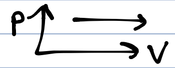
53.html $\boxed{P_a = 1}$ atm $\xrightarrow{\text{add heat}}$ $\boxed{P_b = P_a = 1}$ atm

a) 

b) $W = p\Delta V = nR\Delta T = (0.25\ \text{mol})\ 8.3145\ \frac{J}{\text{mol}\cdot K}\ 100.0\ K = \boxed{208\ J}$

c) piston

d) $\Delta U = nC_v\Delta T$ for any ideal gas process

$= (0.250\ \text{mol})\ 28.46\ \frac{J}{\text{mol}\cdot K}\ (100.0\ K) = \boxed{712\ J}$

e) $Q = \Delta U + W = \boxed{920\ J}$ also can use $Q = nC_p\Delta T$

f) $W = nR\Delta T = \boxed{208\ J}$

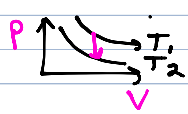
Heat & Work in Thermodynamic Processes

55.html $\Delta U = Q - W$

(B) $U \sim \frac{3}{2}nRT$

More PV fun

(A) Your house gets cold at night (assume its well-sealed)

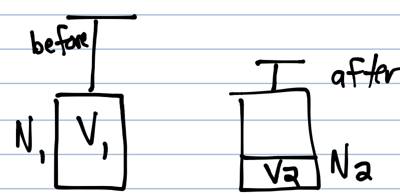


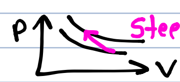
$W = 0$ $(dV = 0)$

$\Delta U = Q$

$Q < 0$

(B) Fast tire pumping. Consider gas in the pump



adiabatic $\Rightarrow Q = 0$ 

steeper than an isotherm

$\Delta U = -W$

$W < 0$

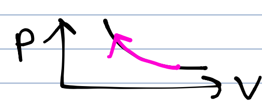
$\Delta U > 0$

$T_2 = T_1 \left(V_1/V_2\right)^{\gamma - 1}$ where $\gamma = \frac{C_P}{C_V}$ and $C_p = C_v + R$

monatomic $\gamma = \frac{C_v + R}{C_V} = \frac{\frac{3}{2}R + \frac{2}{2}R}{3/2\ R} = \frac{5}{3} = 1.67$

diatomic $\gamma = \frac{C_v + R}{C_v} = \frac{\frac{5}{2}R + \frac{2}{2}R}{5/2\ R} = \frac{7}{5} = 1.40$

(C) Slow tire pumping. Consider gas inside to be isothermal



$\Delta U = nC_v\Delta T = 0$

$\rightarrow Q = W$

Which method delivers more air into the tire? Slow or fast?

assume i) P_{tire} does not change significantly

ii) $T_{\text{air in pump}}$ does not change significantly while delivering air

iii) air is diatomic

<u>Quick pump</u>

$T_2 = T_1 (V_1/V_2)^{\gamma-1}$ Once the tire and pump pressures have equilibrated, what fraction of the gas particles initially in pump transfer to tire?

$$f \equiv \frac{N_1 - N_2}{N_1} = 1 - N_2/N_1 \qquad N_1 = \frac{P_1 V_1}{kT_1} \quad N_2 = \frac{P_2 V_2}{kT_2} = \frac{P_{tire}\, V_2}{k\, T_1 \left(\frac{V_1}{V_2}\right)^{0.4}}$$

$$\frac{N_2}{N_1} = \frac{P_{tire}}{P_1} \frac{V_2 \Big/ \left(\frac{V_1}{V_2}\right)^{0.4}}{V_1} = \frac{P_{tire}}{P_1} \frac{V_2}{V_1} \left(\frac{V_2}{V_1}\right)^{0.4} = \frac{P_{tire}}{P_1} \left(\frac{V_2}{V_1}\right)^{1.4}$$

<u>slow pump</u> isothermal

$$f = 1 - N_2/N_1 \qquad \frac{N_2}{N_1} = \frac{P_{tire} V_2}{kT_1} \Big/ \frac{P_1 V_1}{kT_1} = \frac{P_{tire}}{P_1} \frac{V_2}{V_1}$$

Numbers: $P_{tire} = 3\, P_{ambient}$ $\qquad V_2 = \frac{1}{6} V_1$

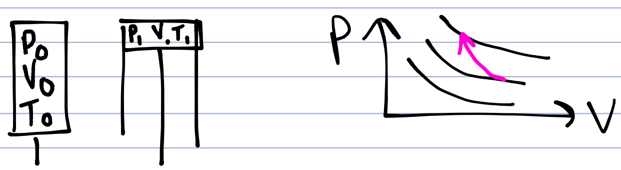
$f_{quick} = 0.756 \qquad f_{slow} = 0.50$

<u>56.html</u> $\Delta U = Q - W \rightarrow Q = \Delta U + W$

$W_{gas} > 0$ so need something in the form of $\Delta U +$ (something > 0)

$\rightarrow \boxed{B}$

<u>Porsche Boxster redux</u> an adiabatic view



$W_{0\to 1} = \frac{1}{\gamma-1}(P_0 V_0 - P_1 V_1)$ p. 132

$T_0 V_0^{\gamma-1} = \text{constant} = T_1 V_1^{\gamma-1}$ eqn 3.14

$$\rightarrow \frac{P_0 V_0}{NK} V_0^{\gamma-1} = \frac{P_1 V_1}{NK} V_1^{\gamma-1} \rightarrow P_0 V_0^{\gamma} = P_1 V_1^{\gamma} \rightarrow P_1 = P_0 (V_0/V_1)^{\gamma}$$

$$\rightarrow W_{0\to 1} = \frac{1}{\gamma-1}\left(P_0 V_0 - P_0 \left(\frac{V_0}{V_1}\right)^{\gamma} V_1\right) = \frac{1}{1.4-1}\left(10^5 Pa\ 2687 cm^3 - 10^5 Pa \left(\frac{11.3}{1}\right)^{1.4} \frac{2687 cm^3}{11.3}\right)$$

$= -1111$ J/stroke

$= -178$ hp @ 7200 rpm

balloon problem $\quad \Delta U = 0 - W = -W$

$\Delta U = n C_v \Delta T \qquad T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1}$ or $T_1 \frac{P_2}{P_1}\frac{V_2}{V_1}$

and $V_2 = V_1\left(\frac{P_1}{P_2}\right)^{1/\gamma} \qquad -4.8 \cdot 10^7$ J

OR $W = \frac{1}{\gamma-1}(P_1V_1 - P_2V_2)$ again, need to use $V_2^{\gamma} = V_1^{\gamma}\frac{P_1}{P_2}$