

**ECHE 260: Introduction to Chemical Systems, Fall 2024**

**Homework #1 (50 points)**

Conceptual Questions and Short Answers (based on pre-reqs):

1. (5 points) For the equation:

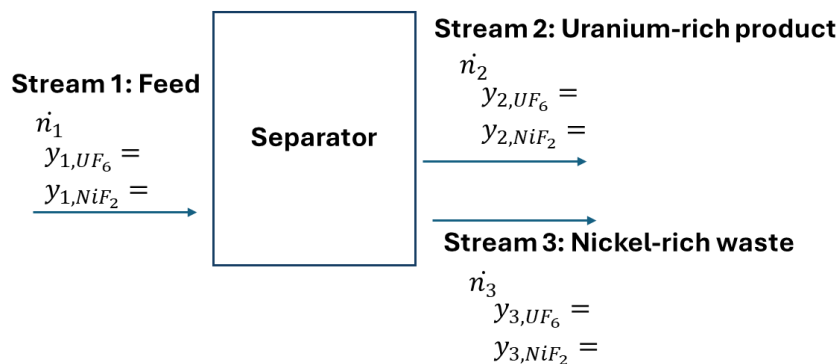
$$m * V^{-b} = \frac{T-c}{a}$$

Where V is volume (L), *m* is mass (kg), T is Temperature (K).

- What are the units of the constant, *b*? Justify your answer.
  - What are the units of the constant, *c*? Justify your answer.
  - What are the units of the constant, *a*? Justify your answer.
2. (5 points) A student filled a 1 L flask with maple syrup (density = 1.34 g/mL) in 2 minutes through a funneling spigot. The time to fill the same flask with water using at the same mass flow rate would be \_\_\_\_\_. Without doing any calculations, justify your answer. You may use equations but do not do a numerical calculation.
- Shorter than with maple syrup
  - Longer than with maple syrup
  - The same as maple syrup
3. (5 points) Rank the following from least number of significant figures to most number of significant figures. You can use inequalities and equalities (> and =).
- $\pi$
  - Ideal gas constant,  $R = 0.821 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K}$
  - 3,000
  - $3.0 \times 10^{-5}$

Quantitative Problem (using Excel):

4. (30 points) At a nuclear fuel fabrication facility, uranium oxide is converted to gaseous uranium hexafluoride ( $\text{UF}_6$ ). Unfortunately, some undesired species are also volatilized (made gaseous) like nickel fluoride ( $\text{NiF}_2$ ). The mixture of  $\text{UF}_6$  and  $\text{NiF}_2$  are fed to a separator which is shown below.



For parts a-c, you must derive all equations by hand and submit them as part of the handwritten PDF solution. You must write and box your final answer. You will submit the excel spreadsheet separately for proof-reading.

- The mol fraction of uranium in the feed,  $y_{1,\text{UF}_6} = 0.82$ . What is the mass fraction of  $\text{UF}_6$  in the feed?
  - Use the provided excel template to practice referencing cells and see an example of a fully labeled spreadsheet (descriptive titles, variables with units)
- In this process, the mixed gas is fed at a temperature of 298K and a molar flowrate of 100 mol/s. Assume an ideal gas—what is the volumetric flowrate of the feed mixture (L/s)? You should do this calculation for a range of pressures (10 mbar to 100 mbar). You can use increments of 10 mbar in your spreadsheet.
- Radioactive species and mixtures can be described by a property called the *specific activity* ( $SA$ ) which is quantified as the decay rate per unit mass. A typical unit of activity is Becquerels per gram (Bq/g). One Bq represents 1 decay per second. In this scenario specific activity for the  $\text{UF}_6$  is 8,000 Bq/g. The specific activity for  $\text{NiF}_2$  is 500 Bq/g. What is the average specific activity for the feed stream?

Reflection (no Excel)

5. (5 points) Review the learning objectives from Unit 1. In which problems on the HW were the objectives tested? You can make a list.