MODEL ANSWER

WINTER– 18 EXAMINATION

Subject Title: Mechanical Engineering Materials Subject 17303

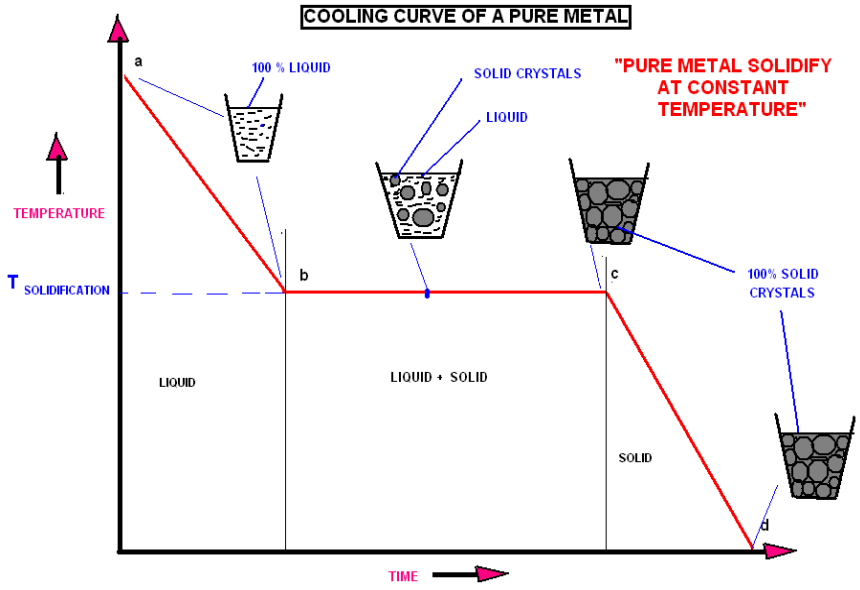
Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in themodel answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may tryto assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given moreImportance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in thefigure. The figures drawn by candidate and model answer may vary. The examiner may give credit for anyequivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constantvalues 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.		Marking Scheme
1	a	**How are metals classified? Name any two types of cast iron.** Metals are classified as ferrous and non ferrous. Example of ferrous metal is iron and remaining all metals are non ferrous **types of cast iron** i)White cast iron ii) Gray cast iron iii) Malleable cast iron iv)Nodular cast iron	1 Mark Any two-1Mark
	b	**Define pure metal. Give two examples** **Pure metal**:-A pure metal only consist of a single element. This means that it only has one type of atom in it. They have metallic bond between their atoms. Examples:-iron, copper, nickel, tin etc.	Def.-1Mark Any 2 examples ½ Mark each
	c	**Define the term solid solubility** The dissolving ability of solute in the solvent, while forming a solid solution is called solid solubility. It occurs when the components have similarities in crystal structure and atomic diameter.	2 Mark
	d	**State the purpose of normalising** i) To eliminate coarse grained structure. ii) To refine grain structure. iii) To produce harder and stronger steel than annealing. iv) To obtain required mechanical properties. v) To relieve internal stresses in some cases.	Any Two 1/2 Mark each -2 Mark

	e	**Describe cast iron in brief** Cast irons are a family of ferrous metals with a wide range of properties produced by being cast into shape. Cast iron contains 2% to 4% carbon and 1% to 3% silicon. Other elements are used to control specific properties. The wide spread use of cast iron is as a result of its low cost and versatile properties. Cast irons have wide range of mechanical properties which make them suitable for use in engineering components	2 Mark
	f	**State the types of polymer materials** i)Acrylics ii)ABS iii)Nylons iv) Polyethlene v)PVC vi)Epoxies vii)Phenolics viii)Polymiders	Any Four ½ Mark each- 2Mark
	g	**Define sintering.** It is one of the steps in the manufacture of a component by powder metallurgy. Sintering is carried out to increase strength and hardness of a green compact and consists of heating the compact to a definite temperature under controlled conditions with or without pressure for a definite period.	2 mark
	h	**State different types of elastomers** i)Natural Rubber (Polyisoprene) ii)SBR (Styrene-Butadiene-Rubber) iii)EPDM(EPDM ETHYLENE PROPYLENE) iv) butyl rubber. v)Polyurethane (AU, EU) vi)Neoprene CR (Polychloroprene)	Any Four ½ Mark each- 2Mark
	i	**NITRIDING** Process of heating of alloy steels in contact with nitrogen gas environment to a temperature of 500 to 550 degree centigrade and held for a long period of time (25 to 100 hours) in the furnace. This forms "hard alloy nitride particles" in the outer surface of the steel.	2 Mark
	J	**Classification Of steel:-** 1)Mild or Low carbon steel:- It contains 0.15 to 0.30% of carbon 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	2 Mark
	K	**Define Polymorphism** Polymorphism is the property of a material to exist more than one crystal lattice in the solid state. E.g. *Cristal structure change from bcc (alpha iron)to fcc (gamma iron) and again in bcc (delta iron) as in pure iron*	2 Marks

	L	**How the defects are located in magnaflux test ?** The component to be inspected for flaws is magnetized and the inspection medium is applied to the component .In the dry method of inspection, a special fine ferromagnetic powder is applied on the surface by means of hand shaker so that powder uniformly distributes on the surface of component .Magnetization of the component is done either by using an external magnetic yoke coil or by passing an electric current through it. A magnetic pole is formed at the crack or flaw, which causes the magnetic powder to concentrate on this area and the flaw gets easily detected.	2 Marks
	m	**Describe pearlite in brief.** Pearlite: It is a mechanical mixture of α ferrite and 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. Eutectoid reaction- 723 ^{0}c. Austenite ⟷ Pearlite i.e. (ferrite + cementite) (88%) + (12%) Pearlite shows alternate plates of ferrire and cementite.	2 Marks
	n	**Define elasticity and malleability of material** Elasticity:-It is the property of material that enables it to regain its original shape & size after load is removed..Elasticity can be expressed by young's modulus 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	1Mark each- 2Mark
	o	**State the applications of ABS** Applications of ABS are as under, • Automobile panels and parts. • Radiator Grills. • TV Cabinets and cameras • Telephones • Refrigerator Liners.	Any four ½ Mark each

Q2	a	**Define creep .What are its stages?** **Creep** (sometimes called **cold flow**) is the tendency of a solid material to move slowly or deform permanently under the influence of mechanical stresses. **Stages of creep** When a material is held under a constant stress for a period of time, **the** process of **creep** can be divided into three **stages** of development: (I) primary **creep** when **the** process begins at a fast rate, (II) secondary **creep** when **the** process proceeds at a steady rate, and lastly (III) tertiary **creep** that occurs quickly	2Mark 2Mark
	b	**Describe cooling curve of pure metal**  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 bc** 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 solid state. Hence pure metals solidifies at	Description-2 Marks Diagram-2 Marks

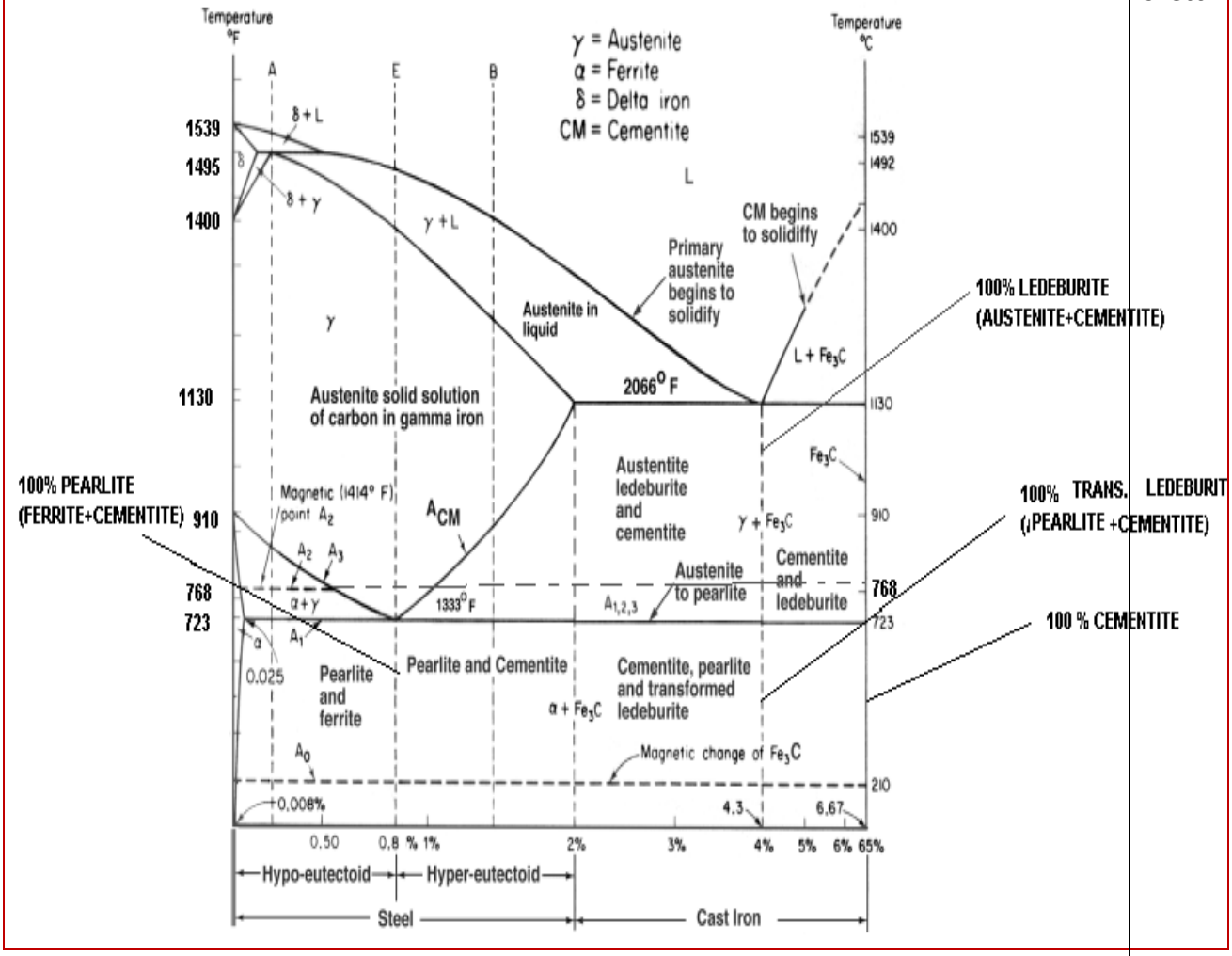
constant temperature

In region cd same as region ab F=1

Draw iron carbon diagram and label it.

c

Neat labeled sketch-4 Marks



d **Compare austempering and martempering** — Any Four points 1Mark each -4M

ustempering	Martempering
It is not a hardening treatment	It is a hardening treatment
It gives bainite product	It gives martensite product
It gives less hardness	It gives more hardness
Greater ductility & toughness	Low ductility & toughness
Less distortion	More distortion
It requires more time	It requires less time

State advantages & limitations of

e **Nitriding**

Advantages of Nitriding — Any four Adv. 1/2 Marks each- 2 M

1) Very high surface hardness in range of 1150 VPN is produced.
2) No quenching is required so nitrided parts have less distortion and warpage.
3) No machining is required after nitriding.
4) Parts are heated to less temp. range so no oxidation and decarburization.
5) Nitrided parts can retain their hardness upto 500 degree centigrade.

Limitations of Nitriding — Any four limitation 1/2 Marks each- 2 M

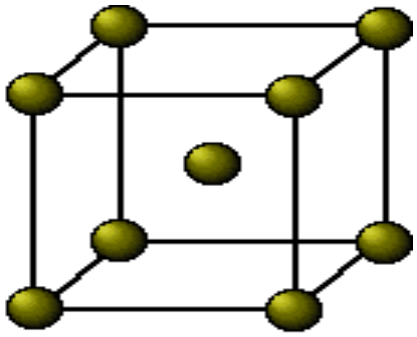
1) Long cycle times (25 to 100 hrs)
2) Brittle case
3) Only special alloy steels containing Al, Mo, V,Cr as alloying elements can only be nitrided.
4) Plain carbon steels cannot be effectively nitrided.
5) High cost.
6) Technical control required.
7) If nitrided part gets accidently overheated.(above 500 ^{0}c) then the hardness will be lost completely.

f **Define annealing. State the objective.**

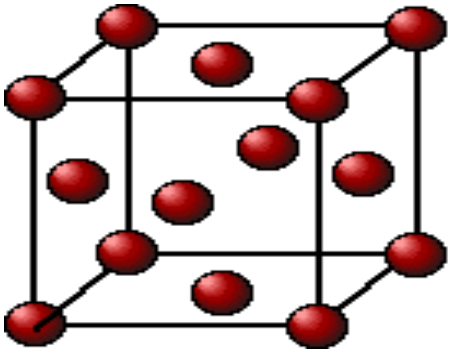
Def.:-Annealing may be defined as the heat treatment in which steel is heated to austenitic region and then cooling very slowly (furnace cooling) in transformation range. — Def:-1M

OBJECTIVES OF ANNEALING : — Any 3 objectives 1M to each- 3M

1) To improve homogeneity of steel.
2) To alter microstructure to improve properties of steel.
3) To restore ductility.
4) To refine the grain size.
5) To relieve the internal stresses in steel.
6) To improve machinability of steel.
7) To reduce strain hardening effect of cold working. This increases ductility.

Q3	a	**Define carburizing. State its advantages** **Definition**: It is Process of introducing the carbon in the outer case of low carbon steels in order to produce a hard martensitic structure after quenching 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. Advantages: 1. For low volume production it is economical. 2. Certain components are heat treated by this method economically. 3. Can be done in any furnace. 4. Process is safe. 5. Less capital investment. 6. No necessity of special space for carburized components. 7. It does not require special controlled atmosphere 8. Same furnace can be used for normalizing, annealing and stress relieving..	2 Marks Any four advantages 1/2M each -2Mark
	b	**Explain with neat sketch BCC and FCC space lattices.** **BODY CENTRED CUBIC UNIT CELL (BCC)** :  EXAMPLES : Iron, Chromium, Molybdenum, Vanadium, Sodium. Effective number of atom in BCC unit cell= 02 One atom on each corner of the cube and one atom in the center. Because the volume of each corner atom is shared 1/8 th part in unit cell and remaining in adjacent cells, each BCC cell contains two atoms. Packing efficiency: 0.68	(sketch 1 mark, description 1 mark)

FACE CENTRED CUBIC UNIT CELL (FCC) (sketch 1 mark, description 1 mark)



EXAMPLES : Iron, Aluminium ,Gold, Silver, Lead, Platinum.

There are 8 corners of the unit cell and each corner has one atom. But each atom is shared by 8 unit cells.
So. total no. of atoms at corners= 1/8 *8=1 atom .
Also, there are 6 faces which have one electron in the centre of it.
Each such electron is shared between 2 unit cells.
This gives the total no. of atoms at the centre of faces of unit cell=1/2 * 6 = 3 atoms.
Adding the two, we get four atoms in a unit cell
1+3=4 atoms.

Packing efficiency: 0.74

c) **Elaborate the purpose of heat treatment.** 4 Marks

There is limitation of the properties of plain carbon steels and alloy steels. Heat Treatment is often associated with increasing the strength of material, but it can also be used to alter certain manufacturability objectives such as improve machining, improve formability, restore ductility after a cold working operation. Thus it is a very enabling manufacturing process that can not only help other manufacturing process, but can also improve product performance by increasing strength or other desirable characteristics.

Steels are suitable for heat treatment. And heat treated for one of the following reasons.

Softening: Softening is done *to reduce strength or hardness, remove residual stresses, improve toughness, restore ductility, refine grain size* or *change the electromagnetic properties of the steel.*

Restoring ductility or removing residual stresses is a necessary operation when a large amount of cold working is to be performed, such as in a cold-rolling operation or wiredrawing.

Hardening: Hardening of steels is done *to increase the strength and wear properties.* One of the pre-requisites for hardening is *sufficient carbon and alloy content*. If there is sufficient Carbon content then the steel can be directly hardened.

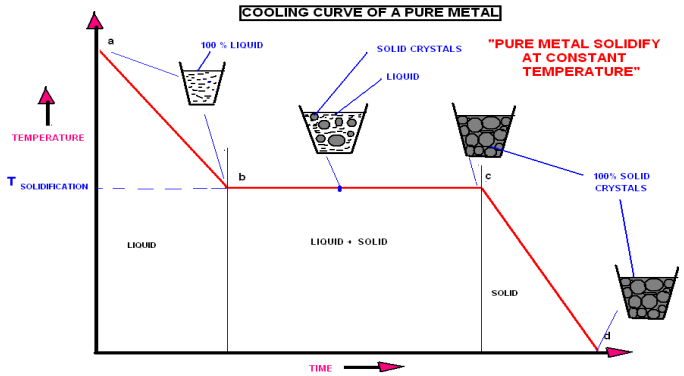
Material Modification: Heat treatment is used to modify properties of materials in addition to hardening and softening. These processes modify the behavior of the steels in a beneficial manner to maximize service life.

d

Metals and their **alloys solidification** defined as a change of state phenomenon (from liquid to solid) associated with emission of a certain amount of heat and the formation of the primary crystalline structure on the way of physical- ly and chemically complicated crystallization process. (2 marks)

pure metal:

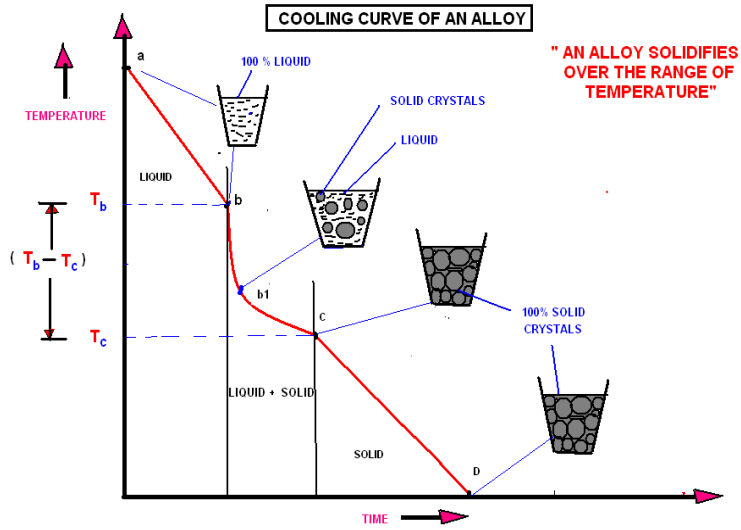
Pure metal solidifies at constant temperature. Cooling curve is as shown below.



(2 marks)

Alloy:

An alloy solidifies over the range of temperature. Cooling curve is as shown below.

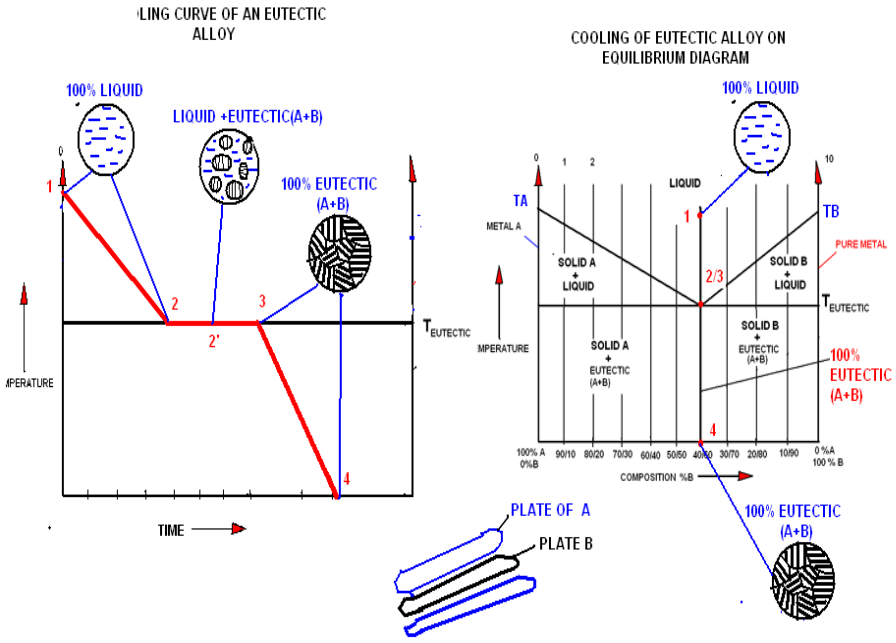


e) **Explain equilibrium diag. for eutectic system.** (sketch 3 marks, description 1 mark)

It is the alloy system between two metals a and b which are completely soluble in liquid stage but completely insoluble in solid stage and showing eutectic reaction.

Examples: Pb-As , Bi-Cd, Th-Ti.

Eutectic alloy forms at a minimum temperature of particular composition of metal B in metal A. and all other composition shows solid A+ eutectic(A+B) or solid B+ eutectic(A+B).



f) **Alloy steels :**

Alloy steels are made by combining carbon *steel* with one or several *alloying* elements, such as manganese, silicon, nickel, titanium, copper, chromium and aluminum.

Purpose: (1 mark)

To Increase hardenability.

- To Increase corrosion resistance. (3 marks)
- To Retain hardness and strength.
- Sulfur, phosphorous, or lead can be added to improve machine ability.
- Again, elements added to steel can dissolve in iron (solid solution strengthening):

  to Increase strength, hardenability, toughness, creep, high temp resistance.

Q4 a) **Differentiate between annealing and normalizing.**

ANNEALING	NORMALIZING
1. heating at A3 + 30 -50 ^{0}c for hypoeutecoid steel A1+ 30 -50 ^{0}c for hypereutecoid steel. 2. Slow cooling in **furnace** itself. Or buried in sand. 3. Less hardness , tensile strength and toughness. 4. Larger grain size**. (coarse pearlite)** 5. Uniform distribution of grains. 6. Internal stress are least.	1. heating at A3 + 30 -50 ^{0}c for hypoeutecoid steel Acm+ 30 -50 ^{0}c for hypereutecoid steel 2. Slightly faster cooling. i.e. Cooling in **air**. 3. Higher hardness , tensile strength and toughness. 4. Fine grain size. **(medium/fine pearlite)** 5. Slightly less distribution of grains. 6. Internal stress are slightly more.

Any four points, 1 mark each -4Mark

b) **State the advantages and limitations of tempering.**

Advantages :

- Reduce internal stresses.
- Improved ductility and toughness.
- Improved machinability.
- Increased impact strength.
- Improve malleability.

(3 Mark)

Limitations:

- Decreased hardness.
- Prolonged heating at high temperature range shows grain growth. Due to which Steel becomes more soft, Chances of temper-imbrittleness

(1 marks)

c) **What is 18:4:1 steel? State its applications.**

18:4:1 steel

It is high speed steel with 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.

2 mark

		applications : • End mills, drills, lathe tools, planar tools. • Punches, reamers, • Routers, taps, saws. • Broaches, chasers, and hobs.	2 Mark
	d	**Define heat treatment. State its objectives.** **Heat Treatment** is the controlled heating and cooling of metals to alter their physical and mechanical properties without changing the product shape. Heat treatment is sometimes done inadvertently due to manufacturing processes that either heat or cool the metal such as welding or forming. **Objectives:** 1. To relieve internal stresses, which are set up in the metal due to cold or hot working 2. To soften the metal. 3. To improve hardness of the metal surface. 4. To improve machinability. 5. To refine grain structure 6. To improve mechanical properties like tensile strength, ductility and shock resistance, etc. 7. To improve electrical and magnetic properties. 8. To increase the resistance to wear, tear, heat and corrosion, etc.	**(definition 1 mark,** **objectives any six -3 marks)**
	e	**State the effect of Mn, S, Ni, W alloy element in steel.** **Mn- manganese :** • Tends to harden steel by encouraging formation of carbide. Like iron carbide fe3c • Kept below 0.75% • It controls harmful effects of Sulpher by forming MnS. **SULPHUR- S :** • Lowers the viscosity of melt(deviates fluidity) • Tends to make it hard and brittle • Kept below 0.1% for most foundry purposes. • Promotes amount of combined carbon, forms FeS. • In wrought iron , it produces red-shortness. It becomes brittle and unworkable. **Ni- nickel :** • Acts as graphatizer but half of silicon • Helps to refine the size if grains and graphite • Addition upto 0.25-2.0%	1Mark for each element- 4Mark

14-30% Ni added in gray irons to resist heat and corrosion and have low expansivity.

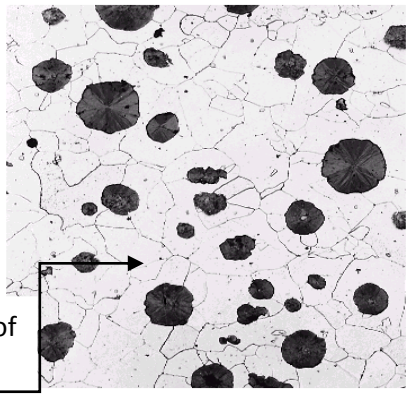
- 8% Ni added in stainless steel.

Tungsten (W) :

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

f **State the types of cast iron with microstructure.** **(1 mark for each type)**

Graphite flakes

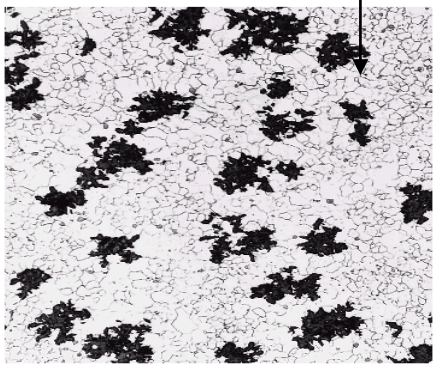


Nodules of carbon

Gray cast iron **nodular/ductile cast**

Cementite/Fe3c

Free carbon accumulated / bull's eye



White cast iron **Malleable cast iron**

Q5 a Describe the composition and applications of Muntz steel — 2Mark

Composition: - 60% copper and 40% Zinc.

Machinability increases by adding 0.4 to 0.8 lead

Application: -- Ship sheathing, condenser tube; pump parts, marine fitting — 2Mark

b **Differentiate between white C.I. and grey C.I.**

White cast iron	**Grey cast iron**	
It is alloy of carbon with iron. Carbon is present in combined form (Carbide -Fe_3C)	It is alloy of carbon and silicon with iron. Carbon is present in free form(Graphite)	Any four points 1Mark each -4 Mark
White in colour(fractured appearance)	Grey colour (fractured appearance)	
It is hard, brittle and not machinable	Better machinability	
Used for machine tool structure	Used for extrusion dies	
Produced by chilling method	Produced by refining pig iron	

c **State the composition and application of naval brass and gun metal**

Naval Brass :--

Composition: -- 60% Copper, 0.8 % tin, and 39.2 % Zinc. — 1Mark

Application: - condenser plates, heat exchanger tube, Marine Construction, propeller shaft, marine hardware. — 1Mark

Gun metal: - — 1Mark

composition: - 2—11 % tin 1—10 % zinc and remaining copper — 1Mark

Application:- valves, pipe fitting, pumps, and bearing , gun barrels

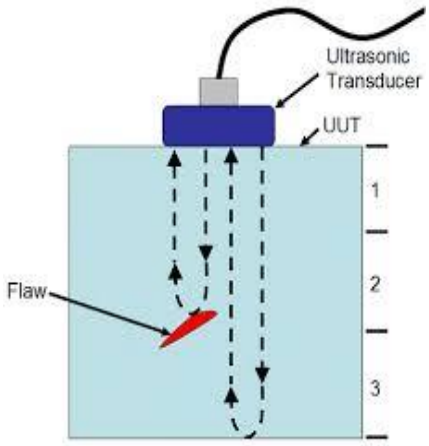
d **Explain porous self lubricated bearing** — 4Mark

These bearings are produced by the process of power metallurgy. These are made from copper or iron base power. Bearing made by this process is having 40—50% porosity.

These pores are impregnated with oil under pressure. The oil from the pores slowly comes out and serves the purpose of lubrication .they does not require external lubrication so it is called as self lubricating bearing.

Used for textile mill, paper mill, and food industry.

	e	**List the applications of high carbon steel** Die block, wheel tires, mandrels, hammers, razors, ball mill parts, Drill, and tap Wire dies and cutting tools,	Any four applications -4 Mark
	f	**Explain the following bearing metals with their properties and uses** i)White metal ii) Leaded bronzes **White metal:-** Properties : it is Ductile, hard and low friction uses: - used where withstand only limited pressure **Leaded bronzes: -** Properties: - Very high wear resistance, good thermal conductivity Uses: - used in bearing when heavy load are to be carried.	1Mark 1Mark 1Mark 1Mark
Q6	a	**Describe NDT. Give applications of NDT** **NDT: -** Non destructive testing as the name implies does not damage Or reduce the service life of the component, usually these tests do not directly measure the mechanical properties but they are used to locate the defect or flaws in the component. **Applications:**-Inspection of large casting and forging, inspection of rail, Cracks in fabrication, cracks in steam & gas turbine balding, inspection of plastics, Ceramics and glass. e.g. dye penetrant test, magna flux, radiography test	2Mark 2Mark
	b	**State the applications of glass wool** Ceiling of residential building, thermal and sound insulation for furnaces, ovens, Water heaters, refrigerators, A.C. system insulations, electrical insulations	Any four 1Mark each -4Mark
	c	**Define stainless steel. State its properties**. Stainless steel contains iron, chromium, manganese, silicon, carbon and, in many cases, significant amounts of nickel and molybdenum. These elements react with oxygen from water and air to form a very thin, stable film that consists of such corrosion products as metal oxides and hydroxides. Stainless steel has high corrosion resistance and hence they do not corrode in most of the usual environmental condition. **Properties: -** high ductility and formability, good weldability and machinability. High resistance to scaling & oxidation, Excellent surface finish.	2Mark 2Mark

	d	**Describe two characteristics and uses of epoxies** **Characteristics:-** Outstanding adhesion properties, good electrical properties, They are expensive, they have strength and toughness. **Uses:-** For manufacturing laminates and casting. , protective coating, Insulating material in electrical application	2Mark 2Mark
	e	**Explain the procedure of ultrasonic crack detection with neat sketch** Ultrasonic (high frequency) waves are emitted from a transducer in to an object and returning waves are analyzed. If the crack is present the sound will bounce off and seen in returned signal .when mechanical sound energy comes back to the transducer, it is converted in to electrical energy.  	Explanation-2Mark Sketch-2Mark
	f	**Define composite materials. How they are classified?** **Composite material :-** Composite material is composed of at least two element working together to produce material properties that are different to the properties of that element on their Own and to increase the strength and stiffness **Classification:-** Fiber composite, particulate composite, laminar composite, Flake composite, and filled composite	2Mark 2Mark