Worksheet

$$H_s = \frac{(1.00\,L)\left(\frac{kJ}{L\cdot{}^\circ C}\right)({}^\circ C)}{(mol)}$$

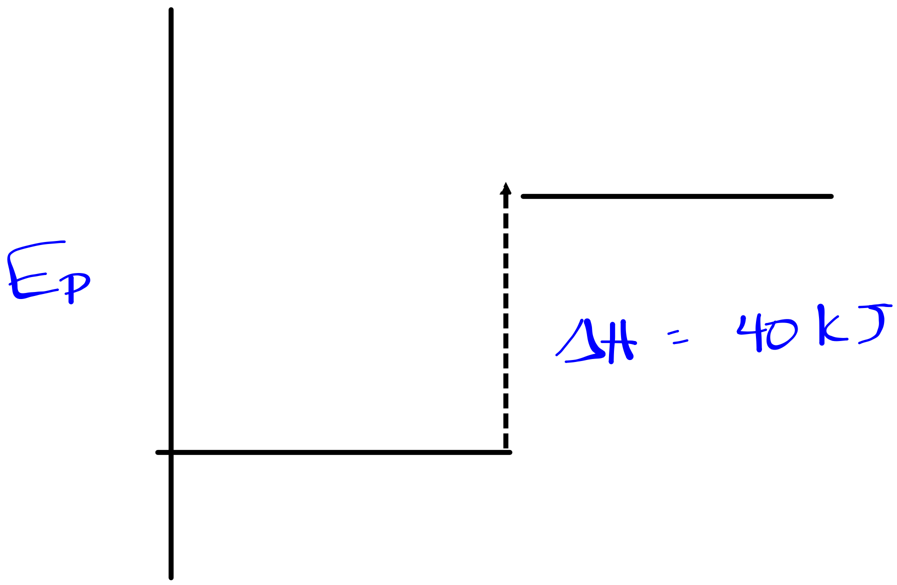
Reference Energy State

Reference energy state - elements are defined as the reference point at which the potential energy is shown to be zero.
Therefore: E_p of $H_{2(g)} = 0$ kJ

0 -285.8 kJ.

Ex. $H_{2(g)} + 1/2O_{2(g)} \longrightarrow H_2O_{(g)}$ $\Delta H_f = -285.8$ kJ

*allows us to describe the enthalpy change for a formation reaction from zero to a final value


Ep
ΔH = 40 kJ

Predicting ΔH_r Using Formation Reactions

The Standard Enthalpy Change (ΔH°_r) for a reaction can be found by writing the formation equation and corresponding standard enthalpy change for each compound in the given equation and then applying Hess's Law.

Ex. $CaO_{(s)} + H_2O_{(l)} \longrightarrow Ca(OH)_{2(s)}$ $\Delta H_r = ?$

Step 1: Write formation equations (with standard enthalpy change) each compound in the given equation.

① $Ca_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow CaO_{(s)}$ $\Delta H_f = -634.9\ kJ$

② $H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$ $\Delta H_f = -285.8\ kJ$

③ $Ca_{(s)} + O_{2(g)} + H_{2(g)} \rightarrow Ca(OH)_{2(s)}$ $\Delta H_f = -986.1\ kJ$

Step 2: Apply Hess's Law

Rev ①

④ $CaO_{(s)} \rightarrow Ca_{(s)} + \frac{1}{2}O_{2(g)}$ $\Delta H_r = 634.9\ kJ$

Rev ②

⑤ $H_2O_{(l)} \rightarrow H_{2(g)} + \frac{1}{2}O_{2(g)}$ $\Delta H_r = 285.8\ kJ$

③ + ④ + ⑤

Enthalpies of Formation to Predict ΔH_r

$$\Delta H_r = \underset{Ca(OH)_2}{\Delta H_f} + (-\underset{CaO}{\Delta H_f}) + (-\underset{H_2O}{\Delta H_f})$$

$$\Delta H_r = \underset{Ca(OH)_2}{\Delta H_f} - (\underset{CaO}{\Delta H_f} + \underset{H_2O}{\Delta H_f})$$

$$\Delta H_r = \underset{\text{products}}{\Delta H_{fp}} - \underset{\text{reactants}}{\Delta H_{fr}}$$

$$\Delta H_r = \Sigma n H_{fp} - \Sigma n H_{fr}$$

knowing that $\Delta H = nH$

Ex. What is the standard molar enthalpy of combustion of methane fuel?

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

$\Delta H_r = nH_r$

$H_r = \frac{\Delta H_r}{n} = \frac{-802.7\ kJ}{1\ mol} = -802.7\ kJ/mol$

$\Delta H_r = \sum nH_{fp} - \sum nH_{fr}$

$\Delta H_r = \left[(1\ mol)\left(-393.5\frac{kJ}{mol}\right) + (2\ mol)\left(-241.8\frac{kJ}{mol}\right)\right] - \left[(1\ mol)\left(-74.4\frac{kJ}{mol}\right) + (2\ mol)\left(0\frac{kJ}{mol}\right)\right]$

$\Delta H_r = (-877.1\ kJ) - (-74.4\ kJ)$

$\Delta H_r = -802.7\ kJ$