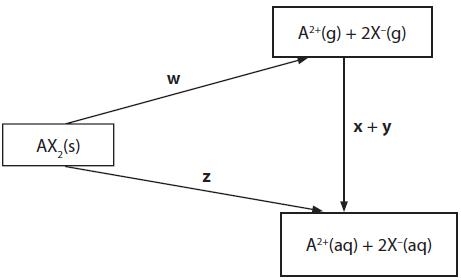
**Questions**

**Q1.**

The following cycle represents the enthalpy changes **w**, **x**, **y** and **z**, occurring when an  
 ionic solute, AX2(s), dissolves in water.



Which of the changes is the lattice energy of AX2(s)?

   **A**     **½ w**

   **B**     **− w**

   **C**     **z**

   **D**     **z − x − y**

**(Total for question = 1 mark)**

**Q2.**

The equation for the enthalpy of hydration for a magnesium ion is

   **A**  Mg2+(s) + aq → Mg2+(aq)

   **B**  Mg2+(g) + aq → Mg2+(aq)

   **C**  Mg2+(aq) → Mg2+(g) + aq

   **D**  Mg2+(aq) → Mg2+(s) + aq

**(Total for question = 1 mark)**

**Q3.**2-methylpropane has a smaller standard molar entropy at 298 K than butane. The best explanation for this is that 2-methylpropane has

   **A**    a lower boiling temperature.

   **B**    a higher standard molar enthalpy change of formation.

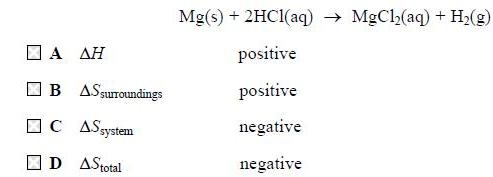
   **C**    fewer ways of distributing energy quanta.

   **D**    more ways of distributing energy quanta.

**(Total for Question = 1 mark)**

**Q4.**

Which of the following is true for the exothermic reaction shown below?



**(Total for question = 1 mark)**

**Q5.**

Which of these solid substances is likely to have the greatest standard entropy? Use of  
 the data booklet is not required.

   **A**  SnO

   **B**  SnO2

   **C**  SnBr2

   **D**  SnBr4

**(Total for question = 1 mark)**

**Q6.**

This question is about calcium chloride, CaCl2.

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, Cl2, is +165 J mol−1 K−1. Use this, and appropriate values from your Data Booklet, to calculate the standard entropy change, , for this reaction.

**(2)**

\*(ii)  Explain fully why the sign for the standard entropy change of the system,  is as you would expect.

**(2)**

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(b)  Calculate the total entropy change, , in J mol−1 K−1, for this reaction, giving your answer to three significant figures.

**(2)**

(c)  Use the standard entropy change of the surroundings, , to calculate the standard enthalpy change, , in 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 cm3 of water.

50.0 cm3 of a 1.00 mol dm−3 solution is formed, and the temperature rise, ΔT, is 15.0°C.

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

Energy transferred in joules = volume of **solution formed** × 4.2 × ΔT

**(1)**

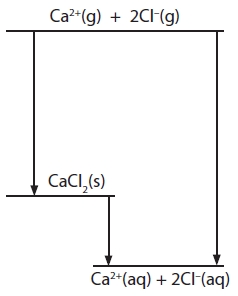
(ii)  Calculate the enthalpy change of solution, , of calcium chloride in kJ mol−1.

**(2)**

\*(iii)  The enthalpy change of hydration of Ca2+(g) is −1560 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 Cl−(g).

**(3)**



Answer ........................................................... 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)**

**Q7.**

When ammonium nitrate crystals dissolve in water, the entropy of the system

   **A**     remains the same.

   **B**     falls, because the hydrated ions are more ordered than the solid.

   **C**     rises, because the ions in the crystal become hydrated in the solution.

   **D**     rises, because the ions are arranged more randomly in the solution than in the  
                crystal.

**(Total for question = 1 mark)**

**Q8.**A decrease in the entropy of the system, Δ*S*system, occurs when

   **A**     water freezes.

   **B**     water boils.

   **C**     water reacts with sodium.

   **D**     water reacts with ethanoyl chloride.

**(Total for question = 1 marks)**

**Q9.**The overall equation for a reaction between two chemicals, M and N, is

M + 2N → P + Q

(a)  This reaction occurs spontaneously at room temperature. Which of the following **must** be true?

**(1)**

   **A**    Δ*H* is positive.

   **B**    Δ*H* is negative.

   **C**    Δ*S* is positive.

   **D**    Δ*S* is negative.

(b)  The reaction above occurs in two stages via an intermediate, T.

M + N → T            slow

N + T → P + Q            fast

From this it can be deduced that the rate equation for the reaction between M and N is

**(1)**

   **A**    rate = k[M][N]

   **B**    rate = k[M][N]2

   **C**    rate = k[M][T]

   **D**    rate = k[N][T]

**(Total for Question = 2 marks)**

**Q10.**

Which reaction has an enthalpy change equal to the enthalpy of hydration of the sodium ion?

   **A**     Na+(g) + excess H2O(l)     →   Na+(aq)

   **B**     Na+(g) + 1 mol of H2O(l)  →   Na+(aq)

   **C**     Na+(s) + excess H2O(l)     →   Na+(aq)

   **D**     Na+(s) + 1 mol of H2O(l)  →   Na+(aq)

**(Total for question = 1 mark)**

**Q11.**

Which reaction has the most positive entropy change for the system, Δ*S*system?

   **A**  NaOH(aq) + HCl(aq) → NaCl(aq) + H2O(l)

   **B**  AgNO3(aq) + NaCl(aq) → AgCl(s) + NaNO3(aq)

   **C**  C2H4(g) + HCl(g) → C2H5Cl(l)

   **D**  C4H10(g) → C2H4(g) + C2H6(g)

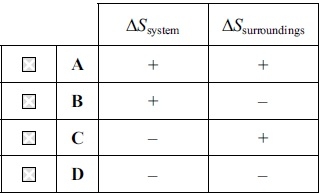
**(Total for question = 1 mark)**

**Q12.**

Barium carbonate decomposes in an endothermic reaction when heated to 1500 K.

BaCO3(s) → BaO(s) + CO2(g)

What are the signs of the entropy changes at 1500 K?



**(Total for question = 1 mark)**

**Q13.**

 The reaction below is carried out at 25 °C. Use the equation and the data to answer the questions that follow.





 (a) The standard entropy change of the system, in J mol−1 K−1, is

**(1)**

   **A**      −186

   **B**      +186

   **C**      −233

   **D**      +233

 (b) The standard entropy change of the surroundings, in J mol−1 K−1, is

**(1)**

   **A**      107.4 × 1000 / 25

   **B**      −107.4 × 1000 / 25

   **C**      107.4 × 1000 / 298

   **D**      −107.4 × 1000 / 298

**(Total for question = 2 marks)**

**Q14.**Calcium carbonate decomposes at high temperature to form calcium oxide and carbon dioxide:

CaCO3(s) → CaO(s) + CO2(g)

Calcium carbonate is **thermodynamically** stable at room temperature because for this reaction

   **A**    the activation energy is high.

   **B**    the enthalpy change, Δ*H*, is positive.

   **C**    entropy change of the system (Δ*S*system) is positive.

   **D**    entropy change of the system (Δ*S*system) is negative.

**(Total for Question = 1 mark)**

**Q15.**

Energy is evolved when one mole of gaseous calcium ions is hydrated.



This reaction is more exothermic than the corresponding value for barium ions, Ba2+, because the

   **A**     ionization energy of calcium is greater than that of barium.

   **B**     lattice energy of calcium oxide is more exothermic than that of barium oxide.

   **C**     solubility of calcium hydroxide in water is less than that of barium hydroxide.

   **D**     ionic radius of Ca2+ is less than that of Ba2+.

**(Total for question = 1 mark)**

**Mark Scheme**

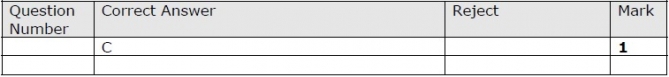
**Q1.**



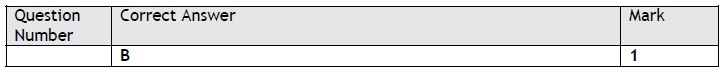
**Q2.**



**Q3.**



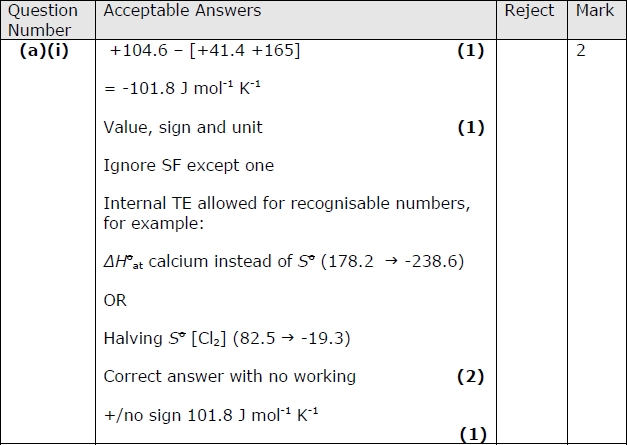
**Q4.**

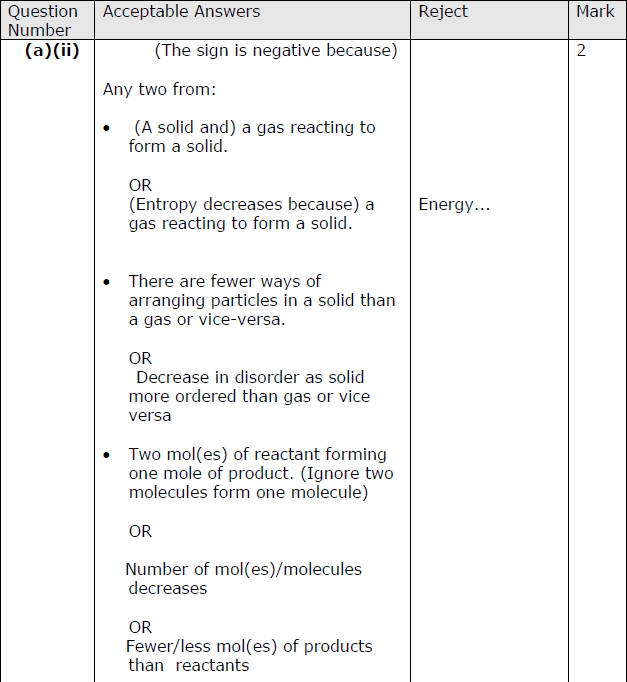


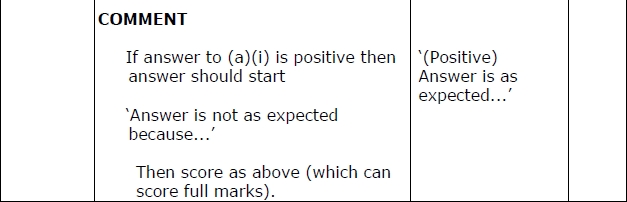
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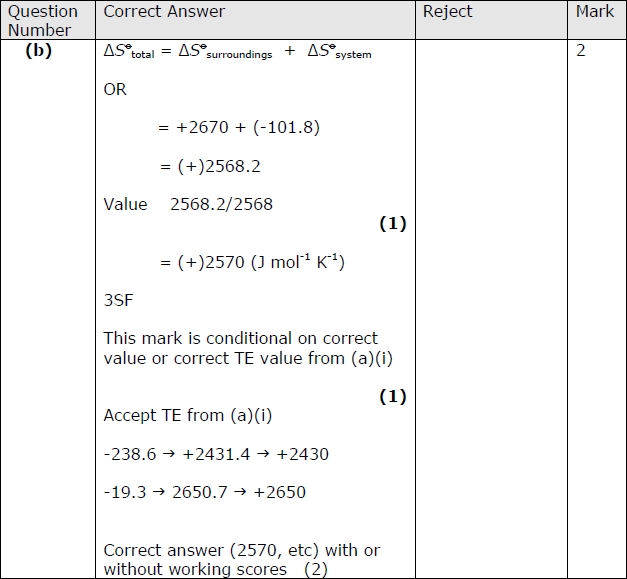


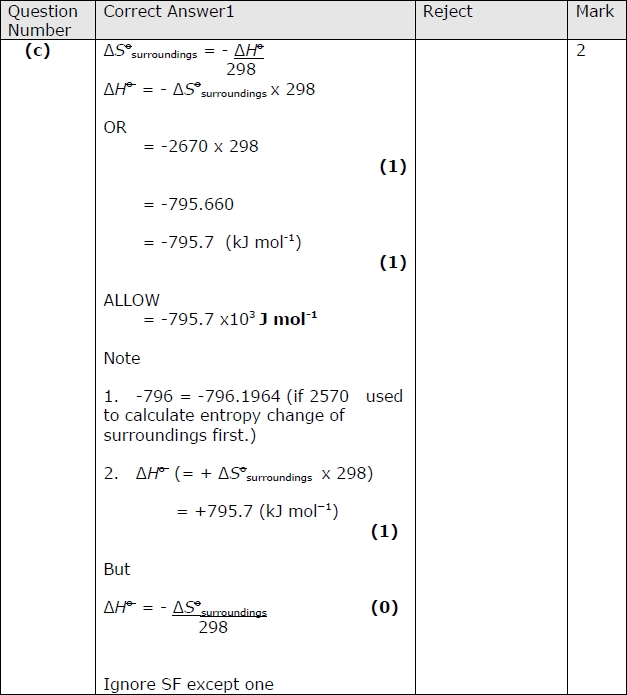
**Q6.**

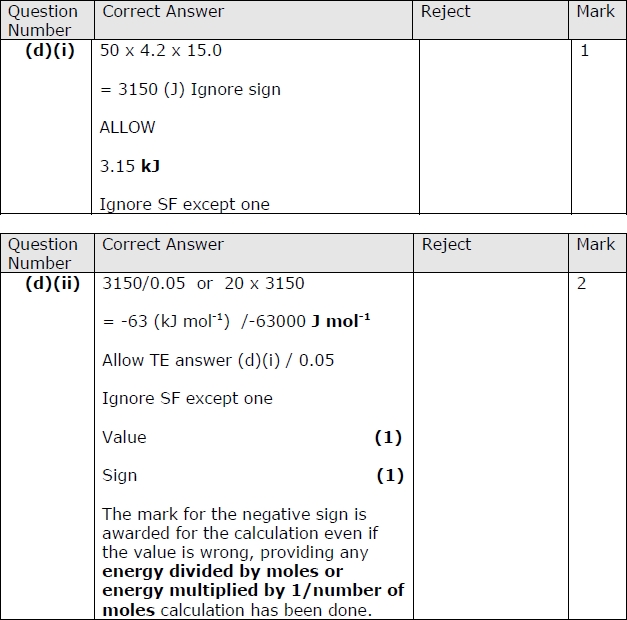


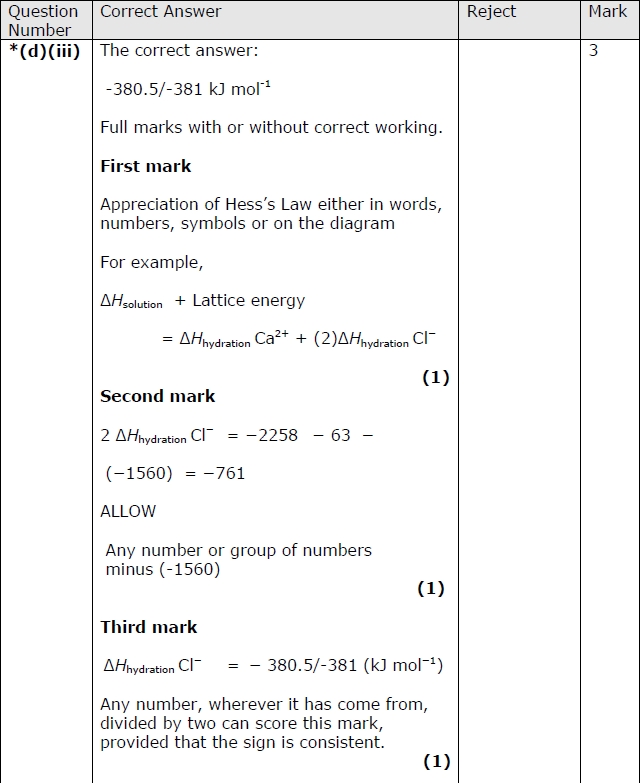


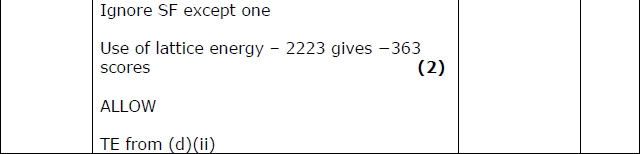


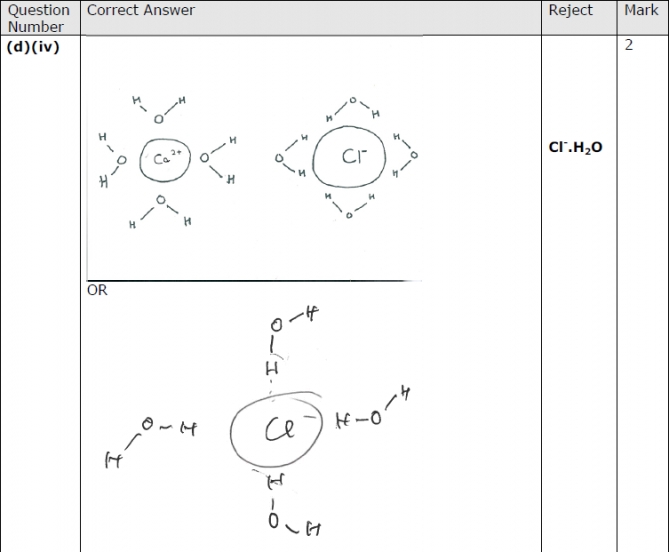


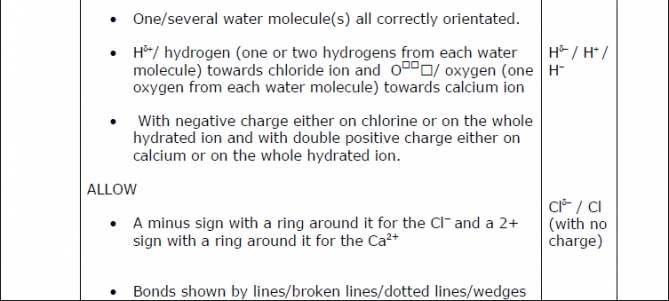


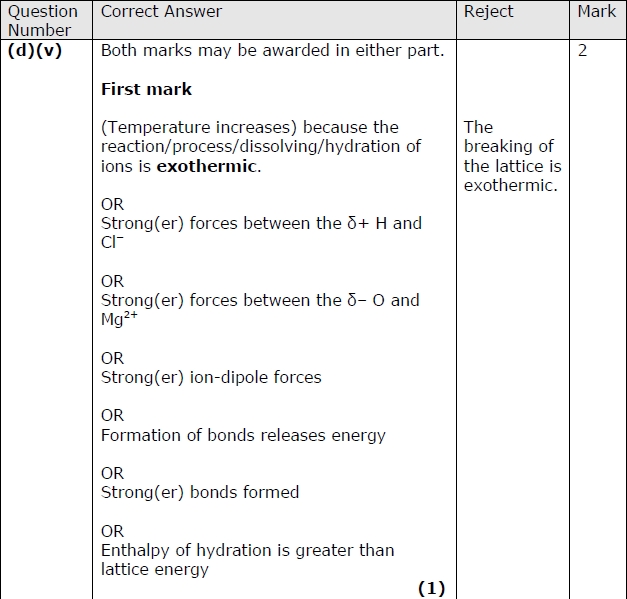


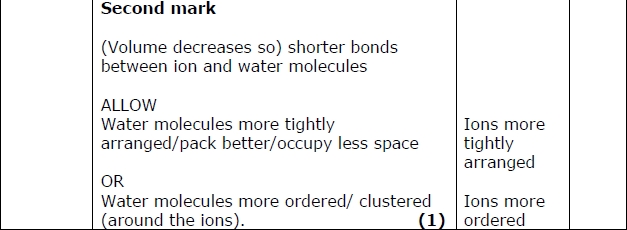




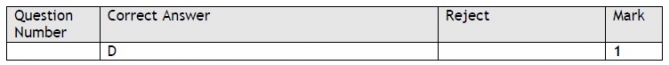






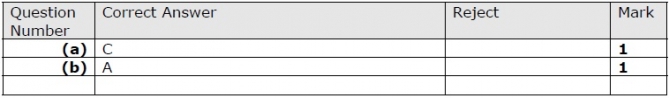


**Q7.**

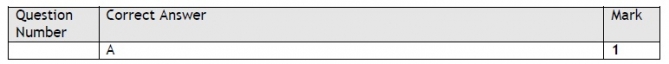


Q8.  


**Q9.**



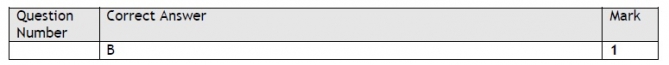
**Q10.**



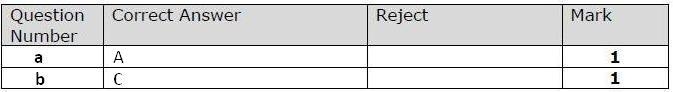
**Q11.**



**Q12.**



**Q13.**



**Q14.**



**Q15.**

