20ME401

Scheme of evaluation

II/IV B.Tech (Regular\Supplementary) DEGREE EXAMINATION

July/August, 2023 **Mechanical Engineering**

Fourth Semester **Materials Engineering**

Time: Three Hours **Maximum:**70 Marks

Answer question 1 compulsory. **(14X1 = 14Marks)**

Answer one question from each unit. **(4X14=56 Marks)**

			CO	BL	M
1	a)	Define brittleness of a material Brittleness is a property of a material which shows a sudden failure without exhibiting a permanent deformation	CO1	L1	1
	b)	Define coordination number The nearest atoms with which an atom has contact in a crystal structure is known as coordination number	CO1	L1	1
	c)	What are Bravis Lattice? A Bravais lattice is a series of discrete points with a consistent arrangement and orientation in a three-dimensional space. Bravais lattice actually denotes all the 14 types of three-dimensional patterns in which the atoms can arrange themselves	CO1	L1	1
	d)	What is meant by Solid Solution Formation of solution that composed of solute and solvent within the solid state is known as solid solution	CO2	L1	1
	e)	What is Isomorphous system Isomorphous system is a binary alloy system in which both the constituting elements are completely soluble in liquid state as well as in the solid state	CO2	L1	1
	f)	Explain Gibb's phase rule P+F = C + n P = Number of phases F = Number of DOF C = Number of components N = Number of external factors	CO2	L2	1
	g)	Explain the purpose of tempering The purpose of tempering usually carried out after hardening to address the ill effects resulted from the martensite transformation	CO3	L2	1
	h)	How do you measure the grain size? Grai size can be measured by several techniques including, liner intercept method, Jeffery's constant method, ASTM method etc. In ASTM method, the number of matching chart of corresponding microstructure obtained at 100X magnification is used to measure the grain size $N = 2^{G-1}$ N = Number of grains per in^2 G = ASTM grain size number	CO3	L2	1
	i)	Outline the purpose of compacting of powders. The purpose of compacting powders in sintering is to increase the green density of the compact and to reduce the porosity by increasing the contact area between the powder particles.	CO4	L2	1
	j)	Illustrate applications of composite materials (Any two to three points related to the following can be given 1 mark) Applications of the composites can be divided into the following industry categories:	CO4	L2	1

		1. aerospace, 2. automotive, 3. construction, 4. marine, 5. corrosion resistant equipment, 6. consumer products, appliance/business equipment, 7. Electronic goods 8. Miscellaneous			
	k)	Where the Hume-Rothery principles are applied? Hume Rothery principles are applied to successfully develop solid solution alloys	CO1	L1	1
	l)	Show purpose of Miller indices The purpose of miller indices is to identify specific directions and planes in a given crystal structure.	CO1	L2	1
	m)	Differentiate crystalline and non- crystalline materials. Crystaline materials are the materials in which the arrangement of atoms or ions can be found in long rage periodicity. In non-crystalline materials, the arrangement of atoms or ions do not follow long rage periodicity.	CO1	L1	1
	n)	Explain two component system. In alloy development, two component systems are called as binary alloys that contains two major elements as the main constituting phases in addition to other negligible elements. The following are the phase reactions usually observed in 2 component systems. 1. Isomorphous, 2. Eutectic, 3. Peritectic, 4. Eutectoid and 5. Peritectoid.	CO2	L2	1
		Unit-I			
2	a)	Illustrate the names of important point defects, line defects and write about each one of them. **Point defects** **2 Marks** **(a)Vacancies** A simplest point defects in a crystal. Refers to missing atom or vacant atomic site. Arise either from imperfect packing during original crystallisation or from thermal vibrations at high temperatures. **(b)Frenkel defect** It is formed by a cation leaving its normal position and moving into an interstial site. **(c) Schottky defect** It is formed by removing one cat ion and one anion from the interior of the crystal and then placing them both at an external surface. **Line defects** Edge dislocation: • Edge dislocation occurs due to the introduction or elimination of an extra row of atoms. • Shear, Tensile and Compressive stress fields may be present in the Edge dislocation. • In this dislocation, Burger’s vectors always perpendicular to the dislocation line.	CO1	L2	7M

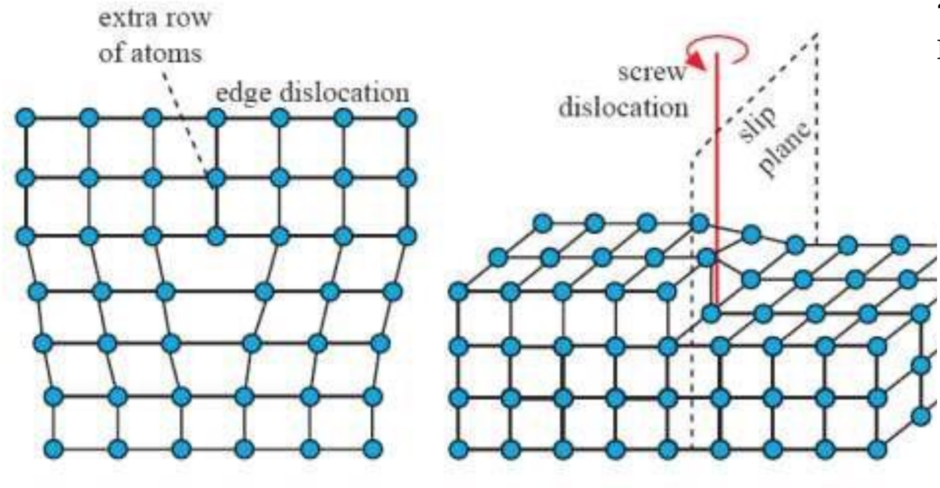
- Region of lattice disturbance extends along an edge inside a crystal.
- This dislocation occurs due to climb and glide motion.
- There are two types of Edge dislocation, positive and negative.

Screw dislocation:

2 Marks

- Screw dislocation provides easy crystal growth because of additional unit cells and atoms can be added to the screw.
- Shear, Tensile and Compressive stress fields are absent in the Screw dislocation.
- In this dislocation, Burger's vectors always parallel to the dislocation line.
- Region of lattice disturbance is in two separate planes and cross each other at right angles.
- This dislocation occurs only due to glide motion.
- Screw dislocation does not show any type like edge dislocation.

2 Marks



1 Mark

b)	Explain the various important mechanical properties of materials briefly.	CO1	L2	7M

(Full marks if they explain any five of the following)

Strength: ability to withstand loads without fracture

- *Yield strength, ultimate tensile strength, fracture strength*

Hardness: resistance to permanent plastic deformation

Toughness: ability to absorb energy without failure

Fracture toughness: ability to resist crack propagation

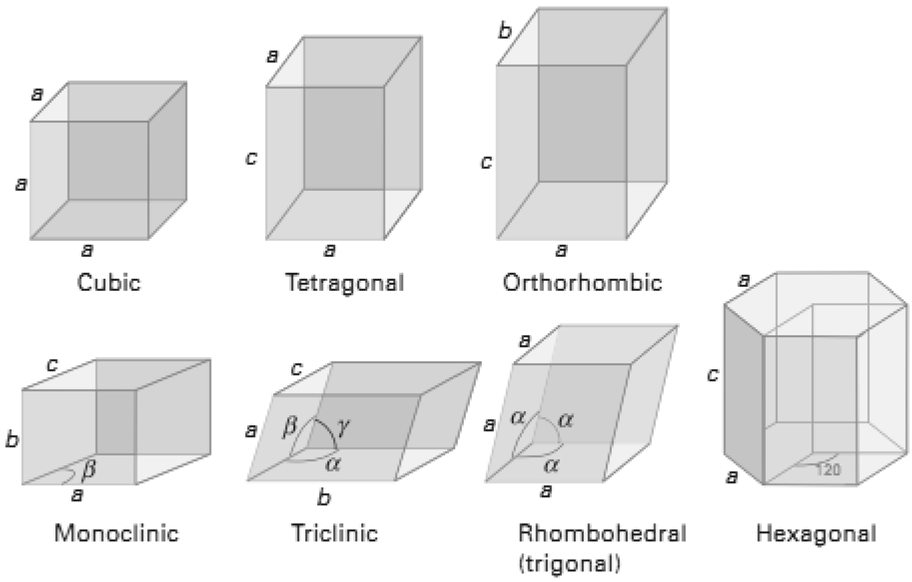
Brittleness: Sudden failure without showing considerable plastic deformation

Ductility: ability to be drawn in to wires and tubes (more % elongation)

Malleability: ability to be deformed into sheets and plates

(OR)

3 a) Draw seven basic crystal structures and explain? — CO1 | L2 | 7M

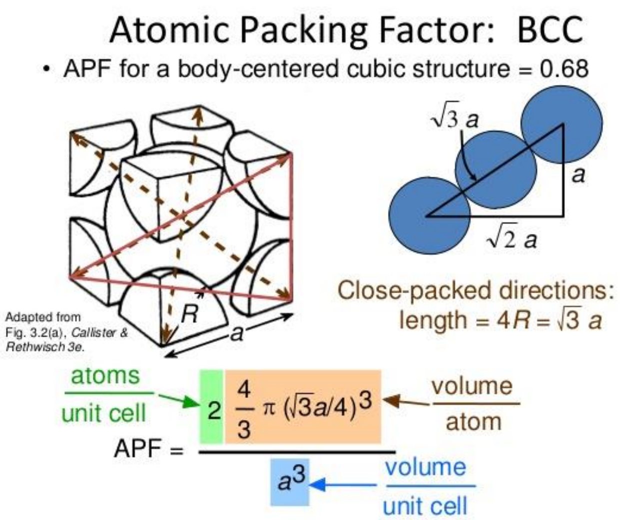


4 marks

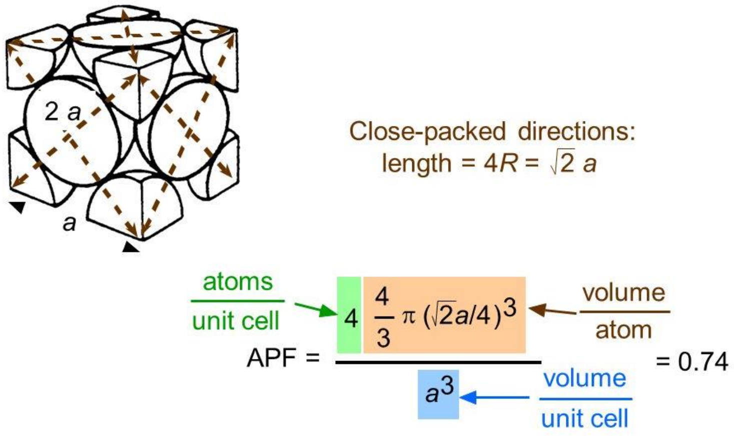
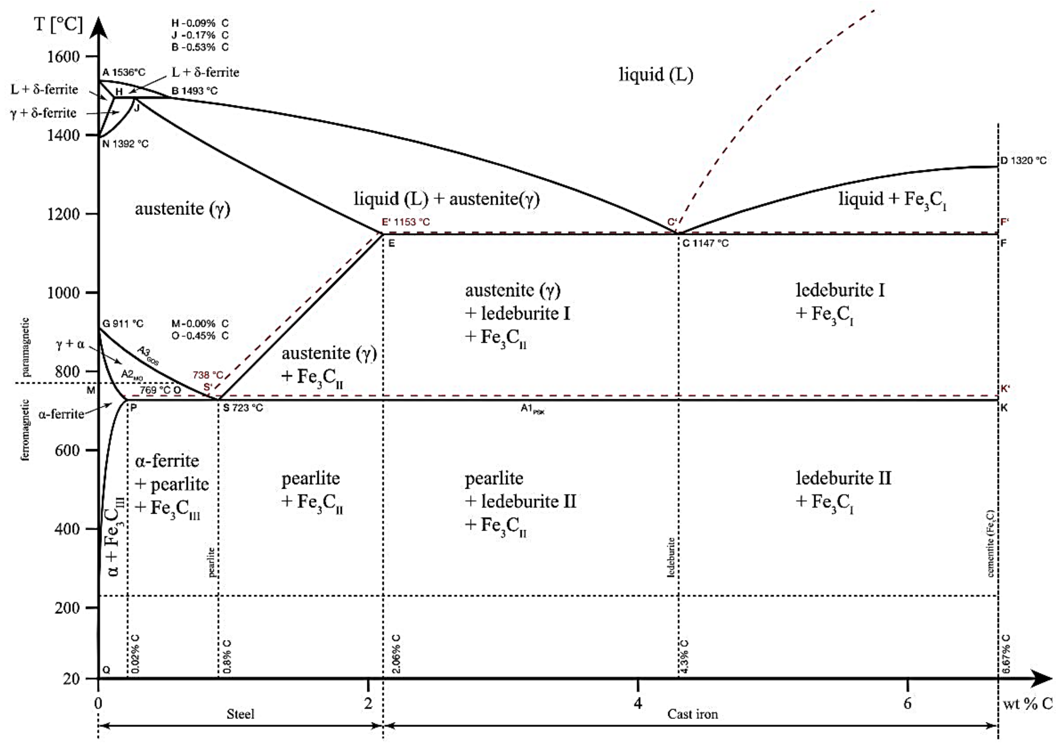
S.No.	System	Relation between primitives	Interfacial angles
1.	*Cubic*	$a = b = c$	$\alpha = \beta = \gamma = 90°$
2.	*Monoclinic*	$a \neq b \neq c$	$\alpha = \beta = 90° \neq \gamma$
3.	*Triclinic*	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma \neq 90°$
4.	*Tetragonal*	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma \neq 90°$
5.	*Orthorhombic*	$a \neq b \neq c$	$\alpha = \beta = \gamma = 90°$
6.	*Rhombohedral*	$a = b = c$	$\alpha = \beta = \gamma \neq 90°$
7.	*Hexagonal*	$a = b \neq c$	$\alpha = \beta = 90°$ $\gamma = 120°$

3 marks

b) Show that FCC is closely packed than that of BCC. — CO1 | L2 | 7M



3 Marks

		 4 marks			
Unit-II					
4	a)	Explain about Iron – Iron carbon equilibrium diagram and explain about all critical points.  For diagram – 5 marks Discussion – 2 marks	CO2	L2	7M
	b)	Classify iron-carbon alloys based on carbon percentage? **Steels and cast irons** Iron–carbon alloys long since were divided into two big groups such as steels and cast irons. The boundary line between these two groups of alloys lies with point E with the carbon content 2.14 % wt. that corresponds to a limit of carbon solubility in iron. But also long before the exact methods of analysis were developed, and materials sciences foundations formulated, craftmen of melting and forging could perfectly distinguish steels from pig-iron, manufacture them and process. These alloys have absolutely different technological properties: steel can be forged, rolled, drawn down to a thin wire, but you cannot do that to the cast iron since it fractures under impact and tensile loads. But cast iron is one of the best foundry alloys, allowing make thin-walled shaped casting. This difference in properties becomes clear when analysing the phase diagram iron–carbon. All steels (the alloys containing less than 2 % wt. of carbon) become single-phase metal when heated. This high-temperature phase is austenite, a solid solution based on FCC iron lattice. Metals having such type of crystal lattice possess the high ductility. Therefore steel is a wrought alloy. On the contrary, the cast iron remains the two-phase metal up to the melting point, and one	CO2	L2	7M

of these phases is hard brittle cementite, which does not allow deforming a material. But cast iron crystallizes in rather narrow temperature range, and crystallisation finishes by eutectic formation at constant temperature. It means that such alloys should have good foundry properties (high fluidity and low shrinkage) and not to form foundry defects. Therefore cast iron is a casting alloy. It is necessary to notice that phase transformations in a solid state give possibility to strengthen steels by heat treatment. As for the cast iron, heat treatment is inefficient, because the eutectic does not change up to the melting temperature.

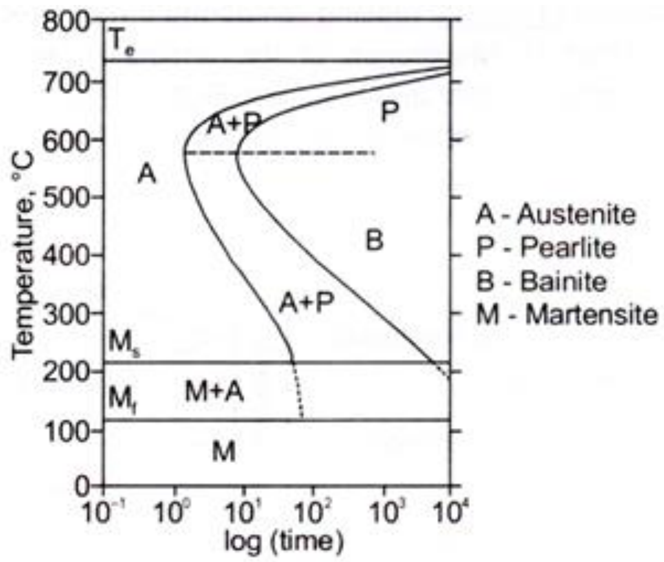
Classification

1) Hypoeutectoid steels contain 0.02 to 0.8 % wt. C. The microstructure of alloys, consists of ferrite (light grains) and pearlite (dark grains of lamellar structure), and the content of pearlite increases with the carbon content.
2) Eutectoid steel has carbon content 0.8 % wt. This steel has pearlite structure: altemating layers of ferrite and cementite.
3) Hypereutectoid steels contain 0.8 to 2.14 % wt. C. Structurally they consist of pearlite grains, surrounded by brittle cementite network. Alloys represented in the right part of the diagram are white cast iron. They contain iron carbide, or cementite Fe3C, instead of pure carbon, or graphite.

By microstructure the following groups of cast irons are distinguished
1) hypoeutectic cast iron contains 2.14 to 4.3 % wt. C. The structure of alloys consists of eutectics (ledeburite) and pearlite grains;
2) eutectic cast iron with carbon content 4.3 % wt. Alloy structure is ledeburite, consisting from cementite (a light component) and pearlite (dark grains);
3) hypereutectic cast iron contains 4.3 to 6.69 % wt. C. The structure consists of primary cementite plates and ledeburite.

(OR)

5	a)	What is TTT diagram and explain the various Iron-Carbon phases on TTT with a neat sketch?	CO2	L1	7M



Cementite or iron carbide

A fixed amount of carbon and a fixed amount of iron are needed to form cementite. Its chemical formula is Fe_3C. It contains 6.67 percent carbon by weight. It is a hard and brittle interstitial compound of low tensile strength but high compressive strength. Its crystal structure is orthorhombic. It is the hardest structure that appears on the iron-iron carbide diagram.

Austenite

Austenite is the name given to the solid solution of iron and carbon. It is an interstitial solid solution of carbon dissolved in iron having a face centered cubic (f.c.c.) crystal structure. Maximum solubility is 2 percent carbon at 1148 °C. It is denoted by γ. Austenite is normally unstable at room temperature. Under certain conditions it is possible to obtain austenite at room temperature (as in austenite stainless steels). Austenite is non-magnetic

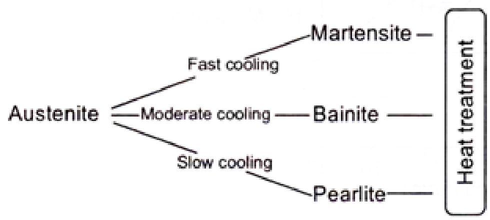
Ferrite

Ferrite is the name given to the solid solution of iron and carbon. It is an interstitial solid solution of a small amount of carbon dissolved in iron having a body centered cubic (b.c.c.) crystal structure. The maximum solubility is 0.025 percent carbon at 723 °C, and it dissolves only 0.008 percent carbon at room temperature. It is the softest structure on the iron-iron carbide diagram.

Pearlite

It is the eutectoid mixture containing 0.80 % carbon and is formed at 723 °C on very slow cooling. It is a very fine platelike or lamellar mixture of ferrite and cementite. The structure of pearlite includes a white matrix (ferritic background) which includes thin plates of cementite (black). Pearlite needs fixed amounts of cementite and ferrite.

A schematic of possible transformations involving austenite decomposition are shown in below figure.

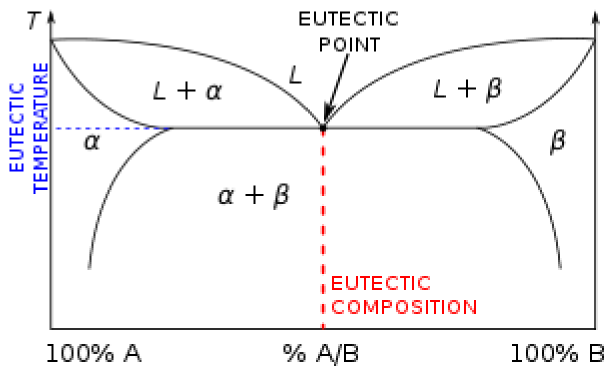


Martensitic transformation can dominate the proceedings if steel is cooled rapid enough so that diffusion of carbon can be seized. Transformation of austenite to Martensite is diffusion-less, time independent and the extent of transformation depends on the transformation temperature. Martensite is a meta-stable phase and decomposes into ferrite and pearlite but this is extremely slow (and not noticeable) at room temperature.

Start of the transformation is designated by M_S, while the completion is designated by M_f in a transformation diagram. Martensite forms in steels possess a body centred tetragonal crystal structure with carbon atoms occupying one of the three interstitial sites available. Tetragonal distortion caused by carbon atoms increases with increasing carbon content and so is the hardness of Martensite. Mechanically, Martensite is extremely hard, thus its applicability is limited by brittleness associated with it. However, structure and the properties can be altered by tempering, heat treatment observed below eutectoid temperature to permit diffusion of carbon atoms for a reasonable period of time.

	b)	Explain the following terms with examples i) eutectoid ii) peritectoid systems	CO2	L2	7M

i). Eutectoid **4 Marks**

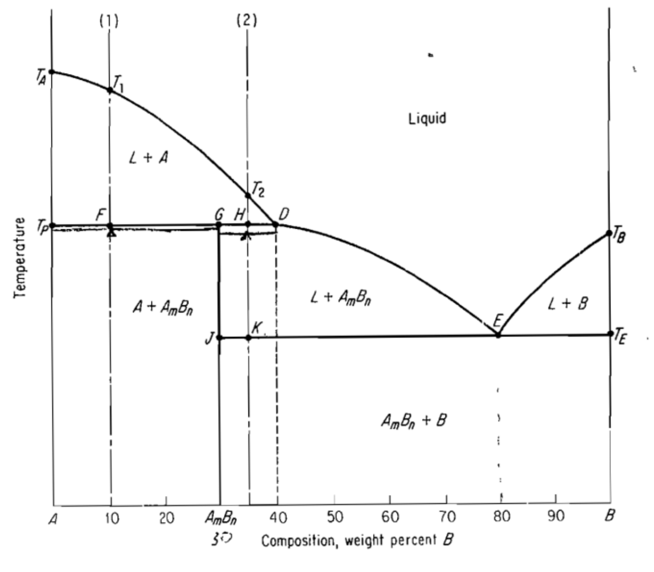


Consider a mixture of elements A and B in their eutectic proportions at a high enough temperature to make the mixture fully liquid. Diagram is marked with an arrow at the eutectic composition and indicating the current temperature (the start temperature in this case). If the mixture is slow cooled, undergoing no change in state until it reaches temperature eutectic temperature, where it starts to solidify at any favorable nucleation sites. Note that the alloy forms into "stripes" which are alternate layers of alpha and beta. These layers are often only of the order of 1 micron across and the reason that the eutectic forms in this way can be understood by considering the diffusion times required to form the solid. The "stripy" microstructure is known as lamellar microstructure.

As the alloy continues to cool the existing nucleation sites will grow, adding alpha to alpha and beta to beta. These nucleating and growing regions of solid alloy will form grains. Grain boundaries occur where growing grains, which will be of differing orientations and from different nucleation sites, meet. Further nucleation sites will continue to form within the liquid parts of the mixture. Remember, though, this happens over a very short time scale and with no further decrease in temperature. The eutectic composition solidifies, like a pure element, at a single temperature, not over a temperature range.

Looking at the phase diagram, it can be seen that the compositions of alpha and beta change with temperature. By considering tie lines and the phase diagram, it can be seen that beta has a decreasing proportion of A in it as the temperature decreases. Similarly the proportion of B in alpha decreases. This means that even though the alloy is now solid, the composition of the stripes of alpha and beta must continue to change as it cools (to room temperature for example). Atoms of A and B will diffuse across these "stripes" to produce the equilibrium compositions of alpha and beta at a given temperature.

ii). Peritectic system **3 Marks**



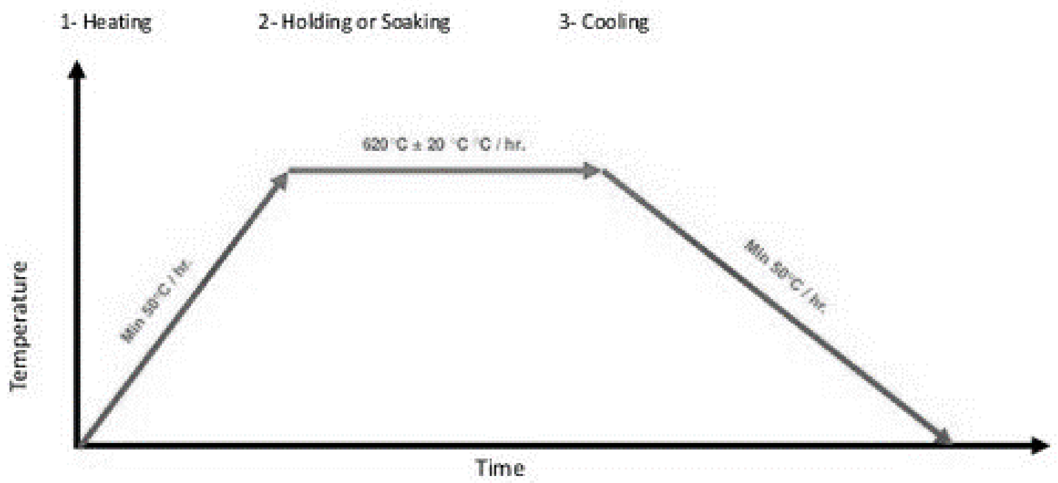
In the peritectic reaction a liquid and a solid react isothermally to form a new solid on cooling. The reaction is expressed in general as

The new solid formed is usually an intermediate phase, but in some cases it may be a terminal solid solution

The peritectic reaction is just the reverse of the eutectic reaction, where –A single phase formed two new phases on cooling.

$$\text{Liquid} + \text{solid}_1 \underset{\text{heating}}{\overset{\text{cooling}}{\rightleftharpoons}} \text{new solid}_2$$

Unit-III

6	a)	What is Heat Treatment? Write the various stages of Heat Treatment Process. Heat treatment is the process of heating and cooling metals, using specific predetermined methods to obtain desired properties. Both ferrous as well as non-ferrous metals undergo heat treatment before putting them to use. There are various reasons for carrying out heat treatment. Some procedures make the metal soft, while others increase hardness. They may also affect the electrical and heat conductivity of these materials. Some heat treatment methods relieve stresses induced in earlier cold working processes. Others develop desirable chemical properties to metals. Choosing the perfect method really comes down to the type of metal and the required properties. In some cases, a metal part may go through several heat treatment procedures. For instance, some superalloys used in the aircraft manufacturing industry may undergo up to six different heat treating steps to optimise them for the application. In simple terms, heat treatment is the process of heating the metal, holding it at that temperature, and then cooling it back. During the process, the metal part will undergo changes in its mechanical properties. This is because the high temperature alters the microstructure of the metal. And microstructure plays an important role in the mechanical properties of a material. The final outcome depends on many different factors. These include the time of heating, time of keeping the metal part at a certain temperature, rate of cooling, surrounding conditions, etc. The parameters depend on the heat treatment method, type of metal and part size.  The most common heat treatment methods include: Annealing, Normalising, Hardening, Ageing, Stress relieving, Tempering etc.	CO3	L1	7M
	b)	Explain carburizing methods in detail? Carburization is a process which involves taking a low carbon steel and transforming it into a high carbon steel. This is done by exposing it to an atmosphere which is dense in carbon. Generally, items are carburized in furnaces, vats, and other enclosed entities. By heating a steel item in a carbon-dense atmosphere, said item will allow carbon atoms to attach to its surface on a molecular level. After these carbon atoms have attached to its surface, it will gain both hardness and strength. One of the most popular forms of case hardening, carburization can provide steel items with varying levels of hardness. Generally, the higher the heat, and the longer the duration of the carburization process, the harder the carburized item will be. **Pack Carburization** Pack carburization is a process which involves placing steel items into a furnace in close proximity to high-carbon items. These high-carbon items include everything from carbon powder, to cast iron particles, and more. The problem with it is that it's unreliable and inconsistent. While it will allow for carbon	CO3	L2	7M

diffusion, this diffusion typically won't occur uniformly across an entire steel item.

Liquid Carburization

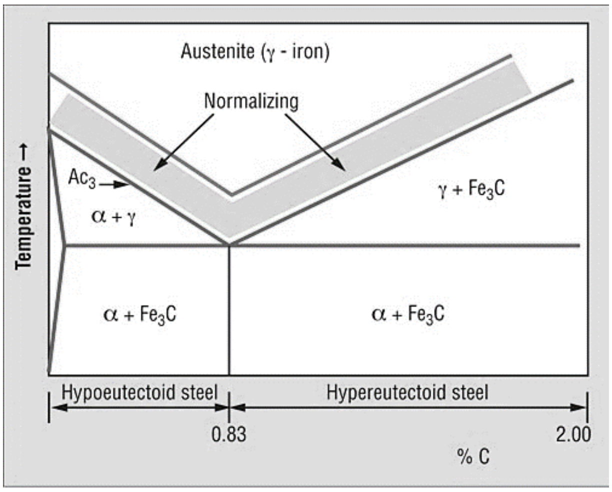
Liquid carburization is a form of carburization which takes place in a sort of liquid vat. This vat is filled with a mixture of substances, typically including cyanide and salt. While metal alloy items are being submerged in this concoction, they come into contact with a collection of carbon molecules. Generally, these carbon molecules will diffuse into the alloyed items in a rapid manner, allowing for a hard case to form in just a short time. Steels which have been liquid carburized typically possess high levels of carbon and low levels of nitrogen.

Gas Carburization

Gas carburization shares similarities with pack carburization, necessitating the pumping of carbon monoxide. The difference is that it doesn't necessitate the presence of carbon-dense items. In this process, carbon monoxide is continuously pumped into an enclosed environment. This environment is heated at extremely high temperatures. High temperatures allow carbon molecules to diffuse into the steel items which are being hard cased. One of the most popular carburization processes in the world, it consistently produces a uniformly-carburized steel. This makes it very useful for mass carburization purposes.

(OR)

7	a)	What are the differences between normalizing and annealing?	CO3	L1	7M



Parameter	Normalizing	Annealing
Process cooling	In ambient air outside the furnace	Controlled cooling inside the furnace
Cooling Rate	Comparatively faster	Slow
Ductility	Relatively lower	Higher
Other properties	Relatively higher hardness, strength, and toughness	Relatively lesser hardness, strength, and toughness
Grain Structure	Fine and more uniform	Coarse and less uniform

		Internal Stresses — Slightly higher — Minimal Costs — Lower — Higher Applicable Materials — Mainly stainless steel, aluminum, brass, copper — Metals and metal alloys like steels, aluminum, brass, copper Applications — Automotive industry, nuclear industry, and construction industry — Mechanical components, electrical components and household items			
	b)	Explain grain boundary strengthening, dispersion strengthening mechanisms	CO3	L2	7M

Internal Stresses	Slightly higher	Minimal
Costs	Lower	Higher
Applicable Materials	Mainly stainless steel, aluminum, brass, copper	Metals and metal alloys like steels, aluminum, brass, copper
Applications	Automotive industry, nuclear industry, and construction industry	Mechanical components, electrical components and household items

b) Explain grain boundary strengthening, dispersion strengthening mechanisms — CO3 — L2 — 7M

Grain-boundary strengthening (or Hall–Petch strengthening) 4 marks

Grain-boundary strengthening (or Hall–Petch strengthening) is a method of strengthening materials by changing their average crystallite (grain) size. It is based on the observation that grain boundaries are insurmountable borders for dislocations and that the number of dislocations within a grain have an effect on how stress builds up in the adjacent grain, which will eventually activate dislocation sources and thus enabling deformation in the neighbouring grain, too. So, by changing grain size one can influence the number of dislocations piled up at the grain boundary and yield strength. For example, heat treatment after plastic deformation and changing the rate of solidification are ways to alter grain size. In grain-boundary strengthening, the grain boundaries act as pinning points impeding further dislocation propagation. Since the lattice structure of adjacent grains differs in orientation, it requires more energy for a dislocation to change directions and move into the adjacent grain. The grain boundary is also much more disordered than inside the grain, which also prevents the dislocations from moving in a continuous slip plane. Impeding this dislocation movement will hinder the onset of plasticity and hence increase the yield strength of the material.

The relation between yield stress and grain size is described mathematically by the Hall–Petch equation:

$\sigma = \sigma i + KD^{-1/2}$

where σ is the yield stress, σi is a materials constant for the starting stress for dislocation movement (or the resistance of the lattice to dislocation motion), K is the strengthening coefficient (a constant specific to each material), and D is the average grain diameter

DISPERSION STRENGTHENING **3 marks**

The strength and hardness in some metal alloys may be enhanced by the presence of extremely small and uniformly dispersed particles within the original phase matrix.

Whether introduced as insoluble particles in powder compaction (dispersion strengthening), or as precipitates in a solid state reaction (precipitation or age hardening), second phase particles are generally the most potent strengthening agent in practical high strength engineering materials. Iron-base, aluminum, nickel, titanium alloys all employ second phases to achieve high strength. The size, shape, and amount of second phase particles controls the mechanical properties of the alloy. Second phase particles in the form of very small uniformly distributed particles are added to the matrix. These will block dislocation motion extremely well, and strengthen the material. This is the basis for all high strength metal alloys.
Example: fine particles of Al_2O_3 in aluminum: slip plane dislocations in Al cannot penetrate into alumina, they get stuck, and the strength goes up.

Unit-IV					
8	a)	Illustrate the merits and demerits of composite materials over conventional materials. **Merits of Composites** **4 marks** 1. A higher performance for a given weight leads to fuel savings. Excellent strength-toweight and stiffness-to-weight ratios can be achieved by composite materials. This is usually expressed as strength divided by density and stiffness (modulus) divided by density. These are so-called "specific" strength and "specific" modulus characteristics. 2. Laminate patterns and ply buildup in a part can be tailored to give the required mechanical properties in various directions 3. It is easier to achieve smooth aerodynamic profiles for drag reduction. Complex double-curvature parts with a smooth surface finish can be made in one manufacturing operation. 4. Part count is reduced. 5. Production cost is reduced. Composites may be made by a wide range of processes. 6. Composites offer excellent resistance to corrosion, chemical attack, and outdoor weath-ering;however,some chemicals are damaging to composites(e.g.,paintstripper),and new types of paint and stripper are being developed to deal with this. Some thermoplastics are not very resistat to some solvents. **Demerits of Composites** **3 marks** 1. Composites are more brittle than wrought metals and thus are more easily damaged. Cast metals also tend to be brittle. 2. Repair introduces new problems, for the following reasons: Materials require refrigerated transport and storage and have limited shelf lives. . Hot curing is necessary in many cases, requiring special equipment. Curing either hot or cold takes time. The job is not finished when the last rivet has been installed. 3. If rivets have been used and must be removed, this presents problems of removal without causing further damage. 4. Repair at the original cure temperature requires tooling and pressure. 5. Composites must be thoroughly cleaned of all contamination before repair. 6. Composites must be dried before repair because all resin matrices and some fibers absorb moisture.	CO4	L2	7M
	b)	What are the applications of the Powder Metallurgy The powder metallurgy process has provided a practical solution to the problem of producing refractory metals, which have now become the basis of making heat-resistant materials and cutting tools of extreme hardness. Another very important and useful item of the products made from powdered metals is porous self-lubricating bearing. In short, modern technology is inconceivable without powder metallurgy products, the various fields of application of which expand every year. Some of the powder metal products are given below. 1. Porous products such as bearings and filters. 2. Tungsten carbide, gauges, wire drawing dies, wire-guides, stamping and blanking tools, stones, hammers, rock drilling bits, etc. 3. Various machine parts are produced from tungsten powder. Highly heat and wear resistant cutting tools from tungsten carbide powders with titanium carbide, powders are used for and die manufacturing. 4. Refractory parts such as components made out of tungsten, tantalum and molybdenum are used in electric bulbs, radio valves, oscillator valves, X-ray tubes in the form of filament, cathode, anode, control grids, electric contact points etc. 5. Products of complex shapes that require considerable machining when made by other processes namely toothed components such as gears. 6. Components used in automotive part assembly such as electrical contacts, crankshaft drive or camshaft sprocket, piston rings and rocker shaft brackets, door, mechanisms, connecting rods and brake linings, clutch facings, welding rods, etc. 7. Products where the combined properties of two metals or metals and non-metals are desired such as non-porous bearings, electric motor brushes, etc. 8. Porous metal bearings made which are later impregnated with lubricants. Copper and graphite powders are used for manufacturing automobile parts and brushes.	CO4	L1	7M

		9. The combinations of metals and ceramics, which are bonded by similar process as metal powders, are called cermets. They combine in them useful properties of high refractoriness of ceramics and toughness of metals. They are produced in two forms namely oxides based and carbide based.			
(OR)					
9	a)	Classify copper and its alloys and write applications for each of them. Copper, Brass and Bronze, otherwise known as the "Red Metals", may look the same initially but are actually quite different. The two important Cu alloys are i. Brass: Alloy of Cu and Zn Brass is mainly an alloy that consists of copper with zinc added. Brasses can have varying amounts of zinc or other elements added. These varying mixtures produce a wide range of properties and variation in color. Increased amounts of zinc provide the material with improved strength and ductility. Brass can range in color from red to yellow depending on the amount of zinc added to the alloy. • If the zinc content of the brass ranges from 32% to 39%, it will have increased hot-working abilities but the cold-working will be limited. • If the brass contains over 39% zinc (example – Muntz Metal), it will have a higher strength and lower ductility (at room temperature) Brass is commonly used for decorative purposes primarily because of its resemblance to gold. It is also a commonly used to make musical instruments due to its high workability and durability. ii. Bronze: Alloy of Cu and Sn Bronze is an alloy that consists primarily of copper with the addition of other ingredients. In most cases the ingredient added is typically tin, but arsenic, phosphorus, aluminum, manganese, and silicon can also be used to produce different properties in the material. All of these ingredients produce an alloy much harder than copper alone. Bronze is characterized by its dull-gold color. You can also tell the difference between bronze and brass because bronze will have faint rings on its surface Bronze is used in the construction of sculptures, musical instruments and medals, and in industrial applications such as bushings and bearings, where its low metal on metal friction is an advantage. Bronze also has nautical applications because of its resistance to corrosion.	CO4	L2	7M
	b)	Illustrate a short note on: (i) Fibre Reinforced Composite Materials (ii) Metal - Matrix Composites	CO4	L2	7M

(i) Fibre reinforced composite material: 3 marks

Fibre reinforced composite can be made from metals, ceramics, glasses or fibre that have been turned into graphite which is known as carbon fibre.

These composites are very expensive as reinforcement of fibre into matrix is difficult. Fibre pull is possible and while increasing or decreasing length bond breaking is observed. In time trial racing bicycle frame carbon fibre is used along with matrix phase which is made up of thermosetting plastic.

In racing car glass fibre is used along with thermosetting plastic.

i) Continuous & aligned composite:

Its features are -

1. The properties are highly anisotropic & depend on the direction in which they are measured.
2. The maximum strength is achieved in longitudinal direction as this is direction of reinforcement.
3. In transverse direction reinforcement is nil hence fracture occurs at relatively low tensile strength.
4. For other directions the strength is in between these two extremes.

ii) Discontinuous fibre reinforced composite:

Its features are as follows 1. Reinforcement efficiency is 1/5 that of continuous. 2. Mechanical properties are isotropic 3. Applications are multidirectional so it is ideal for giving complicated shape.

Fibre glass:

Fibre glass is well known composite, made up of glass fibre, either continuous or discontinuous embedded in polymer matrix (thermosetting). It is popular material due to following reasons.

1. It is easily drawn into high strength fibres from its molten state.
2. It is easily available & its conversion in to fibre is very economical.
3. When combined with plastic it imparts corrosion & chemical resistance property.

Limitations:

1. In spite of very high strength they are not stiff & rigid hence are not suitable for construction purpose.
2. They can be used up to temperature limit of 2000C above this temperature most of the plastic begin to flow.

Applications:

1. Automotive & marine bodies
2. Plastic pipes, shortage containers & industrial pipes.

(ii) Metal - Matrix Composites **4 Marks**

A metal matrix composite (MMC) is a composite material with fibers or particles dispersed in a metallic matrix, such as copper, aluminum, or steel. The secondary phase is typically a ceramic (such as alumina or silicon carbide) or another metal. They are typically classified according to the type of reinforcement: short discontinuous fibers (whiskers), continuous fibers, or particulates. There is some overlap between MMCs and cermets, with the latter typically consisting of less than

20% metal by volume. When at least three materials are present, it is called a hybrid composite. MMCs can have much higher strength-to-weight ratios, stiffness, and ductility than traditional materials, so they are often used in demanding applications.

Compared to monolithic metals, MMCs have:

- Higher strength-to-density ratios
- Higher stiffness-to-density ratios
- Better fatigue resistance
- Better elevated temperature properties
    - -- Higher strength
    - -- Lower creep rate
- Lower coefficients of thermal expansion
- Better wear resistance

The advantages of MMCs over polymer matrix composites are:

- Higher temperature capability
- Fire resistance
- Higher transverse stiffness and strength
- No moisture absorption
- Higher electrical and thermal conductivities
- Better radiation resistance
- No outgassing
- Fabricability of whisker and particulate-reinforced MMCs with conventional metalworking equipment.

Some of the disadvantages of MMCs compared to monolithic metals and polymer matrix composites are:

- Higher cost of some material systems
- Relatively immature technology
- Complex fabrication methods for fiber-reinforced systems (except for casting)
- Limited service experience