

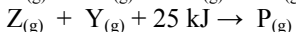
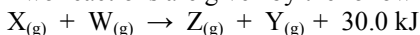
Chapter 5
Energy and Change**Practice Problems****Problem 1**

The molar heat capacities of the elements $\text{Li}_{(s)}$ and $\text{Rb}_{(s)}$ are respectively $24.8 \text{ J/mol}\cdot^\circ\text{C}$ and $31.0 \text{ J/mol}\cdot^\circ\text{C}$.

- (a) Compare the heat absorbed by 1.00 g of each of these metals to increase the temperature by 1°C .
(b) What mass of Rb is required to absorb the same amount of heat as 1.00 g of Li to achieve a temperature change of 1°C ?

Problem 2

Two reactions are given by the following equations:



Find the ΔH° value for the reaction $\text{P}_{(g)} \rightarrow \text{X}_{(g)} + \text{W}_{(g)}$.

Problem 3

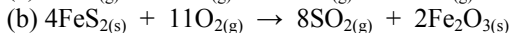
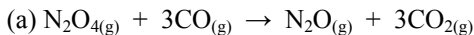
When $\text{CO}_{2(s)}$ sublimates (changes directly from a solid to a gas) at -90°C , ΔH_{sub} is 16.20 kJ/mol . What is the mass of $\text{CO}_{2(s)}$ that must have undergone this process of sublimation if 186.0 kJ of heat is absorbed?

Problem 4

A calorimeter designed to have negligible heat loss is used to determine the specific heat capacity of metals. A piece of thallium having a mass of 111.2 g is warmed to 95.0°C and placed into the calorimeter containing 125.00 g of water at 12.5°C . The water temperature goes up to 14.9°C . Use this information to calculate the specific heat capacity of thallium. The specific heat capacity of water is $4.184 \text{ J/g}\cdot^\circ\text{C}$.

Problem 5

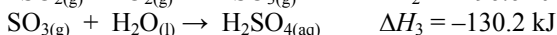
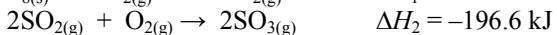
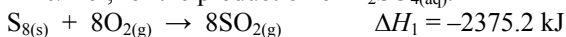
Use the data table of standard enthalpies of formation to help determine the enthalpy of reaction for each of the following reactions.

**Problem 6**

- (a) Write the balanced equation for the complete combustion of glucose, $\text{C}_6\text{H}_{12}\text{O}_{6(s)}$, to form carbon dioxide gas and water (liquid).
(b) When a 2.000 g sample of glucose is burned in a bomb calorimeter, the temperature of 200.00 g of water rises by 37.3°C . What is the molar enthalpy of combustion of glucose?
(c) Use the answers from (a) and (b) and the ΔH°_f values from the data table of standard enthalpies of formation to calculate the ΔH°_f value for glucose.

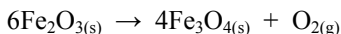
Problem 7

In the Contact process for the production of $\text{H}_2\text{SO}_{4(\text{aq})}$, sulfur is burned to produce $\text{SO}_{2(\text{g})}$. This gas is then converted to $\text{SO}_{3(\text{g})}$ in the presence of a catalyst, and the resulting gas is dissolved in water to form the acid. The equations shown below summarize the process. Use this information to calculate the enthalpy of reaction, in kJ/mol, for the production of $\text{H}_2\text{SO}_{4(\text{aq})}$.



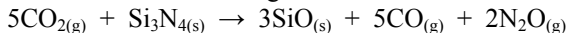
Problem 8

Determine the heat absorbed when a 5.00 g sample of $\text{Fe}_2\text{O}_{3(\text{s})}$ undergoes the following reaction.

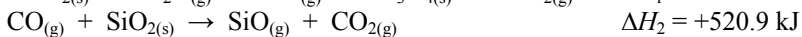
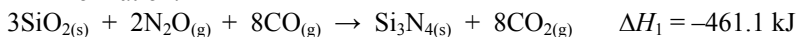


Problem 9

Use the ΔH information given to determine the ΔH_{rxn} value for the following reaction.

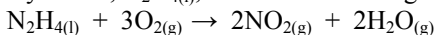


ΔH information:



Problem 10

Hydrazine, $\text{N}_2\text{H}_{4(\text{l})}$, will burn according to the reaction equation below.



(a) Determine the ΔH_{comb} value for this reaction.

(b) Calculate the amount of heat that is given off when a 10.0 kg sample of 87.8 % pure hydrazine is burned.

Answers

1.

(a) Heat required to increase the temperature of 1.00 g of Li metal

$$= \frac{1 \text{ g}}{6.94 \text{ g/mol}} \times 24.8 \text{ J/mol} \cdot ^\circ\text{C} \times 1^\circ\text{C} = 3.57 \text{ J}$$

Heat required to increase the temperature of 1.00 g of Rb metal

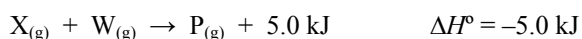
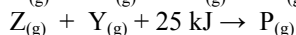
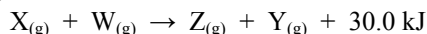
$$= \frac{1 \text{ g}}{85.47 \text{ g/mol}} \times 31.0 \text{ J/mol} \cdot ^\circ\text{C} \times 1^\circ\text{C} = 0.363 \text{ J}$$

(b) To achieve a temperature change of 1°C ,

$$\frac{\text{Mass of Rb}}{1 \text{ g of Rb}} = \frac{3.57 \text{ J}}{0.363 \text{ J}}$$

$$\text{Mass of Rb} = 9.83 \text{ g of Rb}$$

2.



Therefore,



3.

$$n \text{ mol CO}_2 = \frac{\text{Mass of CO}_2}{44.01 \text{ g/mol}}$$

$$\frac{n \text{ mol CO}_2}{1 \text{ mol CO}_2} = \frac{186.0 \text{ kJ}}{16.20 \text{ kJ}}$$

$$n \text{ mol CO}_2 = 11.5 \text{ mol CO}_2$$

$$\frac{\text{Mass of CO}_2}{44.01 \text{ g/mol}} = 11.5 \text{ mol CO}_2$$

$$\text{Mass of CO}_2 = 506 \text{ g of CO}_2$$

4.

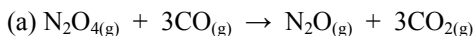
Heat lost by thallium = Heat gained by water

$$-m \cdot c \cdot \Delta T (\text{thallium}) = m \cdot c \cdot \Delta T (\text{water})$$

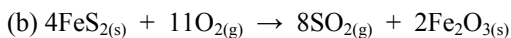
$$-(111.2 \text{ g})(c)(14.9^\circ\text{C} - 95.0^\circ\text{C}) = (125.00 \text{ g})(4.184 \text{ J/g} \cdot ^\circ\text{C})(14.9^\circ\text{C} - 12.5^\circ\text{C})$$

$$c = 0.14 \text{ J/g} \cdot ^\circ\text{C}$$

5.

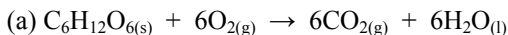


$$\begin{aligned} \Delta H^\circ_{\text{rxn}} &= [\Delta H^\circ_f \text{N}_2\text{O}_{(g)} + 3\Delta H^\circ_f \text{CO}_{2(g)}] - [\Delta H^\circ_f \text{N}_2\text{O}_{4(g)} + 3\Delta H^\circ_f \text{CO}_{(g)}] \\ &= [81.6 \text{ kJ/mol} + 3(-393.5 \text{ kJ/mol})] - [11.1 \text{ kJ/mol} + 3(-110.5 \text{ kJ/mol})] \\ &= -1441.5 \text{ kJ/mol of N}_2\text{O}_4 \end{aligned}$$



$$\begin{aligned} \Delta H^\circ_{\text{rxn}} &= [8\Delta H^\circ_f \text{SO}_{2(g)} + 2\Delta H^\circ_f \text{Fe}_2\text{O}_{3(s)}] - [4\Delta H^\circ_f \text{FeS}_{2(s)} + 11\Delta H^\circ_f \text{O}_{2(g)}] \\ &= [8(-296.8 \text{ kJ/mol}) + 2(-824.2 \text{ kJ/mol})] - [4(-178.2 \text{ kJ/mol}) + 11(0 \text{ kJ/mol})] \\ &= -3310 \text{ kJ/4 mol of FeS}_2 \\ &= -827.5 \text{ kJ/mol of FeS}_2 \end{aligned}$$

6.



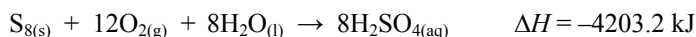
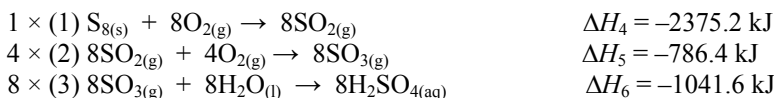
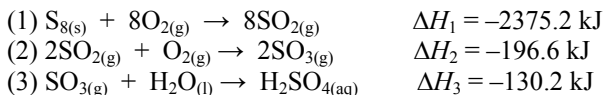
$$\begin{aligned} (b) \text{ Heat gained by water} &= m \cdot c \cdot \Delta T (\text{water}) \\ &= (200.00 \text{ g})(4.184 \text{ J/g} \cdot ^\circ\text{C})(37.3^\circ\text{C}) \\ &= 31\,200 \text{ J} \\ &= 31.2 \text{ kJ} \end{aligned}$$

$$n \text{ mol C}_6\text{H}_{12}\text{O}_6 = \frac{2.000 \text{ g}}{180.18 \text{ g/mol}} = 0.01110 \text{ mol}$$

$$\Delta H^\circ_{\text{comb}} = \frac{-31.2 \text{ kJ}}{0.01110 \text{ mol}} = -2.81 \times 10^3 \text{ kJ/mol}$$

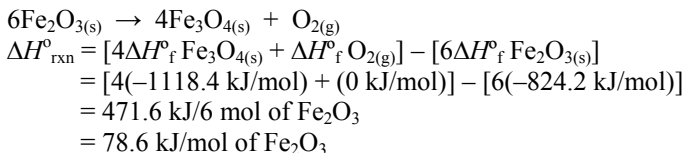
$$\begin{aligned} (c) \Delta H^\circ_{\text{comb}} &= [6\Delta H^\circ_{\text{f}} \text{CO}_2(\text{g}) + 6\Delta H^\circ_{\text{f}} \text{H}_2\text{O}(\text{l})] - [\Delta H^\circ_{\text{f}} \text{C}_6\text{H}_{12}\text{O}_6(\text{s}) - 6\Delta H^\circ_{\text{f}} \text{O}_2(\text{g})] \\ -2.81 \times 10^3 \text{ kJ/mol} &= [6(-393.5 \text{ kJ/mol}) + 6(-285.8 \text{ kJ/mol})] - [\Delta H^\circ_{\text{f}} \text{C}_6\text{H}_{12}\text{O}_6(\text{s}) - 6(0 \text{ kJ/mol})] \\ \Delta H^\circ_{\text{f}} \text{C}_6\text{H}_{12}\text{O}_6(\text{s}) &= -1270 \text{ kJ/mol} \end{aligned}$$

7.



$$\Delta H_{\text{rxn}} = -525.4 \text{ kJ/mol of H}_2\text{SO}_4$$

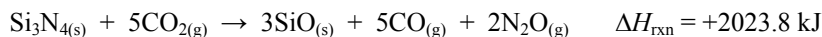
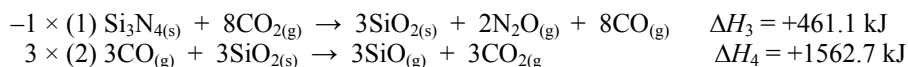
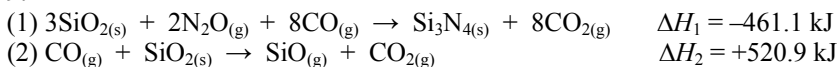
8.



$$n \text{ mol Fe}_2\text{O}_3 = \frac{5.00 \text{ g}}{159.7 \text{ g/mol}} = 0.0313 \text{ mol}$$

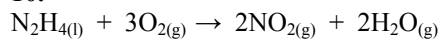
$$\text{Heat absorbed by 5.00 g sample} = 0.0313 \text{ mol} \times 78.6 \text{ kJ/mol} = 2.46 \text{ kJ}$$

9.



$$\Delta H_{\text{rxn}} = +2023.8 \text{ kJ/mol of Si}_3\text{N}_4$$

10.



$$\begin{aligned} \text{(a) } \Delta H_{\text{comb}} &= [2\Delta H_f^\circ \text{NO}_{2(g)} + 2\Delta H_f^\circ \text{H}_2\text{O}_{(g)}] - [\Delta H_f^\circ \text{N}_2\text{H}_{4(l)} - 3\Delta H_f^\circ \text{O}_{2(g)}] \\ &= [2(+33.2) \text{ kJ} + 2(-241.8) \text{ kJ}] - [(+50.6 \text{ kJ/mol}) - 3(0 \text{ kJ/mol})] \\ &= -467.8 \text{ kJ/mol of N}_2\text{H}_4 \end{aligned}$$

$$\text{(b) Mass of N}_2\text{H}_{4(l)} = 10.0 \text{ kg} \times 87.8 \% = 8.78 \text{ kg}$$

$$n \text{ mol N}_2\text{H}_4 = \frac{8.78 \text{ kg}}{32.06 \text{ g/mol}} = 274 \text{ mol of N}_2\text{H}_4$$

$$\text{Heat given off by the 10.0 kg sample} = 274 \text{ mol} \times 467.8 \text{ kJ/mol} = 1.28 \times 10^5 \text{ kJ}$$