

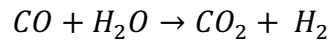
# Introduction to Chemical Engineering

## Problem Sheet 4 – Week 5 – October 10, 2025

**Goals:** The aim of this exercise is to practice applying material balance principles to both reactive and non-reactive systems involving recycle and separation processes. Through these problems, students will strengthen their understanding of system decomposition, degree-of-freedom analysis, and process flow determination.

## Problem 1: Material Balance, Reactive Systems (Midterm 2024-2025)

Hydrogen can be produced by the shift reaction:

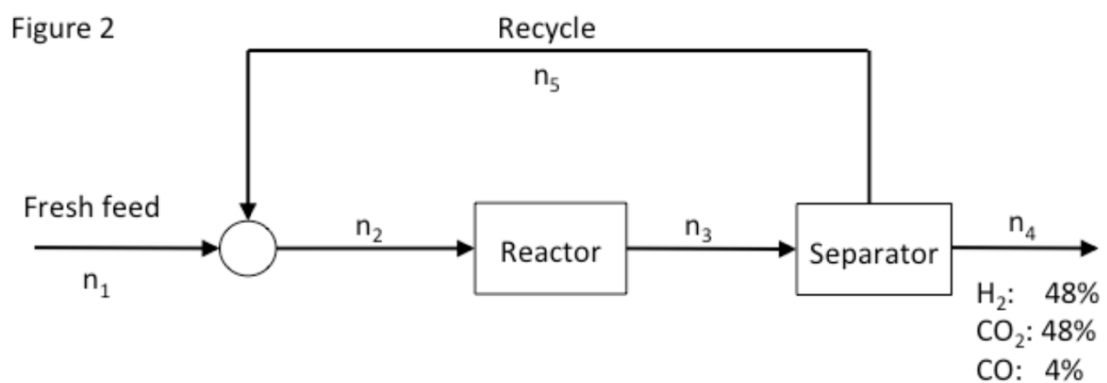


In the reactor system shown in Figure 2, the conditions of conversion have been adjusted so that the  $H_2$  content of the effluent from the reactor is 3%. The composition of the stream that enters in the reactor is 70%  $H_2O$  and 30%  $CO$ . The recycle stream contains only  $H_2O$  and  $CO$ . (All the stream compositions are in mole %).

Basis:  $n_1 = 100 \text{ mol/h}$ .

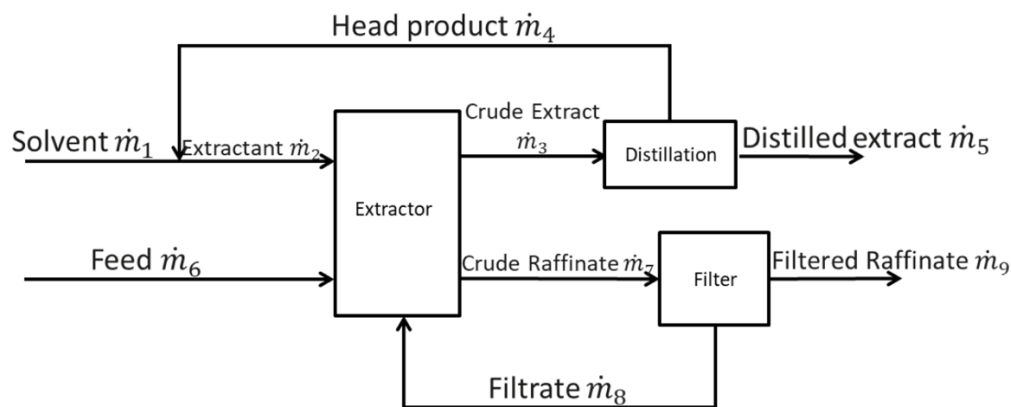
a) Calculate the flow and composition of all streams.

b) Calculate the moles of recycle per mole of hydrogen produced.



## Problem 2: Mass Balance in Non-Reactive Systems (Midterm 2024-2025)

Modern processing plants extract soybean oil by solvent liquid transfer. Extraction occurs by successive washes of hexane solvent. Below is a simplified diagram of the process. The beans are washed in an extractor using hexane. The oil-solvent mixture is then sent to a distillation column, where the oil is sent to storage and the hexane recycled back to the extractor. The washed beans are also sent to a filter to salvage residual hexane, which is then recycled back to the extractor.



Consider the following:

- Each 102 kg of the feed to the extractor contains 2 kg of oil.
- 5%w of feed oil remains in the crude raffinate leaving the extractor.
- For every 100 kg of soybeans fed to the extractor, the crude raffinate (washed beans leaving the extractor, before the filter) carries 25 kg of hexane.
  - The filter recovers 22 kg of that hexane as filtrate (this is recycled to the extractor).
  - the rest is discarded along with the filtered raffinate.
- Distillation head product and the crude extract contain only Hexane and Oil.
- The filtrate and the solvent supplied to the system contain only Hexane.
- The extractant entering the extractor contains 97%w Hexane.
- The crude extract entering the distillation column contains 87%w Hexane.
- The distilled extract that leaving the distillation column contains 8%w Hexane.

### Questions:

- a) Annotate the flow chart correctly with the information provided.
- b) How much Solvent Hexane must be supplied per 100kg of soybeans?

