What Is a Mole Reaction?

When reporting a reaction's change in enthalpy, ΔH, we usually list it with a unit of kilojoules per mole, kJ/mol. But to what species does the mol in kJ/mol refer? Your textbook resolves this by noting that we mean "the enthalpy change *per mole of the reaction (or process) as it is written.*" This definition helps, although it is not clear how a reaction has a number of moles: it is easy for us to visualize a mole of carbon—just weigh out 12.01 g and there you have it, a mole of carbon. But what is a mole of a reaction? To help us think this through we will introduce the unit mol_{rxn} as a substitute for kJ/mol when reporting a reaction's enthalpy (and for reporting other thermodynamic functions).[1]

Let's see how this works. Suppose you and a classmate perform separate calorimetry experiments to determine ΔH for the reaction

$$A + 2B \rightarrow 3C$$

Your classmate performs the experiment using 0.75 mol of A and 1.00 mol of B, finding that q_{rxn} is –1000 kJ. She calculates ΔH by dividing q_{rxn} by the moles of limiting reagent (in this case B), obtaining

$$\Delta H = \frac{q_{\text{rxn}}}{\text{mol B}} = \frac{-1000\ \text{kJ}}{1\ \text{mol B}} = -1000\,\frac{\text{kJ}}{\text{mol B}}$$

You, on the other hand, perform the experiment using 0.75 mol of A and 3.00 mol of B, obtaining a q_{rxn} of –1500 kJ. Because A is the limiting reagent you report ΔH as

$$\Delta H = \frac{q_{\text{rxn}}}{\text{mol A}} = \frac{-1500\ \text{kJ}}{0.75\ \text{mol B}} = -2000\,\frac{\text{kJ}}{\text{mol A}}$$

Both results are correct even though their respective numerical values are different; however, it is disconcerting that the value for ΔH depends on the choice of limiting reagent. If we multiply each value of ΔH by the limiting reagent's stoichiometry in the balanced reaction

$$\left[\frac{-1000\ \text{kJ}}{\text{mol B}} \times \frac{2\ \text{mol B}}{\text{mol}_{\text{rxn}}}\right] = \frac{-2000\ \text{kJ}}{\text{mol}_{\text{rxn}}} = \left[\frac{-2000\ \text{kJ}}{\text{mol B}} \times \frac{1\ \text{mol A}}{\text{mol}_{\text{rxn}}}\right]$$

we obtain the same value of ΔH of -2000 kJ/mol_{rxn} where mol_{rxn} indicates that the value of ΔH is reported for the reaction, not for one of the reactants. Note that the conversion factors $\frac{2\ \text{mol B}}{\text{mol}_{\text{rxn}}}$ and $\frac{1\ \text{mol A}}{\text{mol}_{\text{rxn}}}$ make explicit the relationship between each reactant's stoichiometry and the reaction's enthalpy.

[1] The unit mol_{rxn} is borrowed from the textbook *Chemistry: Structure and Dynamics* by Spencer, Bodner, and Rickard.