# Summary of Intro to Mass balance

What is the balance equation for any conserved quantity? In Words.

In − Out + Gen − Cons. = Accumulation

General Equation:

$$\frac{dM}{dt} = \sum_{k=1}^{K} \dot{M}_k$$

$$\frac{dN}{dt} = \sum_{k=1}^{K} \dot{N}_k$$

Closed System

$$\frac{dM}{dt} = 0$$

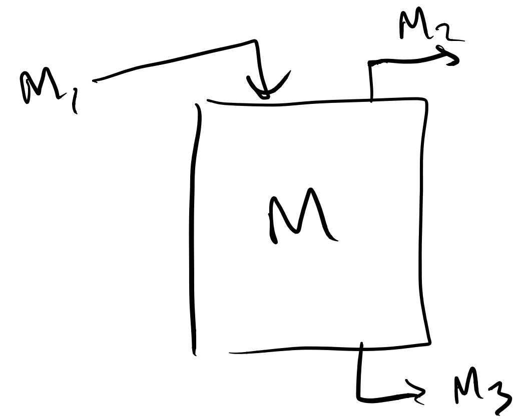
$$\frac{dN}{dt} = 0$$

A tank of Volume $V = 25 m^3$

contains $1.5 \cdot 10^4$ kg $H_2O$

Over two days, inlet delivers $2.0 \cdot 10^3$ kg, $1.3 \cdot 10^3$ kg leaves by outlet and 50 kg evaporates.

What is the mass of the water in tank after 2 days?



Stream labels are additive.

$M_3 = -1.3 \cdot 10^3$ kg
$M_2 = -50$
$M_1 = 2.0 \cdot 10^3$

values of streams can be negative

$$M(t = 2days) = M_1 + M_2 + M_3 + M(t=0)$$

$$M(t=2) - M(t=0) = 2.0 \cdot 10^3 - 1.3$$

$$M(2) - 1.5 \cdot 10^4 = 2.0 \cdot 10^3 - 1.3 \cdot 10^3 - 50$$

$$M(t = 2 days) = 15{,}650 \text{ kg}$$

1,5650

wan qian bai shi

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Storage tank.

1000 mol

if leaks one percent of the contents each minute.

how much is left after 20 minutes?

$$\frac{dN}{dt} = \dot{N}$$

what is $\dot{N}$?

1% per minute. $\rightarrow$ $\dot{N} = -0.01 \cdot N$

$\lambda$

$$\frac{dN}{dt} = -\lambda \cdot N$$

N: dependent variable
t: independent variable

In differential equations

→ Separable equation → here –

rearrange →

$$\frac{dN}{N} = -\lambda \, dt$$

$$\int_{N(t=0)}^{N(t)} \frac{dN}{N} = \int_{t=0}^{t} -\lambda \, dt$$

$$\ln(N(t)) - \ln(N(0)) = -\lambda \cdot t$$

$$\ln\left(\frac{N(t)}{N(0)}\right) = -\lambda \cdot t$$

$$\cancel{\exp}\left(\cancel{\ln}\left(\frac{N(t)}{N(0)}\right)\right) = \exp(-\lambda t)$$

$$N(t) = N(0) \exp(-\lambda \cdot t)$$

$$N(t=20) = 1000 \exp(-0.01 \cdot 20)$$

$$N(t=20) = 818.7 \text{ mol}$$

How do you use half-life in this calculation type?

Turn in for your row

Half-life: time it takes for concentration or amount to be reduced to 1/2 it's original value.

Units? = time.

So to figure out decay constant.

$$N(t) = N(0)\exp(-\lambda \cdot t)$$

your job-
find $\lambda$ in terms of $t_{1/2}$

$$N(t_{1/2}) = \frac{1}{2} N(0)$$

$$\frac{1}{2} \cancel{N(0)} = \cancel{N(0)} \exp(-\lambda \cdot t_{1/2})$$

$$\ln\left(\frac{1}{2}\right) = -\lambda \cdot t_{1/2}$$

$$\cancel{-}\ln(2) = \cancel{-}\lambda\, t_{1/2}$$

$$\boxed{\lambda = \frac{\ln(2)}{t_{1/2}}}$$

# Mass balance w/ chemical Reactions

Differential balance equation for systems w/ chemical Reaction:

Differential form:

$$\boxed{\frac{dN_i}{dt} = \sum_{k=1}^{K} (\dot{N}_i)_k + \left(\frac{dN_i}{dt}\right)_{rxn}}$$

Difference form:

$$\boxed{N_i(t_2) - N_i(t_1) = \sum_{k=1}^{K} \int_{t_1}^{t_2} (\dot{N}_i)_k \, dt + (\Delta N_i)_{rxn}}$$

With Reactions, we have to work w/ stoichiometry

$$C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2$$

(1) (1) (1)

(2) (1) (2)

$$2\,H_2 + O_2 \rightarrow 2\,H_2O$$

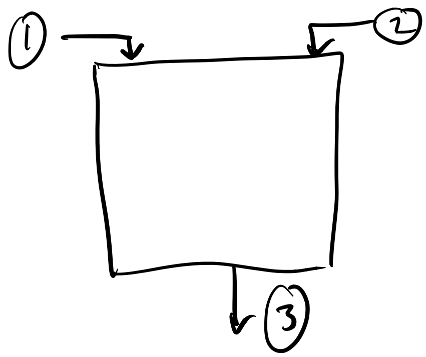
$$H_2 + \tfrac{1}{2}\,O_2 \rightarrow H_2O$$

(1) $\left(\tfrac{1}{2}\right)$ (1)

$C_2H_4$

$Cl_2$

$C_2H_4Cl_2$




$$C_2H_4 \quad \left(\frac{dN_{C_2H_4}}{dt}\right) = \left(\dot{N}_{C_2H_4}\right)_1 + \left(\dot{N}_{C_2H_4}\right)_3 + \left(\frac{dN_{C_2H_4}}{dt}\right)_{RXN}$$

$$\left(\frac{dN_{Cl_2}}{dt}\right) = \left(\dot{N}_{Cl_2}\right)_2 + \left(\dot{N}_{Cl_2}\right)_3 + \left(\frac{dN_{Cl_2}}{dt}\right)_{RXN}$$

$$\left(\frac{dN_{C_2H_4Cl_2}}{dt}\right) = \left(\dot{N}_{C_2H_4Cl_2}\right)_3 + \left(\frac{dN_{C_2H_4Cl_2}}{dt}\right)_{RXN}$$

$$\left(\frac{dN_{C_2H_4Cl_2}}{dt}\right)_{RXN} = -\left(\frac{dN_{Cl_2}}{dt}\right)_{RXN} = -\left(\frac{dN_{CH_4}}{dt}\right)_{RXN}$$