

TOPIC OBJECTIVES: THERMOCHEMISTRY Practice Problems for Exam Preparation
Show ALL Work for credit on separate paper.

- Calculating kinetic energy: A regulation baseball weights 142 g to 149 g. A baseball weighing 143 g is dropped from a window, and just before it hits the sidewalk it has a speed of 9.78 m/s. What is the kinetic energy of the baseball at this moment in joules? In calories?
- Writing thermochemical equations: Aqueous sodium hydrogen carbonate solution reacts with hydrochloric acid to produce aqueous sodium chloride, water, and carbon dioxide gas. The reaction absorbs 11.8 kJ of heat at a constant pressure for each mole of sodium hydrogen carbonate. Write the thermochemical equation for the reaction.
- Manipulating thermochemical equations: When two moles of $\text{H}_2(\text{g})$ and one mole of $\text{O}_2(\text{g})$ react to give liquid water, 572 kJ of heat evolves. Write this equation for ONE mole of liquid water. Give the full reverse thermochemical equation, in which one mole of liquid water dissociates into hydrogen and oxygen.
- Calculating the heat of reaction from the stoichiometry: How much heat is evolved when 907 kg of ammonia is produced according to the following equation? (Assume that the reaction occurs at constant pressure) $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g}) \quad \Delta\text{H} = -91.8 \text{ kJ}$
- Relating heat and specific heat: Calculate the heat absorbed by 15.0 g of water to raise its temperature from 20.0 °C to 50.0 °C (at constant pressure).
- **Calculating ΔH from calorimetric data: Supposed 0.562 g of graphite is placed in a calorimeter with an excess of oxygen at 25.00 °C and 1 atm pressure. Excess O_2 ensures that all carbon burns to form CO_2 . The graphite is then ignited and burns according to the equation:
 $\text{C}_{(\text{graphite})} + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$ On reaction, the calorimeter temperatures rises from 25.00 °C to 25.89 °C. The heat capacity of the calorimeter and its contents was determined in a separate experiment to be 20.7 kJ/°C. What is the heat of reaction at 25.00 °C and 1 atm. Express your answer as a thermochemical equation.
- Applying Hess's Law: What is the enthalpy of reaction, ΔH , for the formation of tungsten carbide, WC, from the elements? (Tungsten carbide is very hard and is used to make cutting tools and rock drills.) $\text{W}_{(\text{s})} + \text{C}_{(\text{graphite})} \rightarrow \text{WC}_{(\text{s})}$ The enthalpy change for this reaction is difficult to measure directly, because the reaction occurs at 1400°C. However, the heats of combustion of the elements of tungsten carbide can be measured:

$$2\text{W}_{(\text{s})} + 3\text{O}_2(\text{g}) \rightarrow 2\text{WO}_3(\text{s}) \quad \Delta\text{H} = -1680.6 \text{ kJ}$$

$$\text{C}_{(\text{graphite})} + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) \quad \Delta\text{H} = -393.5 \text{ kJ}$$

$$2\text{WC}_{(\text{s})} + 5\text{O}_2(\text{g}) \rightarrow 2\text{WO}_3(\text{s}) + 2\text{CO}_2(\text{g}) \quad \Delta\text{H} = -2391.6 \text{ kJ}$$
- Calculating the heat of phase transition from standard enthalpies of formation: Use the values of ΔH°_f to calculate the heat of vaporization, $\Delta\text{H}^\circ_{\text{vap}}$, of carbon disulfide at 25°C. The vaporization process is $\text{CS}_2(\text{l}) \rightarrow \text{CS}_2(\text{g})$
(hint: use $\Delta\text{H} = (\sum\Delta\text{H}^\circ_f \text{ products}) - (\sum\Delta\text{H}^\circ_f \text{ reactants})$)
- Calculating the enthalpy of reaction from standard enthalpies of formation: Large quantities of ammonia are used to prepare nitric acid. The first step consists of the catalytic oxidation of ammonia to nitric oxide, NO. (note: the catalyst may be ignored as it does not participate in the reaction, only speed it up) $4\text{NH}_3(\text{g}) + 5\text{O}_2(\text{g}) \xrightarrow{(\text{Pt catalyst})} 4\text{NO}(\text{g}) + 6\text{H}_2\text{O}(\text{g})$. Use the Table of Standard enthalpies in your text to calculate ΔH° .
- Calculating phase changes with the use of heating and cooling curves: Calculate the total energy in kilojoules of taking 50.0 grams of steam at 110°C and cooling it down to ice at -15°C.
Illustrate this process on a heating/cooling curve diagram.

FOR WATER:

$$\Delta\text{H}_{\text{vap}} = 40.6 \text{ kJ/mol}$$

$$\Delta\text{H}_{\text{fus}} = 6.02 \text{ kJ/mol}$$

$$C_{\text{p gas}} = 2.03 \text{ J/g}^\circ\text{C}$$

$$C_{\text{p liquid}} = 4.184 \text{ J/g}^\circ\text{C}$$

$$C_{\text{p solid}} = 2.06 \text{ J/g}^\circ\text{C}$$

$$\text{H}_2\text{O} = 18.0 \text{ g/mol}$$