10.213 Fall 1999 **Problem 8 (Due Monday, September 27)**

Environmental considerations such as ozone depletion and global warming are driving the replacement of some commonly used chemicals, such as chlorofluorocompounds, (CFCs). The CFCs have commonly been employed as refrigerants. An environmentally friendly substitute must also be able to meet technical requirements. The refrigerant R-12 (CCl_2F_2) was once common in automobile air conditioners. However, R-12 is being replaced by R-134a (CH_2FCF_3) Thermodynamic data for both compounds are attached.

a) Can you justify why replacing R-12 by R-134a is reasonable based on the theory of corresponding states? Using this criteria, should ammonia (NH_3) also be considered as a possible substitute for R-12?

b) The high temperature section of the air conditioner contains pure saturated liquid which was produced by using a compressor to increase the pressure. If the high temperature is at 120 ˚F, determine the corresponding pressures required for the two refrigerants, R-12 and R-134a. Which is substance is the better choice if a lower operating pressure is desired?

c) The function of the high temperature section is to exhaust heat to the environment that is external to the car. Comment on whether the design specifications given thus far would be appropriate for cars driven in Arizona during the summer.

d) For R-134a, determine the enthalpy of the pure saturated liquid in the high temperature section. If the R-134 in the low temperature section of the air conditioner is at the same enthalpy and a pressure of 1 atm what is its temperature? Determine the temperature and weight percent of saturated liquid present in the low temperature section.

e) Cooling of the air in the car is accomplished by heat exchange with the low temperature section of the air conditioning unit. The saturated liquid fraction of the R-134a is evaporated to form pure saturated vapor. If the air conditioner designed for a cooling load of 5 BTU per hour, determine the required flow rate of R-134a.

The data for R-134a was taken from http://www.dupont.com/suva/na/usa/sa/techinfo/engg.html.
This site also contains a truly impressive quantity of thermodynamic data for a wide variety of refrigerants. Included are extensive tables for saturated vapors, saturated liquids, and superheated vapors. Also, included are ln P-H diagrams, the equations of state (EOS) used to calculated the PVT properties, and the temperature dependent heat capacities. Coefficients for Antoine's equation are also given.

Data for R-12 comes from the "Chemical Engineers' Handbook" by R.H. Perry and C. H. Chilton, McGraw Hill, New York, 1973 (5^{th} edition). Often this reference is referred to as "Perry's Handbook", leaving Chilton shortchanged.