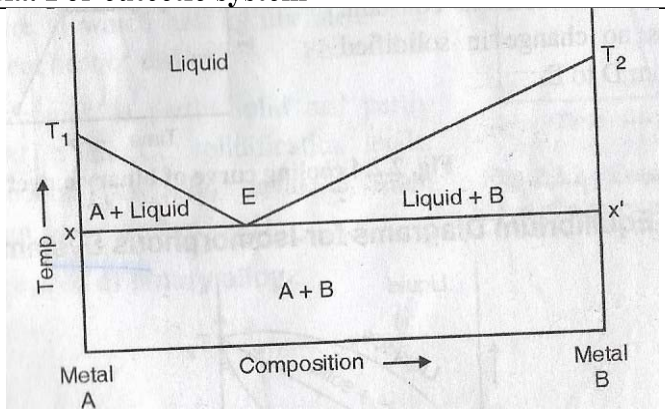
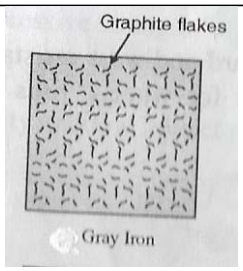
SUMMER – 19 EXAMINATION

Subject Name: Mechanical Engineering Materials **Model Answer** **Subject Code:** 17303

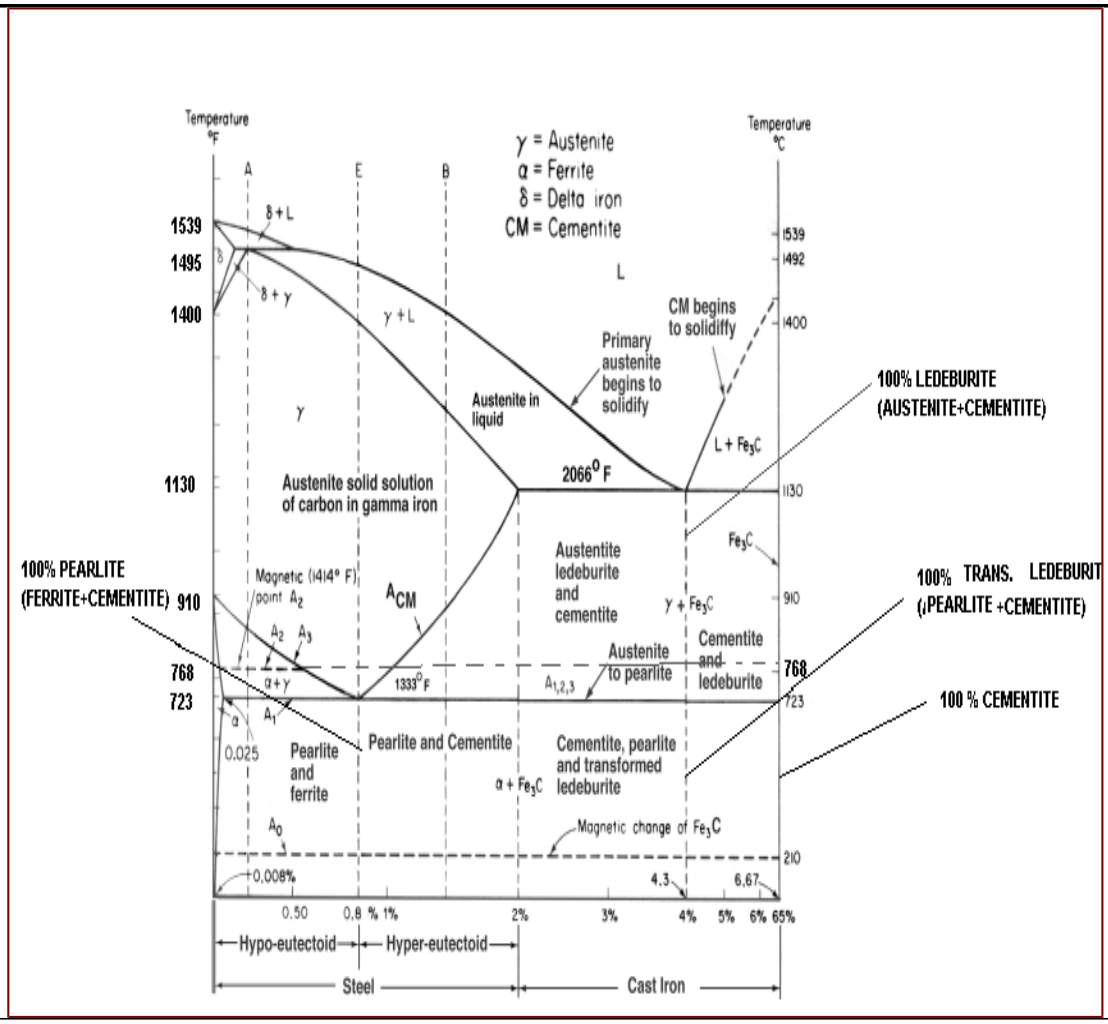
Important Instructions to examiners:

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.

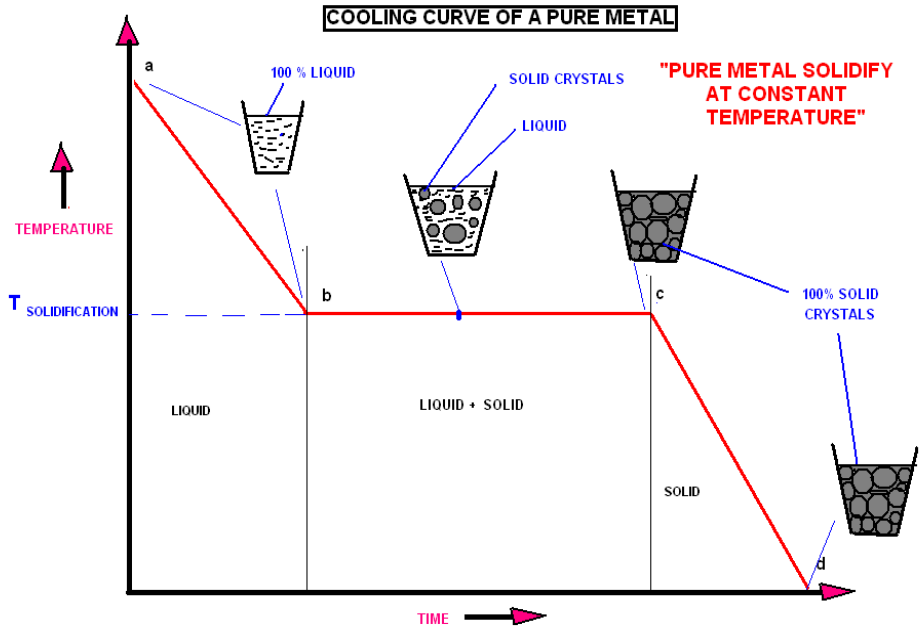
Q.1.		Attempt any TEN of the following:	20 Marks
	a)	**Define Amorphous and crystalline material**	
	Sol.	**Amorphous material**: Amorphous material has no regular arrangement of their molecule. They do not have definite melting point. e.g. Glass **Crystalline material**: - Crystalline material have regular arrangement of molecules, atoms are arranged three dimensional called lattice. The lattice has regular configuration. They have definite melting point e.g. diamond	**1 Mark** **1 Mark**
	b)	**Draw Equilibrium dia. For eutectic system**	
	Sol.		**02 mark**
	c)	**What is mean by Interstitial solid solution**	
	Sol.	These types of solid solution seen when the solute atoms are very small in size compare to other solvent atoms .in this type solution there is no possibilities of substitution atom but only can fit into space.	**02 mark**

	d)	**List any two applications of stress relief annealing: -**	
	Sol.	i) Casting ii) machining iii) cold working iv) welding	**2 Mark Any two 1 Mark each**
	e)	**Name the Process for improving hardness of cutting tools.**	
	Sol.	Hardening process, martempering process.	**2 Mark 1 mark for each**
	f)	**Which Quenching medium used in hardening process(any two)**	
	Sol.	1) Water media 2) oil media 3) brine solution	**2 Mark Any two 1 Mark each**
	g)	**State the Principle nitriding process**	
	Sol.	The component is placed in a heat resistant metal container which is then filled with ammonia, when it is completely purged, it is sealed placed in furnace and raised to temperature. The ammonia dissociates. Temperature about 500°c, holding time 40-100hrs, case depth-0.38mm	**2 Mark**
	h)	**State the Meaning of $40C_8$.**	
	Sol.	0.4% carbon, and 0.8% manganese, unalloyed steel	**2 Mark**
	i)	**Write the Composition of HSS**	
	Sol.	0.7 % Carbon, 18% Tungsten, 4% chromium, and 1% vanadium	**2 Mark**
	j)	**Microstructure of grey cast iron**	
	Sol.		**2 Mark**
	k)	**Select the Material for i)Electric wire ii)Door handle**	
	Sol.	I) Electric wire: - copper, aluminum II) Door handle: - low carbon steel, stainless steel,	**2 Mark** **01 mark for each**
	l)	**What is mean by Thermosetting Plastics**	
	Sol.	Plastics which becomes soft on application of heat, and becomes hard by chemical change they cannot be softened again. This process is not reversible	**2 Mark**
	m)	**Write two Uses of glass wool.**	
	Sol.	i) Thermal and sound insulation in airplanes ii) in furnaces, Oven, water heater,	**Any two 1**

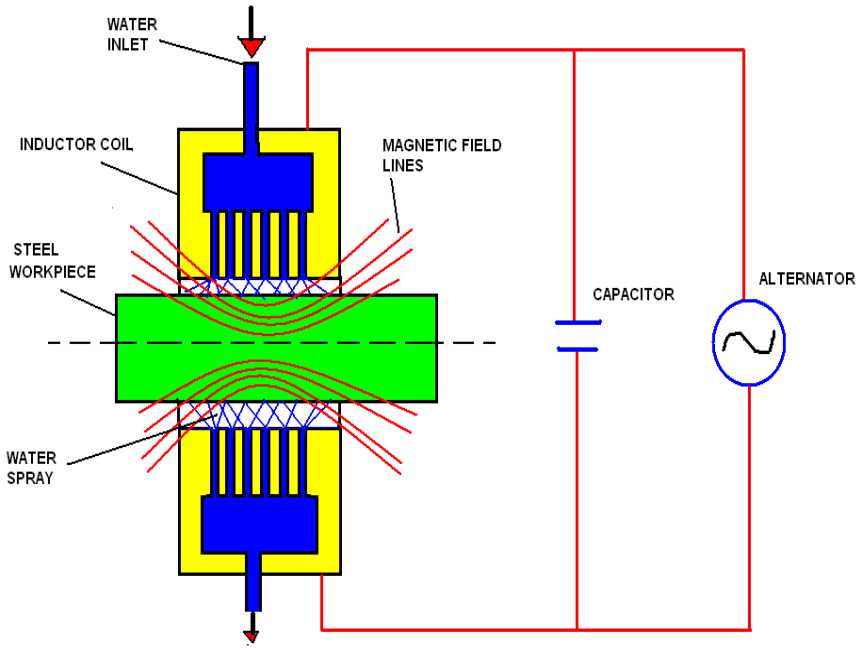
		refrigerators iii) For electric insulation iv) Ceiling of home and other building	**Mark each**
	n)	**List two Types of composite material**	
	Sol.	i) fiber ii) laminar layer iii) particles iv) flake and filled composite.	**Any two 1 mark for each**
Q.2.		**Attempt any FOUR of the following:**	**16 Marks**
	a)	**What is Packing efficiency? State the equation and packing efficiency of FCC structure**	
	Sol.	**Packing efficiency** = volume occupied by atoms in unit cell X 100 total volume of the unit cell No of atoms = 8*1/8 + 6*1/2 =4 Radius for FCC = r = a/2√2 **Packing efficiency** = volume of atom = $4* 4/3 \prod r^3$ volume of unit cell a^3 $= \frac{4*4/3*\prod*(a/2\sqrt{2})^3}{a^3}$ = 74% **Packing efficiency of FCC** = 74%	**01 Marks** **02 Marks** **01 Marks**
	b)	**Draw Iron carbon Phase equilibrium Diagram**	

	Sol.		**04 Marks**
	c)	**Define i)Ferrite ii)Pearlite iii)Austenite iv)Cementite**	
	Sol.	i) **ferrite**: - solid solution of carbon in iron, it has BCC structure, maximum solubility of carbon in iron is 0.02 % at 723°C ii) **Pearlite**: - Pearlite is eutectoid steel. When temp of alloy reaches 723°C (A1) Austenite transform to pearlite. Pearlite has fine ferrite and cementite structure iii) **Austenite**: - Solid solution of carbon in gamma iron. It has FCC structure max solubility of carbon is 2.08% at 1148°C iv) **Cementite**: - this is an intermetallic compound which contain 6.67% C and 93.3% iron it is brittle and hard compound .It has orthorhombic crystal structure	**04 marks** **01 mark for each**
	d)	**Differentiate between annealing and Normalizing(four points)**	
	Sol.		**04 marks**

		<table><tr><th>Sr. no</th><th>Annealing</th><th>Normalizing</th></tr><tr><td>1</td><td>Heating steel about 50°C above A1 heat at this temp..and cooled slowly in furnace</td><td>Heating steel about 40°C above upper critical limit A_{C1} held at this temp. .and cooled slowly in air</td></tr><tr><td>2</td><td>Cooling rate is slow</td><td>Cooling rate faster</td></tr><tr><td>3</td><td>Reduce Hardness and improve machinability</td><td>Produce harder and stronger steel</td></tr><tr><td>4</td><td>It refine crystalline structure of steel</td><td>It refine grain size of steel</td></tr></table>	**01 mark for each**
	e)	**State Composition and Characteristics of HCHC**	
		Composition of HCHC: - 1-2% C, 12% Cr, (W, Mo, V) in small amount High carbon high chromium cold work steel **Characteristics of HCHC**: - I) high wear resistance ii) difficult to machine iii) Used for dies & cutting tool IV) oil or air hardening	**2 Mark** **2 Marks**
	f)	**Explain Self lubricating bearing**	
		These bearing produced by the process of powder metallurgy and made from copper or iron base powder. Bearing made by this process is having 40-50% porosity. These pores are impregnated with oil; under pressure oil from the pores slowly Comes out and serves the purpose of lubrication. They do not require external lubrication therefore called as self lubricating bearing and used in textile, paper, and food industry	**4 Marks**
Q.3.		**Attempt any <u>FOUR</u> of the following:**	**16 Marks**
	a)	**State the property of material i)Making thin sheets ii)Making thin wires**	
	Sol.	**Malleability:-**Malleability is the ability of a material to exhibit deformation when compressive force is applied OR The ability of a material to be drawn into thin sheet **Ductility:-** It is the property of material by virtue of which it can be drawn into thin wires. OR It is the capacity of a material to undergo under tension without rupture	**02 marks each**
	b)	**Explain solidification of pure metal with the help of diagram.**	

	Sol.	 Freezing starts at b and completes at c and between b & c, the metal is in the liquid plus solid state .Above the temperature indicated by point b, the metal is in the liquid state and below c, it is in the solid state. Application of phase rule **In region ab** P+F=C+1 1+F=1+1 Therefore the meaning of F=1 is that the temperature can be varied without changing the liquid phase existing in the system **In region ab** P+F=C+1 2+F=1+1 Therefore the meaning of F=0 is that the temperature can not be varied without changing the liquid and solid phase existing in the system.If temperature is increased ,the metal goes in the liquid state and if decreased,it goes in the soildstate.Hence pure metals solidifies at constant temperature **In region cd same as region ab F=1**	**02 marks for diagram** **02 marks for explanation**
	c)	**Explain induction hardening process with suitable sketch.**	

Sol.



02 marks for diagram

02 marks for Explanation

- heating the medium carbon steel with alternating magnetic field by the phenomenon of electromagnetic induction to austenitic temperature(750-800 centigrade)
- followed by rapid quenching so that austente in the outer case converts to martensite, producing a hard outer layer and soft inner layer of ferrite + pearlite.
- magnetic field lines thread via surface of workpiece in the inductor coil. they induce "eddy currents "by electromagnetic induction in the steel component of the same frequency but revered in direction.
- heating results due to resistance of the steel part.
- intensity of eddy current is maximum in the outer surface and slowly decreases towards centre this effect is called as "skin effect".
- depth of hardening is inversely proportional to frequency of current supplied to inductor coil by high frequency generator.
- as the frequency increases the depth of hardening decreases and vice versa
- Desired frequency of the current can be set to get the required case depth.

d) **State the effect of i)Chromium ii)Nickel iii)Carbon iv)Tungsten on properties of steel**

Sol.

i) Chromium

- increases hardness
- hardenability and wear resistance of steel.
- It increases red hardness of steel.
- Increases corrosion & oxidation resistance of the steel.

ii) Nickel

- Increases hardness, tensile & yield strength without decreasing its ductility.
- It increases the corrosion and oxidation resistance of the steel.

Lowers critical temperature of steel.

- Addition of nickel reduces the coefficient of thermal expansion of steel

iii) Carbon

01mark for each

- Increases hardness
- Increases brittleness
- Reduces ductility
- Increases tensile strength

iv) Tungsten (W) :

- Increase strength.
- helps to form stable carbides
- increases hot hardness.
- used in tool steels.

e) Compare Brass and Bronze on the basis of composition,types,and applications

Sol. **01mark for each**

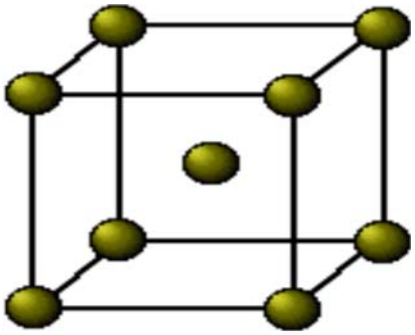
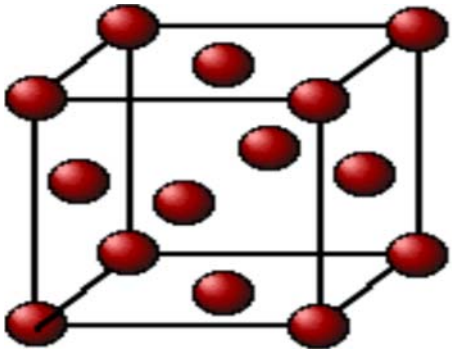
Brass	Bronze
Alloy of copper &zinc	Alloy of copper other than zinc such as Cooper-tin alloy,Cooper-Aluminium alloy etc
Brasses are alloys containing upto 43% Zinc Example-cartridge brass having 30%Zn &70% Cu	Example-Gun metal having 2-11% tin,1-10% Zn and remaining cooper
Types α brass,cap copper,gliding metal,cartridge brass,Admiralty brass,Naval brass,brazing brass	**Types** Aluminium bronze,Tin bronzes,coinage bronze,gun metal,Phosphor bronze,Beryllium bronze,silicon bronze
Applications It can be rolled into thin sheets It can be used for marine castings It is used for valves, plumbing, automobiles fittings, type writer parts, musical instruments Naval brass is used in naval construction	**Applications** It is used for casting ,for making coins and metals , for springs, taps, marine pumps It is used for heavy duty electrical switches, cams and bushings Used for manufacture of corrosion resistant mine cables, ship sheathing, valve parts used for making bushes, cotter pins, clutch disks etc

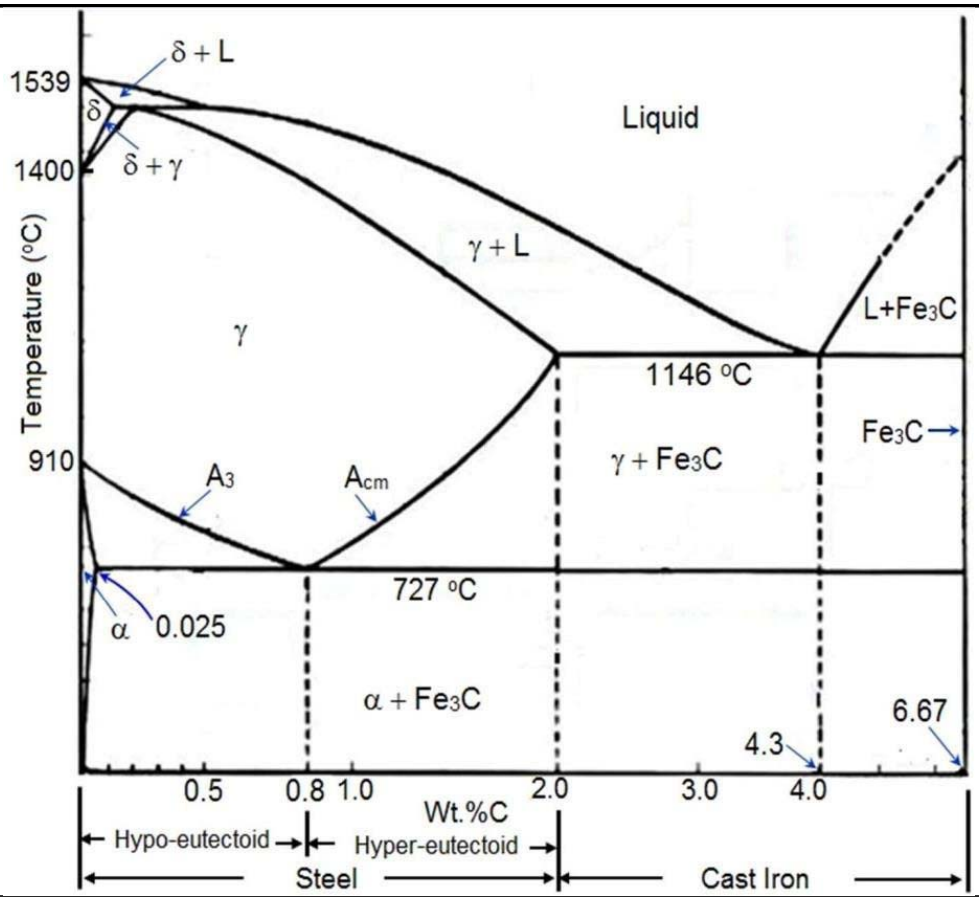
f) Select material for i)Tyre tube ii)Handle of cooker iii)Toys iv)Body of electrical fuse

Sol. i)Tyre tube:-Butadine rubber blended with natural rubber **04 Marks**

OR

Styrene-butadiene rubber **1 Mark each**

		ii) Handle of cooker:-Thermosetting plastics iii)Toys:-Thermoplastic material iv)Body of electrical fuse:-Bakelite material	
Q.4.		**Attempt any FOUR of the following:**	**16 Marks**
	a)	**Draw Sketch of unit cell of BCC and FCC structure**	
	Sol.	**BODY CENTRED CUBIC UNIT CELL (BCC) :**  **FACE CENTRED CUBIC UNIT CELL (FCC)** 	**02 marks for each**
	b)	**State the C% in hyper and hypoeutectiod steels with the help of iron carbon diagram and define**	
	Sol.	**i) Hypoeutectoid steel :-**The steel which contains carbon percentage from 0.008% to 0.8% is called as hypoeutectiod steel **ii)Hypereutectoid steel:-** The steel which contains carbon percentage from 0.8% to 2% is called as hypereutectoid steel	**01 mark for C %** **01 mark Definition** **02 marks diagram**



c) Classify steel on the basis of C% and give one application of each

Sol.

1)Mild or Low carbon steel:-
It contains 0.15 to 0.30% of carbon

02 marks for classification

2)Medium Carbon Steel:-
It contains 0.30 to 0.60% of carbon

3) High Carbon steel:-
It contains 0.60 to 1.5% of carbon

Application

02 marks for application

Low carbon steel:-
They are used for wires, nails, rivets, screws, panels, welding rods, boiler plates, valves, railway axles, gears, blades etc.

Medium Carbon Steel:-
They are used for bolts, axles, lock washers, large forging dies, springs, wheel spokes, hammers, rods, turbinr rotors, crank pins, railway tyres

High Carbon steel:-
Die block, wheel tires, mandrels, hammers, razors, ball mill parts, Drill, and tap Wire dies and cutting tools,

	d)	**What is carburizing? Explain any one method in detail.**	
		Definition: It is Process of introducing the carbon in the outer case of low carbon steels in order to produce a hard martensitic structure in the outer surface. carbon content in the outer case is increased by process of absorption and diffusion.Low carbon steels are heated to 870 – 925 degree centigrade in contact with carbon –rich material for several hours.Highly enriched outer carbon rich surface is hardened by quenching . **SOLID OR PACK CARBURIZING** • Low carbon steels are heated to 870 – 970 degree centigrades in contact with carbon –rich solid material like wood,bone charcoal, semi coak , peat coke ,charred leather together with energizer (mixure of sodium carbonate and barium carbonate) for several hours. • For this steel parts are packed in solid cast iron boxes. • After holding ,steel parts are quenched in water / oil to form martensite in the outer surface of the steel component. 1.formation of carbon monoxide. 2.dissociation of co with evolution of atomic carbon. $2co \longrightarrow co2 + c\ atom$ 3.enrichment of steel surface layer with carbon. $2co + 3fe \longrightarrow fe3c + co2$ Carbon actually gets dissolved in gamma iron to form autenite • Carbon gets diffused in the outer surface of steel .rate of diffusion depends on temperature. • Containers used for pack carburizing are made from heat resistant steel. Batch type or continuous furnaces are used for pack carburizing **GAS CARBURIZING** The steel part is heated in contact with gas like propane, butane, benzene up to 900-950 degree centigrade and hold for sufficient time during which time the carbon atoms gets diffused into outer surface of component then the part is directly quenched into bath to get required hardness in outer case and soft and ductile core. Carburising gases: Gases used are natural gas, methane, propane, butane. Carrier gas with hydrogen is also used. Common atmosphere for gas carburizing is 20% co ,40%hydrogen,40%nitrogen **LIQUID CARBURIZING** • Steel part is heated in molten salt bath in contact with liquid carbon rich material like sodium cynide or potassium cynide to a temperature of 870 – 950 degree centigrade	**01 marks for Definition** **03 marks for any one method explanation**

- Steel parts in the wire baskets are held in the bath for a period of 5minutes to one hour depending upon case depth required.
- At this temperature carbon as well as nitrogen diffuses into outer surface of steel part.
- On subsequent quenchung martensite is formed in the outer case of the component.
- Bath consists of 20 % to 50 % sodium cynide together with 40% sodium carbonate and varying amounts of sodium or barium chlorides.
- Chemical reactions
- sodium cynide in presence with atmospheric oxygen forms sodium cyanate (nacno), which decomposes into sodium carbonate (na2co3), carbon monoxide (co) and active nitrogen (n).
- **$2NACN + O_2 \longrightarrow 2NACNO$**
- **$4NACNO \longrightarrow 2NACN + NA_2CO_3 + CO + 2N$**
- **$2CO \longrightarrow C + CO_2$**

e) Compare cast iron and steel(four points) — **Any four points-1M each**

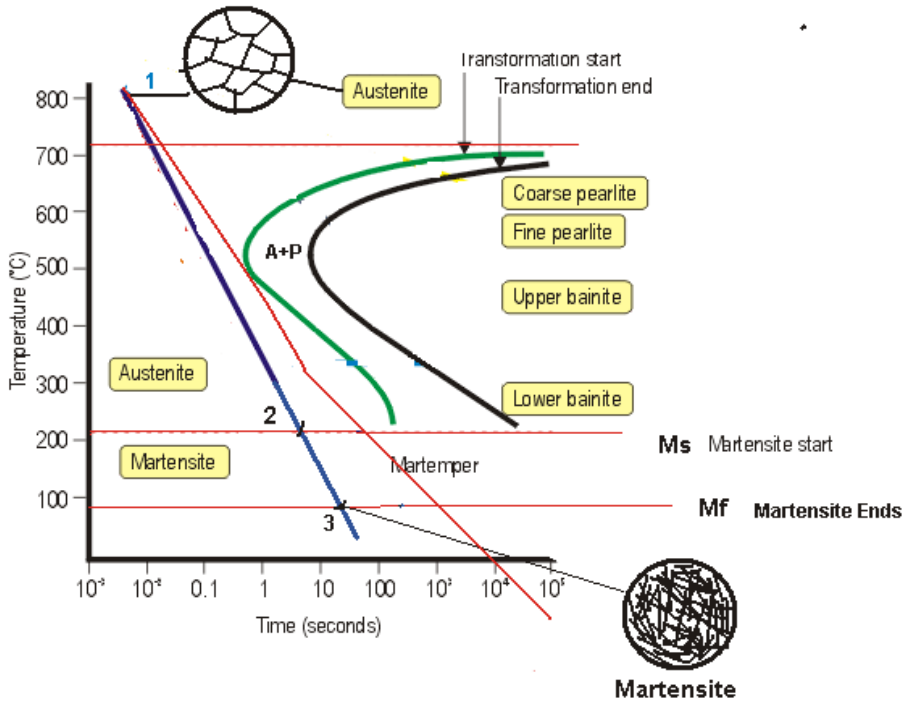
Steel	Cast iron
Carbon % from 0.008 to 1.5%	Carbon % from 2% to 5%
Soft and ductile	Hard and brittle
Good tensile strength	Good compressive strength
High toughness	Low toughness
Low damping capacity	High damping capacity
Types-low,medium and high carbon steel	Types-white cast iron,grey cast iron, malleable cast iron

f) State the desired characteristics of bearing materials — **Any four-1 Mark each**

1) The friction between the bearing and the rotating part should be as small as possible to reduce the power loss in transmission.
2) The affinity between the shaft and the shaft and the bearing material should be minimum.
3) It should be hard and wear resistant for longer life. However, it should not be harder than the shaft so as to avoid the damage of the shaft.
4) It should have sufficient load bearing ability i.e. the material should have good mechanical properties at ambient and elevated temperatures.
5) It should have sufficient plasticity and deformability to take care of large deflections and misalignment.
6) It should have high fatigue resistance.
7) It should have good resistance to galling and seizing.
8) It should have good thermal conductivity.
9) It should have a high oil retaining capacity.
10) It should have a good corrosion resistance.

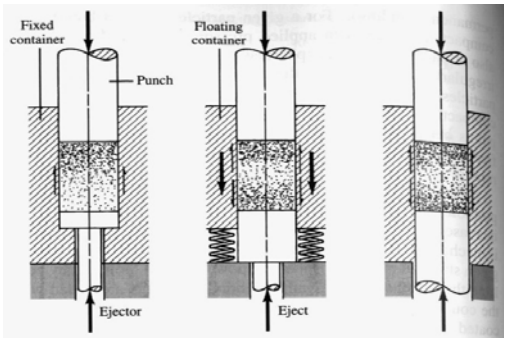
Q.5. Attempt any FOUR of the following: — **16 Marks**

a) Draw TTT diagram for plain carbon steel.

	Sol.		**04 Mark**
	b)	**State the various hardening defects.**	
	Sol.	• Oxidation and decarburization. • Quenching cracks. • Distortion and warpage. • Change in dimensions. • Soft spots. • Mechanical properties not conforming to specifications. • Induced stresses.	**Any four** **01 Mark each**
	c)	**Why tempering is necessary? List its types.**	
	Sol.	Tempering is necessary to eliminate following defects. • Hardened steel has high hardness due to presence of tetragonal martensite. • Hardened steel have high internal residual stresses. • Hardened steel has low values of ductility and impact strength. • Such as hardened steel component cannot be used for practical applications as it has low ductility, high hardness and low ductility. • So it is required to reduce hardness, relieve internal stresses and improve ductility • of hardened steel parts. This is done by subsequent heat treatment of tempering **Types**: 1. low temperature tempering: carried out between 100-200 ° c. 2. medium temperature tempering: carried out between 200-500 ° c.	**03 Marks for description** **01 Mark for types**

		3. high temperature tempering: carried out between 500-700 ° c.	
	d)	**State the characteristics and applications of stainless steel.**	
	Sol.	**Characteristics:** Corrosion resistance Non magnetic High strength to weight ratio. Good thermal and electrical conductivity Can be machined and heat treated. **APLICATIONS :** pressings , chemical and food processing ,, air craft exhaust manifolds, annealing baskets, boiler shells, combustion chambers, nitric acid tanks, furnace parts, surgical instruments, heater bars etc.	**2 Marks** **2 Marks**
	e)	**Differentiate between thermoplastic and thermosetting plastic.**	
	Sol.	**THERMOPLASTIC** / **THERMOSETTING PLASTIC**	**Any four points, 1M each**
		they are formed by addition polymerization only. / they are formed by condensation polymerization.	
		they consists of long-chain linear polymers with negligible cross-links they soften on heating readily, because secondary forces between the individual chain can break easily by heat or pressure or both. / they have three-dimensional network structure. they cross-links and bonds retain their strength on heating and hence, they do not soften on heating. On prolonged heating, however, charring of polymers is caused.	
		by reheating to a suitable temperature, they can be softened, reshaped and thus reused. / They are usually hard, strong and brittle.	
		they can be reclaimed from wastes. / they cannot be reclaimed from wastes.	
		they are usually soluble in some organic solvents. / Due to strong bonds and cross links , they are insoluble in almost all organic solvents.	
	f)	**Explain compacting and sintering process of powder metallurgy.**	
	Sol.	**Compaction:** Usually gravity filled cavity at room temperature Pressed at 60-100 kPa	**Compacting 2M**

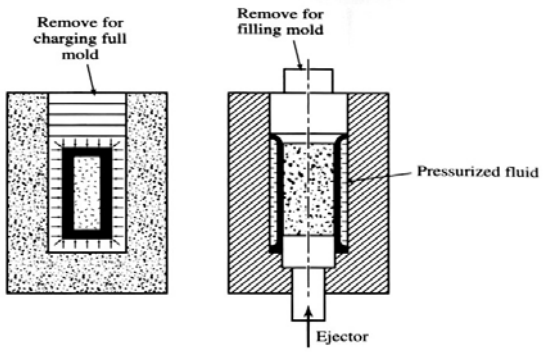
- Produces a "Green" compact
  - Size and shape of finished part (almost)
- Not as strong as finished part.



sintering 2M

- **Isostatic Pressing:** Because of friction between particles

Apply pressure uniformly from all directions

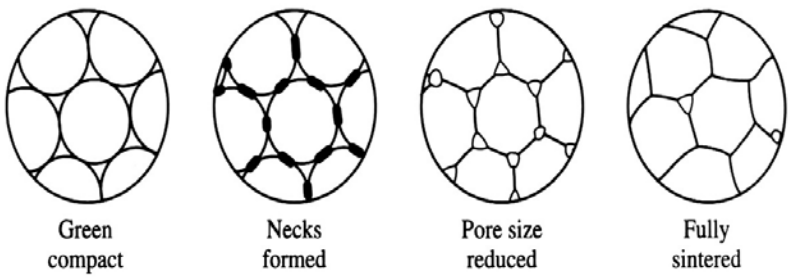


Sintering:

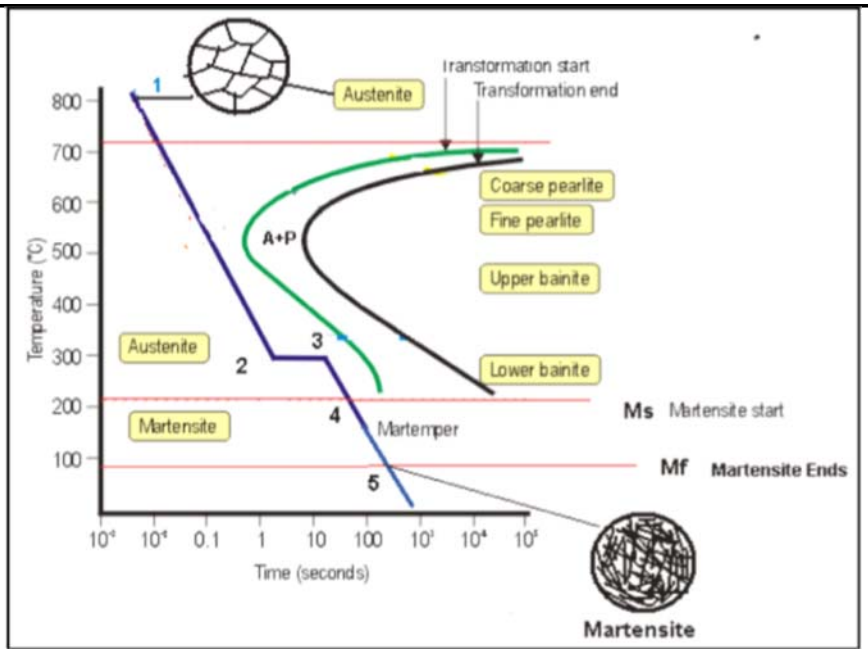
- Parts are heated to ~80% of melting temperature
- Transforms compacted mechanical bonds to much stronger metal bonds
- Many parts are done at this stage. Some will require additional processing
- Final part properties drastically affected
  - Fully sintered is not always the goal. i.e. Self lubricated bushings

- Dimensions of part are affected

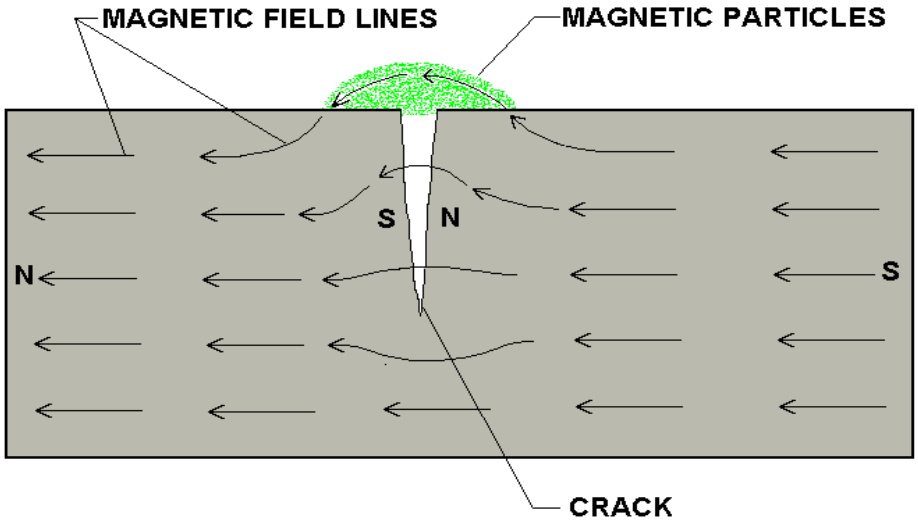
Microstructure changes are as shown below.



Q.6.		Attempt any FOUR of the following:	16 Marks
	a)	**Explain martempering process..**	
	Sol.		

		 • it is a hardening process. • steel is heated to austenitizing temp, then rapidly cooled in salt bath kept at a temp. just above Ms. • holding time should be such that austenite should not transform to bainite. • it is then cooled to room temp. in air or oil to obtain martensite. holding in constant temp. Bath equalizes temperature from surface to centre and minimizes warping and quenching cracks.	**02 marks for diagram** **02 marks for description**
	b)	**State the meaning of :** i) **Fe 300** ii) **20 C8** iii) **40Cr4Mo3** iv) **20Cr18Ni2**	
	Sol.	i) **Fe 300 -** steel with min. tensile strength 300 N/sq.mm ii) **20 C8 -** 0.2 % CARBON AND 0.8 % Mn iii) **40Cr4Mo3 -** low alloy steel 0.4 % c , 1 % Cr, 0.3 % Mo. iv) **20Cr18Ni2 –** high alloy steel 0.2% C, 18% Cr, 2% Ni.	**01 Mark each**
	c)	**Write one applications of: i) OHNS ii) high carbon steel iii) gery CI iv) spring steel**	

	Sol.	**i) OHNS:** Blanking & stamping dies, punches, rotary shear blades, thread cutting tools, milling cutters, reamers, measuring tools, gauging tools, broaches, chasers etc. **ii) high carbon steel:** forging dies, punches, hammers, springs, clutch discs, car bumpers, chisels, vice jaws, shear blades, drills, leaf springs, knives, razor blades, balls and races of ball bearings, mandrels , cutters, files, reamers, wire drawing dies, metal cutting saws. **iii) gery CI:** m/c tool structures, bedways, frame,guide ways, under ground pipes,man hole covers, tunnel segments, cylinder blocks,ic engine heads etc **iv) spring steel:** Saw blades, tape measures, helical springs, and vehicle suspension elements, leaf springs, music wire etc.	**1M for any one application of each material**
	d)	**Write two properties and applications of ABS.**	
	Sol.	**properties:** These are tough, hard and rigid. good chemical &heat resistance. easy in processing & machining. unaffected by water, inorganic salts, alkalis and many acids. they are soluble in ketones, aldehydes and esters. **applications:** For telephone bodies, safety helmets, TV casing, radios, control panels, electronic equipment cases (e.g., computer monitors, printers, keyboards), drainage pipe.	**Any two properties-2 Marks** **Any two applications-2 Marks**
	e)	**Differentiate between destructive and NDT.**	
	Sol.	**DESTRUCTIVE TEST:** 1. carried by destroying the object 2. the object can not be used after test. 3. much easier to carry out. 4. gives more information 5. 100% inspection is not possible. 6. process is not economical and safe. **NON DESTRUCTIVE TEST:** 1. carried without destroying the object 2. object can be used after test. 3. special steps are required. 4. gives specific information 5. 100% inspection is possible. 6. process is economical and safe.	**Any four points -1M each**
	f)	**Suggest NDT method to detect hidden cracks in large metal pipes. Explain.**	

	Sol.	**Suggested method: Magnetic Particle Inspection** **Magnetic Particle Inspection:** The part is magnetized. Finely milled iron particles coated with a dye pigment are then applied to the specimen. These particles are attracted to magnetic flux leakage fields and will cluster to form an indication directly over the discontinuity. This indication can be visually detected under proper lighting conditions.  a magnetic field is established in a component made from ferromagnetic material. The magnetic lines of force travel through the material and exit and reenter the material at the poles. Defects such as crack or voids cannot support as much flux, and force some of the flux outside of the part. Magnetic particles distributed over the component will be attracted to areas of flux leakage and produce a visible indication. Large surface areas of complex parts can be inspected rapidly. Can detect surface and subsurface flaws.	**1 Mark** **3 Marks**