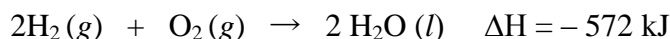


SPONGE BOB: MAINTAIN EXCELLENT BUT NOT OVER CONFIDENT

CHAPTER 8: THERMOCHEMISTRY

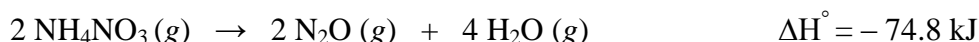
Concept of Enthalpy

- 1 Hydrogen gas burns in air to form water:



How much heat energy is given off if 10.0 kg of hydrogen gas is burnt in excess oxygen?

- 2 Ammonium nitrate, NH_4NO_3 decomposes by the following reaction:



If 74.0 g of H_2O are formed from the reaction, how much heat was released?

Calorimetry

- 1 When 18.70 g sodium chloride was dissolved in 400 cm^3 distilled water, the temperature of the solution decreased by $1.0 \text{ }^\circ\text{C}$.

[Specific heat capacity of solution = $4.20 \text{ Jg}^{-1} \text{ }^\circ\text{C}^{-1}$, density of solution = 1.0 g cm^{-3}]

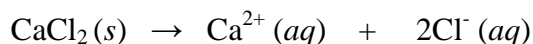
- Calculate the heat of solution of sodium chloride.
- Determine the enthalpy of solution of sodium chloride.

- 2 A sample of 0.02 mol octane, $\text{C}_8\text{H}_{18}(\text{l})$ was burnt in a bomb calorimeter, the temperature of 1000 cm^3 water increased by $24.2 \text{ }^\circ\text{C}$.

[Specific heat capacity of solution = $4.20 \text{ Jg}^{-1} \text{ }^\circ\text{C}^{-1}$, density of solution = 1.0 g cm^{-3}]

- What is the enthalpy of combustion of octane?
- Write the thermochemical equation for the combustion of octane.

- 3 When 1.00 g of calcium chloride, CaCl_2 , is added to 60.0 g of water in a coffee cup calorimeter, it dissolves:



The temperature rises from 20.00°C to 23.51°C . Assuming that all the heat given off by the reaction is transferred to the water, calculate the heat for the reaction.

- 4 An amount of 120.0 mL of coffee in a well-insulated cup at $82.0 \text{ }^\circ\text{C}$ is too hot to drink. What volume of cold fresh milk at $15.0 \text{ }^\circ\text{C}$ need to be added to the coffee in order to achieve a temperature of $65.0 \text{ }^\circ\text{C}$? Assume specific heat capacities and densities of coffee and milk are the same as water.

- 5 100.00 cm^3 of 2.0 mol dm^{-3} hydrochloric acid was added to excess 100.00 cm^3 of 3.0 mol dm^{-3} potassium hydroxide solution. Both solutions are at initial temperature of $30.0 \text{ }^\circ\text{C}$ are mixed in a calorimeter. The maximum temperature of the solution is $41.0 \text{ }^\circ\text{C}$.

[Specific heat capacity of solution = $4.20 \text{ Jg}^{-1} \text{ }^\circ\text{C}^{-1}$]

- Determine the limiting reagent.
- Calculate the enthalpy of neutralization for the reaction.
- Write the thermochemical equation between hydrochloric acid and potassium hydroxide solution.

SPONGE BOB: MAINTAIN EXCELLENT BUT NOT OVER CONFIDENT

- 6 150 cm³ of potassium hydroxide solution of concentration 2.0 M and 250 cm³ of 1.5 M hydroiodic acid were mixed in a calorimeter. If the temperature rise is 10.2 °C, calculate heat evolved from the reaction.
- $$\text{KOH} (aq) + \text{HI} (aq) \rightarrow \text{KI} (aq) + \text{H}_2\text{O} (aq)$$
- [Specific heat capacity solution = 4.2 Jg⁻¹°C⁻¹; density of solution = 1.0 g cm⁻³]
- 7 The enthalpy of combustion of benzoic acid is – 3226.8 kJ mol⁻¹. When 3.2 g benzoic acid, C₆H₅COOH is completely combusted in a bomb calorimeter containing 2.0 kg of water, the temperature of the water increased by 3.8 °C.
- Write the thermochemical equation for the combustion of benzoic acid.
 - Calculate the heat capacity of the calorimeter.
- 8 3.00 g of carbon was burned in a bomb calorimeter containing 2000 g of water at an initial temperature 20 °C. The maximum temperature recorded was 31.3 °C and the enthalpy of combustion of carbon is 402 kJ/mol. Calculate the heat capacity of bomb calorimeter. The specific heat for water is 4.184 J/g °C.

Hess's Law

- 1 Standard enthalpy of formation of CO₂ (g), H₂O (l) and C₅H₁₂ (g) are – 394 kJ mol⁻¹, – 286 kJ mol⁻¹ and – 173 kJ mol⁻¹ respectively. Determine the heat of combustion of pentane, C₅H₁₂ using standard enthalpies of formation given.
- 2 Calculate the heat of combustion of methane using standard heats of formation below:
- $$\begin{aligned}\Delta H_f \text{ CO}_2 (g) &= -394 \text{ kJ mol}^{-1} \\ \Delta H_f \text{ H}_2\text{O} (l) &= -286 \text{ kJ mol}^{-1} \\ \Delta H_f \text{ CH}_4 (g) &= -75 \text{ kJ mol}^{-1}\end{aligned}$$
- 3 Determine the enthalpy of formation of hydrogen peroxide (H₂O₂) by using the data below.

	ΔH° (kJ/mol)
$\text{H}_2 (g) + \frac{1}{2} \text{O}_2 (g) \rightarrow \text{H}_2\text{O} (g)$	-241.82
$2 \text{H} (g) + \text{O} (g) \rightarrow \text{H}_2\text{O} (g)$	-926.92
$2 \text{H} (g) + 2 \text{O} (g) \rightarrow \text{H}_2\text{O}_2 (g)$	-1070.62
$2 \text{O} (g) \rightarrow \text{O}_2 (g)$	-498.34
$\text{H}_2\text{O}_2 (l) \rightarrow \text{H}_2\text{O}_2 (g)$	+51.46

- 4 Draw the Born-Haber cycle for the formation of magnesium chloride, MgCl₂ from magnesium metal and chlorine gas. Calculate the enthalpy of formation of MgCl₂. Given:

Heat of sublimation of magnesium, $\Delta H_1 = +149 \text{ kJ mol}^{-1}$
First ionization energy of magnesium, $\Delta H_2 = +740 \text{ kJ mol}^{-1}$
Second ionization energy of magnesium, $\Delta H_3 = +1456 \text{ kJ mol}^{-1}$
Heat of atomization of chlorine, $\Delta H_4 = +240 \text{ kJ mol}^{-1}$
Electron affinity of chlorine, $\Delta H_5 = -369 \text{ kJ mol}^{-1}$
Lattice energy of MgCl₂, $\Delta H_6 = -3933 \text{ kJ mol}^{-1}$

SPONGE BOB: MAINTAIN EXCELLENT BUT NOT OVER CONFIDENT