

ENHANCEMENT QUESTION: THERMOCHEMISTRY

1. Calculate the heat transferred when a 5.5 g nail is cooled from 37 °C to 25 °C.
[Specific heat of iron = 0.450 J/gK] **Answer: - 29.7 kJ**

2. If a gold ring with a mass of 5.5 g changes in temperature from 25.0 °C to 28.0 °C, how much energy (in joules) has it absorbed?
[Specific heat capacity of gold = 0.129 J/g°C] **Answer: + 2.13 kJ**

3. The addition of 250 J to 30.0 g of copper initially at 22.0 °C will change its temperature to what final value? [c of Cu = 0.387 Jg⁻¹°C⁻¹] **Answer: 43.5 °C**

4. A quantity of 1.922 g of methanol (CH₃OH) was burned in a constant volume bomb calorimeter. Consequently, the temperature of the water rose by 4.20 °C. If the quantity of water surrounding the calorimeter was exactly 2000g and the heat capacity of the calorimeter was 2.02 kJ/°C, calculate the molar heat of combustion of methanol. **Answer: - 731.9 kJ mol⁻¹**

5. A 1.00 mol sample of propane, a gas used for cooking, was placed in a bomb calorimeter with excess oxygen and ignited. The initial temperature of the calorimeter is 25.000 °C and its total heat capacity was 97.1 kJ°C⁻¹. The reaction raised the temperature of the calorimeter to 27.282 °C.
 - a) How many J were liberated in this reaction? **Answer: - 2.22 x 10⁵ J**
 - b) What is heat of reaction of propane with oxygen expressed in kJ/mol of C₃H₈ burned? **Answer: - 222 kJ mol⁻¹**

6. A quantity of 400 mL of 0.6 M HNO₃ is mixed with 400 mL of 0.3 M Ba(OH)₂ in coffee-cup calorimeter (simple calorimeter) that has a heat capacity of 387 J/°C. The initial temperature of both solutions is the same at 18.88 °C. What is the final temperature of the solution? [Heat of neutralization = -56.2 kJ/mol] **Answer: 22.49 °C**

7. Nitrogen oxides undergo many interesting reactions. Calculate ΔH for the overall equation

$$2 \text{NO}_2(g) + \text{O}_2(g) \rightarrow \text{N}_2\text{O}_5(s)$$
 from the following equations:

$$\text{N}_2\text{O}_5(s) \rightarrow 2 \text{NO}(g) + \text{O}_2(g) \quad \Delta H = + 223.7 \text{ kJ}$$

$$\text{NO}(g) + \text{O}_2(g) \rightarrow \text{NO}_2(g) \quad \Delta H = - 57.1 \text{ kJ}$$
Answer: - 109.5 kJ

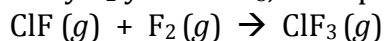
8. The common lead-acid car battery produces a large burst of current, even at low temperatures, and is rechargeable. The reaction that occurs while recharging a “dead” battery is:

$$2 \text{PbSO}_4(s) + 2 \text{H}_2\text{O}(l) \rightarrow \text{Pb}(s) + \text{PbO}_2(s) + 2 \text{H}_2\text{SO}_4(l)$$
 Use the following equations to calculate ΔH_{rxn} of the above reaction.

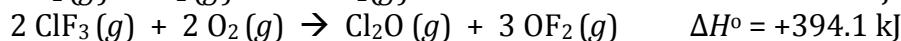
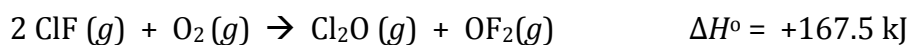
$$\text{Pb}(s) + \text{PbO}_2(s) + 2 \text{SO}_3(g) \rightarrow 2 \text{PbSO}_4(s) \quad \Delta H = - 768 \text{ kJ}$$

$$\text{SO}_3(g) + \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{SO}_4(l) \quad \Delta H = - 132 \text{ kJ}$$
Answer: + 504 kJ

9. Oxidation of ClF by F₂ yields ClF₃, an important fluorinating agent:

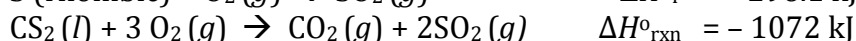
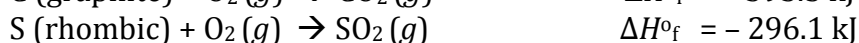
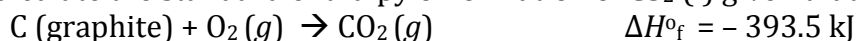


Use the following thermochemical equation to calculate ΔH° for the production of ClF₃:



Answer: - 135.1 kJ

10. Calculate the standard enthalpy of formation of CS₂ (l) given that:



Answer: + 86.3 kJ mol⁻¹

11. Calculate the lattice energy of calcium chloride (CaCl₂); given that:

$$\text{Heat of sublimation of calcium} = +121 \text{ kJ/mol}$$

$$\text{First ionization energy of calcium} = +589.5 \text{ kJ/mol}$$

$$\text{Second ionization energy of calcium} = +1145 \text{ kJ/mol}$$

$$\text{Enthalpy of atomization of chlorine} = +121.4 \text{ kJ/mol}$$

$$\text{Electron affinity of chlorine} = -349 \text{ kJ/mol}$$

$$\text{Enthalpy of formation of CaCl}_2 = -795 \text{ kJ/mol} \quad \textit{Answer: - 2195.3 kJ mol}^{-1}$$

12. With the following data, calculate $\Delta H_{\text{lattice}}$ of CsCl (s):

$$\text{Heat of sublimation of cesium} = +78.2 \text{ kJ}$$

$$\text{First ionization energy of cesium} = +375.7 \text{ kJ}$$

$$\text{Enthalpy of dissociation } \frac{1}{2}\text{Cl}_2(g) = +122 \text{ kJ}$$

$$\text{Electron affinity of chlorine} = -349 \text{ kJ}$$

$$\text{Enthalpy of formation of CsCl}(s) = -442.8 \text{ kJ}$$

Answer: - 669.7 kJ mol⁻¹

13. Construct a Born-Haber cycle to calculate the lattice energy of KBr based on the following data:

$$\text{Standard enthalpy of formation of KBr} = -392 \text{ kJmol}^{-1}$$

$$\text{Enthalpy of sublimation of potassium} = +90 \text{ kJmol}^{-1}$$

$$\text{First ionization energy of potassium} = +420 \text{ kJmol}^{-1}$$

$$\text{Enthalpy of atomization of bromine} = +112 \text{ kJmol}^{-1}$$

$$\text{Electron affinity of bromine} = -342 \text{ kJmol}^{-1}$$

Answer: - 672 kJ mol⁻¹