ii. MOLAR BALANCES

- ANOTHER WAY TO QUANTIFY "MATERIAL". ONLY PRACTICAL IF CHEMICAL IDENTITY OF MATERIAL IS KNOWN.
- IN CONTRAST TO MASS, THE TOTAL NUMBER OF MOLES CAN CHANGE. THEREFORE FOR BOTH A SPECIES BALANCE & THE OVERALL BALANCE THERE IS A GENERATION TERM

OVERALL

ACC MOLES IN SYSTEM = MOLES INTO SYSTEM − MOLES OUT OF SYSTEM + MOLES GENERATED IN SYSTEM

SPECIES

ACC MOLES OF SPECIES IN SYSTEM = MOLES OF SPECIES INTO SYSTEM − MOLES OF SPECIES OUT OF SYSTEM + MOLES OF SPECIES GENERATED IN SYSTEM

ILLUSTRATION THAT MOLES MAY BE GENERATED OR CONSUMED:

$$3H_2 + N_2 \rightarrow 2NH_3$$

4 moles → 2 moles

iii. ATOMIC BALANCES

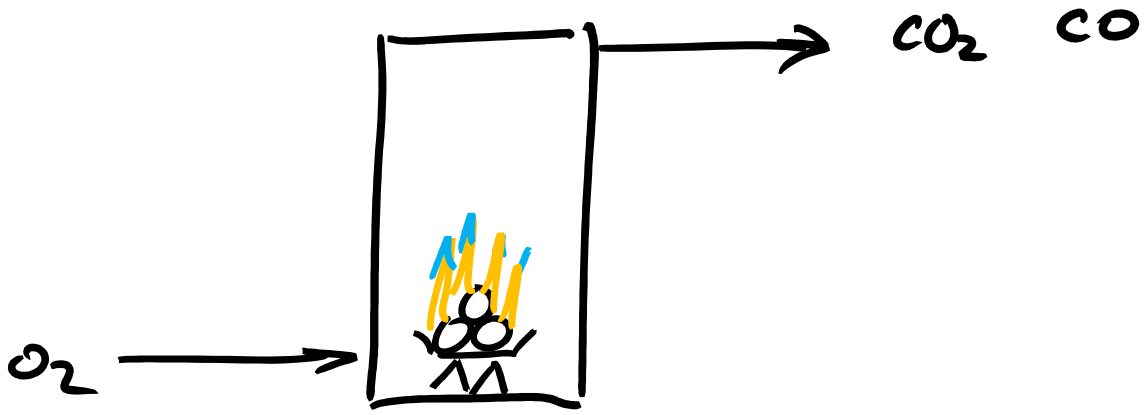
- REFERS TO A BALANCE OF 1 ELEMENT WITHIN ALL COMPONENTS IN THE SYSTEM
- REALLY ANOTHER TYPE OF SPECIES BALANCE. WE ARE ABLE TO CONCEPTUALIZE & DISTINGUISH A UNIT SMALLER THAN A MOLECULE.

ATOMIC

$$\text{ATOM ACC} = \text{ATOM IN} - \text{ATOM OUT}$$

EXAMPLE 3

2710g OF WOOD COMPOSED OF 38.1% CARBON BY MASS IS BURNED IN A FIREPLACE YIELDING 113g OF ASH CONTAINING 82.4% CARBON. 2930g CO_2 IS COLLECTED FROM FIREPLACE. IF ALL THE REMAINING CARBON EXITS AS CO, HOW MUCH CO ENTERS ENVIRONMENT?



CARBON BALANCE

$$ACC = IN - OUT_{CO_2} - OUT_{CO}$$

$$ACC = \text{FINAL STATE IN SYSTEM} - \text{INITIAL STATE IN SYSTEM}$$

$$ACC = (113\,g)(0.824) - (270\,g)(0.381)$$

$$ACC = -939.4\,g$$

$IN = 0$

$OUT_{CO_2} = ?$

2930 g CO_2

1 mol CO_2 — 12.0 g C, 32.0 g O

44.0 g TOTAL

MASS FRACTION OF C IN $CO_2 = \frac{12}{44}$

$= 0.273$

$$OUT_{CO_2} = (2930\,g)(0.273) = 799.0\,g$$

$$-939.4\,g = 0 - 799.0 - OUT_{CO}$$

$$OUT_{CO} = 140.4\,g\ C$$!!

1 mol CO = 12.0 g + 16.0 g = 28.0 g TOTAL

MASS FRACTION OF C IN CO IS $\frac{12}{28} = 0.429$

$$140.4\,g = (0.429)\,M_{CO}^{OUT}$$

$$M_{CO}^{OUT} = 327.3\,g$$

iv. MATHEMATICAL EXPRESSIONS

LET $\dot{m}_i$ = MASS FLOWRATE OF SPECIES i (MASS/TIME)

MASS

Q = VOLUMETRIC FLOWRATE (VOLUME/TIME)

ρ_i = MASS CONC. OF SPECIES i

$= \dot{m}_i / Q$

RARELY USED. ---→ r_i = RATE OF MASS OF SPECIES i GENERATED

MOLES

$\dot{n}_i$ = MOLAR FLOWRATE OF SPECIES i (MOLES/TIME)

c_i = MOLAR CONC. OF SPECIES i

$= \dot{n}_i / Q$

COMMONLY USED ----→ R_i = RATE OF MOLES OF SPECIES i GENERATED

EXAMPLES

FOR A (MASS) SPECIES BALANCE

$$\text{RATE OF ACC} = \text{RATE IN} - \text{RATE OUT} + \text{RATE GEN}$$

$$\text{RATE OF ACC} = \frac{dm_i}{dt}$$

$$\text{RATE IN} = \dot{m}_i^{IN,1} + \dot{m}_i^{IN,2} + \dot{m}_i^{IN,3} + \ldots$$

SUPERSCRIPT INDICATES NAME OF STREAM

i SPECIES

$$\text{RATE OUT} = \dot{m}_i^{OUT,1} + \dot{m}_i^{OUT,2} + \dot{m}_i^{OUT,3} + \ldots$$

$$\text{RATE GEN} = Vr_i$$

SHORTHAND:

$$\frac{dM_i}{dt} = \sum_{IN} \dot{m}_i - \sum_{OUT} \dot{m}_i + Vr_i$$

NOTES:

1. "ACCUM" & "GEN" TERMS DESCRIBE WHAT'S GOING ON INSIDE SYSTEM.
2. EACH TERM HAS UNITS OF "MASS/TIME"
3. $\dot{m}_i$ AND M_i REFER TO DIFFERENT QUANTITIES

SORRY

M_i - THE MASS OF A SPECIES INSIDE SYSTEM

$\dot{m}_i$ - THE MASS FLOWRATE OF A SPECIES INTO SYSTEM

ANOTHER WAY TO WRITE SAME BALANCE...

$$\dot{m}_i = Q\rho_i$$

$$m_i = V\rho_i$$

$$\frac{d[V\rho_i]}{dt} = \sum_{IN}(Q\rho_i) - \sum_{OUT}(Q\rho_i) + Vr_i$$

Refers to conc inside the system

Refer to conc. in each stream

SUMMARY OF BALANCES