

Name

Solution

I. 30 points

Calculate the theoretical flame temperature for acetylene burned in a 10% stoichiometric excess of a synthetic air mixture consisting of 10 mole % O_2 in 90 mole % helium. For helium, use $C_p = 20.785 \text{ J/mol}^\circ\text{K}$ (constant with temperature).

II. 70 points

A conceptual design for a cascaded refrigeration system to reach low temperatures for the liquification of krypton is given in the figure on the next page. The heat of liquification of krypton is 2310 cal/mole, so we will design for $\dot{Q}_{E1} = 2310 \text{ cal/min}$ load on the low temperature evaporator (EVAP #1) to give 1 mole/min of liquid krypton capacity. Krypton has a critical temperature of $209.4^\circ\text{K} = -83^\circ\text{F}$, so we need to cool well below this temperature and therefore choose $T_1 = -120^\circ\text{F}$ for the low temperature evaporator. Refrigerant R-503 is suitable for this low temperature. Assume that the condenser, COND #1, for this R-503 cycle operates with an exiting temperature of $T_4 = -10^\circ\text{F}$. Taking the R-503 as the system, and using reasonable assumptions for the operating conditions and equipment:

a) 10 points

Calculate the mass flowrate of R-503, $\dot{m}_1$, in lbm/min.

b) 10 points

Calculate the work requirement for compressor #1, $\dot{w}_{s1}$, in horsepower assuming the efficiency of the compressor is 0.8.

c) 10 points

Calculate the heat load on COND #1, $\dot{Q}_{C1}$ in Btu/min.

Refrigerant R-500 appears to be appropriate for operation of the second evaporator, EVAP #2, at $T_5 = -20^\circ\text{F}$ (this is 10°F colder than COND #1 to provide for a temperature driving force), and the condensed liquid will leave COND #2 above ambient temperature at $T_8 = 100^\circ\text{F}$. Now, taking the R-500 as the system and again, using reasonable assumptions for the operating conditions and equipment:

d) 10 points

Calculate the heat load on EVAP #2, $\dot{Q}_{E2}$, in Btu/min.

e) 10 points

Calculate the flowrate of R-500, $\dot{m}_2$, in lbm/min.

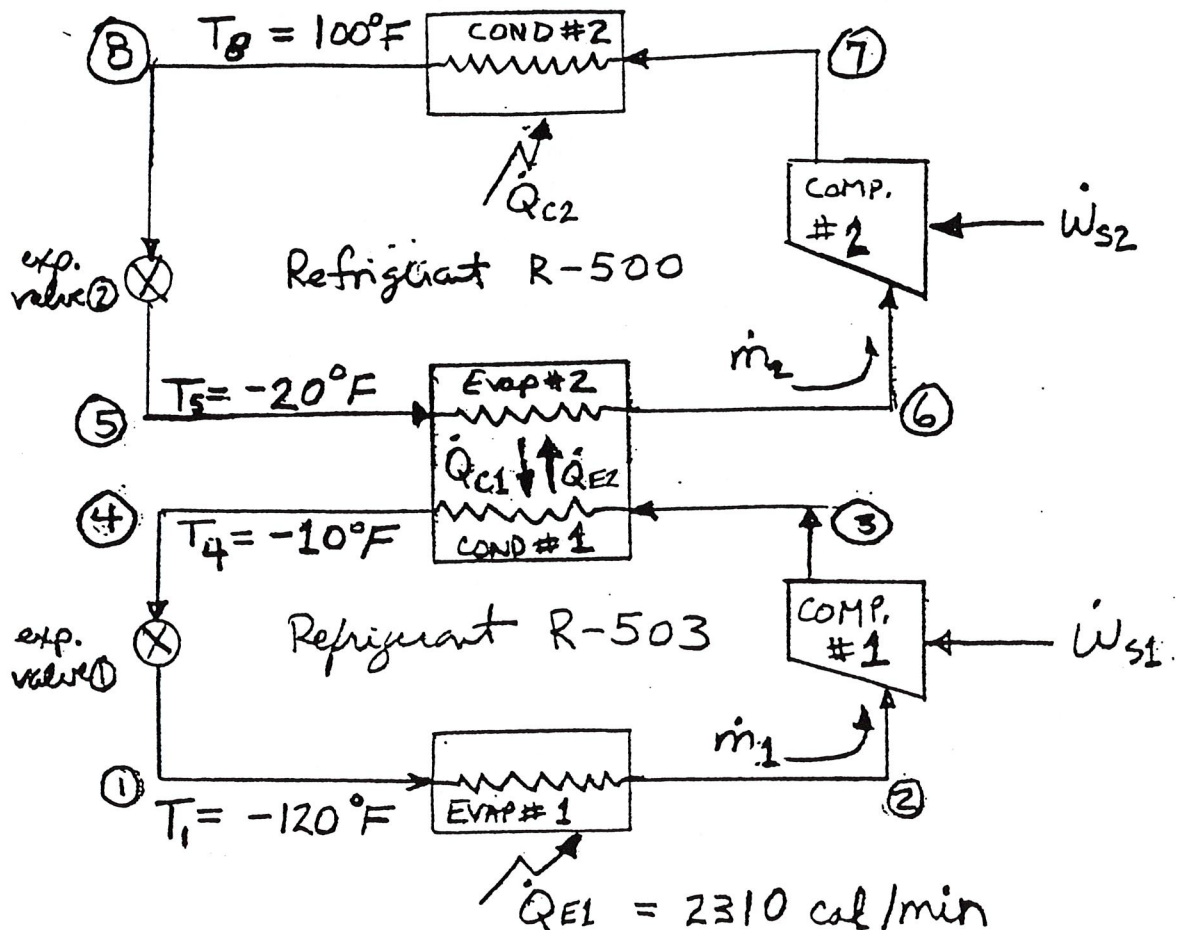
f) 10 points

Calculate the work requirement for compressor #2, $\dot{w}_{s2}$, in horsepower assuming the efficiency of the compressor is 0.8.

g) 10 points

Calculate the heat load on COND #2, $\dot{Q}_{c2}$, in BTU/min.

P-H diagrams for R-503 and R-500 are attached. Please be careful to maintain the formal sign convention that heat added to the system is positive and work done on the system is positive. Be sure to switch systems from R-503 in parts a-c to R-500 in parts d-g. Also, use the numbered points given in the diagram for subscripting your properties.



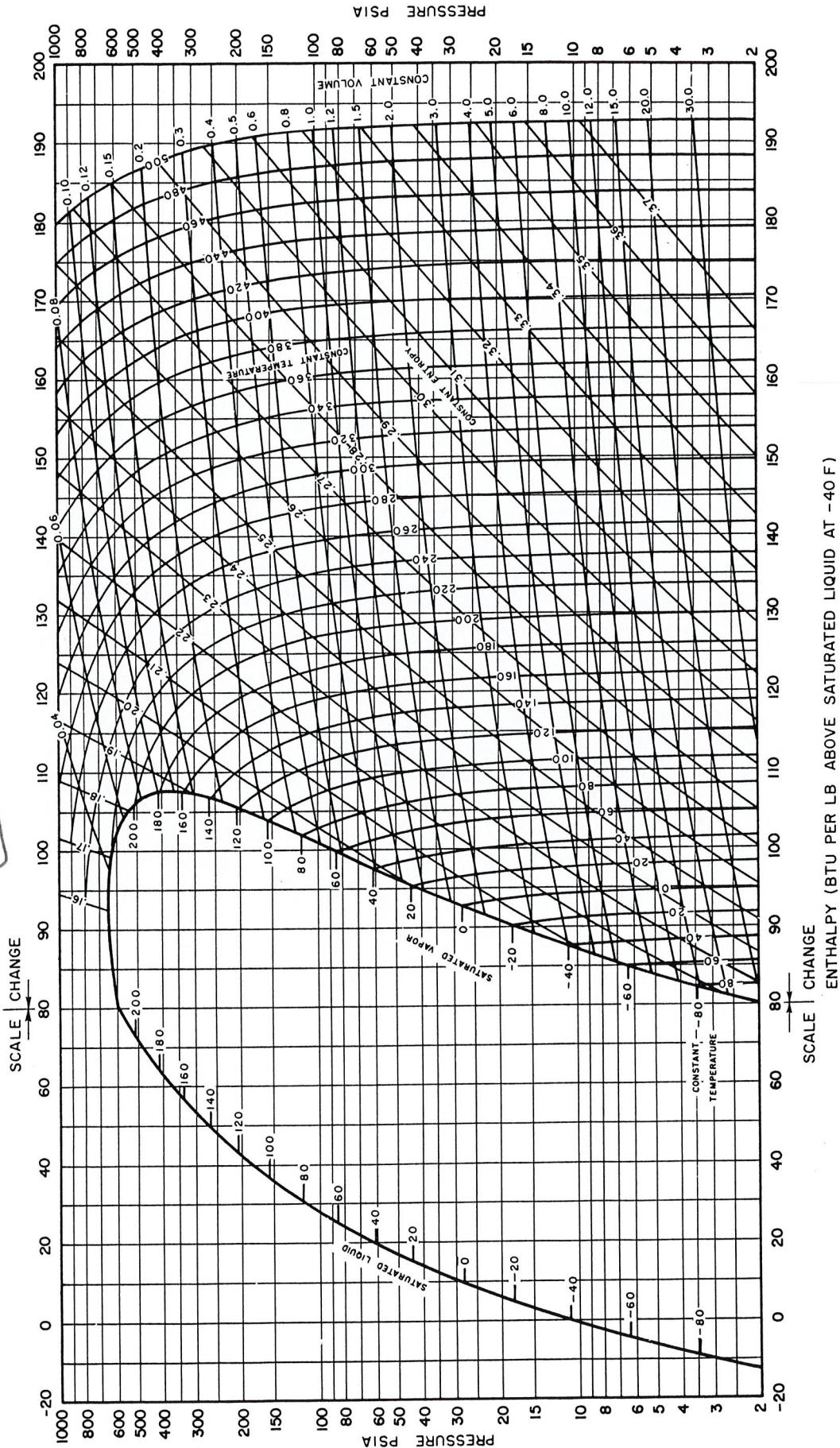


Fig. 9-11. Pressure-enthalpy diagram for refrigerant R-500. Note that 0 of enthalpy scale is taken at -40°F (-40°C). Also note that enthalpy scale changes at 80 Btu per lb. to help technician read superheat values.

R-503

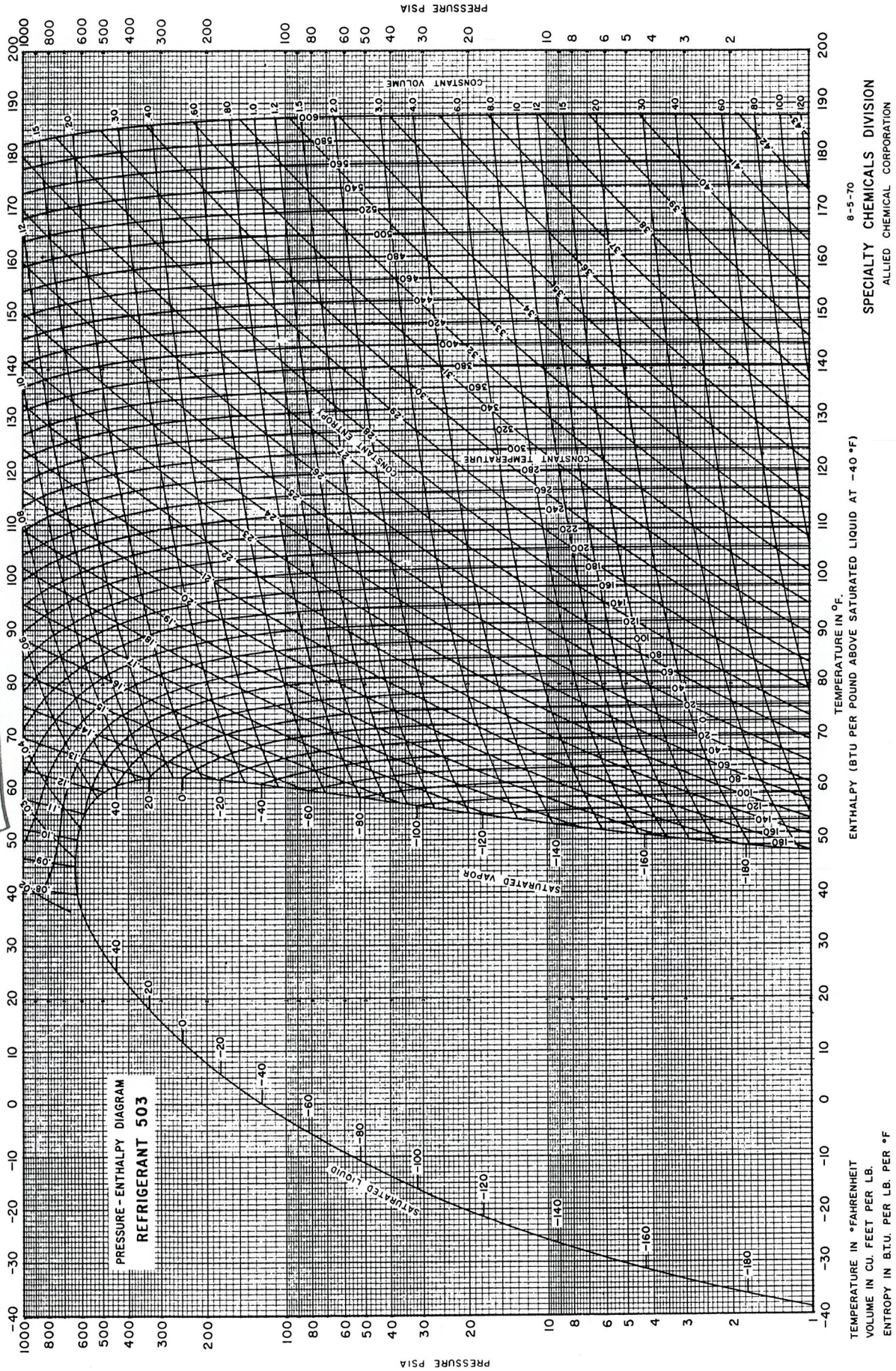


Fig. 9-15. Pressure-enthalpy diagram for refrigerant R-503. (Allied Chemical Corp.)