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CHEMISTRY

Physical Chemistry

Level & Board	AQA (A-LEVEL)
TOPIC:	ENERGETICS
PAPER TYPE:	QUESTION PAPER 1
TOTAL QUESTIONS	10
TOTAL MARKS	68

Energetics - 1

1. This question is about combustion.

(a) State the meaning of the term standard enthalpy of combustion.

(2)

(b) A student does an experiment to determine the enthalpy of combustion of propan-1-ol ($CH_3CH_2CH_2OH$, Mr = 60.0).

Combustion of 0.497 g of propan-1-ol increases the temperature of 150 g of water from 21.2 °C to 35.1 °C

Calculate a value, in kJ mol^{-1} for the enthalpy of combustion of propan-1-ol in this experiment.

The specific heat capacity of water is 4.18 J K^{-1} g^{-1}

(3)

I am Sorry !!!!!

(c) The enthalpy of combustion determined experimentally is less exothermic than that calculated using enthalpies of formation.

Give one possible reason for this, other than heat loss.

(1)

2. This question is about enthalpy changes.

(a) State the meaning of the term enthalpy change as applied to a chemical reaction.

(1)

(b) A student determines the enthalpy change for the reaction between calcium carbonate and hydrochloric acid.

$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$

The student follows this method:

- measure out 50 cm^3 of 1.00 mol dm^{-3} aqueous hydrochloric acid using a measuring cylinder and pour the acid into a 100 cm^3 glass beaker
- weigh out 2.50 g of solid calcium carbonate on a watch glass and tip the solid into the acid
- stir the mixture with a thermometer
- record the maximum temperature reached.

The student uses the data to determine a value for the enthalpy change.

Explain how the experimental method and use of apparatus can be improved to provide more accurate data.

Describe how this data from the improved method can be used to determine an accurate value for the temperature change.

(6)

(c) In a different experiment 50.0 cm^3 of 0.500 mol dm^{-3} aqueous hydrochloric acid are reacted with 50.0 cm^3 of 0.500 mol dm^{-3} aqueous sodium hydroxide.

$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$ $\Delta H = -57.1$ kJ mol^{-1}

The initial temperature of each solution is 18.5 °C

Calculate the maximum final temperature of the reaction mixture.
Assume that the specific heat capacity of the reaction mixture,
$c = 4.18$ J K^{-1} g^{-1}

Assume that the density of the reaction mixture = 1.00 g cm^{-3}

(5)

(d) Suggest how, without changing the apparatus, the experiment in part (c) could be improved to reduce the percentage uncertainty in the temperature change.

(1)

3. Which reaction has an enthalpy change equal to the standard enthalpy of formation of lithium fluoride?

A. $Li(g) + \frac{1}{2}F_2(g) \rightarrow LiF(s)$

B. $Li^+(g) + F^-(g) \rightarrow LiF(s)$

C. $Li^+(aq) + F^-(aq) \rightarrow LiF(s)$

D. $Li(s) + \frac{1}{2}F_2(g) \rightarrow LiF(s)$

(1)

4. Two reactions of iron with oxygen are shown.

$Fe(s) + \frac{1}{2}O_2(g) \rightarrow FeO(s) \qquad \Delta H = -272 \text{ kJ mol}^{-1}$

$2Fe(s) + \frac{2}{3}O_2(g) \rightarrow Fe_2O_3(s) \qquad \Delta H = -822 \text{ kJ mol}^{-1}$

What is the enthalpy change, in kJ mol^{-1} , for this reaction?

$2FeO(s) + \frac{1}{2}O_2(g) \rightarrow Fe_2O_3(s)$

A. +550
B. –278
C. –1094
D. –1372

(1)

5. A bomb calorimeter can be used for accurate determination of the heat change during combustion of a fuel.
A bomb calorimeter is a container of fixed volume that withstands the change in pressure during the reaction.
The fuel is mixed with pure oxygen in the calorimeter, ignited and the temperature change is recorded. The total heat capacity (Ccal) of the calorimeter is calculated using a fuel for which the heat change is known.
In an experiment to calculate Ccal, 2.00 g of hexane (Mr = 86.0) is ignited. A temperature change (ΔT) of 12.4 °C is recorded.
Under the conditions of the experiment, 1.00 mol of hexane releases 4154 kJ of energy when combusted.

(a) The heat energy released in the calorimeter, q = Ccal ΔT
Calculate the heat capacity (Ccal) in kJ K^{-1}

(3)

(b) State why the heat change calculated from the bomb calorimeter experiment is not an enthalpy change.

(1)

(c) The thermometer used to measure the temperature change of 12.2 °C in part (b) has an uncertainty of ± 0.1 °C in each reading.

Calculate the percentage uncertainty in this use of the thermometer.

Suggest one change to this experiment that decreases the percentage uncertainty while using the same thermometer.

(2)

6. This question is about enthalpy changes.

(a) A student determined the enthalpy of combustion of cyclohexane (C_6H_{12}).

The student

- placed a pure sample of cyclohexane in a spirit burner
- placed the spirit burner under a beaker containing 50.0 g of water and ignited the cyclohexane
- extinguished the flame after a few minutes. The results for the experiment are shown in Table 1.

Initial temperature of the water / °C	19.1
Initial mass of spirit burner and cyclohexane / g	192.730
Final mass of spirit burner and cyclohexane / g	192.100

The student determined from this experiment that the enthalpy of combustion of cyclohexane is –1216 kJ mol^{-1}

Use the data to calculate the final temperature of the water in this experiment.

The specific heat capacity of water = 4.18 J K^{-1} g^{-1}
The relative molecular mass (Mr) of cyclohexane = 84.0

(4)

(b) The enthalpy of combustion of cyclohexane is –3920 kJ mol^{-1}
The student concluded that the temperature rise recorded in the experiment was smaller than it should have been.
Suggest a practical reason for this.

(1)

(c) Table 2 gives some values of standard enthalpies of combustion ($\Delta_c H$).

Table 2

Substance	C(s)	$H_2(g)$	$C_6H_{12}(l)$
Standard enthalpy of combustion, $\Delta_c H^o$ / kJ mol^{-1}	−394	−286	−3920

Use the data in Table 2 to calculate the enthalpy change for the reaction represented by this equation

$6C(s) + 6\ H_2(g) \rightarrow C_6H_{12}(l)$

(3)

7. This question is about energetics.

(a) Write an equation, including state symbols, for the reaction with an enthalpy change equal to the enthalpy of formation for iron(III) oxide**.**

(1)

(b) Table 1 contains some standard enthalpy of formation data.

	$CO(g)$	$Fe_2O_3(s$
$\Delta_f H^o$ / kJ mol^{-1}	−111	−822

$Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(s) + 3CO_2(g)$ $\Delta H = -19$ kJ mol^{-1}

Use these data and the equation for the reaction of iron(III) oxide with carbon monoxide to calculate a value for the standard enthalpy of formation for carbon dioxide.
Show your working.

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(3)

(c) Some enthalpy data are given in Table 2.

Process	ΔH / kJ mol^{-1}
$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$	−92
$N_2(g) \longrightarrow 2N(g)$	+944
$H_2(g) \longrightarrow 2H(g)$	+436

Use the data from Table 2 to calculate the bond enthalpy for N−H in ammonia.

(3)

(d) Give one reason why the bond enthalpy that you calculated in part (c) is different from the mean bond enthalpy quoted in a data book (388 kJ mol^{-1}).

(1)

8. A student planned and carried out an experiment to determine the enthalpy of reaction when magnesium metal displaces zinc from aqueous zinc sulfate.

$Mg(s) + Zn^{2+}(aq) \longrightarrow Mg^{2+}(aq) + Zn(s)$

The student used this method:

- A measuring cylinder was used to transfer 50 cm^3 of a 1.00 mol dm^{-3} aqueous solution of zinc sulfate into a glass beaker.
- A thermometer was placed in the beaker.
- 2.08 g of magnesium metal powder were added to the beaker.

- The mixture was stirred and the maximum temperature recorded. The student recorded a starting temperature of 23.9 °C and a maximum temperature of 61.2 °C.

(a) Show by calculation which reactant was in excess.

Use the data to calculate the experimental value for enthalpy of reaction in kJ mol^{-1} (Assume that the specific heat capacity of the solution is 4.18 J $K^{-1}g^{-1}$and the density of the solution is 1.00 g cm^{-3})

(6)

(b) Another student used the same method and obtained a value for the enthalpy of reaction of −142 kJ mol^{-1}

A value for the enthalpy of reaction is −310 kJ mol^{-1}

Suggest the most likely reason for the large difference between the student's experimental value and the data book value.

(3)

(c) Suggest how the students' method, and the analysis of the results, could be improved in order to determine a more accurate value for the enthalpy of reaction.
Justify your suggestions.
Do not refer to the precision of the measuring equipment.
Do not change the amounts or the concentration of the chemicals.

(6)

9. This question is about enthalpy changes.

(a) Write an equation, including state symbols, to show the reaction taking place when the standard enthalpy of combustion for ethanol is measured.

(2)

(b) State the name given to the enthalpy change represented by the following chemical equation.
Explain why this enthalpy change would be difficult to determine directly.

$C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)$

(2)

(c) Standard enthalpies of combustion for carbon and carbon monoxide are −393 kJ mol^{-1} and −283 kJ mol^{-1}, respectively.
Use these data to calculate the enthalpy change for the reaction in part (b).

(2)

(d) Use the following data to calculate a value for the Xe–F bond enthalpy in XeF_4

$Xe(g) + 2F_2(g) \rightarrow XeF_4(g)$ $\quad \Delta H = -252$ kJ mol^{-1}

$F_2(g) \rightarrow 2F(g)$ $\Delta H = -158 \text{ kJ mol}^{-1}$

(3)

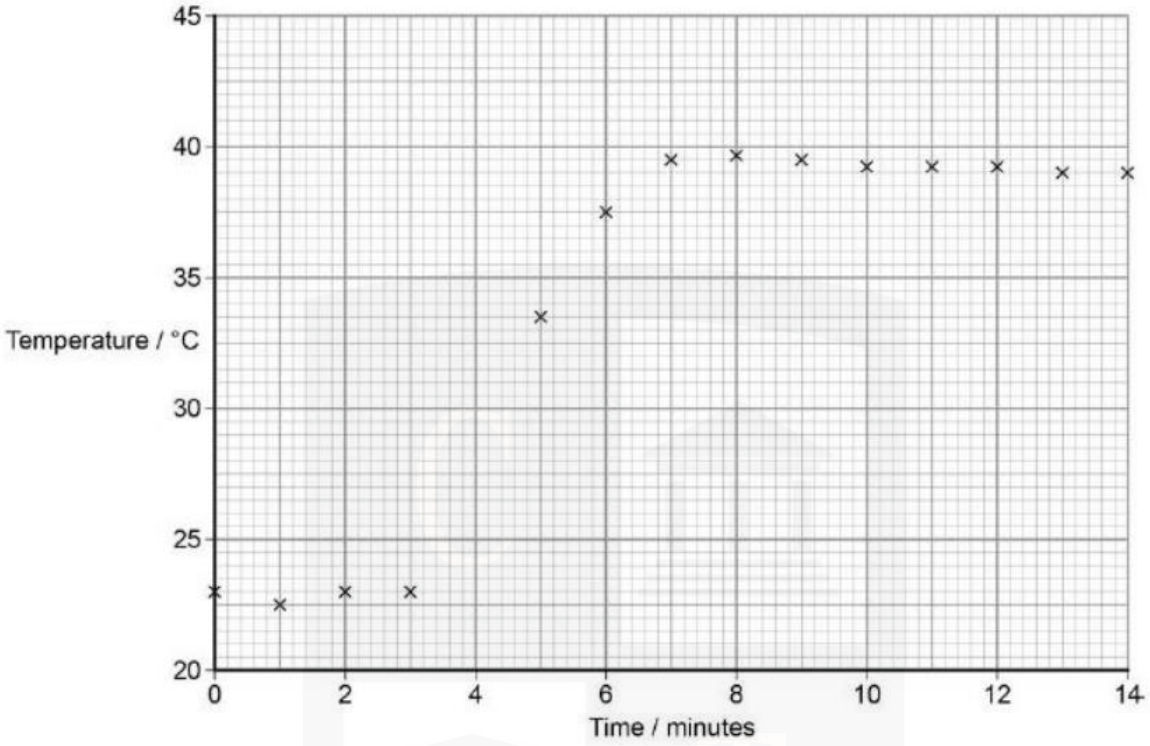
(e) Suggest a reason why the value calculated in part (d) differs from the mean Xe–F bond enthalpy quoted in a data source.

(1)

10. A student carried out a reaction between magnesium ribbon and aqueous trichloroethanoic acid in order to determine the enthalpy change.
The equation for the reaction is shown:

$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$

The student measured the initial temperature of the trichloroethanoic acid and again every minute for 3 minutes before adding the magnesium ribbon at the fourth minute.
The student continued to measure the temperature every minute for a further 10 minutes.



The graph for these measurements is shown below.
The student used 240 mg of magnesium and 10.0 cm^3 of aqueous trichloroethanoic acid (an excess).

Use these data and information determined from the graph above to calculate the enthalpy change, in kJ mol^{-1} for this reaction.

Show your working.
Give your answer to an appropriate precision.
(The specific heat capacity of water = 4.18 J K^{-1} g^{-1})

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