WINTER– 16 EXAMINATION

Model Answer

Subject Code: 17303

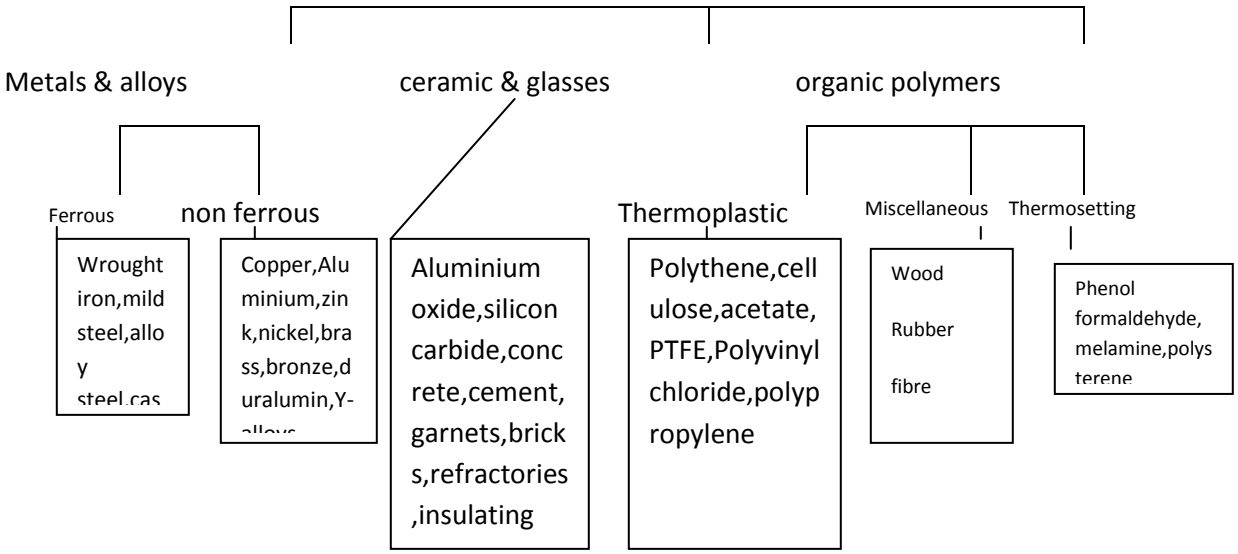
Important Instructions to examiners:

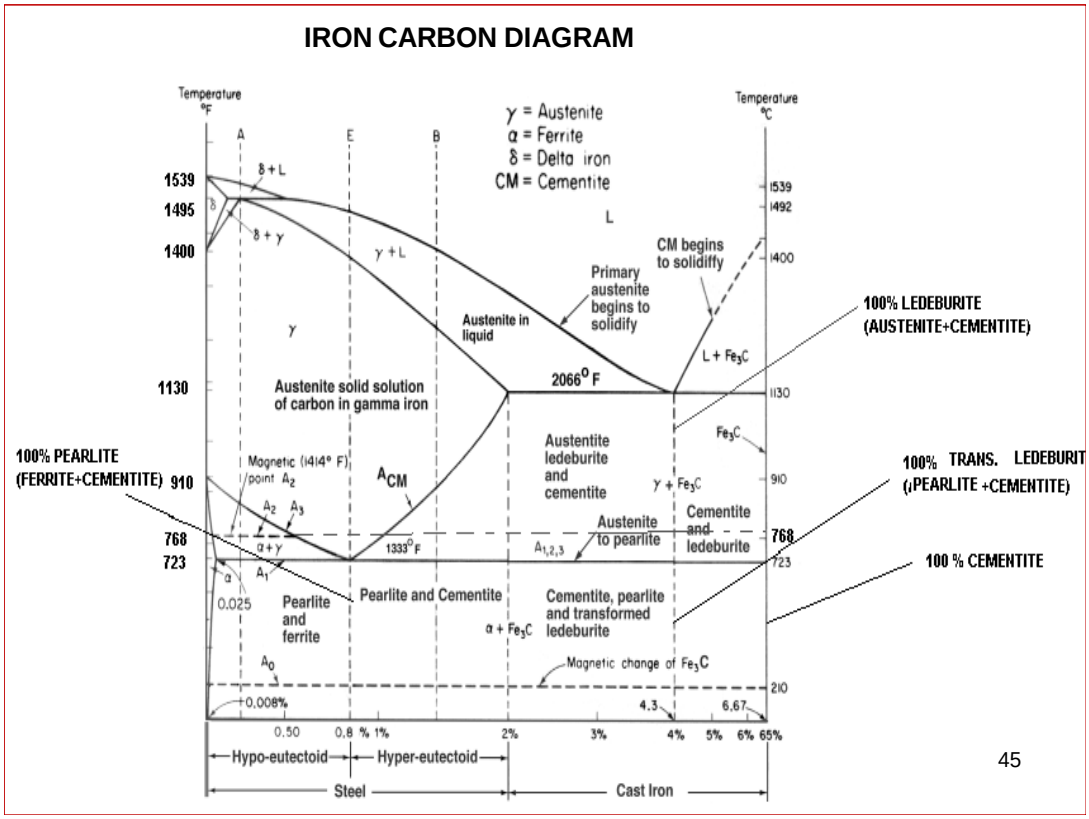
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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. No.	Sub Q. N.	Answer	Marking Scheme
1	a	**Hardness:**-The ability of a material to withstand scratching, wear and abrasion or penetration by harder bodies is known as hardness.	**01**
		Toughness:-Toughness is the amount of energy that a material can absorb before it fractures	**01**
	b	**Fatigue strength:**-Fatigue strength is the property of a material to withstand continuously varying and alternating loads	01
		Malleability:-Malleability is the ability of a material to exhibit deformation when compressive force is applied	01
		OR	
		A property by which a material can be drawn into thin sheets is known as malleability.	
	c	**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.	01
		Alloy:-It is a mixture of two or more elements of which at least one element is a metal and mixture shows metallic properties.	01
	d	It is mixing of two solids into a single phase. It occurs when the components have similarities in crystal structure and atomic diameter.	02

	e	**a) List four objectives of heat treatment** 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	½ marks each
	f	TTT is Time-Temperature-Transformation diagram. It shows the microstructures resulting from non equilibrium cooling which is not possible on Fe-c diagram. It shows various microstructures of steels depending upon cooling rate & also the temperature and time taken for each transformation.	02
	g	**types of cast iron** i)White cast iron ii) Gray cast iron iii) Malleable cast iron iv)Nodular cast iron	½ marks each
	h	**The properties of stainless steel** i)High corrosion resistance ii) High ductility & formability iii)Excellent surface finish iv)Good creep resistance v) Good thermal resistance vi)Easy weldability vii) Good machinability viii) High resistance to oxidation	½ marks each
	i	**composition of Y alloy and Muntz metal** **Y alloy:-**composition is 3.5 to 4.5% copper,1.8 to 2.3% nickel,1.2 to 1.7% manganese and remaining aluminium **Muntz metal:-**Its composition is 60% copper & 40% zinc	

		applications of bronzes	
	j	i) It is used for casting ii) It is used for making coins and metals iii) It is used for springs, taps, marine pumps etc iv) It is used for heavy duty electrical switches, cams and bushings v) Used for manufacture of corrosion resistant mine cables, ship sheathing, valve parts vi) It is used for making bushes, cotter pins, clutch disks etc	½ marks each
	K	**uses of Acrylics** i) It can be used in the form of corrugated sheets for use in industrial building ii)Sanitary ware iii)Fibre optics iv)contact lenses v)sinks,baths vi)Display signs vii)Hospital equipments viii)Aircraft light fixtures	½ marks each
	l	**i)Austenite ii)Pearlite** **Austenite:**-It is a solid solution of carbon in gamma-iron (ϒ-iron).It can dissolve up to 2% of carbon at 1148^0C.Austenite is also a soft and ductile phase.It is a non magnetic phase. **Pearlite:**-It is an intimate mixture of ferrite and cementite.It has distinct lamellar structure and consist of alternate layers of ferrite and cementite	01
	m	**powder metallurgy** It is a branch of engineering materials that deals with the production of metal and non metal powders and subsequently manufacture of components by using these powders. Powder metallurgy components are manufactured by mixing of metal and non metal powders, compacting with simultaneous or subsequent heating at elevated temperatures using a controlled atmosphere to develop metal or metal like component with satisfactory strength and density **different powder making processes**	01 02

	n	i)Machining ii) Crushing iii) Milling IV) Graining V) Atomization	½ marks each
2	a	**a) classification of engineering materials mentioning one example . Any one example for each type of material** **ENGINEERING MATERIALS**  	04
	b	**Packing efficiency:** **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 **Importance:**-The manner in which atoms are arranged in the solid state in a unit cell controls the properties of materials. The packing of atoms in a unit cell of the crystal structure of a material is known as atomic packing. Knowing the type of unit cell for a particular crystalline solid and the corresponding atomic radii, it is possible to calculate the true density of the crystalline solid. It gives the idea about how closely packed a particular unit cell is i.e. it gives an idea about the relative amount of free space available in the unit cell.	02 02

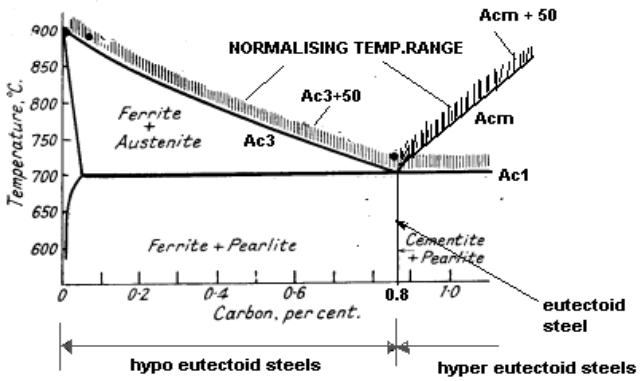
	c	**iron carbide phase diagram**  	04
	d	Normalizing is the heat treatment which involves heating of the given steel to " austenite temp.range" holding it & there after cooling to room temperature at slow rate of cooling, generally "air cooling". A typical normalizing process involves following steps, 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"	01 for figure and 03 for explanation

The air cooling used may be,

- Still air cooling

Forced air cooling

NORMALISING TEMPERATURE RANGE



10

e effect of following alloying elements on properties of steel — 01 for each

i) 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

ii) Chromium:-increases hardness, hardenability and wear resistance of steel. It increases red hardness of steel. Increases corrosion & oxidation resistance of the steel.

iii) Molybdenum: - It increases red hardness of steel. Increases hardness, hardenability & wear resistance, reduces temper brittleness,

iv) Tungsten:-increases creep resistance and hardenability of steel, imparts secondary hardness to the steel, improves heat resistance

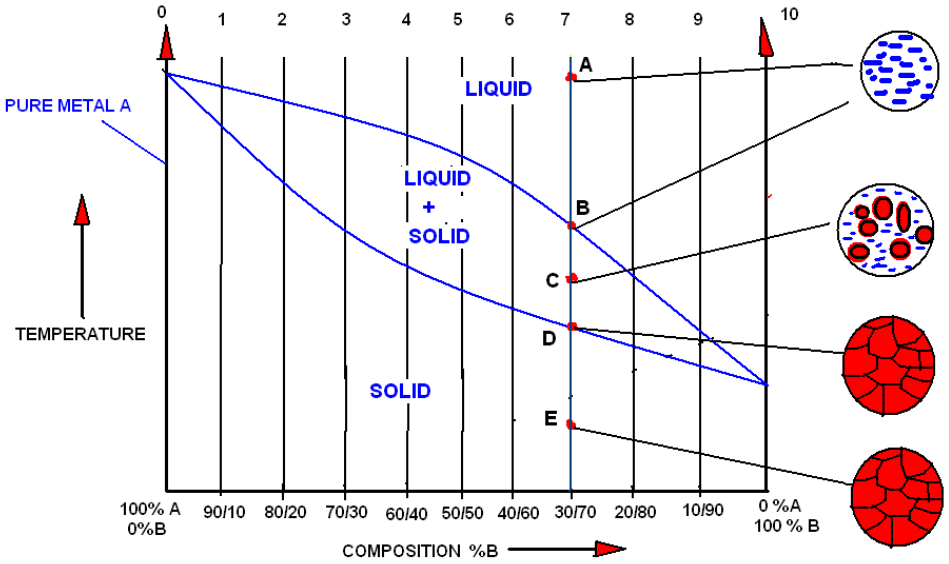
f advantages and four limitations of powder metallurgy Any four — ½ marks each

Advantages of powder metallurgy:-

i) A combination of metals and non-metals powdered parts can be possible
ii) High dimensional accuracy is possible.
iii) Fine surface finish can be achieved.
iv) No wastage of material as scrap
v) Porous parts such as porous self lubricating bearings manufacturing is Possible by this method only.
vi) Production of cemented carbide tools is possible only by this method.
vii) Large scale production of small and simple parts gives best result.
viii) Highly skilled and qualified person not required.
ix) p/m parts can be welded, soldered and brazed

		x) Articles of any desired porosity can be manufactured **Limitations of powder metallurgy:-** i) P/m parts do not give good physical properties as wrought or cast parts ii) Cost of powder production is high. iii) Relatively high tool and die cost. iv) Complicated shaped parts can not manufactured by this method. v) Process is not economical for small scale production vi) Many metal powders are explosive at room temperature. Vii) Some metals are difficult to compress, since they tend to cold- weld to the walls of the die, thus causes excessive wear on the die. viii) Parts pressed from the top tend to be less dense at the bottom, thus density variation Occurs. ix) There are design limitations on the die as regards of p/m process.	
3	a	Attempt the following (any four) **Describe subcritical annealing.** Annealing process conducted at a temperature below the lower critical for ferrous material and below the full anneal temperature for nonferrous materials. Also referred to as "process annealing". This anneal is used to restore ductility to the material for subsequent cold-working/forming operations. Carried in between two stages of cold working processes like wire rolling ,wire drawing tube drawing etc. After one stage of cold rolling the steel gets "work hardened" i.e. Its hardness gets increased and further cold rolling becomes impossible as steel may get cracked during next stge due to high hardness. The steel after first stage of rolling is subjected to process annealing where it gets heated to "recrystallizing temp". (recrystallizing temp = 0.5 to 0.6 times melting temperature) in the furnace. In this process following three changes occur in grains/crystals as under Recovery, recrystalization and grain growth.	Correct description 04 m

3	b	**Compare flame hardening with induction hardening.** **FLAME HARDENING** • surface of steel is heated rapidly by oxyacetylene flame , then quenching. • success depends on skill of operator. • Suitable for large shaped components • Internal surfaces may be heated and hardened **OPERATING VARIABLES ARE** • distance between flame & work piece. • gas pressure, • flame or work travel rate, • type, volume and application of quench. • any shaped parts are suitable for **INDUCTION HARDENING** • steel is heated by high freq. electric induction current and cooled rapidly. • success is related to selection and design of proper work coil. • Suitable for round shaped components • Internal surfaces are difficult to heat. **OPERATING VARIABLES ARE** • induced voltage • flow of current • resistance offered by work • shape and design of coil & • rate of heating.	Any four pts 01 m each
3	C	**Explain isomorphous system with neat sketch.** **ISOMORPHOUS SYSTEM** • alloy system of two metals a and b which are completely soluble in the liquid stage as well as in solid stage. • both the type of metals have same unit cells and space lattice EXAMPLES; Cu-Ni, Au-Ag, Mo-W. Isomorphous binary phase diagrams are found in a number of metallic and ceramic systems. In the isomorphous systems, only one solid phase forms; the two components in the system display complete solid solubility. Typically, the isomorphous system has a liquid area, a solid area, and an area that is a mixture of both liquid and solid. Typically, a binary isomorphous phase diagram consists of two phase boundaries: the liquidus and the solidus.	Explanation 2m, sketch 2m .



ISOMORPHOUS SYSTEM

3 d

List different steps used to produce the component by P/M tech. State the importance of sintering.

Steps 2m, importance 2m

Steps In Powder Metallurgy.

- Powder Production
- Blending or Mixing
- Compaction
- Sintering
- Impregnation with oil
- Finishing

Importance of sintering.

Sintering is effective when the process reduces the porosity and enhances properties such as strength, electrical conductivity, translucency and thermal conductivity;

yet, in other cases, it may be useful to increase its strength but keep its gas absorbency constant as in filters or catalysts. During the firing process, atomic diffusion drives powder surface elimination in different stages, starting from the formation of necks between powders to final elimination of small pores at the end of the process.

3 e

What are desirable properties of bearing materials? Also mention any two materials used for bearing materials.

Properties 2 m, any two materials ½ each.

properties of bearing metals:

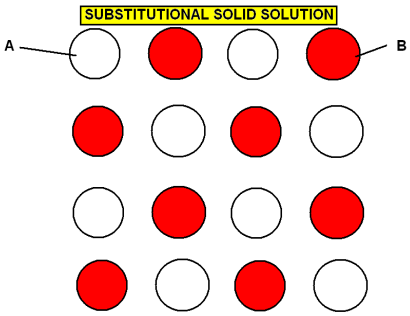
1. have good corrosion resistance.
2. high fatigue strength.
3. high compressive strength.
4. should be hard and wear resistance for longer life.
5. the affinity between the shaft and bearing material should be minimum.
6. antifriction and good lubricating properties.

		7. high thermal conductivity. 8. should have antiseizing properties. **bearing materials are.** babbits (snsb) tin antimony,plain tin bronzes (10-15% tin), phosphur bronzes (10-13% tin, 0.3-10% phosphur rest cu), chrome steel – sae 52100, martensitic stainless steel – aisi 440c,Aluminum Bronze, Gun Metal etc.	
3	f	**State the properties and applications of polysters.** Properties of Polyesters 1. Resistant to stretching and shrinking 2. Resistant to most chemicals 3. Quick drying 4. Crisp and resilient when wet or dry 5. Wrinkle resistant 6. Mildew resistant 7. Abrasion resistant 8. Retains heat-set pleats and crease 9. Easily washed 10. Strong. **Applications of Polyesters** 1. Apparel**:** Every form of clothing 2. Home Furnishings**:** Carpets, curtains, draperies, sheets and pillow cases, wall coverings, and upholstery 3. Other Uses**:** Hoses, power belting, ropes and nets, thread, tire cord, auto upholstery, sails, floppy disk liners, and fiberfill for various products including pillows and furniture	Properties 2m, applications 2m.
4		**Attempt the following (any four)**	
	a	What is nitriding? State its advantages and limitations. **NITRIDING** • process of heating of alloy steels in contact with nitrogen bearing gas environment to a temperature of 500 to 550 degree centigrades and held for a long period of time (25 to 100 hours) in the furnace. • during holding period ,there is a chemical reaction in the gas and the free nitrogen atoms are liberated. • these atoms penetrate into outer surface of the steel component and combine with alloying elements to form “hard alloy nitride particles” in the outer surface of the steel.due to which outer surface becomes extremely hard and wear resistant. • hard outer surface is formed without quenching. • maximum case depth achieved is around 0.03 mm to 0.6 mm.	Description 1m, Any three advantages ½ m each, any three disadvantage ½ m each.

		advantages of nitriding • high corrosion resistance • increased fatigue resistance. • very hard outer layer • wear resistance. **disadvantages of nitriding** • long cycle times (25 to 100 hrs) • brittle case • only special alloy steels containing al,mo,v.cr as alloying elements can only be nitrided. • plain carbon steels cannot be effectively nitrided. • high cost. • technical control required. • if nitrided part gets accidently overheated.(above 500 ^{0}c) then the hardness will be lost completely.	
4	B	**Give the classification of tool steel.** SHOCK-RESISTING TOOL STEELS COLD-WORKED TOOL STEELS Oil-hardened Air-hardened High Carbon, High Chromium HOT-WORKED TOOL STEELS Chromium-based Tungsten-based Molybdenum-based HIGH-SPEED TOOL STEELS Tungsten-based Molybdenum-based WATER-HARDENED TOOL STEELS	Any four 1m each
4	C	**Define i) cementite ii) ferrite** i) **Cementite :**It is a intermetallic stable carbide compound. Called as iron carbide, CM, fe_3c. Cementite contains 6.67 % C by wt. Very very hard and brittle interstitial compound. Associated Crystal structure is orthorhombic ii) **Ferrite:** It is an interstitial solid solution of carbon dissolved in α-iron. Maximum solubility of carbon is 0.008 % at room temp. and this solubility limit increases up to 0.025 % at 723 ^{0}c. Associated Crystal structure is BCC (body centered cubic) – structure.	02 m each definition.
4	D	**What is carburizing? List its advantages and limitations.** **CARBURIZING** • 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 centigrades in contact with carbon –rich material for several hours.	Description 1m, any three adv, ½ m each, any three limitations ½

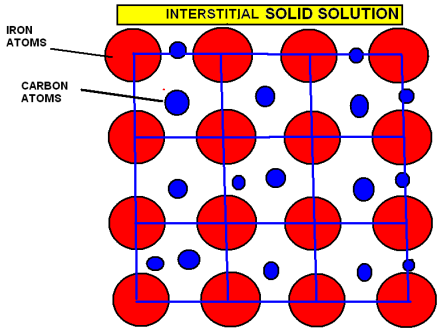
		• highly enriched outer carbon rich surface is hardened by quenching . advantges: • it produces hard workpiece surface. • cores largely retains their toughness and ductility. • case depth is around 1.27 mm. • hardness about 65 rc. disadvantages: • dimensional deviations by the high temperature process and hardening treatment. • selective increase of angle points. • expensive machining. • different furnaces required as per the component sizes. • carburising time is long. • no control on case of carburising. • not suited for direct quenching. • process is dirty and dusty. • loading and unloding operation requires considerable floor space and time	m each.
4	E	**What are the properties and applications of Naval brass?** properties: • it has increased resistance to salt water corrosion. • high tensile strength (300-400 mpa) • higher hardness (brinell hardness 80-135 hb) • suited to fabrication by hot forging. applications : condenser plates, welding rods, propeller shafts, piston rods, valve stems. leaded naval brass with 1.75% lead (pb) used for marine hardware.	Properties 2m, applications 2m.
4	F	**State the characteristics and applications of ABS** characteristics: • these are tough, hard and rigid. • light weight and impacr resistant. • 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 : car interior and exterior parts, mobile phone bodies. tv and computer cabinets. toy manufacturing. luggage, laptop cases, protective helmets and canoes.	Characteris tics 2m, applications 2m.

5	A	**Attempt the following (any four)** Differentiate between austempering and martempering. AUSTEMPERING 1. cooled in isothermal bath maintained in between nose of ttt diag and ms temp. i.e. 510 to 220 ^{0}c. 2. austenite transforms to bainite . 3. hardness of bainite is rc 60. 4 no need of further tempering as internal stresses are not developed MARTEMPERING 1. cooled in isothermal bath maintained just above ms temp. i.e. above 220 ^{0}c. then cooled in air. 2 austenite transforms to martensite. 3 hardness of martensite is rc 64. 4 tempering is essential to relieve internal stresses.	1m each point.
5	B	**What are the properties and applications of high carbon steels?** Properties • hard, wear resistant, brittle and difficult to machine and weld. • can be hardened by heat treatment. • can not cold work and hot worked. • have high strength, lower elongation • can be quench hardened applications • used in applications where surface subject to abrasion tools, knives,files, chisels, agri implements. 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.	Properties 2m, applications 2m
5	C	**Define i) substitutional solid solution ii) interstitial solid solution** 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.	2m each, sketch preferred.



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.



5 D

what is the properties and applications of copper?

properties

- highly ductile and posses fcc cristal structure.
- density is 8920 kg/cu.m
- melting point 1083 0c
- higher thermal & electrical properties.
- corrosion resistance.
- non magnetic and pleasing color.
- it cab ne welded, brazed and soldered. i.e. ease of fabrication.
- good machinability.
- easily finished by plating.
- antibacterial

applications

roofing, gutters radiators, gaskets, kettles, pressure vessels, distallry condenser and heat exchanger applications
bolts, studs, welding tips, contact pins, switch gears, relays and precision electrical equipments.

Four properties ½ m each, four applications ½ m each

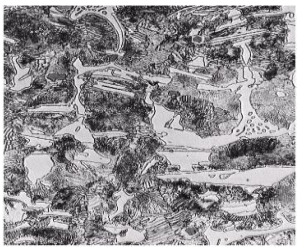
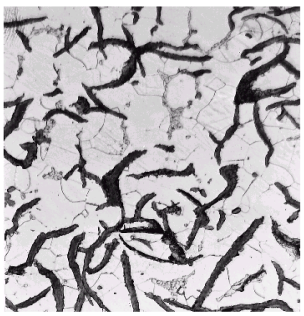
5 E

What is composite material? State its properties and applications.

- definition: any combination of two or more different materials at the macroscopic level.

or

Description 1m, prop. and

		◆ two inherently different materials that when combined together produce a material with properties that exceed the constituent materials. ■ reinforcement phase (e.g., fibers) ■ binder phase (e.g., compliant matrix) properties ◆ uniform mechanical properties in the plane of the flakes ◆ higher strength ◆ higher flexural modulus ◆ higher dielectric strength and heat resistance ◆ better resistance to penetration by liquids and vapor lower cost applications ■ aerospace industry ■ sporting goods ■ automotive ■ construction	applications 3m.
5	f	**Draw microstructure of white CI and gray CI Giving two applications of each.** microstructure of white CI  applications: ❑ wear resisting components as ❑ extrusion dies ❑ cement mixer liners ❑ jcb bucket teeths ❑ plough tooth ❑ ball mills ❑ foundary ❑ drawing dies etc. microstructure of gray CI  Applications:	Microstr ucture 1m each, any two applications of each type ½ m each.

Engines-

Cylinder blocks, liners,
Brake drums, clutch plates
Pressure pipe fittings
Machinery beds
Furnace parts, ingot and glass moulds.

attempt the following (any four)

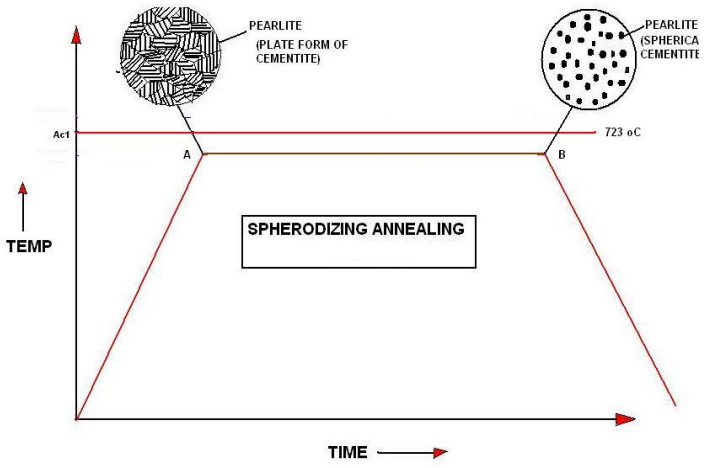
6

Explain spherodise annealing with its applications.

A

Explanation 3m, applications 1m. sketch preferred.

spherodizing annealing :
-spherodizing annealing is done to improve the “machinability” of the steel.
-here plate form of cementite is converted into globular or spherical form of cementite.
-effective for high carbon steels,high carbon tool steels,all alloy steels,ball bearing steels.
following two methods are used.
prolonged holding below ac1 temp:here the steel is heated below ac1 temp.& held at this temperature for prolonged period of time(6 to7 hrs) to convert plate form of cementite into globular or spherical form of cementite.



SPHERODIZING ANNEALING

applications:
this process applied for the following.
high carbon steels,high carbon tool steels,all alloy steels,ball bearing steels.

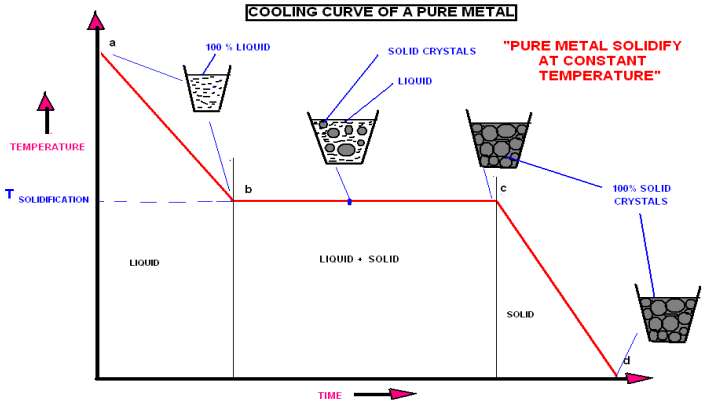
Explain solidification of pure metal with neat sketch.

6

B

Sketch 2m, explanation 2m.

Pure metal solidify at a constant temperature. Liquid changes into solid. Thermodynamically both solid and liquid have same energy at melting point. And therefore both are stable at melting point. Below melting point solid becomes more stable than liquid.



6 C **What are the properties and applications of nano materials?** Prop. 2m, applications 2m.

Properties:

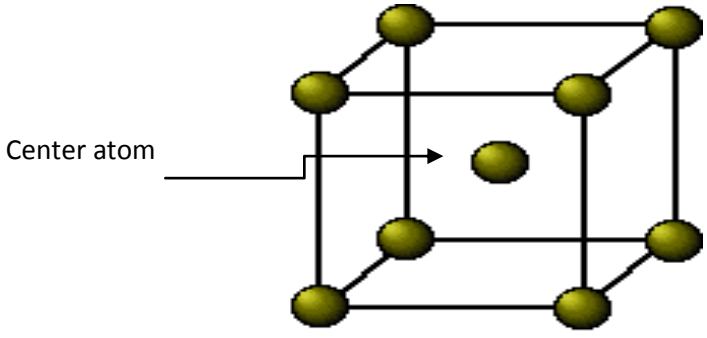
"Mechanical Properties of Nanoparticles" deals with bulk metallic and ceramic materials, influence of porosity, influence of grain size, superplasticity, filled polymer composites, particle-filled polymers, polymer-based nanocomposites filled with platelets, carbon nanotube-based composites.

Applications :

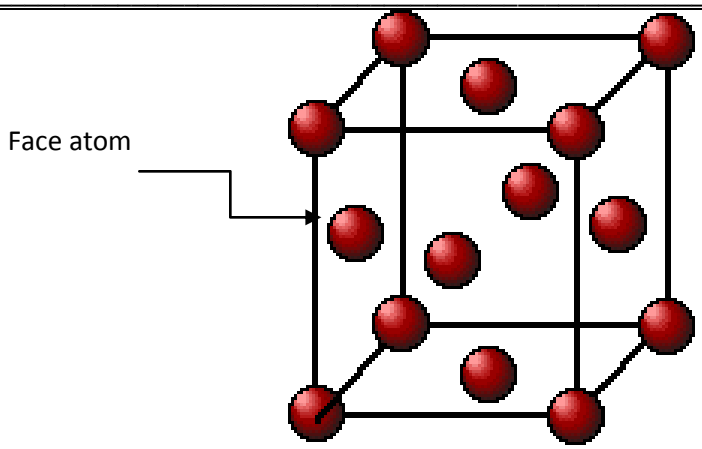
Nanomaterials having wide range of applications in the field of electronics, fuel cells, batteries, agriculture, food industry, and medicines, etc... It is evident that nanomaterials split their conventional counterparts because of their superior chemical, physical, and mechanical properties and of their exceptional formability.

6 D **Draw the following crystal structures. i)BCC ii) FCC**

body centred cubic unit cell (bcc) 2m each sketch.



face centred cubic unit cell (fcc)



6 E **Explain properties of gray cast iron and white cast iron.** 2m for each.

Properties of gray cast iron :
Dull gray crystalline or granular structure , it gives glistering effect due to reflection of lightby graphite flakes. Fracture shows black spots.

- Contains carbon in the form of graphite flakes.
- Silicoin encourges formation of graphite.
- It is btittle may broken by hammer blow. 150-200 bhn
- It is cheap, having low melting point -1150 to 1200 oc
- Easily machined.

Properties of white cast iron :

Carbon exclusively present in the form of cementite and martensite.
Mn encourages formation of carbides.
Very hard and brittle 400-600 bhn
It has limited applications.
High wear resistant
Can not machined.
Widely used to produce wrought iron and malleable ci.

6 f **Explain properties of high speed steel and spring steel.** 2m each

properties of high speed steel
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.
They contain 0.6 % carbon, 4% Chromium, 5-12% Cobalt.
Carbon imparts hardness of at-least 60 HRC of martensite formed. Chromium increase hardenability & corrosion resistance. Cobalt increases the thermal conductivity, melting point, red hardness & wear resistance of high speed steels.
properties of spring steel:

- should have high yield strength
- high hardness and toughness
- higher fatigue and creep strength

		• high impact strength • higher resilience i.e. load per unit deflection should be high. • high tensile strength and high modulus of elasticity.	