17.

([redacted] The lowest possible temperature in outer space is 2.7 K. [redacted]hat is the root-mean-square speed of hydrogen molecules at this [redacted]mperature? (Use Table 20-1.)

$T = 2.7\ K$

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

For hydrogen $M = 2\ g/mole = 0.002\ Kg/mole$

$$v_{rms} = \sqrt{\frac{3 \times 8.31 \times 2.7}{0.002}} = \boxed{183\ m/s}$$

18.

[redacted] Calculate the root-mean-square speed of helium atoms at [redacted]00 K. The molar mass of helium is 4.00 g/mol.

For helium $M = 4\ g/mole = 0.004\ Kg/mole$

$$v_{rms} = \sqrt{\frac{3 \times 8.31 \times 1000}{0.004}} = \boxed{2496\ m/s}$$

23.

E. What is the average translational kinetic energy of nitroge molecules at 1600 K, in joules

$$\bar{K} = \frac{3}{2} k_B T = \frac{3}{2} \times (1.38 \times 10^{-23})(1600)$$

$$= 3.31 \times 10^{-20} \text{ J}$$

40.

What is the internal energy of 1.0 mol of an ideal monatomic gas at 273 K?

$$E_{int} = \frac{3}{2} nRT = \frac{3}{2} \times 1 \times 8.31 \times 273$$

$$= \boxed{3403 \text{ J}}$$

because $E_{int} = \bar{K}$

$k_B = nR$

44.

(46) 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.

a) $Q = +20.9\ J$

$V_i = 50\ cm^3 \longrightarrow V_f = 100\ cm^3$

$P = 1\ atm = \text{Const.}$

$$\Delta E_{int} = Q - W = 20.9 - P\Delta V$$

$$= 20.9 - (1.01 \times 10^5)(100\times10^{-6} - 50\times10^{-6})$$

$$= 20.9 - 5.1 = \boxed{15.8\ J}$$

b) $Q = n\, C_p\, \Delta T = \cancel{n}\, C_p \dfrac{P\Delta V}{\cancel{n} R}$

but: $\Delta T = \dfrac{P\Delta V}{nR}$

$$\Rightarrow C_p = \frac{Q \times R}{P\Delta V} = \frac{20.9 \times 8.31}{1.01\times10^5 \times (50\times10^{-6})}$$

$$\boxed{C_p = 34.4\ J/\text{mole K}}$$

c) $C_v = C_p - R = 34.4 - 8.31 = \boxed{26.1\ J/\text{mole K}}$

[redacted]. (a) One liter of gas with $\gamma = 1.3$ is at 273 K and 1.0 atm pressure. It is suddenly compressed (adiabatically) to half its original volume. Find its final pressure and temperature. (b) The gas is now cooled back to 273 K at constant pressure. What is its final volume?

a) Adiabatic process ; $V_2 = \frac{V_1}{2}$

$$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$$

$$P_2 = P_1 \left(\frac{V_1}{V_2}\right)^{\gamma} = 1 \times (2)^{1.4} = \boxed{2.64 \text{ atm}}$$

$$T_i V_i^{\gamma-1} = T_2 V_2^{\gamma-1} \Rightarrow \left(\frac{V_1}{V_2}\right)^{\gamma-1} = \frac{T_2}{T_1}$$

$$\Rightarrow T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{\gamma-1} = 273 \times 1.23 = \boxed{336 K}$$

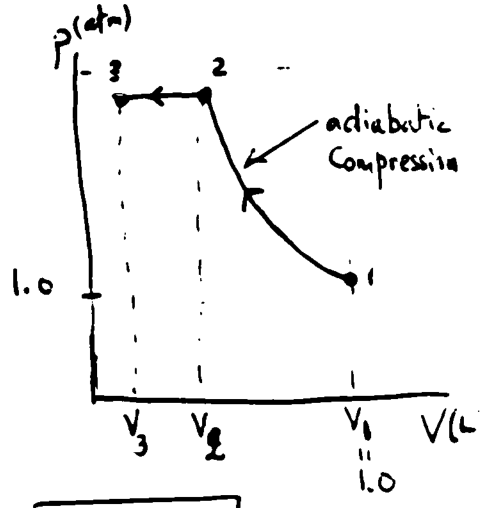
b)

$$P_2 V_2 = nRT_2$$

$$P_3 V_3 = nRT_3$$

but $P_2 = P_3$ (constant pressure)

$$\Rightarrow \frac{V_2}{V_3} = \frac{T_2}{T_3}$$



$$\Rightarrow V_3 = V_2 \frac{T_3}{T_2}$$

$$= 0.5 \times \frac{273}{336} = \boxed{0.4 \text{ L}}$$

•••59 Figure 19-25 shows a cycle undergone by 1.00 mol of an ideal monatomic gas. For 1 → 2, what are (a) heat Q, (b) the change in internal energy ΔE_{int}, and (c) the work done W? For 2 → 3, what are (d) Q, (e) ΔE_{int}, and (f) W? For 3 → 1, what are (g) Q, (h) ΔE_{int}, and (i) W? For the full cycle, what are (j) Q, (k) ΔE_{int}, and (l) W? The initial pressure at point 1 is 1.00 atm ($= 1.013 \times 10^5$ Pa). What are the (m) volume and (n) pressure at point 2 and the (o) volume and (p) pressure at point 3? SSM

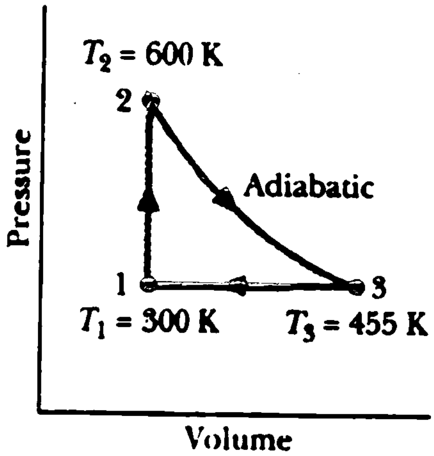


Fig. 19-25 Problem 59.

For 1 → 2: (isovolumetric)

a) $Q = n\,C_v\,\Delta T = 1 \times \frac{3}{2} \times 8.31 \times (600-300) = \boxed{3740\,J}$

b) $\Delta E_{int} = n C_v \Delta T = Q = 3740\,J$

c) $W = 0$

For 2 → 3: (adiabatic)

d) $Q = 0$

e) $\Delta E_{int} = n C_v \Delta T = 1 \times \frac{3}{2} \times 8.31 \times (455-600) = \boxed{-1810\,J}$

f) $W = -\Delta E_{int} = \boxed{+1810\,J}$

For 3 → 1: (isobaric)

g) $Q = n\,C_p\,\Delta T = 1 \times \frac{5}{2} \times 8.31 \times (300-455) = \boxed{-3220\,J}$

h) $\Delta E_{int} = n C_v \Delta T = \frac{1}{2} \times \frac{3}{2} \times 8.31 \times (300-455) = \boxed{-1930\,J}$

i) $W = Q - \Delta E_{int} = \boxed{-1290\,J}$

79. A sample of ideal gas expands from an initial pressure and volume of 32 atm and 1.0 L to a final volume of 4.0 L. The initial temperature of the gas is 300 K. What are the final pressure and temperature of the gas and how much work is done by the gas during the expansion, if the expansion is (a) isothermal, (b) adiabatic and the gas is monatomic, and (c) adiabatic and the gas is diatomic?

$$V_i = 1\,L \qquad\qquad V_f = 4\,L$$

$$P_i = 32\,atm \quad \longrightarrow \quad P_f = ?$$

$$T_i = 300\,K \qquad\qquad T_f = ?$$

a) Isothermal process $\quad T_f = T_i = 300\,K$

$$\Rightarrow P_i V_i = P_f V_f \Rightarrow P_f = \frac{P_i V_i}{V_f} = \frac{32 \times 1}{4} = \boxed{8\ atm}$$

$$W = nRT \ln\left(\frac{V_f}{V_i}\right) = P_i V_i \ln\left(\frac{V_f}{V_i}\right)$$

$$= 1 \times 10^{-3} \times 32 \times 1.01 \times 10^{5} \ln\left(\frac{4}{1}\right) = \boxed{4400\,J}$$

b) Adiabatic process $\quad Q = 0$

$$P_i V_i^{\gamma} = P_f V_f^{\gamma} \qquad P_f = P_i \left(\frac{V_i}{V_f}\right)^{\gamma}$$

$$= 32 \left(\frac{1}{4}\right)^{1.67} = \boxed{3.2\,atm}$$

$$T_i V_i^{\gamma - 1} = T_f V_f^{\gamma - 1}$$

$$T_f = T_i \left(\frac{V_i}{V_f}\right)^{\gamma - 1} = 300 \left(\frac{1}{4}\right)^{0.67} = \boxed{119\,K}$$

$$W = \cancel{Q}^{\,0} - \Delta E_{int} = -\Delta E_{int} = -\frac{3}{2} n R \Delta T = -\frac{3}{2} \Delta(PV)$$

$$= -\frac{3}{2}\left(P_f V_f - P_i V_i\right) = \boxed{2880\,J}$$