2.3 Energetics and Thermodynamics: 30-minute Pack

AQA 7405 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 This question tests key definitions used throughout the energetics and thermodynamics topic.

(a) State what is meant by the standard enthalpy of formation of a compound. **(1)**

(b) State what is meant by the standard enthalpy of combustion of a substance. **(1)**

(c) State what is meant by the standard enthalpy of atomisation of an element. **(1)**

(d) State Hess's law. **(1)**

(Total for Question 1 is 4 marks)

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2 Standard enthalpies of combustion (kJ/mol): delta Hc[C(s)] = -393, delta Hc[H_2(g)] = -286, delta Hc[CH_4(g)] = -890.

(a) Write a balanced equation, including state symbols, to represent the standard enthalpy of formation of methane. **(2)**

(b) Using a Hess's law cycle and the enthalpies of combustion given, calculate the standard enthalpy of formation of methane. Show your working. **(3)**

(c) The accepted literature value for the standard enthalpy of formation of methane is -74.8 kJ/mol. Comment on the agreement between your calculated value and this literature value. **(1)**

(d) State Hess's law. **(2)**

(Total for Question 2 is 8 marks)

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3 Enthalpy of hydration of $Na^+(g)$ ion = -406 kJ/mol. Lattice dissociation enthalpy of NaCl(s) = +771 kJ/mol. Enthalpy of solution of NaCl(s) = +3.9 kJ/mol.

(a) Define enthalpy of hydration. **(2)**

(b) Construct a Hess's law cycle linking the enthalpy of solution, the lattice dissociation enthalpy and the two enthalpies of hydration for NaCl, and use it to calculate the enthalpy of hydration of the chloride ion, $Cl^-(g)$. Show your working. **(4)**

(c) The small positive value for the enthalpy of solution of NaCl shows that dissolving NaCl is only very slightly endothermic overall. Explain what this tells you about the relative magnitudes of the lattice dissociation enthalpy and the total enthalpy of hydration of the ions. **(2)**

(Total for Question 3 is 8 marks)

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Mark scheme · 2.3 Energetics and Thermodynamics: 30-minute Pack

Question 1

(a) the enthalpy change when 1 mole of a compound is formed from its elements in their standard states, under standard conditions, oe **B1**

(a) Answer: Enthalpy change forming 1 mole of compound from its elements in standard states.

(b) the enthalpy change when 1 mole of a substance is completely combusted in excess oxygen, under standard conditions, with all reactants and products in their standard states, oe **B1**

(b) Answer: Enthalpy change when 1 mole of a substance is completely burned in excess oxygen under standard conditions.

(c) the enthalpy change when 1 mole of gaseous atoms is formed from the element in its standard state, under standard conditions, oe **B1**

(c) Answer: Enthalpy change forming 1 mole of gaseous atoms from the element in its standard state.

(d) the total enthalpy change for a reaction is independent of the route taken, provided the initial and final conditions (states) are the same, oe **B1**

(d) Answer: Total enthalpy change is independent of route, provided initial and final states are the same.

Question 2

(a) C(s) + $2H_2(g)$ -> $CH_4(g)$, correctly balanced **M1**

(a) all state symbols correct: (s), (g), (g) cao **A1**

(a) Answer: C(s) + $2H_2(g)$ -> $CH_4(g)$

(b) correct Hess's law relationship: delta Hf(CH_4) = delta Hc(C) + 2 x delta Hc(H_2) - delta Hc(CH_4) (oe, allow a correctly drawn or described cycle) **M1**

(b) correct substitution: -393 + 2 x (-286) - (-890) **M1**

(b) delta Hf(CH_4) = -75 (kJ/mol) cao **A1**

(b) Answer: delta Hf(CH_4) = -75 kJ/mol

(c) very good/close agreement (within about 1 kJ/mol, less than 1-2% difference) oe; any sensible comment referencing the closeness of the two values, ecf from (b) **B1**

(c) Answer: Very good agreement - the calculated value (-75 kJ/mol) is within about 1 kJ/mol of the literature value (-74.8 kJ/mol).

(d) the total enthalpy change of a reaction is independent of the route taken **B1**

(d) provided the initial and final conditions/states are the same in each route oe **B1**

(d) Answer: The total enthalpy change of a reaction is independent of the route taken, provided the initial and final conditions are the same.

Question 3

(a) the enthalpy change when one mole of gaseous ions is dissolved in (sufficient) water **B1**

(a) to form one mole of aqueous ions, under standard conditions (at infinite dilution) oe **B1**

(a) Answer: The enthalpy change when one mole of gaseous ions dissolves in water to form one mole of aqueous ions, under standard conditions.

(b) correct cycle relationship: delta Hsol = delta H(lattice dissociation) + delta Hhyd(Na^+) + delta Hhyd(Cl^-) (oe, allow cycle described or drawn) **M1**

(b) correct substitution: 3.9 = 771 + (-406) + delta Hhyd(Cl^-) **M1**

(b) correct rearrangement: delta Hhyd(Cl^-) = 3.9 - 365 (= -361.1) **A1**

(b) -361 (kJ/mol) awrt, cao **A1**

(b) Answer: delta Hhyd(Cl^-) = -361 kJ/mol

(c) the lattice dissociation enthalpy and the total (sum of the) hydration enthalpies of the ions are very similar in magnitude (almost equal and opposite) oe **B1**

(c) because the small overall enthalpy of solution is the (small) difference between these two large, opposing enthalpy values oe **B1**

(c) Answer: The lattice dissociation enthalpy (+771 kJ/mol) and the total hydration enthalpy (-406 + -361 = -767 kJ/mol) are almost equal and opposite; the small enthalpy of solution is the small difference between these two large values.

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