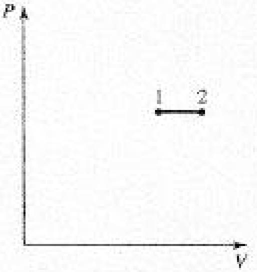
18.85 The Dew Point. The vapor pressure of water (Problem 18.84) decreases as the temperature decreases. If the amount of water vapor in the air is kept constant as the air is cooled, a temperature is reached, called the *dew point,* at which the partial pressure and vapor pressure coincide and the vapor is saturated. If the air is cooled further, vapor condenses to liquid until the partial pressure again equals the vapor pressure at that temperature. The temperature in a room is 30.0°C. A meteorologist cools a metal can by gradually adding cold water. When the can temperature reaches 16.0°C, water droplets form on its outside surface. What is the relative humidity of the 30.0°C air in the room? The table below lists the vapor pressure of water at various temperatures:

Temperature (°C)	**Vapor Pressure (Pa)**
10.0	1.23×10^3
12.0	1.40×10^3
14.0	1.60×10^3
16.0	1.81×10^3
18.0	2.06×10^3
20.0	2.34×10^3
22.0	2.65×10^3
24.0	2.99×10^3
26.0	3.36×10^3
28.0	3.78×10^3
30.0	4.25×10^3

18.85: The partial pressure of water in the room is the vapor pressure at which condensation occurs. The relative humidity is $\frac{1.81}{4.25} = 42.6\%$.

19.30 A cylinder contains 0.250 mol of carbon dioxide (CO_2) gas at a temperature of 27.0°C. The cylinder is provided with a frictionless piston, which maintains a constant pressure of 1.00 atm on the gas. The gas is heated until its temperature increases to 127.0°C. Assume that the CO_2 may be treated as an ideal gas. a) Draw a pV-diagram for this process. b) How much work is done by the gas in this process? c) On what is this work done? d) What is the change in internal energy of the gas? e) How much heat was supplied to the gas? f) How much work would have been done if the pressure had been 0.50 atm?

19.30: a)



b)
$$pV_2 - pV_1 = nR(T_2 - T_1)$$
$$= (0.250\ \text{mol})(8.3145\ \ \text{J/mol·K})(100.0\ \text{K}) = 208\ \text{J}.$$

c) The work is done on the piston.

d) Since Eq. (19.13) holds for any process,

$$\Delta U = nC_V\Delta T = (0.250\ \text{mol})(28.46\ \ \text{J/mol·K})(100.0\ \text{K}) = 712\ \text{J}.$$

e) Either $Q = nC_P\Delta T$ or $Q = \Delta U + W$ gives $Q = 924 \times 10^3$ J to three significant figures.

f) The lower pressure would mean a correspondingly larger volume, and the net result would be that the work done would be the same as that found in part (b).

19.32 A monatomic ideal gas that is initially at a pressure of 1.50×10^5 Pa and with a volume of $0.0800\ \text{m}^3$ is compressed adiabatically to a volume of $0.0400\ \text{m}^3$. a) What is the final pressure? b) How much work is done by the gas? c) What is the ratio of the final temperature of the gas to its initial temperature? Is the gas heated or cooled by this compression?

19.32: a) See also Exercise 19.36;

$$p_2 = p_1\left(\frac{V_1}{V_2}\right)^{\gamma} = (1.50 \times 10^5\ \text{Pa})\left(\frac{0.0800\ \text{m}^3}{0.0400\ \text{m}^3}\right)^{\frac{5}{3}} = 4.76 \times 10^5\ \text{Pa}.$$

b) This result may be substituted into Eq. (19.26), or, substituting the above form for p_2,

$$W = \frac{1}{\gamma - 1}p_1V_1\left(1 - \left(\frac{V_1}{V_2}\right)^{\gamma-1}\right)$$
$$= \frac{3}{2}(1.50 \times 10^5\ \text{Pa})(0.0800\ \text{m}^3)\left(1 - \left(\frac{0.0800}{0.0400}\right)^{\frac{2}{3}}\right) = -1.06 \times 10^4\ \text{J}.$$

c) From Eq. (19.22), $(T_2/T_1) = (V_2/V_1)^{\gamma-1} = (0.0800/0.0400)^{2/3} = 1.59$, and since the final temperature is higher than the initial temperature, the gas is heated (see the note in Section 19.8 regarding "heating" and "cooling.")