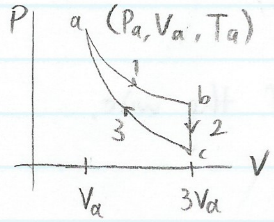
Physics 7B

Final Review Session

1. 

$* \; P_c = P_b/3$

Path 1 (Isothermal): $\Delta T = 0$

Heat: $Q = -W, \quad W = -nRT \ln\left(\frac{V_2}{V_1}\right)$

$Q = 1 \cdot R \cdot T_a \ln\left(\frac{3V_a}{V_a}\right)$

$= RT_a \ln(3)$

Work: $W = -Q \rightarrow W = -RT_a \ln(3)$

ΔS: $\Delta S = \int \frac{dq}{T_a} = R\ln(3)$

Path 2 (Isochoric): $\Delta V = 0 \rightarrow W = 0$

Heat: $Q = \Delta U = \frac{5}{2} nR(T_b - T_a)$

(from path 1: $P_a V_a = P_b (3V_a)$

$\Rightarrow P_b = \frac{P_a}{3}$)

$\frac{P_b}{T_b} = \frac{P_c}{T_c} \Rightarrow T_c = \frac{T_b}{3} = \frac{T_a}{3}$

$\Longrightarrow Q = \frac{5}{3} RT_a$

Work: $W = 0 \quad (\Delta V = 0)$

ΔS: $\Delta S = \frac{5}{2} R \int_{T_a}^{\frac{T_a}{3}} \frac{dT}{T} = \frac{5}{2} R \ln\left(\frac{1}{3}\right)$

Path 3 (Adiabatic): $Q = 0$

Heat: $Q = 0$ (Definition of adiabatic)

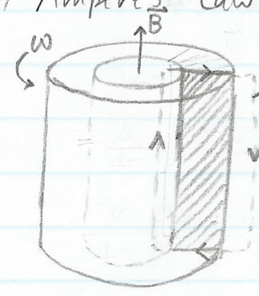
Work: $W = \Delta U = \frac{5}{2} nR(T_c - T_a)$

$= \frac{5}{2} R\left(-\frac{2}{3} T_a\right) = -\frac{5}{3} RT_a$

ΔS: $\Delta S = 0 \quad (\Delta Q = 0)$

d) $e = 1 - \frac{T_L}{T_H} = 1 - \frac{T_a}{3T_a} = \boxed{\frac{2}{3}}$

2. a) Ampere's Law: $\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{encl}$



Amperian loop.

I_{encl} = amt of charge passing through the shaded area per unit time.

$= \frac{dQ}{dt} = \underbrace{\frac{dQ}{dV}}_{\rho} \cdot \frac{dV}{dt} = \frac{Q}{\pi(r_2^2 - r_1^2) l} \cdot \frac{dV}{dt}$

$dV = l(r_2^2 - r_1^2)\, d\theta$

$\hookrightarrow \frac{dV}{dt} = l(r_2^2 - r_1^2) \underbrace{\frac{d\theta}{dt}}_{\omega} = l\omega(r_2^2 - r_1^2)$

$= \frac{Q}{\cancel{\pi(r_2^2 - r_1^2) l}} \cancel{l} \omega \cancel{(r_2^2 - r_1^2)}$

$= \frac{Q\omega}{\pi}$

$B(2l) = \mu_0 \frac{Q\omega}{\pi} \rightarrow \boxed{\vec{B} = \frac{\mu_0 Q \omega}{2\pi l} \hat{z}}$

$\hookrightarrow$ $2l$ because the magnetic field is parallel to the Amperian loop twice, both inside and outside