Physics 262 Third Term Exam (Spring 2003)
Solutions

1. Since the amount of energy transferred is small, we assume the temperature of the Sun and the Earth remain unchange, hence,

$$\begin{aligned}
\Delta S &= \frac{Q_{Sun}}{T_{Sun}} + \frac{Q_{Earth}}{T_{Earth}} \\
&= \frac{-1000\text{J}}{5700\text{K}} + \frac{1000\text{J}}{290\text{K}} \\
&= 3.27 \text{ J/K}
\end{aligned}$$

2. (a) From $C_p/C_v = \gamma = 5/3$ and $C_p - C_v = R$, we have $C_v = 3R/2$, $R = 8.315\text{J/(mol K)}$.

$$\begin{aligned}
\Delta E_{int} &= nC_v \Delta T \\
Q - W &= nC_v(T_f - T_i) \\
T_f &= T_i - \frac{W}{nC_v} \\
&= 327 \text{ K}
\end{aligned}$$

(b) For an adiabatic process, using the ideal gas law and the relation PV^γ=constant, we can derive

$$\begin{aligned}
T_f V_f^{\gamma-1} &= T_i V_i^{\gamma-1} \\
V_f &= \left(\frac{T_i}{T_f}\right)^{\frac{1}{\gamma-1}} V_i \\
V_f &= 0.132 \text{ m}^3
\end{aligned}$$

3. The charge of a proton is $q = 1.60 \times 10^{-19}$ C and its mass is $m_p = 1.67 \times 10^{-27}$ kg. Let a be the acceleration of the proton. $E = 2.3 \times 10^3$ N/C, $u = 2.5 \times 10^4$ m/s, $s = 2.0$ mm.

$$\begin{aligned}
F &= m_p a \\
qE &= m_p a \\
\Rightarrow \quad a &= 2.20 \times 10^{11} \text{ ms}^{-2} \\
2as &= v^2 - u^2 \\
v &= 3.9 \times 10^4 \text{ ms}^{-1}
\end{aligned}$$

4. Gauss's Law states that the electric flux through a closed surface equals the net charge enclosed by the surface divided by ϵ_0. Since it is given that in all three cases, (a)-(c), the surface completely surrounds the charge, $q = 2.0 \times 10^{-6}$C, by Gauss's Law, for (a)-(c), we have

$$\begin{aligned}
\text{electric flux} &= \frac{q}{\epsilon_0} \\
&= 2.26 \times 10^5 \text{ N m}^2\text{/C}
\end{aligned}$$

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