Name: ____________________

Date: _____________

PROBLEM 5.46

A stream of liquid n-pentane flows at a rate of 50.4 L/min into a heating chamber, where it evaporates into a stream of air 15% in excess of the amount needed to burn the pentane completely. The temperature and gauge pressure of the entering air are 336K and 208.6 kPa. The heated gas flows into a combustion furnace in which a fraction of the pentane is burned. The product gas, which contains all of the unreacted pentane and no CO, goes to a condenser in which both the water formed in the furnace and the unreacted pentane are liquefied. The uncondensed gas leaves the condenser at 275K and 1 atm absolute. The liquid condensate is separated into its components, and the flow rate of the pentane is measured and found to be 3.175 kg/min.

(a) Calculate the fractional conversion of pentane achieved in the furnace and the volumetric flow rates (L/min) of the feed air, the gas leaving the condenser, and the liquid condensate before its components are separated.

Strategy

As we have said several times, the key to solving most of the problems in the text is to draw a flowchart, label it completely, and use it to keep track of what you know and what remains to be determined. At this point in the text, the processes described in the problems are becoming more and more complex. If you're finding it difficult to convert the verbal descriptions into flowcharts, you are not alone. Most students struggle with this task until they have done it often enough to become proficient. Many students find that the following four-step method helps them achieve that proficiency.

(1) The first time you read through the description, look only for the different process elements involved—reactors, absorbers, extractors, condensers, heaters, crystallizers etc. As you encounter these, draw and label them on your paper.

(2) Read the problem again. This time, consider the material streams involved in the process—feed streams from outside the process going to process units, product streams going from units to the outside, and streams going from one unit to another. Each time material "moves" in the process description, draw the appropriate arrow on your flowchart.

(3) Read the description one last time. Your goal with this reading is to write all information given about the process materials (flow rates, mole or mass fractions, phases, temperatures, and pressures) on the corresponding streams on the chart.

(4) The final tasks are to choose a basis of calculation if one is not specified in the process statement and to make sure that each stream is fully labeled, defining variables as needed so that the flow rate of every stream component can be expressed in terms of labeled variables and numbers.

Let's build the flowchart for this problem using this systematic approach. We strongly recommend that you make the effort to fill in the blank spaces as directed rather than jumping ahead to see the results. Once you've tried something yourself, whether you get it right or not, you'll understand the worked-out solution in a way that you never can if you simply look at the solution.