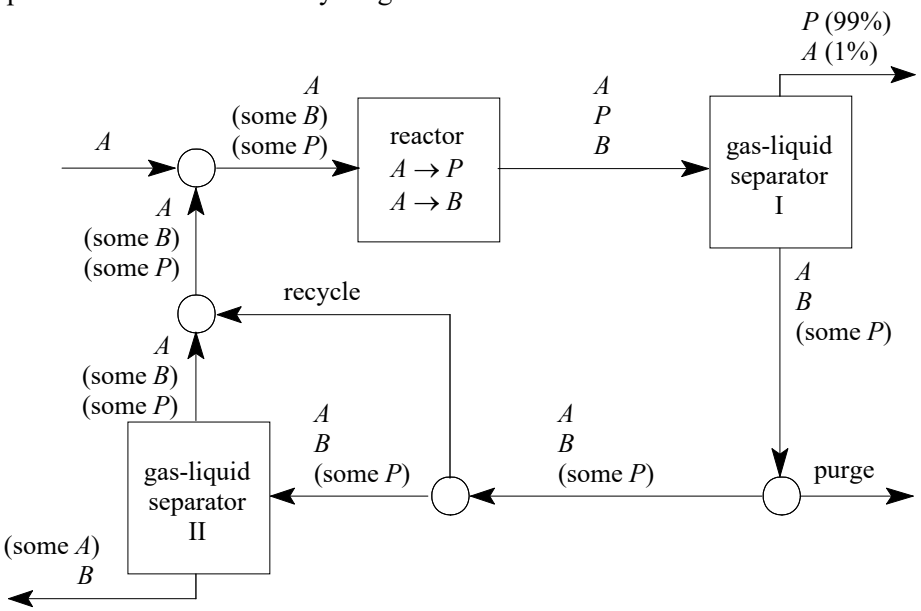
EngrD 2190 - Chemical Process Design & Analysis
Process Economic Analysis with Spreadsheets - 2025

Your company has decided to produce P by the reaction $A \rightarrow P$. Unfortunately, there is a parallel reaction, $A \rightarrow B$. Both reactions are irreversible. Both reactions are incomplete; the reactor effluent contains reactant A, product P and worthless by-product B.

The boiling points at 1 atm are P (30°C), A (50°C), and B (55°C). Purifying P to ≥99% (minimum purity to sell) by distillation is easy, but separating A and B is more difficult.

A generic process is shown below. To produce and sell product P, you need only a reactor and separator I. The A+B mixture in the separator I liquid bottoms stream is recycled with an imperfect second separator to separate A from B before recycling.



There are two options for the reactor. Reactor Type 1 has a high conversion of A but has poor selectivity for P over B. Reactor Type 2 has a lower conversion of A, but has better selectivity for P over B.

There are two options for separator I. Both options produce a tops product with 99% P, but differ by the amount of P in the liquid bottoms. Separator I Type 1 recovers more of the product P (the ratio P:A in the bottoms is <1:20). Separator I Type 2 allows more P to escape via the liquid stream, but costs less and is less expensive to operate.

There are two options for separator II. The expensive option (Type 1) has a high A:B ratio in the tops and a low A:B ratio in the bottoms. The cheaper option (Type 2) has a moderate A:B ratio in the tops and a moderate A:B ratio in the bottoms.

Because B is toxic, disposal requires special treatment and is expensive. The disposal cost is determined by the total amount of any effluent that contains B. That is, the disposal cost for 1 mol of a mixture with 10% A and 90% B is the same as the disposal cost for 1 mol with 90% A and10% B.

Goal: Start with $10,000,000 and maximize the ROI for your process in the first year. Your total expenses for the first year – purchase equipment and operate the process – must not exceed $10,000,000.