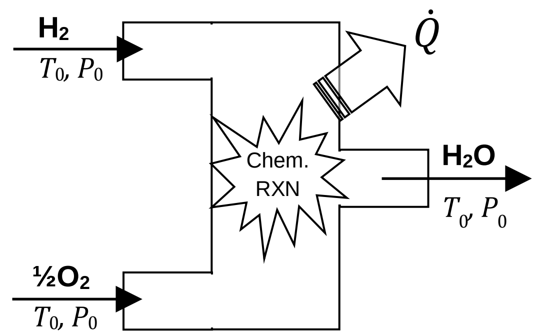
Conservation of energy and combustion



Consider H_2 reacting with O_2 in a steady-state reaction chamber, resulting in heat transfer out of the system. All inlets and exits are maintained at standard temperature and pressure, T_0 and P_0. The reaction produces 1 kmol/s of H_2O using stoichiometric flow rates of H_2 and O_2:

$$H_2 + \frac{1}{2} O_2 \rightarrow H_2O$$

Write conservation of energy for the process. Will you use a mass-based specific enthalpy or a mole-based specific enthalpy? Why?

We have different chemical species entering and leaving the chamber. This poses a problem concerning a reference state for specific enthalpy. And so, let us choose T_0 and P_0 to be the reference state where all species have zero enthalpy. But wait, what just happened to conservation of energy?

We know from experience that reacting hydrogen with oxygen produces large rates of heat transfer. The problem is that our standard thermodynamic conservation of energy equation only tracks internal energy, kinetic energy, and gravitational potential energy. In systems involving chemical reactions, chemical energy (stored in chemical bonds) is also involved. We can fix this by adding specific chemical energy (energy per unit mass or mole) to the mass flow terms:

The difference between the chemical energies of the products and the reactants for a given chemical reaction per unit mole is the ____________________ ____ ____________________.

Though it is called an enthalpy, it actually represents the chemical energy stored in a chemical species. Think of it as a *chemical* enthalpy if you like. We'll call the normal, everyday enthalpy a *thermodynamic* enthalpy. If we add the two together to get a total, thermochemical enthalpy, we have

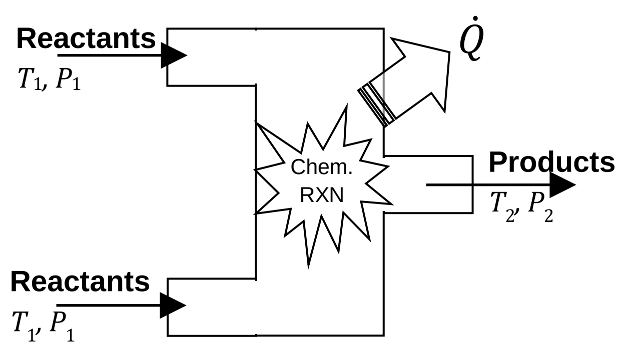
Remember how we said we wanted specific enthalpy to be zero for any chemical species at T_0 and P_0? We really want the *thermodynamic* enthalpy part to be zero. If we're at some T and P other than T_0 and P_0 we can make this work by subtracting the value for h at T_0 and P_0 from the value of h:

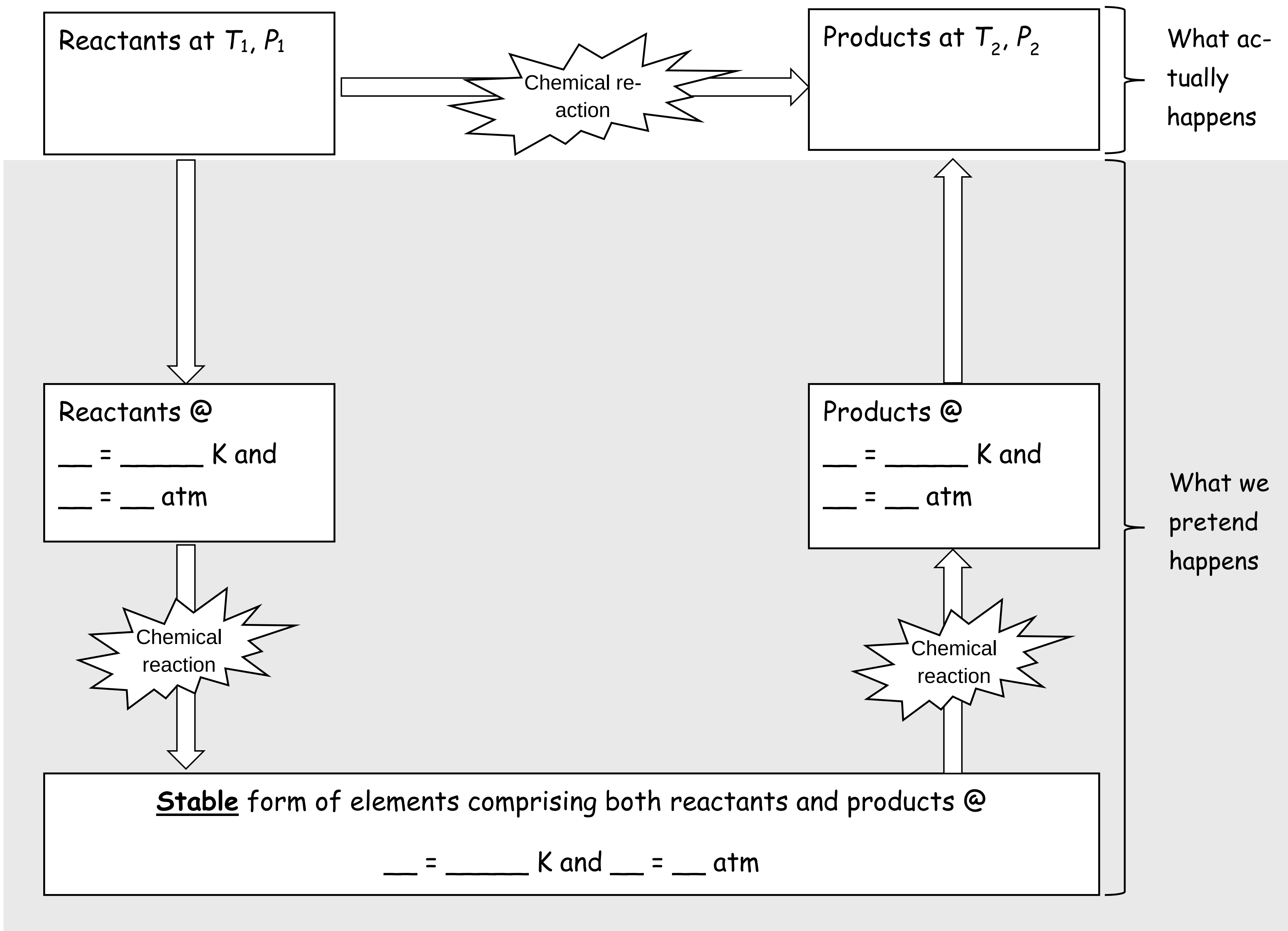
If we now use the total thermochemical enthalpy in our conservation of energy equation it will work in cases involving chemical reactions too!

But there is still a problem. We need information on any chemical reaction we can dream up, which is a big pain in the behonkus. As a way around this, we give a special name to chemical enthalpy of compounds formed at T_0 and P_0 with stoichiometric amounts of reactant ______________ ____ ________ ____________ __________. And that is

$$\Delta \bar{h}_f^0 =$$

Lastly, we can catalog pretty much any chemical reaction happening with any reactants forming any products at any temperature/pressure by pretending like it happens as follows.





Reactants at T_1, P_1
Chemical re-action
Products at T_2, P_2
What ac-tually happens
Reactants @
__ = ______ K and
__ = __ atm
Products @
__ = ______ K and
__ = __ atm
What we pretend happens
Chemical reaction
Chemical reaction
Stable form of elements comprising both reactants and products @
__ = ______ K and __ = __ atm

And so for any one species, reactant or product

$$\bar{h} =$$