18P. A sample of an ideal gas is taken through the cyclic process *abca* shown in Fig. 20-20; at point *a*, $T = 200$ K. (a) How many moles of gas are in the sample? What are (b) the temperature of the gas at point *b*, (c) the temperature of the gas at point *c*, and (d) the net heat added to the gas during the cycle?

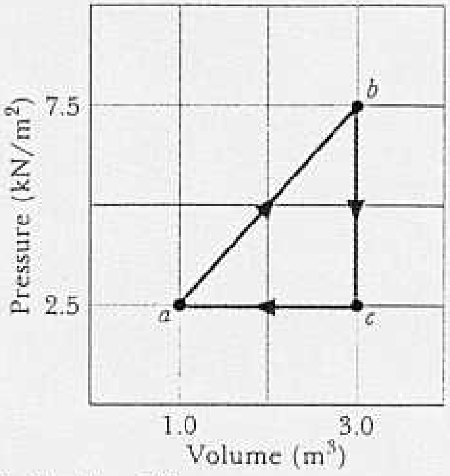


FIGURE 20-20 Problem 18.

20-18 (a) at point a, $P_a = 2.5 \times 10^3$ pa, $V_a = 1\,m^3$, $T_a = 200K$

use $PV = nRT \Rightarrow n = \frac{P_a V_a}{R T_a} = \frac{2.5 \times 10^3 \times 1}{8.31 \times 200}$

$= \underline{1.5 \text{ moles.}}$

(b) at point b $\quad T_b = \frac{P_b V_b}{n R} = \frac{(7.5 \times 10^3 \, Pa)(3 m^3)}{1.5 \times 8.31}$

$= \underline{1800 K} \approx \underline{1.8 \times 10^3 K}$

(c) at point c $\quad T_c = \frac{P_c V_c}{n R} = \frac{(2.5 \times 10^3 \, Pa)(3.0 m^3)}{(1.5)(8.31)} = \underline{602 K}$

$= \underline{6.0 \times 10^2 K}$

(d) For cyclic process $\Delta E_{int} = 0 \Rightarrow Q = W$ (First law of T.D)

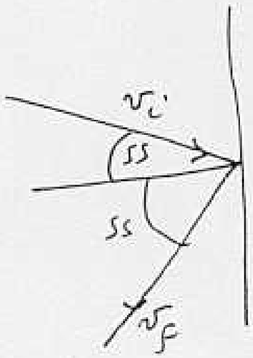
W = area of the triangle abc $= \frac{1}{2}(3-1)(7.5-2.5) \times 10^3$

$= \underline{5.0 \times 10^3 \text{ J.}}$

33P. The mass of the H_2 molecule is 3.3×10^{-24} g. If 10^{23} H_2 molecules per second strike 2.0 cm² of wall at an angle of 55° with the normal when moving with a speed of 1.0×10^5 cm/s, what pressure do they exert on the wall?

$v_i = v_f = 1\times10^{5} \frac{cm}{s} = 1\times10^{3} \frac{m}{s}$, $m = 3.3\times10^{-24}$ g

$= 3.3\times10^{-27}$ kg



20-33 $P = \left(\frac{F}{A}\right)_{wall} = \left(\frac{\Delta P/\Delta t}{A}\right)_{wall}$

$\Delta P_{H_2} = P_f - P_i = m(-v_f + v_i)\cos 55^\circ$

$= -2 m v \cos 55^\circ$

$= -2\times3.3\times10^{-27}\ kg \times 1\times10^{3}\ \frac{m}{s}\cos 55^\circ$

$= -3.79\times10^{-24}\ \frac{kg\cdot m}{s}$

total change of momentum $= N\Delta P_{He} = -0.378\ \frac{kg\cdot m}{s}$

$\therefore (\Delta p)_{wall} = 0.378\ \frac{kg\cdot m}{s}$, $\Delta t = 1\ s$

$(F)_{wall} = 0.378\ N$

$\therefore P = \frac{0.378}{2\times10^{-4}\ m^2} = 1890\ pa$

$\simeq 1.9\times10^{3}\ pa$

35E. (a) Determine the average value in electron-volts of the translational kinetic energy of the particles of an ideal gas at 0.00°C and at 100°C. (b) What is the translational kinetic energy per mole of an ideal gas at these temperatures, in joules?

20-35

note $\underline{\underline{1 eV}} = \underline{\underline{1.6 \times 10^{-19} J}}$ (e = charge of the electr

(a) $\bar{K} = \frac{3}{2} kT = \frac{3}{2}(1.38 \times 10^{-23} \frac{J}{K})(273)$ at 0°C

$= 5.65 \times 10^{-21} J = \underline{\underline{3.53 \times 10^{-2} eV}}$

at 100°C = 373 K

$\bar{K} = \frac{3}{2}(1.38 \times 10^{-23})(373) = 7.72 \times 10^{-21} J = \underline{\underline{4.82 \times 10^{-2} eV}}$

(b) use $\bar{K} = \frac{3}{2} kT = \frac{3}{2} nRT = \frac{3}{2} RT$ (for n = 1)

at T = °C = 273 K

$\Rightarrow \bar{K} = \frac{3}{2}(8.31)(273) = \underline{\underline{3.4 \times 10^{3} J}}$

at T = 100°C = 373 K

$\bar{K} = \frac{3}{2}(8.31)(373) = \underline{\underline{4.65 \times 10^{3} J}}$

63P. Let 20.9 J of heat be added to a particular ideal gas. As a result, its volume changes from 50.0 cm^3 to 100 cm^3 while the pressure remains constant at 1.00 atm. (a) By how much did the internal energy of the gas change? If the quantity of gas present is 2.00×10^{-3} mol, find the molar specific heat at (b) constant pressure and (c) constant volume.

20-63 $Q = 20.9\,J$ ~~changed~~ $V_i = 50 \times 10^{-6}\,m^3$ & $V_f = 100 \times 10^{-6}\,m^3$

but $P_i = P_f = 1\,atm = 1.01 \times 10^5\,pa$

(a) $W = p\Delta V = 1.01 \times 10^5 (100 - 50) \times 10^{-6} = 5.05\,J$

$Q = \Delta E_{int} + W \Rightarrow \Delta E_{int} = Q - W = 20.9 - 5.05$

$= \underline{15.85\,J}$

(b) $\Delta E_{int} = n C_v \Delta T = 15.85$

$C_v = \dfrac{15.85}{n\,\Delta T} = \dfrac{15.85}{(W/R)}$, $p\Delta V = nR\Delta T$

$\Rightarrow \Delta T = \dfrac{p\Delta V}{nR} = \dfrac{W}{nR}$

$= \dfrac{15.85}{\cancel{2 \times 10^{-3}}\,(5.05/8.31)} =$

$= \underline{26.08\ \frac{J}{mol\,K}}$

(c.) $C_p = C_v + R = \underline{34.39\ \frac{J}{mol\,K}}$

85P. One mole of an ideal monatomic gas traverses the cycle shown in Fig. 20-27. Process $1 \rightarrow 2$ takes place at constant volume, process $2 \rightarrow 3$ is adiabatic, and process $3 \rightarrow 1$ takes place at constant pressure. (a) Compute the heat Q, the change in internal energy ΔE_{int}, and the work done W, for each of the three processes and for the cycle as a whole. (b) If the initial pressure at point 1 is 1.00 atm, find the pressure and the volume at points 2 and 3. Use 1.00 atm = 1.013×10^5 Pa and R = 8.314 J/mol·K.

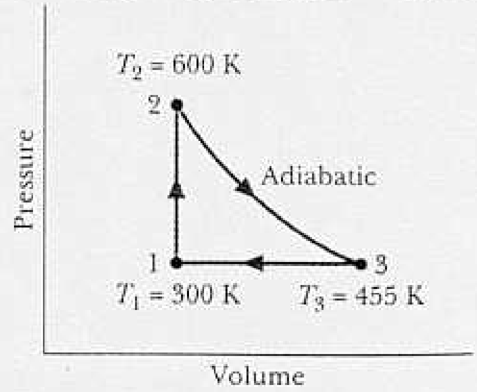


FIGURE 20-27
Problem 85.

20 85 $\quad n = 1$, monatomic $\Rightarrow C_V = \frac{3}{2}R$, $C_p = C_V + R = \frac{5}{2}R$

(a) process $1 \rightarrow 2$, $\Delta V = 0 \Rightarrow \underline{W = 0}$

$Q = n C_V \Delta T = (1)(\frac{3}{2}R)(600-300) = \underline{3.74 \times 10^3 \text{ J}}$

$\Delta E_{int} = n C_V \Delta T = Q = \underline{3.74 \times 10^3 \text{ J}}$

process $2 \rightarrow 3$ adiabatic $\Rightarrow \underline{Q = 0}$

$\Delta E_{int} = n C_V \Delta T = \frac{3}{2}(8.31)(455-600) = \underline{-1.81 \times 10^3 \text{ J}}$

$W = Q - \Delta E_{int} = \underline{1.81 \times 10^3 \text{ J}}$

Process $3 \rightarrow 1$ $\quad \Delta p = 0 \Rightarrow Q = n C_p \Delta T$

$Q = \frac{5}{2}(8.31)(300-455) = \underline{-3.22 \times 10^3 \text{ J}}$

$\Delta E_{int} = n C_V \Delta T = \underline{-1.93 \times 10^3 \text{ J}}$

$W = Q - \Delta E_{int} = \underline{-1.29 \times 10^3 \text{ J}}$

$$Q_{total} = Q_{1\to2} + Q_{2\to3} + Q_{3\to1} = 3.74\times10^{3} + 0 - 3.22\times10^{3}$$
$$= \underline{\underline{5.2\times10^{2}\ \text{J}}}.$$

$$(\Delta E_{int})_{total} = \cdots \quad = 3.74\times10^{3} - 1.81\times10^{3} - 1.93\times10^{3}$$
$$= 0 \quad \text{(Cyclic process)}$$

$$W_{total} = Q_{total} = 5.2\times10^{2}\ \text{J}$$

b) $P_1 = 1.0\ \text{atm} = 1.01\times10^{5}\ \text{Pa}$

$$\Rightarrow V_1 = \frac{nRT}{P_1} = \frac{(1)(8.31)(300)}{1.01\times10^{5}\ \text{Pa}} = \underline{\underline{2.46\times10^{-2}\ \text{m}^3}}$$

process $1\to2 \Rightarrow \Delta V = 0 \Rightarrow V_2 = V_1 = \underline{\underline{2.46\times10^{-2}\ \text{m}^3}}$

$$P_2 = \frac{nRT_2}{V_2} = \frac{(1)(8.31)(600)}{2.46\times10^{-2}} = \underline{\underline{2.02\times10^{5}\ \text{Pa}}}$$
$$\approx \underline{\underline{2\ \text{atm}}}$$

process $3\to1 \Rightarrow \Delta P = 0 \Rightarrow P_3 = P_1 = \underline{\underline{1\ \text{atm}}}$

$$V_3 = \frac{nRT_3}{P_3} = \frac{(1)(8.31)(455)}{1.01\times10^{5}} = 3.73\times10^{-2}\ \text{m}^3$$