Heat Energy Past Paper Questions IGCSE Edexcel

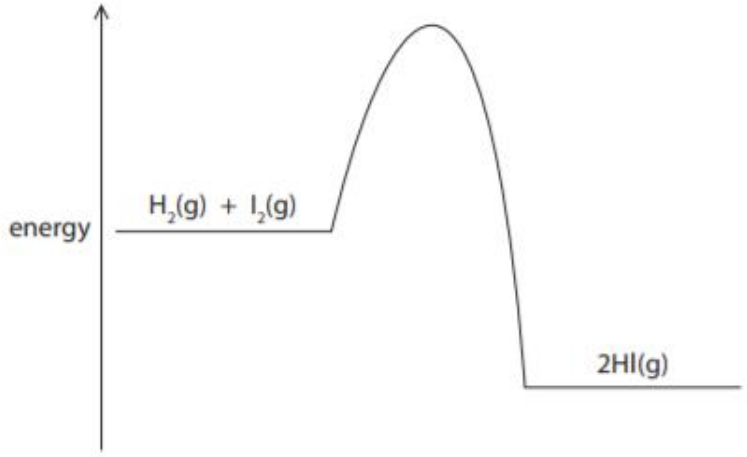
1.

Hydrogen iodide can be manufactured from its elements using this reaction.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = -9 \text{ kJ/mol}$$

A temperature of 500 °C, a pressure of 4 atm and a platinum catalyst are used in this manufacturing process.

(a) The diagram shows the reaction profile if a catalyst is not used.



(i) On the diagram, draw the reaction profile when a platinum catalyst is used.

(1)

(ii) Label the diagram to show the enthalpy change (ΔH) and the activation energy (E_{cat}) for the reaction with the catalyst.

(2)

(b) A manufacturer carries out this reaction using the same catalyst, a pressure of 4 atm, but a temperature of 400 °C.

(i) State the effect of this change in temperature on the rate of the reaction.

(1)

.....

.....

(ii) Explain the effect of this change on the yield of hydrogen iodide.

(2)

.....

(c) The manufacturer then carries out this reaction using the same catalyst, a temperature of 500 °C, but a pressure of 2 atm.

(i) Suggest what effect this change in pressure would have on the rate of the reaction.

(1)

.....

.....

(ii) Explain the effect of this change on the yield of hydrogen iodide.

(2)

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2.

Bromine reacts with hydrogen to form hydrogen bromide.

The equation for the reaction is

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

The table shows some average bond energies.

Bond	H—H	Br—Br	H—Br
Average bond energy in kJ/mol	436	193	366

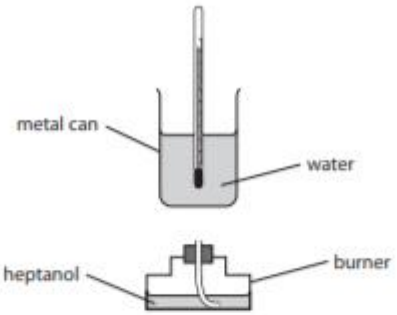
Use the values in the table to calculate the enthalpy change for the reaction between hydrogen and bromine.

(3)

3.

Heptanol and hydrogen are both used as fuels.

(a) A student uses this apparatus to find the heat energy released from the combustion of heptanol.



He uses this formula

$$Q = m \times 4.18 \times \Delta T$$

[Q = heat energy released, m = mass of water in g, ΔT = change in temperature of water]

1.00 cm^3 water has a mass of 1.00 g.

(i) State the measurements that the student needs to record to find a value for the heat energy released.

(2)

(ii) The student burns 0.75 g of heptanol and calculates Q to be 19 kJ.

Use this information to calculate the molar enthalpy change, in kJ/mol, for the combustion of heptanol.
[M_r of heptanol = 114]

(3)

molar enthalpy change = ... kJ/mol

(b) The equation for the combustion of hydrogen is

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

(i) This equation shows the reaction, including the covalent bonds in the molecules.

$$2H{-}H + O{=}O \rightarrow 2H{-}O{-}H$$

The table gives the average (mean) bond energies.

Bond	Average bond energy in kJ/mol
H—H	436
O=O	498
H—O	464

Use the values in the table to calculate the enthalpy change, ΔH, for the reaction.

Include the sign in your answer.

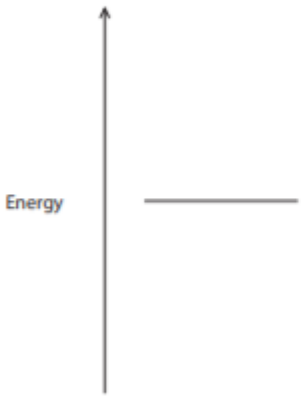
(3)

$\Delta H =$ ..... kJ

(ii) Complete the energy level diagram for the reaction between hydrogen and oxygen by showing the reactants and products.

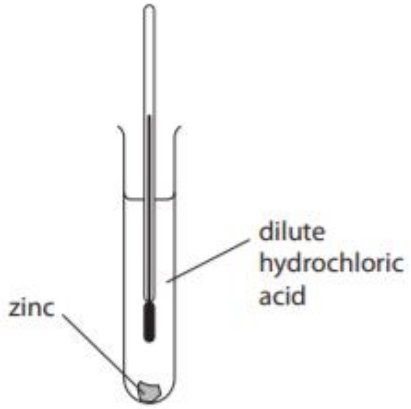
Label the enthalpy change, ΔH, for the reaction.

(2)



4.

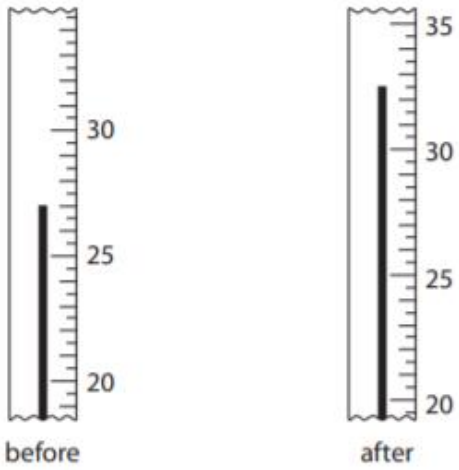
In an experiment, a student adds a piece of zinc to some dilute hydrochloric acid in a test tube.



The student measures the temperature before adding the zinc.

After adding the zinc, he stirs the mixture and measures the highest temperature reached.

The diagram shows his results.



(a) Use the readings to complete the table, giving all values to the nearest 0.5 °C.

(2)

Temperature in °C after adding the zinc	
Temperature in °C before adding the zinc	27.0
Change in temperature in °C	

(b) The student wants to find out if there is a relationship between the reactivity of a metal and the temperature rise.

He repeats the experiment four times, using a different metal each time.

The table shows his results.

Metal added	Temperature rise in °C
magnesium	7.5
gold	0.0
iron	3.0
calcium	10.5

(i) State three factors that the student should keep constant in each experiment.

(3)

1 .....

2 .....

3 .....

(ii) Using information from the table, state the relationship between the reactivity of a metal and the temperature rise.

(1)

.....

.....

(iii) State why there is no temperature rise when gold is added to the acid.

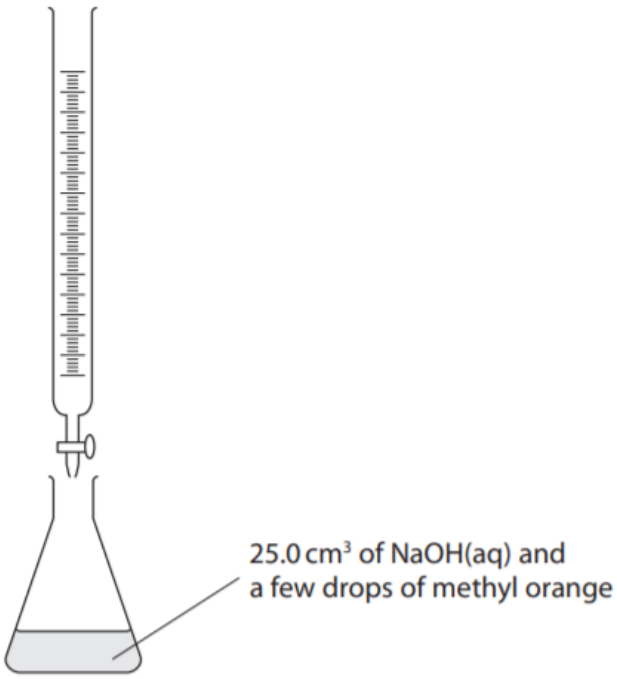
(1)

.....

.....

5.

This apparatus can be used to find the volume of dilute sulfuric acid needed to neutralise 25.0 cm^3 of aqueous sodium hydroxide, NaOH.



(a) Describe how to use the apparatus to find the volume of dilute sulfuric acid needed to neutralise the sodium hydroxide.

Assume that the apparatus is clean and does not need rinsing.

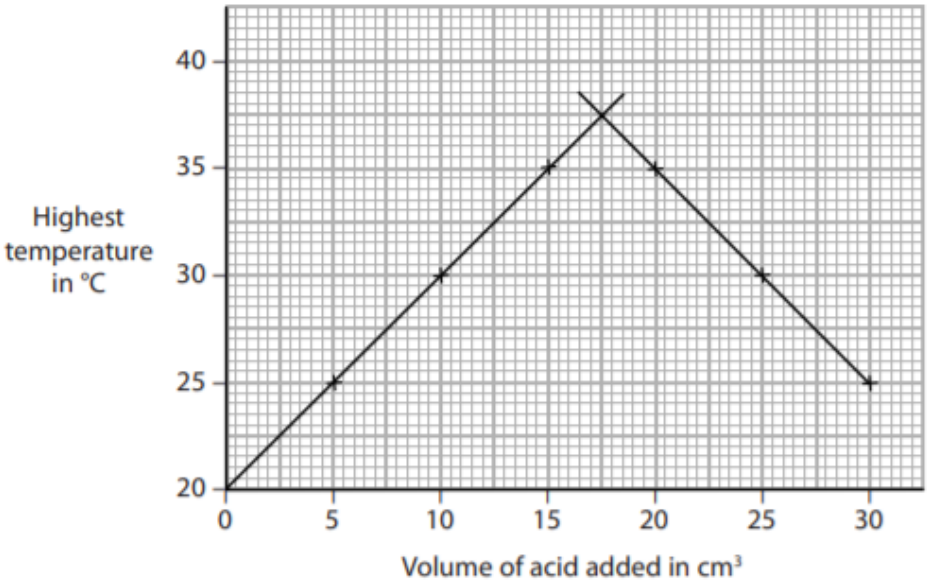
(4)

(b) The volume of dilute sulfuric acid needed can also be found by measuring the highest temperature reached when the two solutions are mixed.

In a series of experiments, different volumes of dilute sulfuric acid are added separately to 25.0 cm^3 samples of aqueous sodium hydroxide.

The graph shows the highest temperatures in each experiment.

In each reaction, the starting temperatures of the two solutions are the same.



Use the graph to answer these questions.

(i) State the starting temperature of each experiment.

(1)

starting temperature = ... °C

(ii) Find the volume of acid required to exactly neutralise the sodium hydroxide.

(1)

volume of acid = ... cm^3

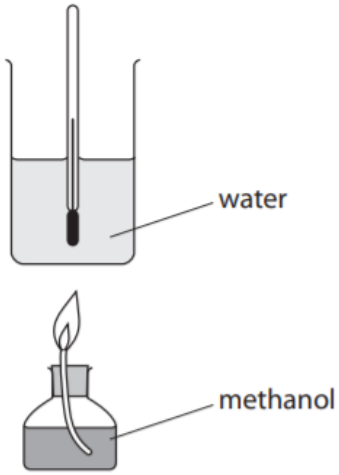
(iii) Find the two different volumes of acid that produce an increase in temperature of 10°C.

(1)

..... and .....

6.

A student uses this apparatus to find the increase in temperature of water when methanol, CH_3OH, is burned.



(a) There are several reasons why the increase in temperature is less than expected.

(i) One reason is the incomplete combustion of methanol to form only carbon monoxide and water.

Write the chemical equation for this incomplete combustion.

(2)

(ii) State another reason why the increase in temperature is less than expected.

(1)

(b) The student records these results.

mass of burner and methanol before combustion	84.7 g
mass of burner and methanol after combustion	83.2 g
mass of water	125 g
temperature of water at start	22 °C
temperature of water at end	58 °C

(i) Calculate the heat energy change (Q), in joules, in this experiment using the expression

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

where m is the mass of water in grams and ΔT represents the increase in temperature.

(2)

$Q =$ ..... J

(ii) The relative molecular mass of methanol is 32

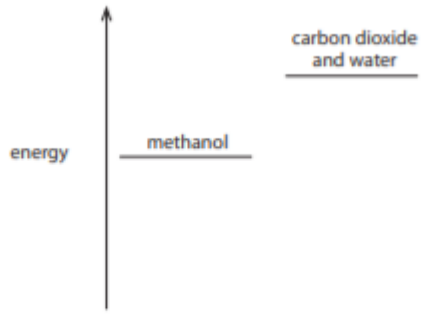
Use this information and your value for Q to calculate the molar enthalpy change, ΔH, for the combustion of methanol.

Give your answer in kJ/mol.

(4)

$\Delta H =$ ..... kJ/mol

(iii) The student draws an energy level diagram for the complete combustion of methanol.



Identify the two mistakes in his diagram.

(2)

1 .....

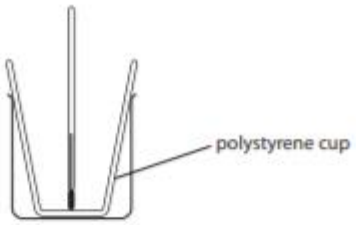
.....

2 .....

.....

7.

A student uses this apparatus to investigate the change in temperature when dilute hydrochloric acid is added to aqueous sodium hydroxide.



This is the student's method.

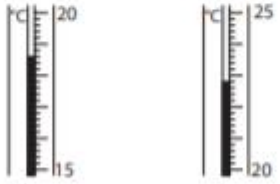
- pour some aqueous sodium hydroxide into the polystyrene cup
- record the temperature of the sodium hydroxide
- add some dilute hydrochloric acid and stir the mixture
- record the highest temperature of the mixture

The student repeats the experiment using different volumes of the two solutions.

(a) Explain why the student uses a polystyrene cup to contain the solution, rather than a beaker.

(2)

(b) The diagram shows the thermometer readings for one experiment before and after adding the acid.



before after

Record the temperatures before and after adding the acid.

(2)

before ..... °C

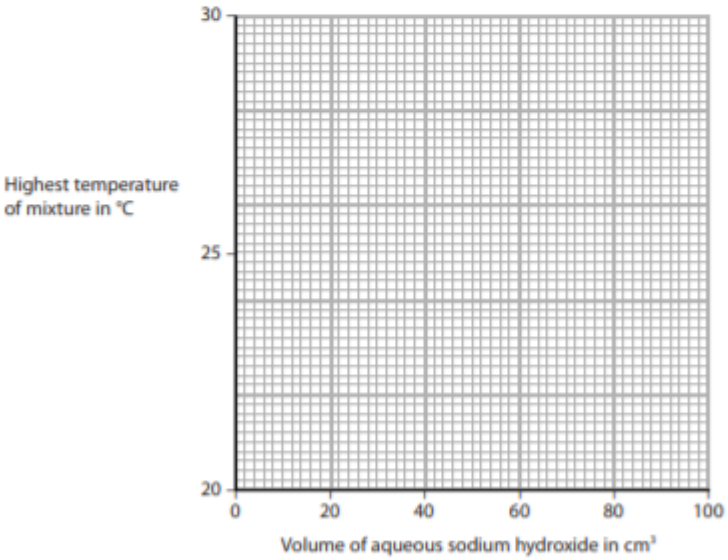
after ..... °C

(c) The table shows the results of a series of experiments.

The initial temperatures of the aqueous sodium hydroxide and the dilute hydrochloric acid are the same.

Experiment	Volume of aqueous sodium hydroxide in cm^3	Volume of dilute hydrochloric acid in cm^3	Highest temperature of mixture in °C
1	10	90	22.2
2	20	80	24.2
3	30	70	26.0
4	70	30	24.0
5	80	20	23.0
6	90	10	22.0

(i) Plot the results from the table on the grid.



Draw a straight line of best fit for experiments 1, 2 and 3.

Draw a second straight line of best fit for experiments 4, 5 and 6.

Extend both lines so that they cross.

(4)

(ii) The point where the two lines cross indicates when equal amounts, in moles, of sodium hydroxide and hydrochloric acid react.

Use your graph to find the volumes that contain equal amounts of sodium hydroxide and hydrochloric acid.

(2)

volume of sodium hydroxide ..... cm^3

volume of hydrochloric acid ..... cm^3

(iii) The equation for the reaction between sodium hydroxide and hydrochloric acid is

$$NaOH + HCl \rightarrow NaCl + H_2O$$

Explain which solution, the sodium hydroxide or the hydrochloric acid, has the greater concentration.

(2)

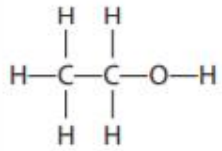
8.

(b) Ethanol can be used as a fuel.

This is the equation for the complete combustion of ethanol.

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

These are the displayed formulae for ethanol, oxygen, carbon dioxide and water.

	O═O	O═C═O	H—O—H
ethanol	oxygen	carbon dioxide	water

The table gives some average (mean) bond energies.

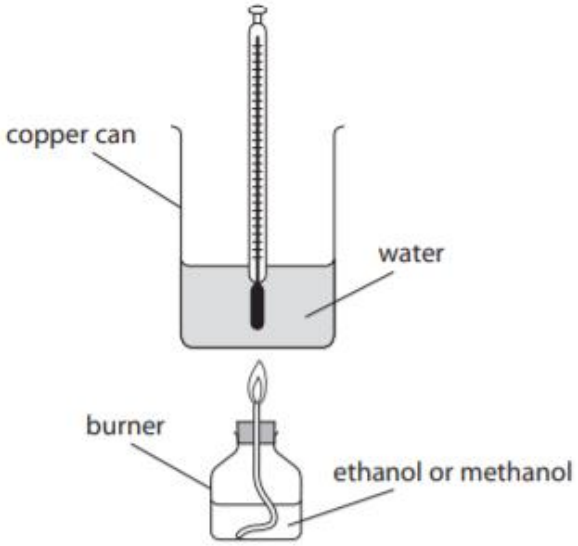
Bond	Average bond energy in kJ/mol
C—C	348
C—H	412
C—O	360
H—O	463
O═O	496
C═O	743

Use this information to calculate the enthalpy change (ΔH) when one mole of ethanol is completely burned.

(4)

(c) Ethanol and methanol can both be used as fuels.

A student uses this apparatus to find out how much energy is produced when one mole of ethanol and one mole of methanol are burned.



The table shows some of the student's results.

Fuel	Formula mass of fuel	Energy given out by 1.00 g of fuel in kJ	Energy given out by 1 mol of fuel in kJ
ethanol (C_2H_5OH)	46.0	20.9	961
methanol (CH_3OH)		15.6	

(i) Calculate the energy given out by 1 mol of methanol.

(2)

energy given out = ... kJ