國立清華大學 101 學年度碩士班考試入學試題

系所班組別：工程與系統科學系碩士班 甲組

考試科目（代碼）：材料熱力學（2502）

　　*請在【答案卷、卡】作答

1. Consider an isolated system consisting of a kilogram of lead and a kilogram of water illustrated below. (13%)

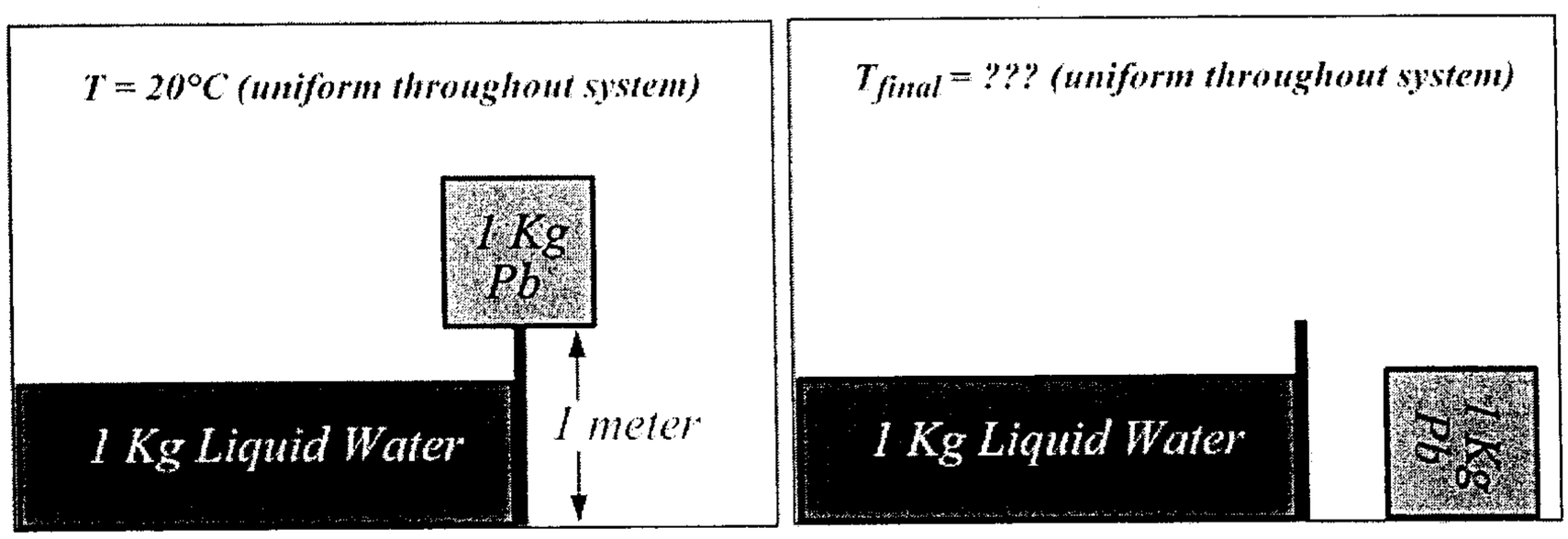


Figure: Isolated system illustrated before and after

The heat capacity of 1 kilogram of Pb is given by C_{Pb}; the heat capacity of 1 kilogram of water is given by C_{H2O}; all other heat capacities in the isolated system can be neglected. C_{Pb} and C_{H2O} may be considered independent of any constraints (e.g., constant pressure or constant volume) and to be independent of temperature.

(a) Derive an expression for the final temperature after a process leading to the figure on the right of the illustration.

(b) Would the temperature be larger or smaller if the block of lead had fallen to the left (i.e., into the water)? Pleae justify your answer.

2. The initial state of one mole of a monatomic ideal gas is P=6.24 atm and T=568K . Now the gas is allowed to expand freely and adiabatically from 1/3 of the volume to fill the entire container. Compute the followings: (18%)

(a) the change in pressure and temperature.

(b) the change in internal energy (U) and enthalpy (H) between the initial state and final state.

(c) the change in Gibbs free energy (G) and entropy (S) between the initial state and final state.

3. For the binary phase diagram given below, please answer the following questions. (30%)

   (a) List the components in the phase diagram.

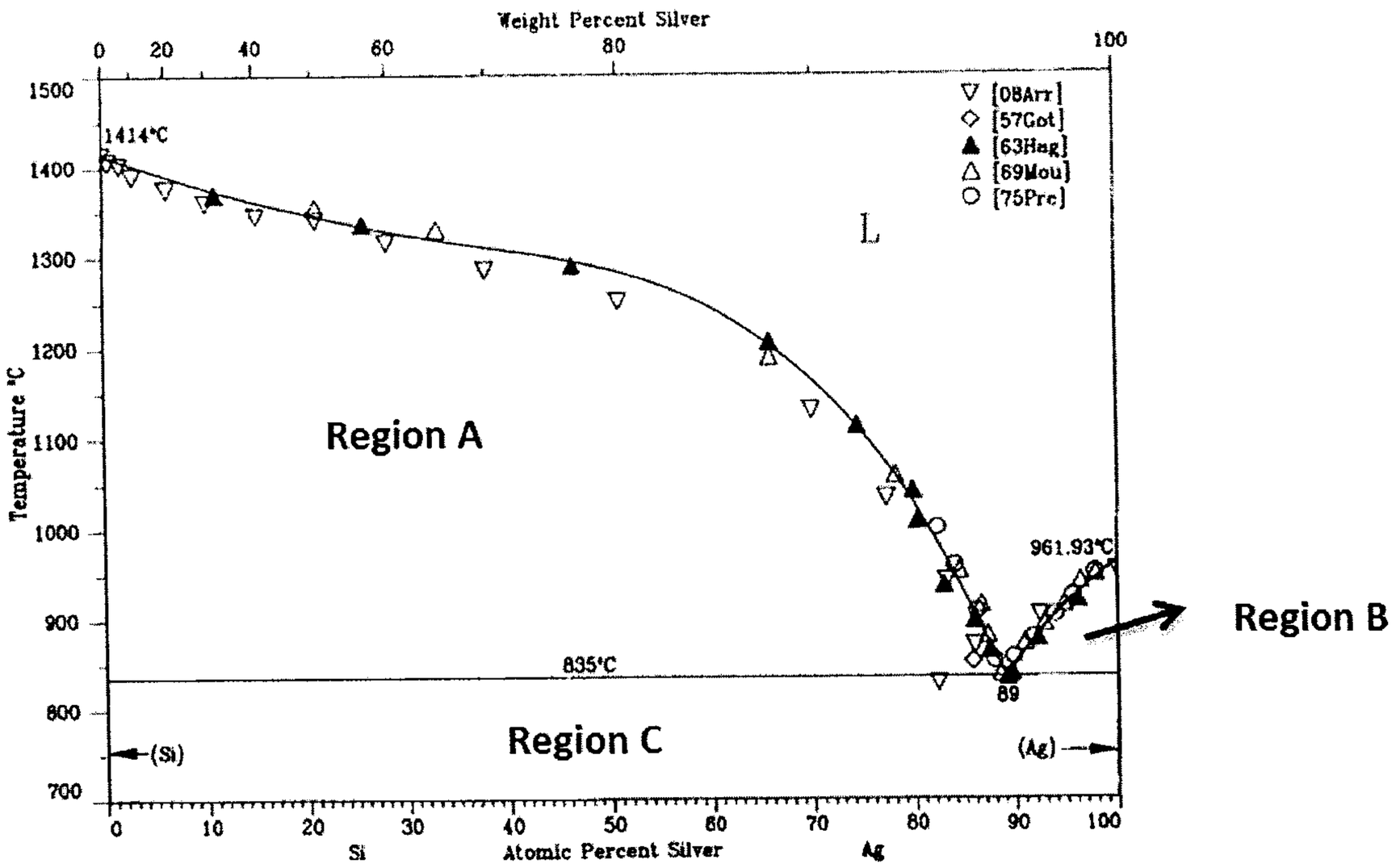
   (b) Fill in the phases in the region A, B and C.

   (c) What is the eutectic composition and eutectic temperature?

   (d) draw schematics of plausible moalr free energy curves showing the common tangent construction at 1100°C.

   (e) draw schematics of chemical potentials of the two components, μ_{Si} and μ_{Ag}, as a function of composition, X_{Ag}, at 1100°C.

   (f) Calculate the Gbbs free energy of the eutectic melt relative to unmixed liquid Si and liquid Ag.



R.W. Olesinski, A.B. Gokhale, and G.J. Abbaschian, 1989.

4. Pure Nickel exists in two solid forms *α –Ni (fcc)* and *β –Ni (bcc)* with the transition at $T_{\alpha\rightarrow\beta} = 630$ K at atmospheric pressure. β –Ni melts at $T_m = 1728$ K. The enthalpy of formation of α –Ni at 198 K is $\Delta H_{\alpha,0} = 0$ J/mole. The entropy of formation of α –Ni at 298 K is $\Delta S_{\alpha,0} = 29.8$ J/moleK. The heat capacitenies of the solid forms are given below. You could refer Table 1 for the enthalpy of β –Ni at the melting temperature, $\Delta H_{\beta,m}$. (14 %)

$C_{p,\alpha} = 32.6 - 1.97\times10^{-3} T - 5.586\times10^{5} T^{-2}$

$C_{p,\beta} = 29.7 + 4.18\times10^{-3} T - 9.33\times10^{5} T^{-2}$

(a) Calculate the enthalpy of transformation $\Delta H_{\alpha\rightarrow\beta}$ and $\Delta S_{\alpha\rightarrow\beta}$,

(b) Calculate the entropy of transformation $\Delta H_{\alpha\rightarrow\beta}$ and $\Delta S_{\alpha\rightarrow\beta}$.

5. For the reaction $CO_{(g)} + 1/2\ O_{2\,(g)} \leftrightarrow CO_{2(g)}$. (25%)

(a) The total pressure at equilibrim is P_T , and the partial pressures of CO_2 and CO are P_{CO2} and P_{CO} , respectively. Write dwon a general expression for the partial pressure of oxygen, P_{O2}, at equilibrium using the conecpt of the equilibrium constant and its relation to the free energy of reaction, ΔG_{rea}.

(b) For a fixed P_{CO2}/P_{CO} ratio, make plots that show the relation between (i) P_{O2}, and P_T ,and (ii) P_{O2} and T. <u>You are required to clearly label the value of slop and intercept in the figures.</u>

(c) For a general reaction beginning with n_{CO2}, n_{O2} and n_{CO} moles of the substances, write down an expression for the reaction constant in terms of the final number of moles of O_2, x.

---------- End of problem sets----------

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Atmosphere　　1 atm = 1.01325 bar = 101.325 kPa

Gas constant　　R = 8.3144 joules/degree-mole=82.06 cm^3-atm/degree-mole

Boltzmann's constant　k = 1.38054 x 10^{-23} joules/degree

Table 1　　Molar heats of melting and transformation

Substance	Trans	ΔH_{trans} , J	T_{trans} , K
Ag	s→l	11090	1234
Al	s→l	10700	934
Au	s→l	12600	1338
Cu	s→l	12970	1356
Si	s→l	50200	1685
Ni	s→l	17150	1728
Bi	s→l	10900	544