Registration No: | | | | | | | | | | |

Total Number of Pages:02 **M.Tech**

P1MTBC03

1st Semester Regular/Back Examination 2017-18

Physical Metallurgy

BRANCH: INDUSTRIAL METALLURGY, METALLURGICAL AND MATERIALS ENGG

Time: 3 Hours

Max Marks: 100

Q.CODE: B933

Answer Question No.1 and 2 which are compulsory and any four from the rest.

The figures in the right hand margin indicate marks.

Q1 **Answer the following questions:** **(2 x 10)**

a) Show the planes (112) (102) and [110] [211]direction in cubic crystal?

b) What is Burger's vector? How to determine it? Explain using Edge dislocation?

c) Define coordination number and atomic packing factor?

d) Distinguish between crystalline and non-crystalline solid?

e) Explain Hall – Petch equation and Reverse Hall-Petch equation?

f) What is Peritectic reaction?

g) Derive Gibb's phase rule? What is the minimum and maximum number of phases which could exist in a pure metal?

h) Mention any two differences between interstitial solid solutions and substitutional solid solutions?

i) Why grain boundaries are are favourable sites for nucleation or growth for precipitates?

j) Draw a neat sketch of a cooling curve for a pure metal?

Q2 **a)** Draw a neat sketch of iron – carbon equilibrium diagram? Mention all Invariant reactions, phases, lines and temperatures? **(10)**

b) What are the effect of non – equilibrium cooling? What is the dendritic segregation? **(10)**

Q3 **a)** Calculate the equilibrium number of vacancies per cubic meter for copper at 1000^0C. The energy for vacancy formation is 0.9ev/atom; the atomic weight and density (at 1000^0C) for copper are 63.5g/mol and 8.4g/cm^3 respectively. (*Boltzmann constant : 8.62*$\times 10^{-5}$*ev/K and Avogadro's no.6.023*$\times 10^{23} atom/mol$) **(10)**

b) State Home – Rothery rules that favors the substitutional solid solutions? **(10)**

Q4 **a)** Rewrite the expression for the total free energy change for nucleation for the case of a cubic nucleus of edge length a (instead of a sphere of radius r). Now differentiate this expression with respect to a* and solve for both the critical cube edge length, a*, and also free energy ΔG*. Is ΔG* greater for cube or sphere? **(10)**

b) Explain the effect of undercooling on Nucleation rate and Growth rate of transformations. (use required schematics) **(10)**

Q5 **a)** After being slowly cooled from the austenite region, a simple iron-carbon steel exhibits a microstructure consisting of 40 percent pearlite and 60 percent ferrite. **(10)**

Estimate the carbon concentration of the steel.

Describe the equilibrium microstructure that would be obtained if the steel were heated to 730°C and held there for a long period of time.

What would be the equilibrium structure of this steel if it were heated to 850°C?

Make sketches of all of these microstructures.

b) A sheet of steel 3 mm thick has nitrogen atmosphere on both sides at 900^{o}C. The diffusion coefficient of nitrogen in steel at this temperature is 1.2×10^{-10} m^2/s. The diffusion flux is found to be -1.0×10^{-7} kg/m^2-s. Also, it is known that the concentration of nitrogen in the steel at left surface is 1.5 kg/m^3. How far into the sheet from this left side will the will the concentration be 3 kg/m^3. Assume steady state diffusion. **(10)**

Q6 **a)** Describe in your own words the three strengthening mechanisms (i.e., grain size reduction, solid-solution strengthening, and strain hardening). Be sure to explain how dislocations are involved in each of the strengthening techniques **(10)**

b) Estimate the size of critical nucleus of tin when it is supercooled by 20^{o}C. Assume nucleation to be homogeneous. The enthalpy change for solidification of tin is 0.42GJ/m^3. The liquid/solid interfacial energy is 0.055 J/m^2. The melting point of tin is 232^{o}C **(10)**

Q7 **a)** Two metals A (melting point 800 ºC) and B (melting point 600 ºC) form a binary isomorphous system. An alloy having 35% B has 75% solid and rest liquid whereas an alloy having 55%B has 25% solid at 700 ºC. Estimate the composition of solidus and liquidus at the above temperature. **(10)**

b) What is the effect of various alloying elements on TTT diagram? Draw a TTT diagram for a eutectoid steel **(10)**