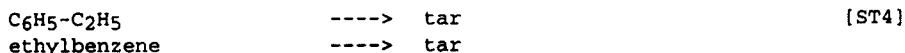Consider the manufacture of styrene from ethylbenzene. The reactions that occur are

C_6H_5-C_2H_5	---->	C_6H_5-C_2H_3 + H_2	[ST1]
ethylbenzene	---->	styrene + hydrogen	
C_6H_5-C_2H_5	---->	C_2H_4 + C_6H_6	[ST2]
ethylbenzene	---->	ethylene + benzene	
C_6H_5-C_2H_5 + H_2	---->	CH_4 + C_6H_5-CH_3	[ST3]
ethylbenzene + hydrogen	---->	methane + toluene	
C_6H_5-C_2H_5	---->	tar	[ST4]
ethylbenzene	---->	tar	
CH_4 + 2 H_2O	---->	CO_2 + 4 H_2	[ST5]
methane + water	---->	carbon dioxide + hydrogen	
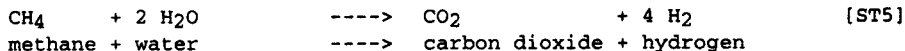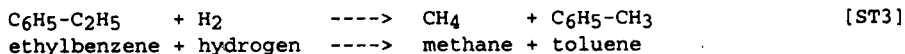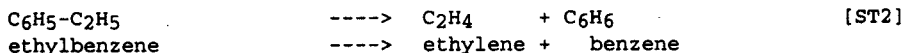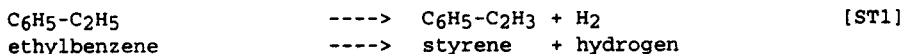
Assume you are given the selectivities in the styrene process (e.g., 90% of the ethylbenzene converts to styrene, 5% converts to benzene, 3% converts to toluene, and the rest decomposes to CO_2 and hydrogen).

a. Tabulate several of the physical properties (~~as in Table 1.3, Chapter 1~~) for all the species you would expect in this process. Comment on these species. Which boil at very low temperatures, which at very high temperatures? Classify all species as being reactants, products, by-products and waste for this process.

b. Find prices for those species having commercial value. If all the ethylbenzene could be converted to product, what is the maximum gross profit attainable?

c. Using the selectivities above, adjust the maximum gross profit attainable. These are assumed selectivities. You would have to find better values in the literature or in the data built up in a corporate file on this process to carry out this analysis accurately.

d. Let all the prices vary by as much as 10%. What are the ranges for the maximum and minimum gross profit bounds in parts b and c?

e. Suppose only $x\%$ of the ethyl benzene converts per pass in the reactor. Argue that this process would require a purge stream or something equivalent. Explain your answer clearly. Suggest alternatives to using a purge stream. For $x = 70\%$, compute the recycle rate for the unconverted ethyl benzene as a function of the fraction, b, that one elects to purge.