Recitation 4

••6 On a linear X temperature scale, water freezes at −125.0°X and boils at 375.0°X. On a linear Y temperature scale, water freezes at −70.00°Y and boils at −30.00°Y. A temperature of 50.00°Y corresponds to what temperature on the X scale?

$$\mathrm{T_X} = m\,\mathrm{T_Y} + b$$

$$m = \frac{\mathrm{T_{X2}} - \mathrm{T_{X1}}}{\mathrm{T_{Y2}} - \mathrm{T_{Y1}}} = \frac{375.0 - (-125.0)}{-30.00 - (-70.00)} = \frac{25}{2}.$$

$$b = \mathrm{T_{X1}} - m\mathrm{T_{Y1}} = -125.0 - \frac{25}{2}(-70.00) = 750.0°.$$

$$\mathrm{T_X} = \frac{25}{2}\mathrm{T_Y} + 750.0°.$$

$$\mathrm{T_{X3}} = \frac{25}{2}(50.00°) + 750.0° = 1375°\mathrm{X}.$$

••17 SSM WWW An aluminum cup of 100 cm^3 capacity is completely filled with glycerin at 22°C. How much glycerin, if any, will spill out of the cup if the temperature of both the cup and the glycerin is increased to 28°C? (The coefficient of volume expansion of glycerin is 5.1×10^{-4}/C°.)

$$\Delta V_{\text{gly}} - \Delta V_{\text{Al}} = V\beta_{\text{gly}}\Delta T - V\beta_{\text{Al}}\Delta T = V\Delta T\left(\beta_{\text{gly}} - \beta_{\text{Al}}\right)$$
$$= (100\ \text{cm}^3)(6.0\text{C°})[5.1 \times 10^{-4}/\text{C°} - 3(2.3 \times 10^{-5}/\text{C°})]$$
$$= 0.26\ \text{cm}^3.$$

•27 **SSM** Calculate the minimum amount of energy, in joules, required to completely melt 130 g of silver initially at 15.0°C.

$c = 236\ \text{J/(kg}\cdot\text{K)};\ T_m = 1235\ \text{K};\quad L_F = 105\ \text{kJ/kg};$

$$Q_1 = cm\Delta T = \left(236\,\frac{\text{J}}{\text{kg}\cdot\text{K}}\right)(0.130\ \text{kg})(1235\ \text{K} - 288.0\ \text{K}) = 29.05\ \text{kJ}.$$

$$Q_2 = L_F m = (105\ \text{kJ/kg})(0.130\ \text{kg}) = 13.65\ \text{kJ}.$$

$$Q = Q_1 + Q_2 = 29.05\ \text{kJ} + 13.65\ \text{kJ} = 42.7\ \text{kJ}.$$

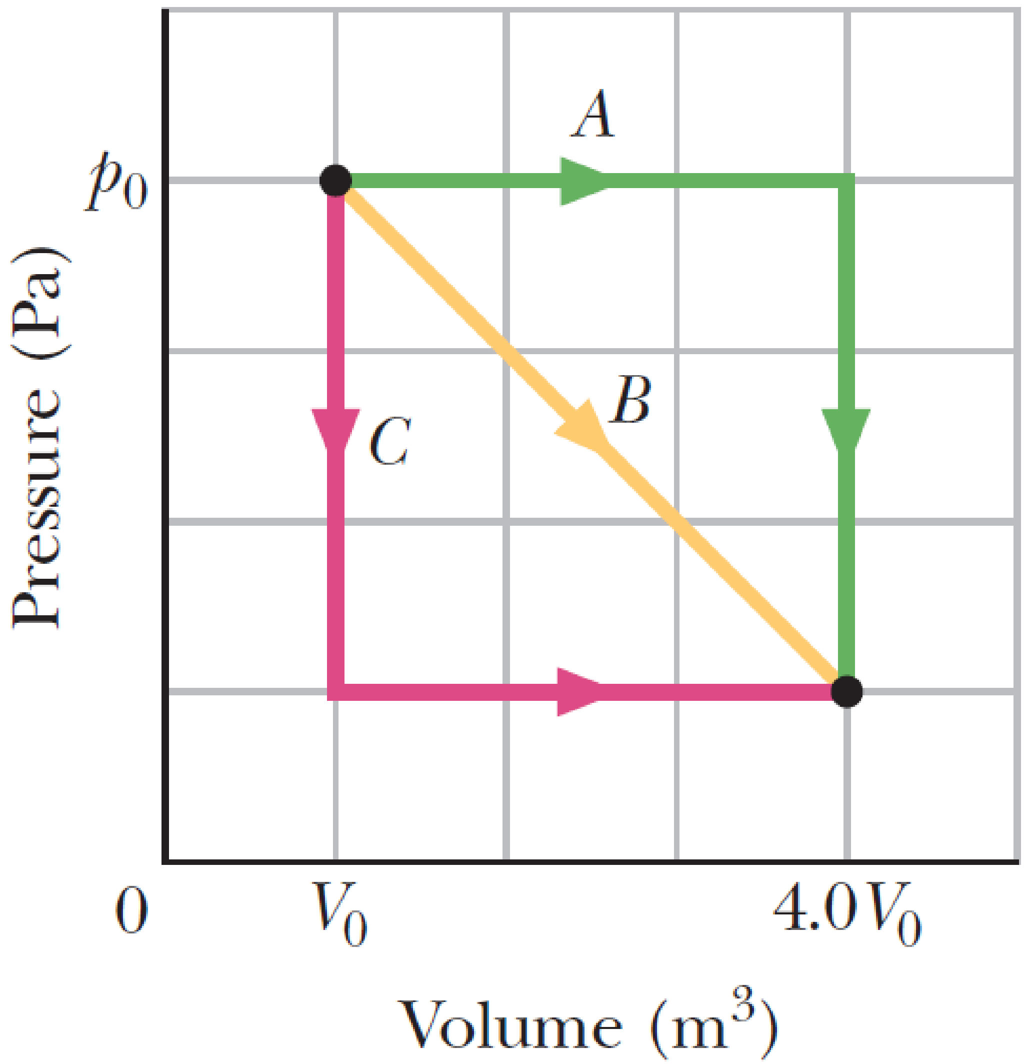
••31 ILW What mass of steam at 100°C must be mixed with 150 g of ice at its melting point, in a thermally insulated container, to produce liquid water at 50°C?

$$-L_v m_s + c m_s(50°\text{C} - 100°\text{C}) + L_F m_i + c m_i(50°\text{C} - 0.0°\text{C}) = 0$$

$$-L_v m_s - (50\text{C}°)\, c m_s + L_F m_i + (50\text{C}°) c m_i = 0$$

$$m_s = \frac{L_F + (50\text{C}°)c}{L_v + (50\text{C}°)\, c} m_i = \frac{333\ \text{J/g} + (50\text{C}°)(4.187\ \text{J/g}\cdot\text{K})}{2256\ \text{J/g} + (50\text{C}°)\,(4.187\ \text{J/g}\cdot\text{K})}(150\ \text{g})$$
$$= 33\ \text{g}.$$

•43 In Fig. 18-36, a gas sample expands from V_0 to $4.0V_0$ while its pressure decreases from p_0 to $p_0/4.0$. If $V_0 = 1.0\ \text{m}^3$ and $p_0 = 40$ Pa, how much work is done by the gas if its pressure changes with volume via (a) path A, (b) path B, and (c) path C?



The work in a p-V is given by the area under the p curve. The area of a single square in the p-V diagram is

$$V_0 \frac{p_0}{4} = (1.0\ \mathrm{m}^2)\left(\frac{40\ \mathrm{Pa}}{4}\right) = 10\ \mathrm{J}$$

a)

$$W = 12(10\ \mathrm{J}) = 120\ \mathrm{J}.$$

b)

$$W = 3(10\ \mathrm{J}) + \frac{9}{2}(10\ \mathrm{J}) = 75\ \mathrm{J}.$$

c)

$$W = 3(10\ \mathrm{J}) = 30\ \mathrm{J}.$$

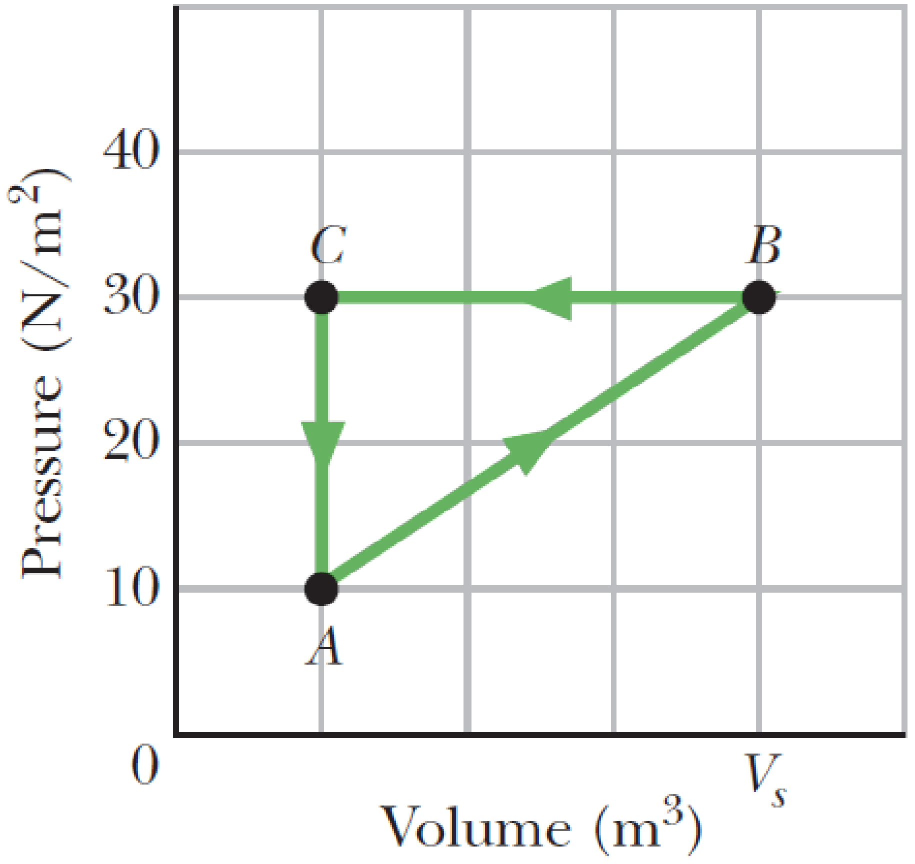
•45 SSM ILW A gas within a closed chamber undergoes the cycle shown in the *p*-*V* diagram of Fig. 18-38. The horizontal scale is set by $V_s = 4.0\ \text{m}^3$. Calculate the net energy added to the system as heat during one complete cycle.

$$E_{int,i} = E_{int,f} \Longrightarrow \Delta E_{int} = 0.$$

$$\Delta E_{int} = Q - W = 0 \Longrightarrow Q = W$$

$$W = -\frac{1}{2}(20\ \text{Pa})[3.0\ \text{m}^2] = -30\ \text{J}.$$

$$Q = -30\text{J}.$$



••58 A solid cylinder of radius $r_1 = 2.5$ cm, length $h_1 = 5.0$ cm, emissivity 0.85, and temperature 30°C is suspended in an environment of temperature 50°C. (a) What is the cylinder's net thermal radiation transfer rate P_1? (b) If the cylinder is stretched until its radius is $r_2 = 0.50$ cm, its net thermal radiation transfer rate becomes P_2. What is the ratio P_2/P_1?

a)

$$P_1 = \varepsilon\sigma A_1(T_{\text{env}}^4 - T^4)$$

$$A_1 = 2\pi r_1 h_1 + 2[\pi r_1^2] = 2\pi(0.025\text{m})(0.025\text{m})^2 + 2\pi(0.025\text{m})$$

$$= 1.18 \times 10^{-2}\text{m}^2$$

$$P_1 = (0.85)\left(5.67 \times 10^{-8}\,\frac{\text{W}}{\text{m}^2 \cdot \text{K}^4}\right)(1.18 \times 10^{-2}\text{m}^2)[(323\text{ K})^4 - (303\text{ K})^4]$$

$$= 1.4\text{ W}$$

b)

$$V_2 = V_1$$

$$\pi r_2^2 h_2 = \pi r_1^2 h_1$$

$$h_2 = \left(\frac{r_1}{r_2}\right)^2 h_1 = \left(\frac{2.5\ \text{cm}}{0.50\ \text{cm}}\right)^2 (5.0\ \text{cm}) = 125\ \text{cm}$$

$$\frac{P_2}{P_1} = \frac{\varepsilon\sigma A_2(T_{\text{env}}^4 - T^4)}{\varepsilon\sigma A_1(T_{\text{env}}^4 - T^4)} = \frac{A_2}{A_1} = \frac{2\pi r_2 h_2 + 2[\pi r_2^2]}{2\pi r_1 h_1 + 2[\pi r_1^2]} = \frac{r_2 h_2 + r_2^2}{r_1 h_1 + r_1^2}$$

$$= \frac{(0.50\ \text{cm})(125\ \text{cm}) + (0.5\ \text{cm})^2}{(2.5\ \text{cm})(5.0\ \text{cm}) + (2.5\ \text{cm})^2} = 3.3.$$

••65 Ice has formed on a shallow pond, and a steady state has been reached, with the air above the ice at −5.0°C and the bottom of the pond at 4.0°C. If the total depth of *ice* + *water* is 1.4 m, how thick is the ice? (Assume that the thermal conductivities of ice and water are 0.40 and 0.12 cal/m · C° · s, respectively.)

$$P_{\text{ice}} = P_{\text{wtr}}$$

$$k_{\text{ice}}\, A \frac{T_{\text{int}} - T_{\text{C}}}{L_{\text{ice}}} = k_{\text{wtr}}\, A \frac{T_{\text{H}} - T_{\text{int}}}{L_{\text{water}}}$$

$$\frac{L_{\text{ice}}}{L_{\text{wtr}}} = \frac{k_{\text{ice}}}{k_{\text{wtr}}} \frac{T_{\text{int}} - T_{\text{C}}}{T_{\text{H}} - T_{\text{int}}} = \frac{0.40 \frac{\text{cal}}{\text{m} \cdot \text{C}^{\circ}}}{0.12 \frac{\text{cal}}{\text{m} \cdot \text{C}^{\circ}}} \frac{0.0°\text{C} - (-5.0\ °\text{C})}{4.0\ °\text{C} - 0.0°\text{C}} = 4.17.$$

$$L_{\text{ice}} + L_{\text{wtr}} = 1.4$$

$$L_{\text{ice}} + \frac{L_{\text{ice}}}{4.17} = 1.4$$

$$L_{\text{ice}} = \frac{1.4}{1 + 1/4.17} = 1.1\ \text{m}$$