※ 考生請注意：本試題 ☑可　□不可 使用計算機

1. (15%) In a solid, the potential energy U_N for two atoms a distance r apart is

$$U_N = U_A + U_R = -\frac{A}{r} + \frac{B}{r^m}$$

Suppose A, B and m are known constants. ($m > 1$).

(a) Determine the equilibrium spacing r_o. (in terms of A, B and m) (5%)

(b) Determine the bonding energy U_o. (in terms of A, B and m) (5%)

(c) Estimate the elastic modulus of the solid from bonding stiffness at small stretch. (in terms of A, B and m) (5%)

2. (20%) Calculate the sieve analysis of the following aggregate

Sieve size	Percent passing (%)
3/8in	100
No. 4	94
No. 8	82
No. 16	66
No. 30	36
No. 50	29
No. 100	3
No. 200	0

(a) What is the maximum-size-aggregate? (4%)

(b) Calculate the Fineness Modulus. (5%)

(c) If the weight of this aggregate sample was measured under various conditions with the following

results:　　Oven-dry weight = 5216g

　　　　　　Saturated-surface-dry weight =5227g

　　　　　　Weight of sample submerged in water = 3295g

Find the aggregate dry bulk specific gravity and the absorption capacity. (6%)

(d) Why is the absorption capacity an important parameter? (5%)

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3. (25%) About portland cement,

(a) What is the role of gypsum? (5%)

(b) What are the primary chemical reactions during the hydration? (10%)

(c) What chemical compounds contribute to early strength gain? (5%)

(d) Discuss the water-to-cementitious material ratio on the quality of hardened concrete. (5%)

4. (10%) Sketch the stress-strain behavior of steel, and identify (i) the modulus of elasticity (ii) the

modulus of resilience (iii) proportional limit (iv) yield strength and (v) the ultimate strength on graph.

5. (20%) Phase diagram of carbon steel
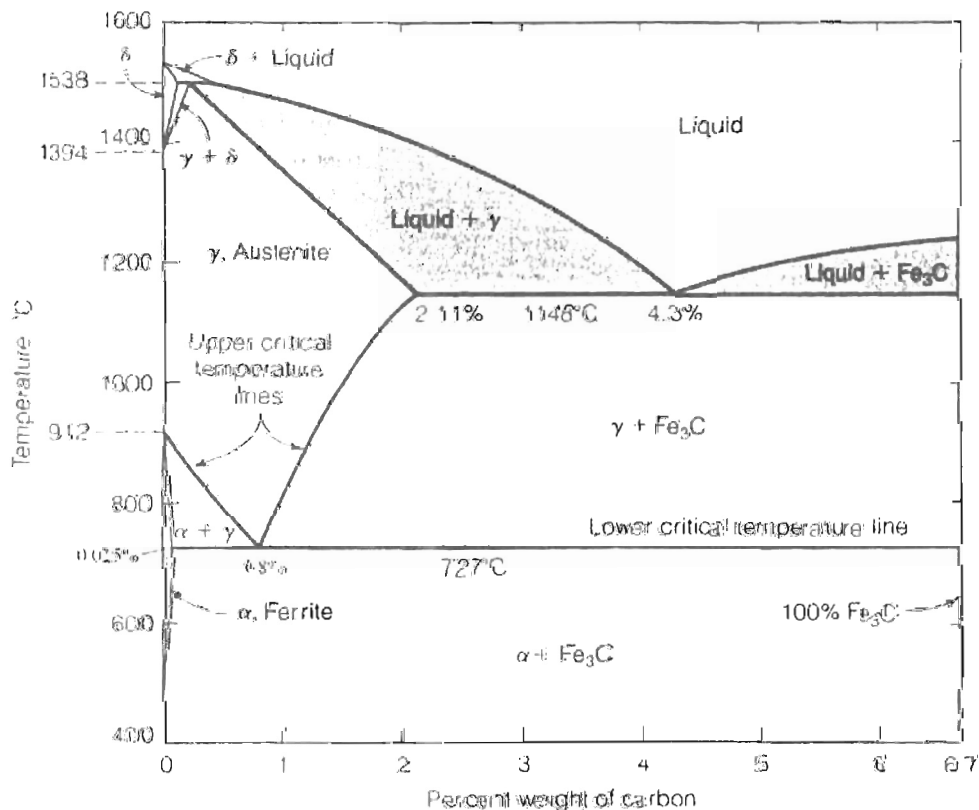
(a) For a 0.4 wt% carbon steel, what is the carbon content of Fe_3C at 600 °C? When temperature is slightly above 727°C, what is the carbon content of austenite γ? (6%)

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(b) For a 1.0 wt% carbon steel, what is the weight percent of austenite in the steel when temperature is slightly above 727°C ?   What is the weight percent of ferrite in the steel when temperature is slightly below 727°C?   (6%)

(c) Describe the eutectoid reaction in low carbon steel.   (4%)

(d) What is the effect of increasing the carbon content in steel?   (4%)

6. (10%) Metal A has a FCC crystal structure, an atomic density of 12.0g/cm^3 and an atomic weight 106.4g/mol. Note the Avogadro's number $N_A = 6.023 \times 10^{23}$ atoms/mol. Determine

(a) The atomic radius of Metal A.   (5%)

(d) Sketch the (011) plane of Metal A, and calculate its planar density.   (5%)