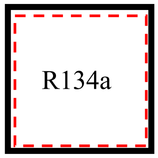
A closed, rigid tank contains a two-phase liquid-vapor mixture of Refrigerant 134a initially at -20 °C with a quality of 50.0%. There is heat transfer into the tank until the refrigerant is at a final pressure of 4 bar (abs).

a. Determine the final temperature, in °C.
b. If the final state is in the superheated vapor region, at what temperature, in °C, does the tank contain only saturated vapor?
c. Locate the initial and final states on a *p-v* plot and show the process line between them. Indicate lines of constant temperature on the *p-v* plot.

SOLUTION:

The system is the R134a contained in the tank.



First determine the properties at the initial state (state 1). Since we're given a quality of $x_1 = 0.500$, the R134a must be in a SLVM phase. Use the R135a SLVM-temperature property table with $T_1 = -20$ °C to determine the following properties,

$p_1 = p_{sat\,@\,-20\,°C} = 1.3273$ bar (abs),
$v_{f1} = 0.00073623$ m^3/kg, $v_{g1} = 0.14739$ m^3/kg.

Using the given quality of $x_1 = 0.500$,

$v_1 = (1 - x_1)v_{f1} + x_1 v_{g1}$ => $v_1 = 0.074063$ m^3/kg.

Since the tank is closed and rigid, the tank volume and mass will remain the same throughout the process. Thus, the specific volume at the final state will be identical to the specific volume at the initial state,

$v_2 = v_1$ => $v_2 = 0.074063$ m^3/kg.

The final pressure is given as $p_2 = 4$ bar (abs). Referring to the R134a SLVM-pressure property table at this pressure,

$v_{g2} = 0.051207$ m^3/kg.

Since $v_2 > v_{g2}$, the R134a at state 2 must be a SHV. Using the R134a SHV Table at $p_2 = 4$ bar (abs),

$v(T = 100\ °C) = 0.073275$ m^3/kg,
$v(T = 110\ °C) = 0.075505$ m^3/kg.

Using linear interpolation,

$T_2 = 100\ °C + \left(\frac{110\ °C - 100\ °C}{v_{110\ °C} - v_{100\ °C}}\right)(v_2 - v_{100\ °C})$ => $T_2 = 103.5$°C.

Thus, the final tank temperature is $\boxed{T_2 = 104\ °C}$ and $\boxed{\text{the final R134a phase is a SHV}}$.

The temperature at which the tank only contains saturated vapor may be found by finding the saturation temperature corresponding to the final specific volume ($v_2 = 0.074063$ m^3/kg). Using the R134a SLVM-temperature table,

$v_{g\,@\,Tsat = -4\,°C} = 0.079866$ m^3/kg,
$v_{g\,@\,Tsat = 0°C} = 0.069309$ m^3/kg,

so that via linear interpolation,

$T_{sat} = -4\ °C + \left(\frac{0\ °C - [-4\ °C]}{v_{g,0\ °C} - v_{g,-4\ °C}}\right)(v_2 - v_{-4\ °C})$ => $\boxed{T_{sat} = -1.80\ °C}$.

Note that linear interpolation could have also been performed using the data from the R134a SLVM-pressure table. The result would be the same to within the error resulting from the linear interpolation approximation.

The process is shown in the following *p*-*v* sketch,