國立東華大學

Department of Physics
National Dong Hwa University, 1, Sec. 2,
Da Hsueh Rd., Shou-Feng, Hualien, 974, Taiwan

General Physics II, Midterm 3
PHYS10400, Class year 98
04-01-2010

General Physics II, Midterm 3 Solution

1, (a) $e \equiv \frac{W_{carnot}}{|Q_h|} = \frac{|Q_h|-|Q_c|}{|Q_h|} = 1 - \frac{|Q_c|}{|Q_h|}$

in a Carnot cycle, $\Delta E_{in} = 0$ (for the path $A \to B$)

$\therefore |Q_h| = |-W_{AB}|$ $\quad W_{AB} \equiv$ work done between $A \to B$

$A \to B$, $|Q_h| = |-W_{AB}| = nRT_h \ln(\frac{V_B}{V_A})$ absorb energy

$C \to D$, $|Q_c| = |-W_{CD}| = nRT_c \ln(\frac{V_C}{V_D})$

$\therefore \frac{|Q_c|}{|Q_h|} = \frac{T_c}{T_h} \frac{\ln(\frac{V_c}{V_D})}{\ln(V_B/V_A)}$ — ①

But $P_i V_i^{\gamma} = P_f V_f^{\gamma} \Rightarrow T_i V_i^{\gamma-1} = T_f V_f^{\gamma-1}$ as given

$B \to C$ $\quad T_h V_B^{\gamma-1} = T_c V_C^{\gamma-1}$
$D \to A$ $\quad T_h V_A^{\gamma-1} = T_c V_D^{\gamma-1}$
$\Bigg\} \Rightarrow \left(\frac{V_B}{V_A}\right)^{\gamma-1} = \left(\frac{V_C}{V_D}\right)^{\gamma-1}$

$\therefore \frac{V_B}{V_A} = \frac{V_C}{V_D}$ — ②

From ① and ② $\quad \frac{|Q_c|}{|Q_h|} = \frac{T_c}{T_h}$.

Therefore $\quad e_{Carnot} = 1 - \frac{|Q_c|}{|Q_h|} = 1 - \frac{|T_c|}{|T_h|}$

(b) for an engine to have perfect performance $e = 1$
$\rightarrow |Q_c| = 0$ or $T_c \to 0$, this

(c) The perfect engine requires $T_c = 0$ not possible
or $Q_c = 0$, that means it will not gives up or
waste any energy, this is not possible in reality

2. (a) Entropy is a measure of disorder

(b) Thermodynamics $dS = \frac{dQ_r}{T}$, $dQ_r \equiv$ the amount of heat transferred when system follow a reversible path

(c) In a Carnot cycle,

the total change in entropy for a cycle

$$\Delta S = \Delta S_h + \Delta S_c = \frac{|Q_h|}{T_h} - \frac{|Q_c|}{T_c}$$, But $\frac{|Q_c|}{|Q_h|} = \frac{T_c}{T_h}$

$\therefore$ $\Delta S = 0$ for a Carnot cycle

(d) In a free expansion. Since it is an adiabatic process

$V_i \to V_f$. $dW = 0$, $dQ = 0$. $dE_{in} = 0$ $\Delta T = 0$ $T_i = T_f$

It is <u>irrevisible</u>, We can find a reversible process to Calculate the entropy change

$$\Delta S = \int_i^f \frac{dQ_r}{T} = \frac{1}{T}\int_i^f dQ_r$$

$dE_{in} = 0$. $\therefore \int_i^f dQ_r = \int_i^f dW$

$$\therefore \Delta S = \frac{1}{T}\int dW = nR\ln\left(\frac{V_f}{V_i}\right)$$ for an ideal gas expand from $V_i \to V_f$

$\Delta S > 0$

3 (a) In a special case, $q_1 = q_2 = q$, $a = b = d$, then E_1 and E_2 will be equal in magnitude. and making the same angle θ with the $\hat{x}$ axis. So the $\hat{y}$ components will cancel each other

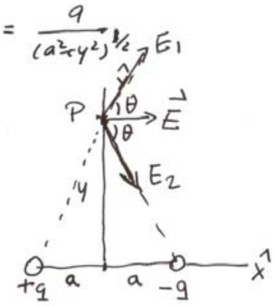
$$\vec{E}_{1y} = \vec{E}_{2y} = 0$$

$$E = 2k_e \frac{q}{(a^2+y^2)}\cos\theta, \quad \cos\theta = \frac{a}{r} = \frac{a}{(a^2+y^2)^{1/2}}$$

$$= 2k_e \frac{q}{(a^2+y^2)} \frac{a}{(a^2+y^2)^{1/2}}$$

$$= 2k_e \frac{qa}{(a^2+y^2)^{3/2}}$$

for two charges



(b) If $y >> a$

$$\vec{E}_x = 2k_e \frac{qa}{(a^2+y^2)^{3/2}} = 2k_e \frac{qa}{y^3}$$

4 (a) Gauss law $\Phi_E = \oint \vec{E} \cdot \vec{A} = \frac{q_{in}}{\epsilon_0}$, Φ_E = Total electric flux

$\vec{E}$ = Electric field

A = An area enclose the Charge, Gauss Surface

q_{in} = Total charge within the enclosed Gauss Surface

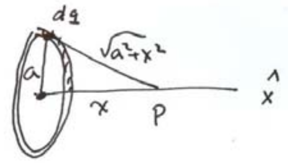
or. $\epsilon_0 \Phi_E = q_{in}$

(b) for a point change Q

$$\Phi_E = E \oint dA = E \cdot 4\pi r^2 = \frac{Q}{\epsilon_0}$$

$$\therefore \vec{E} = \frac{1}{4\pi r^2} \frac{Q}{\epsilon_0} = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2} \hat{r}$$ ← in $\hat{r}$ direction

5. Charged Ring



$$V = k_e \int \frac{dq}{r} = k_e \int \frac{dq}{\sqrt{x^2+a^2}}$$

$$= k_e \frac{1}{\sqrt{x^2+a^2}} \underbrace{\int dQ}_{\text{total charge}}$$

$$= k_e \frac{Q}{\sqrt{x^2+a^2}}$$

6. for a plate (large) $E = \frac{\sigma}{\epsilon_0}$ (You can use Gauss law to get this easily)

$\Delta V = E d$ (definition of the potential difference)

$$= \frac{\sigma d}{\epsilon_0} = \frac{Q d}{\epsilon_0 A}$$

$$C = \frac{Q}{\Delta V} = \frac{Q}{\frac{Qd}{\epsilon_0 A}} = \frac{\epsilon_0 A}{d}$$