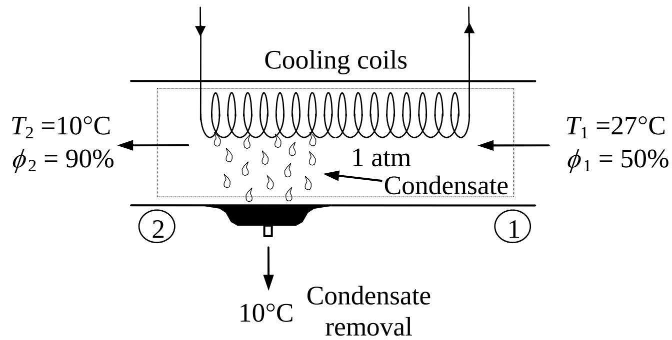
14-90 Atmospheric air enters the evaporator of an automobile air conditioner at a specified pressure, temperature, and relative humidity. The dew point and wet bulb temperatures at the inlet to the evaporator section, the required heat transfer rate from the atmospheric air to the evaporator fluid, and the rate of condensation of water vapor in the evaporator section are to be determined.

Assumptions **1** This is a steady-flow process and thus the mass flow rate of dry air remains constant during the entire process $(\dot{m}_{a1} = \dot{m}_{a2} = \dot{m}_a)$. **2** Dry air and water vapor are ideal gases. **3** The kinetic and potential energy changes are negligible.

Analysis The inlet and exit states of the air are completely specified, and the total pressure is 1 atm. The properties of the air at the inlet and exit states may be determined from the psychrometric chart (Fig. A-31) or using EES psychrometric functions to be (we used EES)

$$T_{\text{dp1}} = \mathbf{15.7°C}$$
$$T_{\text{wb1}} = \mathbf{19.5°C}$$
$$h_1 = 55.60 \text{ kJ/kg dry air}$$
$$\omega_1 = 0.01115 \text{ kg H}_2\text{O/kg dry air}$$
$$\boldsymbol{v}_1 = 0.8655 \text{ m}^3\text{ / kg dry air}$$
$$h_2 = 27.35 \text{ kJ/kg dry air}$$
$$\omega_2 = 0.00686 \text{ kg H}_2\text{O/kg dry air}$$



The mass flow rate of dry air is

$$\dot{m}_a = \frac{\dot{\boldsymbol{V}}_1}{\boldsymbol{v}_1} = \frac{\boldsymbol{V}_{\text{car}}\text{ACH}}{\boldsymbol{v}_1} = \frac{(2\text{ m}^3\text{/change})(5\text{ changes/min})}{0.8655\text{ m}^3} = 11.55\text{ kg/min}$$

The mass flow rates of vapor at the inlet and exit are

$$\dot{m}_{v1} = \omega_1 \dot{m}_a = (0.01115)(11.55\text{ kg/min}) = 0.1288\text{ kg/min}$$

$$\dot{m}_{v2} = \omega_2 \dot{m}_a = (0.00686)(11.55\text{ kg/min}) = 0.07926\text{ kg/min}$$

An energy balance on the control volume gives

$$\dot{m}_a h_1 = \dot{Q}_{\text{out}} + \dot{m}_a h_2 + \dot{m}_w h_{w2}$$

where the the enthalpy of condensate water is

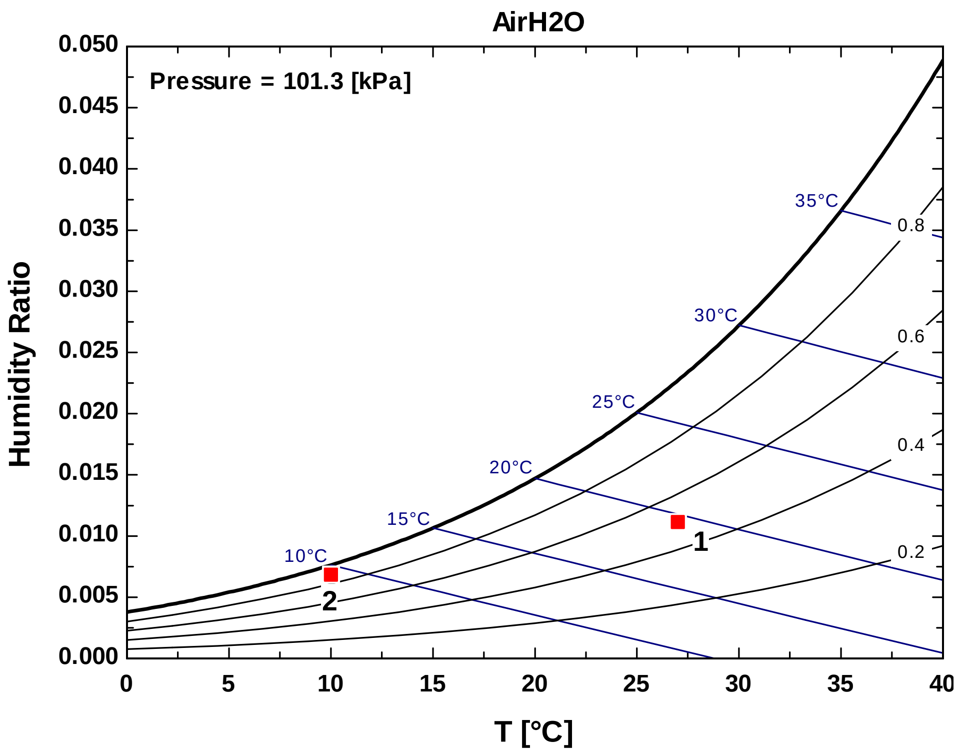
$$h_{w2} = h_{f@10°\text{C}} = 42.02\text{ kJ/kg} \quad \text{(Table A-4)}$$

and the rate of condensation of water vapor is

$$\dot{m}_w = \dot{m}_{v1} - \dot{m}_{v2} = 0.1288 - 0.07926 = \mathbf{0.0495\ kg/min}$$

Substituting,

$$\dot{m}_a h_1 = \dot{Q}_{\text{out}} + \dot{m}_a h_2 + \dot{m}_w h_{w2}$$
$$(11.55\text{ kg/min})(55.60\text{ kJ/kg}) = \dot{Q}_{\text{out}} + (11.55\text{ kg/min})(27.35\text{ kJ/kg}) + (0.0495\text{ kg/min})(42.02\text{ kJ/kg})$$
$$\dot{Q}_{\text{out}} = 324.4\text{ kJ/min} = \mathbf{5.41\ kW}$$



Discussion We we could not show the process line between the states 1 and 2 because we do not know the process path.