EG What is the work involved in raising a book of mass about 1.0 kg from the floor to the table 75 cm above ground?

$$w = \text{weight} \times 0.75\text{m} = [\text{mass} \times g]\ (75\text{ cm})$$
$$= (1.0\text{ kg})(9.81\text{ m/s}^2)(0.75\text{ m})$$
$$= 7.4\text{ kg m}^2/\text{s}^2 = 7.4\text{ J}$$

EG Calculate the work done by a system in which a reaction results in the formation of 1.0 mol of gas at 25°C and 100 kPa.

Since we know P, T and n, we can calculate V using the Ideal Gas Law.

$$PV = nRT$$
$$V = \frac{nRT}{P} = \frac{(1\text{mol})(8.314\text{ J/mol/K})(298\text{K})}{100\text{ kPa}}$$
$$= 25\text{ J/kPa} = 25\text{L}$$

Note that 1 Joule = kg m^2/s^2 and 1 kPa = 1000 Pa = 1000 N/m^2
so we have 1J/kPa = 1 (kg m/s^2)m/(1000 N/m^2)
= 1 m^3/1000 = 1000 cm^3 = 1 L

V is actually ΔV because this is the volume change associated with the reaction. Now, work done by the system is:

work of expansion = opposing force $\times$ distance
$= (P_{ext} \times A) \times h$
$= P_{ext} \times \Delta V$
= (100 kPa)(25 L) = 2500 kPa L = 2500 J = 2.5 kJ

HESS' LAW

The standard enthalpy of a rxn is the sum of the standard enthalpies of the rxns (step rxns) into which the overall rxn may be divided.

EG Given the thermochemical equations for the hydrogenation of propene and for the combustion of propane:

$C_3H_6\ (g) + H_2\ (g) \longrightarrow C_3H_8\ (g)$ $\Delta H^\circ = -124$ kJ
$C_3H_8\ (g) + 5O_2\ (g) \longrightarrow 3CO_2\ (g) + 4H_2O\ (l)$ $\Delta H^\circ = -2220$ kJ

Calculate the standard enthalpy of combustion of propene.

This is a combustion rxn, which means propane is reacting with O_2.
We need to first balance the required rxn as follows:

$C_3H_6\ (g) + 9/2\ O_2\ (g) \longrightarrow 3CO_2\ (g) + 3H_2O\ (l)$ $\Delta H^\circ = ?$

which can be broken down into:

$C_3H_6\ (g) + H_2\ (g) \longrightarrow C_3H_8\ (g)$ $\Delta H^\circ = -124$ kJ
$C_3H_8\ (g) + 5O_2\ (g) \longrightarrow 3CO_2\ (g) + 4H_2O\ (l)$ $\Delta H^\circ = -2220$ kJ
$H_2O\ (l) \longrightarrow H_2\ (g) + \frac{1}{2}\ O_2\ (g)$ $\Delta H^\circ = +286$ kJ
$C_3H_6\ (g) + 9/2\ O_2\ (g) \longrightarrow 3CO_2\ (g) + 3H_2O\ (l)$ $\Delta H^\circ = -2058$ kJ

NB The information of the enthalpies of formation, ΔH°_f, of most substances is assumed to be known, i.e. we can look it up. Here, we invert the $\Delta H^\circ_f(H_2O,l)$ to get the 3rd required rxn.
Also: The standard heat of combustion for propene is -2058 kJ/mol, since we have one mole of C_3H_6 as the starting reactant.

EG Calculate the enthalpy of combustion of liquid benzene from the standard enthalpies of formation of the reactants and products.

EG A 50.0 g piece of copper metal at 80.0°C is placed in 100 mL of water at 10.0°C. Assuming no heat loss to the surrounding, what will be the final temperature of the copper-water system? Given that the molar heat capacities of Cu(s) and $H_2O(l)$ are 24.5 J/°C/mol and 75.2 J/°C/mol, respectively.

Let the final temperature be T_f – this is what we want.

C_P[Cu(s)] = (24.5 J/°C/mol) x (50.0 g / 63.55 g/mol) = 19.3 J/°C
$C_P[H_2O(l)]$ = (75.2 J/°C/mol) x (100 mL x 1 g/mL) / 18.02 g/mol)
= 417 J/°C

Amount of heat loss by Cu = Amount of heat gain by H_2O
(19.3 J/°C) x (80.0°C – T_f) = (417 J/°C) x (T_f – 10.0°C)

Solving this... T_f = 5714 J / (436 J/°C) = 13.1°C

NB Cu decreases by ~67°C while H_2O increases by only 3.1°C because the heat capacity of water is over 20 times that of Cu.