Name:	Target Grade:	Actual Grade:

BRIGHT CULTURE

ENERGY CHANGES
MCQ and STRUCTURED QUESTIONS

READ THESE INSTRUCTIONS FIRST

INSTRUCTIONS TO CANDIDATES

1. Find a quiet, comfortable spot free place from distractions.

2. Spend one minute on each mark.

3. Time yourself for every single question.

4. Every chapter has their own question types. Ensure that you know the different question type for each chapter.

5. Make a conscientious effort to remember your mistakes, especially in terms of answering techniques. E.g Take a picture for the mistakes that you made, keep it in a photo album, and revise it over and over again.

6. Highlight question types that you tend to keep making mistakes and review them nearing exams.

7. Always review the common questions and question type that you tend to make mistakes nearing exams.

8. During exams, classify the question type and recall what you have learnt, how you need to analyse the questions for the different question type, what you need to take note of and answer with the correct answering techniques!

✨ **Wishing you all the best for this test!**

You've got this!

💡 **With lots of love,**
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If you are struggling in this paper, means you need to work harder!

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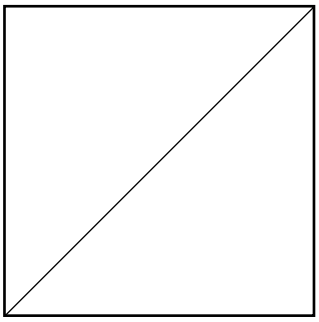


ENERGY CHANGES MCQ

Paper 1

1 The equation for a particular reaction is shown below.

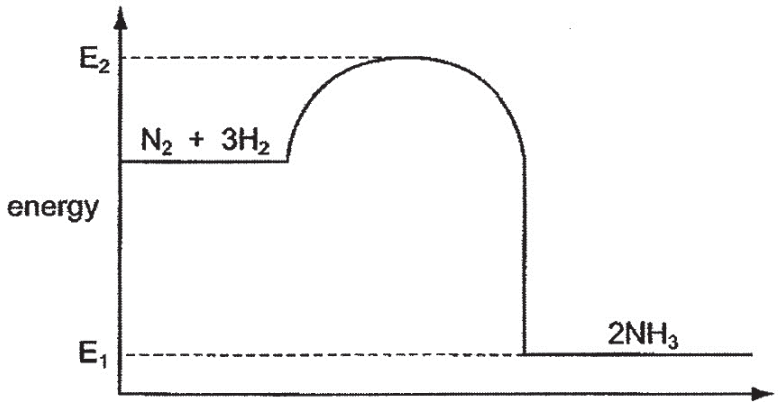
$$2AgI + light \rightarrow 2Ag + I_2$$

Why is this an endothermic reaction?

A Energy is required to vaporise iodine.
B It involves the formation of covalent I – I bonds.
C It involves the transfer of electrons from iodide ions to silver ions.
D Light energy is absorbed when the reaction takes place.

2 The energy profile diagram is that for the Haber process.

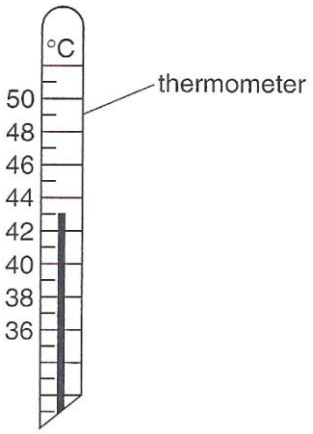
$N_2 + 3H_2 \rightleftharpoons 2NH_3$ $\Delta H = -92\,kJ$



What does the energy change E_2 - E_1 represent?

A activation energy of the forward reaction
B activation energy of the reverse reaction
C enthalpy change of the forward reaction
D enthalpy change of the reverse reaction

3 A thermometer is placed in warm water and the temperature is measured as shown.



When a solid is dissolved in the water, an exothermic change takes place. The temperature changes by 5°C.

What is the final temperature?

A 38.0 °C
B 38.5 °C
C 48.0 °C
D 48.5 °C

4 Nitrogen(II) oxide and chlorine react according to the equation shown below.

$$2NO_2(g) + Cl_2(g) \rightarrow 2NOCl(g) \qquad \Delta H = -38 \text{ kJ}$$

The activation energy for the forward reaction is 62 kJ. What is activation energy for the reverse reaction?

A - 62 kJ
B 24 kJ
C 38 kJ
D 100 kJ

5 The conversion of graphite to diamond has an only small value for enthalpy change as shown.

$$C \text{ (graphite)} \rightarrow C \text{ (diamond)} \qquad \Delta H = +2.1 \text{ kJ/mol}$$

However, the production of synthetic diamonds using this reaction is very difficult.

Which statement helps to explain this?

A Diamond has a larger number of covalent bonds than graphite.
B Only exothermic reactions can occur readily.
C The activation energy of the reaction is large.
D The reaction between diamond and graphite is reversible.

6 Ammonium chloride dissolves in water according to the equation shown below.

$$NH_4Cl\ (s) \rightarrow NH_4Cl\ (aq) \qquad \Delta H = +15.0\ kJ/mol$$

When 0.2 moles of ammonium chloride dissolves in 50.0 cm^3 of water,

1	the concentration of the solution is 4.0 mol/dm^3.
2	the energy level of NH_4Cl increases.
3	the heat liberated is 3.0 kJ.
4	the temperature of the solution falls.

Which one of the following statements are correct?

A 1, 2, and 3
B 1, 2, and 4
C 1, 3 and 4
D 2, 3 and 4

7 The table shows some bond energies.

Bond	kJ/ mol
C – C	346
C – H	413
Si – Si	176
Si – H	318

Which statement is correct?

A Si – Si chains are more stable than C – C chains.
B Si – Si bonds are the least readily broken of those listed.
C Methane, CH_4, is chemically more stable than silane, SiH_4.
D 346 kJ is the energy evolved when 1 mole of graphite sublimes.

8 Which is an endothermic process?

A $C(s) + O_2(g) \rightarrow CO_2(g)$
B $HCl(aq) + NaOH\ (aq) \rightarrow NaCl(aq) + H_2O(l)$
C $6CO_2(g) + 6H_2O(g) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$
D $H_2O(g) \rightarrow H_2O(l)$

9 Which requires the largest number of electrons for complete discharge during electrolysis?

A 4 mol of aluminium ions
B 5 mol of hydroxide ions
C 6 mol of copper(II) ions
D 7 mol of oxide ions

10 The combustion of methane is an exothermic process.

$$CH_4\,(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) \qquad \triangle H = -890\ kJ/mol$$

How much methane should be used to produce 2670 kJ of heat?

A 48 g
B 64 g
C 96 g
D 120 g

11 A hand warmer bag purchased by skiers consists of powdered iron, water, salt and sawdust. When the bag is shaken, it becomes hot because the following reaction occurs.

$$4Fe\,(s) + 3O_2\,(g) \rightarrow 2Fe_2O_3\,(s) \qquad \triangle H = -823\ kJ/mol$$

Which statement is **not** true about the reaction above?

A The energy change involved in bond-forming is more than that in bond- breaking.
B The energy level of products is lower than that of the reactants.
C The energy level of reactants is lower than that of the products.
D The temperature of the reaction mixture increases.

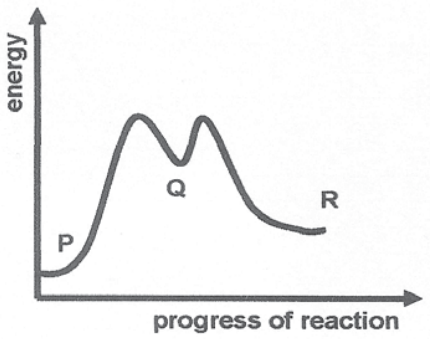
12 In the conversion of compound P into compound R, it was found that the reaction proceeded by way of compound Q, which could be isolated.

The steps involve were:

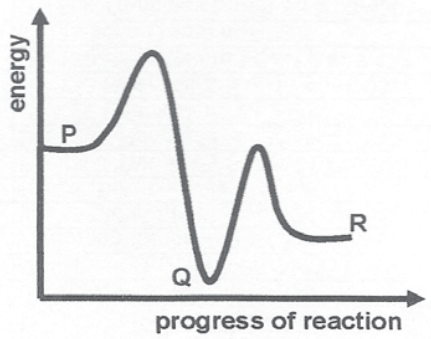
$P \rightarrow Q \quad \triangle H$ = negative
$Q \rightarrow R \quad \triangle H$ = positive

Which one of the following reaction profiles agrees with this data?

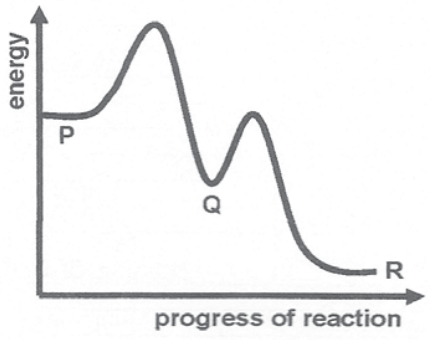
A



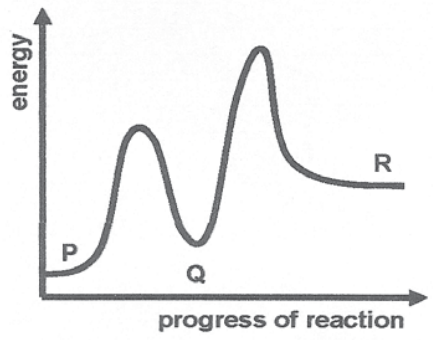
C



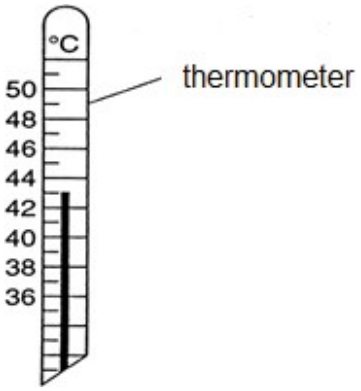
B



D



13 A thermometer is placed in water and the temperature measured is shown.

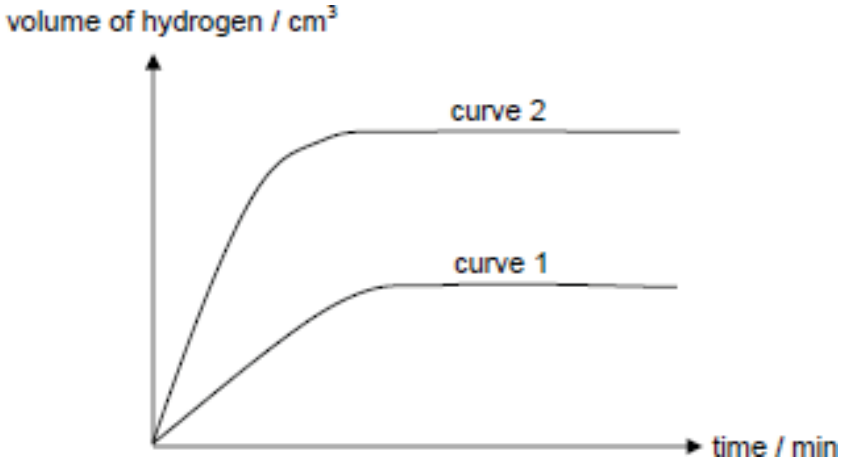


An endothermic change takes place as a solid is dissolved in the water. The temperature change is 4.5 ^{o}C.

What would be the temperature reading immediately after the reaction?

A 38.0 °C
B 38.5 °C
C 47.0 °C
D 47.5 °C

14 In the graph below, curve 1 was obtained when 25.0 cm^3 of 1.0 mol/dm^3 of dilute hydrochloric acid is reacted with an excess of magnesium ribbons at 30 ^{o}C.



Which of the following changes would result in curve 2?

A adding a catalyst to the reaction
B heating the acid to a higher temperature
C using 25.0 cm^3 of 2.0 mol/dm^3 of dilute hydrochloric acid
D using finely powdered magnesium metal of the same mass

15 Ethyne (H–C=C–H) undergoes addition of hydrogen to form ethane as shown.

$$C_2H_2\ (g) + 2H_2\ (g) \rightarrow C2H_6\ (g)$$

The average bond energies of the bonds in the substances involved are shown in the table below.

bond	C–H	C–C	C=C	C=C	H–H
bond energy / kJ/mol	413	347	612	839	432

What is the enthalpy change for this reaction?

A –296 kJ/mol
B -176 kJ/mol
C +176 kJ/mol
D +296 kJ/mol

16 Ammonium chloride dissolves in water according to the equation below.

$$NH_4Cl\ (s) \rightarrow NH_4Cl\ (aq) \qquad \Delta H = +15.0\ kJ/mol$$

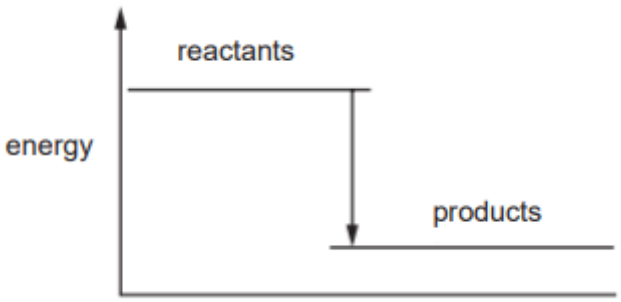
When 0.2 moles of ammonium chloride dissolves in 50.0 cm^3 of water,

1. the concentration of the solution is 4.0 mol/dm^3.
2. the energy level of NH_4Cl increases.
3. the heat liberated is 3.0 kJ.
4. the temperature of water falls.

Which of the above statements are correct?

A 1, 2 and 3
B 1, 2 and 4
C 1, 3 and 4
D 2, 3 and 4

17 A diagram for the energy change during a chemical reaction is shown.



For which reaction(s) would this be an appropriate diagram?

1 $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

2 $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

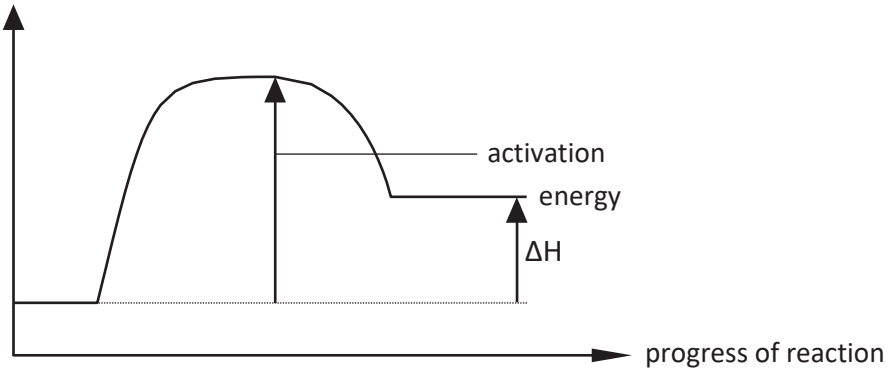
3 $2C + O_2 \rightarrow 2CO$

A 1 only
B 1 and 2 only
C 1 and 3 only
D 1, 2 and 3

18 Which of the following statements best describes the mechanism of a hydrogen-oxygen fuel cell?

A Hydrogen and oxygen undergo redox reaction to generate electricity.
B Hydrogen ions react with hydroxide ions to generate electricity.
C Electricity is used to provide heat energy.
D Electricity is used to generate hydrogen and oxygen.

19 The energy profile diagram for the forward direction of a reversible reaction is shown.



For the reverse reaction, which row correctly shows the sign of the activation energy and the type of enthalpy change?

	sign of activation energy	type of enthalpy change
A	negative	endothermic
B	negative	exothermic
C	positive	endothermic
D	positive	exothermic

ENERGY CHANGE STRUCTURED QUESTIONS

Paper 2 Section A

1 Hydrazine, N2H4, is commonly used as a liquid rocket fuel. It reacts with oxygen in the equation shown below.

$$N_2H_4 + O_2 \rightarrow N_2 + 2H_2O$$

(a) Suggest why the combustion of hydrazine has negligible adverse environmental impact.

……

……[1]

(b) Do the reactants or products have stronger bonds? Explain your answer.

……

……

……

…… [3]

(c) Sketch a labeled energy profile diagram for the above reaction.

[2]

(d) 10 g of hydrazine was burnt in 50 dm^3 of air.

(i) Did the hydrazine undergo complete combustion? Show your working.

[3]

(ii) Given that 194 kJ of energy was involved in the burning of 10g of hydrazine, calculate the enthalpy change in kJ/ mol for the reaction of hydrazine with oxygen.

[2]

2 5 g of hydrogen reacts with 142 g of chlorine to form hydrogen chloride. The reaction is exothermic and can be represented by the equation shown.

$$H_2 + Cl_2 \rightarrow 2HCl \qquad \Delta H = -184\ \text{kJ/mol}$$

a. Explain with supporting calculations which reactant is in excess.

……

……

……

……[3]

b. Calculate the energy released when 4 g of hydrogen reacts completely with 71 g of chlorine.

You may assume that no other side reaction occurs.

……[1]

c. Explain why the reaction is exothermic, in terms of the energy changes that take place during bond breaking and bond making.

……

……

……

……[3]

[Total: 7]

3 Table 7.1 shows the enthalpy of combustion of three fuels.

fuel	enthalpy change of combustion (kJ/mol)
ethanol	- 1370
hydrogen	- 256
octane	- 5510

combustion of ethanol: $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

(a) Use ideas about breaking and forming bonds to explain why the enthalpy change for combustion of ethanol is negative.

……

……[2]

(b) Octane also undergoes combustion to produce carbon dioxide. The equation for the combustion of octane is given below.

$$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$$

Calculate the volume of carbon dioxide that will be produced when ethanol undergoes combustion to produce 100 kJ of energy.

[2]

(c) Explain why the combustion of hydrogen is considered a 'cleaner' alternative as compared to octane and ethanol.

……...

……...

……..[2]

[Total: 6 marks]

4 On a camping trip, a boy scout can only pack 1 kg of fuel for use. He has to decide which fuel to bring along. The table below shows the energy released by the complete combustion of some compounds used as fuels.

compound	Mr	boiling point/ °C	ΔH in kJ/mol
methane	16	-162	-880
propane	44	-42	-2200
heptane	100	98	-4800

(a) Explain why the fuels have relatively low boiling point.

…….

……. [1]

(b) Which fuel produces the most energy when 1 kg of the compound is burnt? Hence, determine the fuel which the boy scout is most likely to bring along.

[2]

(c) The boy scout finally decided to bring along heptane for his camping trip. Using the data from the table, suggest why his decision differs from your answer in **(b)**.

……..

……..[1]

(d) Calculate the bond energy of the O=O bond in the combustion of methane given the following bond energies.

bond	bond energy in kJ/mol
C – H	410
O – H	460
C = O	740

[2]

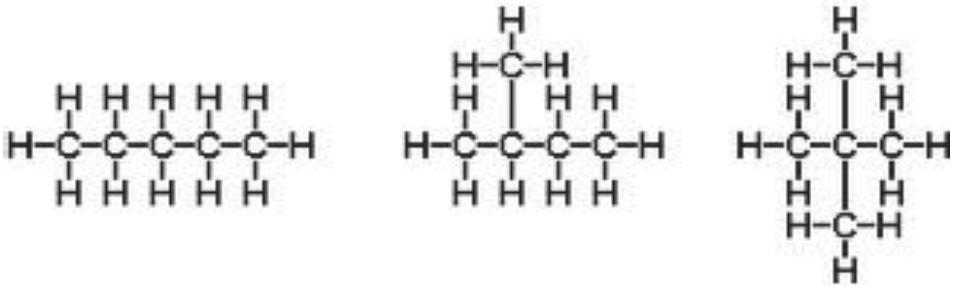
[Total: 6]

5 Alkanes like propane and butane are found in Liquefied Petroleum Gases(LPG).

(a) An experiment shows that complete combustion of 1.0 dm^3 (measured at room temperature and pressure) of butane produces 120 kJ of energy.
Calculate a value for the enthalpy change of complete combustion (kJ/mol) of butane, giving the correct sign.

[1]

(b) **(i)** The alkane with 5 carbon atoms, pentane exists as several isomers shown below.
One is straight chain pentane while the other two are branched chain pentane.



Will the two isomers which are branched chain pentane have the same enthalpy change on complete combustion as the straight chain pentane?
Explain your reasoning.

……

……[1]

(ii) The table shows the enthalpy changes of combustion of hexane and heptane.

name	formula	enthalpy change of combustion / kJ/ mol
hexane	C_6H_{14}	-4163
heptane	C_7H_{16}	-4817

Using the data given, estimate the enthalpy change of combustion in kJ/mol of octane, C_8H_{18}. Explain the method you use to arrive at your answer.

……

……

……[2]

(c) Some students studied the graph below that shows the amount of fossil fuel burned in the world between 1960 and 2010.

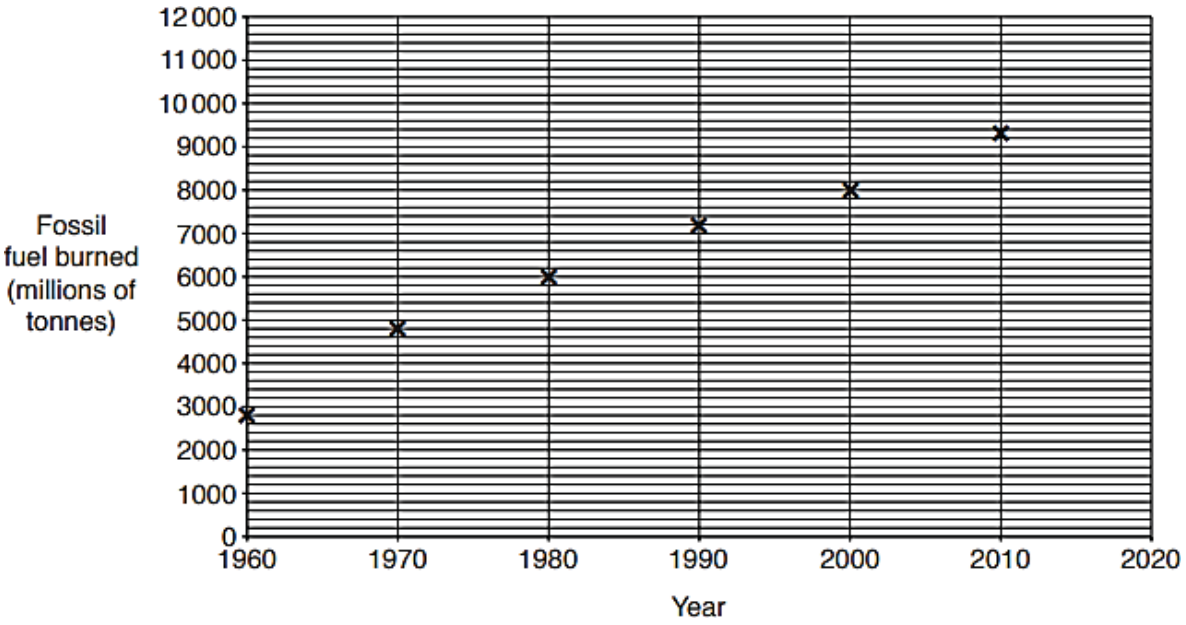


Fig 3.1

(i) One student says that the amount of fossil fuels burned has increased by the same amount every ten years.
Is the student correct? Use data from the graph to justify your answer.

……

…… [1]

(ii) Another student says that it is very difficult to estimate the amount of fossil fuel we will use in 100 years' time. Suggest reasons the student could give to justify this statement.

……

……

……

…… [2]

(iii) The graph below shows the changes in average global temperature from 1960 to 2010.

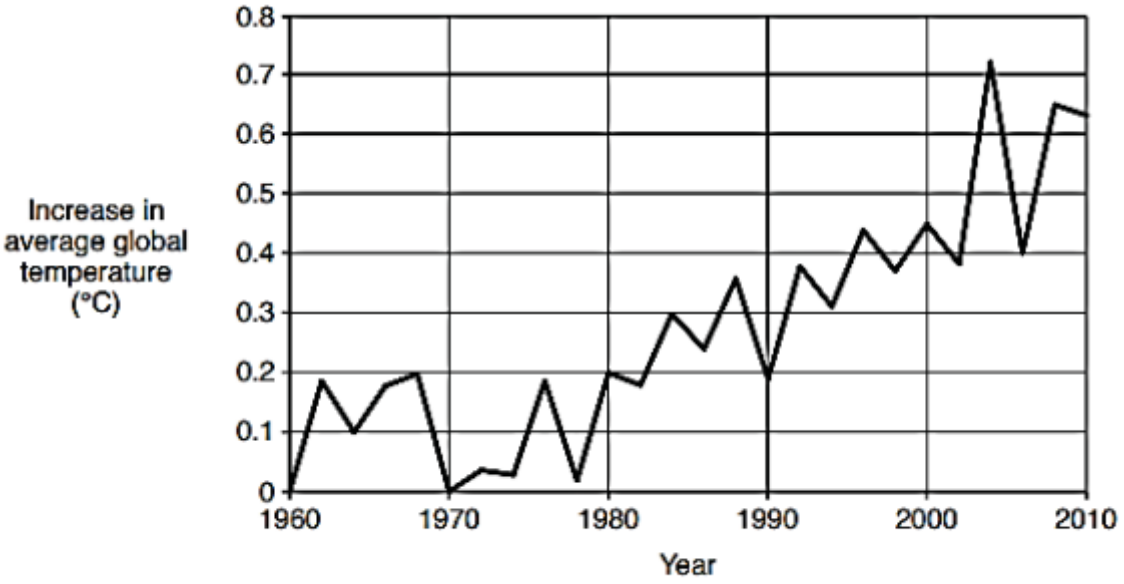


Fig 3.2

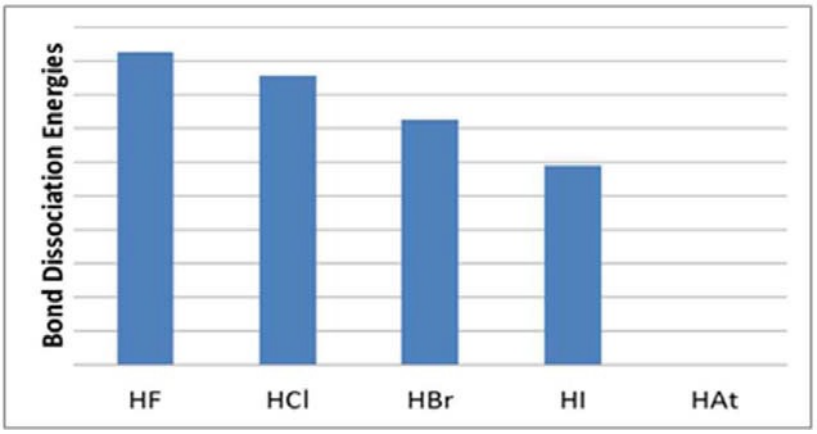
Describe the link between the trends shown in the graphs in Fig 3.1 and Fig 3.2.

……

……..[1]

[T
otal: 8]

6 The bond dissociation energies of some hydrogen halides are shown in the chart below. Bond dissociation energy is the energy that must be provided to the molecule in order to break the bond.



(a) Describe the trend shown in the above chart.

……..…… [1]

(b) Predict the bond dissociation energy of hydrogen astatide, HAt, by drawing the rectangular bar in the chart above. [1]

(c) **(i)** Suggest which one of the hydrogen halides forms the strongest acid.

…….. [1]

(ii) Explain your answer to **(c)(i)**.

……

……..…… [2]

(d) Hydrogen bromide can be produced by reacting hydrogen and bromine according to the following reaction.

$$H_2\,(g) + Br_2\,(g) \rightarrow 2HBr\,(g)$$

The bond energies of some bonds are shown in the table below.

bond	H-H	H-Br	Br-Br
bond energy (kJ/mol)	432	363	193

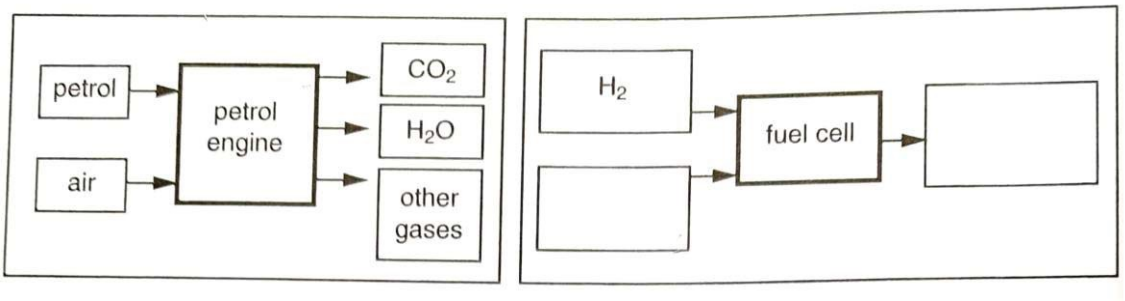
Calculate the enthalpy change of this reaction and state whether it is exothermic or endothermic.

[2]

[Total: 7]

7 Most vehicles have petrol or diesel engines, but some use fuel cells.

The flow charts show the substances entering and leaving a petrol engine and a fuel cell.



(a) Complete the flow chart for the fuel cell by filling in the empty boxes. [1]

(b) The waste products from vehicles with petrol engines cause more harm to human health than those from vehicles with fuel cells.

Explain why this statement is true.

.....

.....

.....

..... [3]

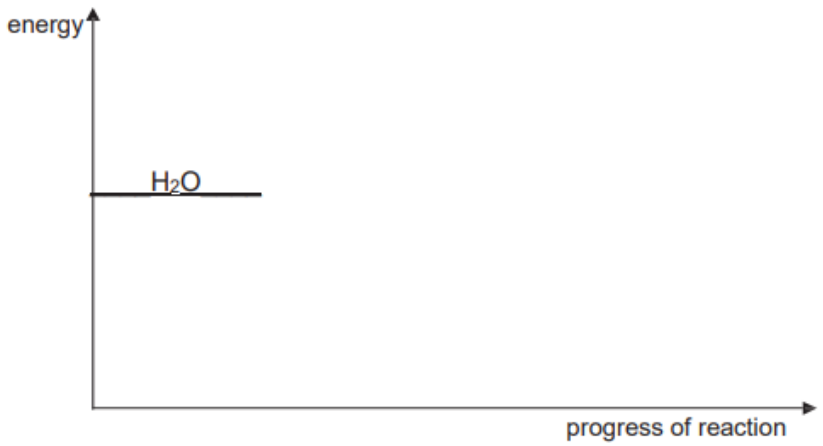
(c) Hydrogen for fuel cells can be obtained from water by electrolysis.

Electricity is used to provide energy for the electrolysis.

Complete the energy profile diagram for the electrolysis of water.

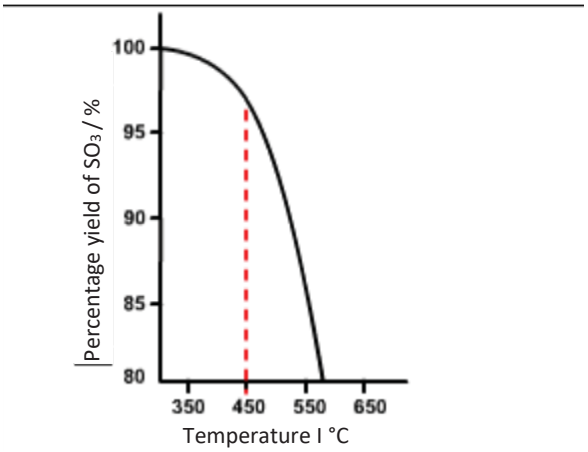
Your diagram should include

- the **formulae of the products** of the electrolysis,
- a label for the **enthalpy change of reaction**.



[2]

8 The graph below shows the percentage conversion to sulfur trioxide from sulfur dioxide and oxygen gas during the Contact Process.



(a) Give two reasons, other than cost, why the optimal temperature for Contact Process is 450 °C.

.....

.....

.....[2]

(b) Write down the chemical equation for the formation of sulfur trioxide from sulfur dioxide and oxygen.

.....[1]

(c) Explain, in terms of bond breaking and bond forming, why the conversion of sulfur dioxide and oxygen to sulfur trioxide is an exothermic reaction.

.....

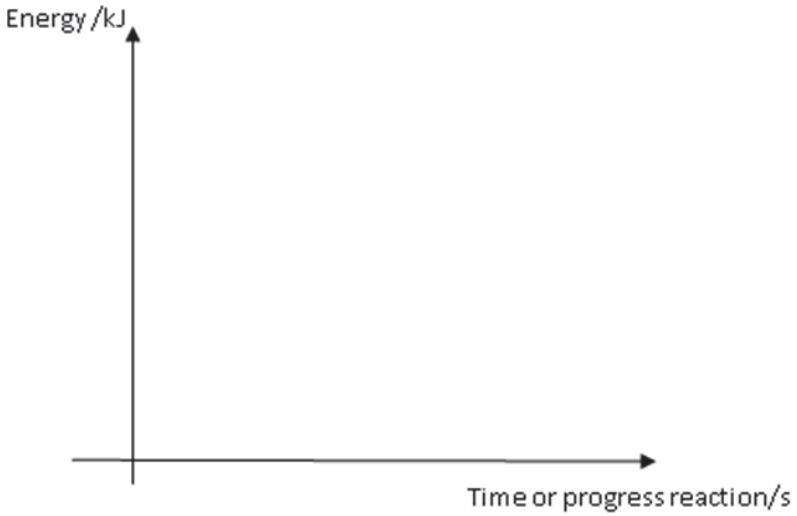
.....

.....[3]

(d) Draw an energy profile diagram to show the formation of sulfur trioxide from sulfur dioxide and oxygen.

Your diagram should show and label

- formulae of the reactants and products
- the activation energy for the reaction,
- the enthalpy change of reaction.



[3]

[Total: 9]

9 Hydrogen is increasingly being used as a 'clean fuel' in fuel cells. They react with oxygen to produce less harmful or pollutive substances.

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

_____[1]

(b) The enthalpy change of the reaction is known to be -572 kJ. Given that the H–H bond energy is 436 kJ mol^{-1} and the O=O bond energy is 495 kJ mol^{-1}, calculate the O–H bond energy.

[2]

(c) State a disadvantage of using hydrogen as a fuel.

_____[1]

ANSWERS FOR ENERGY CHANGES MCQ

Paper 1

1 The equation for a particular reaction is shown below.

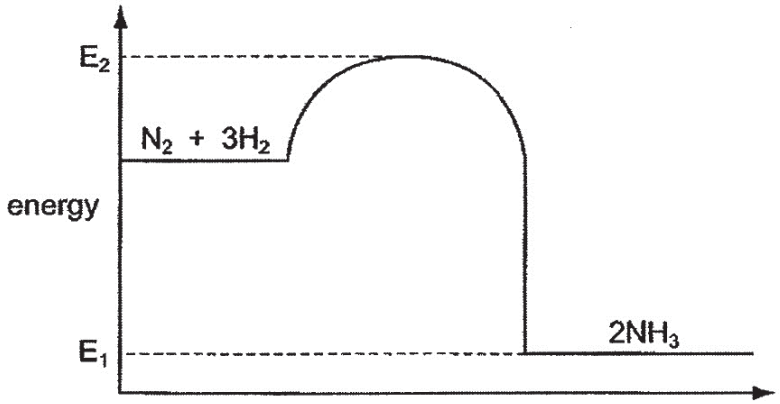
$$2AgI + light \rightarrow 2Ag + I_2$$

Why is this an endothermic reaction?

A Energy is required to vaporise iodine.
B It involves the formation of covalent I – I bonds.
C It involves the transfer of electrons from iodide ions to silver ions.
D Light energy is absorbed when the reaction takes place.

2 The energy profile diagram is that for the Haber process.

$N_2 + 3H_2 \rightleftharpoons 2NH_3$ $\Delta H = -92\,kJ$



What does the energy change $E_2 - E_1$ represent?

A activation energy of the forward reaction
B activation energy of the reverse reaction
C enthalpy change of the forward reaction
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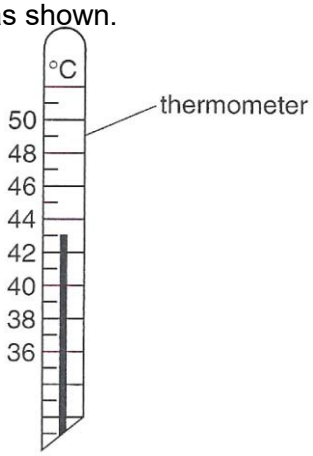
3 A thermometer is placed in warm water and the temperature is measured as shown.



When a solid is dissolved in the water, an exothermic change takes place. The temperature changes by 5°C.

What is the final temperature?

A 38.0 °C
B 38.5 °C
C 48.0 °C
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4 Nitrogen(II) oxide and chlorine react according to the equation shown below.

$$2NO_2(g) + Cl_2(g) \rightarrow 2NOCl(g) \qquad \Delta H = -38 \text{ kJ}$$

The activation energy for the forward reaction is 62 kJ. What is activation energy for the reverse reaction?

A - 62 kJ
B 24 kJ
C 38 kJ
D 100 kJ

5 The conversion of graphite to diamond has an only small value for enthalpy change as shown.

$$C \text{ (graphite)} \rightarrow C \text{ (diamond)} \qquad \Delta H = +2.1 \text{ kJ/mol}$$

However, the production of synthetic diamonds using this reaction is very difficult.

Which statement helps to explain this?

A Diamond has a larger number of covalent bonds than graphite.
B Only exothermic reactions can occur readily.
C The activation energy of the reaction is large.
D The reaction between diamond and graphite is reversible.

6 Ammonium chloride dissolves in water according to the equation shown below.

$$NH_4Cl\ (s) \rightarrow NH_4Cl\ (aq) \qquad \Delta H = +15.0\ kJ/mol$$

When 0.2 moles of ammonium chloride dissolves in 50.0 cm^3 of water,

1	the concentration of the solution is 4.0 mol/dm^3.
2	the energy level of NH_4Cl increases.
3	the heat liberated is 3.0 kJ.
4	the temperature of the solution falls.

Which one of the following statements are correct?

A 1, 2, and 3
B 1, 2, and 4
C 1, 3 and 4
D 2, 3 and 4

7 The table shows some bond energies.

Bond	kJ/ mol
C – C	346
C – H	413
Si – Si	176
Si – H	318

Which statement is correct?

A Si – Si chains are more stable than C – C chains.
B Si – Si bonds are the least readily broken of those listed.
C Methane, CH_4, is chemically more stable than silane, SiH_4.
D 346 kJ is the energy evolved when 1 mole of graphite sublimes.

8 Which is an endothermic process?

A $C(s) + O_2(g) \rightarrow CO_2(g)$
B $HCl(aq) + NaOH\ (aq) \rightarrow NaCl(aq) + H_2O(l)$
C $6CO_2(g) + 6H_2O(g) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$
D $H_2O(g) \rightarrow H_2O(l)$

9 Which requires the largest number of electrons for complete discharge during electrolysis?

A 4 mol of aluminium ions
B 5 mol of hydroxide ions
C 6 mol of copper(II) ions
D 7 mol of oxide ions

10 The combustion of methane is an exothermic process.

$$CH_4\,(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) \qquad \triangle H = -\,890\ kJ/\,mol$$

How much methane should be used to produce 2670 kJ of heat?

A 48 g
B 64 g
C 96 g
D 120 g

11 A hand warmer bag purchased by skiers consists of powdered iron, water, salt and sawdust. When the bag is shaken, it becomes hot because the following reaction occurs.

$$4Fe\,(s) + 3O_2\,(g) \rightarrow 2Fe_2O_3\,(s) \qquad \triangle H = -\,823\ kJ/mol$$

Which statement is **not** true about the reaction above?

A The energy change involved in bond-forming is more than that in bond- breaking.
B The energy level of products is lower than that of the reactants.
C The energy level of reactants is lower than that of the products.
D The temperature of the reaction mixture increases.

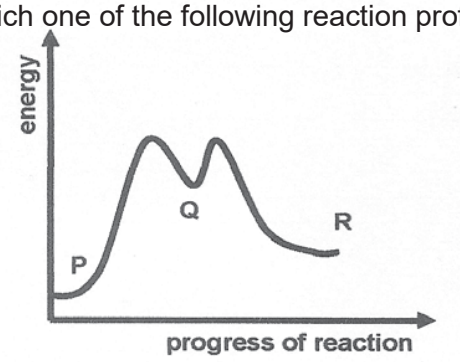
12 In the conversion of compound P into compound R, it was found that the reaction proceeded by way of compound Q, which could be isolated.

The steps involve were:

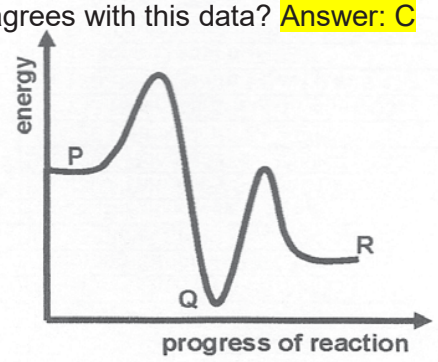
$P \rightarrow Q$ $\triangle H$ = negative
$Q \rightarrow R$ $\triangle H$ = positive

Which one of the following reaction profiles agrees with this data? Answer: C

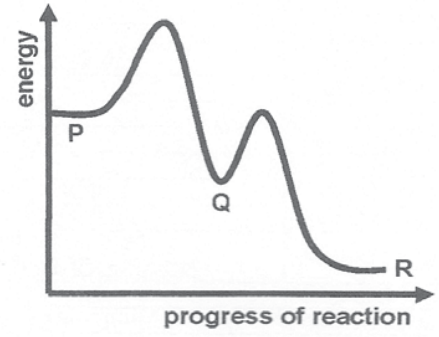
A



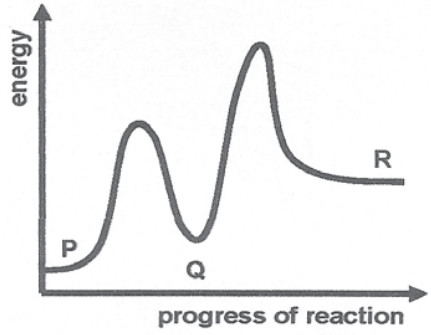
C



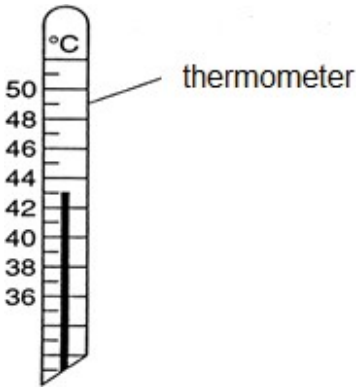
B



D



13 A thermometer is placed in water and the temperature measured is shown.

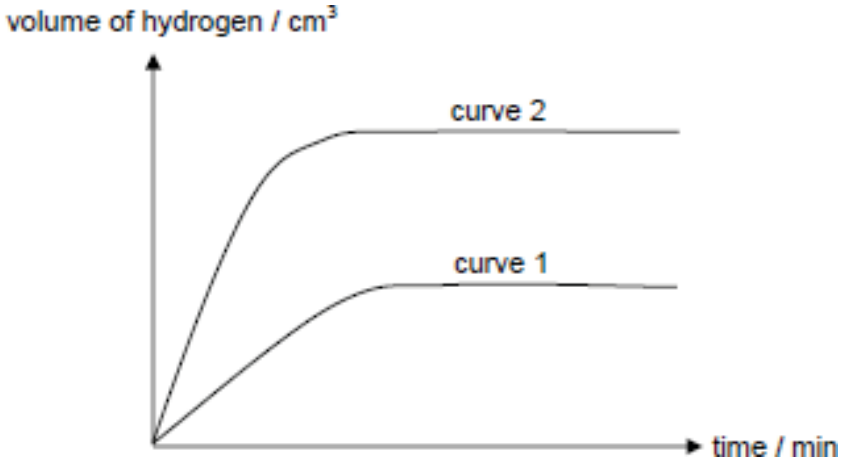


An endothermic change takes place as a solid is dissolved in the water. The temperature change is 4.5 ^{o}C.

What would be the temperature reading immediately after the reaction?

A 38.0 °C
B 38.5 °C
C 47.0 °C
D 47.5 °C

14 In the graph below, curve 1 was obtained when 25.0 cm^3 of 1.0 mol/dm^3 of dilute hydrochloric acid is reacted with an excess of magnesium ribbons at 30 ^{o}C.



Which of the following changes would result in curve 2?

A adding a catalyst to the reaction
B heating the acid to a higher temperature
C using 25.0 cm^3 of 2.0 mol/dm^3 of dilute hydrochloric acid
D using finely powdered magnesium metal of the same mass

15 Ethyne (H–C=C–H) undergoes addition of hydrogen to form ethane as shown.

$$C_2H_2\ (g) + 2H_2\ (g) \rightarrow C2H_6\ (g)$$

The average bond energies of the bonds in the substances involved are shown in the table below.

bond	C–H	C–C	C=C	C=C	H–H
bond energy / kJ/mol	413	347	612	839	432

What is the enthalpy change for this reaction?

A –296 kJ/mol
B -176 kJ/mol
C +176 kJ/mol
D +296 kJ/mol

16 Ammonium chloride dissolves in water according to the equation below.

$$NH_4Cl\ (s) \rightarrow NH_4Cl\ (aq) \qquad \Delta H = +15.0\ kJ/mol$$

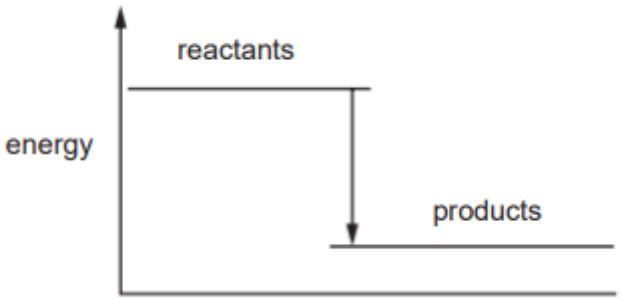
When 0.2 moles of ammonium chloride dissolves in 50.0 cm^3 of water,

1 the concentration of the solution is 4.0 mol/dm^3.
2 the energy level of NH_4Cl increases.
3 the heat liberated is 3.0 kJ.
4 the temperature of water falls.

Which of the above statements are correct?

A 1, 2 and 3
B 1, 2 and 4
C 1, 3 and 4
D 2, 3 and 4

17 A diagram for the energy change during a chemical reaction is shown.



For which reaction(s) would this be an appropriate diagram?

1 $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

2 $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

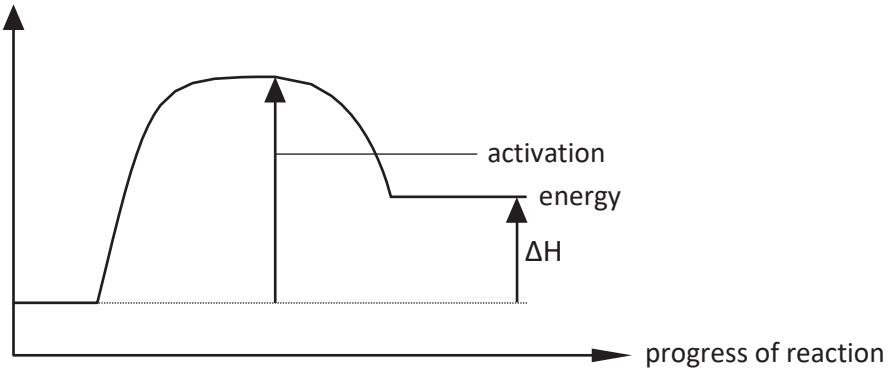
3 $2C + O_2 \rightarrow 2CO$

A 1 only
B 1 and 2 only
C 1 and 3 only
D 1, 2 and 3

18 Which of the following statements best describes the mechanism of a hydrogen-oxygen fuel cell?

A Hydrogen and oxygen undergo redox reaction to generate electricity.
B Hydrogen ions react with hydroxide ions to generate electricity.
C Electricity is used to provide heat energy.
D Electricity is used to generate hydrogen and oxygen.

19 The energy profile diagram for the forward direction of a reversible reaction is shown.



For the reverse reaction, which row correctly shows the sign of the activation energy and the type of enthalpy change?

	sign of activation energy	type of enthalpy change
A	negative	endothermic
B	negative	exothermic
C	positive	endothermic
D	positive	exothermic

ENERGY CHANGE STRUCTURED QUESTIONS

Paper 2 Section A

1 Hydrazine, N2H4, is commonly used as a liquid rocket fuel. It reacts with oxygen in the equation shown below.

$$N_2H_4 + O_2 \rightarrow N_2 + 2H_2O$$

(a) Suggest why the combustion of hydrazine has negligible adverse environmental impact.

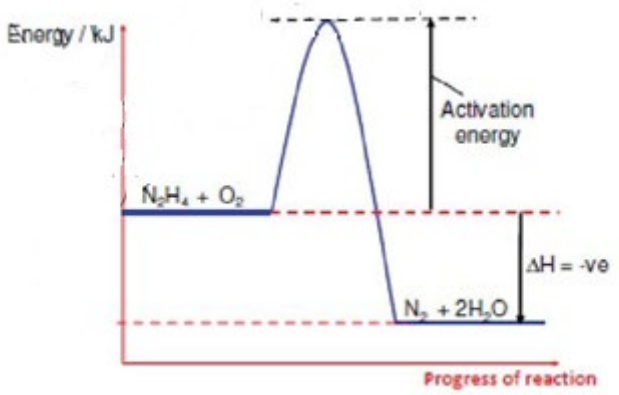
The only products of the combustion are nitrogen and water vapour which are components of clean air [1]

(b) Do the reactants or products have stronger bonds? Explain your answer.

- The products have stronger bonds. [no marks]
- The total energy absorbed during the breaking of bonds in N_2H_4 and O_2 is less than the the total energy released during the forming of bonds in N_2 and H_2O
- reaction of hydrazine with oxygen is a exothermic

[1] for idea that energy absorbed during bond breaking is less than energy re eased released during bond forming
[1] correct relation of substances in bond breaking and bond for forming [3]

(c) Sketch a labeled energy profile diagram for the above reaction.



[1] for correct energy profile

[1] for labeled axes, reactants, products, activation energy & △H

[2]

(d) 10 g of hydrazine was burnt in 50 dm^3 of air.

(i) Did the hydrazine undergo complete combustion? Show your working.

No of moles of hydrazine
= 10 / (14x2 + 4)
= 0.313 [1]

Volume of oxygen in air
= 21% x 50
= 10.5 dm^3

No. of moles of oxygen
= 10.5/24
= 0.438 [1]

Mole ratio of O_2 : N_2H_4
1 : 1
0.438 : 0.438

Since 0.438 moles of N_2H_4 is required and only 0.313 moles is available, N_2H_4 is the limiting reagent and is completely used up and hence, underwent complete combustion.

[3]

(ii) Given that 194 kJ of energy was involved in the burning of 10g of hydrazine, calculate the enthalpy change in kJ/ mol for the reaction of hydrazine with oxygen.

0.313 moles of hydrazine releases 194 kJ of energy 1 mole of hydrazine releases 194/ 0.3 3 [1]
= 621 J

Hence $\triangle H$ = - 621 kJ/mo [1]

[2]

2 5 g of hydrogen reacts with 142 g of chlorine to form hydrogen chloride. The reaction is exothermic and can be represented by the equation shown.

$$H_2 + Cl_2 \rightarrow 2HCl \qquad 6.H = -184\ kJ/mol$$

a. Explain with supporting calculations which reactant is in excess.

Hydrogen;
Number of moles of H_2 = 5/2 = 2.5 mol
Number of moles of Cl_2 =142/71 = 2 mol;
Mole ratio is 1: 1, hence hydrogen is in excess [3]

b. Calculate the energy released when 4 g of hydrogen reacts completely with 71 g of chlorine.

You may assume that no other side reaction occurs.

Energy released = 184 x 2 = 368 kJ; [1]

c. Explain why the reaction is exothermic, in terms of the energy changes that take place during bond breaking and bond making.

Energy taken in to break bonds in hydrogen and chlorine; is less than;
energy given out to form bonds in hydrogen chloride; [3]
[Total: 7]

3 Table 7.1 shows the enthalpy of combustion of three fuels.

fuel	enthalpy change of combustion (kJ/mol)
ethanol	- 1370
hydrogen	- 256
octane	- 5510

combustion of ethanol: $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

(a) Use ideas about breaking and forming bonds to explain why the enthalpy change for combustion of ethanol is negative.

The energy released in the formation of O-H and C=O bonds is larger: than the energy required to break the C-H, O-H, C-C and H-H bonds.; [2]

(b) Octane also undergoes combustion to produce carbon dioxide. The equation for the combustion of octane is given below.

$$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$$

Calculate the volume of carbon dioxide that will be produced when ethanol undergoes combustion to produce 100 kJ of energy.
Moles of ethanol required to produce 100 kJ of energy 100 / 1370
= 0.07299 moles;

From the equation above,
1 mole of C_2H_5OH = 2 moles of CO_2
0.07299 moles of C_2H_5OH = 0.1460 moles of CO_2

Volume of CO_2 produced= 3.50 dm^3; [2]

(c) Explain why the combustion of hydrogen is considered a 'cleaner' alternative as compared to octane and ethanol.

Combustion of hydrogen produces water which does not contain carbon and produce carbon monoxide which is a 12ollutant or carbon dioxide which is responsible for global warming. [2]

[Total: 6 marks]

4 On a camping trip, a boy scout can only pack 1 kg of fuel for use. He has to decide which fuel to bring along. The table below shows the energy released by the complete combustion of some compounds used as fuels.

compound	Mr	boiling point/ °C	ΔH in kJ/mol
methane	16	-162	-880
propane	44	-42	-2200
heptane	100	98	-4800

(a) Explain why the fuels have relatively low boiling point.

……

……. [1]

(b) Which fuel produces the most energy when 1 kg of the compound is burnt? Hence, determine the fuel which the boy scout is most likely to bring along.

[2]

(c) The boy scout finally decided to bring along heptane for his camping trip. Using the data from the table, suggest why his decision differs from your answer in **(b)**.

……..

……..[1]

(d) Calculate the bond energy of the O=O bond in the combustion of methane given the following bond energies.

bond	bond energy in kJ/mol
C – H	410
O – H	460
C = O	740

[2]
[Total: 6]

4(a)	They are covalent compounds with weak intermolecular forces of attraction which require little energy to break	1	Some students could not even answer this lower sec bonding question.
(b)	No of moles of methane = 1000/16 = 62.5 Amount of energy produced by burning 62.5 moles methane = 880 x 62.5 = 55 000 kJ No. of moles of propane = 1000/44 = 22.7 Amount of energy produced by burning 22.7 moles propane = 2200 x 22.7 = 49 940 kJ No. of moles of heptane = 1000/100 = 10 Amount of energy produced by burning 10 moles heptane = 4800 x 10 = 48 000 kJ Therefore, methane produces the most energy when burnt. The boy scout is most likely to bring along methane	 1 1	Generally well-answered
(c)	Heptane is in the liquid state at room temperature. It is easier to be transported than methane which is a gas at room temperature	1	Generally well-answered
(d)	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ Bond breaking = 4(410) + 2x Bond forming = 2(740) + 4(460) = 3320 kJ 4(410) + 2x – 3320 = -880 **x = 400 kJ/mol**	½ ½ 1	Many students are still unable to calculate

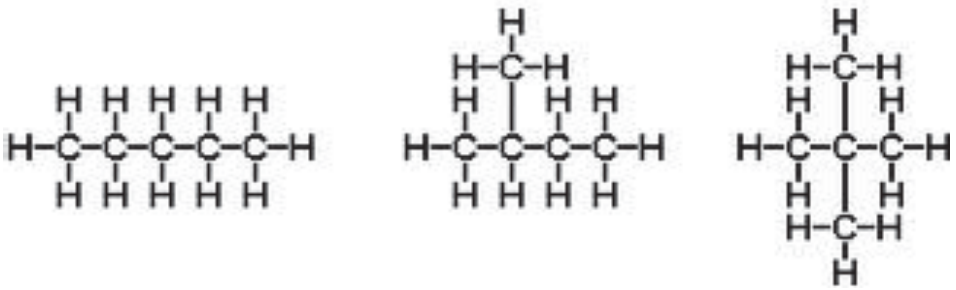
5 Alkanes like propane and butane are found in Liquefied Petroleum Gases(LPG).

(a) An experiment shows that complete combustion of 1.0 dm^3 (measured at room temperature and pressure) of butane produces 120 kJ of energy.
Calculate a value for the enthalpy change of complete combustion (kJ/mol) of butane, giving the correct sign.

ΔH = - 24 x 120 = - 2880kJ/mol reject if no unit and sign

[1]

(b) (i) The alkane with 5 carbon atoms, pentane exists as several isomers shown below.
One is straight chain pentane while the other two are branched chain pentane.



Will the two isomers which are branched chain pentane have the same enthalpy change on complete combustion as the straight chain pentane?
Explain your reasoning.

Yes, same (not similar) type bond and same number of bond [1]

(ii) The table shows the enthalpy changes of combustion of hexane and heptane.

name	formula	enthalpy change of combustion / kJ/ mol
hexane	C_6H_{14}	-4163
heptane	C_7H_{16}	-4817

Using the data given, estimate the enthalpy change of combustion in kJ/mol of octane, C_8H_{18}. Explain the method you use to arrive at your answer.

Difference in ΔH 4187- 4163 = 654 kJ

from hexane to heptane, increase in one CH_2 group

from heptane to octane, same increase of one CH_2 group

so ΔH for octane = -(4187 + 654) = -5471 kJ/mol [2]

(c) Some students studied the graph below that shows the amount of fossil fuel burned in the world between 1960 and 2010.

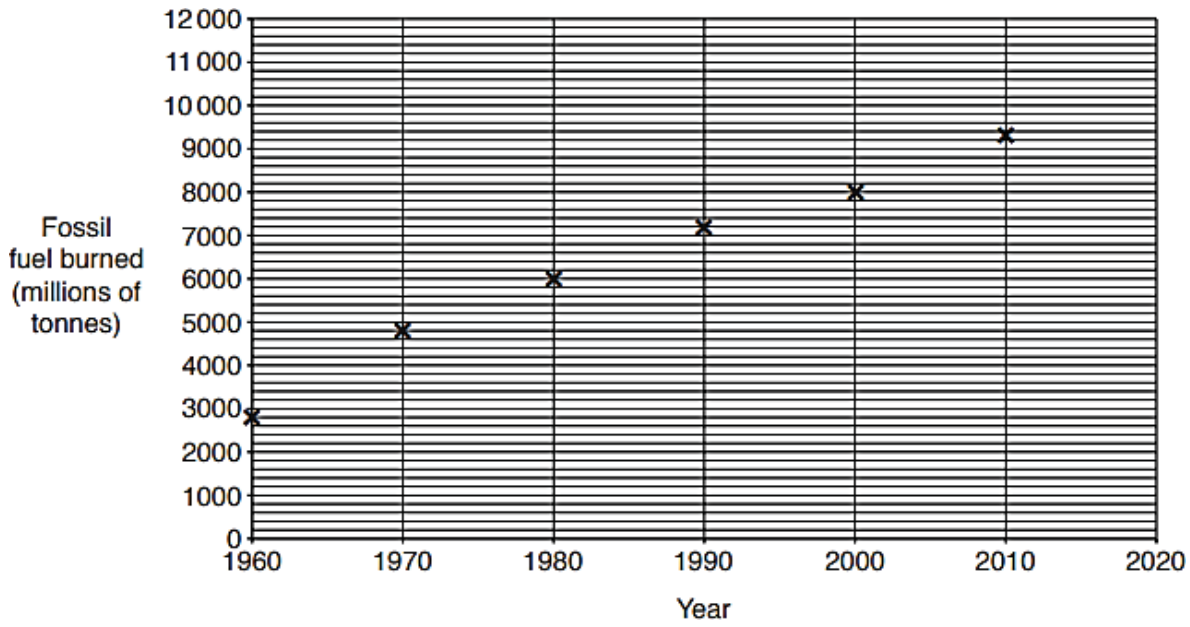


Fig 3.1

(i) One student says that the amount of fossil fuels burned has increased by the same amount every ten years.
Is the student correct? Use data from the graph to justify your answer.

No, quote any two data that shows a difference for every ten years.

Egs of data that can be used: 1960 -70, 2000 millions of tons bigger that 1970 to 80 which has increase 1200 millions of tons, or 1990 – 2000, increase of 800 millions of tons smaller than 2000 – 2010 increase of 1300 millions of tons [1]

(ii) Another student says that it is very difficult to estimate the amount of fossil fuel we will use in 100 years' time. Suggest reasons the student could give to justify this statement.

alternative / renewable forms of energy being used;

fossil fuel running out [2]

(iii) The graph below shows the changes in average global temperature from 1960 to 2010.

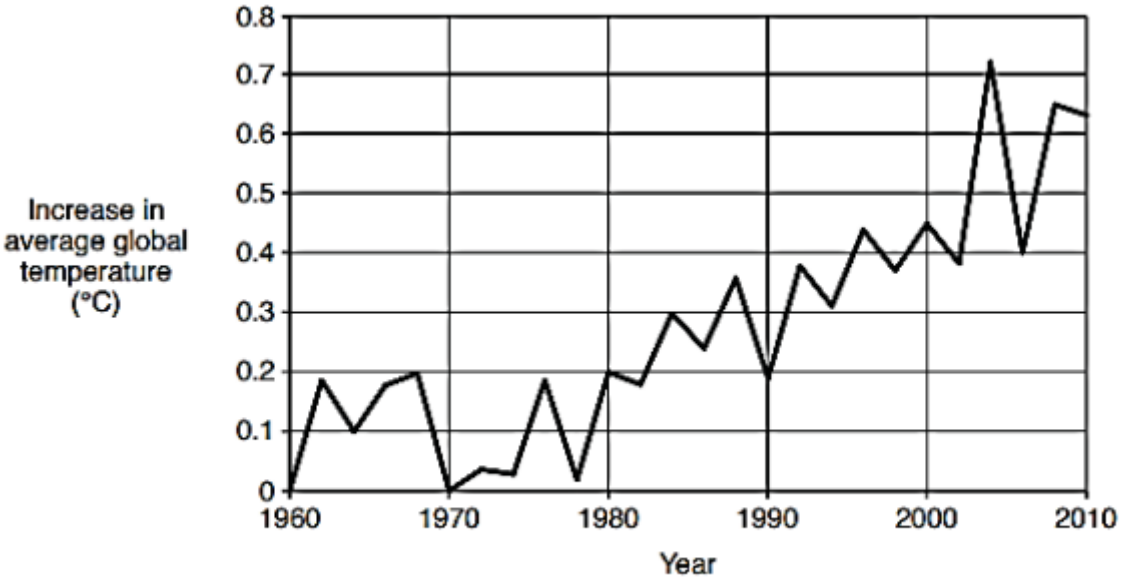


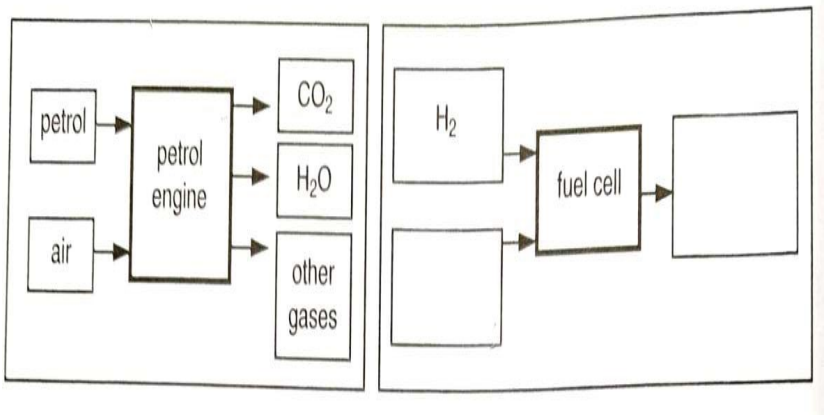
Fig 3.2

Describe the link between the trends shown in the graphs in Fig 3.1 and Fig 3.2.

As the amount of fossil fuel burnt increase, the increase average global temperature is higher [1]

[Total: 8]

6 The bond dissociation energies of some hydrogen halides are shown in the chart below. Bond dissociation energy is the energy that must be provided to the molecule in order to break the bond.

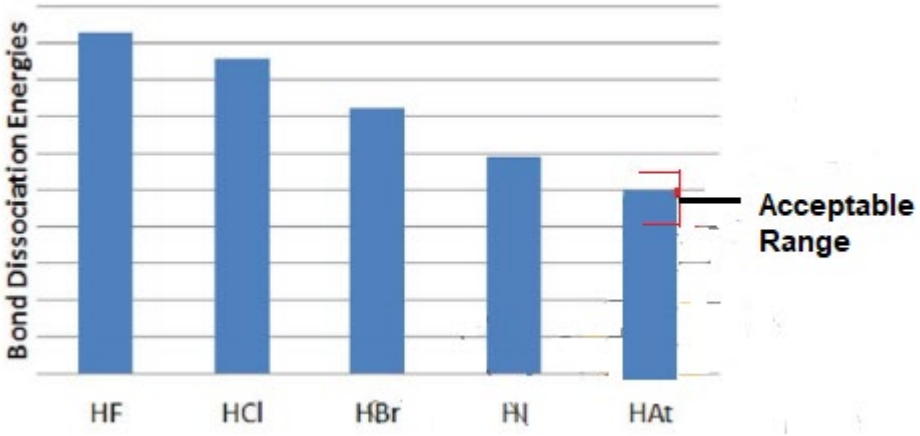


(a) Describe the trend shown in the above chart.

The bond dissociation energies of hydrogen halides decreases from HF to HAt.[1]

(b) Predict the bond dissociation energy of hydrogen astatide, HAt, by drawing the rectangular bar in the chart above. [1]

Answers:



Accept if answer is between 200-275kJ/mol

(c) **(i)** Suggest which one of the hydrogen halides forms the strongest acid.

HAt Note: chemical name is acceptable. [1]

(ii) Explain your answer to **(c)(i)**.

HAt has the lowest bond dissociation energy therefore hydrogen ions will be produced most easily. [2]

(d) Hydrogen bromide can be produced by reacting hydrogen and bromine according to the following reaction.

$$H_2\,(g) + Br_2\,(g) \rightarrow 2HBr\,(g)$$

The bond energies of some bonds are shown in the table below.

bond	H-H	H-Br	Br-Br
bond energy (kJ/mol)	432	363	193

Calculate the enthalpy change of this reaction and state whether it is exothermic or endothermic.

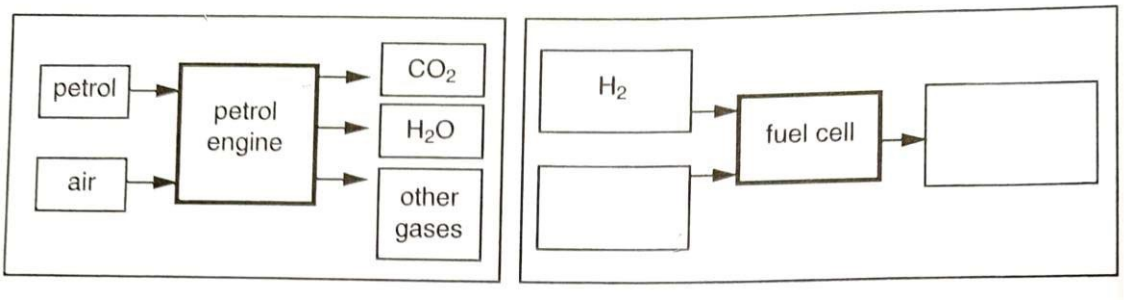
Enthalpy change 432 + 193 – 2(363) = -101 kJ

Exothermic reaction [2]

[Total: 7]

7 Most vehicles have petrol or diesel engines, but some use fuel cells.

The flow charts show the substances entering and leaving a petrol engine and a fuel cell.



(a) Complete the flow chart for the fuel cell by filling in the empty boxes. [1]

(b) The waste products from vehicles with petrol engines cause more harm to human health than those from vehicles with fuel cells.

Explain why this statement is true.

……

……

……

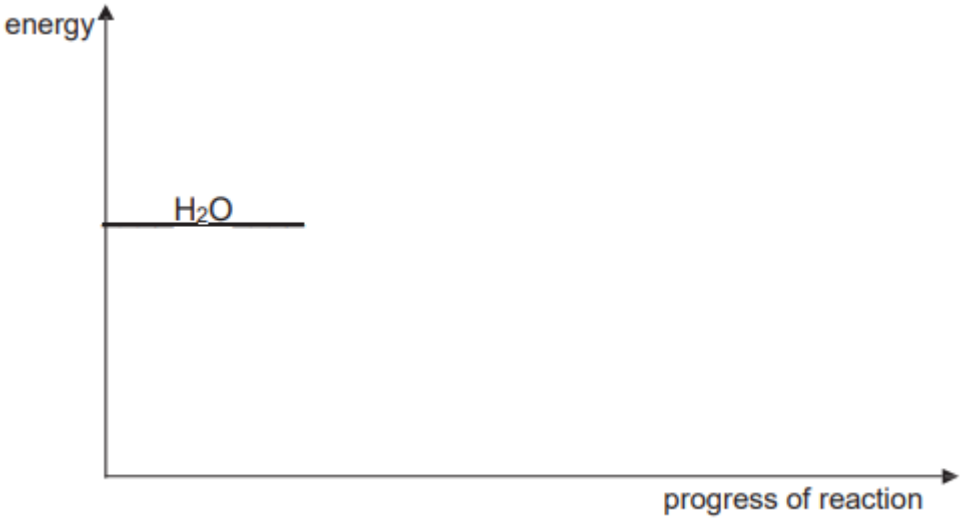
…… [3]

(c) Hydrogen for fuel cells can be obtained from water by electrolysis.

Electricity is used to provide energy for the electrolysis.

Complete the energy profile diagram for the electrolysis of water.

Your diagram should include
a. the **formulae of the products** of the electrolysis,
b. a label for the **enthalpy change of reaction**.



[2]

Answers:

<table>
<tr><td>7</td><td>(a)</td><td>Methane traps heat, causing global warming</td><td></td></tr>
<tr><td></td><td>(bi)</td><td>
<table>
<tr><td></td><td>C</td><td>H</td><td>Cl</td></tr>
<tr><td>Mass / g</td><td>0.242</td><td>0.04</td><td>0.718</td></tr>
<tr><td>Ar</td><td>12</td><td>1</td><td>35.5</td></tr>
<tr><td>No. of moles</td><td>$\frac{0.242}{12} = 0.02016$</td><td>$\frac{0.04}{1} = 0.04$</td><td>$\frac{0.718}{35.5} = 0.02022$</td></tr>
<tr><td>Ratio</td><td>$\frac{0.02016}{0.02016} = 1$</td><td>$\frac{0.04}{0.2016} \approx 2$</td><td>$\frac{0.02022}{0.02016} \approx 1$</td></tr>
</table>
Empirical formula = CH_2Cl</td><td>[1]
Or
[1]

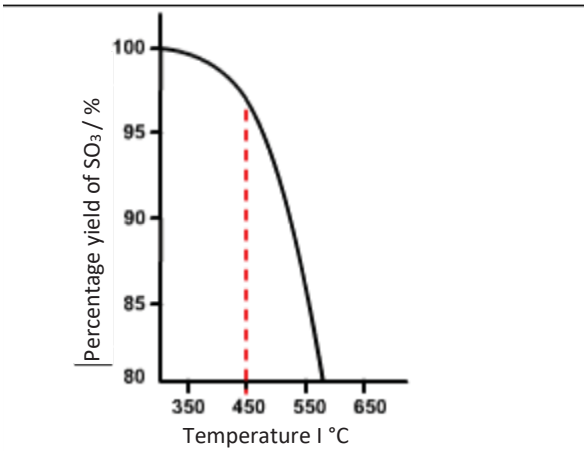
[1]</td></tr>
<tr><td></td><td>(bii)</td><td>M_r of $CH_2Cl = 12 + 1 + 1 + 35.5 = 49.5$
$n = \frac{99}{49.5} = 2$
Hence, molecular formula = $(CH_2Cl)_2$ = $C_2H_4Cl_2$</td><td>[1]</td></tr>
<tr><td></td><td>(ci)</td><td>At higher temperature of 100°C, the propane molecules have more kinetic energy
and hence move faster, as compared to a lower temperature of 60°C.</td><td>[1]

[1]</td></tr>
<tr><td></td><td>(cii)</td><td>Molecules/particles have different (relative molecular) masses, such that methane has a Mr of 16 whereas propane has a Mr of 44.

Methane (molecules) move or diffuse faster / propane (molecules) move or diffuse slowest</td><td>[1]

[1]</td></tr>
</table>

9 The graph below shows the percentage conversion to sulfur trioxide from sulfur dioxide and oxygen gas during the Contact Process.



(a) Give two reasons, other than cost, why the optimal temperature for Contact Process is 450 °C.

When the temperature is too low, the speed of reaction is slow; When the temperature is too high, the yield of the reaction is low [2]

(b) Write down the chemical equation for the formation of sulfur trioxide from sulfur dioxide and oxygen.

$2SO_2 + O_2 \rightarrow 2SO_3$

[1]

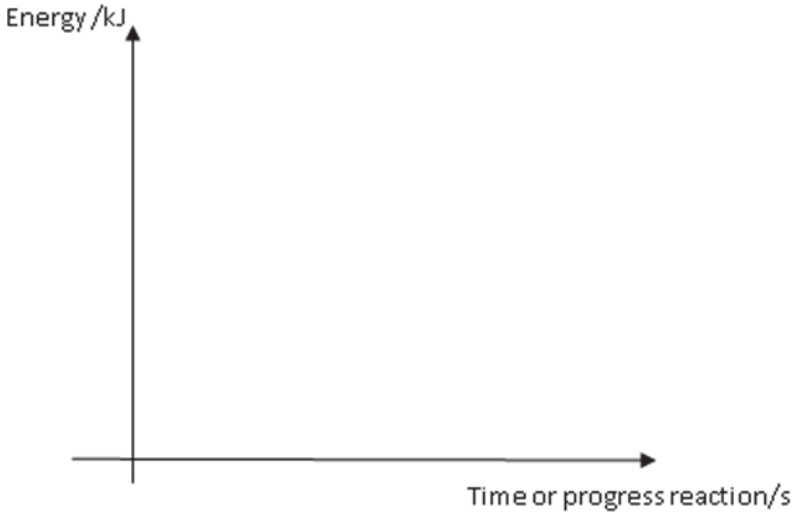
(c) Explain, in terms of bond breaking and bond forming, why the conversion of sulfur dioxide and oxygen to sulfur trioxide is an exothermic reaction.

The total energy absorbed to break bonds in 2 moles of SO_2 and 1 mole of O_2 is less than the total energy released to form bonds in 2 moles of SO_3.

(energy absorbed to break bonds; energy released to form bonds; correct comparison; (minus 1 if reactants and products are not specified)) [3]

(d) Draw an energy profile diagram to show the formation of sulfur trioxide from sulfur dioxide and oxygen.

Your diagram should show and label
a. formulae of the reactants and products
b. the activation energy for the reaction,
c. the enthalpy change of reaction.



Answer:
reaction pathway with names of products and reactants; activation energy; enthalpy change;

[3]

[Total: 9]

10 Hydrogen is increasingly being used as a 'clean fuel' in fuel cells. They react with oxygen to produce less harmful or pollutive substances.

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

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ [1]

(b) The enthalpy change of the reaction is known to be -572 kJ. Given that the H–H bond energy is 436 kJ mol^{-1} and the O=O bond energy is 495 kJ mol^{-1}, calculate the O–H bond energy.

let the O–H bond energy by ***x***
$\Delta H = -572 = 2(+436) + (+495) + 4(-x)$
$x = 485$ kJ mol^{-1} (3 sf

[2]

(c) State a disadvantage of using hydrogen as a fuel.

It is difficult to store and transport. [1]