Gas Calculations and MIPS

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The atmospherics simulation in Stationeers currently features seven gasses that behave according to most ideal gas laws.

Name	Formula (g)	Specific heat (c_g)
Hydrogen	H_2	20.4
Nitrogen	N_2	20.6
Oxygen	O_2	21.1
Pollutant	X	24.8
Carbon dioxide	CO_2	28.2
Water	H_2O	72
Nitrous oxide	N_2O	23

Where specific heat is given in joules per mole Kelvin (and note that a joule is equivalent to a liter kilo-pascal). We will index these gases via their formula, and let G be the set of indices:

$$G = \{ \mathrm{H_2}, \mathrm{N_2}, \mathrm{O_2}, \mathrm{X}, \mathrm{CO_2}, \mathrm{H_2O}, \mathrm{N_2O} \}.$$

1 Moles and pressures in compositions

Fix A a gas mixture, and let $g \in G$ be the index of one of the seven gases. We define n_A to be the total number of moles of any and all gases in A, and $n_A(g)$ to be the number of moles of gas g specifically in A.

Note that P_{AB} is the sum of the pressures (partial pressures) P_A and P_B.

2 Combining gas compositions

Let A and B be gas compositions, and let P_A be the kilo-pascal pressure of composition A, T_A the kelvin temperature, n_A the total moles, and $n_A(g)$ the moles of gas g; similarly for B. Then for T_{AB} the resulting temperature of combining the compositions:

$$T_{AB} = \frac{T_A S_A + T_B S_B}{S_A + S_B} \tag{1}$$

Where, for M either A or B

$$S_M = \frac{s_M}{n_M} \tag{2}$$

And where

$$s_M = \sum_{g \in G} s_M(g) \tag{3}$$

$$s_M(g) = n_M(g) \cdot c_g \tag{4}$$

3 Mixing two gas compositions

3.1 Final temperature

Let A and B be gas compositions, and let P_A, T_A, r_A and $n_A(g)$ be the kilo-pascal pressure, Kelvin temperature, mixer ratio, and moles of gas $g \in G$ for composition A; similarly for B. The final temperature T_{AB} of mixing the compositions via either a gas mixer in a 1:1 ratio, or moving all gas from one volume to another, is calculated:

$$T_{AB} = \frac{T_A S_A + T_B S_B}{S_A + S_B} \tag{5}$$

Where, for M_1 either A or B and $M_2 = A$ if M_1 is B, or $M_2 = B$ if M_1 is A

$$S_{M_1} = p_{M_1} r_{M_1} s_{M_1} \tag{6}$$

And where

$$p_{M_1} = \frac{P_{M_2}}{P_{AB}} \tag{7}$$

$$s_{M_1} = \sum_{g \in G} s_{M_1}(g) \tag{8}$$

$$s_{M_1}(g) = \frac{n_{M_1}(g) \cdot c_g}{n_{M_1}} \tag{9}$$

3.2 Total moles in AB

Considering that one composition may have more moles per volume than the other, the mixer will only function for as long as both compositions have pressure.

3.3 Final pressure

Using the ideal gas law, where V_{AB} is the sum of volumes down downstream from the mixer, $n_{AB} = n_A + n_B$ the total moles, and $R \doteq 8.314$ the ideal gas law constant:

$$P_{AB} = \frac{n_{AB} \cdot R \cdot T_{AB}}{V_{AB}} \tag{10}$$