key

WS 3 – Communicating Energy Changes

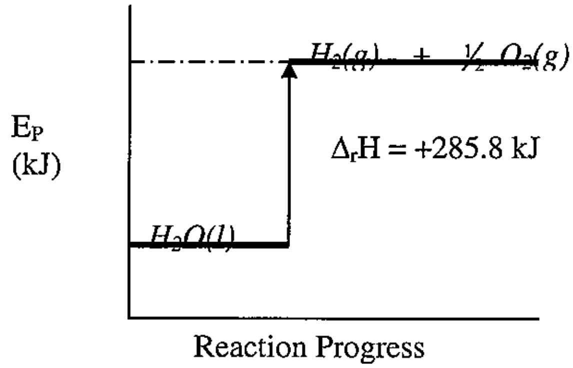
Part I

Rewrite the following equations expressing the balanced equation with one mole of the substance underlined and using the Δ_rH notation. Sketch a labelled potential energy diagram for each question.

Example

$\underline{2\ H_2O(l)}\ +\ 571.6\ kJ\ \rightarrow\ 2\ H_2(g)\ +\ O_2(g)$

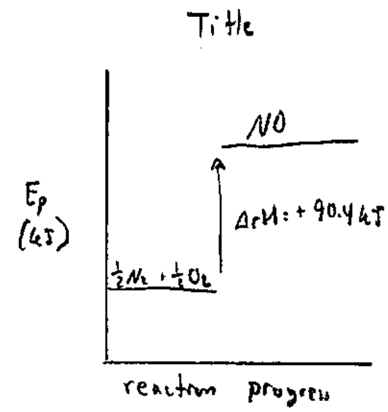
Answer: $H_2O(l)\ \rightarrow\ H_2(g)\ +\ \frac{1}{2}\ O_2(g)\quad \Delta_rH = +\ 285.8\ kJ$



1. $N_2(g)\ +\ O_2(g)\ +\ 180.8\ kJ\ \rightarrow\ \underline{2\ NO(g)}$

$\frac{1}{2} N_{2(g)} + \frac{1}{2} O_{2(g)} + 90.4\ kJ \rightarrow NO_{(g)}$

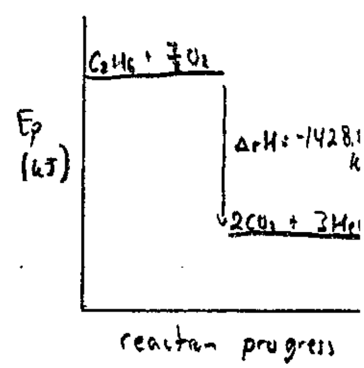
$\frac{1}{2} N_{2(g)} + \frac{1}{2} O_{2(g)} \rightarrow NO_{(g)} \quad \Delta_rH = +90.4\ kJ$



2. $\underline{2\ C_2H_6(g)}\ +\ 7\ O_2(g)\ \rightarrow\ 4\ CO_2(g)\ +\ 6\ H_2O(g)\ +\ 2857\ kJ$

$C_2H_{6(g)} + \frac{7}{2} O_{2(g)} \rightarrow 2\ CO_{2(g)} + 3\ H_2O_{(g)} + 1428.5\ kJ$

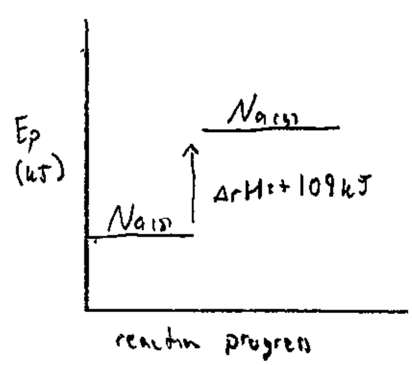
$\Delta_rH = -1428.5\ kJ$



3. $\underline{2\ Na(s)}\ +\ 218\ kJ\ \rightarrow\ 2\ Na(g)$

$Na_{(s)} + 109\ kJ \rightarrow Na_{(g)}$

$Na_{(s)} \rightarrow Na_{(g)} \quad \Delta_rH = +109\ kJ$



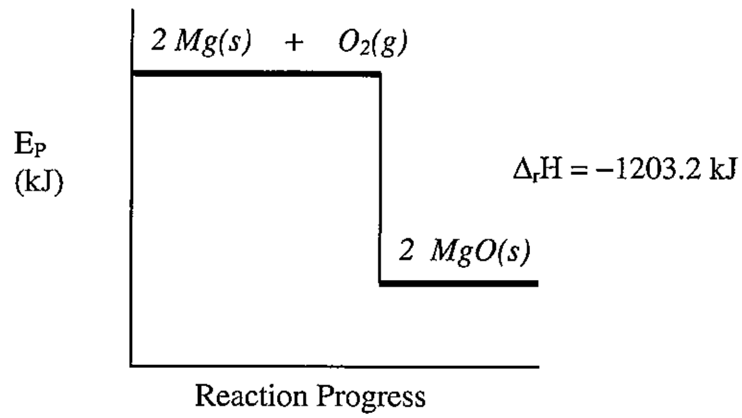
Part II

Rewrite the following equations to have the simplest whole number coefficients and by expressing the energy change as a term in the equation. Sketch a labelled potential energy diagram for each question.

Example

$Mg(s) + \frac{1}{2} O_2(g) \rightarrow MgO(s)$ $\Delta_r H = -601.6$ kJ

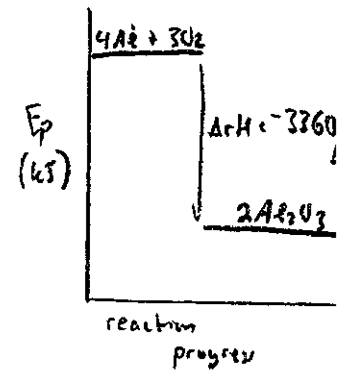
Answer: $2\,Mg(s) + O_2(g) \rightarrow 2\,MgO(s) + 1203.2$ kJ



1. $2\,Al(s) + \frac{3}{2} O_2(g) \rightarrow Al_2O_3(s)$ $\Delta_r H = -1680.0$ kJ

$4\,Al_{(s)} + 3\,O_{2(g)} \rightarrow 2\,Al_2O_{3(s)}$ $\Delta_r H = -3360.0$ kJ

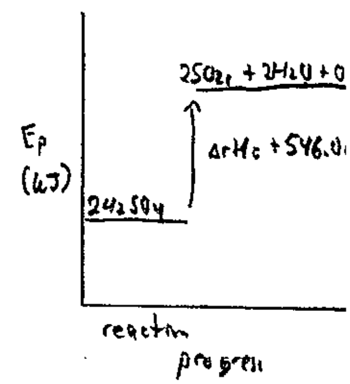
$4\,Al_{(s)} + 3\,O_{2(g)} \rightarrow 2\,Al_2O_{3(s)} + 3360.0$ kJ



2. $H_2SO_{4(l)} \rightarrow SO_{2(g)} + H_2O_{(g)} + \frac{1}{2} O_{2(g)}$ $\Delta_r H = +273.0$ kJ

$2\,H_2SO_{4(l)} \rightarrow 2\,SO_{2(g)} + 2\,H_2O_{(g)} + O_{2(g)}$ $\Delta_r H = +546.0$ kJ

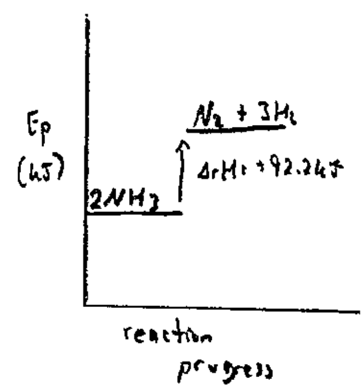
$2\,H_2SO_{4(l)} + 546.0\text{ kJ} \rightarrow 2\,SO_{2(g)} + 2\,H_2O_{(g)} + O_{2(g)}$



3. $NH_3(g) \rightarrow \frac{1}{2} N_2(g) + 3/2\,H_2(g)$ $\Delta_r H = +46.1$ kJ

$2\,NH_{3(g)} \rightarrow N_{2(g)} + 3\,H_{2(g)}$ $\Delta_r H = +92.2$ kJ

$2\,NH_{3(g)} + 92.2\text{ kJ} \rightarrow N_{2(g)} + 3H_{2(g)}$



Part III

1. Given the reaction $3\ NO_2(g) + H_2O(l) \rightarrow 2\ HNO_3(l) + NO(g)$ $\Delta_rH = -72.0$ kJ, calculate the molar enthalpy of reaction, Δ_rH_m for:
   a) $NO_2(g)$ b) $H_2O(l)$
   c) $HNO_3(l)$ d) $NO(g)$

if, $\Delta_rH = n\Delta_rH_m$

$\therefore \Delta_rH_m = \frac{\Delta_rH}{n}$

a) $\Delta_rH_{m\ NO_2} = \frac{-72.0\ kJ}{3\ mol} = -24.0\ kJ/mol$

b) $\Delta_rH_{m\ H_2O} = \frac{-72.0\ kJ}{1\ mol} = -72.0\ kJ/mol$

c) $\Delta_rH_{m\ HNO_3} = \frac{-72.0\ kJ}{2\ mol} = -36.0\ kJ/mol$

d) $\Delta_rH_{m\ NO} = \frac{-72.0\ kJ}{1\ mol} = -72.0\ kJ/mol$

2. The molar enthalpy of combustion of butane is –2657.3 kJ/mol. Write the balanced reaction for the combustion of butane, including energy in the reaction.

$2\ C_4H_{10(g)} + 13\ O_{2(g)} \rightarrow 8\ CO_{2(g)} + 10\ H_2O_{(g)} + 5314.6\ kJ$

3. Calculate the heat released (enthalpy change) when 100 g of methane is burned in a water heater. $\Delta_cH_m = -802.5$ kJ/mol $CH_4(g)$.

$\Delta_cH = n\Delta_cH_m$

$= \left(\frac{100\ g}{16.05\ g/mol}\right)(-802.5\ kJ/mol) = -5000\ kJ = \boxed{-5.00\ MJ}$

4. Calculate the enthalpy change when 5.00 g of glucose is burned during cellular respiration. The molar enthalpy of reaction for glucose is –2802.5 kJ/mol.

$\Delta_cH = n\Delta_cH_m$

$= \left(\frac{5.00\ g}{180.18\ g/mol}\right)(-2802.5\ kJ/mol) = 77.76...\ kJ = \boxed{-77.8\ kJ}$

5. What mass of ethane is required to produce 1500 kJ of energy during a combustion reaction? The molar enthalpy of combustion of ethane is –1251.0 kJ/mol.

$\Delta_rH = n\Delta_rH_m$

$-1500\ kJ = n\ (-1251.0\ kJ/mol)$

$n = 1.199...\ mol$

$m = nM$

$= (1.199...\ mol)(30.08\ g/mol)$

$= 36.067...\ g$

$= \boxed{36.07\ g}$