MAM4xx Units Conversions (`conversions.hpp`)

Employing the SI definition for molar mass (molecular weight) and the following (slightly tortured) notation:

- Number concentration of species: N_C
- Mass mixing ratio: M_R
- Volume mixing ratio (equivalent to molar mixing ratio--thanks ideal gas law!): V_R
- Molecular weight of species/dry air: $M_z,\ z \in \{s, \alpha\}$
- Density of species/dry air: $\rho_z,\ z \in \{s, \alpha\}$
- Avogadro's number: N_A
- Units of meters, kilograms, moles denoted as per convention and number of molecules of species/dry air as: $\#_z,\ z \in \{s, \alpha\}$
  We have, for the following conversion functions:
- `mmr_from_number_conc()`

$$M_R = \frac{N_C \times M_s}{\rho_\alpha \times N_A} \rightarrow \frac{\left[\frac{\#_s}{\cancel{\mathrm{m}^3}}\right]\left[\frac{\mathrm{kg}_s}{\mathrm{mol}_s}\right]}{\left[\frac{\mathrm{kg}_\alpha}{\cancel{\mathrm{m}^3}}\right]\left[\frac{\#}{\mathrm{mol}}\right]} = \frac{\left[\cancel{\#_s}\right]\left[\mathrm{kg}_s\right]}{\left[\mathrm{kg}_\alpha\right]\left[\frac{\#}{\cancel{\mathrm{mol}}}\right]\left[\mathrm{mol}_s\right]\cancel{\#_s}} = \frac{\left[\mathrm{kg}_s\right]}{\left[\mathrm{kg}_\alpha\right]}$$

- `number_conc_from_mmr()`

$$N_C = \frac{M_R \times \rho_\alpha \times N_A}{M_s} \rightarrow \frac{\left[\frac{\cancel{\mathrm{kg}_s}}{\cancel{\mathrm{kg}_\alpha}}\right]\left[\frac{\cancel{\mathrm{kg}_\alpha}}{\mathrm{m}^3}\right]\left[\frac{\#}{\mathrm{mol}}\right]}{\left[\frac{\cancel{\mathrm{kg}_s}}{\mathrm{mol}_s}\right]} = \frac{\cancel{\left[\frac{\#}{\mathrm{mol}}\right]}\cancel{[\mathrm{mol}_s]}^{\#_s}}{\mathrm{m}^3} = \frac{\#_s}{\mathrm{m}^3}$$

- `mmr_from_vmr()`

$$M_R = \frac{V_R \times M_s}{M_\alpha} \rightarrow \frac{\left[\frac{\cancel{\mathrm{mol}_s}}{\cancel{\mathrm{mol}_\alpha}}\right]\left[\frac{\mathrm{kg}_s}{\cancel{\mathrm{mol}_s}}\right]}{\left[\frac{\mathrm{kg}_\alpha}{\cancel{\mathrm{mol}_\alpha}}\right]} = \left[\frac{\mathrm{kg}_s}{\mathrm{kg}_\alpha}\right]$$

- `vmr_from_mmr()`

$$V_R = \frac{M_R \times M_\alpha}{M_s} \rightarrow \frac{\left[\frac{\cancel{\mathrm{kg}_s}}{\cancel{\mathrm{kg}_\alpha}}\right]\left[\frac{\cancel{\mathrm{kg}_\alpha}}{\mathrm{mol}_\alpha}\right]}{\left[\frac{\cancel{\mathrm{kg}_s}}{\mathrm{mol}_s}\right]} = \left[\frac{\mathrm{mol}_s}{\mathrm{mol}_\alpha}\right]$$