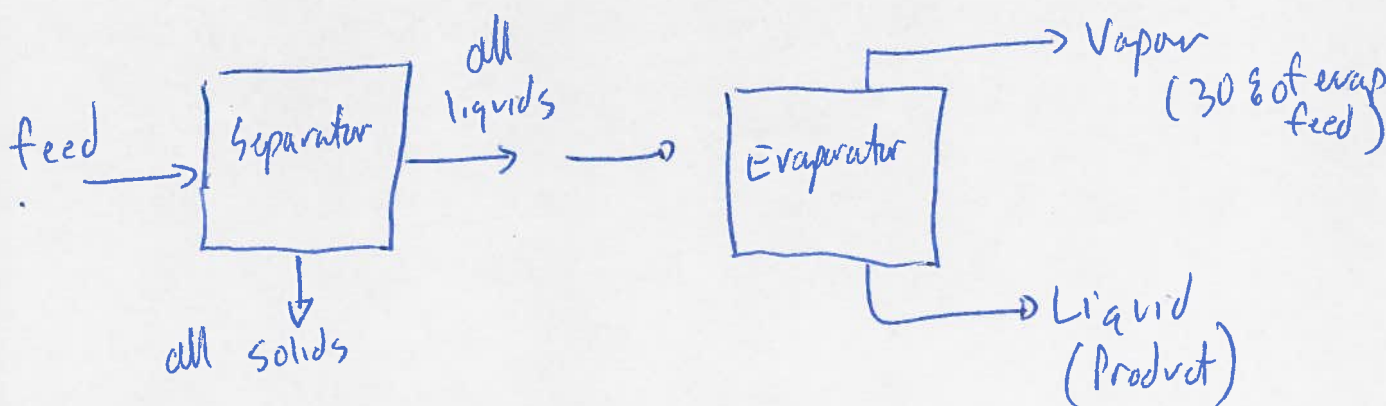


6. A liquid stream containing 80% by mass H_2O , 15% by mass dissolved $NaOH$ and 5% by mass suspended solids (small 1 cm diameter particles of plastic). The liquid stream is moving at a rate of 500 kg/h. The stream passes through a separator where all of the plastic is removed by settling. After the separator, the liquid is sent to an evaporator. In the evaporator, heat is added to boil some of the liquid. In this evaporator, 30% of the water is removed in a vapour stream (the vapour contains no $NaOH$). All of the remaining liquid is the product.

- Calculate the rate of plastic removal in the separator. (/2)
- Calculate the total flow rate entering the evaporator (/2)
- Determine the flow rate of the product stream (/3)
- What is the proportion (%) of $NaOH$ in the product stream? (/4)



$$\text{Feed} = 500 \text{ kg/h} \quad W_{H_2O} = 0.80$$

$$W_{NaOH} = 0.15$$

$$W_{plastic} = 0.05$$

- a) mass balance on plastic in separator

$$I + G = O + A$$

$$IN = OUT$$

$$(500 \text{ kg/h})(0.05) = OUT = \boxed{25 \text{ kg/h}}$$

- b) mass balance on everything in separator

$$I + G = O + A$$

$$IN = OUT1 + OUT2$$

$$500 \text{ kg/h} = 25 \text{ kg/h} + OUT2$$

$$OUT2 = \boxed{475 \text{ kg/h} = \text{feed to evap}}$$

EXTRA WORK (Q6)

c) mass balance on water on evaporator

$$I + G = O + A$$

$$I_N = OUT_1 + OUT_2$$

$$\cancel{475 \text{ kg/h}} \quad \text{VAPOUR} \quad \text{LIQUID}$$
$$(500 \text{ kg/h})(0.80) = 0.30(500)(0.80) + OUT_2$$

$$400 \text{ kg/h} = 120 \text{ kg/h} + OUT_2$$

$$OUT_2 = 280 \text{ kg/h water in product}$$

overall balance on separator

$$I + G = O + A$$

$$I_N = OUT_1 + OUT_2$$

$$475 \text{ kg/h} = 120 \text{ kg/h} + OUT_2$$

$$\boxed{OUT_2 = 355 \text{ kg/h product}}$$

d) Fraction of NaOH in product

$$355 \text{ kg/h} - 280 \text{ kg/h} = 75 \text{ kg/h NaOH in product}$$

$$\text{fraction (\%)} = 100 \frac{75 \text{ kg/h NaOH}}{355 \text{ kg/h TOTAL}} = 0.21(100)$$
$$= \boxed{21.1\%}$$