ABE 201
Biological Thermodynamics 1

Mass Balance Fundamentals

Review

- Systems are defined by their boundary
  - A boundary is a closed loop
- Accumulation = in – out
  + generation - consumption
- Solving Material Balance Problems
  - Organize your information
  - Draw a diagram
  - Assemble your equations
  - Solve!

Cash Register

At the start of your shift the register held $105.25.

- John bought 3 Den Pops for $.75 each.
- Sarah bought a bag of chips, a candy bar, and a Den Pop for $5.37
- Keith grabbed a five out of your drawer to make change.

Define the continuity equation terms and determine the accumulation of money in the cash register.

$$Acc = In – Out + Gen - Con$$

Steady-state? Acc not equal to 0

$$Gen = Con = 0$$

$$Acc = (3*0.75 + 5.37) – (5)$$

$$Acc = (7.62) – (5)$$

$$Acc = \$2.62$$

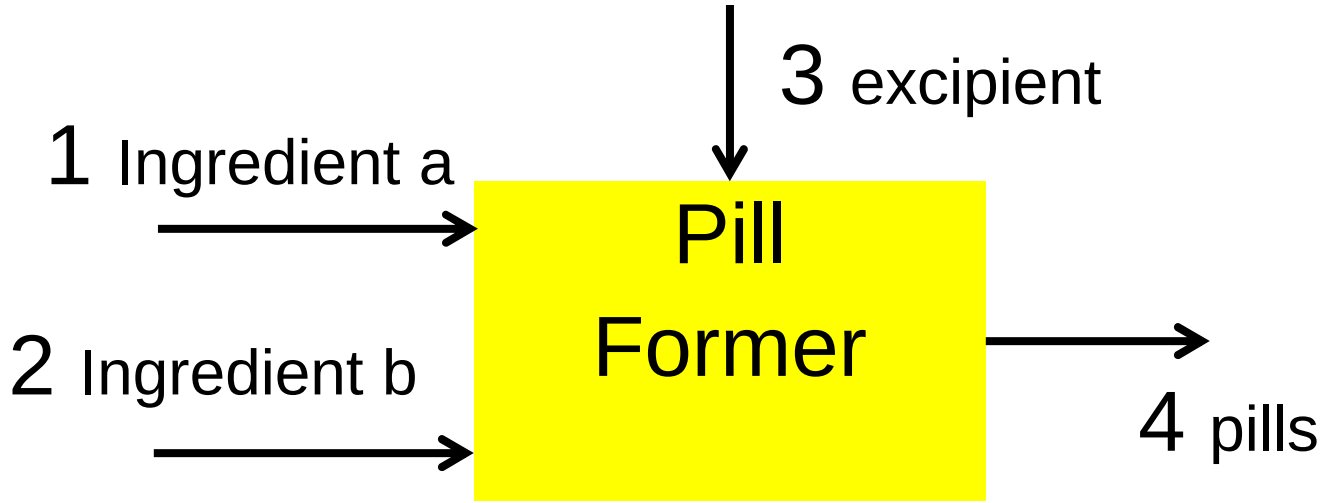
Pill Formulation

A pill former produces 120,000 pills an hour. Each pill has a mass of 1.25g and contains 50mg of the first active ingredient and 175mg of the second active ingredient. The remainder of the mass is excipient.

What are the raw material needs for this process?

- Draw and label the process diagram
- Make a table with the information given

- Decide how many materials must be tracked! All materials must be accounted for in every stream!
- Solve for necessary mass flow rates of all streams



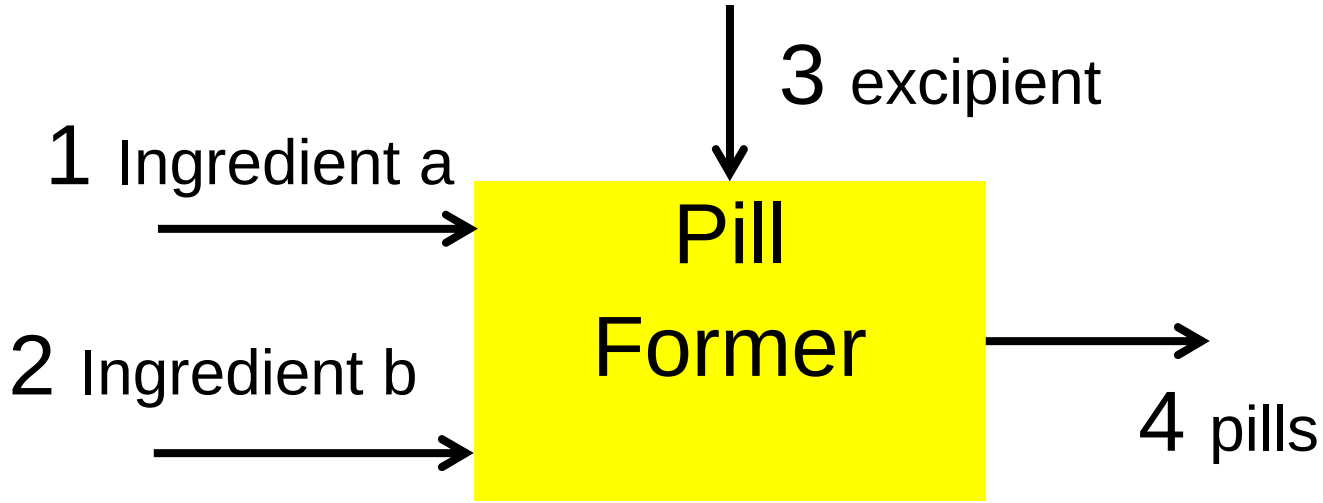
m_4 = 120,000 pills/hr * 1.25 g/pill * 1 kg/1000g = 150 kg/hr

	1	**2**	**3**	**4**
m (kg/h)	m_1	m_2	m_3	m_4
x_a	1	0	0	?
x_b	0	1	0	?
x_e	0	0	1	?

$x_{3,a} + x_{3,b} + x_{3,e} = 1$

$(0.050\ g/\ 1.25g) + (0.175\ g/\ 1.25\ g) + x_{3,e} = 1$

$x_{3,a} = 0.04$, $x_{3,b} = 0.14$, $x_{3,e} = 0.82$



m_4 = 120,000 pills/hr * 1.25 g/pill * 1 kg/1000g = 150 kg/hr

	1	**2**	**3**	**4**
m (kg/h)	m_1	m_2	m_3	150
x_a	1	0	0	0.04
x_b	0	1	0	0.14
x_e	0	0	1	0.82

$x_{3,a} + x_{3,b} + x_{3,e} = 1$

$(0.050\ g/\ 1.25g) + (0.175\ g/\ 1.25\ g) + x_{3,e} = 1$

$x_{3,a} = 0.04$, $x_{3,b} = 0.14$, $x_{3,e} = 0.82$

Acc = In – Out + Gen - Con

Total Mass

$$0 = (m_1 + m_2 + m_3) - (m_4) + 0 - 0$$

$$0 = (m_1 + m_2 + m_3) - (150)$$

Drug a Mass

$$0 = (x_{1,a} * m_1 + x_{2,a} * m_2 + x_{3,a} * m_3) - (x_{4,a} * m_4)$$

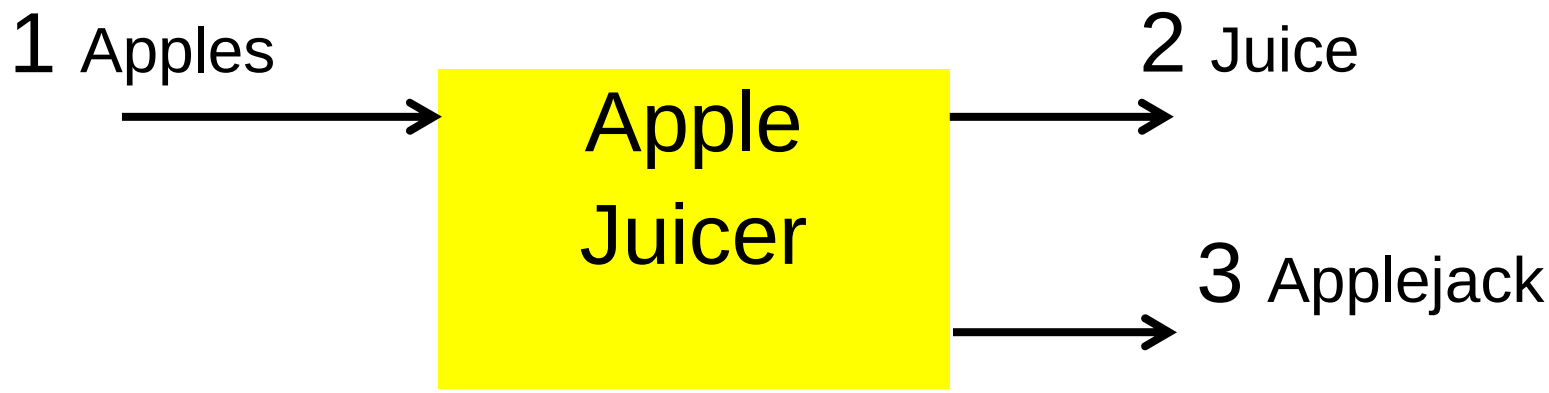
$$0 = (1 * m_1) - (0.04 * 150)$$

$$m_1 = 6 \text{ kg/hr}$$

$$m_2 = 21 \text{ kg/hr}, \; m_3 = 123 \text{ kg/hr}$$

Apple Cider

A process to make fruit drinks operating at steady-state takes in 125 kg of apples per hour and produces 88 kg of apple cider per hour. If the incoming apples have a moisture content of 80%, how much water is in the applejack if the juice is 12% sugar (and the remainder water)?



	1	2	3
m (kg/h)	125	88	m_3
X_{solid}	$X_{1,so}$	0	$X_{3,so}$
X_{water}	0.80	0.88	$X_{3,w}$
x_{sugar}	$X_{1,sg}$	0.12	$X_{2,sg}$

$x_{2,w} = 1 - 0.12 = 0.88$

Acc = In – Out + Gen - Con

$0 = (m_1) - (m_2 + m_3) + 0 - 0$

$0 = (125) - (88 + m_3) + 0 - 0$ m_3= 37 kg/hr

Water Mass

$$0 = (x_{1,w} * m_1) - (x_{2,w} * m_2 + x_{3,w} * m_3)$$

$$0 = (0.80 * 125) - (0.88 * 88 + x_{3,w} * 37)$$

$$x_{3,w} = 0.61$$