Example problems:

$$2\overset{2.016}{H_2}(g) + O_2(g) \longrightarrow 2H_2O(g)\ ;\ \Delta H = -484\ kJ$$

Calculate the enthalpy change for the combustion of 1.00 kg of hydrogen gas.

1-Convert 1.00 kg of hydrogen gas to moles (formula weight)

2- Convert moles of hydrogen gas to enthalpy (chemical equation)

$2.016\ g\ H_2 = 1\ mol\ H_2 \qquad 2\ mol\ H_2 = -484\ kJ \qquad 10^3 g = kg$

$$1.00\ kg\ H_2 \times \frac{10^3 g}{kg} \times \overset{①}{\frac{1\ mol\ H_2}{2.016\ g\ H_2}} \times \overset{②}{\frac{-484\ kJ}{2\ mol\ H_2}} = -12\bar{0}000\ kJ$$

$$\boxed{\Delta H = -120000\ \frac{kJ}{kg}}$$

FW: 46.026

$$2\,HCHO_2(l) + O_2(g) \longrightarrow 2\,CO_2(g) + 2\,H_2O(l)$$

If 50.3 kJ of heat was released when 5.48 g of formic acid are burned at constant pressure, then what is the enthalpy change of this reaction per mole of formic acid?

$$\Delta H = \frac{Q_{\text{constant pressure}}}{\text{moles } HCHO_2} = \frac{kJ}{mol}$$

$$Q_{\text{constant pressure}} = -50.3\text{ kJ}$$

$$5.48\text{ g } HCHO_2 \times \frac{\text{mol } HCHO_2}{46.026\text{ g } HCHO_2} = 0.119\text{ mol}$$

$$\Delta H = \frac{-50.3\text{ kJ}}{0.119\text{ mol}} = \boxed{-422\text{ kJ/mol } HCHO_2}$$

If we were asked to write the above in the form of a THERMOCHEMICAL EQUATION instead of enthalpy per mole of formic acid, how would we write it?

$$\boxed{2\,HCHO_2(l) + O_2(g) \longrightarrow 2\,CO_2(g) + 2\,H_2O(l)\ ;\ \Delta H = -844\text{ kJ}}$$

$$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)\ ;\ \Delta H = -906\ kJ$$

What is the enthalpy change when 150. L of nitrogen monoxide are formed by this reaction at 25.0 C and 1.50 atm pressure?

1- Use the ideal gas equation to convert 150, L of NO to moles NO.
2- Use the chemical equation to change moles NO to enthalpy

$PV = nRT$

$n = \dfrac{PV}{RT}$

$P = 1.50\ atm \quad R = 0.08206\ \dfrac{L\cdot atm}{mol\cdot K}$

$V = 150.L \quad T = 25.0°C = 298.2\ K$

1

$$n_{NO} = \frac{(1.50\ atm)(150.L)}{\left(0.08206\ \frac{L\cdot atm}{mol\cdot K}\right)(298.2\ K)} = 9.19\ mol\ NO$$

$4\ mol\ NO = -906\ kJ$

$$9.19\ mol\ NO \times \frac{-906\ kJ}{4\ mol\ NO} = \boxed{-2080\ kJ}$$

2

Heat of formation / enthalpy of formation!

$$\begin{array}{ccccccc} -20.50 & & 0 & & -285.8 & & -296.8 \\ 2\,H_2S(g) & + & 3\,O_2(g) & \longrightarrow & 2\,H_2O(l) & + & 2\,SO_2(g) \end{array} \;\Big]\; \Delta H_f^o,\ kJ/mol$$

What is the enthalpy change at standard conditions when 25.0 grams of hydrogen sulfide gas is reacted?

1 - Find the enthalpy of reaction (Hess' Law and heats of formation)
2- Convert 25.0 g of hydrogen sulfide to moles hydrogen sulfide (formula weight)
3- Convert moles hydrogen sufide to enthalpy (chemical equation)

$$\Delta H_r = \sum \Delta H^o_{f,\,products} - \sum \Delta H^o_{f,\,reactants}$$

1

$$[2(-285.8)+2(-296.8)] - [2(-20.50)+3(0)]$$

$$-1165.2 - (-41)$$

$$\Delta H = -1124.2$$

$34.086\,g\ H_2S = 1\ mol\ H_2S$ | $2\ mol\ H_2S = -1124.2\ kJ$

$$25.0\,g\ H_2S \times \frac{1\ mol\ H_2S}{34.086\,g\ H_2S} \times \frac{-1124.2\ kJ}{2\ mol\ H_2S} = \boxed{-412\ kJ}$$

2 3

propane

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g);\ \Delta H = -2043\ kJ$$

Calculate the volume of propane gas at 25.0 C and 1.08 atm required to provide 565 kJ of heat using the reaction above.

1- Convert -565 kJ of energy to moles propane (chemical equation)
2- Convert moles of propane to volume (ideal gas equation)

$$1\ mol\ C_3H_8 = -2043\ kJ$$

$$-565\ kJ \times \frac{1\ mol\ C_3H_8}{-2043\ kJ} = 0.27655\ mol\ C_3H_8 \quad (1)$$

$$V = \frac{nRT}{P} \quad (2)$$

$n = 0.27655\ mol\ C_3H_8$ $\quad P = 1.08\ atm$

$R = 0.08206\ \frac{L \cdot atm}{mol \cdot K}$

$T = 25.0\ °C = 298.2\ K$

$$V = \frac{(0.27655\ mol\ C_3H_8)(0.08206\ \frac{L \cdot atm}{mol \cdot K})(298.2\ K)}{(1.08\ atm)}$$

$$= \boxed{6.27\ L\ C_3H_8\ \text{required}}$$