Problem 1

There are two technically viable routes to the production of a hydrocarbon solvent, S, starting with feed material A. Route 1 uses a disproportionation reaction, in which feed material A is converted to the desired solvent S and another solvent R, both of which are marketable products. Route 2 starts with the same chemical A but uses a hydrodealkylation reaction to produce the desired solvent. The reaction schemes for each process are shown below.

$$\text{Route 1} \quad 2A \rightarrow S + R$$

$$\text{Route 2} \quad A + H_2 \rightarrow S + CH_4$$

Assuming that pure A is fed to the process, the solvents S and R are separable by simple distillation, and both are much less volatile than either methane or hydrogen, sketch PFDs for Routes 1 and 2. Which process do you think will be more profitable? Explain your reasoning and assumptions.

Problem 2

Consider the following process in which liquid feed material *A* (normal BP of 110°C) is reacted with gaseous feed material *G* to produce main product *C* and by-products *R* and *S* via the following reactions:

$$A + G \rightarrow C + S$$

$$G + C \rightarrow R$$

Both feeds enter the process at ambient temperature and pressure. Both reactions occur in the gas phase at moderate temperature and pressure (250°C and 10 bar). The normal boiling points of *G, S*, and *C* are less than −120°C. By-product *R* has a normal boiling point of 75°C and is highly soluble in water. Product *C* is very soluble in water but *G* and *S* are insoluble. The single-pass conversion through the reactor is low for feed *A*, and the ratio of *G* to *A* in the feed to the reactor should be maintained in excess of 4 to minimize the chance of other unwanted side reactions. Using this information, and assuming that both *A* and *G* are expensive, do the following:

a. Draw a preliminary process flow diagram identifying the main unit operations (reactors, compressors, pumps, heat exchangers, and separators), and identify the recycle structure of the process.
b. Justify the methods used to recycle *A* and *G*.
c. What unit operations do you suggest for your separators? Justify your choices.
d. How would your PFD change if the price of feed material *G* were very low?