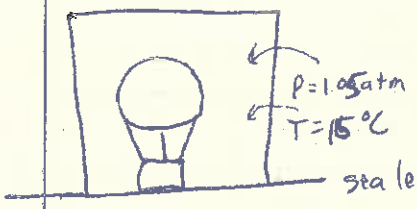
Context-rich problem

discussion/ch19.html

engineeringtoolbox.com
0.7 atm ⇒ 10,000'



no heat exchange : $Q=0$

$\Rightarrow \Delta U = -W$

and $\Delta U = n C_V \Delta T$

adiabatic $W = \frac{1}{\gamma-1}(P_1V_1 - P_2V_2)$

$T_2 = T_1\left(\frac{P_2}{P_1}\right)\left(\frac{V_2}{V_1}\right)$

$\Rightarrow$ need V_2:

$V_2^{\gamma} = V_1^{\gamma}\frac{P_1}{P_2}$ = [illegible]

$\Rightarrow V_2 = V_1\left(\frac{P_1}{P_2}\right)^{1/\gamma} = 2\cdot10^{-3}\left(\frac{1.05}{0.700}\right)^{1/1.67}$

$= 2.55\cdot10^{-3}\,m^3$

$T_1 = 288.15\,K$
$P_1 = 1.05\,atm$
$V_1 = 2.00\cdot10^{-3}\,m^3$
$P_2 = 0.70\,atm$
$V_2 = ?$
$T_2 = ?$

$\gamma = 1.67$
He gas is monatomic

$n = \frac{N_{He}}{N_A} = \frac{M_{He}}{m_{He}N_A} = \frac{\rho_{He}V_{balloon}/m_{He}}{N_A}$

$= \frac{0.179\,kg/m^3\ 2\cdot10^{-3}\,m^3 / 4\cdot1.67\cdot10^{-27}\,kg}{6.022\cdot10^{23}}$

$= 8.9\cdot10^{-4}\,mol$

$n = \frac{PV}{RT} = 8.9\cdot10^{-4}\,mol$ ✓

$C_{V,He} = 12.47$

$\Rightarrow T_2 = T_1\frac{P_2}{P_1}\frac{V_2}{V_1} = 288.15\,K\ \frac{0.700\,atm}{1.05\,atm}\ \frac{2.55\cdot10^{-3}}{2\cdot10^{-3}} = 244.89\,K$

also: $T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1} = 244.87\,K$ ✓

$\Rightarrow \Delta U = nC_V\Delta T = 8.9\cdot10^{-4}\,mol\ 12.47\,\frac{J}{mol\cdot K}\cdot(244.89 - 288.15) = \boxed{-4.8\cdot10^{-2}\,J}$

also

$\Delta U = -W = -\frac{1}{\gamma-1}(P_1V_1 - P_2V_2)$

$= -\frac{1}{1.67-1}\left(1.05\ 1.013\cdot10^5\,Pa\ 2\cdot10^{-3}\,m^3 - 2.55\cdot10^{-3}\,m^3\ 0.70\cdot1.013\cdot10^5\,Pa\right)$

$= \boxed{-4.8\cdot10^{-2}\,J}$ ✓

altitude.org/air-pressure.php

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