Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

1. Attempt any ten: [20 MARKS]

a) **State two uses of OHNS. [Any two, , 1 mark each]**
Taps, Blanking & forging dies. Threading dies, Expansion reamers. Etc.

b) **State two applications of low carbon steels. [Any two,, 1 mark each]**
Wires, nails, rivets, screws, welding rods, ship plates, tubes, fan blades, etc.

c) **Give any two uses of gray cast iron. [Any two, , 1 mark each]**
m/c tool structures, bedways, frame, guide ways, under ground pipes, man hole covers, tunnel segments, cylinder blocks, ic engine heads etc.

D) State any two uses of duralumin. [Any two, 1 mark each]
in wrought condition used for forging, stamping, bars, sheets, tubes and rivets. typical applications are truck and marine structures, pipes railings & furniture. Cables and electrical wires, in aeroplane in the form of alclad sheets etc.

E) State two applications of aluminum bronzes. [any two, 1 mark each]
Al bronzes are used for gears, propeller hubs, blades, pump parts, bearing, non sparking tools, drawing and forming dies.

F) Classify metallic materials. [2 marks]

Ferrous	**non ferrous**
Plain carbon Steels, alloy steel, tool steel, stainless steel, cast iron	Cu and cu alloys Brass, bronze. Al and al alloys

G) State any two adv. Of non ferrous over ferrous materials. [any two, 1 mark each]

- light in weight.
- better strength to weight ratio,
- extremely ductile and soft
- good malleability & formability,
- good corrosion resistance,
- high electrical and thermal conductivity.
- non toxic, non magnetic and non sparking.
- pleasing color. Etc.

H) Define ductility and brittleness. [1 mark each]
Ductility: ability of materials to drawn into thin wires without rupture. OR
Ability of a material to undergo permanent deformation through elongation or bending at room temp. without rupture.

Brittleness : Tendency of material fracture or fail upon the application of a relatively small amount of force, impact or shock.
materials which breaks when subjected to impact loads and having very low tensile strength.

I) State any two purposes of heat treatment. [any two , 1 mark each]

- To improve machinability.
- to relieve internal stresses.
- improve mechanical properties such as ductility, strength, hadness, toughness etc.
- change in grain size.
- increase resistance to heat and corrosion.
- modify electrical and magnetic properties.
- change the chemical composition. To remove gases.

J) Classify annealing depending up on specific purpose. [2 marks]

- full or conventional annealing.
- isothermal annealing.
- spherodizing annealing.
- homogenizing annealing
- bright annealing
- black annealing
- stress relieving annealing.

K) What is hardening ? write any two quenching media. [2 marks]

hardening of steel may be defined as process of imparting hardness, wear resistance and abrasion resistance to steel.

process consists of heating the steel to "hardening temperature range" ,holding there for some time and followed by quenching it in water or oil to get martensitic hard structure in the steel. **[1 mark]**

quenching media. : water, oil , brine solution etc **[any two , 1/2 mark each]**

l) State any four mechanical peoperties of engg. metal. [any four, 1/2 mark each]

strength, hardness , toughness, ductility , corrosion resistance, brittleness, malleability, resilience, creep, yield strength, stiffness etc.

M) State any two types of case hardening methods involving thermo-chemical treatment. [any two, I mark each]

1. carburising
   - solid or pack carburising.
   - gas carburising.
   - liquid carburising.
2. nitriding
3. cyniding

N) Classify cast iron on the basis of form of carbon present in them. [2 marks]

white cast iron , gray cast iron , nodular cast iron, malleable cast iron.

2. Attempt any two: [16 marks]

a) define following phases. [2 marks each, 1 for definition, 1 for crystal structure]

i) Cementite :

It is a intermetallic stable carbide compound. called as iron carbide, CM, fe_3c. Cementite contains 6.67 % C by wt. Very very hard and brittle interstitial compound.

Associated Crystal structure is orthorhombic

ii) Austenite :

It is an interstitial solid solution of carbon dissolved in ɣ gamma iron. solubility of C is 0.8% at 723 ^{0}c and this limit increases up to 2 % at 1140 ^{0}c.

Associated Crystal structure is FCC (face centered cubic) structure

iii) Ferrite:

It is an interstitial solid solution of carbon dissolved in α-iron. Maximum solubility of carbon is 0.008 % at room temp. and this solubility limit increases up to 0.025 % at 723 ^{0}c.

Associated Crystal structure is BCC (body centered cubic) - structure.

iv) Martensite :

It is an interstitial super saturated solution of carbon trapped in BCC epsilon iron.

Due to higher cooling rate , insufficient time is allowed for the carbon to diffuse out of solution , although some movement of the iron atoms takes place , the structure can not become BCC , while the carbon is trapped in solution , resultant structure called martensite. Associated Crystal structure is BCT – (body centered tetragonal) structure .

b) i) define phase. What do you mean by phase diagram?

[definition 1 mark, meaning 3 marks]

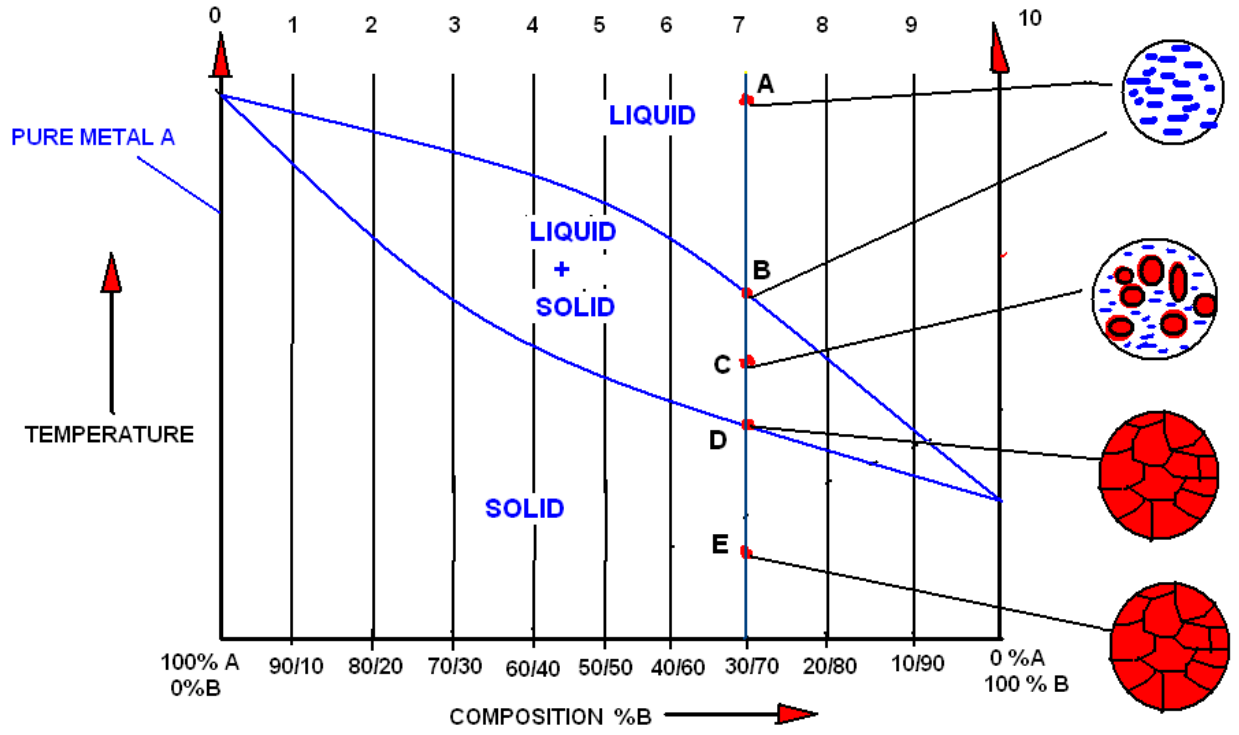
Phase : phase is a form of material with identifiable composition (chemistry), definable structure, and distinctive boundaries (interfaces) which separate it from other phases.

Phase diagram :

- drawn between temperature and composition.
- defines an alloy system between two metals / elements.
- gives changes in the structure of an alloy with temperature.
- gives relative amounts of phases in an alloy at a particular temperature.

ii) Draw a neat labeled sketch of phase diagram for an isomorphous alloy. [4 marks]

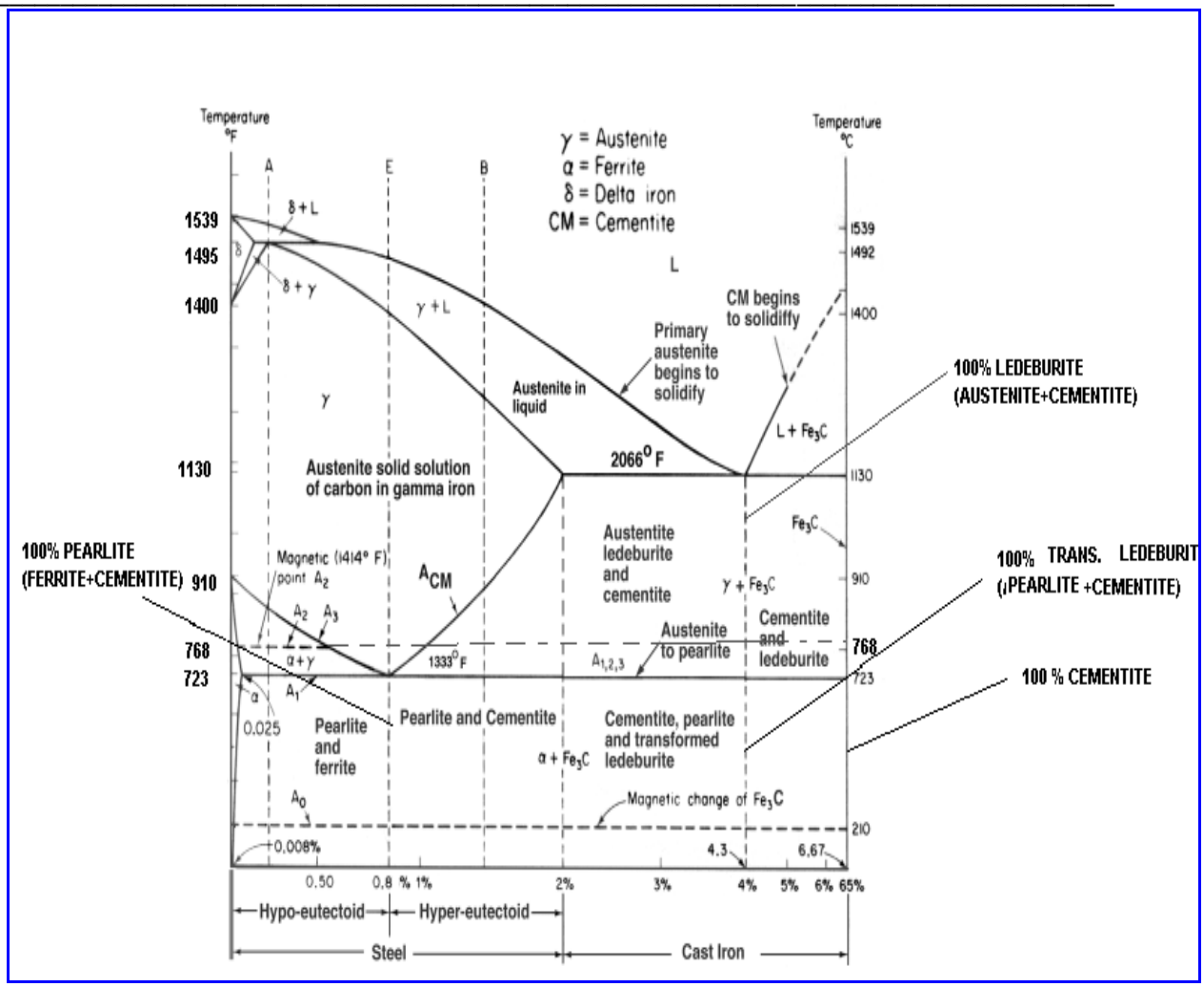
- alloy system of two metals a and b which are completely soluble in the liquid stage as well as in solid stage.
- both the type of metals have same unit cells and space lattice
- examples; cu-ni, au-ag, mo-w.



phase diagram for an isomorphous alloy

c). Draw the iron- carbon equilibrium diagram and label all the phases. Also represent (i) key temp. (ii) phase reactions (iii) composite microstructures on it.

[labeled diagram 4 mark, temp. 1 mark, phase reactions 2 mark, composite microstructure 1 mark]



iron- carbon equilibrium diagram

(i) **key temp:** 210 ^{0} c, 723^0, 910^0 ,1 130^0 , 1400^0, 1495^0, 1539^0 etc.

(ii) phase reactions

1. Eutectoid reaction. (At 723 ^{0}c)

$$\text{Austenite} \xrightarrow{723\ ^0\text{c.}} \text{ferrite + cementite}$$

i.e. (pearlite)

2.Eutectic reaction:

$$\text{Ledeburite} \xrightarrow{1140\ ^0\text{c.}} \text{austenite + cementite}$$

ŗ + fe$_3$c

3. Peritectic reation:

$$\text{Austenite} \xrightarrow{1495\ ^0\text{c.}} \text{delta iron + liquid (molten metal)}$$

ŗ δ + L

(iii) composite microstructures

pearlite, ledeburite etc to be shown on diagram.

Q3

a) Why is tungsten so important as a constituent of high speed steels (HSS)

High speed steels constitute the most important class of tool steels. As the name suggests, the steels are used for high speed cutting at such high speeds that the tool tip becomes red hot. Hence they are based on tungsten addition to steel in substantial amounts because this element gives red hardness to steel i.e. the capability of maintaining high hardness and a keen cutting edge even up to the red hot temperature of 600 degree

Red hardness is the ability of the high speed steels to maintain their high hardness of Rc67 even at the red hot temperature of 550 to 600 degree. During high speed cutting the tool tip becomes red hot. But even then the tool continues to be hard and goes on cutting. This is due to red hardness.

Red hardness is obtained due to the fine precipitation of complex alloy carbides of tungsten during the tempering of martensite in high speed steels.Thats why tungsten is very important constituent of high speed steel

tungsten is added up to 18% along with vanedium and chromium in high speed steel.

Description-4 Marks

b)Differentiate between 4M

i)Bainite and pearlite based on mechanical properties of a)strength b)ductility

ii)Fine pearlite and coarse pearlite based on mechanical properties of a)hardness b)ductility

-Bainite,pearlite ,fine pearlit and coarse pearlite these products are found on TTT(Time temperature and transformation) diagram. Depending upon cooling rate different products are found in steels.When steel cooling rate is slowest coarse pearlite is formed, then fine pearlite at slight fastest speed then bainite for intermediate speed and for very rapid cooling martensite is formed.

It is found that as we go down from Ac1(lower critical temperature) temperature to Ms temperature on TTT diagram pearlite becomes more and more fine i.e. crystals of pearlite becomes smaller in size and large in numbers, then it is called as bainite and martensite.The non equilibriumness in pearlite structure increases due to stresses in it increases and pearlite structure becomes more & more hard and less & less ductile as we go from Ac1(lower critical temperature) to Ms temperature.

Bainite(found in lower part of TTT diagram)	Pearlite(found in upper part of TTT diagram)
More strength	Low strength
Less ductility	More ductility

Difference-2 Marks

coarsepearlite (found in upper part of TTT diagram)	Fine pearlite(found in lower part of TTT diagram)
Low hardness	More hardness
More ductility	Less ductility

Difference-2 Marks

c) Which stainless steel is best suited for surgical instruments? Explain 4M

-Martensitic stainless steel is suitable material for surgical instruments. The property requirement for surgical instruments is high hardness, high wear resistance and corrosion resistance. Martensitic stainless steel fulfills

the criteria. The composition of this steel is 0.15-1.2% C,1%si,1%Mn,12-18%Cr.In this,Cr in solid solution form is less than 13%.This steel shows austenite at high temperature and can be hardened by hardening process to form martensite in it. The room temperature structure shows needle of martensite along with chromium carbide particles.

Name of steel-1 Mark
Explanation-3 Marks

d) What is carburizing? How it is done?

-Carburising is method of introducing carbon into low carbon steel in order to produce a hard case and soft core.Carburising increases the carbon content of the steel surface by a process of absorption and diffusion. **1 Mark**

Process-Low carbon steel (about 0.20% carbon) is heated at 870 degree to 950 degree in contact with gaseous, solid or liquid carbon containing substances for several hours. The high carbon steel surface is hardened by quenching process

Methods-

i) Pack carburizing-It involves packing the components into cast iron or steel boxes along with carburizing material like coke, wood or charcoal, together with energizer. Then it is heated up to 900 to 950 degree and kept at this temperature about 5 hours & then quench it.
ii) Gas carburizing-In this components are heated along with gas carburizing medium consist of 20%CO, 40%H2 and 40%N gas. They are heated up to 900 degree & hold for some time & then quench it.
iii) Liquid carburizing-In liquid carburizing a bath of 30-50% sodium cyanide,40%sodium carbonate and some amount of sodium or barium chloride is used. The bath containing the components is heated up to 870-950 degree & then hold for about 1 hour & quench it.

Any one method- 3Marks

e) State any four benefits of annealing.

i)Removal of residual stresses
ii) To refine the grain or crystal size in the steel
iii) To increase the uniformity of the phase distribution in the steel
iv) To reduce the hardness of steel
vi) To improve the ductility of steel
vii) To improve the machinability of steel

Any four each 1 Mark-4Marks

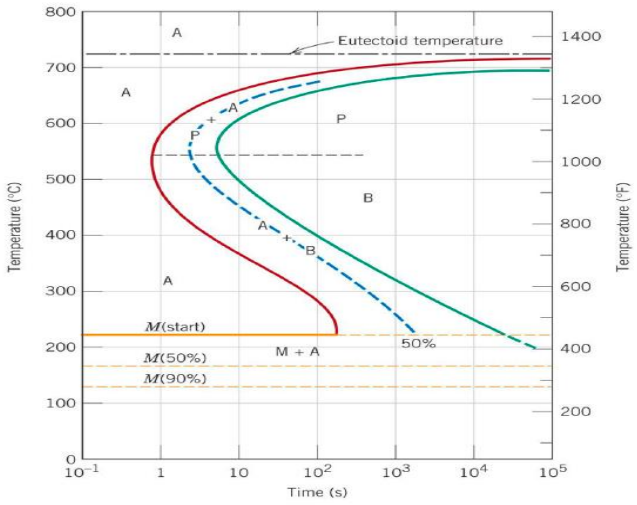
f) What are the principal advantages of austempering compared with the conventional quench and temper method?

-advantages of Austempering

i) Steels treated thus are tougher (impact strength) and more ductile than steels after tempering
ii) Less warping and distortion than conventional quench.
iii) Less danger of quenching cracks because the quench is not very drastic
iv) Austempering gives bainite product
v) Tempering is not needed after austempering **Any four advantages 1M to each-4 Marks**

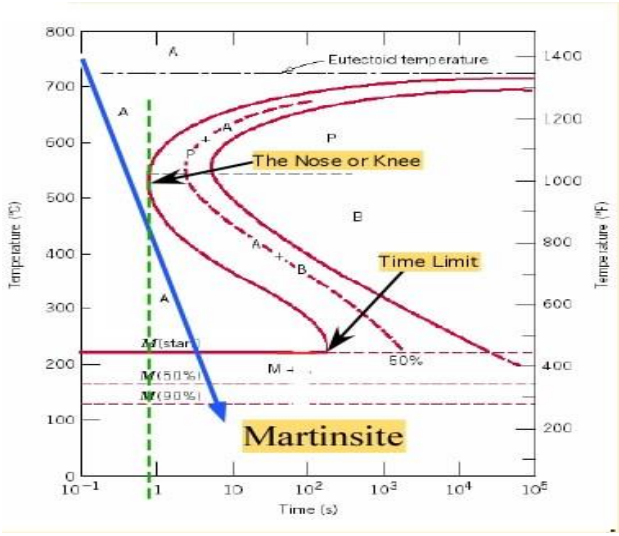
Q4

a) i) Sketch an Isothermal transformation (I-T) diagram for an eutectoid (0.8%C)plain carbon steel and
ii) a)Show a cooling curve that will result in a structure of 100 percent martensite
b)Show a critical cooing curve



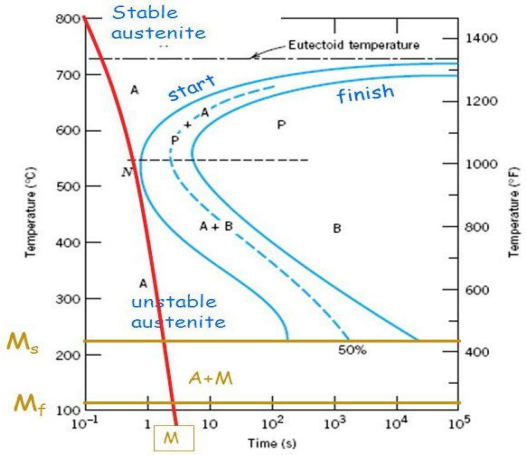
Isothermal transformation (I-T) diagram for an eutectoid (0.8%C)- 4Marks

ii)a)



cooling curve that will result in a structure of 100 percent martensite-2Marks

ii b)



Critical cooling curve shows the cooling rate, which gives 100% martensite, if steel is cooled just slower than critical cooling curve then austenite to pearlite or bainite transformation starts

Critical cooling curve-2Marks

b) i)Draw unit cells of following crystal structures

a) Face –centered cubic

b) Body –centered cubic

ii) Calculate packing efficiency for FCC crystal structure

Face centered cubic

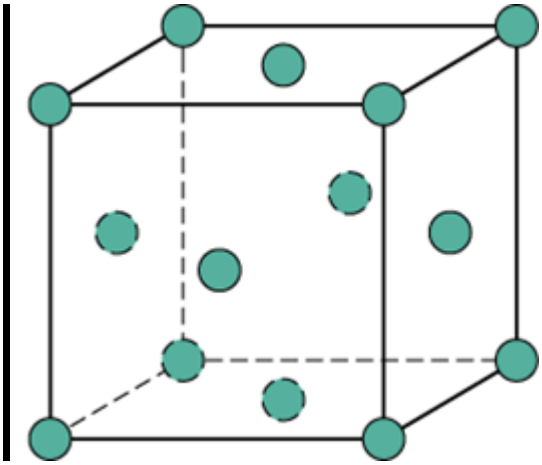


Diagram-2 Marks

Body centered cubic

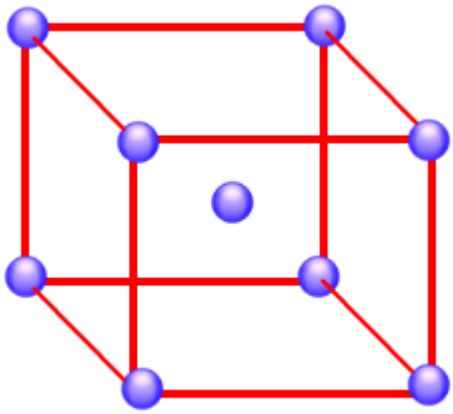
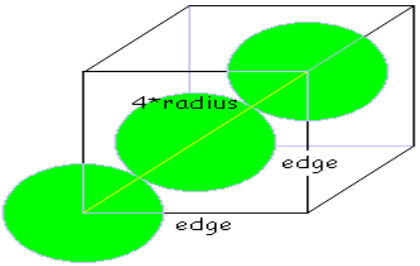


Diagram-2 Marks

Packing efficiency of FCC structure



edge = $2\sqrt{2}$ * radius

So, volume of the occupied unit cell $= 4 \times \frac{4}{3}\pi r^3$

$$\therefore \text{Packing efficiency} = \frac{\text{Volume occupied by four spheres in the unit cell}}{\text{Total volume of the unit cell}} \times 100\ \%$$

$$= \frac{4 \times \frac{4}{3}\pi r^3}{\left(2\sqrt{2}r\right)^3} \times 100\ \%$$

$$= \frac{\frac{16}{3}\pi r^3}{16\sqrt{2}r^3} \times 100\ \%$$

$$= 74\%$$

Calculation of packing efficiency-4 Marks

c) State any two improved mechanical properties of plain carbon steels when following alloying elements are added to it.

i) Chromium-

a) Increases red hardness of steel

b) Increases hardness and wear resistance of steel

ii) Nickel-

a) Increases hardness

b) Increases tensile and yield strength

iii)Manganese-

a) Increases tensile and yield strength

b) Increases hardness & hardenability

iv) Molybdenum-

a) Increases red hardness of steel

b) Increases hardness and wear resistance of steel

1M for each alloying element-4 Marks

Q.No.5. Solve any Four : [16 MARKS]

a) State any four characteristics of aluminium alloys

- High heat conductivity
- Good conductor of electricity
- Good resistance to corrosion
- Can be easily cold worked, rolled, forged, extruded and drawn into wires.
- Ductile in nature
- Extremely light in weight

(Any four of above)

b) State any two examples of following classes of composite materials: i) Laminated ii) Fibre Reinforced

1. **Laminates**: Layered composites are called as laminates.Examples are as under,
   a. **Plywood**: It is laminated composite of thin layer of wood in which successive layers have different orientation of grain or fibres. **Plywood** is a sheet material manufactured from thin layers or "plies" of wood veneer that are glued together with adjacent layers having their wood grain rotated up to 90 degrees to one another. It is an engineered wood from the family of manufactured boards which includes medium-density fibreboard (MDF) and particle board (chipboard).
   b. Copper stainless steel laminates
   c. Laminated Plastic sheets
   d. TUFNOL: Layers of woven textiles bonded with thermosetting resin,providing high tensile strength and rigidity. **(Any two example of above with applications)**

2. **Glass Fibre reinforced Plastic:** This is the plastic reinforced with fine fine glass fibres. It has excellent strength and formability.Glass reinforced fibre is also called as **Fiberglass** (or **fibreglass**) is a type of fiber reinforced plastic where the reinforcement fiber is specifically glass fiber. The glass fiber may be randomly arranged but is commonly woven into a mat. The plastic matrix may be a thermosetting plastic-most often epoxy, polyester resin- or vinylester, or a thermoplastic. The glass fibers are made of various types of glass depending upon the fiberglass use. These glasses all contain silica or silicate, with varying amounts of oxides of calcium, magnesium, and sometimes boron. To be used in fiberglass, glass fibers are made with very low levels of defects. Applications of fiberglass include, aircraft, boats, automobiles, bath tubs and enclosures, hot tubs, septic tanks, water tanks, roofing, pipes, cladding, casts, surfboards, and external door skins. **(Any two example of above with applications)**

   Fibre reinforced composites :
   a. carbonfibre reinforced : used for aerospace and badminton rackets
   b. Glass fibre reinforced
   c. Natural fibre reinforced : tree stem

c) State any four differences between thermoplastic and thermosetting materials

Thermo plastics	Thermosetting Plastics
1.Composed of chain molecules	1.Composed of cross linked molecules
2.Can be repeatedly softened by heat and hardened by cooling	2.Can be softened only first time when Heated. But cannot be softened on subsequent cooling
3. Comparatively softer and less strong	3.Stronger and Harder
4.Cannot be used at Higher Temperatures	4.Can be used at Higher Temperatures
5.Produced by additional Polymerization	5.Produced by Condensation and Polymerization.
6.Can be easily Moulded and remoulded Into Any shape	6. Cannot be moulded and remoulded into new shape.
7. Used for Toys,combs,toilet goods, tapes Hoses,pipes	7.Used for Telephone receivers,cabinets Camera bodies.

(Any four correct points --- 04 Marks)

d) List different types of rubbers.

- Natural Rubber
- Butadiene Rubber
- Styrene Butadiene Rubber
- Acrylonitrile butadiene Rubber
- Butyl Rubber
- Silicone Rubber

(Any four correct types --- 04 Marks)

e) Draw Flow charts for different types of heat treatment processes..

1. Hardening Heat Treatment Process

Loading steel components in furnace

Heating steels to Hardening Temperature range in furnace as under,
Hypoeutectoid steels – AC3 + 50 ^{O}C
Eutectoid steels – AC1 + 50 ^{O}C
Hyper eutectoid steels – AC1 + 50 ^{O}C
Alloy steels – 800 to 900 ^{O}C

Holding steel components in furnace to a particular time dependent on size of component and type of steel

Quenching in water,oil or oil depending upon type of steel and hardenability of steel to room temperature to form MARTENSITE along with other constituents.

2. Annealing Heat Treatment Process

Loading steel components in furnace

Heating steels to Annealing Temperature range in furnace as under,
Hypoeutectoid steels – AC3 + 50 ^{O}C
Eutectoid steels – AC1 + 50 ^{O}C
Hyper eutectoid steels – AC1+ 50 ^{O}C
Alloy steels – 780 to 900 ^{O}C

Holding steel components in furnace to a particular time dependent on size of component and type of steel

Cooling in FURNACE by switching OFF the furnace to room temperature to form COARSE PEARLITE IN STEEL along with other constituents

3. Normalizing Heat Treatment Process

Loading steel components in furnace

Heating steels to Normalizing Temperature range in furnace
Hypoeutectoid steels – AC3 + 50 ^{O}C
Eutectoid steels – AC1 + 50 ^{O}C
Hyper eutectoid steels – ACm + 50 ^{O}C
Alloy steels – 800 to 900 ^{O}C

Holding steel components in furnace to a particular time dependent on size of component and type of steel

Cooling in still AIR or in AIR FLOW to room temperature to form FINE PEARLITE IN STEEL along with other constituents

(ANY TWO FLOW CHARTS 02 MARKS EACH. Note that flowcharts for heat treatment processes like Case hardening processes,Surface hardening processes may also be considered if solved by student)

f) State chemical composition for following steels.

i) 40 Cr 4 Mo 3
Carbon – 0.40 % , Cr-1% , Mo – 0.3%

ii) 40 C 8
Carbon – 0.40 % , Mn- 0.8 %
iii) 20 Cr 18 Ni 2
Carbon – 0.20 % ,Cr- 4 % , Ni-0.5%
iv) X 20 Cr 18 Ni 2
High Alloy steel , Carbon – 0.20 % , Cr- 18 % , Ni – 2%
(Each correct answer 01 mark)

Q.No.6. Solve any Four : [16 MARKS]

a) Give any two uses for following polymetric materials i. Phenol formaldehyde ii.Bakelite

i. **Phenol formaldehyde** : Billiard Balls,Laboratory countertops, Motor housings, Telephones, Coatings
ii. **Bakelite**: Electrical Parts, Moulded parts, Handle Knobs for Door, Automobile parts

b) Describe application of powder metallurgy for manufacturing of porous bearings.

Porous or self lubricated bearings are made from powder metallurgy process. These bearings are made from Bronze, Tin, Copper, Iron . Powders of copper, tin iron, aluminium are used for making these bearing. They are manufactured by powder metallurgy process by following sequence of powder preparations, mixing or blending , compacting, sintering followed by impregnation of oil in the porosity of bearings.
These bearings possess the interconnected porosity to the extent of 30% to 60 %. The pores are small to the extent of 0.03 mm diameter. In the impregnation process, the oil under pressure is impregnated into the pores.The oil forms the lubricating film on the working surface. There is no necessity of lubricating these bearings from externally and hence these bearings are also called as self lubricated bearings.

c) Explain the technique of powder metallurgy.

Powder metallurgy is the branch of metallurgy which deals with the production of metal and nonmetal powders and subsequent manufacturing of components or parts using these powders.
Process involves following steps,
a.**Production of Metal/Non metal powders** and mixtures.Powders are made in proper particle size and shape. Various methods like melt automization, Milling,Shotting, Graining, Condensation,Thermal decomposition,Reduction, Electrodeposition, Hydrometallurgical reduction may be used for powder manufacturing. Automization is most commonly used.
b.**Blending and mixing of powders**.Here powders are blended to obtain uniform homogenious mixture. Lubricants are added to reduce friction between die wall and punches.Mixing is done in various types of mixers.
c.**Compacting powder in dies to semi finished compacted shape of component**.
d.**Sintering or heating the compacted component in furnace.** Sintering is carried out to increase the strength and hardness of green compact and consista of heating the compact to high temperature under controlled conditions with or without pressure for 2 to 3 hours.
d. Infiltration is process of filling the pores of PM part with molten metal with lower melting point.This increases increase in parts hardness and tensile strength.
e.**Sizing or coining of part**
f.**Testing and Inspection** of PM part in respect of properties like size,shape distribution,porosity,chemical composition,surface characteristics of particles of PM parts.

d) Which nondestructive testing method is best suited to following situations ? i) To determine wall thickness of bottom of steel tank. ii) To sort out bars of mixed steels

i) **Ultrasonic Testing method** is best suited to determine the wall thickness of the steel tanks.Here the wall thickness can be accurately measured .
ii) **Magnetization of steel bars with magnet** can be the best suited method to sort out the Austenitic steel bars from ferritic and martensitic steel bars.

e) State any four characteristics of unalloyed copper.

- Crystalline, non magnetic and reddish in colour.
- High electrical conductivity.
- Malleable and Ductile.
- Good corrosion resistance.
- Light in weight.
- Can be cold worked i.e.rolled,deep drawn.

f) State four desirable properties of bearing materials.

- Should have low coefficient of friction
- Should have high fatigue strength
- Should have high corrosion resistance
- Should have high compressive strength
- Should be hard and Wear resistant
- Should be tough and shock resistant.

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