ชื่อ..รหัส.. *

มหาวิทยาลัยเทคโนโลยีพระจอมเกล้าธนบุรี

การสอบปลายภาคการศึกษาที่ 2 ปีการศึกษา 2554

ข้อสอบวิชา PHY 207 Thermal and Statistical Physics **ภาควิชาฟิสิกส์ชั้นปีที่ 2**

วันสอบ วันศุกร์ที่ 18 พฤษภาคม พ.ศ. 2555 **เวลา 9.00-12.00 น**

คำเตือน

1. เขียนชื่อ-รหัส ลงในช่องว่างที่กำหนดทุกแผ่น
2. ข้อสอบมี 10 ข้อ 12 แผ่น คะแนนรวม 100 คะแนน
3. ทำข้อสอบลงในที่ว่างตามลำดับข้อนั้นๆ ถ้าที่ว่างเขียนคำตอบไม่พอให้เขียนต่อด้านหลัง
4. อนุญาตให้ใช้เครื่องคำนวณตามประกาศของมหาวิทยาลัยฯ
5. ไม่อนุญาตให้นำเอกสารใดๆเข้าห้องสอบ

ข้อที่	คะแนนเต็ม	คะแนนได้
1	10	
2	10	
3	10	
4	10	
5	10	
6	10	
7	10	
8	10	
9	10	
10	10	
รวม	100	

ผู้ออกข้อสอบ ดร.จีรวุฒิ แก้วเสนีย์

ข้อสอบชุดนี้ได้ผ่านการกลั่นกรองจากคณะกรรมการฯของภาควิชาฟิสิกส์แล้ว

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สูตรคำนวณ

$$d'Q = dU + d'W\,,\quad TdS = dU + d'W$$

$$\left(\frac{\partial u}{\partial v}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_v - P\,,\quad \left(\frac{\partial h}{\partial P}\right)_T = -T\left(\frac{\partial v}{\partial T}\right)_P + v$$

$$\left(\frac{\partial s}{\partial P}\right)_v = \frac{c_v}{T}\left(\frac{\partial T}{\partial P}\right)_v\,,\quad \left(\frac{\partial s}{\partial v}\right)_P = \frac{c_P}{T}\left(\frac{\partial T}{\partial v}\right)_P$$

$$Tds = c_v dT + T\left(\frac{\partial P}{\partial T}\right)_v dv$$

$$Tds = c_P dT - T\left(\frac{\partial v}{\partial T}\right)_P dP$$

$$Tds = c_P\left(\frac{\partial T}{\partial v}\right)_P dv + c_v\left(\frac{\partial T}{\partial P}\right)_v dP$$

$$\eta = \left(\frac{\partial T}{\partial v}\right)_u = -\frac{1}{c_v}\left(\frac{\partial u}{\partial v}\right)_T\,,\quad \mu_j = \left(\frac{\partial T}{\partial P}\right)_h = -\frac{1}{c_P}\left(\frac{\partial h}{\partial P}\right)_T$$

$$\left(\frac{\partial F}{\partial T}\right)_V = -S,\quad \left(\frac{\partial F}{\partial V}\right)_T = -P,\quad \left(\frac{\partial G}{\partial T}\right)_P = -S,\quad \left(\frac{\partial G}{\partial P}\right)_T = V$$

$$\left(\frac{\partial U}{\partial S}\right)_V = T,\quad \left(\frac{\partial U}{\partial V}\right)_S = -P,\quad \left(\frac{\partial H}{\partial S}\right)_P = T,\quad \left(\frac{\partial H}{\partial P}\right)_S = V$$

$$\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V\,,\quad \left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$$

$$\left(\frac{\partial S}{\partial P}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_P\,,\quad \left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$$

$$\left(\frac{\partial P}{\partial T}\right)_{23} = \frac{l_{23}}{T(v''' - v'')};\quad T = T_v$$

$$\left(\frac{\partial P}{\partial T}\right)_{12} = \frac{l_{12}}{T(v'' - v')};\quad T = T_m$$

$$\left(\frac{\partial P}{\partial T}\right)_{13} = \frac{l_{13}}{T(v''' - v')};\quad T = T_s$$

$$\Delta G = RT(n_1 \ln x_1 + n_2 \ln x_2)$$

$$\Delta G = n_1(\mu_1 - g_1) + n_2(\mu_2 - g_2)$$

$$\mu = -T\left(\frac{\partial S}{\partial n}\right)_{U,X} = \left(\frac{\partial F}{\partial n}\right)_{T,X} = \left(\frac{\partial G}{\partial n}\right)_{T,Y} = \left(\frac{\partial U}{\partial n}\right)_{S,V}$$

$$E_{total} = U = \sum_j \varepsilon_j N_j$$

$$\overline{N}_j = \overline{N}_j^{g} = \overline{N}_j' = \frac{1}{\Omega}\sum_k N_{jk}\mathcal{W}_k$$

B-E $$\omega_j = \frac{(g_j + N_j - 1)!}{(g_j - 1)!\,N_j!}$$

$$\mathcal{W}_k = \mathcal{W}_{B-E} = \prod_j \frac{(g_j + N_j - 1)!}{(g_j - 1)!\,N_j!}$$

F-D $$\omega_j = \frac{g_j!}{(g_j - N_j)!\,N_j!}$$

$$\mathcal{W}_k = \mathcal{W}_{F-D} = \prod_j \frac{g_j!}{(g_j - N_j)!\,N_j!}$$

M-B $$\omega_j = g_j^{N_j}$$

$$\mathcal{W}_k = \mathcal{W}_{M-B} = N!\prod_j \frac{g_j^{N_j}}{N_j!}$$

$$\frac{\overline{N}_j}{g_j} = \frac{1}{\exp\left(\frac{\varepsilon_j - \mu}{k_B T}\right) - 1}$$

$$\frac{\overline{N}_j}{g_j} = \frac{1}{\exp\left(\frac{\varepsilon_j - \mu}{k_B T}\right) + 1}$$

$$\frac{\overline{N}_j}{g_j} = \exp\frac{\mu - \varepsilon_j}{k_B T}$$

$$\frac{\overline{N}_j / N}{g_j} = \exp\frac{\mu - \varepsilon_j}{k_B T}$$

$$Z = \sum_j g_j \exp\frac{-\varepsilon_j}{k_B T}$$

$$S = k_B \ln\Omega$$

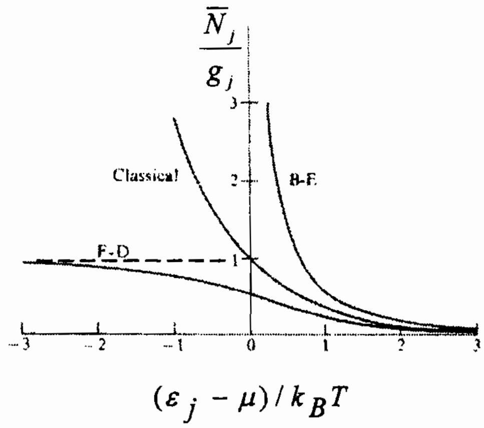
ชื่อ..รหัส.. 3

1. Describe briefly the basic principles of the zeroth law, the first law, the second law and the third law of the thermodynamics.

2. (a) Describe briefly difference of the Bose-Einstein statistics, the Fermi-Dirac statistics and the Maxwell-Boltzmann statistics.

   (b) Describe briefly difference of Bosons particles and Fermions particles.

3. Describe detail of the curves in the figure.



4. The equation of state of a certain gas is $(P+b)v = RT$.

(a) Find the entropy change in an isothermal process.

(b) Compute Joule coefficient (η) and Joule-Thomson coefficient (μ_j) where b is a constant.

Assume that c_v and c_p are constants.

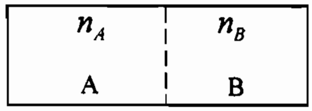
5. The pressure on water $1\times10^{-4}\,m^3$, initially at $0^\circ C$, is slowly increased from $1atm$ to $10atm$. Estimate the temperature change if the process is adiabatic. [Hint: Being with an appropriate TdS relation, $\left(\frac{\partial V}{\partial T}\right)_P = V_0\beta$, $c_P = 420J/K$ and $\beta = -6.8\times10^{-5}K^{-1}$].

6. For a two-component open system $dU = TdS - PdV + \mu_1 dn_1 + \mu_2 dn_2$.

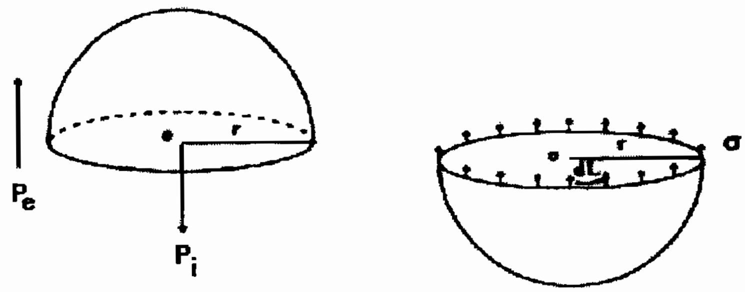
(a) Derive a similar expression for dG.

(b) Derive <u>Maxwell relations</u> for this system from it.

7. A volume V is divided into two parts by a frictionless diathermal partition. There are n_A moles of an ideal gas A on one side of the partition and n_B moles of an ideal gas B on the other side. Calculate the change in entropy (ΔS) of the system which occurs when the partition is removed.

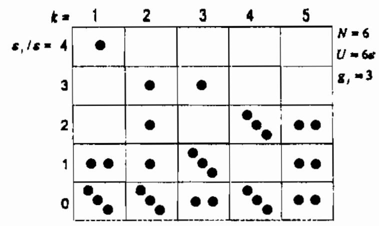


8. Show that the pressure P_i inside a bubble of radius r in a liquid which is under an external pressure P_e is given by $P_i - P_e = \frac{2\sigma}{r}$ where σ is surface tension forces. [Hint: $\bar{F}_{\downarrow} = \bar{F}_{\uparrow}$].



ชื่อ..รหัส..

9. Fermions particles are distributed among the states of the five equally spaced energy levels shown in figure. Assume that the total number of particles $(N = 6)$, the total energy $(U = 6\varepsilon)$ and the degeneracy $(g_j = 3)$ of each level.



(a) Find the thermodynamic probability of each macrostates($\mathcal{W}_k$).

(b) Find the total number of microstates of the assembly(Ω).

10. For a system obeying M-B statistics, the chemical potential of the system is given by equation.

$$\mu = -k_B T \ln Z \text{ , where } Z \text{ is the partition function.}$$

Find the Gibbs function (G) and the Helmholtz function (F).