MODEL ANSWER

SUMMER– 17 EXAMINATION

Subject Title: **Mechanical Engineering Materials** 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. No.	Sub Q. N.	Answer	Marking Scheme
1	a	**Unit cell:-**The smallest geometric repetitive unit of space lattice which repeats in all direction to form the space lattice is known as unit cell. **Space lattice**:-It is the three dimensional, regular, repetitive arrangements of atoms within a single crystal of a crystalline material.	1 Mark 1 Mark
	b	**Properties of materials:-**An engineer must have an intimate knowledge of the properties and behavioral characteristics of the materials that he intends to use. While designing a product you need to select materials to create the product. For selecting materials, you must assess the properties of each material to ensure that the selected material is appropriate for manufacturing the desired product. The understanding of the properties of materials is highly essential because without this information & knowledge, the designing of manufacturing process may be expensive & complex task	2 Mark
	c	Definition of **i) Phase:-**Any homogeneous, physically distinct and mechanically separable portion of a system is known as phase. **ii) Solid solution:-**Solid solution is microscopically homogeneous mixture of atoms of two or more elements right down to atomic level, one of the element should be essentially a metal and mixture shows metallic properties	1 Mark 1 Mark
	d	**Heat treatment**:-Heat treatment process is used to change the external properties of material by changing its internal microstructure. The external properties of material like tensile strength, impact strength, ductility, hardness depends upon the internal microstructure of the material. The internal microstructure can be change by using heat treatment process by	1 Mark

		adopting different rates of cooling **Advantages of heat treatment:-** i)Relieving internal stresses developed during cold working,welding,casting,forging,etc ii)Improve machinability and corrosion resistance iii)change in grain size iv)improve hardness, ductility and toughness v)improve electrical and magnetic properties	Any two advantages 1/2 mark each
	e	**Classification Of steel:-** **i)Mild or Low carbon steel:-** It contains 0.15 to 0.45% of carbon **ii)Medium Carbon Steel:-** It contains 0.45 to 0.80% of carbon **iii) High Carbon steel:-** It contains 0.80 to 1.5% of carbon	2 Mark
	f	**Various quenching medias for heat treatment** i)Water ii)Oil iii) brine solution iv)Air v)Furnace cooling	Any Four quenching media 1/2 Mark each
	g	**Alloy steel:-**Alloy steels are carbon steel with other metals added specifically to improve the properties of steel significantly. common alloying elements are chromium(Cr),Nickel(Ni),Maganese(Mn),Silicon(Si),Vanadium(V),Molybdenum(Mo),Tungsten(W) **Examples:-**Stainless steel, Tool steel, Free cutting steel, shock resisting steel, Heat resisting steel, spring steel	1 Mark Any two examples 1/2 Mark each
	h	**Types of cast iron** i)White cast iron ii) Gray cast iron iii) Malleable cast iron iv)Nodular cast iron	1/2 Mark for each
	i	**Properties of copper** • Highly ductile and posses fcc crystal structure. • density is 8920 kg/cu.m • melting point 1083 ºC • Higher thermal & electrical properties. • Corrosion resistance. • Non magnetic and pleasing color. • It can be welded, brazed and soldered. i.e. ease of fabrication. • Good machinability. **Applications of copper** Roofing, gutters radiators, gaskets, kettles, pressure vessels, distillery condenser and heat exchanger applications, bolts, studs, welding tips, contact pins, switch gears, relays and precision electrical equipments.	Any two properties 1/2 Mark each Any two applications1/ 2 Mark each

	J	**Properties of Aluminum:-** i)It is ductile & malleable due to its FCC structure ii)It is light in weight iii)It has very good thermal and electrical conductivity iv)It has excellent corrosion & oxidation resistance v)It is non magnetic vi)It has silvery white colour vii)It can be alloyed with other metals viii)It can be cold worked and also hot worked	Any Four properties 1/2 Mark each
	K	A **Polymer** is a chemical substance made up of repeating units or molecules to form a long flexible chain. Poly means many and mer means a unit. Polymeric materials are composed of a number of small units called monomers connected with each other **Examples:**-Plastics,rubber,polyvinyl chloride(PVC),polystyrene,ABS, Polyster resins, Epoxy resins, silicon resins	1 Mark Any two examples 1/2marks each
	L	**Non metallic materials & their applications:-** i)Polymers:-Toys,combs,hoses,pipes,telephone receivers, electric plugs, TV cabinets, camera body ii)Rubbers(elastomers):-Pneumatic tyre & tubes, heels and soles,gaskets,belts,shoe, flooring, seals,O-rings iii)Ceramic:-Porcelain,pottery,brick, glass,diamond,garnet,silicon carbide,asbestos, rocks,cement iv)Insulating materials:-stoppers, Roofs and partition, brake linings, for refrigerators, furnaces	1/2Mark for each non metallic material & 1/2 Mark for each applications
	m	**Application of powder metallurgy:-** i)Porous products eg,bearing and filters ii)Automotive components such as electrical contacts, crankshaft drive, piston rings, connecting rods and brake linings iii)Products of complex shapes that require considerable machining when made by other processes eg.gears iv)Products where the combined properties of two metals or of metals and non metals are desired non –porous bearings, electric motor bushes v)clocks and timing devices,typewriters,adding machines,calculators,permanent magnets vi)Grinding wheels vii)Refractory parts made of tungsten and molybdenum are used in electric bulbs,X-ray tubes,cathode,anode viii)Atomic energy applications	Any Four applications 1/2 Mark each
	n	**Advantages of non destructive testing:-** i)The component does not break or damage even after testing the product ii) Internal /external defects, flaws can be detected. ii)These tests are more reliable, safe and economical iii)These are extremely useful in revealing defects in components like cracks,porosity ,inclusion,blow holes,flaws,cavities	1/2 Mark each

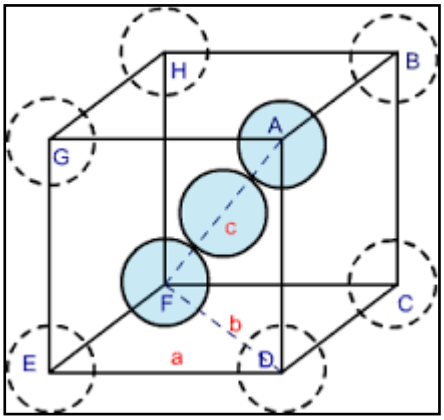
iv)These are more accurate

Q2 a

Packing efficiency:-The fractional amount of volume or space occupied by atoms in an unit cell is called atomic packing efficiency. The packing arrangement of atoms depends on the relative radii of the atoms involved and also on the character of bonding between atoms

Packing efficiency=Volume of atoms in unit cell
Volume of the unit cell

1 Mark



Calculation of packing efficiency of BCC unit cell

3 Mark

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

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

$$= \frac{(8/3)\pi r^3 \times 100}{64/(3\sqrt{3})r^3}\%$$

$$= 68\%$$

b

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

1 Mark

1 Mark

Plasticity:-It is the ability of material to be permanently deformed without fracture even after the load is removed. It is the property of material, which retains the deformation ,produced under load permanently

1 Mark

Density:-Density of material is defined as the mass per unit volume of the material

1 Mark

Strength:-It is defined as the capacity of material by virtue of which it can withstand an external force

C

Substitutional solid solution:

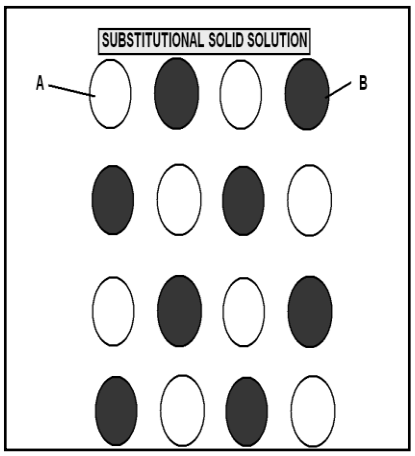
• Here the atoms of two elements are nearly same in size & substitutes each others position in space lattice.
• They have nearly same size
• Same electrochemical nature
• Solution has lower valancy.

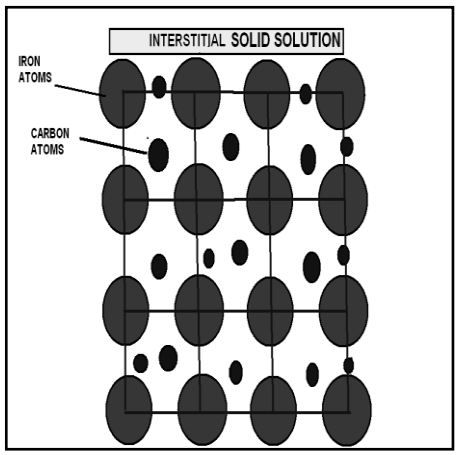
1 Mark

interstitial solid solution:

• here iron atoms are large in size and number and basic space lattice is of iron.
• carbon atoms are small in diameter and occupies interstitial space between two larger iron atoms.

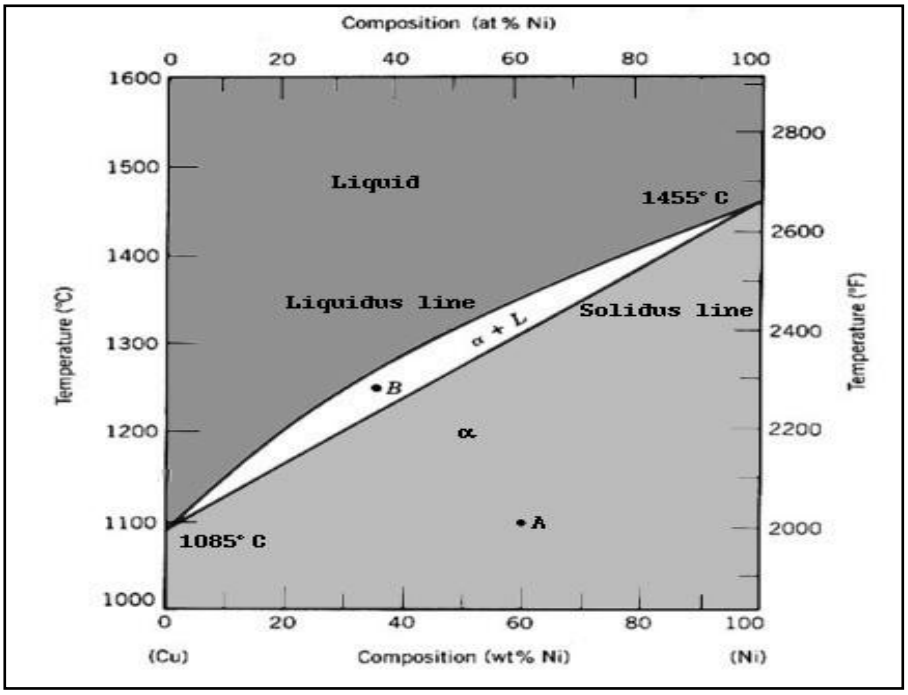
1 Mark





2 Mark for each sketch

d



Neat sketch of Cu-Ni system 2 marks

Cu-Ni binary system:-

Isomorphous system is formed by the elements which are completely soluble in liquid as well a solid state. Extreme left line on diagram shows 100% Cu whereas extreme right hand line shows 100% Ni.As we move from left to right Ni percentage increases. Melting point of Cu is 1085 degree C while 1455 degree C for Ni.Above liquidus line both elements are completely

Explanation-2 Mark

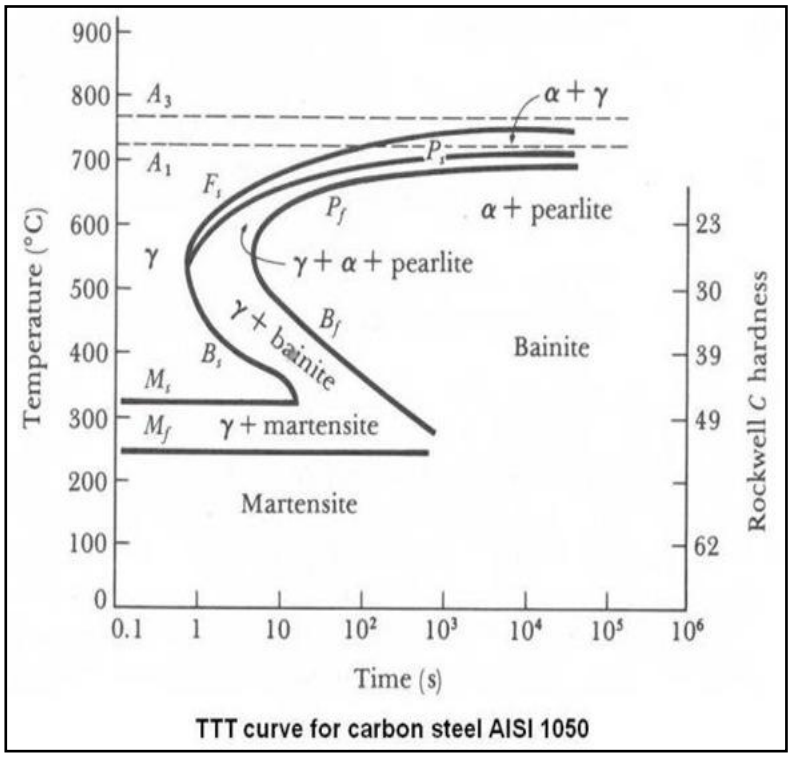
soluble in each other and exists in liquid state. Below solidus line both elements are completely soluble in each other and exists in solid state α.In between solidus and liquidus line the state is α+L.

e

i) To increase hardness, wear resistance and cutting ability of the steel.
ii) To alter the physical, mechanical or chemical properties of steels
iii) To reduce or eliminate internal residual stresses.
iv) To modify grain size of the steel
v) To improve ductility & toughness
vi) To improve electrical and magnetic properties
vii) Improve machinability
Viii) Increase corrosion resistance of the steel

Any Four objectives 1/2 Mark each

f



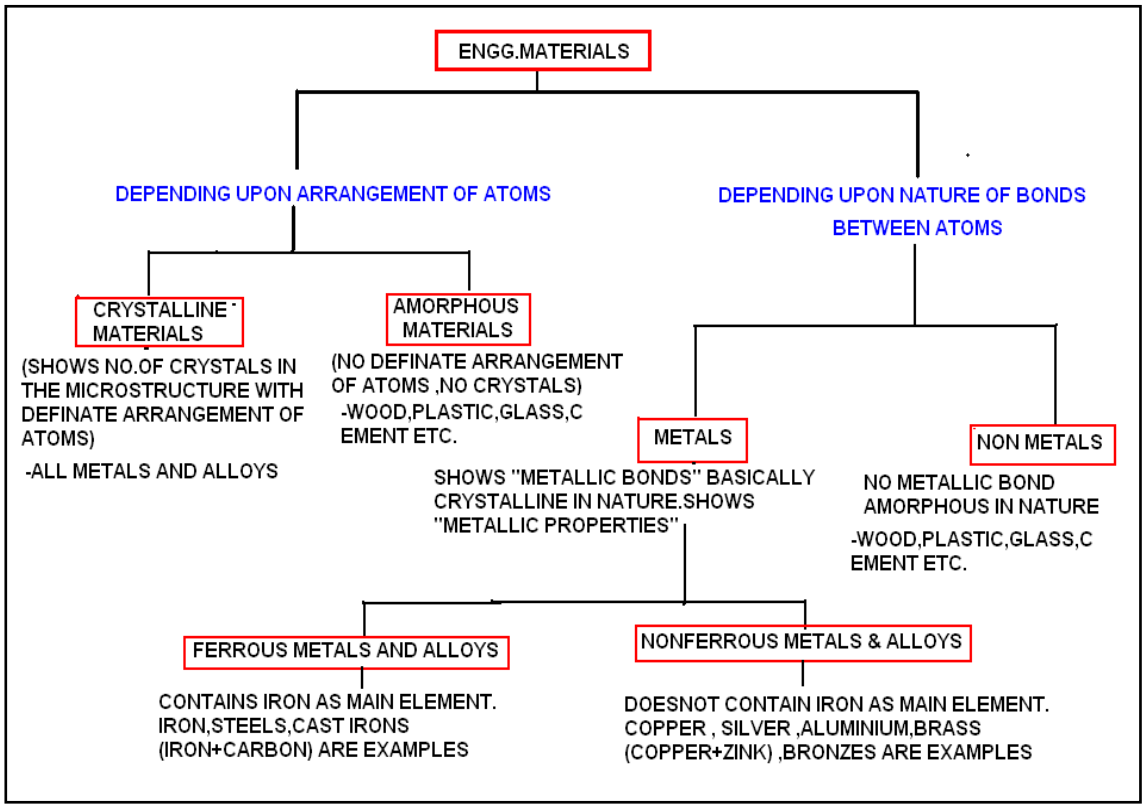
TTT curve for carbon steel AISI 1050

Neat sketch-2 Mark

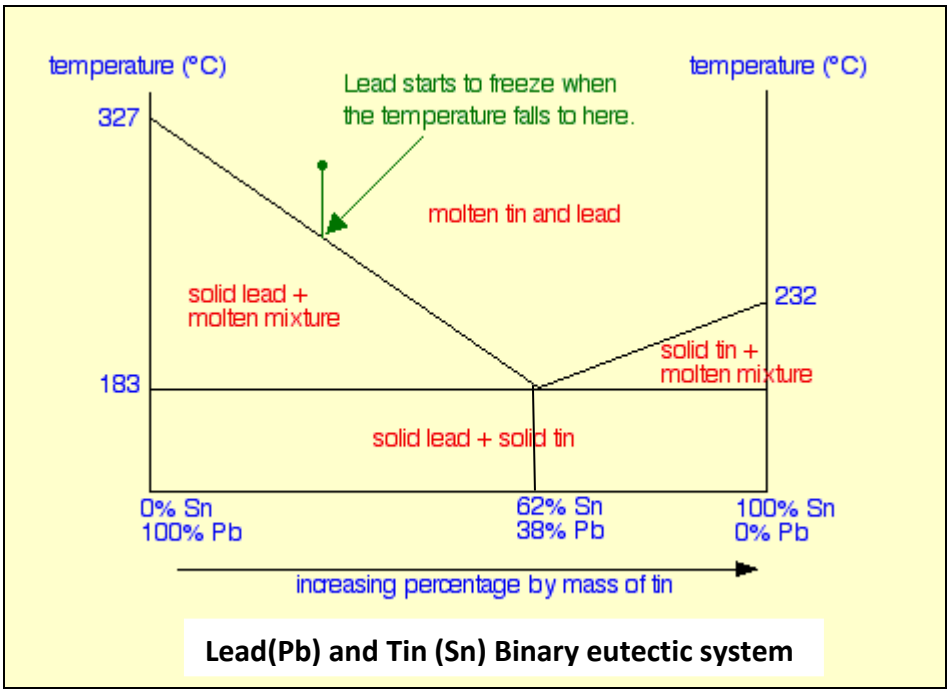
TTT diagram:-On X axis Log time scale is provided and on Y axis temperature scale is provided. There are two horizontal lines on diagram, upward line is called as Ms temperature line i.e. start of martensite temperature transformation line and lower line is called Mf line i.e. finish of martensite transformation line. At extreme top horizontal line is there called as Ac1 line at 723 degree C.As we down the pearlite becomes more and more fine and hardness of the steel increases. As the percentage of the carbon in steel increases, the nose of TTT diagram shifts in rightward direction. The left curve in the diagram represents start of pearlite and right curve indicates finish of pearlite. In the upper right region coarse and fine pearlite is obtained, in the intermediate region upper and lower banite is obtained and in the bottom region martensite is obtained .In between two curves austenite, ferrite and pearlite exists. Depending upon the cooling rate various transformation products are obtained on the diagram.

Explanation-2 Mark

3		**Attempt any four.**	1 mark for each type(any four)
	a)	**Give the detail classification of engineering materials.**	



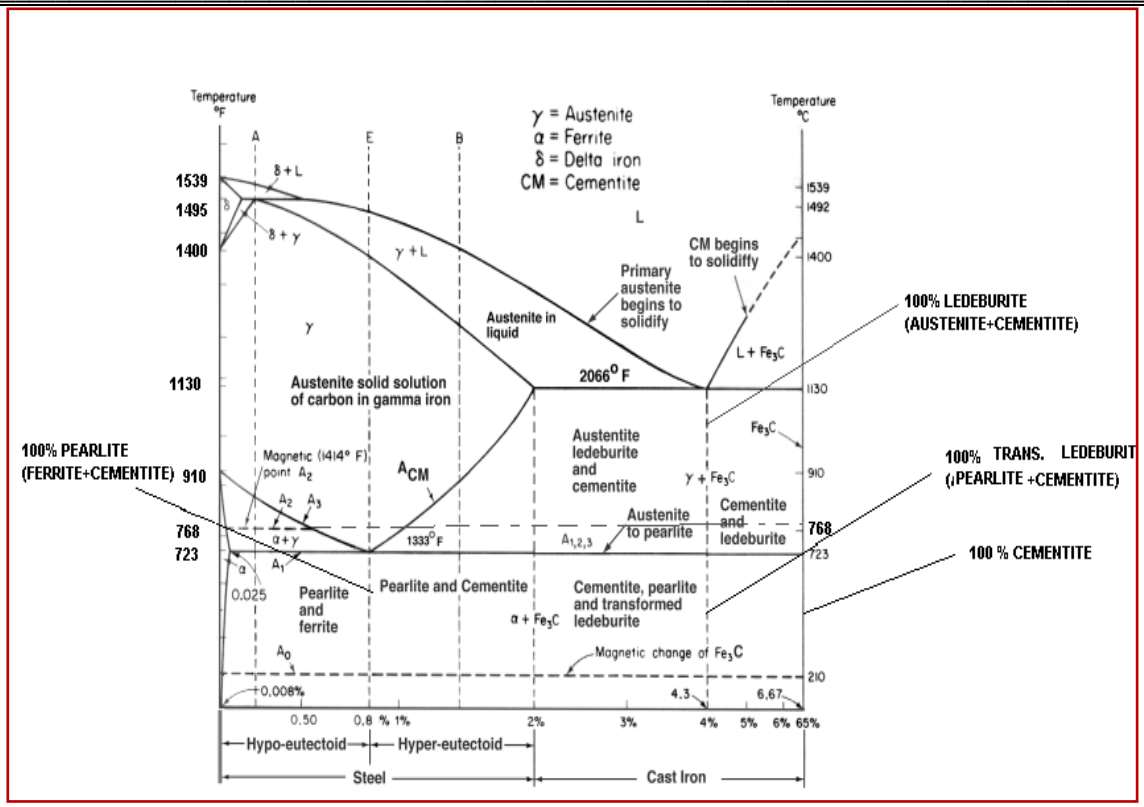
	b)	**Explain lead and tin binary eutectic system with neat sketch.**	Sketch 2m, description 2m.



Lead(Pb) and Tin (Sn) Binary eutectic system

		• It is the alloy system between two metals lead and tin which are completely soluble in liquid stage but completely insoluble in solid stage and showing eutectic reaction. • Eutectic mixture found at a temperature of 183 degrees Celsius. And composition of eutectic is 62 % tin and 38 % lead. • At this temperature molten lead and tin directly solidifies as a eutectic of both elements.	
	c)	**What are various phases exist on Fe-Fe3c diagram?** **Ferrite**: α- alpha solid solution It is an interstitial solid solution of carbon dissolved in α-iron.(BCC- structure.). Maximum solubility of carbon is 0.008 % at room temp. and this solubility limit increases up to 0.025 % at 723 ^{0}c. **Cementite** : (Fe_3C) called as iron carbide, CM, fe_3c. Cementite contains 6.67 % C by wt. It is a intermetallic stable carbide compound. Crystal structure is orthorhombic. Very very hard and brittle interstitial compound. **Austenite** :γ –gamma solid solution. It is an interstitial solid solution of carbon dissolved in ŗ gamma iron (FCC structure). solubility of C is 0.8% at 723 ^{0}c and this limit increases up to 2 % at 1140 ^{0}c. **Pearlite**: (ferrite + cementite) austenite transforms to pearlite on very slow cooling. In an eutectoid steel (0.8%C steel) austenite transform to pearlite at 723 ^{0}c. Pearlite shows alternate plates of ferrire and cementite. **Ledeburite**: (r + Fe_3C) It is an eutectic mixture of austenite and cementite contains 4.3% C at 1140 ^{0}c.	1 mark each with suitable description.(a ny four)
	d)	**Define annealing. State the effects of annealing on properties of steel.** Annealing may be defined as the heat treatment process in which the given steel is heated to annealing temperature range, hold for some time and there after cooled slowly in the furnace by switching off the furnace leading to formation of coarse pearlitic structure in the steel. • It improves homogeneity of steel. • It alters microstructure of steel. • it restores ductility. • refines the grain size. • relieves the internal stresses in steel. • imroved machinability of steel. • It reduces strain hardening effect of cold working. this increases ductility.	Definition 1 m, Effects 3 m

	e)	**State the effect of following elements on steel.** **i) Nickel ii)molybdenum iii) chromium iv) tungsten** **Nickel** : Provides strength, stability and toughness. Higher amount of Ni stabilizes austenitic structure at room temperature. Helps in formation of free graphite. **molybdenum** : Usually < 0.3% increase hardenability and strength Mo-carbides help increase creep resistance at elevated temps typical application is hot working tools. **chromium** : Usually < 2% increase hardenability and strength Offers corrosion resistance by forming stable oxide surface typically used in combination with Ni and Mo. **tungsten :** helps to form stable carbides increases hot hardness. used in tool steels.	1 m each.
	f)	**What is 18-4-1 tool steel? State its application.** It is high speed steel having following composition. 18% tungsten, 4% chromium, 1% vanadium. These are high alloyed tool steels developed initially to do high speed metal cutting. Now, they used in a wide variety of machining operations. These are characterized by high hardness (60-65 HRC at 600-650°C), high red hardness, wear resistance, reasonable toughness and good hardenability. **Applications :** End mills, drills, lathe tools, planar tools. Punches, reamers, Routers, taps, saws. Broaches, chasers, and hobs.	Composition 1m, Description 1m, Applications 2m.
4.	a)	**Attempt any four.** **Draw a neat sketch of iron-iron carbide equilibrium phase diagram.**	Labeled sketch 4m



b) **What is normalizing? State its purpose & explain how normalizing is carried out.**

Definition 1m,

Purpose 1m, process 2m.

Normalizing is the heat treatment which involves heating of the given steel to "austenite temp. range" holding it & there after cooling to room temperature at slow rate of cooling, generally "air cooling".

purpose:

- To eliminate coarse grained structure.
- To reduce segregation.
- To refine grain structure.
- To produce harder and stronger steel than annealing.
- To obtain required mechanical properties.
- To relieve internal stresses in some cases.

Process:

A typical normalizing process involves following steps,

1. Heating of steel: here the steel, depending upon its type is heated to the normalizing temperature range. For plain carbon steel this range is,

- Ac3 + 50 for hypo eutectoid steels.
- Ac1 + 50 for eutectoid steel.
- Acm + 50 for hyper eutectoid steels.

For various alloy steels the normalizing temperature range is around 780 to 850 0c, depending upon the type of steels.

2. Holding of steel: here the steel is kept at this normalizing temperature for some time for equalization of temperature depending upon the weight and area of steel part.

3. Cooling of steel: here the steel is cooled from this normalizing temp. To room

temperature with a slow rate of cooling in the "air". Here the austenite in the steel is transformed into the " fine pearlite structure"
The air cooling used may be still air cooling or Forced air cooling.

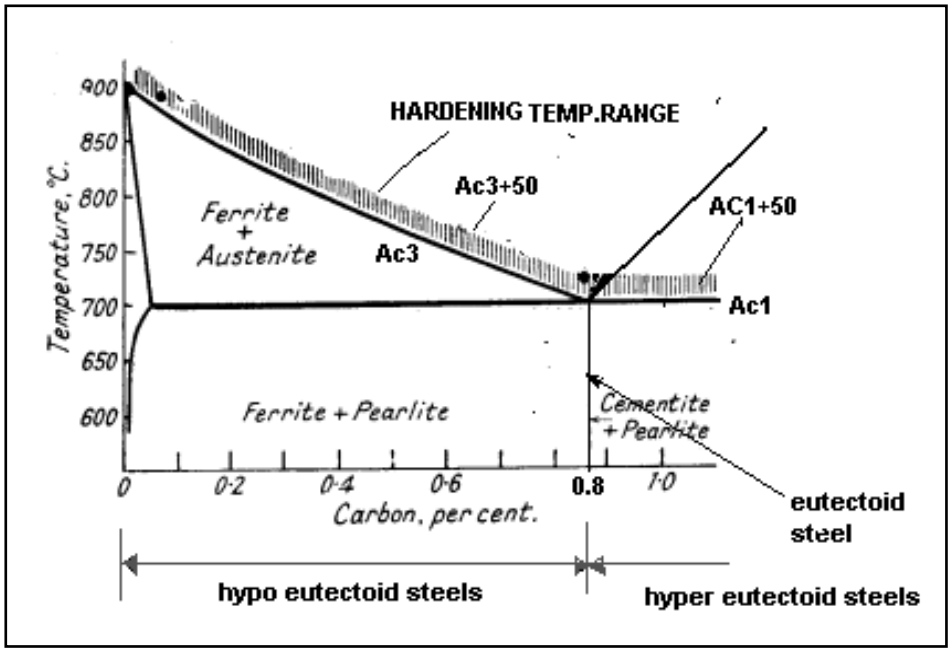
c) **Define hardening. Explain how hardening is carried out.**

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

Definition 1m,

Process 3m.

Process :



- 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.
- Heating of steel: here the steel depending upon its type is heated to austenitizing temperature. this temp. Range is called as "hardening temperature range".
  Ac3 + 50 for hypo eutectoid steels.
  Ac1 + 50 for eutectoid steel.
  Ac1 + 50 for hyper eutectoid steels
- Holding of steel: here the steel is hold at this temperature for some time for equilization of temperature.
- Cooling of steel: here steel is cooled from austenizing temperature to room temperature in a suitable cooling medium with the cooling rate which exceeds the "critical cooling rate" so that austenite gets transformed into hard and brittle "martensitic structure". due to formation of martensitic structure the hardness of steel increases.

	d)	**What is stainless steel? State the properties and applications of stainless steel.** **Stainless steel:** It is an alloy steel containing higher amount of Cr and Ni. High degree of corrosion resistance and chemical resistance. Mostly used for heat resisting applications. Cr makes surface passive by forming surface oxide film. But for forming film it should be in contact with oxydizing agent. Ni is added to form this film in weak oxydizing environment. Generally cr 12 % and ni 8 % **Properties** : o High corrosion resistance. o Non magnetic in nature. o Higher hardness and tensile strength. o Can Not Be Hardened By Heat Treatment. **Applications** : o pressings o chemical and food pressing equipments o air craft exhaust manifolds o boiler shells o shafts o valves etc.	Description 1m, Properties one & half mark, applications one & half mark.
	e)	**What is muntz metal? State its properties and applications.** Muntz metal is brass having composition as 60% cu & 40% zn. **properties** : high strength, corrosion resistance. excellent hot working properties. **applications** : sheets for ship sheathing, condenser heads, Perforated metals, architectural work, valve stems, brazing rods, condenser tubes.etc.	Composition 1m, Properties 1m, Applications 2m.
	f)	**What is brass? State the properties and applications.** Brass is an alloy of Cu and Zn. By varying amount of Cu and Zn different brasses can be developed. It is a substitutional alloy. Different brasses are- Muntz metal, Naval brass, Cartridge brass, Admiralty brass etc. **Properties**: ▪ high strength, corrosion resistance. Malleable than bronze. ▪ excellent hot working properties. ▪ it has increased resistance to salt water corrosion. ▪ it has high conductivity and malleabilty. ▪ it has good cold working properties. ▪ Exhibits Low friction.	description 1m, Properties 1 & 1/2 m, Applications 1 & 1/2m.

		Applications: ▪ Gears, bearings, ammunition casings and valves. ▪ Condenser plates, welding rods, propeller shafts, piston rods, valve stems. ▪ sheets for ship sheathing, ▪ perforated metals, architectural work, ▪ Brazing rods, condenser tubes.etc. Evaporators, condensate coolers, heaters, water heaters, generator, air coolers.	
5	a	Carburizing is a process of adding carbon to surface. This is done by exposing the part to carbon rich atmosphere at the elevated temperature (nearly melting point) and allows diffusion to transfer the carbon atom in the steel. Carburizing increases the carbon content of the low carbon steel by a process of absorption and diffusion in order to produce a hard case (surface). Low carbon steel is heated in a carbon rich environment pack carbonizing packing in charcoal or coke makes thick layer. Gas carburizing use of propane or other gas in a closed furnace makes thin layer. Liquid carburizing molten salt bath containing sodium cyanide barium chloride thickness between the other two. Followed by quenching hardness about 60 HRC is obtained. *Methods: 1)Pack Carburizing 2)Gas Carburizing 3)Liquid Carburizing *Applications: 1)In case hardening of gears . 2) Cam shafts . 3) Bearings	2 1 1
	b	Surface Hardening: In many engineering application it is desirable that steel being used should have a hardened surface to resist wear and tear .At this time it should have soft and tough interior or core so that it can absorb any shocks .e.g. Cam ,Gears etc.It can be heated above A3 temperature for hypo eutectoid steel and above A1 temperature for hyper eutectoid steels by 50o C. *Needs of surface hardening: 1) To Increase wear resistance 2)To Increase mechanical properties 3) To increase surface hardness 4) To Improve ductility 5) To Increase impact resistance 6) To Improve fatigue strength 7)To Rebuild worn or undersize part 8)To serve as an ornamental finish.	2 2

c

Differentiate between White Cast Iron and Gray Cast Iron

4(Any four)

Sr. No.	White Cast Iron	Gray Cast Iron
1	It is an alloy of Carbon chemically bounded with Iron 1.7% to 4.5% of carbon and0.5% to 3% of silicon	It is an alloy of Carbon and silicon with Iron. 2.5% to 4% carbon and 1% to 3% silicon
2	carbon is present in the form of carbide of iron.	carbon is present in the form of graphite flakes.
3	When fractured it shows bright white fracture	When fractured it shows gray appearance
4	Under normal condition it is brittle and not machinable	It has better machinability
5	Used in cement mixers, in some drawing dies, ball mills and extrusion nozzles.	Engine cylinders, pump housings, electrical boxes, valve bodies and decorative castings

d

Composition of

i)40Cr4Mo2:Free cutting steel having 0.4 % Carbon,1% Cromium and 0.2 % Molybdenum — 1

ii)FeE400:Plain Carbon Steel with Yield Strength 400 N/mm^2 — 1

iii)45C10S18:Medium Alloy Steel with 0.45 % Carbon,1 % Mangenese,0.18 % Sulphur. — 1

iv)40C8:Unalloyed steel with 0.4 % Carbon and 0.8 % Mangenese. — 1

e

Desirable Properties of bearing material — 4(Any four)

1)They should have high fatigue strength.

2) They should have good corrosion resistance.

3) They should have high compressive strength.

4) They should be hard and wear resistant.

5) They should be low in cost and easily available.

6) They should have low coefficient of friction.

7)It must be tough,shock resistant and sufficient ductile.

8)The affinity between shaft and bearing material should be minimum.

f

Sr no.	Thermoplastics	Thermosetting Plastics
1	They are formed by addition polymerization	They are formed by condensation polymerization
2	They consist of long chain linear polymers with negligible crosslinks	They have three dimensional network structure
3	The soften on heating and harden on cooling	They do not soften on heating once hardened and set
4	By reheating to a suitable temperature they can be softened reshaped and thus reused.	They retain their shapes and structure even on heating hence they cannot be reshaped and reused.
5	They are usually soft weak and less brittle.	They are usually hard strong and more brittle.
6	They are recycled from west.	They cannot recycled from west
7	They are generally soluble in some organic solvents.	Due to strong bonds and cross links they are insoluble in almost all organic solvents.
8	Typical uses are in toys for kids, combs, insulating tapes.	Telephone receiver, television cabins, camera parts

4Any four

6 a Compare Austempering and Martenpering

Sr No.	Austempering	Martempering
1	It is not hardening Process	It is hardening Process
2	This process transforms austenite to bainite.	This process transforms austenite to martensite.
3	It is also called as a isothermal quenching	It is also called as stepped quenching or interrupted quenching. marquenching
4	Quenching time in salt bath is longer to get bainite.	Quenching time in salt bath is shorter to get martensite.
5	Very few alloy steels are subjected to this treatment	The process is very suitable for high hardenable steels
6	Less warping and distorsion	Better elongation and hardness

4Any four

b Suggest suitable steel for

i) Crankshaft of IC Engine :Medium-carbon steel alloys are composed of predominantly the element iron, and contain a small percentage of carbon (0.25% to 0.45%) — 1

ii) Propeller shaft of truck: material with high torsional rigidity as well as material that can take a lot of fatigue .We can use alloy 303 or any low carbon steel with 10-18 % chromium and 5-8 % nickel. — 1

iii) Car bodies:Galvanised and cold rolled steel — 1

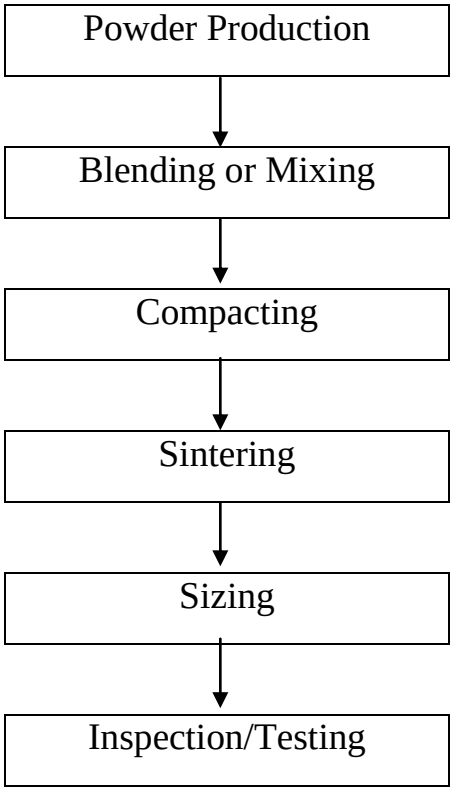
iv) Household Utensils:Stainless steel. — 1

c State properties and application of glass wool

*Properties

1) It provides excellent insulation against heat and cold.
2) They have very high tensile strength. — 2
3) They can be performed to hold their shape without use of special

		surface covering. 4) These products are limited to a maximum temperature of about 200^0C. *Applications: 1) Thermal and sound insulation in airplanes. 2) Furnace, ovens, water heaters, freezers. 3) Industrially glass wool blankets, blocks, and boards are used to reduce losses of heat from pipes boilers. 4) Used in electrical insulation.	2
	d	Acrylics: It is a group of vinyl plastics which are most widely used in Polymethyl Methacrylate (PMMA) *Properties 1) It is much tougher than glass 2) It is low abrasion resistant 3) It is good electric insulator. 4) It is having high resistance to sunlight * Applications 1) Sheets 2) Industrial building 3) Lenses 4) Display door signs 5)Sink baths 6) Sanitary wares	2 1 1

	e	Block diagram of Powder metallurgy  	01 mark for each term
	f	Nondestructive testing These are the tests which do not damage or reduce the service life of a component.Usually these tests do not directly measure mechanical properties such as tensile strengths,hardness but they are used to locate flaws,defects in the components.They make the component more reliable,safe and economical. *Methods of NDT 1)Magnetic Particle Inspection 2)Dye Penetrant Test 3)Ultrasonic Inspection 4)Radiography 5)Eddy Current Inspection 6)Visual Inspection	2 2