ชื่อ...รหัส...

มหาวิทยาลัยเทคโนโลยีพระจอมเกล้าธนบุรี

การสอบปลายภาคการศึกษาที่ 2 ปีการศึกษา 2555

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

วันสอบ วันจันทร์ที่ 20 พฤษภาคม พ.ศ. 2556 **เวลา 9.00-12.00 น.**

<u>คำสั่ง</u>

1. เขียนชื่อ-รหัส ลงในช่องว่างที่กำหนดทุกแผ่น
2. ข้อสอบมี 10 ข้อ รวมทั้งหมด 12 แผ่น คะแนนเต็ม 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**	

ข้อสอบชุดนี้ได้ผ่านการกลั่นกรองจากคณะกรรมการฯของภาควิชาฟิสิกส์แล้ว

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สูตรคำนวณ

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

F-D $\quad \omega_j = \dfrac{g_j!}{(g_j - N_j)!N_j!}$

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

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

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

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

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

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

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

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

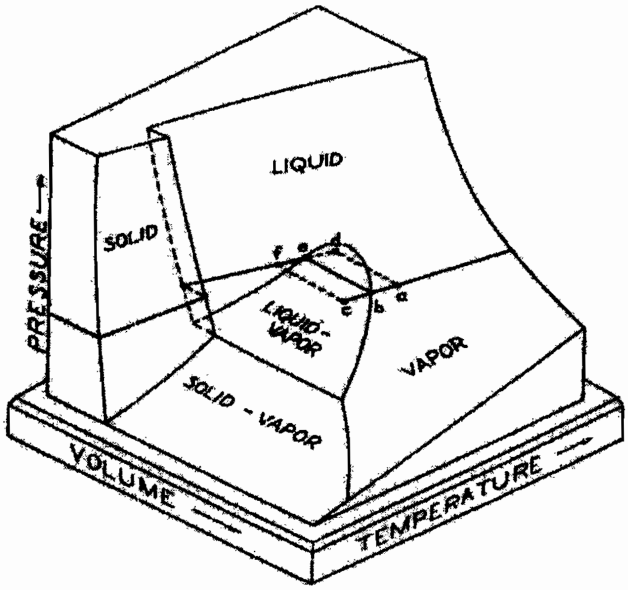
$$S = k_B \ln\Omega$$

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 the meaning of chemical potential (μ) of the thermodynamics.

(b) Describe briefly the meaning of entropy (S) in the meaning of statistical thermodynamics.

3. Describe the meaning of path $a \to b \to c$ and $f \to e \to d$ in the figure. [Keywords: metastable equilibrium state, unstable equilibrium state, supercooled vapor and superheatted liquid].



4. (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.

5. The pressure on water $1\times10^{-4}\,m^3$, initially at $0^\circ C$, is slowly increased from 1 atm to 10 atm.

Calculate the heat transferred (dQ) if the process is isothermal. [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. Liquid helium has a normal boiling point of 4.2 K. However, at a pressure of 1 mm of mercury, it boils at 1.2 K. Estimate the average latent heat (l_{23}) of vaporization of helium in this temperature range. [Hint: Being with an appropriate the Clausius-Clapeyron equation, $1\ atm = 1.013 \times 10^5 Pa$ and $1\ mmHg = 133.3 Pa$].

7. A container of volume V is divided by partitions into three parts containing one kilomole of helium gas, two kilomoles of neon gas, and three kilomoles of argon gas, respectively. The temperature of each gas is initially $300\ K$ and the pressure is $2\ atm$. The partitions are removed and the gases diffuse into each other.

   (a) Calculate the mole fraction of each gas in the mixture.

   (b) Calculate the partial pressure of each gas in the mixture.

   (c) Calculate the change of the Gibbs function of the system in the mixing process.

   (d) Calculate the change of the entropy of the system in the mixing process.

8. Show that the radiant energy density (u) of blackbody radiation is given by

$$u = \sigma T^4$$, when σ is the Stefan-Boltmann constant.

[Hint: Being with an appropriate the combine first and second laws equation, $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_V - P$].

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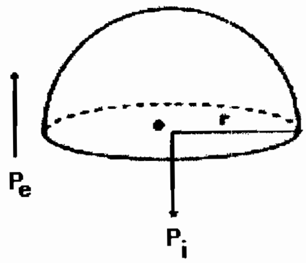
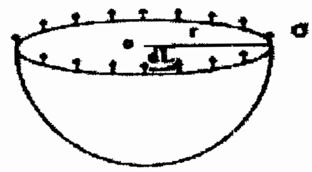
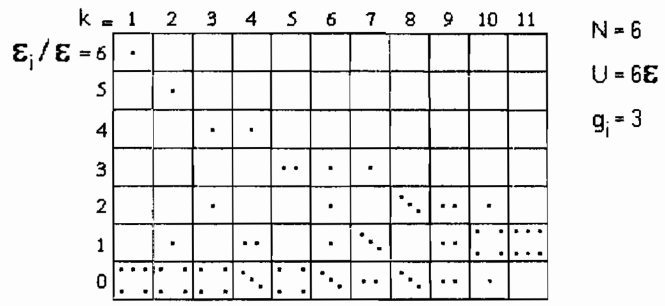
9. Show that the pressure P_i inside a bubble of radius r in a liquid which is under an external pressure P_e is given by $P_i - P_e = \dfrac{2\sigma}{r}$ where σ is surface tension forces. [Hint: $\bar{F}_{\downarrow} = \bar{F}_{\uparrow}$].





10. Bosons particles are distributed among the states of the seven 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).