Worksheet: Material balances on a stripping column

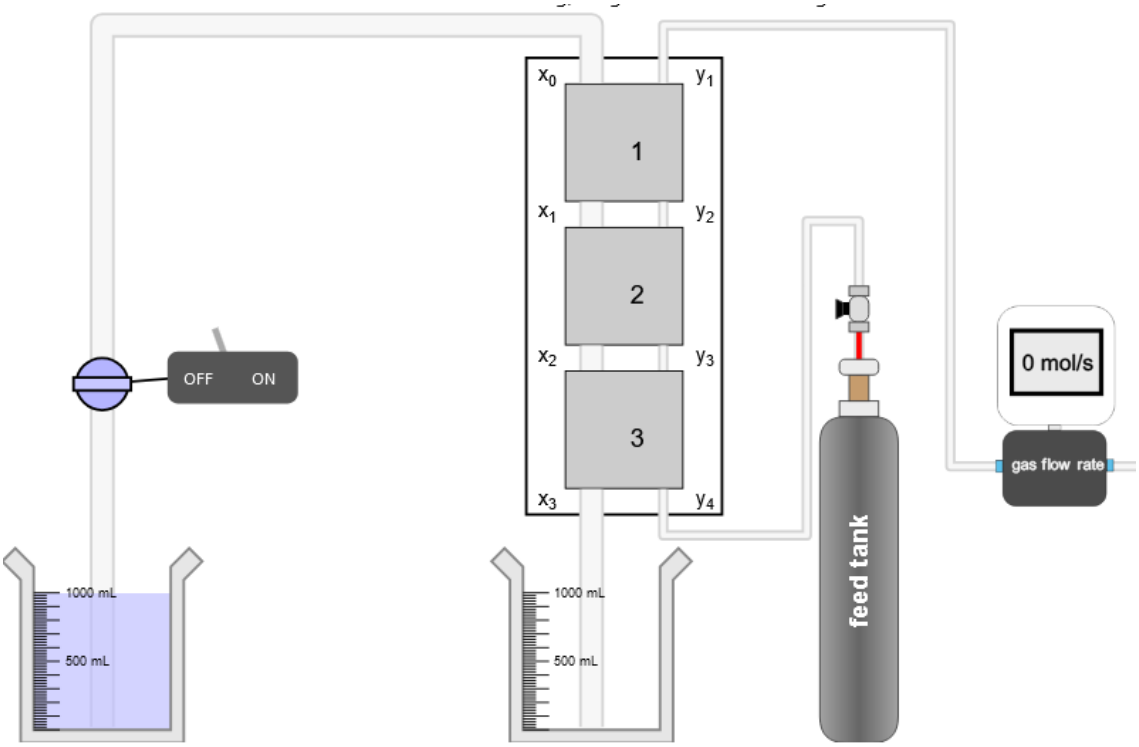
Name(s) _____

This experiment applies material balances to a trayed stripping column that removes an impurity from a liquid feed by stripping the impurity into a gas stream. This is a steady-state counter-flow experiment.

Student learning objectives

1. Be able to apply material balances to a system.
2. Be able to explain what happens in a stripping column.
3. Be able to apply the relation between gas-phase mole ratio and liquid-phase mole ratio (Henry's law).

Equipment



The system consists of three stages where the liquid phase (water) flows down and the gas phase flows up. The phases leaving each stage are in phase equilibrium. The equilibrium is described by Henry's law: $yP = Hx$

where y is the mole ratio of solute flow rate in the gas to total gas-phase flow rate and x is the mole ratio of solute flow rate in the liquid phase to the total liquid flow rate.

H = Henry's constant (bar)

P = pressure (bar)

Questions to answer before starting the experiment

How many independent mass balances can you write for this stripping column? Explain.

The two phases contact each other in a counter-current flow. What might be the advantage of counter-current flow over co-current flow?

Where is the highest concentration of solute, at the top or the bottom of the column? Why?

Procedure:

The system pressure is 1.0 bar.

1. Click on the valve above the gas tank to open it and start gas flow.
2. Turn on the liquid pump and click on the corresponding valve to start liquid water (with dissolved solute) flow into the column.
3. Record the flow rate of the gas. gas flow rate: _____ mole/s
4. Use the timer on your phone and measure a change in volume in the outlet beaker. Calculate the liquid mass flow rate and molar flow rate.

Starting volume (mL)	Stopping volume (mL)	Elapsed time (s)	Volumetric flow rate (mL/s)	Mass flow rate (g/s)	Molar flow rate (mol/s)

6. Move the mouse over each stream and record the solute mole ratio.

Stream	Solute mole ratio (ppm)
x_0	
x_1	
x_2	
x_3	
y_1	
y_2	
y_3	
y_4	

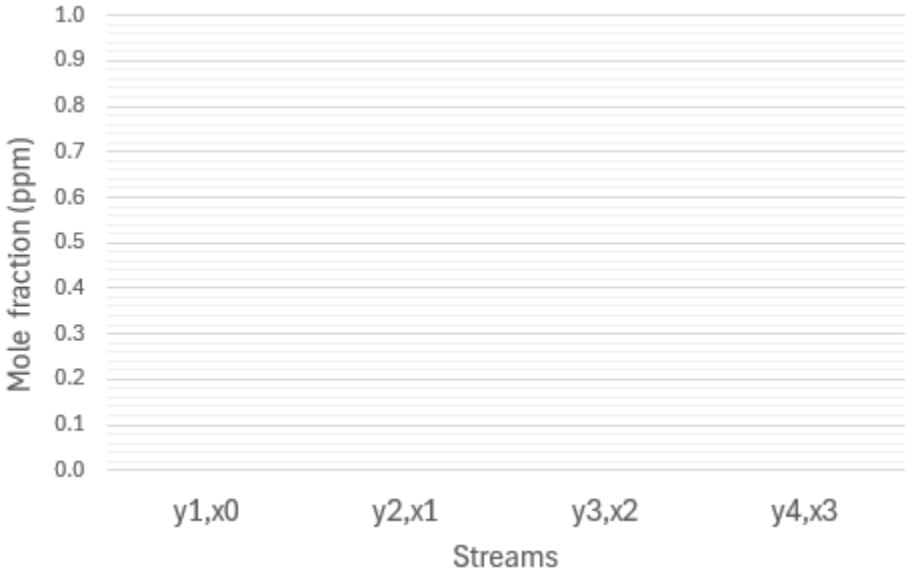
Data Analysis:

Carry out mass balances on the solute for each stage to determine if mass balances are satisfied.

The streams leaving each stage (e.g., x_1 and y_1) are in equilibrium. Determine the Henry's law constant for each stage from the equation $yP = Hx$.

Stage	H (bar)
1	
2	
3	
average	

Plot the solute mole ratios for the gas phase and the liquid phase.



Questions to answer

1. Where might these measurements have errors?

2. What safety precautions would you take to conduct this experiment in the laboratory?

3. To make the process more effective, would you run at low pressure or high pressure? Why?

4. To make this process more effective, would you run at low temperature or high temperature? Why?