Using the following information, determine the $\Delta_{rxn}H°$ for $CH_4(g) + H_2O(l) \rightarrow CO(g) + 3H_2(g)$

$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$ $\Delta_{rxn}H° = -566$ kJ/mol•rxn
$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ $\Delta_{rxn}H° = -570$ kJ/mol•rxn
$CO_2(g) + 2H_2O(l) \rightarrow CH_4(g) + 2O_2(g)$ $\Delta_{rxn}H° = +890$ kJ/mol*rxn

$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(l)}$ $\Delta_r H° = \frac{-890\ kJ}{mol\ rxn}$

$\frac{3}{2} \times [2H_2O_{(l)} \rightarrow 2H_{2(g)} + O_{2(g)}]$ $\Delta_r H° = \frac{+570\ kJ}{mol\ rxn} \times \frac{3}{2}$

$\frac{1}{2} \times [2CO_{2(g)} \rightarrow 2CO_{(g)} + O_{2(g)}]$ $\Delta_r H° = \frac{+566\ kJ}{mol\ rxn} \times \frac{1}{2}$

$CH_{4(g)} + 2O_{2(g)} + 3H_2O_{(l)} + CO_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(l)} + 3H_{2(g)} + \frac{3}{2}O_{2(g)} + CO_{(g)} + \frac{1}{2}O_{2(g)}$

cancel stuff

$CH_{4(g)} + H_2O_{(l)} \rightarrow 3H_{2(g)} + CO_{(g)}$

$\Delta_r H° = -890 + (\frac{3}{2} \times 570) + (\frac{1}{2} \times 566) = +248\ kJ/mol\ rxn$

How much energy is required to make 10 kg of H_2 (g)

$10000\ g\ H_2 \times \frac{1\ mol}{2\ g} = 5000\ mol\ H_2 \times \frac{1\ mol \cdot rxn}{3\ mol\ H_2} \times \frac{248\ kJ}{mol \cdot rxn} = 4.1 \times 10^5\ kJ$

Assume that coal is pure carbon. Write the balanced chemical equation for the burning of coal.

$$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$$

$$\Delta_r H^\circ = -393\ kJ/mol \cdot rxn$$

How many joules of heat can be generated when 100 pounds of coal is burned? The $\Delta_f H^\circ$ of H_2O (l) = -285 kJ/mol and the $\Delta_f H^\circ$ of CO_2 (g) = -393 kJ/mol

$$100\ lb\ C \times \frac{1\ kg}{2.2\ lb} \times \frac{1000\ g}{kg} \times \frac{1\ mol}{12\ g} \times \frac{-393\ kJ}{1\ mol\ rxn} = -1.49 \times 10^6\ kJ$$

How many kilograms of CO_2 will be produced in this process?

$$100\ lb\ C \times \frac{1\ kg}{2.2\ lb} \times \frac{1000\ g}{kg} \times \frac{1\ mol\ C}{12\ g} \times \frac{1\ mol\ CO_2}{1\ mol\ C} \times \frac{44\ g\ CO_2}{1\ mol\ CO_2} \times \frac{1\ kg}{1000\ g} = 166.7\ kg\ CO_2$$

Write the balanced equation for the combustion of natural gas - CH_4 (g)

$$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(l)}$$

$$\Delta_r H^\circ \{[(2 \times -285\,kJ/mol) + (-393\,kJ/mol)] - (-74\,kJ/mol) = -889\,\frac{kJ}{mol\ rxn}$$

How many joules of heat can be generated when 100 pounds of natural gas is burned? The $\Delta_f H^\circ$ of H_2O (l) = -285 kJ/mol, the $\Delta_f H^\circ$ of CO_2 (g) = -393 kJ/mol and the $\Delta_f H^\circ$ of CH_4 (g) = -74 kJ/mol.

$$100\ lb_{CH_4} \times \frac{1\,kg}{2.2\,lb} \times \frac{1000\,g}{1\,kg} \times \frac{1\,mol}{16\,g} \times \frac{-889\,kJ}{mol\ rxn} = -2.53\times10^6\,kJ$$

How many kilograms of CO_2 will be produced in this process?

$$100\ lb_{CH_4} \times \frac{1\,kg}{2.2\,lb} \times \frac{1000\,g}{1\,kg} \times \frac{1\,mol\,CH_4}{16\,g\,CH_4} \times \frac{1\,mol\,CO_2}{1\,mol\,CH_4} \times \frac{44\,g\,CO_2}{1\,mol\,CO_2} \times \frac{1\,kg}{1000\,g} = 125\,kg\,CO_2$$

Compare coal to natural gas

Coal

$$\frac{-1.49\times10^6\,kJ}{166.7\,kg\,CO_2} = \frac{-8938\,kJ}{kg\,CO_2}$$

CH_4

$$\frac{-2.53\times10^6\,kJ}{125\,kg\,CO_2} = \frac{-20240\,kJ}{kg\,CO_2}$$

Consider the combustion of gasoline C_8H_{18}.

Write the balanced chemical equation for this process

$$C_8H_{18\,(l)} + \frac{25}{2}O_{2\,(g)} \longrightarrow 8\,CO_{2\,(g)} + 9\,H_2O_{(l)}$$

You combust 2.8 grams of gasoline in a calorimeter that contains 2.00 L of water and the temperature of the water increases by 15.97 °C. The $\Delta_f H°$ of H_2O (l) = -285 kJ/mol and the $\Delta_f H°$ of CO_2 (g) = -393 kJ/mol. What is the $\Delta_f H°$ of C_8H_{18}?

$$q = (2000\,g)(4.184\,\frac{J}{g°C})(15.97°C) = 133637\ J \text{ given off}$$

$$2.8g\ C_8H_{18} \times \frac{1\,mol}{114g} = 0.0246\ mol\ C_8H_{18}$$

$$\Delta_r H° = \frac{-133637\,J}{0.0246\,mol} = -5441\,\frac{kJ}{mol}$$

$$\left[\left(8 \times -393\,\frac{kJ}{mol}\right) + \left(9 \times -285\,\frac{kJ}{mol}\right)\right] - \Delta_f H°_{C_8H_{18}} = -5441\,\frac{kJ}{mol}$$

$$-5709\,\frac{kJ}{mol} - \Delta_f H°_{C_8H_{18}} = -5441\,\frac{kJ}{mol}$$

$$\Delta_f H°_{C_8H_{18}} = -268\,\frac{kJ}{mol}$$