國立高雄大學 103 學年度研究所碩士班招生考試試題

科目：材料科學導論
考試時間：100 分鐘

系所：化學工程及材料工程學系
（乙組）
本科原始成績：100 分

是否使用計算機：是

1. (10%) The metal rubidium has a BCC crystal structure. If the atomic radius for the rubidium atom is 2.48 Å and monochromatic x-radiation having a wavelength of 0.071 nm is used for X-ray diffraction, determine the (a) corresponding crystallographic planes and (b) diffraction angles of the first three diffraction peaks. (can be expressed in the form of $\theta = \sin^{-1}x$)

2. (20 %) Consider one alloy that initially has a uniform carbon concentration of 0.25 wt % and is to be treated at 900℃. If the concentration of carbon at the surface is suddenly brought to and maintained at 1.3 wt. %, how long will it take to achieve a carbon content of 0.8 wt % at a position 0.6 mm below the surface? The diffusion coefficient for carbon in iron at this temperature is 1.6×10^{-11} m^2/s.

z	*erf(z)*	*z*	*erf(z)*	*z*	*erf(z)*
0	0	0.55	0.5633	1.3	0.9340
0.025	0.0282	0.60	0.6039	1.4	0.9523
0.05	0.0564	0.65	0.6420	1.5	0.9661
0.10	0.1125	0.70	0.6778	1.6	0.9763
0.15	0.1680	0.75	0.7112	1.7	0.9838
0.20	0.2227	0.80	0.7421	1.8	0.9891
0.25	0.2763	0.85	0.7707	1.9	0.9928
0.30	0.3286	0.90	0.7970	2.0	0.9953
0.35	0.3794	0.95	0.8209	2.2	0.9981
0.40	0.4284	1.0	0.8427	2.4	0.9993
0.45	0.4755	1.1	0.8802	2.6	0.9998
0.50	0.5205	1.2	0.9103	2.8	0.9999

3. (1) (10%) Plot the Fe-Fe_3C phase diagram, label all the phases and describe the phase transformations for eutectic, eutectoid, peritectic reactions and the corresponding temperatures and compositions.
   (2) (20%) Consider 3.0 kg of austenite containing 0.9 wt % C, (a) make schematic sketches of the microstructure that would be observed for conditions of very slow cooling at the following temperatures: 1000°C, 728°C, and 726°C. Label all phases and indicate their approximate compositions. (Hint: the solubility limit of C in Fe is about 0.022 wt. % at 727°C); (b) Consider the structures at 726°C, how many kilograms each of total ferrite and cementite form? How many kilograms each of pearlite and the proeutectoid phase form?

4. (20 %) Considering the solidification of a pure material, if the surface energy of solid-liquid is γ, the volume free energy difference between the solid and liquid phase is ΔG_v. The total free energy change for homogeneous nucleation is equal to the sum of these two contributions.

科目：材料科學導論
考試時間：100 分鐘

系所：化學工程及材料工程學系
（乙組）
本科原始成績：100 分

是否使用計算機：是

(a) Derive the formula of total free energy change ΔG_{Total} as a function of nucleus radius r.
(b) Plot the curves of surface energy, volume free energy difference, and total free energy change as a function of nucleus radius r.
(c) If there is a critical radius r^* corresponding to a maximum total energy of ΔG^*, derive the expression for r^* and ΔG^*, respectively.
(d) Explain the meaning of r^* and ΔG^*, respectively.
(e) Schematically plot two ΔG_{Total} vs. r curves at temperature of T_1 and T_2 (assume $T_1 > T_2$), and explain the influence of temperature on nucleation.

5. Graphite, diamond, and carbon nanotubes are all carbon-based materials which have distinct properties, try to explain the reasons that cause such different properties in the viewpoints of their structure and chemical bonding. (10%)

6. The figure below shows carrier concentration as a function of temperature for n-type and intrinsic Si. Explain the physical meanings of the freeze-out, extinction, and intrinsic regions. (10 %)