14.1 $Q = +500$ J (heat in)

$W = +250$ J (work out)

$\Delta U = ?$

$\Delta U = Q - W = +500 - (+250)$

$\boxed{\Delta U = 250 \text{ J}}$ >0 (internal energy increases)

14.3 $W = -150$ J (work in)

$\Delta U = -300$ J (internal energy decreases)

$Q = ?$

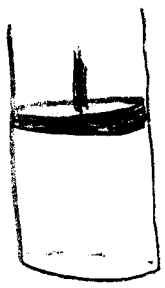
$\Delta U = Q - W$

$\Rightarrow Q = \Delta U + W = -300 \text{ J} - 150 \text{ J}$

$\boxed{Q = -450 \text{ J}}$ (heat removed)

14.29 $V_1 = 6000 \text{ cm}^3 = 0.006 \text{ m}^3$

$P_1 = 10.0 \text{ atm} = 1.01 \text{ MPa}$



isothermal expansion

$V_2 = 12{,}000 \text{ cm}^3 = 0.012 \text{ m}^3$

$W = ?$

$W = nRT \ln\left(\frac{V_2}{V_1}\right)$ (14.7) isothermal expansion

and $P_1V_1 = P_2V_2 = nRT$

$\Rightarrow W = P_1V_1 \ln\left(\frac{V_2}{V_1}\right) = (1.01 \times 10^6 \text{ Pa})(0.006 \text{ m}^3) \ln\left(\frac{12000}{6000}\right)$

$= 4200 \text{ J}$

$\boxed{W = 4.2 \text{ kJ}}$

14.43

tire	bag
air	
$P = 4.5$ atm	$P = 1$ atm
$T = 27^\circ C = 320 K$	$T_f = ?$

air: $\gamma = 1.4$ (only in this specific problem!)

adiabatic: rapid expansion (or compression)

$PV^\gamma = \text{const.}$ (14.8)

Ideal gas law always applies

$\Rightarrow P_1 V_1^\gamma = P_2 V_2^\gamma$ but $V_1 = ?$, $V_2 = ?$ $\Rightarrow PV = nRT$, $V = \frac{nRT}{P}$

$$P_1 \left[\frac{nRT_1}{P_1}\right]^\gamma = P_2 \left[\frac{nRT_2}{P_2}\right]^\gamma$$

$$\frac{P_1 T_1^\gamma}{P_1^\gamma} = \frac{P_2 T_2^\gamma}{P_2^\gamma} \Rightarrow P_1^{1-\gamma} T_1^\gamma = P_2^{1-\gamma} T_2^\gamma$$

$$\Rightarrow T_2^\gamma = \frac{P_1^{1-\gamma} T_1^\gamma}{P_2^{1-\gamma}} = \left(\frac{P_1}{P_2}\right)^{1-\gamma} T_1^\gamma$$

$$\left(T_2^\gamma\right)^{1/\gamma} = \left(\frac{P_1}{P_2}\right)^{(1-\gamma)/\gamma} T_1^{\gamma/\gamma}$$

$$T_2 = \left(\frac{P_1}{P_2}\right)^{(1-\gamma)/\gamma} T_1$$

$$= \left(\frac{4.5}{1}\right)^{(1-1.4)/1.4} (300 K) = \cancel{(4.5)^{-0.286}\ (27^\circ C)}$$

$$= (300 K)(4.5)^{-0.286} = \boxed{195.1 K = T_2}$$

14.57 Engine between

$T_H = 200°C = 473\ K$

$T_c = 100°C = 373\ K$

$e = 20\%\ e_{ideal}$

$$e_{ideal} = e_c = 1 - \frac{T_c}{T_H} = \frac{T_H - T_c}{T_H} \qquad (14.13)$$

$$e_c = 1 - \frac{373}{473} = 0.211 = \boxed{21.1\% = e_c}$$

$e = 0.2 \times e_c = (0.2)(21.1\%)$

$\boxed{e = 4.23\ \%}$