Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/B. Tech (CT)/SEM-5/CT-505/2011-12

2011
METALLURGY

Time Allotted : 3 Hours   *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words
as far as practicable.

GROUP – A
(Objective Type Questions)

1.   Answer any *ten* of the following questions :   10 × 1 = 10

   A.   Choose the correct alternatives for the following :

   i)   At the eutectic point in a binary system, the number of phases in equilibrium is

   a)   zero   b)   one

   c)   two   d)   three.

   ii)   The number of C atoms per unit cell in a diamond cubic structure is

   a)   4   b)   2

   c)   8   d)   1.

5416   [Turn over

iii) At the eutectic point in a binary system (at fixed pressure)

    a)   one degree of freedom exist

    b)   compositions as well as relative volume fractions of the phases in equilibrium are fixed

    c)   compositions of the phases in equilibrium are fixed but their relative volume fractions can change

    d)   only one phase can exist at equilibrium.

iv) Keeping other variables unchanged, to increase the depth of carburization by a factor of 2, the time of carburization should be increased by a factor of
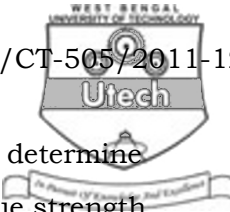
    a)   2   b) $\sqrt{2}$

    c)   4   d) $2\sqrt{2}$.

v) In binary system, the following eutectic reaction exists :

L (60 % B) = α (20 % B) + β (80 % B)

The equilibrium amount of pro-eutectic α-phase just below the eutectic temperature in an alloy containing 50 % B would be

    a)   60 %   b)   50 %

    c)   75 %   d)   25 %.

vi) A three point bend test is used to determine

a) tensile strength   b) fatigue strength

c) flexural strength d) impact strength.

vii) Number of slip systems in FCC metals is

a) 3   b) 6

c) 12   d) 24.

viii) The yield strength of materials with grain size d

a) increases linearly with d

b) decreases linearly with d

c) increases linearly with $\sqrt{d}$

d) decreases linearly with $\sqrt{d}$.

ix) The structure of martensite in steel is

a) body-centered cubic

b) body-centered tetragonal

c) face-centered cubic

d) face-centered tetragonal.

x) The characteristic diffusion distance in a material with diffusivity D in time t is proportional to

a) $Dt^{\frac{1}{2}}$ b) $Dt^{\frac{1}{2}} t$

c) $D^{\frac{1}{2}} t^{\frac{1}{2}}$ d) Dt.

xi) When the particle size decreases, the surface to volume ratio

a) increases   b) decreases

c) remains constant d) is material-dependent.

xii) At constant pressure, the maximum degrees of freedom in a binary phase diagram are

a) 0   b) 1

c) 2   d) 3

xiii) Life of lining in LD converter depends on

a) Furnace Atmosphere

b) Mechanical Stress

c) Composition of Slag

d) Thermal Shock

e) All of these.

B. Fill in the blanks.

xiv) Duralumin is an alloy of aluminium with .... , ... , ...

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following.   3 × 5 = 15

2. *A* and *B* are two elements having limited solid solubility. They form a eutectic system with eutectic temperature $800°C$. At this temperature *A* dissolves in *B* to the extent of 10%, forming β solid solution and *B* dissolves in *A* to the extent of 15% to form α solid solution. *A* and *B*, in pure form, melt at $1200°C$ and $900°C$ respectively. The eutectic is formed at a nominal composition of 60% *B*. At room

temperature, *A* and *B* have negligible solid solubility. Assuming that all the phase boundaries are linear,

a) sketch the phase diagram, marking all the phase fields.

b) for an alloy with nominal composition of 40% *B*, calculate

    i)   percentage of primary α;

    ii)   percentage of eutectic

    iii)   percentage of total amount of α, at a temperature just below the eutectic temperature

c) Sketch a typical cooling curve for this alloy starting from the liquid state to room temperature.

$$1 + (3 \times 1) + 1$$

3. a) Schematically draw the Continuous Cooling Transformation (CCT) diagram of a plain C eutectoid steel, including the M_s and M_f lines. On this diagram show the cooling curves to obtain (i) coarse pearlite (ii) fine pearlite and (iii) 50% pearlite – 50 % martensite.

b) The diffusion coefficient for Al in Cu is $2 \cdot 5 \times 10^{-24}$ m^2/s at 200°C and $3 \cdot 1 \times 10^{-17}$ m^2/s at 500 $^\circ$C. What is the activation energy for the diffusion of Al in Cu ? What is the diffusion coefficient at 380°C ?

$$2 + 2 + 1$$

4. a) Draw a typical stress-strain diagram for a tensile test on

    i) Mild Steel

    ii) Pure Aluminium

    iii) Pure Copper

    iv) Ceramic Material.

  b) Write down the effects of the three following factors on the tensile strength, impact strength and creep of mild steel :

    i) Grain size

    ii) Low temperature and

    iii) Annealing $\left(4 \times \frac{1}{2} \right) + 3$

5. Draw a generalised flow curve for FCC single crystals and explain each stage with respect to strain hardening of the crystal.

6. Calculate $\Delta f *_{het}$ as a fraction of $\Delta f *_{homo}$, when the interfaces shown in the figure below, have the following energies : $\gamma_{\alpha\beta} = 0 \cdot 5 \, \text{Jm}^{-2}$, $\gamma_{\alpha\delta} = 0 \cdot 5 \, \text{Jm}^{-2}$ and $\gamma_{\beta\delta} = 0 \cdot 01 \, \text{Jm}^{-2}$
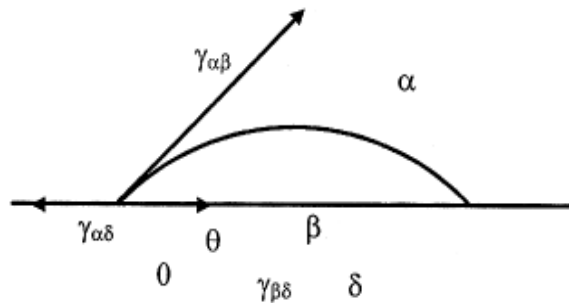
OR

7. Write short notes on any *three* of the following : 3 × 5

a) Merits and demerits of Powder Metallurgy

b) Comparison between Toughness and Resilience

c) Ingot Casting of Steel

d) Stress-Strain Curve

e) Ductile and Brittle Fracture

f) Nucleation and Growth and Homogeneous and Heterogeneous Nucleation.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

8. Recovery, recrystallization and grain growth are phenomena intimately associated with the annealing of a plastically deformed crystalline material. Explain each of these phenomena with respect to microstructure and various properties (internal stress, tensile strength, ductility and electrical conductivity)

9. a) Derive Fick's first law and second lay respectively.

b) Write short notes on carburization and decarburization.

c) A diffusion couple of 95% Cu – 5% Zn and pure copper is annealed at $900°C$ for 50 hr. The zinc concentration at a depth of 2 mm inside the copper bar was found to be 0·3 % after the anneal. Determine the diffusion coefficient of zinc in copper. 5 + 5 + 5

10. a) Derive Schmid's law of critical resolve shear stress.

   b) Distinguish between 'slip' and 'twinning'.

   c) If a steel has a value of σ_i = 150 MPa and

   k = 0·70 MPa $m^{1/2}$, what is the value of yield stress if the grain isze is ASTM no. 6 ?

   (ASTM no. 6 : 496 grains/mm^2)   5 + 5 + 5

11. Describe with neat sketch the Corex process and describe its functioning. What are its advantages over traditional Blast Furnace route. DRI improves Electric Arc Melting process. Explain.   7 + 3 + 5

12. Why is Aluminium difficult to extract from its ore by Carbon reduction ? Describe Bayer process of Alumina Production and process of electrolysis of Alumina. What is the role of Cryolite in the process ? Mention some important properties & use of Aluminium.   2 + 7 + 3 + 3

13. What are the advantages of continuous casting over ingot casting ? Continuous casting is of how many types ? What type of lubricant is used in different CC processes ? What is the role of Tundish in continuous casting ? Describe different types of lining used in Tundish. Why are dams & weirs used within Tundish ?   2 + 2 + 2 + 3 + 4 + 2