the greatest concentration of hydrochloric acid?

Test tube ☐

(1)

(ii) Why did you choose this test tube?

_____

_____

(1)

(d) The student predicted that if the temperature of the acid was increased the reaction would take place faster.

Tick (✓) **two** statements in the table which explain why.

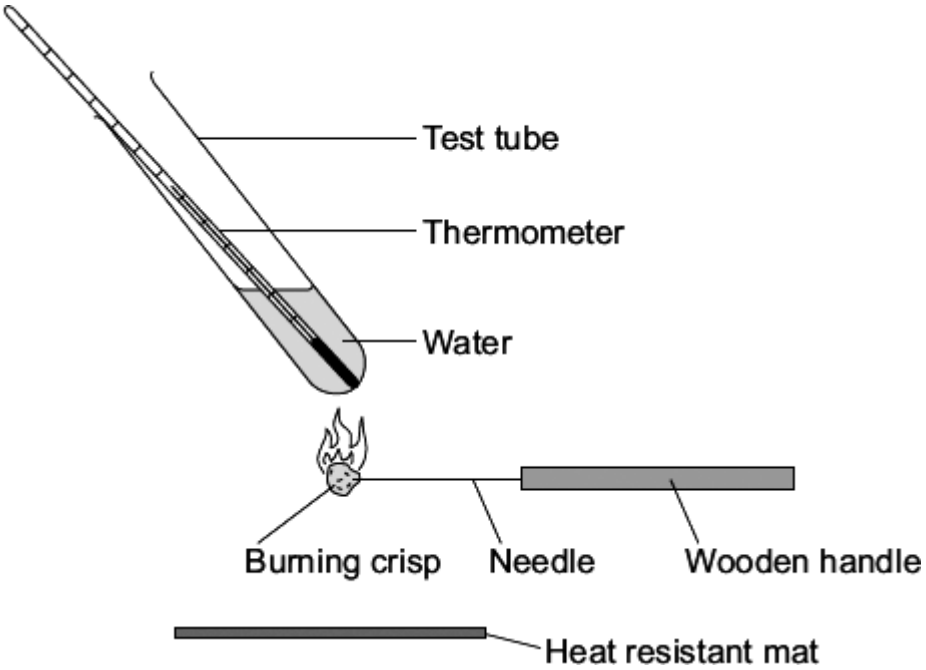
Statement	Tick (✓)
The particles move faster	
The particles collide with less energy	
The particles collide more often	
The particles are bigger	

(2)

(Total 8 marks)

Q8.

A student investigated the amount of energy released when four different makes of plain salted crisps were burned.



The following method was used for each make of plain salted crisp. The pieces of crisp were all the same size.

- The starting temperature of the water was measured.
- The piece of crisp was burned underneath the test tube.
- The final temperature of the water was measured.

(a) The results of the investigation are shown in the table.

	Make 1	**Make 2**	**Make 3**	**Make 4**
Final temperature of the water in °C	26	25	29	25
Starting temperature of the water in °C	19	20	20	21
Temperature rise of the water in °C	7	5	9	

(i) Calculate the temperature rise for **make 4**.

_____

Temperature rise = _____ °C

(1)

(ii) Which make of crisp, **1**, **2**, **3** or **4**, releases the most energy?

Make _____

Give a reason for your answer.

_____

_____

(2)

(b) The energy needed by a student is about 9000 kJ each day.

(i) One large bag of crisps states that the energy released by the crisps is 240 kcal.

Calculate the energy of this bag of crisps in kJ.

1 kcal = 4.2 kJ

_____

_____

Answer = _____ kJ

(2)

(ii) Eating too many crisps is thought to be bad for your health.

Use the information above and your knowledge to explain why.

_____

_____

_____

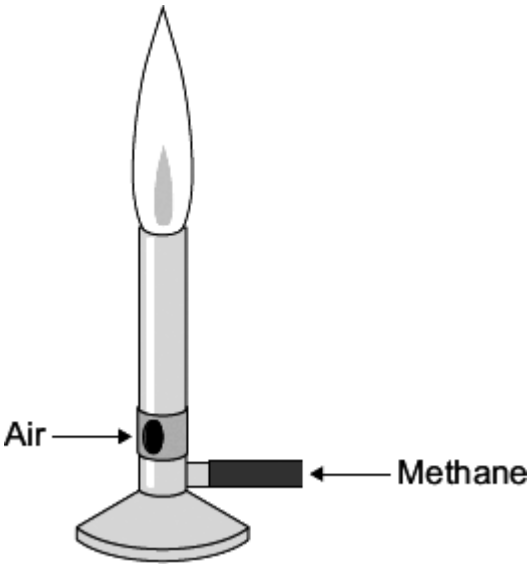
_____

(2)

(Total 7 marks)

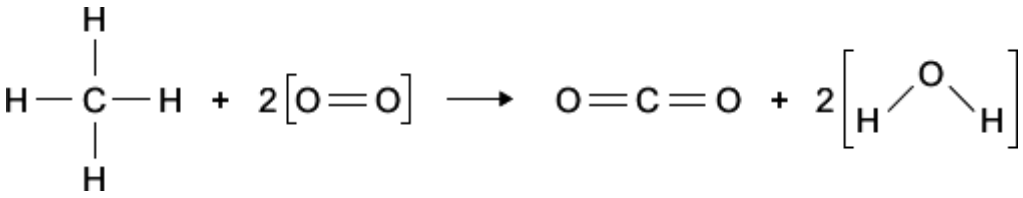
Q9.

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

Energy change = _____ kJ per mole

(3)

(ii) This reaction releases heat energy.

Explain why, in terms of bond energies.

(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?

(1)

(Total 6 marks)

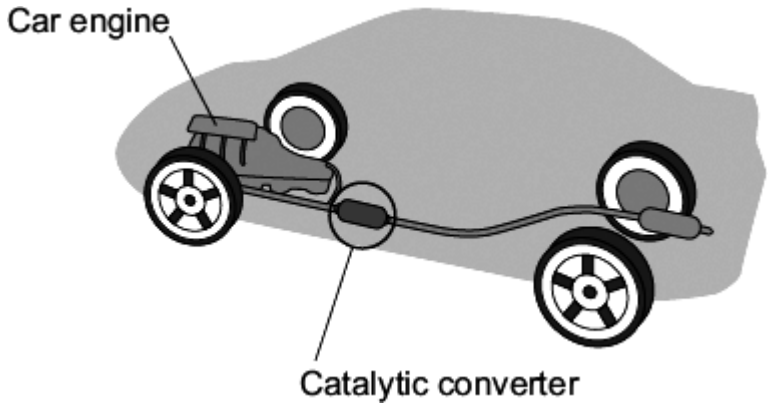
Q10.

Read the information about car engines.

Burning petrol in air is an exothermic reaction. This reaction is used in car engines.

When petrol burns it produces harmful substances such as nitrogen oxides and carbon monoxide.

A catalytic converter stops these harmful substances being released into the air.



(a) Draw a ring around the correct answer to complete each sentence.

(i) The exothermic reaction makes the temperature

of the engine

decrease.
increase.
stay the same.

(1)

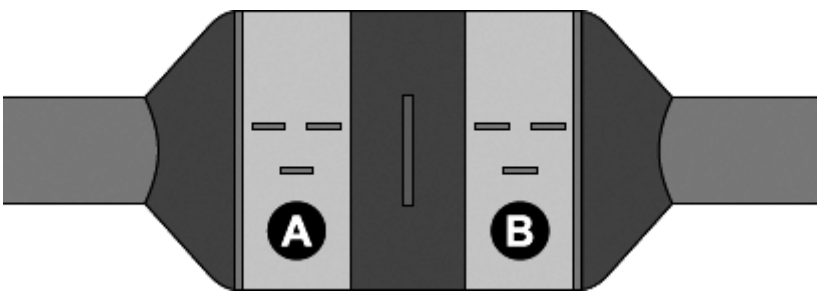
(ii) This is because during

exothermic reactions

energy is taken in from the surroundings.
energy is given out to the surroundings.
there is no energy change.

(1)

(b) The diagram shows a catalytic converter which removes harmful substances.
The catalytic converter has two parts, **A** and **B**, which contain different catalysts.



(i) The equation for the reaction that takes place in part **A** is:

$$2NO \rightarrow N_2 + O_2$$

Which **one** of the substances shown in the equation is a compound?

Give the formula of this compound.

_____

(1)

(ii) The equation for the reaction that takes place in part **B** is:

$$2CO + O_2 \rightarrow 2CO_2$$

Why is it important to stop carbon monoxide (CO) from being released into the air?

_____

_____

(1)

(c) The table lists some statements about catalysts. Only **two** statements are correct.

Tick (✓) the **two** correct statements.

Statement	**Tick (✓)**
A catalyst can speed up a chemical reaction.	
A catalyst is used up in a chemical reaction.	
Different reactions need different catalysts.	
A catalyst does **not** change the rate of a chemical reaction.	

(2)

(d) Modern catalytic converters contain nanosized particles of catalyst.
Less catalyst is needed when nanosized catalyst particles are used.

(i) Complete the sentence.

The size of nanosized particles is _____ than normal sized particles.

(1)

(ii) The catalysts contain platinum.

Suggest why a manufacturer of catalytic converters would want to use less catalyst.

_____

_____

(1)
(Total 8 marks)

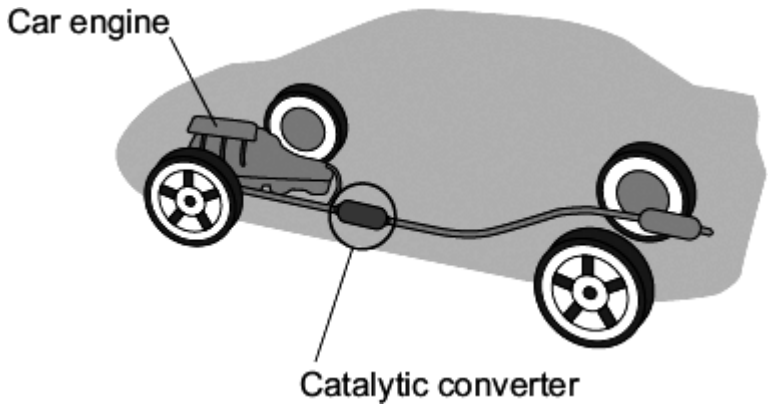
Q11.

Read the information about car engines.

Burning petrol in air is an *exothermic* reaction. This reaction is used in car engines.

When petrol burns it produces harmful substances such as nitrogen oxides and carbon monoxide.

A catalytic converter stops these harmful substances being released into the air.



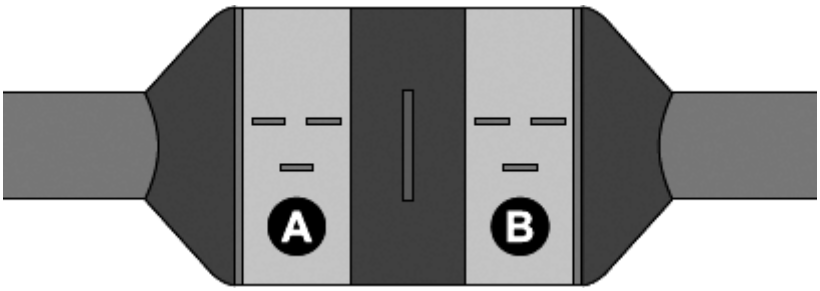
(a) The reaction is *exothermic*. What is the meaning of *exothermic*?

_____

_____

(1)

(b) The catalytic converter has two parts shown as **A** and **B** in the diagram.



Part **A** contains a catalyst made from platinum and rhodium.

Part **B** contains a catalyst made from platinum and palladium.

(i) Why are catalysts used in chemical reactions?

_____

_____

(1)

(ii) One reaction in part **A** is shown by this equation.

$$2NO \rightarrow N_2 + O_2$$

Suggest why this reaction helps the environment.

_____

_____

(1)

(iii) The equation for one of the reactions in part **B** is shown below.

Balance this equation.

$$\_\_\_\_ CO + O_2 \rightarrow \_\_\_\_ CO_2$$

(1)

(iv) The catalytic converter works for many years without replacing the catalyst.

Explain why the catalyst does not need to be replaced.

_____

_____

(1)

(v) Suggest why different catalysts are used in parts **A** and **B**.

_____

_____

(1)

(c) Modern catalytic converters contain nanosized particles of catalyst. Using nanosized particles reduces the cost of the catalytic converter.

Suggest and explain why the use of nanosized catalyst particles reduces the cost of the catalytic converter.

Your answer should include information about the size and surface area of the particles.

_____

_____

_____

_____

_____

_____

_____

(3)

(Total 9 marks)

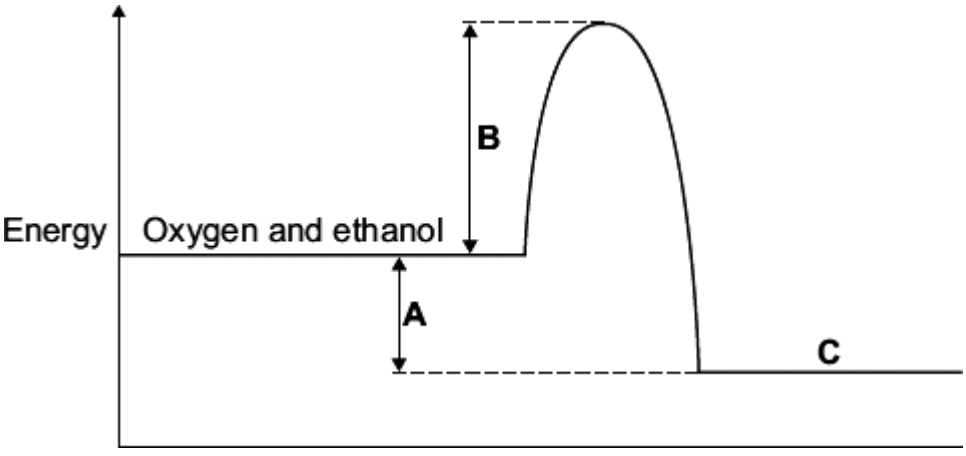
Q12.

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?

_____

_____

(1)

(Total 4 marks)

Q13.

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

_____

_____

_____

_____

Energy change = _____ kJ

(3)

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

_____

_____

_____

(1)

(Total 4 marks)

Q14.

Read the information in the box.

Flash powder is used to produce special effects at pop concerts.

Flash powder contains aluminium. The powder burns with a bright white flame and gives out lots of heat and light. It also produces white smoke.

The flash powder is placed on stage in a special container. At the bottom of the container there is a thin piece of wire. When the flash is needed, electricity is passed through the wire. The wire gets hot and starts the aluminium burning.

(a) When aluminium burns the reaction is exothermic.

Give **one** piece of information from the box which shows that the reaction is exothermic.

_____

(1)

(b) The hot wire provides energy to start the aluminium burning.

Draw a ring around the name given to the energy needed to start a chemical reaction.

activation energy **potential energy** **solar energy**

(1)

(c) When aluminium burns it reacts with oxygen to make aluminium oxide.

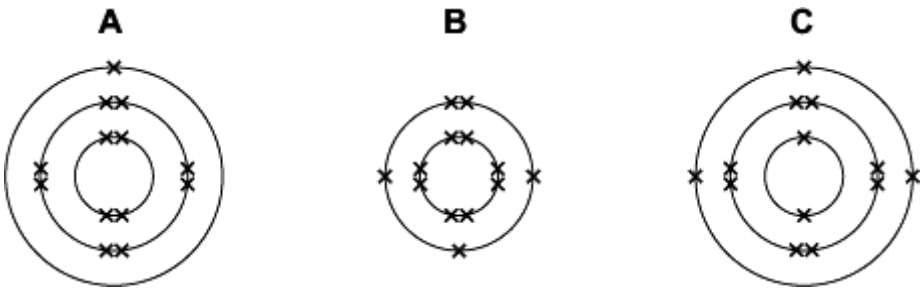
Complete the word equation for this reaction.

aluminium + _____ → _____

(1)

(d) An aluminium atom has 13 electrons.

Which diagram, **A**, **B** or **C**, represents the electronic structure of an aluminium atom?



The electronic structure of an aluminium atom is diagram ☐

(1)

(e) The white smoke produced is aluminium oxide.

Aluminium oxide contains aluminium ions (Al^{3+}) and oxide ions (O^{2-}).

Draw a ring around the correct word in each box to complete each sentence.

(i) Electrons have [a negative / no / a positive] charge.

(1)

(ii) When an aluminium atom (Al) turns into an aluminium ion (Al^{3+})

it [gains / loses / shares] three electrons.

(1)

(iii) When an oxygen atom (O) turns into an oxide ion (O^{2-})

it [gains / loses / shares] [one / two / three] electrons.

(2)

(Total 8 marks)

Q15.

Read the information in the box.

Flash powder is used to produce special effects at pop concerts.

Flash powder contains aluminium. The powder burns with a bright white flame and gives out lots of heat and light. It also produces white smoke.

The flash powder is placed on stage in a special container. At the bottom of the container there is a thin piece of wire. When the flash is needed, electricity is passed through the wire. The wire gets hot and starts the aluminium burning.

(a) When aluminium burns the reaction is *exothermic*.

What is the meaning of *exothermic*?

_____

_____

(1)

(b) The hot wire provides energy to start the aluminium burning.

What is the name given to the heat energy needed to start a chemical reaction?

_____ energy

(1)

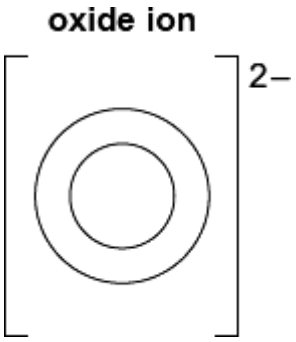
(c) The white smoke produced is aluminium oxide.

Aluminium oxide contains aluminium ions (Al^{3+}) and oxide ions (O^{2-}).

(i) Complete the diagram to show the electronic structure of an oxide ion.

The atomic number of oxygen = 8

Use crosses (x) to represent the electrons.



(1)

(ii) The bonding in aluminium oxide is ionic.

What causes the aluminium ions and oxide ions to be held together strongly?

_____

_____

(1)

(Total 4 marks)

Q16.

Hydrogen peroxide decomposes slowly to give water and oxygen.

The reaction is *exothermic*.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

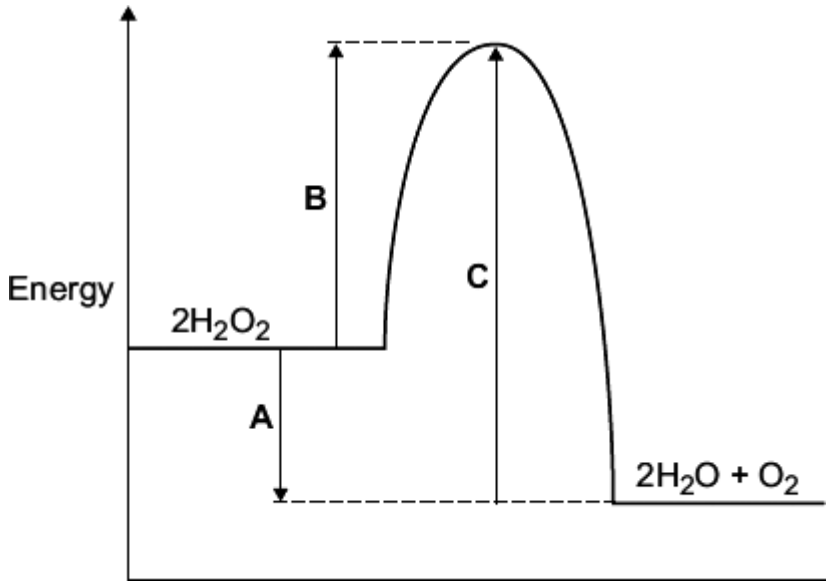
(a) In an *exothermic* reaction, energy is given out.

Draw a ring around the correct answer to complete the sentence.

In an *exothermic* reaction, the temperature	goes down.
	goes up.
	stays the same.

(1)

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



The energy changes, **A**, **B** and **C**, are shown on the diagram.

Use the diagram to help you answer these questions.

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

(1)

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

(1)

(iii) Hydrogen peroxide decomposes quickly when a small amount of manganese(IV) oxide is added.

Draw a ring around the correct answer to complete each sentence.

Hydrogen peroxide decomposes quickly because

manganese(IV) oxide is

- a catalyst.
- an element.
- a solid.

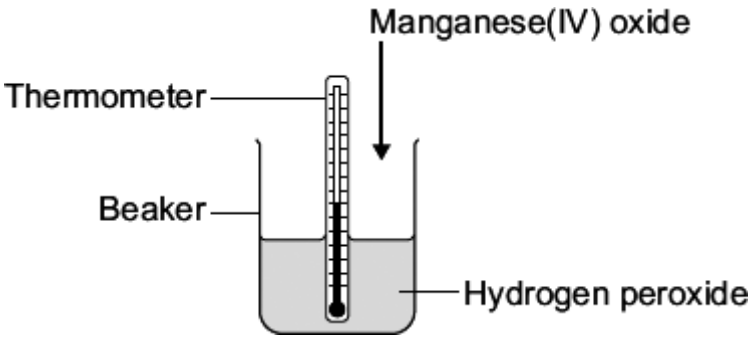
The manganese(IV) oxide has lowered the

- activation energy.
- boiling point.
- temperature.

(2)

(c) A student did an experiment to find the amount of energy produced when hydrogen peroxide solution is decomposed using manganese(IV) oxide.

The apparatus the student used is shown in the diagram.



The student first measured the temperature of the hydrogen peroxide. Then the student added the manganese(IV) oxide, stirred the mixture and recorded the highest temperature.

(i) Suggest why the student stirred the mixture before recording the highest temperature.

_____

_____

(1)

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

Suggest how the student could change the apparatus so that less heat is lost.

_____

_____

(1)

(Total 7 marks)

Q17.

Hydrogen peroxide decomposes to give water and oxygen.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

The reaction is *exothermic*.

(a) Explain, in terms of bond breaking and bond making, why the decomposition of hydrogen peroxide is *exothermic*.

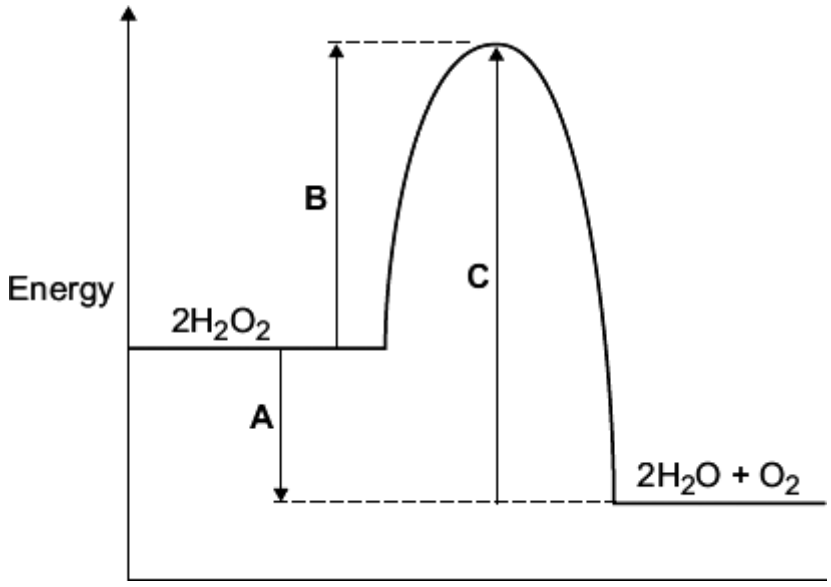
_____

_____

_____

(1)

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



The energy changes, **A**, **B** and **C**, are shown on the diagram.

Use the diagram to help you answer these questions.

(i) How do you know that this reaction is *exothermic*?

_____

_____

_____

(1)

(ii) The decomposition of hydrogen peroxide is slow.
What does this suggest about energy change **B**?

_____

_____

_____

(1)

(iii) Hydrogen peroxide decomposes quickly when a small amount of manganese(IV) oxide is added.

Explain why.

_____

_____

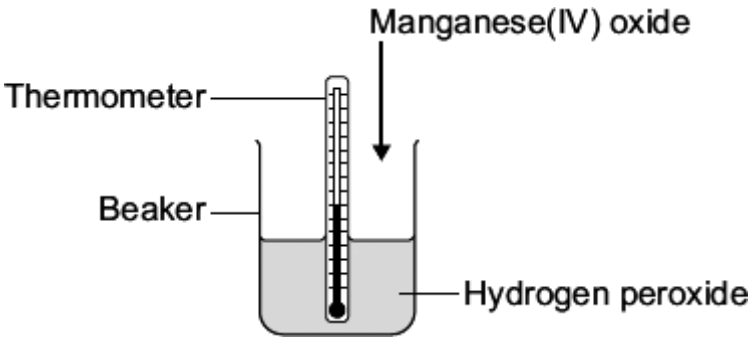
_____

_____

(2)

(c) A student did an experiment to find the amount of energy produced when hydrogen peroxide solution is decomposed using manganese(IV) oxide.

The apparatus the student used is shown in the diagram.



The student first measured the temperature of the hydrogen peroxide. Then the student added the manganese(IV) oxide and recorded the highest temperature.

The temperature rise was smaller than expected.

Suggest why.

_____

_____

_____

_____

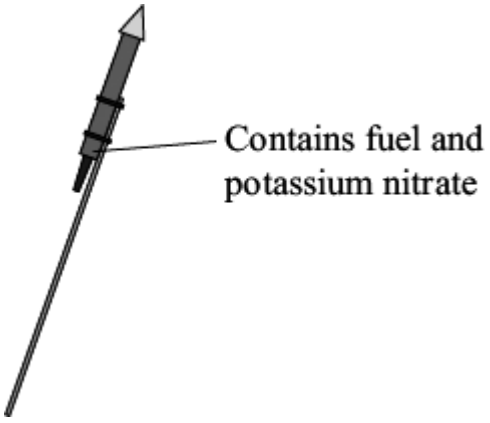
_____

(2)

(Total 7 marks)

Q18.

Firework rockets contain fuel and potassium nitrate.



The potassium nitrate provides oxygen for the fuel to react.

(a) The table shows how a student worked out the relative formula mass (M_r) of potassium nitrate.

Some of the numbers are missing.

Relative atomic masses (A_r): N = 14; O = 16; K = 39.

Name of atom	**Number of**	A_r	**Mass**

(symbol)	atoms		
potassium (K)	1	39	39
nitrogen (N)	1	14	14
oxygen (O)		16	
		The M_r of potassium nitrate =	101

(i) The mass of oxygen is not shown in the table.

Draw a ring around the correct mass of oxygen.

16 **32** **48**

(1)

(ii) Draw a ring around the number of oxygen atoms in the formula of potassium nitrate.

1 **2** **3**

(1)

(b) When the fuel reacts with the oxygen an *exothermic* reaction takes place.

What does *exothermic* mean?

_____

_____

_____

_____

(2)

(c) The fuel contains carbon. Carbon reacts with oxygen to make carbon dioxide.

Which **two** statements in the table explain why carbon dioxide is a gas at room temperature?

Tick (✓) the **two** statements.

Statement	Tick (✓)
It has a giant structure	
It has a low boiling point.	
It is made of small molecules.	
It is made of ions.	

(2)

(Total 6 marks)

Q19.

During a thunderstorm lightning strikes the Eiffel Tower.

By M. G. Loppé [Public domain], via Wikimedia Commons

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*.

(a) Nitrogen and oxygen in the air do not react easily.

What makes nitrogen and oxygen react during thunderstorms?

_____

(1)

(b) Complete the word equation for the reaction of nitrogen with oxygen.

nitrogen + _____ → _____

(1)

(c) In an *endothermic* reaction, energy is taken in from the surroundings.

Draw a ring around the correct answer to complete the sentence.

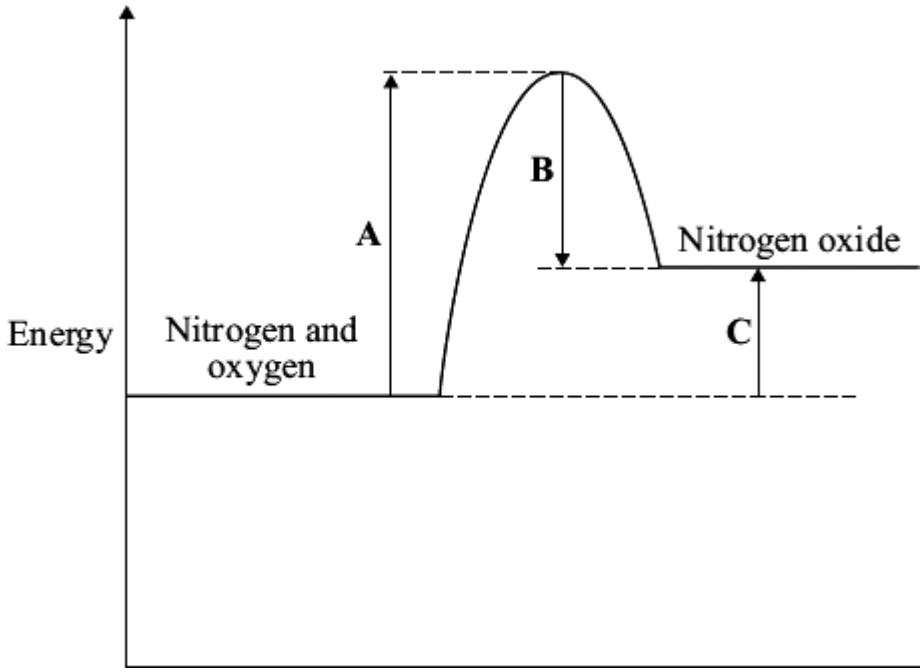
In an *endothermic* reaction, the energy needed to break existing bonds is

less than
more than
the same as

the energy released from forming new bonds.

(1)

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



Use the energy level diagram to help you to answer these questions.

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

(1)

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

(1)

(Total 5 marks)

Q20.

During a thunderstorm lightning strikes the Eiffel Tower.

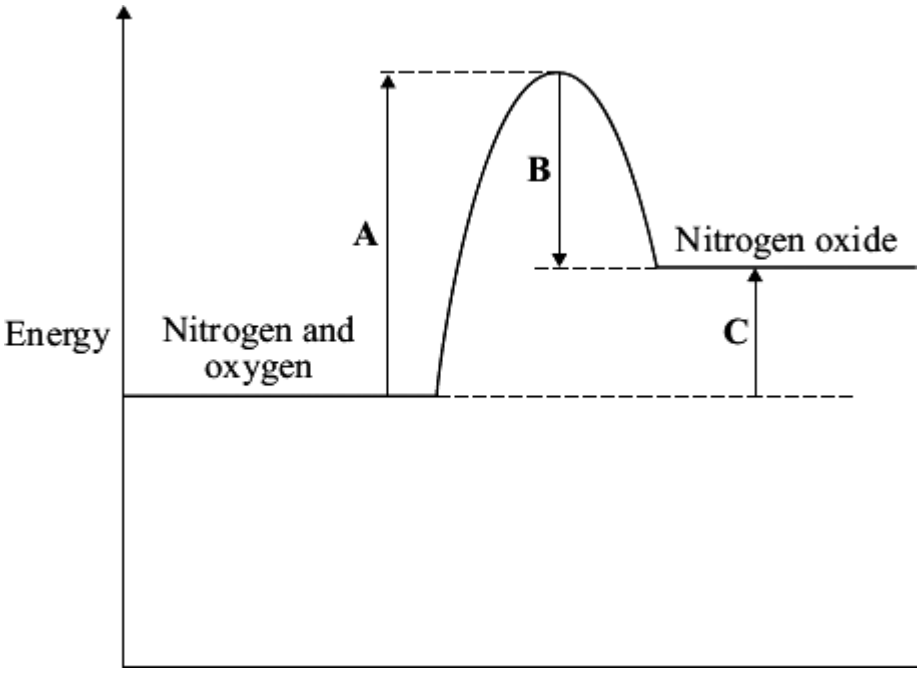
By M. G. Loppé [Public domain], via Wikimedia Commons

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:

$$N_2 \quad + \quad O_2 \quad \rightarrow \quad 2NO$$

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

$$N \equiv N \quad + \quad O = O \quad \rightarrow \quad 2\ N = O$$

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.

_____

_____

_____

_____

Energy change = _____ kJ

(3)

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

_____

_____

_____

(1)

(Total 6 marks)

Q21.

(a) Read the article about the mineral strontianite.

Strontianite is a mineral that was discovered near the village of Strontian in Scotland. At first some scientists thought that strontianite was barium carbonate.

Strontianite

In 1790, Professor Adair Crawford and William Cruikshank were both lecturers in chemistry and doctors of medicine. They investigated the properties of strontianite. They found that strontianite had different properties from barium carbonate. They concluded that strontianite contained a new element.

After this, other scientists also showed that strontianite and barium carbonate had different properties. Strontianite is now known to be strontium carbonate.

Rob Lavinsky, iRocks.com – CC-BY-SA-3.0 [CC-BY-SA-3.0], via Wikimedia Commons

(i) What evidence did Crawford and Cruikshank use to prove that strontianite was **not** barium carbonate?

_____

_____

(1)

(ii) Crawford and Cruikshank's conclusion was immediately accepted by other scientists. Suggest why.

_____

_____

(1)

(iii) How was the reliability of the work of Crawford and Cruikshank confirmed?

_____

_____

(1)

(b) One of Crawford and Cruikshank's experiments was repeated in a school laboratory.

Samples of strontianite and barium carbonate were reacted with hydrochloric acid to produce strontium chloride and barium chloride.

Solid strontium chloride and solid barium chloride were separately added to water. The change in temperature of the water was measured.

The results of the experiments are shown below.

	Experiment 1 Strontium chloride dissolved in water	**Experiment 2** Barium chloride dissolved in water
Temperature of water before adding the chloride in °C	19.5	19.6
Temperature of water after adding the chloride in °C	21.2	17.5

(i) State **one** variable that should be controlled to make it a fair test.

_____

_____

(1)

(ii) Which experiment, **1** or **2**, is endothermic?

Explain how you know.

Experiment ☐ because _____

_____

(1)

(iii) The results prove that strontium chloride and barium chloride must be different even if all of the variables had not been controlled when they were dissolved. Explain why.

_____

_____

(1)

(c) In 1808, Humphry Davy was the first person to extract strontium. He did this by the electrolysis of molten strontium chloride. Strontium formed at the negative electrode.

Suggest why strontium ions are attracted to the negative electrode.

_____

_____

(1)

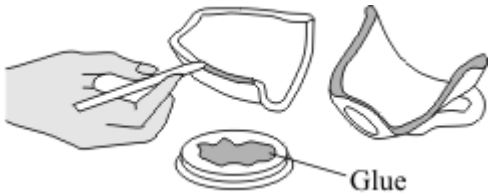
(Total 7 marks)

Q22.

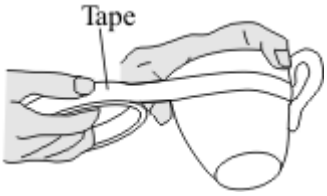
The following steps show how to use a type of glue.

Step 1 Measure out equal amounts of the liquids from tubes **A** and **B**.

Step 2 Mix the liquids to make the glue.
Put a thin layer of the glue onto each of the surfaces to be joined.



Step 3 Assemble the pieces to be joined and then hold them together with tape.



Step 4 Leave the glue to set.

(a) When liquids **A** and **B** are mixed a chemical reaction takes place.

(i) This reaction is exothermic.

Complete the sentence below using a word or phrase from the box.

decrease	**increase**	**stay the same**

During the reaction the temperature of the mixture will _____ .

(1)

(ii) When the glue sets it forms a giant covalent structure.

Draw a ring around **one** property that you would expect the set glue to have.

good conductor of electricity **low melting point** **high melting point**

(1)

(b) The time taken for the glue to set at different temperatures is given in the table below.

Temperature in °C	**Time taken for the glue to set**
20	3 days
60	6 hours

90	1 hour

(i) Complete the sentences below using words or phrases from the box.

decrease	**increase**	**stay the same**

When the temperature is increased the time taken for the glue to set

_____

When the temperature is increased the rate of the setting reaction

_____

(2)

(ii) Put a tick (✓) next to the **two** reasons why an increase in temperature affects the rate of reaction.

Reason	(✓)
It gives the particles more energy.	
It increases the concentration of the particles.	
It increases the surface area of the particles.	
It makes the particles move faster.	

(2)
(Total 6 marks)

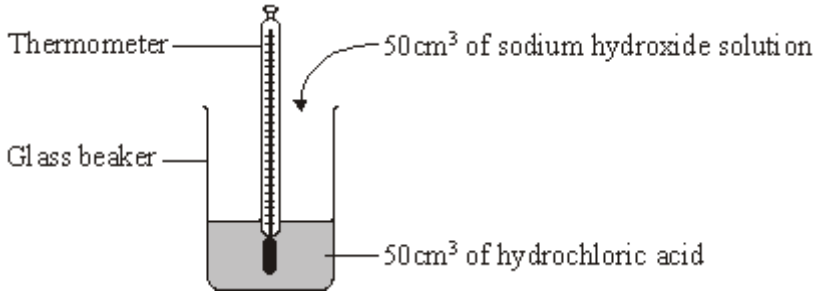
Q23.

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 cm^3 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.

_____

_____

(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.

_____

_____

(1)

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

_____

_____

(1)

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

_____

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

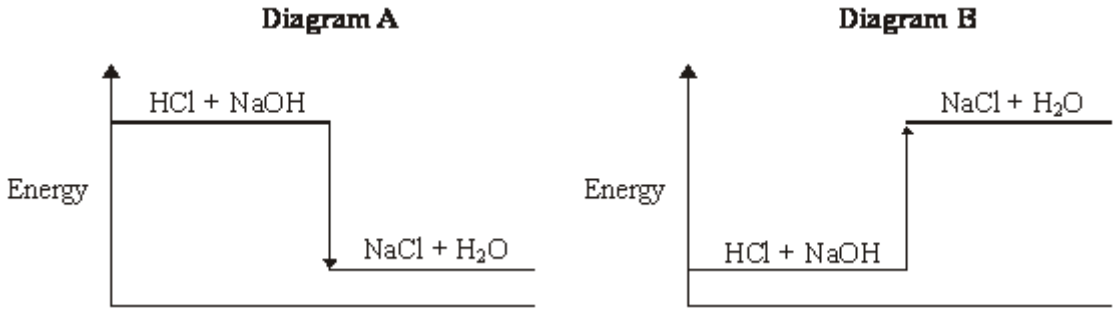
_____

Answer = _____ J

(1)

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

Explain why.



_____

_____

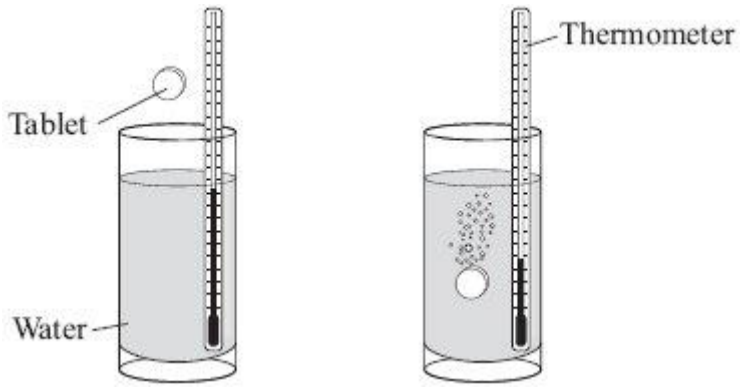
(1)

(Total 7 marks)

Q24.

An indigestion tablet contains sodium hydrogencarbonate and citric acid.

When the tablet is added to cold water a chemical reaction takes place and there is a lot of fizzing.



(a) The formula of the gas that causes the fizzing is CO_2

Name this gas _____ .

(1)

(b) This chemical reaction is endothermic.

(i) Tick (✓) the statement which describes what happens to the temperature of the solution.

Statement	Tick (✓)
The temperature of the solution will increase.	
The temperature of the solution will decrease.	
The temperature of the solution will stay the same.	

(1)

(ii) Tick (✓) the statement which describes what happens to the energy during the reaction.

Statement	Tick (✓)
Energy is given out to the surroundings.	
Energy is taken in from the surroundings.	
No energy is given out to or taken from the surroundings.	

(1)

(Total 3 marks)

Q25.

An airship caught fire when it was coming in to land in 1937. The airship was filled with hydrogen. A spark or flame ignited the hydrogen. The hydrogen reacted with oxygen in the air to produce water.

(a) Write a word equation for the reaction of hydrogen with oxygen.

_____

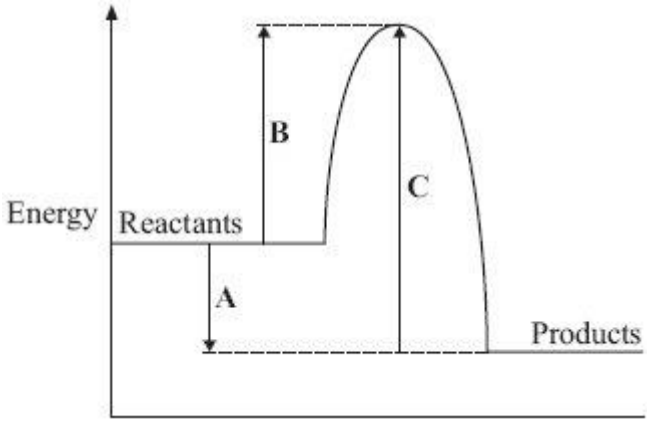
(1)

(b) Draw a ring around the correct answer in each box to complete this sentence.

When reactions take place, energy is [released / supplied] to break the existing bonds and energy is [released / supplied] when new bonds form.

(1)

(c) An energy level diagram for the reaction of hydrogen and oxygen is shown below.



Use the energy level diagram above to help you to answer these questions.

(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)

(iii) Explain why the hydrogen and oxygen needed a spark or flame to start the reaction.

_____

_____

(1)

(Total 5 marks)

Q26.

An airship caught fire when it was coming in to land in 1937. The airship was filled with hydrogen. A spark or flame ignited the hydrogen. The hydrogen reacted with oxygen in the air to produce water.

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

$$2\ H – H + O = O \rightarrow 2\ H – O – H$$

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

Bond	Bond energy in kJ per mole

H – H	436
O = O	498
O – H	464

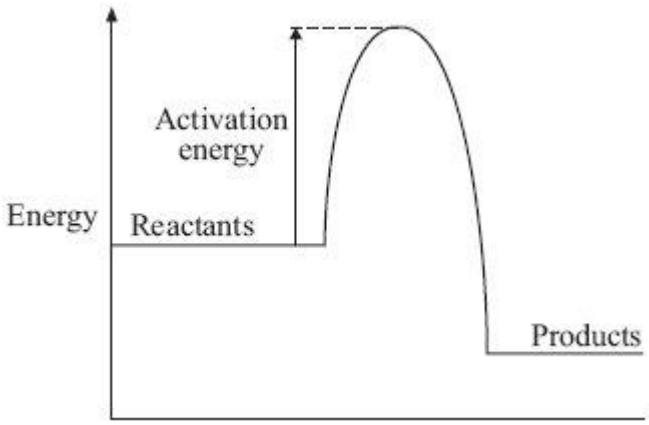
Energy change = _____ kJ

(3)

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

(1)

(c) Use the energy level diagram for this reaction to help you to answer these questions.



(i) The hydrogen did **not** burn until ignited by a spark or flame.

Explain why.

(1)

(ii) Platinum, a transition metal, causes hydrogen to ignite **without** using a spark or flame.

Explain why.

_____

_____

_____

_____

(2)

(Total 7 marks)

Q27.

Distress flares are used to attract attention in an emergency.

Flares often contain magnesium. Magnesium burns to form magnesium oxide.

(a) The distress flare burns with a bright flame because the reaction is very *exothermic*.

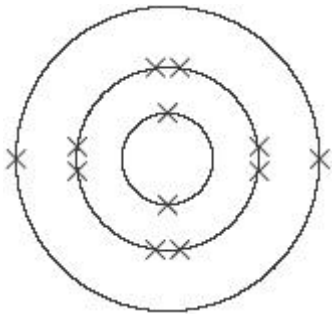
Complete the following sentence using the correct words from the box.

gives out heat	**stores heat**	**takes in heat**

An *exothermic* reaction is one which _____

(1)

(b) The diagram shows the electronic structure of a magnesium atom.
The atomic (proton) number of magnesium is 12.



Magnesium atom

The atomic (proton) number of oxygen is 8.

Which diagram, **A**, **B**, **C** or **D**, shows the electronic structure of an oxygen atom?

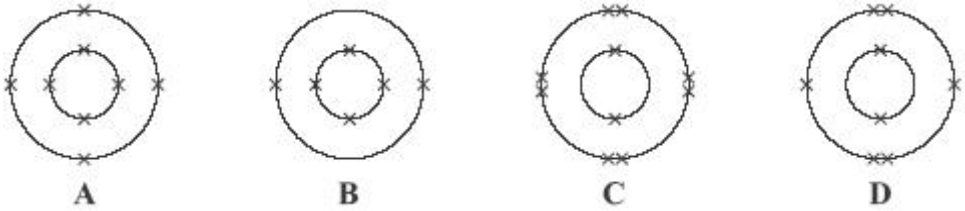
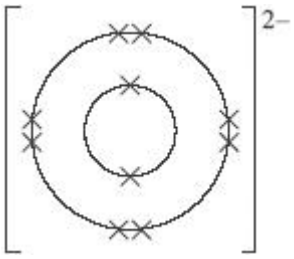


Diagram _____

(1)

(c) Magnesium ions and oxide ions are formed when magnesium reacts with oxygen. The diagram shows the electronic structure of an oxide ion.



Oxide ion

Which diagram, **J**, **K**, **L** or **M**, shows the electronic structure of a magnesium ion?

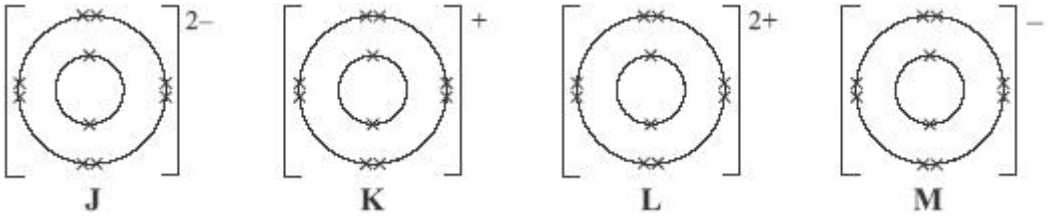


Diagram _____

(1)

(d) Indigestion tablets can be made from magnesium oxide. The magnesium oxide neutralises some of the hydrochloric acid in the stomach.

Draw a ring around the name of the salt formed when magnesium oxide reacts with hydrochloric acid.

magnesium chloride **magnesium hydroxide** **magnesium sulfate**

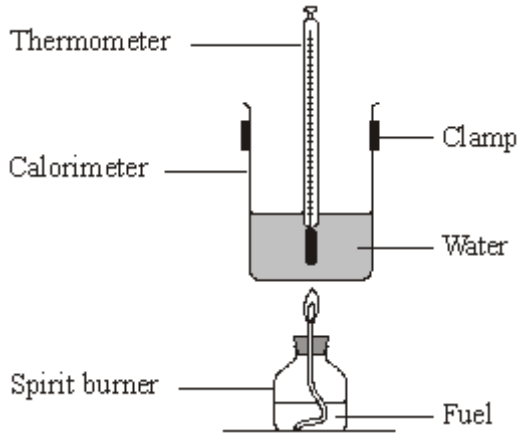
(1)

(Total 4 marks)

Q28.

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.

_____

_____

_____

_____

(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.

_____

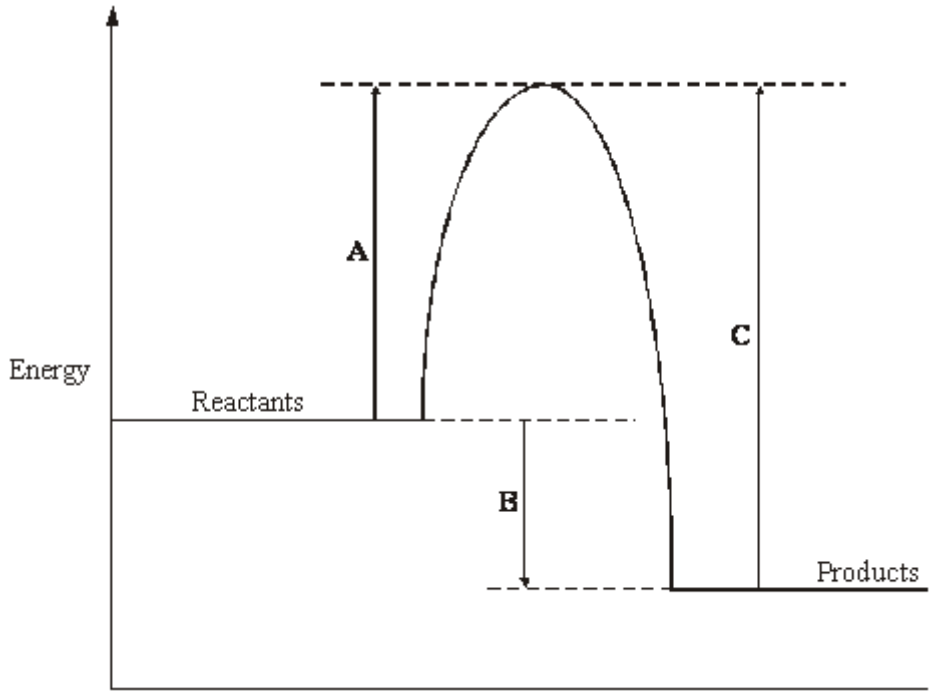
_____

_____

_____

(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?

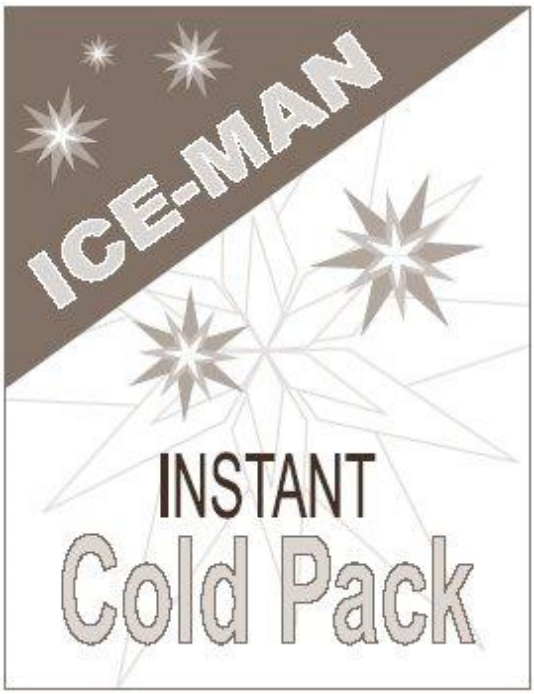
_____

(1)

(Total 6 marks)

Q29.

Instant cold packs are used to treat sports injuries.



One type of cold pack has a plastic bag containing water. Inside this bag is a smaller bag containing ammonium nitrate.

The outer bag is squeezed so that the inner bag bursts. The pack is shaken and quickly gets very cold as the ammonium nitrate dissolves in the water.

(a) **One** of the statements in the table is correct.

Put a tick (✓) next to the correct statement.

Statement	(✓)
The bag gets cold because heat energy is given out to the surroundings.	
The bag gets cold because heat energy is taken in from the surroundings.	
The bag gets cold because plastic is a good insulator.	

(1)

(b) Draw a ring around the word that best describes the change when ammonium nitrate dissolves in water.

electrolysis **endothermic** **exothermic**

(1)

(c) Suggest and explain why the pack is shaken after the inner bag has burst.

_____

_____

_____

_____

(2)

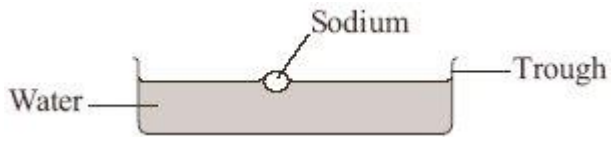
(Total 4 marks)

Q30.

(a) Read a student's report about the reaction between sodium and water.

The reaction between sodium and water

A small piece of sodium was added to some water in a trough.



The sodium floated and started to react.

The sodium moved along the surface of the water and melted to give a ball of molten metal.

The ball became smaller and smaller until it had all gone.

A gas was given off and a colourless solution was left.

The word equation for this reaction is:

sodium + **water** → **sodium hydroxide** + **hydrogen**

Use the information from the student's report to answer these questions.

(i) Which information shows that sodium has a low density?

_____

(1)

(ii) Which information shows that the reaction is exothermic?

_____

(1)

(iii) Name the gas given off.

_____

(1)

(b) The periodic table on the Data Sheet may help you to answer these questions.

(i) Sodium is in Group 1.

Name a Group 1 element that is more reactive than sodium.

_____

(1)

(ii) Here are some statements about Group 1 elements.

Only **two** of these statements are correct.

Put a tick (✓) next to the two correct statements.

Statement	(✓)
They are halogens	
They are metals	
They form covalent compounds	
They form ions with a +1 charge	

(2)

(c) Dimitri Mendeleev put forward his periodic table in 1869.

Complete these sentences by drawing a ring around the correct answer.

(i) Mendeleev arranged the elements in order of their

atomic weight
density
reactivity

(1)

(ii) The table is called a periodic table because elements with

identical
the same
similar

properties occur at regular intervals.

(1)

(iii) The vertical columns are known as

groups
periods
rows

(1)

(d) How did Mendeleev overcome the problem of undiscovered elements when he designed his table?

_____

(1)

(Total 10 marks)

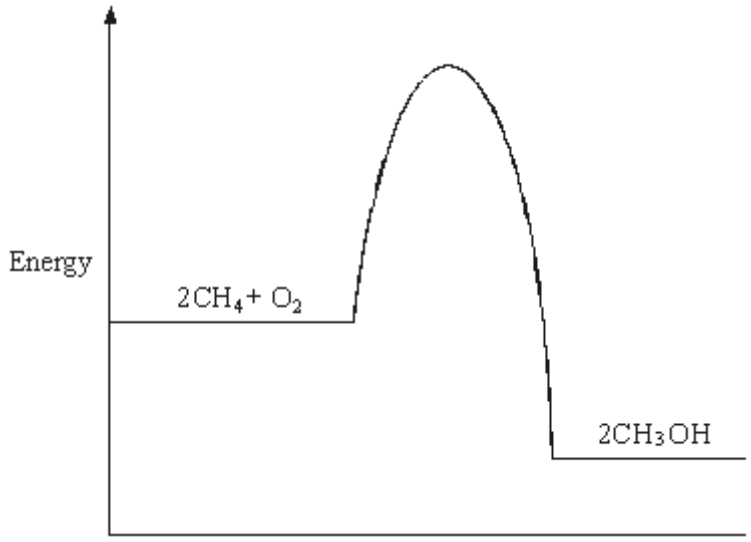
Q31.

Methanol (CH_3OH) can be made by reacting methane (CH_4) and oxygen (O_2) in the presence of a platinum catalyst. The reaction is exothermic.

An equation that represents the reaction is:

$$2CH_4 + O_2 \rightarrow 2CH_3OH$$

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



(i) Use the diagram to explain how you know that this reaction is exothermic.

_____

_____

_____

(1)

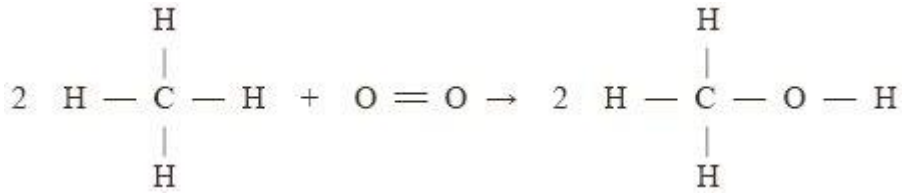
(ii) Explain, in terms of the energy level diagram, how the platinum catalyst increases the rate of this reaction.

_____

_____

(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	498
C — O	805
O — H	464

_____

_____

_____

_____

_____

Energy change = _____ kJ

(3)

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

_____

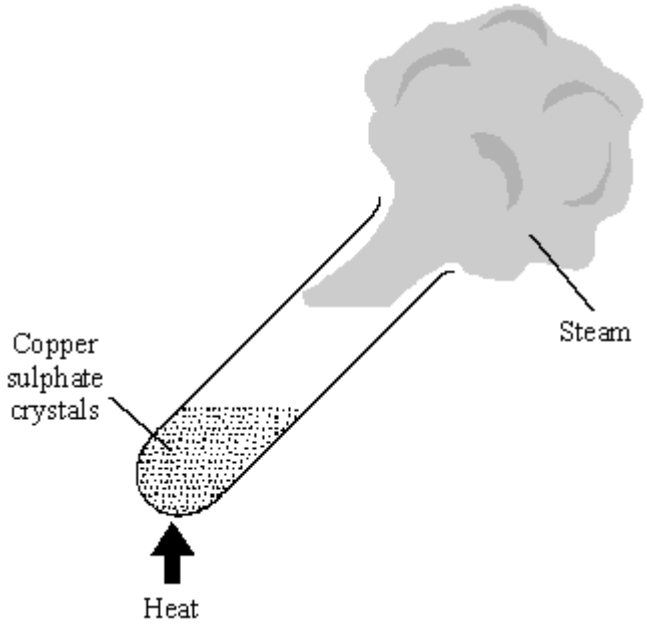
_____

(1)

(Total 6 marks)

Q32.

A student heated some blue copper sulphate crystals. The crystals turned into white copper sulphate.



(a) The blue copper sulphate had to be heated to change it into white copper sulphate.

State whether the reaction was exothermic or endothermic. _____

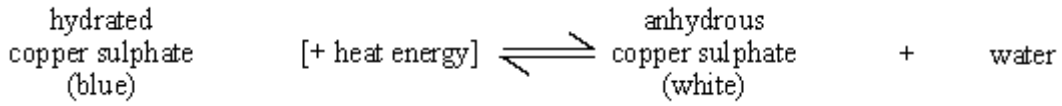
Explain your answer.

_____

_____

(1)

(b) The word equation for this reaction is shown below.



(i) What does the symbol ⇌ tell you about this reaction?

_____

(1)

(ii) How could the student turn the white powder back to blue?

_____

(1)

(Total 3 marks)

Q33.

The reaction of methane with steam is used in industry to make hydrogen.

(a) One of the reactions in this process is represented by this equation.

CH_4 (g) + H_2O ⇌ CO (g) + $3H_2$ (g)

The forward reaction is endothermic.

State the conditions of temperature and pressure that would give the maximum yield of hydrogen.

Explain your answers.

(i) Temperature

_____

_____

_____

_____

(2)

(ii) Pressure

_____

_____

_____

_____

(2)

(iii) Which one of the following metals is most likely to be a catalyst for this process? Draw a ring around your answer.

aluminium **lead** **magnesium** **nickel** **sodium**

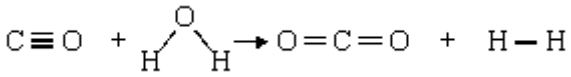
Give a reason for your choice.

_____

_____

(1)

(b) A second stage in this process is represented by this equation.



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

Bond	Bond energy in kJ/mol
C ≡ O	1077
C = O	805
H – H	436
O – H	464

_____

_____

_____

_____

_____

_____

Nett energy transfer = _____ kJ/mol

(3)

(ii) State whether this reaction is exothermic or endothermic. _____

Explain, by reference to your calculation, how you know.

_____

_____

_____

_____

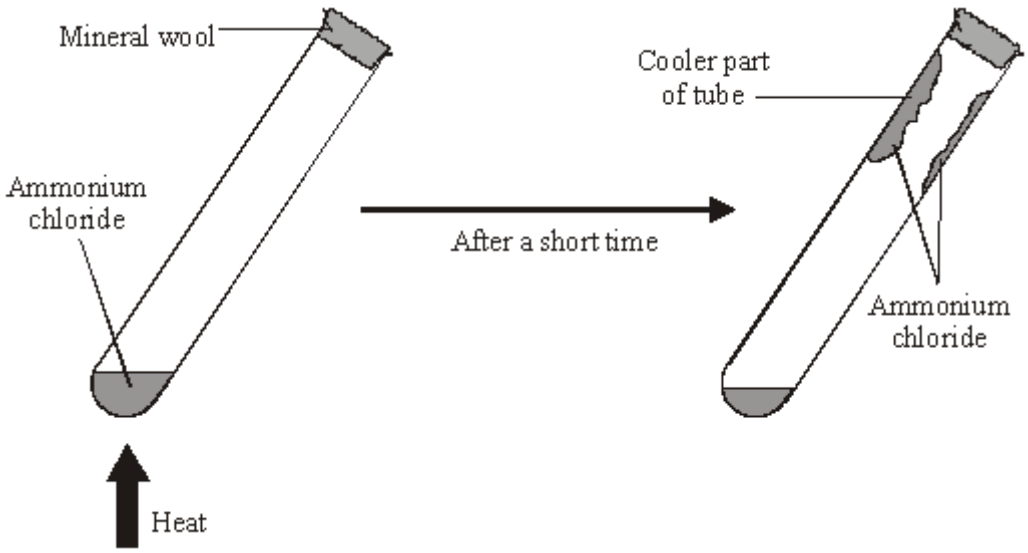
(2)

(Total 10 marks)

Q34.

A student did two experiments using ammonium chloride.

(a) In the first experiment the student heated a small amount of ammonium chloride in a test tube.



Two reactions take place in the test tube.

Reaction **1**	ammonium chloride → ammonia + hydrogen chloride (colourless gases)
Reaction **2**	ammonia + hydrogen chloride → ammonium chloride

(i) Complete the sentences by crossing out the **incorrect** word in each box.

Reaction **1** takes place at a [high / low] temperature.

Reaction **2** takes place at a [high / low] temperature.

(1)

(ii) Draw a ring around the word which best describes reactions **1** and **2**.

combustion displacement oxidation reduction reversible

(1)

(iii) Suggest a reason for the mineral wool at the top of the test tube.

_____

_____

(1)

(b) In the second experiment the student mixed a small amount of ammonium chloride with some water in a beaker.

The temperature of the water was measured before and after adding the ammonium chloride.

Temperature before adding the ammonium chloride	20°C

Temperature after adding the ammonium chloride	16°C

Draw a ring around the word which best describes the process which takes place.

combustion displacement endothermic exothermic freezing

(1)

(Total 4 marks)

Q35.

Silicon is an important element used in the electronics industry.

(a) Silicon can be made by heating a mixture of sand (silicon dioxide) with magnesium powder.

The equation for this reaction is shown below.

$$SiO_2\ (s) + 2Mg\ (s) \rightarrow 2MgO\ (s) + Si\ (s)$$

Calculate the mass of silicon dioxide needed to make 1 g of silicon.

Relative atomic masses: O = 16; Si = 28

_____

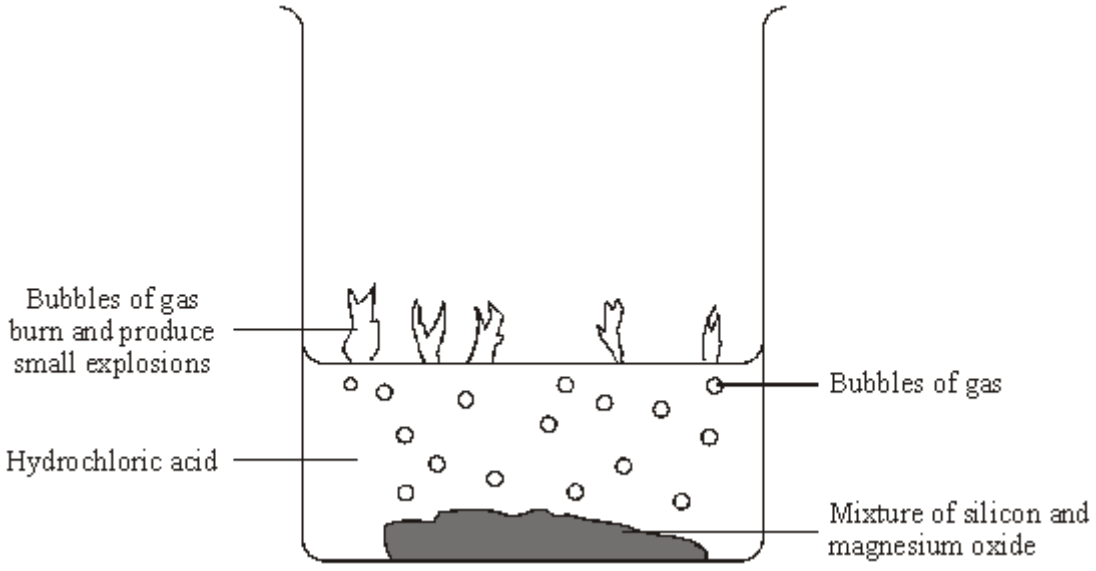
_____

_____

Mass = _____g

(3)

(b) The resulting mixture of magnesium oxide and silicon is added to a beaker containing hydrochloric acid. The silicon is then filtered from the solution.



(i) The magnesium oxide reacts with the hydrochloric acid and forms magnesium chloride ($MgCl_2$) solution and water.

magnesium oxide + hydrochloric acid → magnesium chloride solution + water

Write a balanced symbol equation for this reaction, including state symbols.

(2)

(ii) The gases produced are a mixture of several silicon hydrides.

One of the gases produced in the reaction is the silicon hydride with the formula SiH_4. The structure of this molecule is similar to methane, CH_4.

Draw a diagram to show the bonding in a molecule of SiH_4. Represent the electrons as dots and crosses and only show the outer shell (energy level) electrons.

(1)

(iii) A sample of a different silicon hydride was found to contain 1.4 g of silicon and 0.15 g of hydrogen.

Calculate the formula of this silicon hydride. You must show all your working to gain full marks.

Relative atomic masses: H = 1; Si = 28

(4)

(iv) The silicon hydrides react immediately they come into contact with oxygen in the air. They burst into flames with a small explosion and give out energy.

Which letter, **A** to **H**, best describes this reaction?

Energy involved in breaking and forming bonds	Activation energy	Rate of reaction	Letter
The energy released from forming new bonds is greater than the energy needed to break existing bonds	high	fast	**A**
		slow	**B**
	low	fast	**C**
		slow	**D**
The energy needed to break existing bonds is greater than the energy released from forming new bonds	high	fast	**E**
		slow	**F**
	low	fast	**G**
		slow	**H**

Letter _____

(1)

(c) The structure of silicon is similar to the structure of diamond.

Describe the structure of silicon and explain why it has a high melting point. You may draw a diagram if this helps.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 15 marks)

Q36.

A student investigated some instant soup.

(a) Instant soup contains a food additive which has the formula:

NaH_2PO_4

Give the names of all the elements in this compound.

The periodic table on the Data Sheet may help you to answer this question.

_____

_____

(2)

(b) The student investigated the reaction which takes place when soup powder is added to cold water.

The student thought that the reaction might be *exothermic.*

(i) What is meant by the term *exothermic* reaction?

_____

_____

(2)

(ii) Describe an experiment that the student could do to prove that this reaction is exothermic.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 8 marks)

Q37.

The monomer chloroethene is made from ethene in a two-stage process,

(a) The first stage is to convert ethene to 1,2-dichloroethane.

$$2C_2H_4(g) + 4HC1(g) + O_2(g) \rightleftharpoons 2C_2H_4Cl_2(g) + 2H_2O(g)$$

ethene 1,2-dichloroethane

State and explain the effect of increasing the pressure on:

(i) the yield of 1,2-dichloroethane;

_____

_____

(2)

(ii) the rate of reaction.

_____

_____

(2)

(b) In the second stage 1,2-dichloroethane is converted into chloroethene.

$C_2H_4C1_2 \rightarrow C_2H_3C1 + HCl$

This reaction is a thermal decomposition.

Suggest what would need to be done to decompose 1,2-dichloroethane.

_____

_____

(1)

(Total 5 marks)

Q38.

Some of the hydrogen and chlorine are reacted together to form hydrogen chloride.

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

Bond	Bond energy in kJ/mol
Cl–Cl	242
H–Cl	431
H–H	436

(i) Use the bond energies to calculate the energy change for the formation of hydrogen chloride.

_____

_____

_____

_____

Energy change = _____ kJ/mol

(3)

(ii) Is this reaction exothermic or endothermic? Explain your answer.

_____

_____

_____

(2)

(iii) Explain why hydrogen chloride only acts as an acid when dissolved in water.

_____

_____

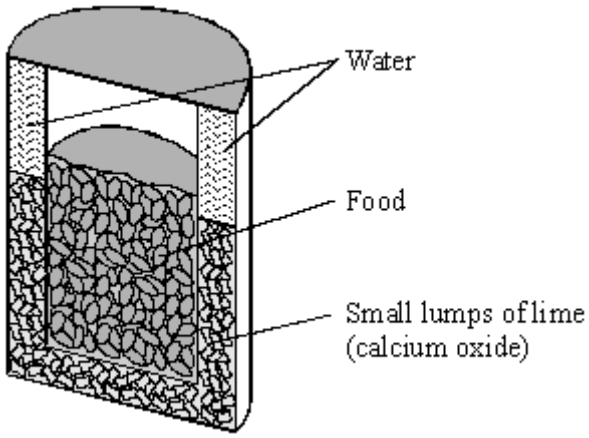
_____

(3)

(Total 8 marks)

Q39.

Mountaineers can warm their food in self-heating, sealed containers.



(a) The water is allowed to react with the lime. The heat from the reaction warms the food. What type of reaction causes a rise in temperature?

_____

(1)

(b) Some students investigated the effect of adding different sized lumps of lime to water. The results of their investigation are shown.

Time in minutes	Temperature in °C		
	Large lumps of lime	Small lumps of lime	Powdered lime
0	18	18	18
1	19	20	28
2	21	23	43
3	24	27	63
4	28	32	88
5	33	38	100

What do these results show? Give an explanation for your answer.

(2)

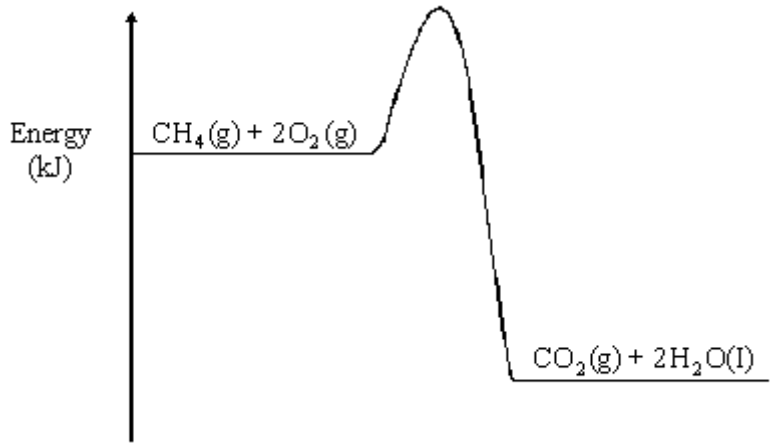
(c) Suggest and explain **one** disadvantage of using powdered lime to heat food.

(2)

(Total 5 marks)

Q40.

Many hydrocarbons are used as fuels. An energy level diagram is shown for the combustion of the hydrocarbon methane.



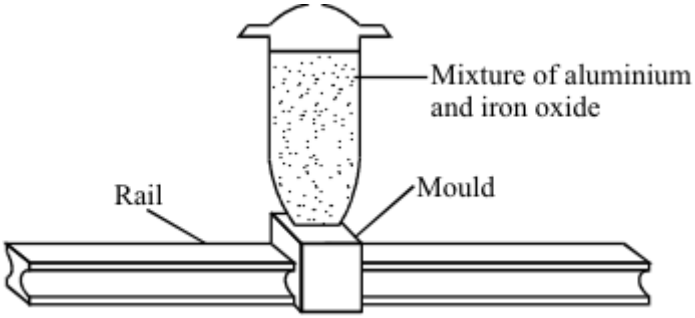
Describe and explain why the line rises and then falls to a lower level.

(Total 4 marks)

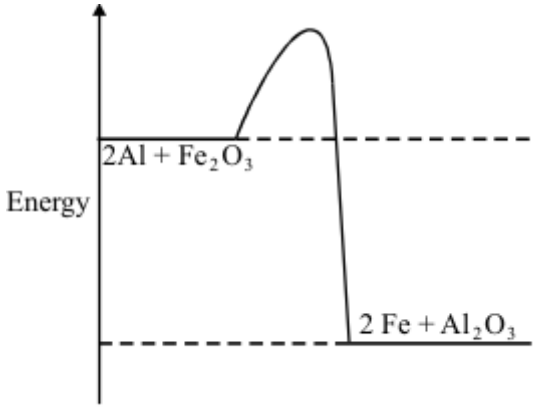
Q41.

The reaction between aluminium and iron oxide is used to weld together railway lines.

$$2Al(s) + Fe_2O_3(s) \rightarrow 2Fe(l) + Al_2O_3(s)$$



A simple, qualitative energy level diagram for this reaction is shown.



Use the energy level diagram to:

(i) describe the idea of activation energy;

_____

_____

(1)

(ii) explain why the reaction produces molten iron.

_____

_____

_____

_____

(2)

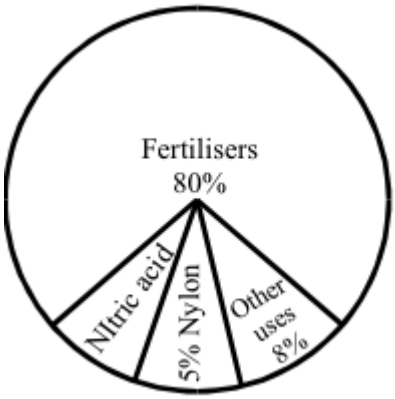
(Total 3 marks)

Q42.

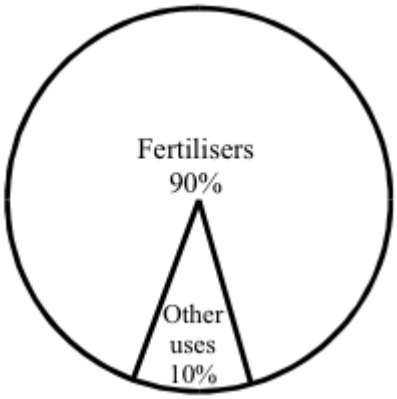
Ammonia and nitric acid are both important chemicals. Nitric acid is made from ammonia.

The charts below show substances made from ammonia and nitric acid.

Substances made from ammonia



Substances made from nitric acid



(a) Use the charts to help you answer these questions.

(i) What is the main use of both ammonia and nitric acid?

_____

(1)

(ii) Work out the percentage of ammonia used to make nitric acid.

Percentage = _____ %

(1)

(iii) 100 million tonnes of ammonia are made in the world each year.

How much of this ammonia is used to make nylon?

_____ million tonnes

(1)

(b) The word equations below show how nitric acid is made.

1. nitrogen + hydrogen → ammonia
2. ammonia + oxygen → nitrogen monoxide + water
3. nitrogen monoxide + oxygen → nitrogen dioxide
4. nitrogen dioxide + water → nitric acid

Use the word equations to help you answer these questions.

(i) From which **two** elements is ammonia made?

_____ and _____

(1)

(ii) Name **two** of the raw materials needed to make nitric acid.

_____ and _____

(2)

(c) A large amount of nitric acid is reacted with ammonia to make a fertiliser.

nitric acid + ammonia → fertiliser

(i) The reaction is a neutralisation reaction.

What type of chemical must ammonia be?

_____

(1)

(ii) Complete the chemical name for the fertiliser made from ammonia and nitric acid.

ammonium _____

(1)

(iii) The reaction of nitric acid with ammonia is exothermic.

Name the piece of equipment you could put into the solution to prove that the reaction is exothermic.

_____

(1)

(Total 9 marks)

Q43.

The word equation below shows a reaction used in an industrial process.

chromium oxide + aluminium → chromium + aluminium oxide

The reaction is highly exothermic.

(a) What is an exothermic reaction?

_____

_____

(2)

(b) Name the products of this reaction.

_____

(1)

(c) In the reaction one substance is reduced.

(i) Name the substance which is reduced.

_____

(1)

(ii) What happens to the substance when it is reduced?

_____

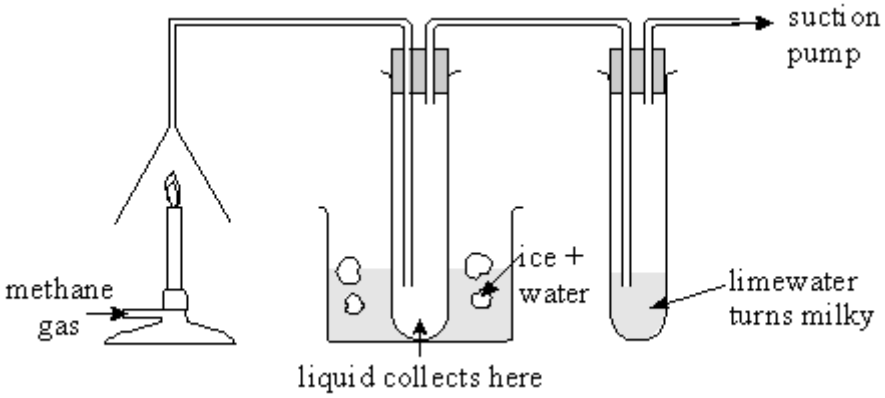
_____

(1)

(Total 5 marks)

Q44.

Methane CH_4 contains the elements carbon and hydrogen only. A student wanted to find out which new substances are produced when methane is burned. The student set up the apparatus shown below.



(a) Which gas in the air reacts with methane when it burns?

_____

(1)

(b) Name the liquid collected.

_____

(1)

(c) Name the gas which turns limewater milky.

_____

(1)

(d) When methane burns an exothermic reaction takes place. What is meant by an exothermic reaction?

_____

_____

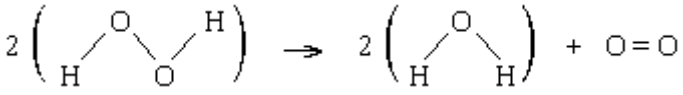
(2)

(Total 5 marks)

Q45.

At room temperature, hydrogen peroxide decomposes very slowly to form water and oxygen.
The decomposition is speeded up when a catalyst is added.

(a) The following equation represents the decomposition of hydrogen peroxide. The structural formulae of the chemicals involved are shown.



Use the following information about bond energies to answer this part of the question.

BOND	BOND ENERGY (kJ)
O = O	498
O – O	146
H – O	464

(i) Calculate the energy needed to break all the bonds in the reactants.

_____

_____

_____

_____ kJ

(2)

(ii) Calculate the energy released when new bonds are formed in the products.

_____

_____

_____

_____ kJ

(2)

(iii) Calculate the energy change for this reaction.

_____

_____ kJ

(1)

(iv) Is the reaction exothermic or endothermic?

_____

Explain why.

_____

_____

(1)

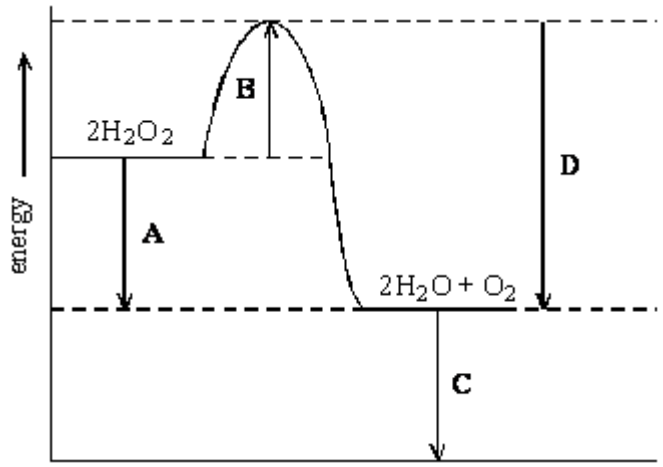
(b) (i) What is meant by ‘activation energy’?

_____

_____

(1)

(ii) The energy level diagram for the decomposition of hydrogen peroxide into water and oxygen is shown below.



Which energy change, **A**, **B**, **C** or **D**, is the activation energy? _____

(1)

(iii) Explain, in terms of energy, how a catalyst makes hydrogen peroxide decompose more quickly.

_____

_____

_____

(1)

(Total 9 marks)

Q46.

(i) Which acid from the list should the student add to sodium hydroxide solution to make sodium sulphate?

ethanoic acid **hydrochloric acid** **nitric acid** **sulphuric acid**

_____

(1)

(ii) When the acid was added to the alkali the beaker became warm.
Name the type of reaction that releases heat.

_____

(1)

(iii) Use the Data Sheet to help you to write the formula of sodium sulphate.

Formula: _____

(1)

(Total 3 marks)

Q47.

(a) (i) Which acid should the student add to sodium hydroxide solution to make sodium sulphate?

_____ acid

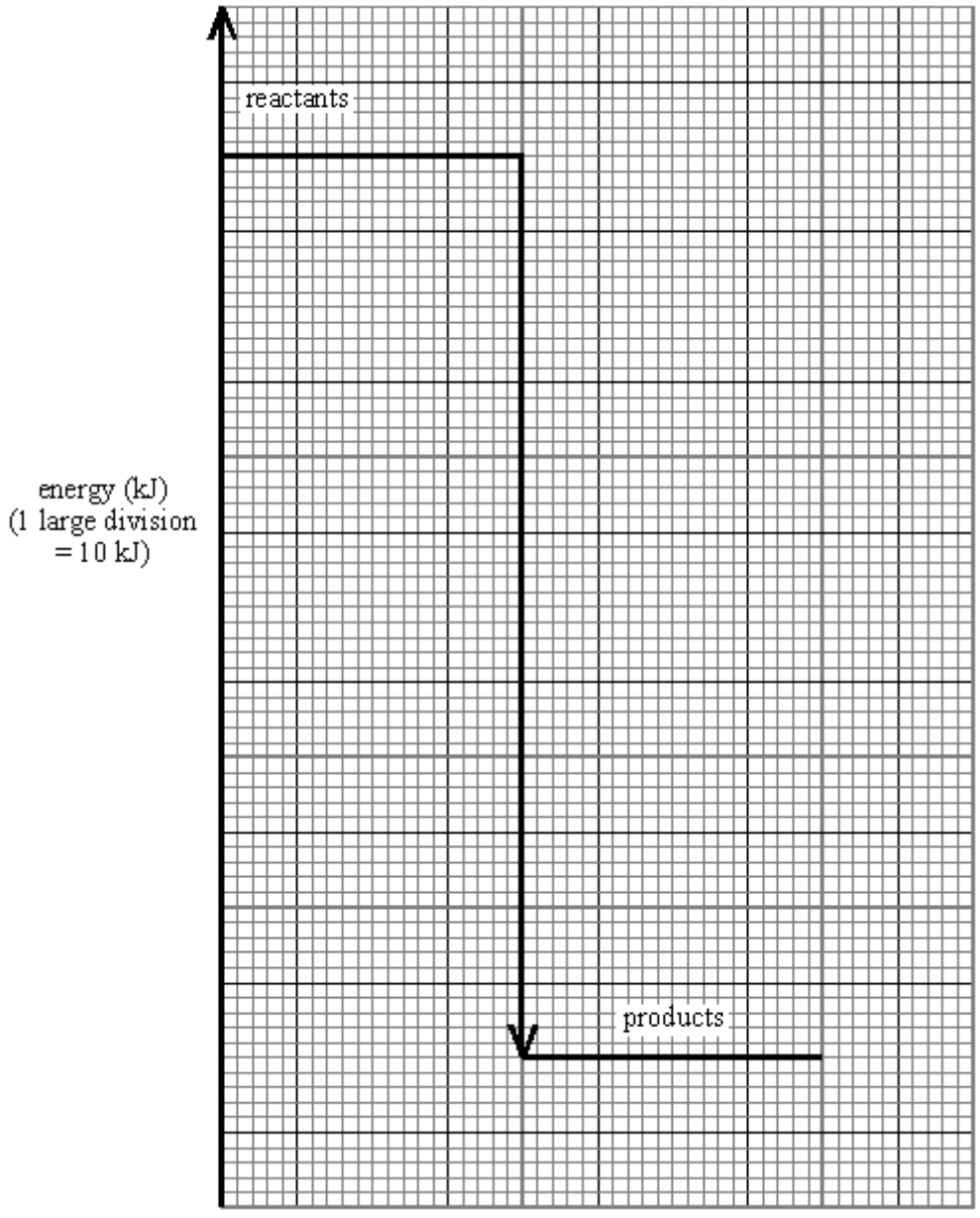
(1)

(ii) Use the table on the Data Sheet to help you to write the formula of sodium sulphate.

Formula: _____

(1)

(b) The student noticed that the solution in the beaker got warm when the acid reacted with the alkali.
The energy diagram below represents this reaction.



(i) In terms of **energy**, what type of reaction is this?

_____

(1)

(ii) Use the energy diagram to calculate a value for the amount of energy released during this reaction.

_____

Energy released _____ kJ

(1)

(iii) Explain, in terms of bond breaking and bond forming, why energy is released during this reaction.

_____

_____

_____

_____

(3)

(iv) The reaction takes place very quickly, without the help of a catalyst. What does this suggest about the activation energy for this reaction?

_____

_____

(1)

(Total 8 marks)

Q48.

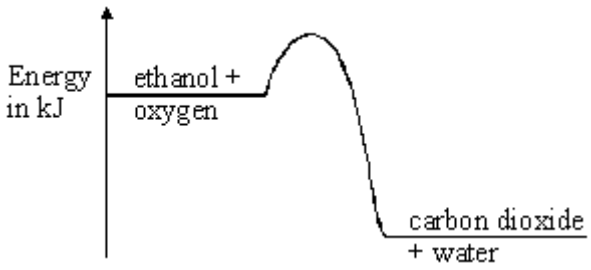
Ethanol is used as a fuel.

(a) Balance the symbol equation for the combustion reaction.

$C_2H_5OH + O_2 \rightarrow CO_2 + H_2O$

(1)

(b) The energy level diagram represents the combustion of ethanol.



Describe what must happen to the molecules of ethanol and oxygen to allow them to react.

_____

_____

_____

_____

_____

_____

(3)

(c) We can use bond energies to calculate the energy change for the reaction between hydrogen and oxygen.

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

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

(i) Calculate the total bond energy of the reactants.

_____

_____

_____

Total bond energy of reactants = _____ kJ

(2)

(ii) Is the reaction between hydrogen and oxygen exothermic or endothermic? Use bond energies to explain your answer.

_____

_____

_____

_____

_____

_____

_____

(2)

(Total 8 marks)

Q49.

Hydrogen chloride is made by reacting hydrogen with chlorine.

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

Bond	Bond energy in kJ
H – H	436
Cl – Cl	242
H – Cl	431

Is the reaction between hydrogen and chlorine exothermic or endothermic?
Use the bond energies to explain your answer.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(Total 3 marks)

Q50.

In the Haber process, nitrogen and hydrogen react to make ammonia.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

nitrogen + hydrogen $\rightleftharpoons$ ammonia

Pressure in atmospheres	**% ammonia present at equilibrium**				
	Temperature in ºC				
	100	**200**	**300**	**400**	**500**
10	88.2	50.7	14.7	3.9	1.2
25	91.7	63.6	27.4	8.7	2.9
50	94.5	74.0	39.5	15.3	5.6
100	96.7	81.7	52.5	25.2	10.6
200	98.4	89.0	66.7	38.8	18.3
400	99.4	94.6	79.7	55.4	31.9
1000	99.9	98.3	92.6	79.8	57.5

The actual conditions used in the Haber process are usually 450 °C and 200 atmospheres.

(a) What effect does increasing the pressure have on the percentage of ammonia

made? Use the balanced symbol equation to explain why.

(2)

(b) A lower temperature of 100 °C gives high percentages of ammonia at most pressures. Why is this temperature **not** used in the Haber process?

(1)

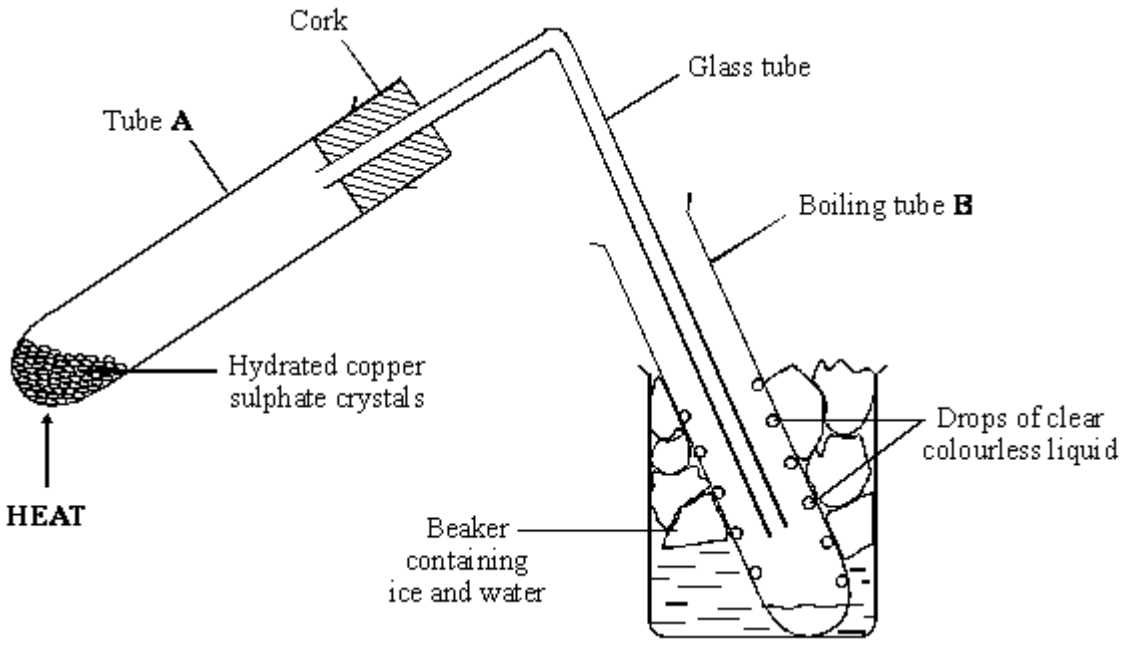
(c) Describe and explain the effect of an increase in the temperature on the reaction between nitrogen and hydrogen in the Haber process.

(3)

(Total 6 marks)

Q51.

The diagram shows the apparatus for an experiment. Hydrated copper sulphate crystals were heated. They became anhydrous copper sulphate.



(a) Name a suitable piece of equipment to heat tube **A**.

_____

(1)

(b) Use words from the box to complete the **two** spaces in the table. You may use each word once or not at all.

black	blue	orange	red	purple	white

Name	**Colour**
Hydrated copper sulphate crystals	_____
Anhydrous copper sulphate	_____

(2)

(c) What is the purpose of the ice and water in the beaker?

_____

_____

(1)

(d) Drops of a clear, colourless liquid formed on the inside of tube **B**.

(i) Name the liquid.

_____

(1)

(ii) Explain how the liquid came to be inside tube **B**.

_____

_____

_____

(2)

(e) Anhydrous copper sulphate can be turned into hydrated copper sulphate. What would you need to add? Apart from the change in colour, what could you observe?

_____

_____

_____

(2)

(f) Copper sulphate can be made from black copper oxide by reacting it with an acid. Name the acid.

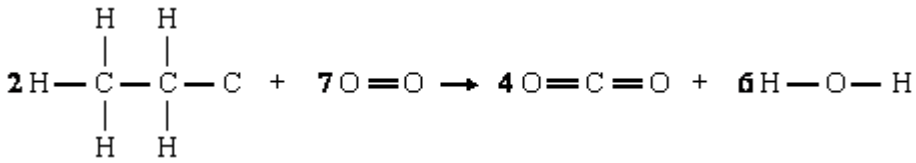
_____

(1)

(Total 10 marks)

Q52.

The balanced equation for the combustion of ethane is shown using structural formulae.



(a) Complete the table to show the number of bonds broken and made when two molecules of ethane react with seven molecules of oxygen.

Type of bond	Number of bonds broken	Number of bonds made
C — C		
C — H		
O = O		
C = O		
H — O		

(2)

(b) The combustion of ethane is a strongly exothermic process. Draw a labelled energy level diagram showing the endothermic and exothermic parts of the overall reaction. Indicate the activation energy on the diagram.

(4)

(c) Explain, in terms of particles and the activation energy of a reaction, how a catalyst is able to increase the rate of reaction.

_____

_____

_____

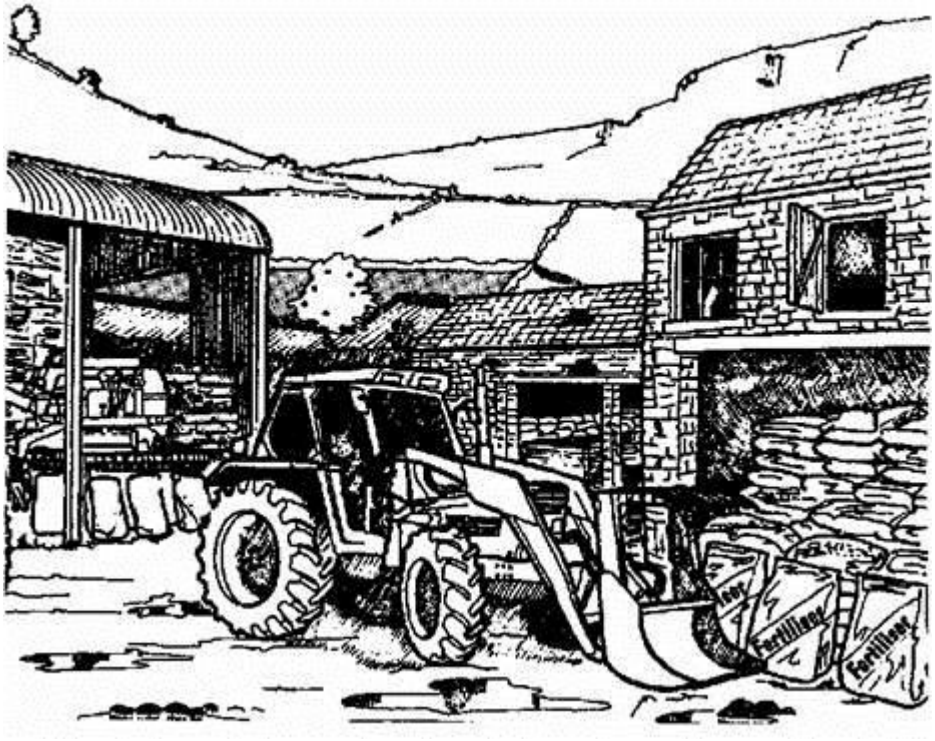
_____

(2)

(Total 8 marks)

Q53.

Ammonium nitrate and ammonium sulphate are used as fertilisers.



(i) Which acid reacts with ammonia to form ammonium nitrate?

_____

(1)

(ii) Which acid reacts with ammonia to form ammonium sulphate?

_____

(1)

(iii) The reactions in (i) and (ii) are both exothermic. How can you tell that a reaction is exothermic?

_____

_____

(1)

(iv) The reactions in (i) and (ii) are both examples of acid + base reactions. What is the

name of the chemical change which takes place in every acid + base reaction?

_____

(1)

(Total 4 marks)

Q54.

Wax is a fuel.

A young child watched a candle burning and wondered where the wax had gone.

(a) Complete the sentence below.

When wax burns, energy is released as _____

(1)

(b) Why does the wax disappear as it burns?

_____

_____

(1)

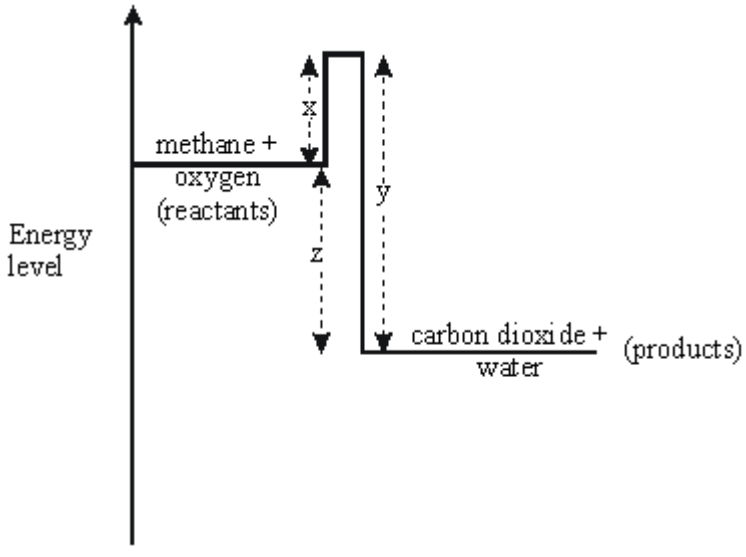
(Total 2 marks)

Q55.

The symbol equation below shows the reaction when methane burns in oxygen.

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

An energy level diagram for this reaction is shown below.



(a) Which chemical bonds are broken and which are formed during this reaction?

_____

_____

_____

_____

_____

(4)

(b) Explain the significance of x, y and z on the energy level diagram in terms of the energy transfers which occur when these chemical bonds are broken and formed.

_____

_____

_____

_____

_____

_____

_____

(5)

(Total 9 marks)

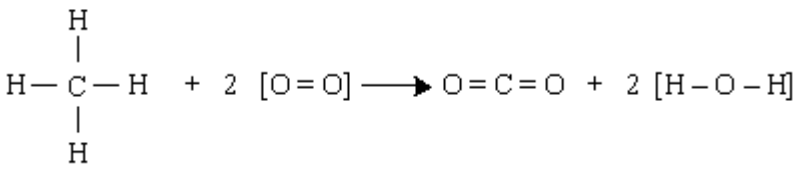
Q56.

The symbol equation shows the reaction between methane and oxygen.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

methane oxygen carbon dioxide water

The structural formulae in the equation below show the bonds in each molecule involved.



In the three stages shown at (i), (ii) and (iii) below, calculate the net energy transfer when the formula mass (1 mole) of methane reacts with oxygen.

(i) Write down the bonds broken and the bonds formed during the reaction.

Bonds broken		**Bonds formed**	
number	**type**	**number**	**type**

(4)

(ii) Calculate the total energy changes involved in breaking and in forming each of these bonds.

Total energy change in breaking bonds	**Total energy change in forming bonds**

(4)

(iii) Describe, as fully as you can, what the above figures in (ii) tell you about the overall reaction.

_____

_____

_____

_____

_____

(2)

(Total 10 marks)

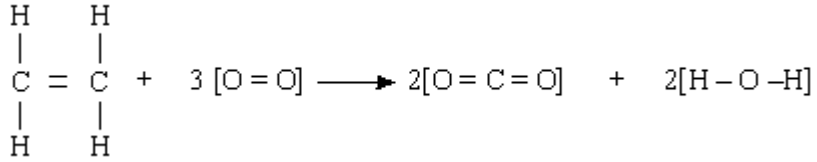
Q57.

You will find the information on the Data Sheet helpful when answering this question.

This equation shows the reaction between ethene and oxygen.

$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

The structural formulae in the equation below show the bonds in each molecule involved.



Use the three stages shown at (a), (b) and (c) below to calculate the nett energy transfer when the formula mass (1 mole) of ethene reacts with oxygen.

(a) Write down the bonds broken and the bonds formed during the reaction. (Some

have already been done for you.)

Bonds broken	
Number	Type
4	[C – H]
1	[C = C]

Bonds formed	
Number	Type
4	[C = O]

(2)

(b) Calculate the total energy changes involved in breaking and in forming all of these bonds. (Some have already been done for you.)

Total energy change in breaking bonds
[4 × 413] = 1652
[1 × 612] = 612
Total = kJ

Total energy change in forming bonds
4 × [805] = 3220
Total = kJ

(4)

(c) Describe, as fully as you can, what the figures in (b) tell you about the overall reaction.

_____

_____

_____

_____

_____

(2)

(Total 8 marks)