國立中山大學107學年度碩士暨碩士專班招生考試試題

科目名稱：工程數學【材光系碩士班乙組】　　題號：439001

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

1. Find the general solution of $y'+\frac{2}{3}xy=xy^{-2}$ (20%)

2. Solve the ordinary differential equation of $y''-4y'+4y=6e^{2x}$ (15%)

3. Find the directional derivative of $f(x,y)=\frac{x^2+y^2}{x-y}$ at P: (2, 1) in the direction of $\vec{a}=3\vec{i}+\vec{j}$ (15%)

4. Solve the linear system by using the Gauss elimination method. (15%)

$$
\begin{aligned}
&3w-6x+y-z=-11\\
&w+x-2y+3z=10\\
&2w+2x-3y+2z=9\\
&w-2x+y-2z=-8
\end{aligned}
$$

5. Solve the partial differential equation of $x\frac{\partial w}{\partial x}+\frac{\partial w}{\partial t}=xt^2$, $w(x,0)=0$ *if* $x\geq 0$, $w(0,t)=0$ *if* $t\geq 0$ (20%)

6. Find the Fourier cosine transform for $f(x)=kx^2$ if $0<x<a$, $f(x)=0$ if $x>a$. (15%)

試題隨卷繳回

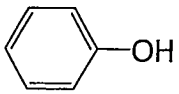
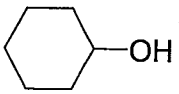
國立中山大學107學年度碩士暨碩士專班招生考試試題

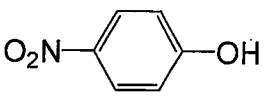
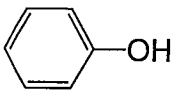
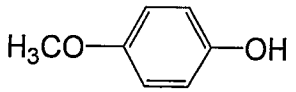
科目名稱：有機化學【材光系碩士班甲組】
※本科目依簡章規定「不可以」使用計算機(問答申論題)

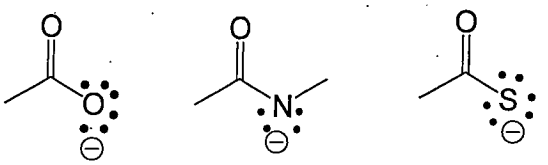
題號：439002

(1) (Total: 30%, each 5%) Arrange the compounds in each set in order of the referred properties (from the least to the most or using " > " to indicate the order).

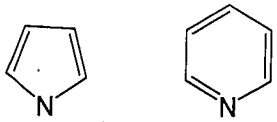
(a) CF_3COOH, CCl_3COOH, CH_3COOH (Acidity)

(b)   CH_3COOH (Acidity)

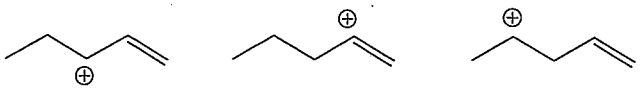
(c)    (Acidity)

(d)  (Nucelophilicity)

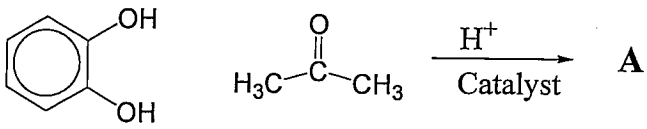
(e)

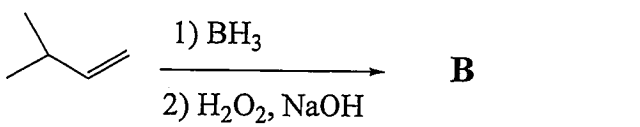
 CH_3ONa (Basicity)

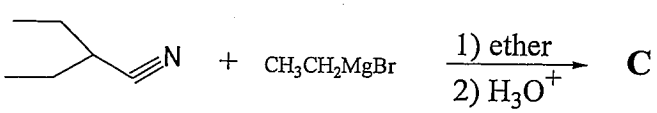
(f)

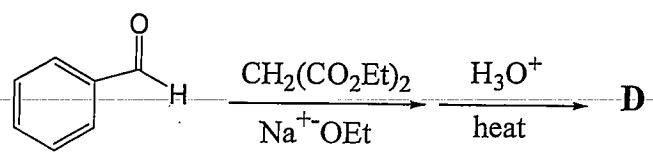
 (Stability)

(2) (Total: 20%, each 5%) Give the chemical structures of products A, B, C and D in the following reactions (a) ~ (d)

(a) 

(b) 

(c) 

(d) 

(3) (Total: 20%, each: 5%) Propose structures for compounds that fit the following ^{1}H NMR data:

(a) $C_4H_6Cl_2$
2.18 δ (3H, singlet)
4.16 δ (2H, doublet, J = 7 Hz)
5.7 δ (1H, singlet, J = 7 Hz)

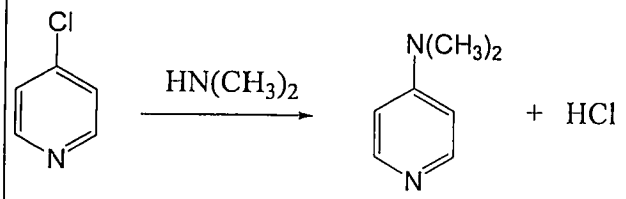
(b) $C_{10}H_{14}$
1.30 δ (9H, singlet)
7.30 δ (5H, singlet)

(c) $C_{10}H_{14}$
1.20 δ (6H, triplet)
2.70 δ (4H, quartet)
7.18 δ (4H, broad singlet)

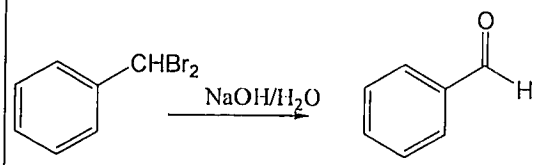
(d) $C_5H_{10}O$
0.95 δ (6H, doublet, J = 7 Hz)
2.10 δ (3H, singlet)
2.43 δ (1H, multiplet)

(4) (Total: 30%, each 5%) Give the mechanistic steps involved in the following reactions (a) ~ (f):

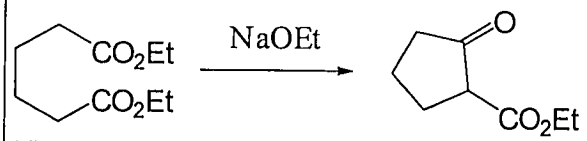
(a)



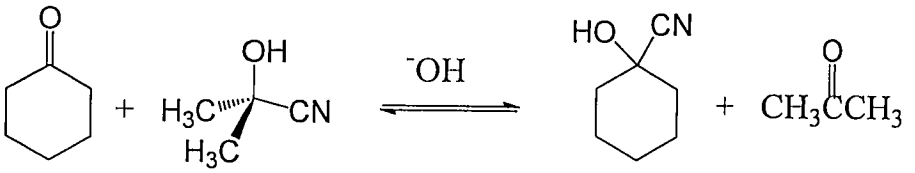
(b)



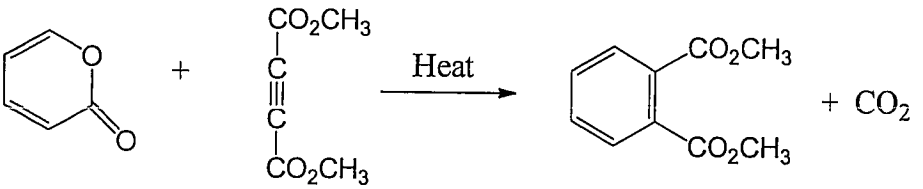
(c)



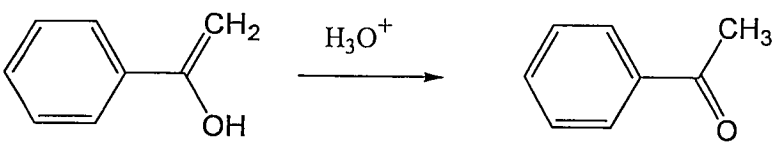
(d)



(e)



(f)



國立中山大學107學年度碩士暨碩士專班招生考試試題

科目名稱：普通物理 【材光系碩士班丙組】　　題號：439003

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）(問答申論題)　　共2頁 第 1頁

Problem 1. [Mechanics: 35 points]

Materials are made of atoms linked by the electrostatic force. Around the equilibrium positions, the electrostatic force can be modeled as a spring with elastic constant k.

(a) [10 points] Consider 2 identical atoms with mass m, connected by a force modeled as a spring with elastic constant k. The center of mass is stationary (not moving). Assume the 2 atoms only move in x-direction, solve the angular frequency of the vibration motion of the 2 atoms. How many vibration modes?

(b) [5 points] While the atoms are vibrating, is the energy conserved? is the momentum conserved? is the angular momentum conserved (with respect to the center of mass)?

(c) [20 points] Now consider 2 identical particles with mass m, connected by a spring with elastic constance k. Each particle is attached to a wall with the spring (same elastic constant k). Assume the 2 atoms only move in x-direction, how many vibration modes? Also solve the angular frequencies of each vibration mode. (See the Figure 1 as an example. x_1 and x_2 are the displacements from the equilibrium positions for particle 1 and 2. Note that the figure is just a demonstration, not the solution)

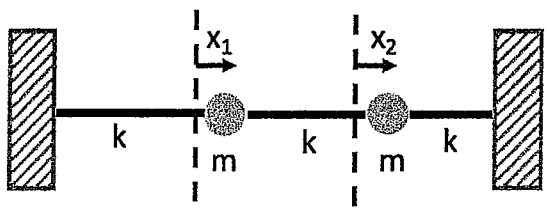


Figure 1

Problem 2. [Electromagnetism: 35 points]

Electromagnetic fields are the dominant forces in materials science. They are also directly related to optoelectronic applications. The electric field at a distance $\boldsymbol{r}$ from a point charge Q is:

$$\mathbf{E} = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}\hat{\boldsymbol{r}},$$

where $\hat{\boldsymbol{r}}$ is the unit vector along the vector $\boldsymbol{r}$. Consider the following questions in the vacuum, and use the units in the above formula.

(a) [7 points] Find the electric field (magnitude and direction) a distance s away from the midpoint between two charges: $-q$ at $z = -d/2$ and q at $z = +d/2$.

(b) [7 points] The two equal and opposite charges in **(a)** is an electric dipole. Prove first the following approximation (hint: use Taylor's expansion):

$$(1+x)^\alpha \approx 1 + \alpha x, \quad \text{as } x \ll 1.$$

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Then use this approximation to calculate, when $s \ll d$, the electric field (the first two non-vanishing terms).

(c) [7 points] Find the capacitance of a spherical conductor of radius R, with total charge Q on its surface.

(d) [7 points] If we add a tiny charge dq to the surface of the conductor in **(c)** by bringing it from infinity, what is the work done if the charge is increased from 0 to Q. That is the energy stored in the capacitor.

(e) [7 points] Following **(d)**, prove

$$\text{Energy} = \frac{1}{2}\epsilon_0 \int |\mathbf{E}|^2 dv.$$

Problem 3. [Thermodynamics: 20 points]

(a) [10 points] An ideal gas of N molecules expands in such a way that the temperature of the gas remains constant T. Find the work done when the volume expands from V_1 to V_2. Boltzmann constant is k.

(b) [7 points] According the Maxwell-Boltzmann distribution, the number of particles n_i corresponding to the energy E_i in the most probable distribution at temperature T is given by:

$$n_i = A\, e^{f(E_i,T)},$$

where A is a constant. What is the function $f(E_i, T)$? (Boltzmann constant is k)

(c) [3 points] What is then the ratio of the occupation numbers at two energy levels E_i and E_j, that is, n_j/n_i?

Problem 4. [Waves/Optics: 10 points]

(a) [5 points] Let a string be stretched between two clamps separated by a fixed distance L (both ends are fixed). Find wave lengths of all possible standing waves.

(b) [5 points] If there are some plane wave $f(x,t)$, which follows the wave equation:

$$\frac{d^2 f}{dt^2} = \left(135.7 + \frac{T}{\rho - 1.05}\right)\frac{d^2 f}{dx^2},$$

where T is the tension and ρ is the density of the medium. What is the velocity of this wave?

國立中山大學107學年度碩士暨碩士專班招生考試試題

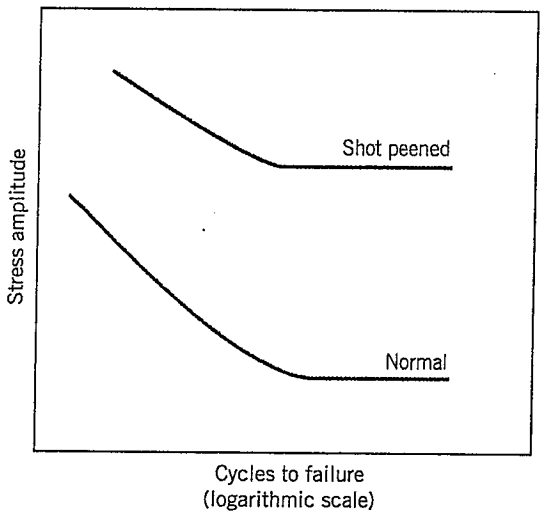
科目名稱：材料科學【材光系碩士班丙組】　　題號：439004

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

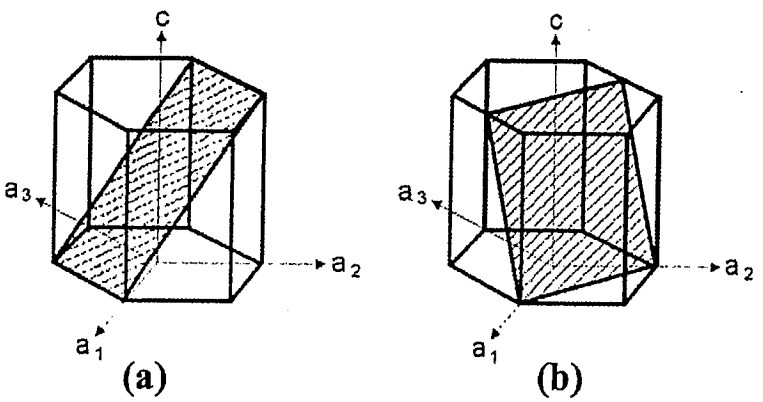
(1) Grain boundary strengthening is a very common strengthening method of materials. Discuss how the misorientation of a grain boundary affects the strengthening effect of this grain boundary? 8 points

(2) Elongation and area reduction of a tensile test specimen can both be used to measure the ductility of a material. Which one is the better way to measure the ductility of a material? Justify your answer. 8 points

(3) Shot peening is a process using small steel balls bombard the surface of a metal part. The steel balls act like a hammer, bombard the surface and causing deformation and compression stresses. The figure given below shows the effect of shot peening on the fatigue property of a metal. Explain this figure. 8 points



(4) What are the Miller-Bravais indices of the planes shown in (a) and (b)? 3 points each. 6 points



(5) Explain the following terms: (a) phase, 3 points, (b) peritectic reaction, 3 points, (c) metastable phase, 3 points, (d) bainite, 3 points, (e) glass-ceramic, 3 points, (f) intrinsic semiconductor, 3 points, and (g) luminescence, 2 points. 20 points

(6) The parameter, K_{Ic}, is used to know the fracture toughness of a material. Explain what is K_{Ic}, and how do you measure it? 8 points

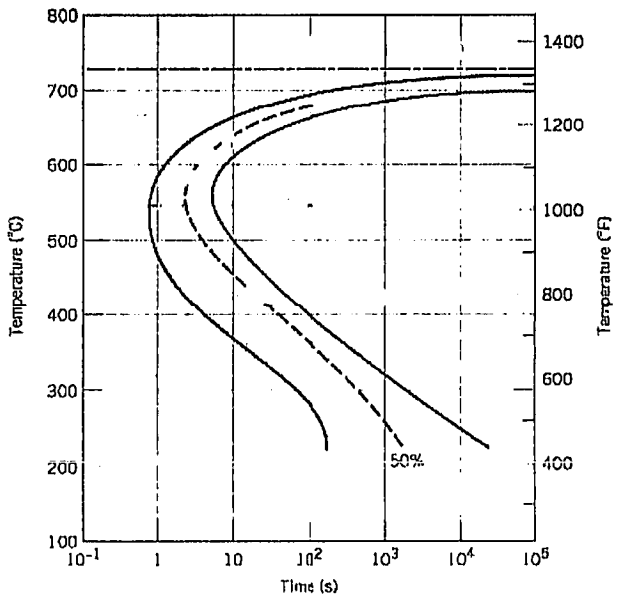
(7) What can we know about diffusion from Fick's first and second laws? 12 points

國立中山大學107學年度碩士暨碩士專班招生考試試題

科目名稱：材料科學【材光系碩士班丙組】　　題號：439004

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

(8) The figure shown below is a T-T-T diagram. The shape of this T-T-T diagram is a typical one. Explain why it has this kind of shape. 10 points



(9) Give five phase transformation names in materials, e.g. solidification. 10 points

(10) Give the unit of (a) shear stress, (b) diffusion coefficient, (c) Young's modulus, (d) strain rate and (e) electrical conductivity. 2 points each. 10 points

國立中山大學107學年度碩士暨碩士專班招生考試試題

科目名稱：物理化學【材光系碩士班甲組】　　題號：439005

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

1. The density of a noble gas was found to be 1.23 g/L at 330 K and 25.5 kPa. What is the molar mass of the compound? (20%)

2. Given the van der Waals constants for ethane gas as $a = 5.0\ L^2\ bar/mol^2$, $b = 0.07\ L/mol$, for 20.0 mol of ethane at 300 K and under 30 bar
   (a) Find the second virial coefficient B at this temperature.
   (b) Calculate the compressibility factor Z from the first two terms.
   (c) Estimate the approximate molar volume from Z.
   (d) What is its Boyle temperature T_B? (20%)

3. When 2 mole of water supercooled to -10 °C freezes isothermally, what are the entropy change of the system and surroundings? Give the molar enthalpy of the melting of ice at 0 °C is 6025 J/mol, the molar heat capacities of ice and water are 37.3 and 75.3 J/mol.K, respectively. (20%)

4. The vapor pressure of methyl bromide is 13.0 torr at -70 °C and 117 torr at -36.7 °C. Evaluate
   (1) the molar enthalpy of vaporization of methyl bromide
   (2) the vapor pressure of methyl bromide at -40 °C. (20%)

5. On the basis of the following proposed mechanism, calculate the rate law for the methane, where the mechanism was summarized as follows: (20%)

   $CH_3CHO \xrightarrow{k_{obs}} CH_4(g) + CO(g)$

   A proposed mechanism is

   $CH_3CHO \rightarrow CH_3 + CHO$ (k_1)
   $CH_3 + CH_3CHO \rightarrow CH_4 + CH_3CO$ (k_2)
   $CH_3CO \rightarrow CH_3 + CO$ (k_3)
   $2CH_3 \rightarrow C_2H_6$ (k_4)

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國立中山大學107學年度碩士暨碩士專班招生考試試題

科目名稱：熱力學【材光系碩士班乙組】　　題號：439006

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　

請於答案卷上依序做答，並清楚標明題號

1. **(25%)** **(a, 4%)** The thermodynamic properties *U, H, A* and *G* are known of the variables, *T, S, P* and *V*. For a homogeneous fluid of constant composition, there are four fundamental property relations. Write down the four relations of *dU, dH, dA* and *dG*. **(b, 2%)** Define the heat capacity at constant volume (C_v) and at constant pressure (C_p). **(c, 5%)** The complete differential internal energy U can be written in terms of the partial derivative $dU=\left(\frac{\partial U}{\partial V}\right)_T dV+\left(\frac{\partial U}{\partial T}\right)_V dT$, derive the relation $C_p=C_v+R$ for one mole of ideal gas. **(d, 5%)** Define the partial molar property ($\overline{M_i}$), the chemical potential (μ_i), the fugacity (f_i), the activity (a_i) and activity coefficient (r_i) of species *i* in a solution. **(e, 4%)** Define the Raoult's law and Henry's law, respectively. **(f, 5%)** Draw two schematic figures that illustrate the vapor pressure of a component of a binary solution (A-B) exhibiting positive deviation and negative deviation from Raoultian behavior, respectively.

2. **(25%)** **(a, 5%)** Draw a schematic *T-x* (temperature-composition) phase diagram for a binary A-B system with one liquid phase (L), two terminal solid phases (α and β), one eutectic reaction and one peritectic reaction . Please label all phase regions. **(b, 5%)** Figure 1 shows the Ag-Sb binary phase diagram. Please calculate the change of entropy (△S) when 100 grams of pure silver (Ag) is mixing with 5 grams of pure antimony (Sb), to form a homogeneous binary alloy. The atomic weights of Ag and Sb are 107.9 (g/mol) and 121.7 (g/mol), respectively. **(c, 5%)** Write down the eutectic reaction and the peritectic reaction in figure 1 at 485 ° C (T_1) and 702.5° C (T_2), respectively. **(d, 5%)** Sketch the Gibbs free energies of mixing (ΔG^{mix}) for the liquid and phases (i.e., the (Ag), (Sb), ε and ζ) as a function of composition at temperatures T_1 and T_2. **(e, 5%)** Sketch the activities (a_i) of Ag and Sb as a function of composition at temperatures T_1 and T_2. Note that the standard state of each case needs to be given.

3. **(15%)** A rigid and isolated container with volume of 10 (Liter, *L*) is divided by a divider into two parts: 2.5 (*L*) and 7.5 (*L*). At very beginning, one part (2.5 (*L*)) is filled with one mole of A gas at 300 K and 1 bar; while the other part (7.5 (*L*)) is filled with two moles of B gas at 600 K. And both A and B gases follow the ideal gas law. As the divider is removed, A and B gases are allowed to mix together. Please calculate the following terms: **(a, 3%)** the temperature of gas mixture. **(b, 3%)** the pressure of gas mixture. **(c, 3%)** the change in entropy. **(d, 3%)** the change in Gibbs free energy. **(e, 3%)** the change in enthalpy. (Note: $C_p=3.5R$ and $C_V=2.5R$, $R=8.3146\ m^3PaK^{-1}mol^{-1}$, 1 bar=$10^5$ pa).

4. **(15%)** A Carnot engine, rated at 10^5 kW, generates steam from a heat reservoir at 800 K and discards heat to a cold reservoir at 300 K. **(a, 5%)** What is the entropy change of the heat reservoir at 300K? **(b, 5%)** What is the rate at which heat is absorbed from the heat reservoir and discarded to the cold reservoir? **(c, 5%)** A practical engine operates between the same heat and cold reservoirs but with an efficiency which is 50% of that of a Carnot engine.

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國立中山大學107學年度碩士暨碩士專班招生考試試題

科目名稱：熱力學【材光系碩士班乙組】　　題號：439006

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

5. **(20%)** A steel casting weighing 4 kg has an initial temperature of 400°C; 40 kg of water initially at 25℃ is contained in a perfectly insulated steel tank weighing 5 kg. The steel casting is immersed in the water and the system is allowed to reach equilibrium. **(a, 5%)** What is the final equilibrium temperature? **(b, 5%)** What is the entropy change of the steel casting? **(c, 5%)** What is the entropy change of the water? **(d, 5%)** what is the *total* entropy change ($\triangle S_t$)? (Note: $C_{p,steel}$=0.5 (kJ/kg) and $C_{p,water}$=4.2 (kJ/kg)).

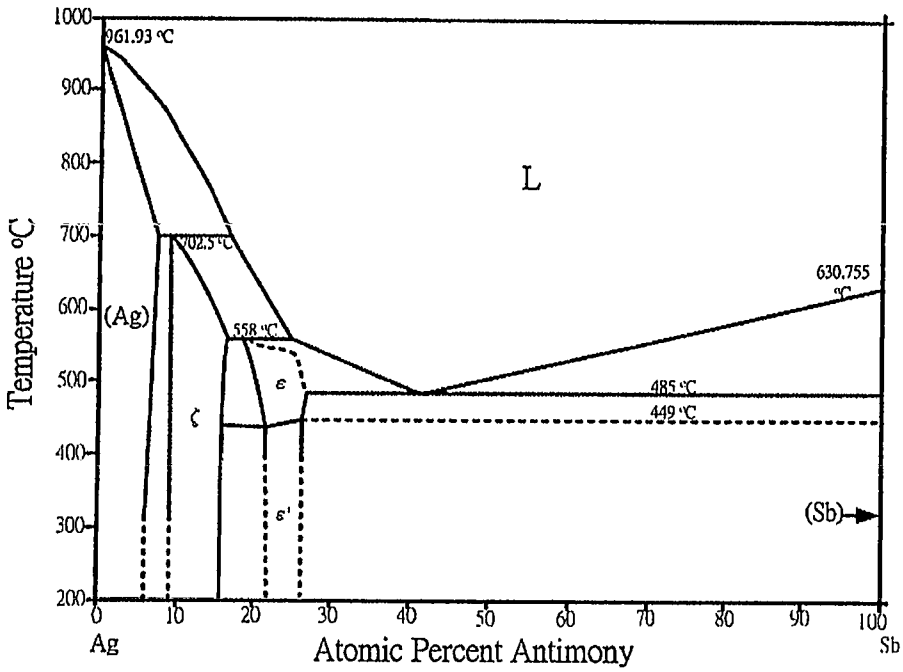

Figure 1 Ag-Sb binary phase diagram.

	Conversion factors and gas constant
Pressure	1 bar= 10^5 $Kgm^{-1}S^{-2}$= 10^5 Pa=0.986923 atm= 14.5038 psia =0.986923 atm
Energy	1 J= 1Kgm^2s^{-2}= 1Nm=1m^3Pa=0.239006 cal
Gas constant	R= 8.314 $Jmol^{-1}K^{-1}$ =8.314 $m^3Pamol^{-1}K^{-1}$=83.14 $cm^3barmol^{-1}K^{-1}$