Answers

1.

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

$$= \frac{1\text{ g}}{6.94\text{ g/mol}} \times 24.8\text{ J/mol·°C} \times 1\text{°C} = 3.57\text{ J}$$

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

$$= \frac{1\text{ g}}{85.47\text{ g/mol}} \times 31.0\text{ J/mol·°C} \times 1\text{°C} = 0.363\text{ J}$$

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

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

Mass of Rb = 9.83 g of Rb

2.

$X_{(g)} + W_{(g)} \rightarrow Z_{(g)} + Y_{(g)} + 30.0\text{ kJ}$

$Z_{(g)} + Y_{(g)} + 25\text{ kJ} \rightarrow P_{(g)}$

$X_{(g)} + W_{(g)} \rightarrow P_{(g)} + 5.0\text{ kJ}$ $\quad \Delta H^\circ = -5.0\text{ kJ}$

Therefore,

$P_{(g)} \rightarrow X_{(g)} + W_{(g)}$ $\quad \Delta H^\circ = +5.0\text{ kJ}$

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 mol CO_2 = 11.5 mol CO_2

$$\frac{\text{Mass of } CO_2}{44.01\text{ g/mol}} = 11.5\text{ mol } CO_2$$

Mass of CO_2 = 506 g of CO_2

4.

Heat lost by thallium = Heat gained by water

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

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

$c = 0.14\text{ J/g·°C}$

5.

(a) $N_2O_{4(g)} + 3CO_{(g)} \rightarrow N_2O_{(g)} + 3CO_{2(g)}$

$\Delta H^\circ_{rxn} = [\Delta H^\circ_f N_2O_{(g)} + 3\Delta H^\circ_f CO_{2(g)}] - [\Delta H^\circ_f N_2O_{4(g)} + 3\Delta H^\circ_f CO_{(g)}]$

$= [81.6\text{ kJ/mol} + 3(-393.5\text{ kJ/mol})] - [11.1\text{ kJ/mol} + 3(-110.5\text{ kJ/mol})]$

$= -1441.5\text{ kJ/mol of } N_2O_4$

(b) $4FeS_{2(s)} + 11O_{2(g)} \rightarrow 8SO_{2(g)} + 2Fe_2O_{3(s)}$

$\Delta H^\circ_{rxn} = [8\Delta H^\circ_f SO_{2(g)} + 2\Delta H^\circ_f Fe_2O_{3(s)}] - [4\Delta H^\circ_f FeS_{2(s)} - 11\Delta H^\circ_f O_{2(g)}]$

$= [8(-296.8\text{ kJ/mol}) + 2(-824.2\text{ kJ/mol})] - [4(-178.2\text{ kJ/mol}) - 11(0\text{ kJ/mol})]$

$= -3310\text{ kJ/4 mol of } FeS_2$

$= -827.5\text{ kJ/mol of } FeS_2$

6.

(a) $C_6H_{12}O_{6(s)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(l)}$

(b) Heat gained by water = $m \cdot c \cdot \Delta T$ (water)

= (200.00 g)(4.184 J/g·°C)(37.3°C)

= 31 200 J

= 31.2 kJ

$$n \text{ mol } C_6H_{12}O_6 = \frac{2.000 \text{ g}}{180.18 \text{ g/mol}} = 0.01110 \text{ mol}$$

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

(c) $\Delta H^\circ_{comb} = [6\Delta H^\circ_f CO_{2(g)} + 6\Delta H^\circ_f H_2O_{(l)}] - [\Delta H^\circ_f C_6H_{12}O_{6(s)} - 6\Delta H^\circ_f O_{2(g)}]$

-2.81×10^3 kJ/mol = [6(–393.5 kJ/mol) + 6(–285.8 kJ/mol)] – [$\Delta H^\circ_f C_6H_{12}O_{6(s)}$ – 6(0 kJ/mol)]

$\Delta H^\circ_f C_6H_{12}O_{6(s)} = -1270$ kJ/mol

7.

(1) $S_{8(s)} + 8O_{2(g)} \rightarrow 8SO_{2(g)}$ $\quad \Delta H_1 = -2375.2$ kJ

(2) $2SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)}$ $\quad \Delta H_2 = -196.6$ kJ

(3) $SO_{3(g)} + H_2O_{(l)} \rightarrow H_2SO_{4(aq)}$ $\quad \Delta H_3 = -130.2$ kJ

$1 \times$ (1) $S_{8(s)} + 8O_{2(g)} \rightarrow 8SO_{2(g)}$ $\quad \Delta H_4 = -2375.2$ kJ

$4 \times$ (2) $8SO_{2(g)} + 4O_{2(g)} \rightarrow 8SO_{3(g)}$ $\quad \Delta H_5 = -786.4$ kJ

$8 \times$ (3) $8SO_{3(g)} + 8H_2O_{(l)} \rightarrow 8H_2SO_{4(aq)}$ $\quad \Delta H_6 = -1041.6$ kJ

$S_{8(s)} + 12O_{2(g)} + 8H_2O_{(l)} \rightarrow 8H_2SO_{4(aq)}$ $\quad \Delta H = -4203.2$ kJ

$\Delta H_{rxn} = -525.4$ kJ/mol of H_2SO_4

8.

$6Fe_2O_{3(s)} \rightarrow 4Fe_3O_{4(s)} + O_{2(g)}$

$\Delta H^\circ_{rxn} = [4\Delta H^\circ_f Fe_3O_{4(s)} + \Delta H^\circ_f O_{2(g)}] - [6\Delta H^\circ_f Fe_2O_{3(s)}]$

= [4(–1118.4 kJ/mol) + (0 kJ/mol)] – [6(–824.2 kJ/mol)]

= 471.6 kJ/6 mol of Fe_2O_3

= 78.6 kJ/mol of Fe_2O_3

$$n \text{ mol } Fe_2O_3 = \frac{5.00 \text{ g}}{159.7 \text{ g/mol}} = 0.0313 \text{ mol}$$

Heat absorbed by 5.00 g sample = 0.0313 mol × 78.6 kJ/mol = 2.46 kJ

9.

(1) $3SiO_{2(s)} + 2N_2O_{(g)} + 8CO_{(g)} \rightarrow Si_3N_{4(s)} + 8CO_{2(g)}$ $\quad \Delta H_1 = -461.1$ kJ

(2) $CO_{(g)} + SiO_{2(s)} \rightarrow SiO_{(g)} + CO_{2(g)}$ $\quad \Delta H_2 = +520.9$ kJ

$-1 \times$ (1) $Si_3N_{4(s)} + 8CO_{2(g)} \rightarrow 3SiO_{2(s)} + 2N_2O_{(g)} + 8CO_{(g)}$ $\quad \Delta H_3 = +461.1$ kJ

$3 \times$ (2) $3CO_{(g)} + 3SiO_{2(s)} \rightarrow 3SiO_{(g)} + 3CO_{2(g}$ $\quad \Delta H_4 = +1562.7$ kJ

$Si_3N_{4(s)} + 5CO_{2(g)} \rightarrow 3SiO_{(s)} + 5CO_{(g)} + 2N_2O_{(g)}$ $\quad \Delta H_{rxn} = +2023.8$ kJ

$\Delta H_{rxn} = +2023.8$ kJ/mol of Si_3N_4

10.

$N_2H_{4(l)} + 3O_{2(g)} \rightarrow 2NO_{2(g)} + 2H_2O_{(g)}$

(a) $\Delta H_{comb} = [2\Delta H°_f\, NO_{2(g)} + 2\Delta H°_f\, H_2O_{(g)}] - [\Delta H°_f\, N_2H_{4(l)} - 3\Delta H°_f\, O_{2(g)}]$

$= [2(+33.2)\text{ kJ} + 2(-241.8)\text{ kJ}] - [(+50.6\text{ kJ/mol}) - 3(0\text{ kJ/mol})]$

$= -467.8\text{ kJ/mol of } N_2H_4$

(b) Mass of $N_2H_{4(l)} = 10.0\text{ kg} \times 87.8\,\% = 8.78\text{ kg}$

$$n\text{ mol } N_2H_4 = \frac{8.78\text{ kg}}{32.06\text{ g/mol}} = 274\text{ mol of } N_2H_4$$

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