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Workshop #8: Thermochemistry

Show calculation setups and answers for each question. *Please note that your instructor may opt to assign specific questions from those listed below.*

1. Calculate the change in internal energy (in J) for a balloon that is heated by adding 215 cal of heat. It expands, doing 422 J of work on the atmosphere.

2. Consider the following *balanced* reaction: $CH_3OH(g) \rightarrow CO(g) + 2H_2(g)$, where $\Delta H = +90.7$ kJ. If the enthalpy change is 16.5 kJ, how many grams of hydrogen gas are produced?

3. A 50.00 g sample of an unknown substance absorbed 2.578 kJ of energy as it changed from a temperature of 25.0 ºC to 89.7 ºC. What is the specific heat of this unknown substance (in J/g ºC)?

4. An alloy of mass 25.0 g was heated to 88.6 °C and then placed in a calorimeter that contained 61.2 g of water at 19.6 °C. The temperature of the water rose to 21.3 °C. Determine the specific heat of the alloy (in J/g ºC).

5. 100.0 g of copper metal, initially at 100.0 ºC, is added to a calorimeter containing 250.0 g of H_2O at 15.0 ºC. If the specific heat of copper is 0.389 J/g ºC, what is the final temperature of the water and copper mixture?

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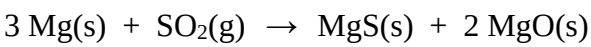
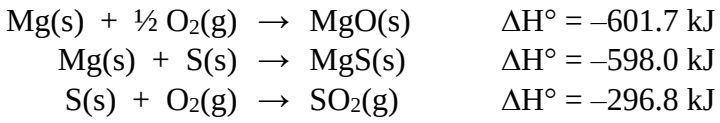
6. The chemical equation for the combustion of magnesium in sulfur dioxide is



$$3\ Mg(s) + SO_2(g) \rightarrow MgS(s) + 2\ MgO(s)$$

Calculate the $\Delta H°_{rxn}$ (in kJ) given the following thermodynamic data:

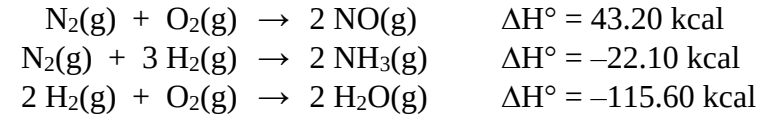


$$Mg(s) + \tfrac{1}{2}\ O_2(g) \rightarrow MgO(s) \qquad \Delta H° = -601.7\ kJ$$
$$Mg(s) + S(s) \rightarrow MgS(s) \qquad \Delta H° = -598.0\ kJ$$
$$S(s) + O_2(g) \rightarrow SO_2(g) \qquad \Delta H° = -296.8\ kJ$$

7. Consider the following thermochemical equation:

$$4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g)$$

Determine the $\Delta H°_{rxn}$ (in kcal) given the following thermochemical data:



$$N_2(g) + O_2(g) \rightarrow 2\ NO(g) \qquad \Delta H° = 43.20\ kcal$$
$$N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g) \qquad \Delta H° = -22.10\ kcal$$
$$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g) \qquad \Delta H° = -115.60\ kcal$$

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8. Consider the neutralization reaction of sodium hydroxide and sulfuric acid in a coffee-cup calorimeter.

$$2\ NaOH(aq)\ +\ H_2SO_4(aq)\ \rightarrow\ Na_2SO_4(aq)\ +\ 2\ H_2O(l)$$

100.0 mL of 1.00 M aqueous NaOH is mixed with 100.0 mL of 1.00 M aqueous H_2SO_4, each at 24.0 °C, were mixed. The maximum temperature achieved was 30.6 °C. Calculate the enthalpy change of reaction (in kJ/mol) of Na_2SO_4 produced. The specific heat of the reaction is known to be 4.184 J/g ºC. The density of the reaction mixture is 1.00 g/mL. Assume the volumes are additive.

9. Suppose 50.0 mL of HCl is combined with 100.0 mL of 1.05 M NaOH in a coffee-cup calorimeter. The reaction mixture, initially at 22.0 ºC, reached a final temperature of 30.2 ºC. Determine the molarity of the HCl solution assuming all of the HCl reacted and that NaOH is present in excess. The specific heat of the reaction is known to be 0.96 cal/g ºC, and the heat of neutralization is 13.6 kcal/mol. The density of the reaction mixture is 1.02 g/mL. Assume the volumes are additive.