

# Entropy

## Question Paper

<b>Level</b>	A Level
<b>Subject</b>	Chemistry
<b>Exam Board</b>	Edexcel
<b>Topic</b>	Energetics II
<b>Sub Topic</b>	Entropy
<b>Booklet</b>	Question Paper
<b>Paper Type</b>	Open-Response 1

**Time Allowed:** 72 minutes

**Score:** /60

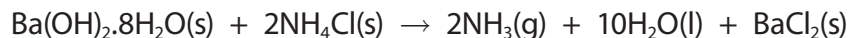
**Percentage:** /100

**Grade Boundaries:**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 This is a question about entropy changes.

Consider the reaction between the two solids, hydrated barium hydroxide and ammonium chloride. When these substances are mixed together, a white paste is formed and the temperature decreases. An equation for this process is given below.



(a) (i) Identify **one** hazard associated with a named substance in this reaction.

(1)

(ii) Use the standard molar entropies below to calculate the standard entropy change of the system ( $\Delta S_{\text{system}}^\ominus$ ) for this reaction at 298 K. Give a sign and units with your answer.

Compound	$S^\ominus / \text{J mol}^{-1} \text{K}^{-1}$
$\text{Ba(OH)}_2 \cdot 8\text{H}_2\text{O(s)}$	427
$\text{NH}_4\text{Cl(s)}$	95
$\text{NH}_3\text{(g)}$	192
$\text{H}_2\text{O(l)}$	70
$\text{BaCl}_2\text{(s)}$	124

(3)

\*(iii) Give **two** reasons why the sign of your answer to (a)(ii) is as you would expect.

(2)

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(b) The standard enthalpy change for this reaction is  $\Delta H_r^\ominus = +162 \text{ kJ mol}^{-1}$ .

Use this value to calculate the standard entropy change of the surroundings ( $\Delta S_{\text{surroundings}}^\ominus$ ) for this reaction at 298 K. Include a sign and units in your answer.

(2)

(c) Use your answers to (a)(ii) and (b) to calculate the total entropy change ( $\Delta S_{\text{total}}^\ominus$ ) for this reaction. Include a sign and units in your answer.

(1)

(d) What would be the effect, if any, on the value of  $\Delta S_{\text{total}}^\ominus$  from (c) of a small increase in temperature? Justify your answer and state any assumptions that you have made.

(3)

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- (e) The values of total entropy change and equilibrium constant of a reaction are related by the following equation.

$$\Delta S_{\text{total}} = R \ln K$$

The equation for the dissolving of barium hydroxide is



- (i) Calculate the value of the equilibrium constant,  $K$ , for this equation at 298 K.

$$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$$

(1)

- (ii) What does the value of the equilibrium constant suggest about the solubility of barium hydroxide?

Justify your answer.

(1)

- (iii) For the dissolving of calcium hydroxide, the value of the total entropy change is  $-106 \text{ J mol}^{-1} \text{ K}^{-1}$

Compare the values of the total entropy changes for these two hydroxides and show that they are consistent with the trend in the solubility of Group 2 hydroxides.

(2)

(Total for Question = 16 marks)

2 This question is about magnesium chloride,  $\text{MgCl}_2$ .

It can be formed by burning magnesium in chlorine.



Remember to include a sign and units in your answers to the calculations in this question.

(a) (i) The standard molar entropy at 298 K for 1 mol chlorine molecules,  $\text{Cl}_2$ , is  $+165 \text{ J mol}^{-1} \text{ K}^{-1}$ . Use this, and appropriate values from your Data Booklet, to calculate the standard entropy change of the system,  $\Delta S_{\text{system}}^{\ominus}$ , for this reaction.

(2)

\*(ii) Explain fully why the sign for the standard entropy change of the system,  $\Delta S_{\text{system}}^{\ominus}$  is as you would expect.

(2)

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(b) Calculate the total entropy change,  $\Delta S_{\text{total}}^{\ominus}$ , in  $\text{J mol}^{-1} \text{ K}^{-1}$ , for this reaction, giving your answer to three significant figures.

(2)

- (c) Use the standard entropy change of the surroundings,  $\Delta S_{\text{surroundings}}^{\ominus}$ , to calculate the standard enthalpy change,  $\Delta H^{\ominus}$ , in  $\text{kJ mol}^{-1}$ , for the reaction at 298 K.

(2)

- (d) 0.0300 mol of magnesium chloride, prepared by burning magnesium in chlorine, is added to 51.5  $\text{cm}^3$  of water.  
50.0  $\text{cm}^3$  of 1.00  $\text{mol dm}^{-3}$  solution is formed, and the temperature rise,  $\Delta T$ , is 22.5°C.

- (i) Calculate the energy transferred in joules for this process using:

$$\text{Energy transferred in joules} = \text{volume of solution} \times 4.2 \times \Delta T$$

(1)

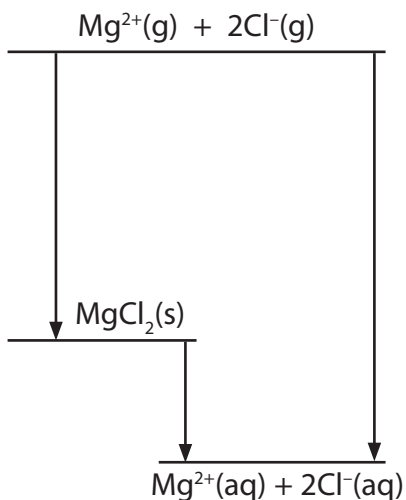
- (ii) Calculate the enthalpy change of solution,  $\Delta H_{\text{solution}}^{\ominus}$ , of magnesium chloride in  $\text{kJ mol}^{-1}$ .

(2)

\*(iii) The enthalpy change of hydration of  $\text{Mg}^{2+}(\text{g})$  is  $-1920 \text{ kJ mol}^{-1}$ .

Use this, your value from (d)(ii), and the experimental lattice energy from your Data Booklet, to calculate the enthalpy change of hydration of  $\text{Cl}^{-}(\text{g})$ .

(3)



Answer .....  $\text{kJ mol}^{-1}$

(iv) Draw a diagram to represent a hydrated chloride ion.

(1)

(v) Suggest why the addition of anhydrous magnesium chloride to water results in an increase in temperature and a decrease in volume.

(2)

Temperature increases.....

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Volume decreases.....

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**(Total for Question = 17 marks)**

3 This question is about calcium chloride,  $\text{CaCl}_2$ .

It can be formed by burning calcium in chlorine.



You must include a sign and units in your answers to the calculations in this question.

(a) (i) The standard molar entropy at 298 K for 1 mole of chlorine molecules,  $\text{Cl}_2$ , is  $+165 \text{ J mol}^{-1} \text{ K}^{-1}$ . Use this, and appropriate values from your Data Booklet, to calculate the standard entropy change,  $\Delta S_{\text{system}}^{\ominus}$ , for this reaction.

(2)

\*(ii) Explain fully why the sign for the standard entropy change of the system,  $\Delta S_{\text{system}}^{\ominus}$ , is as you would expect.

(2)

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(b) Calculate the total entropy change,  $\Delta S_{\text{total}}^{\ominus}$ , in  $\text{J mol}^{-1} \text{ K}^{-1}$ , for this reaction, giving your answer to three significant figures.

(2)



- (c) Use the standard entropy change of the surroundings,  $\Delta S_{\text{surroundings}}^{\ominus}$ , to calculate the standard enthalpy change,  $\Delta H^{\ominus}$ , in  $\text{kJ mol}^{-1}$ , for the reaction at 298 K.

(2)

- (d) 0.0500 mol of calcium chloride, prepared by burning calcium in chlorine, is added to 51.8  $\text{cm}^3$  of water.

50.0  $\text{cm}^3$  of a 1.00  $\text{mol dm}^{-3}$  solution is formed, and the temperature rise,  $\Delta T$ , is 15.0°C.

- (i) Calculate the energy transferred, in joules, for this process using:

$$\text{Energy transferred in joules} = \text{volume of solution formed} \times 4.2 \times \Delta T$$

(1)

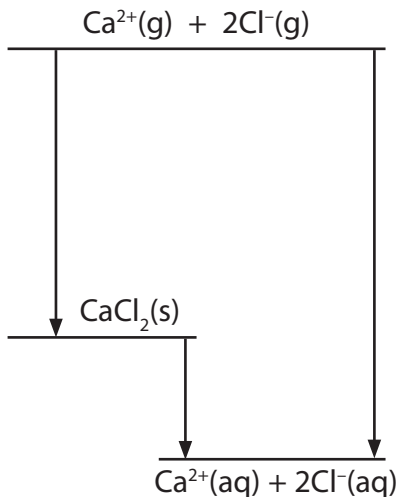
- (ii) Calculate the enthalpy change of solution,  $\Delta H_{\text{solution}}^{\ominus}$ , of calcium chloride in  $\text{kJ mol}^{-1}$ .

(2)

\*(iii) The enthalpy change of hydration of  $\text{Ca}^{2+}(\text{g})$  is  $-1560 \text{ kJ mol}^{-1}$ .

Use this, your value from (d)(ii) and the experimental lattice energy from your Data Booklet, to calculate the standard enthalpy change of hydration of  $\text{Cl}^{-}(\text{g})$ .

(3)



Answer .....  $\text{kJ mol}^{-1}$

(iv) Draw diagrams to represent hydrated calcium ions and hydrated chloride ions.

(2)

(v) Suggest why the addition of anhydrous calcium chloride to water results in an increase in temperature and a decrease in volume.

(2)

Temperature increases .....

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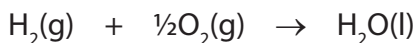
Volume decreases .....

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**(Total for Question = 18 marks)**

4 The equation for the combustion of hydrogen is



- (a) Use the standard molar entropies on page 2 and page 25 of the data booklet to calculate the standard entropy change of the system ( $\Delta S_{\text{system}}^{\ominus}$ ) for this reaction.

Note that the standard molar entropies of the elements are given **per atom** so that the standard molar entropy of oxygen,  $S^{\ominus}[\frac{1}{2}\text{O}_2(\text{g})] = +102.5 \text{ J mol}^{-1} \text{ K}^{-1}$ .

(3)

- (b) The standard enthalpy change for the combustion of hydrogen is  $-285.8 \text{ kJ mol}^{-1}$ . Use this value to calculate the entropy change of the surroundings for the combustion of hydrogen at 298 K. Give your answer to **3** significant figures and include a sign and units.

(3)

- (c) Use your answers to (a) and (b) to calculate the total entropy change ( $\Delta S_{\text{total}}^{\ominus}$ ) for the combustion of 1 mol of hydrogen. Include a sign and units in your answer. (2)

- \*(d) By considering both the thermodynamic stability and the kinetic inertness of a mixture of hydrogen and oxygen, explain why hydrogen does not react with oxygen unless ignited. (2)

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**(Total for Question = 10 marks)**