Cambridge AS & A Level

CHEMISTRY

Paper 2

Topical Past Paper Questions

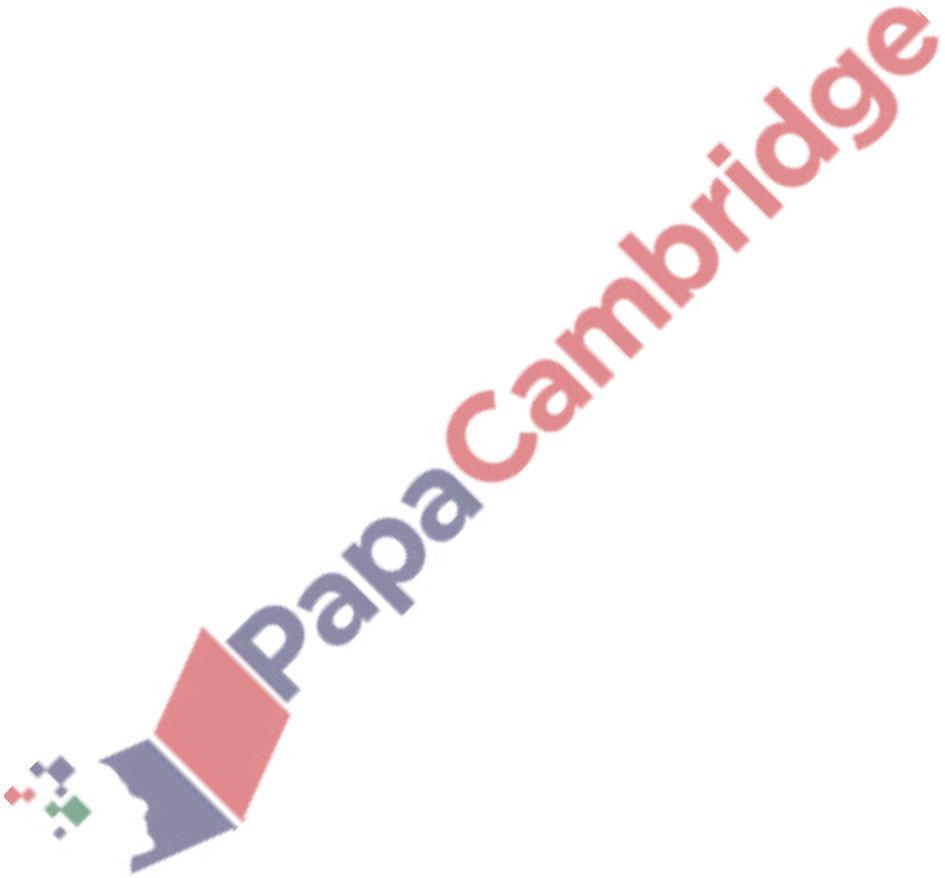
+ Answer Scheme

2015 - 2021

PapaCambridge

Chapter 5

Chemical energetics



5.1 Enthalpy change, △H

20. 9701_w16_qp_21 Q: 2

For many compounds the enthalpy change of formation cannot be calculated directly. An indirect method based on enthalpy changes of combustion can be used.

The enthalpy change of combustion can be found by a calorimetry experiment in which the heat energy given off during combustion is used to heat a known mass of water and the temperature change recorded.

(a) (i) Explain the meaning of the term *standard enthalpy change of combustion*.

.....

.....

..... [3]

(ii) Write the equation for the complete combustion of ethanol, C_2H_5OH.

..... [1]

(b) In an experiment to determine the enthalpy change of combustion of ethanol, 0.23 g of ethanol was burned and the heat given off raised the temperature of 100 g of water by 16.3 °C.

(i) Calculate the heat energy change, q, during the combustion of 0.23 g of ethanol.

q = ... J [1]

(ii) Calculate the enthalpy change on burning 1 mole of ethanol. Include a sign in your answer.

ΔH = ... kJ mol^{-1} [1]

(iii) Suggest **two** reasons why the value for the enthalpy change of combustion of ethanol determined by a simple laboratory calorimetry experiment is likely to be lower than the true value.

.....

.....

.....

..... [2]

(c) The table gives some enthalpy change of combustion values.

substance	enthalpy change of combustion / kJ mol^{-1}
C(s)	–393.5
$H_2(g)$	–285.8
$C_3H_7OH(l)$	–2021.0

(i) Construct a labelled energy cycle to show how these values could be used to calculate the enthalpy change of formation of $C_3H_7OH(l)$, ΔH_f.

$$3C(s) + 4H_2(g) + \frac{1}{2}O_2(g) \xrightarrow{\Delta H_f} C_3H_7OH(l)$$

[3]

(ii) Calculate the enthalpy change of formation, ΔH_f, of $C_3H_7OH(l)$.

ΔH_f = ... kJ mol^{-1} [2]

[Total: 13]

21. 9701_w15_qp_22 Q: 2

Chemical reactions are accompanied by enthalpy changes.

(a) Explain the meaning of the term *standard enthalpy change* of reaction.

.....

.....

..... [2]

(b) The enthalpy change of hydration of anhydrous magnesium sulfate, ΔH_{hyd} $MgSO_4$, can be calculated by carrying out two separate experiments.

In the first experiment 45.00 g of water was weighed into a polystyrene cup and 3.01 g of $MgSO_4$ was added and stirred until it was completely dissolved. The temperature of the water rose from 23.4 °C to 34.7 °C.

(i) Calculate the amount of heat energy transferred to the water during this dissolving process.

You can assume that the specific heat capacity of the solution is the same as that of water, 4.18 $J g^{-1} K^{-1}$.

heat energy = ... J [1]

(ii) Calculate the amount, in moles, of $MgSO_4$ dissolved.

amount = ... mol [1]

(iii) Calculate the enthalpy change of solution, ΔH_{soln}, of $MgSO_4(s)$.

You must include a sign with your answer.

ΔH_{soln}, of $MgSO_4(s)$ = ... $kJ\,mol^{-1}$ [1]

In the second experiment, the enthalpy change of solution for the hydrated salt, $MgSO_4.7H_2O(s)$, was calculated and found to be $+9.60\,kJ\,mol^{-1}$.

(iv) Use the equation below for the hydration of anhydrous magnesium sulfate to construct a suitable, fully labelled energy cycle that will allow you to calculate the enthalpy change for this reaction, ΔH_{hyd} $MgSO_4$.

$$MgSO_4(s) + 7H_2O(l) \rightarrow MgSO_4.7H_2O(s)$$

[1]

(v) Calculate the enthalpy change for this reaction, ΔH_{hyd} $MgSO_4$. Include a sign in your answer.

ΔH_{hyd} $MgSO_4$ = ... $kJ\,mol^{-1}$ [1]

[Total: 7]

5.2 Hess' Law, including Born-Haber cycles

22. 9701_m19_qp_22 Q: 2

The elements in Group 17 of the Periodic Table are called the halogens. They form stable compounds with both metals and non-metals.

The table gives some data about F_2, HC*l* and CaF_2.

	F_2	HC*l*	CaF_2
boiling point/K	85	188	2773
relative formula mass	38.0	36.5	78.1

(a) (i) State what is meant by the term *relative formula mass*.

.....

.....

..... [2]

(ii) F_2 and HC*l* are both covalent molecules.

Suggest why the boiling point of HC*l* is higher than that of F_2.

.....

.....

..... [2]

(iii) Explain why CaF_2 has a very high boiling point.

.....

..... [1]

(iv) CaF_2(aq) can be made by the reaction of calcium carbonate with hydrofluoric acid, HF(aq).

Write an equation for this reaction. Include state symbols.

..... [2]

(b) (i) Complete the electronic configuration of a chloride ion.

$1s^2$ ..... [1]

(ii) When Cl_2 is passed over hot iron, $FeCl_3$ is formed.

However, when $I_2(g)$ is passed over hot iron, the following reaction occurs.

$$Fe(s) + I_2(g) \rightarrow FeI_2(s)$$

State what you would observe during the reaction between Fe and I_2. Explain why $FeI_2(s)$ is formed rather than $FeI_3(s)$.

observation .....

.....

explanation .....

.....

.....

[2]

(iii) FeI_2 is soluble in water.

A student carries out a chemical test to confirm that a solution of FeI_2 contains aqueous iodide ions, $I^-(aq)$. The student adds a single reagent and a precipitate forms.

Identify the reagent the student uses. State the colour of the precipitate that forms.

reagent .....

colour of precipitate .....

[2]

(iv) Compounds containing I^- are often contaminated by bromide ions, Br^-.

Identify a further reagent that the student could use to show that the precipitate formed in **(iii)** contained iodide ions.

..... [1]

(c) HOF is the only known molecule that contains only the elements hydrogen, oxygen and fluorine.

(i) Draw a 'dot-and-cross' diagram to represent the bonding in a molecule of HOF.

Show the outer shell electrons only.

[2]

(ii) HOF can be made by the reaction of F_2 with ice at −40 °C. The reaction is similar to the reaction of Cl_2 with cold water.

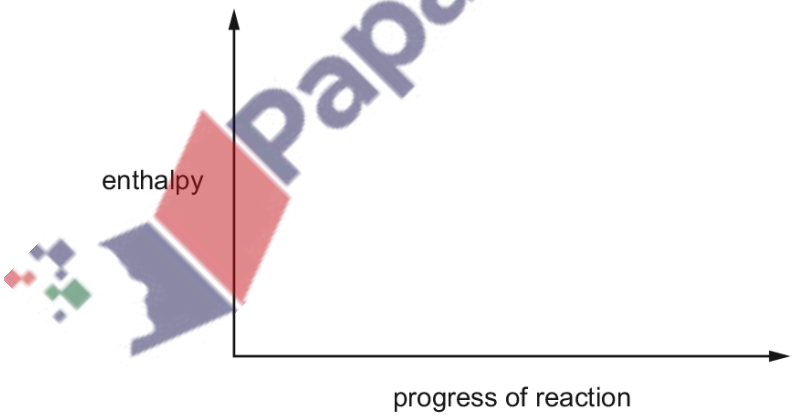
Suggest an equation for the reaction of F_2 with ice.

..... [1]

(iii) HOF is an unstable compound and decomposes to form HF and O_2.

$$HOF \rightarrow HF + \tfrac{1}{2}O_2 \qquad \Delta H = -139\,kJ\,mol^{-1}$$

Draw a fully labelled reaction pathway diagram on the axes provided to show the decomposition of HOF into HF and O_2.



[2]

(iv) Pure HF is a colourless liquid at 273 K. The liquid contains HF molecules that have strong hydrogen bonds between them.

Draw a fully labelled diagram to suggest how a hydrogen bond can form between two HF molecules.

[3]

(d) Interhalogen compounds, such as BrCl or IF_5, contain two or more different halogen atoms that are covalently bonded.

D is an interhalogen compound that contains only chlorine and fluorine.

At 0 °C and 101 325 Pa, 1 dm^3 of **D** has a mass of 4.13 g.

(i) Use the general gas equation to calculate the relative molecular mass, M_r, of **D**.

M_r = ...
[3]

(ii) Use your answer to **(i)** to determine the molecular formula of **D**.

If you were unable to calculate the M_r in **(i)**, assume that the M_r is 130.5. This is **not** the correct value.

molecular formula of **D** = ...
[1]

[Total: 25]