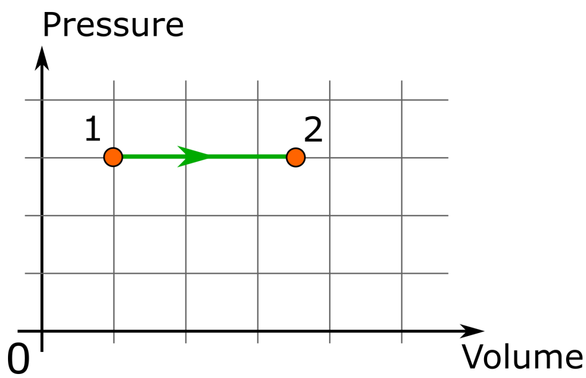
# Physics 202

## Group Quizbit | Thermo - Kinetic Theory, 1st Law

Work as a group to produce a single handwritten solution to these questions. Start with fundamental principles and using multiple representations to communicate understanding of the physics.

1. Consider the constant pressure (isobaric) expansion of an ideal gas shown in the figure. During this process, the average kinetic energy per particle is ...

   □ (a) increased by a factor of 5/2.
   □ (b) decreased by a factor of 5/2.
   **X (c) increased by a factor of 7/2.**
   □ (d) decreased by a factor of 7/2.




2. You have 2 moles of a monatomic gas that is initially at a temperature of 500 K. If 5000 J of heat is added to the gas, and the gas performs 7.5 kJ of work, what is the final temperature of the gas?

(Q1)

$n = 2\,\text{mol}$ $\quad$ $PV = nRT$

$T_i = 500\,\text{K}$ $\quad$ $R = 8.31\,\frac{\text{J}}{\text{K}\cdot\text{mol}}$

$\Delta Q = 5000\,\text{J}$ , $\Delta W = -7500\,\text{J}$

$E = \frac{3}{2}nRT$ ; $\Delta E = \Delta Q + \Delta W$

$\Delta E = 5000\,\text{J} - 7500\,\text{J}$

$\Delta E = -2500\,\text{J}$

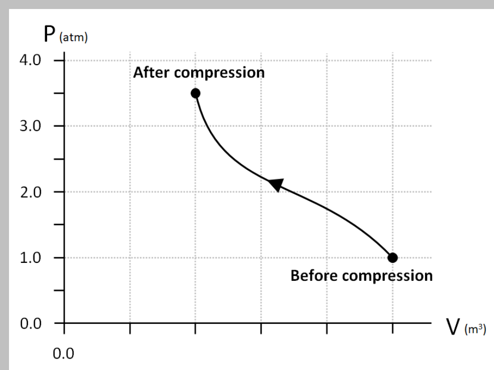
$\Delta E = \frac{3}{2}nR\Delta T = \frac{3}{2}nR(T_f - T_i)$

$\frac{2\Delta E}{nR} + T_i = T_f$

$T_f = \frac{2(-2500\,\text{J})}{3(2\,\text{mol})(8.31\,\frac{\text{J}}{\text{K}\cdot\text{mol}})} + 500\,\text{K}$

$T_f \doteq 400\,\text{K}$

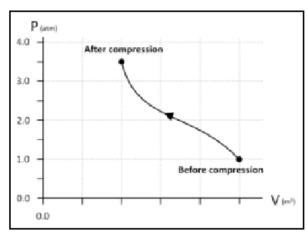
3. While developing a revolutionary prototype hydrogen fuel cell technology, Bernice performs an experiment with vaporized water at 100 °C. Bernice compresses the water vapor in the container and obtains the pictured PV graph of the water vapor during the compression. Benny, as a misguided and unfunny prank, has erased some of the horizontal axis labels. If we treat the water vapor as a monatomic ideal gas, by what factor does the RMS average velocity of the water vapor molecules change?




Part (b)

| |
|---|
| **Problem Orientation**<br>1 pt - PV=nRT eq. |
| **Solution Exploration**<br>0.5 pt - $P_f = 7/2\ P_i$<br>1 pt - $V_f = 2/5\ V_i$<br>1 pt - $1/2mv^2 = 3/2k_bT$ eq. |
| **Solution Execution**<br>1.5 pts - change in temperature<br>1 pt - finding $v_{rms}$ factor |
| **Solution Evaluation**<br>0.5 pts - correct answer and units |

**(b)** Once the system has stabilized at 100 °C, Bernice compresses the water vapor in the container and obtains the pictured PV graph of the water vapor during the compression. Benny, as a misguided and unfunny prank, has erased some of the horizontal axis labels. If we treat the water vapor as a monatomic ideal gas, by what factor does the RMS average velocity of the water vapor molecules change?




$PV = nRT$

$P_f = 3.5 P_i$

$V_f = \frac{2}{5} V_i$

$P\ V = nR\ T$ ($P$ ↑ ×3.5, $V$ ↓ ×$\frac{2}{5}$, $nR$ const, $T$ ↑ ×$(3.5)(\frac{2}{5})$)

⇒ Temp went up by $\frac{7}{5}$ ⇒ 373K → 522 K

$\overline{KE} = \frac{3}{2} k_B T$

$\Rightarrow \frac{1}{2} \bar{m} v_{rms}^2 = \frac{3}{2} k_B T$

$v_{rms} = \sqrt{\frac{3 k_B T}{\bar{m}}}$ ⇒ $v_{rms}$ is proportional to $\sqrt{T}$

$v_{rms,f} = \sqrt{\frac{7}{5}}\ v_{rms,i}$ ⇒ $v_{rms}$ increases by a factor of 1.18 (or 18% increase)