

# CHEMICAL PROCESS CALCULATIONS

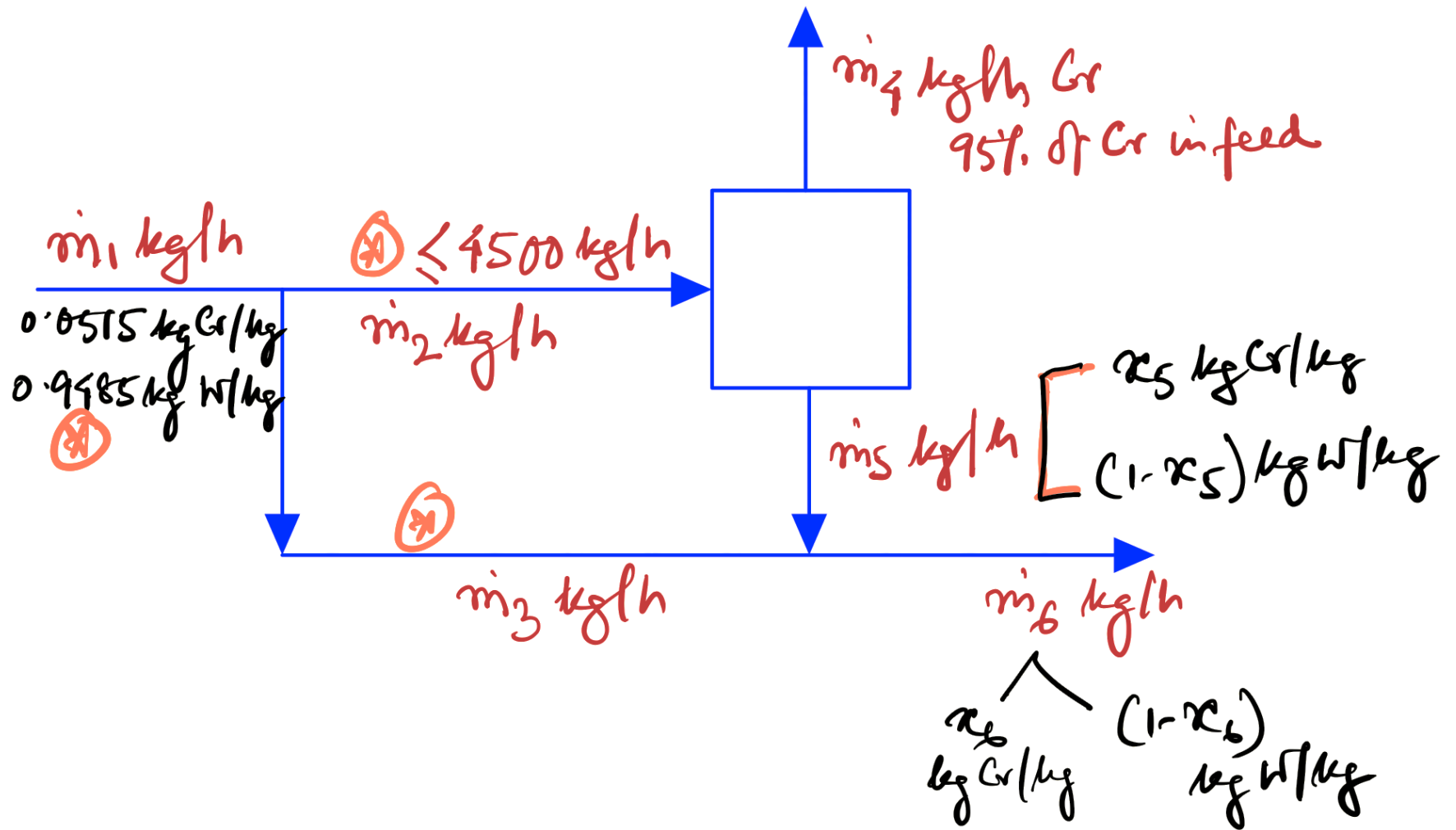
**(Material Balance Calculations: Fundamentals & Single Unit)**

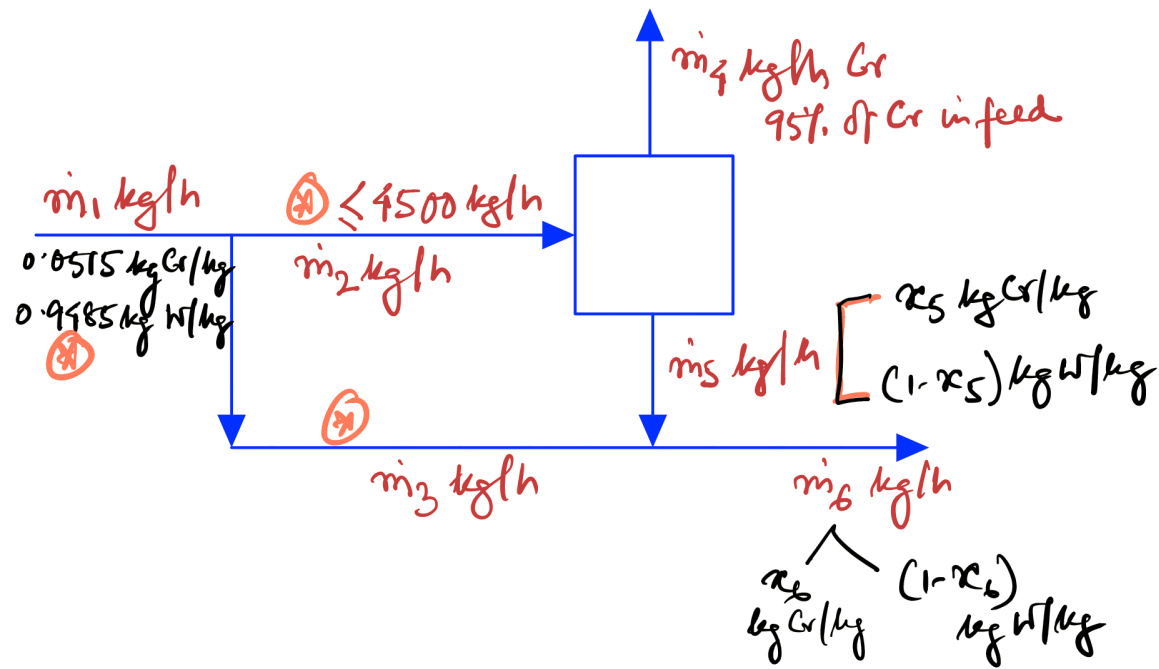
Lecture # 9: September 12, 2022

A stream containing 5.15 wt% chromium (Cr) is contained in the wastewater from a metal finishing plant. The wastewater stream is fed to a treatment unit that removes 95% of the chromium in the feed and recycles it to the plant. The residual liquid stream leaving the treatment unit is sent to a waste lagoon. The treatment unit has a maximum capacity of 4500 kg wastewater/h. If wastewater leaves the finishing plant at a rate higher than the capacity of the treatment unit, the excess (anything above 4500 kg/h) bypasses the unit and combines with the residual liquid leaving the unit, and the combined stream goes to the waste lagoon.

(a) Without assuming a basis of calculation, draw and label a flowchart of the process.

(b) Wastewater leaves the finishing plant at a rate 6000 kg/h. Calculate the flow rate of liquid to the waste lagoon, and the mass fraction of Cr in this liquid.





$$\dot{m}_1 = 6000 \text{ kg/h}$$

$$\Rightarrow \dot{m}_2 = 4500 \text{ kg/h}$$

Treating unit mass:

$$\dot{m}_2 = \dot{m}_4 + \dot{m}_5$$

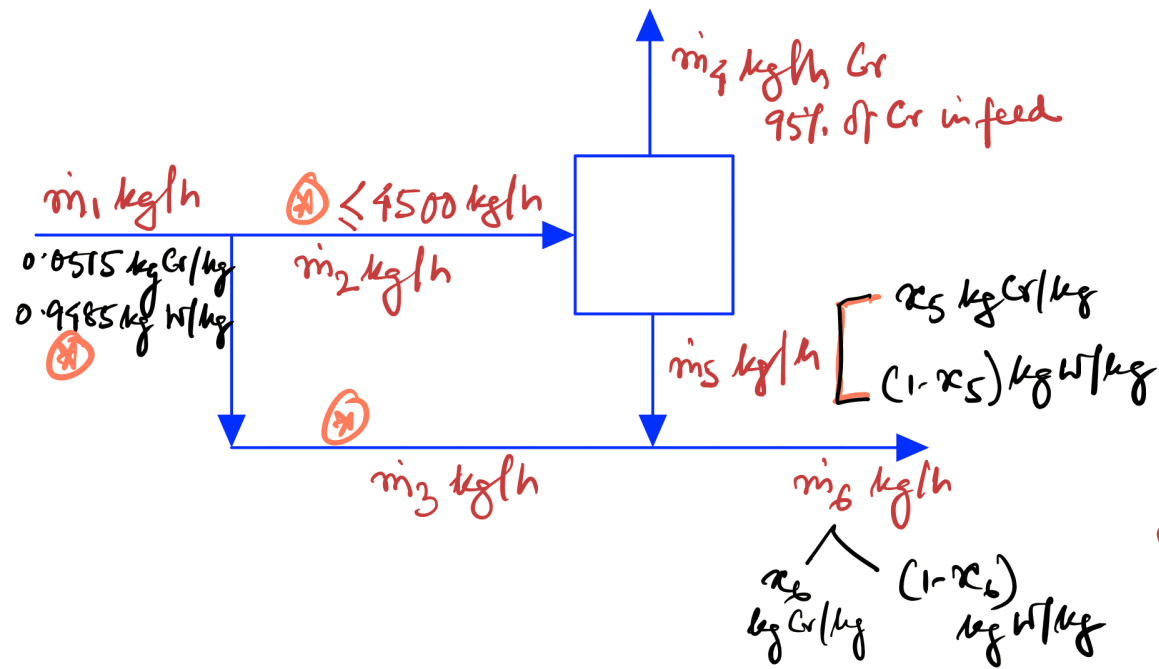
$$\Rightarrow \dot{m}_5 = 4279.8 \text{ kg/h}$$

Bypass Mass:

$$\dot{m}_1 = \dot{m}_2 + \dot{m}_3$$

95% Cr removal

$$\dot{m}_4 = 0.95 \times (0.0515 \times 4500) = 220.2 \text{ kg Cr/h}$$



Treating Unit - Cr:

$$0.0515 \dot{m}_2 = \dot{m}_4 + x_5 \dot{m}_5$$

$$\Rightarrow x_5 = 0.002699 \text{ kg Cr/kg}$$

Mixing point mass:

$$\dot{m}_5 + \dot{m}_3 = \dot{m}_6$$

$$\Rightarrow \dot{m}_6 = 5779.8 \text{ kg/h}$$

Mixing point Cr:

$$\dot{m}_5 x_5 + \dot{m}_3 \times 0.0515 = \dot{m}_6 x_6$$

$$\Rightarrow x_6 = 0.0154 \text{ kg Cr/kg}$$

# Stoichiometry

- Proportion of chemical species that combine with one another
- Relative number of molecules/moles of reactants and products in a reaction
- Number of atoms of any atomic species on both sides of a reaction must be same
- Stoichiometric coefficients
- Stoichiometric ratio