Engineering Materials and Metallurgy

2 Marks Question & Answers

Unit – I
CONSTITUTION OF ALLOYS AND PHASE DIAGRAMS
PART – A

1. What is a n alloy?
A metal alloy, or simple an alloy, is a mixture of two or more metals or a metal (metals) and a non-metal (non-metals).

2. How many components are found in an alloy?
Two or more components are found in an alloy.

3. What is meant by base metal?
In an alloy, the element which is present in the largest proportion is called the base metal.

4. What are alloying elements?
In an alloy, all elements other than the base metal are called the alloying elements.

5. Differentiate between substitutional and interstitial solid solution.
In a **substitutional solid solution**, the solute atoms (impurities) substitute for parent solve nt atoms in a crystal lattice.
In **interstitial solid solution**, the solute atoms fit in to the space between the solvent or parent atoms.

6. State Hume Rother y's rules for formation of substitutional solid solutions.
1. Size factor: The atoms must be of similar size, with less than a 15% difference in atomic radius (in order to minimize the lattice strain).
2. Crystal structure: The materials must have the same crystal structure.
3. Valence: The atoms must have the same valence.
4. Electro negativity: The atoms must have approximately the same electro negativity.

7. What are intermediate phase s?
If an alloying element is added in excess of the limit of solid solubility, a second phase appears along with the primary solution. If the se cond phase differs in both crystal structure and properties from primary solid solution, then it is known as an 'intermediate' phase.

8. What are intermetallic compounds?

The compound formed by two or more metals in apparently stoichiometric proportion is called intermetallic compounds.

9. What are electron compounds?
If two metals consist of atoms more or less similar size but different valency, then the compounds formed are called electron compounds.

10. Define ‘phase’. What different kinds of phases are possible?
A phase is defined as any physically distinct, homogeneous and mechanically separable portion of a substance. Three different kinds of phases are solid, liquid and vapour.

11. What is an equilibrium phase diagram?
A phase diagram can be defined as a plot of the composition of phases as a function of temperature in any alloy system under equilibrium condition.

12. What are the advantages of the equilibrium diagrams?

1. To show what phases are present at different compositions and temperature under equilibrium conditions.
2. To indicate the equilibrium solid solubility of one element in other element.
3. To indicate the temperature range over which solidification of a material occurs.
4. To indicate the temperature at which different phases start to melt.

13. State Gibb’s phase rule?
Gibb’s phase rule is given by

$$F=C-P+2$$

Where,
F=degrees of freedom of system or number of variables (such as temperature, pressure or composition) that may be changed independently without altering the equilibrium;
C=number of components (usually elements or compounds) forming the system; and
P=no of phases present in the system.

14. What are cooling curves?
Cooling curves are obtained by plotting the measured temperatures at equal intervals during the cooling period of a melt to a solid.

15. What is liquidus line? A Solidus line? A solvus line?
In a phase diagram, liquidus line is the line or boundary that separates liquid and liquid+solid phase regions.
Solidus line is a line or boundary that separate solid and solid+liquid phase region.
Solvus line separate single-phase solid regions from two-phase solid regions.

16. What pieces of information can be obtained for each point in a phase diagram?
Using a phase diagram, one can obtain at least the following three information.
1. The phases that are present, 2. The composition of each phase, and
3. The amount of each phase present.

17. What is tie-line?
A tie line is simply an isothermal line drawn through point of consideration, extending across the two-phase region and terminating at the phase boundary lines on either side.

18. What is the lever-law calculation and what information can it provide?

Opposite arm of lever
Phase fraction= ----------------------------
Total length of tie line

Opposite arm of lever
and phase percentage = --------------------------- × 100
Total length of tie line

Using the lever law calculations, one can compute the phase fraction and the phase percentage.

19. What is mean by invariant reaction?
The eutectic reaction is also called an invariant reaction since it occurs under equilibrium conditions at a specific temperature and alloy composition that cannot be varied.

20. Differentiate between eutectic and eutectoid reactions.

Eutectic reaction is give n by

Cooling
Liquid Solid 1 + Solid 2
Heating

Eutectoid reaction can be written as

Cooling
Liquid iron (Austenite) + Fe_3C (Cementite)
Heating

21. Distinguish between peritectic and peritectoid reactions.

The **peritectic reaction** can be written as

Cooling
Liquid + Solid 1 Solid 2
Heating

The **peritectoid reaction** can be written as

Cooling
Solid 1 + Solid 2 Solid 3
Heating

22. What do you understand by 'allotropy of iron'?
Allotropy refers to the possibility of existence of two or more different crystal structures for a substance depending upon temperature.

23. Define: ferrite and austenite.

Ferrite is a primary solid solution based on iron having BCC structure. Maximum solubility of carbon in iron is 0.025% carbon at 723°C, while its solubility at room temperature is only about 0.008%.

Austenite is a primary solid solution based on iron having FCC structure. The maximum solubility of carbon in FCC iron is about 2% at 1140°C.

24. Define: Ceme ntite and Pearlite?

Cementite is the name given to the carbide of iron (Fe_3C). It is the hard, brittle, intermetallic compound of iron with 6.69% of carbon.

Pearlite is the eutectoid mixture of ferrite (87.5%) and cementite (12.5%). It is formed when austenite decomposes during cooling. It contains 0.8% of carbon.

25. Define: martensite, and bainite ?

Martensite is the super saturated solid solution of carbon in iron. It is formed when a steel is very rapidly cooled from the austenitic state.

Bainite is a decomposition product of austenite , consisting of an aggregate of ferrite and carbide. Bainite has hardness in between the hardness of pearlite and martensite.

26. Why is the iron-carbon equilibrium diagram usually not shown beyond 6.67% carbon?
This is because in practice, all steels and cast irons have carbon contents less than 6.67 wt% C.

27. What is steel?
The ferrous alloy having the carbon composition ranging from 0.008 to 2% is known as steel.

28. What is meant b y eutectoid, hypoeutectoid, hypereutectoid steels?
Steels that contain 0.8% C (the eutectoid amount of carbon) are called **eutectoid steels.**
Steels having less than 0.8% C are known as **hypoeutectoid steels.**
Steels having more than 0.8% C are known as **hypereutectoid steels.**

29. How do cast irons differ from steels in terms of carbon content?
Composition from 0.008% to 2% carbon represent **steel** and those above 2% carbon represent **cast iron** .

30. Distinguish between hypoeutectic and hypereutectic cast irons.
Cast irons that contain less than 4.3% C are termed as hypoeutectic whereas cast irons that contains more than 4.3% C termed as hypereutectic.

Unit – II
HEAT TREATMENT
PART – A

1. Define the term ‘heat treatment’.
Heat treatme nt may be defined as an operation or combination of operations involving heating a nd cooling of a metal/alloy in solid state to obtain desirable properties.

2. What are the purposes of the processing heat treatments?
1. To relieve internal stresses. 2. To improve machinability. 3. To refine grain size.
4. To soften the metal. 5. To improve hardness of the metal surface.
6. To improve mechanical properties (like tensile strength, hardness, ductility, etc.)

3. List the various stages of a heat treatment process.

Stage 1: Heating a metal/allo y beyond the critical temperature.

Stage 2: Holding at that temperature for a sufficient period of time to allow necessary changes to occur.

Stage 3 : Cooling the meta l/alloy (i.e., quenching) at a rate necessary to obtain the desired properties. That is, cooling at a rate necessary to obtain the desired changes in the nature form, size and distribution of micro-constituents.

4. List some of the important heat treatment operations widely used.

1. Annealing, 2. Normalizing. 3. Hardening. 4. Tempering. 5. Austempering. 6. Mar tempering and 7. Case hardening.

5. What is meant by annealing?

Annealing is defined as a softening process consisting of heating the steal to a temperature at or near the critical point, holding there for a proper time and then allowing it to cool slowly in the furnace itself.

6. What are the purposes of annealing?

1. To relieve or remove stresses. 2. To induce softness. 3. To refine grain structure,
4. To alter ductility, toughness, electrical, magnetic or other properties.
5. To remove gase s. 6. To produce a definite microstructure.

7. List the different type s of annealing.

a) Full annealing. b) Process annealing. c) Stress relie f annea ling.
d) Recrystallisation annealing, and e) Spheroidise annealing.

8. What is meant by normalizing?

Normalizing is similar to full annealing, but cooling is established in still air rather than in the furnace.

9. Differentiate between normalizing and full annealing.

S. No.	Normalising	Full Annealing
1.	Normalising is more economical tha n full annealing (since no furnace is required to control the cooling rate).	Full annealing is costly
2.	Normalising is less time consuming.	Full annealing is more time consuming.
3.	Normalising temperature is higher than full annealing.	Annealing temperature is lower than normalising.
4.	It provides a fine grain structure.	It provides coarse grain structure.

10. What is quenching? List some of the quenching medium generally used in industries.

Quenching refers accelerated cooling.

Some of the quenching medium that are used generally in industries are: 5-10% caustic soda, 5-20% brine (NaCl), cold water, warm water, mineral oil (obtained during the refining of crude petroleum), animal oil, vegetable oil (such as linseed, cottonseed, and rapeseed).

11. What are the fac tors should be considered while selecting a quenching medium?

1. Desired rate of heat removal. 2. Required temperature interval.
3. Boiling point. 4. Viscosity. 5. Flash point (if combustible).
6. Stability under repeated use. 7. Possible reactions with the material being quenched. 8. Cost.

12. What are the three stages for quenching?
Stage 1: Vapour-jacket stage.
Stage 2: Vapour-transport cooling stage.
Stage 3: Liquid Cooling stage.

13. Rate the order the effectiveness of the following quench media: oil, brine, water, and molten salt.
Molten salt, brine, water and oil.

14. What does the term hardening refer? What are the factors affecting the hardness?
Hardening refers to the heat treatment of steel which increases its hardness b y quenching.
The hardness obtained from the hardening process depends upon the following factors: 1. Carbon content, 2. Quenching medium, 3. Specimen size, and 4. Other factors.

15. Distinguish the work hardening with the age hardening process.
Work hardening also known as strain hardening, is the process of hardening a metal, while working on it (under cold-working conditions).
Age hardening also known precipitation hardening, is the process of hardening a metal when allowed to remain or age after heat treatment.

16. The tempering process usually follows hardening process. Justify.
The martensite which is formed during hardening process is too brittle and lacks good ductility and toughness. Hence, it cannot be used for more applications. Also the internal residual stresses that are introduced during hardening have a weakening effect. The ductility and toughness of martensite can be enhanced and these internal stresses are relieved by a heat treatment process known as **tempering.**

17. What is the effect of: (a) tempering temperature, and (b) tempering time, on the hardness of steels?
a) The hardness gradually decreases as the temperature is increased.
b) The hardness decreases with the increase in tempering.

18. What do you mean by temper embrittlement?
The tempering of some steels/steel alloys may r esult in a reduction of toughness (i.e., increase in brittleness). This phenomenon is referred as temper embritlement.

19. What is TTT diagram?
The TTT diagram is a plot of temperature versus the logarithm of time for a steel alloy of definite composition. It is a tool used b y heat treaters to predict quenching reactions in steels.

20. What is the significa nce of TTT diagram in the heat treatment of steel?
The TTT diagram is most useful in giving an ove rall picture of the transformation behaviour of austenite. This enables the metallurgist to interpret the response of a steel to any specified heat treatment.
Using a TTT diagram, one can plan practical heat treatment operations to get desirable microconstituents, to control limited hardening or softening, and the time of soaking.

21. Why are TTT diagrams usually not applicable to industrial engineering practices?

The data for the construction of TTT diagrams are obtained from the isothermal transformation of austenite at differing temperatures. But most industrial heat treatments involve continuous cooling from the austenitic temperature to room temperature. Thus a TTT diagram may not five a fully accurate representation of the temperatures and times of the transformations occurring.

22. What is CCT diagram?

The CCT diagram is a plot of temperature versus the logarithm of time for a steel alloy of definite composition. It is used to indicate when transformations occur as the initially austenitised material is continuously cooled at a specified rate. In addition, it is also used to predict the final microstructure and mechanic al characteristic s.

23. Define the term critical cooling rate. What are the factors affecting it?

- The slowest rate of cooling of austenite that will result in 100% martensite transformation is known as the critical cooling ra te.
- Factors affecting the critical rate are: 1. Chemical composition of steel, 2. Hardening temperature, and 3. Metallurgical na ture (i.e, Purity) of steel.

24. What is significance of the critical cooling rate?

The critical cooling rate is most important in hardening. In order to obtain a 100% martensitic structure on hardening, the cooling must be must be much higher than the critical cooling rate.

25. What is meant b y hardenability? What are the factors affecting it?

- The term **hardenability** refers to the ease with which hardness ma y be attained. In other words, hardenability is a measure of ease of forming martensite.
- The factors affecting the hardenability are: 1. Composition of the steel, 2. Austenitic grain size, 3. Structure of the steel before quenching, and 4. Quenching medium and the method of quenching.

26. What is the difference between hardness and hardenability?

- The term **hardness** is the property of a material by virtue of which it is able to resist abrasion, indentation a nd scratching. It is a mechanical property related to strength and is a strong function of the carbon content of a metal.
- On the other hand, **hardenability** is the susceptibility of a material to get hardened. It is affected by the alloying elements in the material and grain size.

27. What is the benefit of the Jominy end-quench test?

For determining the hardenability of a given material.

28. What are hardenability curves? What are the uses of the m?

- The hardness curves are obtained from the data of Rockwell C hardness readings taken along the length and the distance from the quenched end.
- The main pra ctical uses of end-quench hardenability curves are:
  1. If the quench rate (i.e., cooling rate) for a given part is known, the Jominy haardenability curves can predict the hardne ss of that part.
  2. If the hardness at any point ca n be measured, the cooling rate at that point may be obtained from the hardenability curve for that material.

29. What is martempering and austempering?

Martempering, also known as marquenching, is a interrupted cooling procedure used for steels to minimize stresses, distortion and cracking of steels that may develop during rapid quenching.

The **Austempering** is an isothermal heat treatment process, usually used to reduce quenching distortion and to make tough and strong steels.

30. What do you mean by the term case hardening?

In many applications, it is desirable that the surface of the components should have high hardness, while the inside or core should be soft. The treatments given to steels to achieve this are called surface heat treatments or surface hardening.

31. List some of the surface-hardening techniques employed for altering surface chemistry.

1. Diffusion methods:

a) Carburizing, b) Nitriding, c) Cyaniding, and d) Carbonitriding.

2. Thermal methods: a) Flame hardening, and b) Induction hardening.

32. What are the differences between surface hardening by diffusion methods and thermal methods?

In **diffusion surface-hardening method,** the hardness of the surface is improved by diffusing interstitial elements like carbon, nitrogen, or both into the surface of steel components.

In **thermal method of surface hardening,** only the surface of the steel components are heated to temperature above the upper critical temperature and is suddenly quenched to get martensite formation on the surface which gives higher hardness at the surface.

33. Differentiate between pack carburizing and gas carburizing.

In **pack carburizing,** the components to be treated are packed into steel boxes, along with the carburizing mixture, so that a space of roughly 50 mm exists between them.

Gas carburizing overcomes the drawbacks difficulties of pack carburizing by replacing the solid carburizing mixture with a carbon-providing gas.

34. In what ways, cyaniding differs from carburizing?

The salt bath composition for cyaniding gives a case high in nitrogen, whereas carburizing gives a case rich in carbon.

35. What is meant by selective hardening technique?

Selective hardening (or heating) technique is a technique by which different properties are obtained simply by varying the thermal histories of the various regions.

36. What are some selective heating techniques employed for surface hardening?

1. Flame hardening, and 2. Induction hardening.

37. In what ways, flame hardening differs from induction hardening?

The mechanism and purpose of induction hardening are the same as for flame hardening. The main difference is that in induction hardening the source of heat input is an induced electric current instead of using flame.

Unit – III
FERROUS AND NON-FERROUS METALS
PART – A

1. What are metals? Classify engineering materials.

Metals are elemental substances. Metals are composed of elements which readily give up electrons to provide a metallic bond and electrical conductivity.

Type s of metals: 1. Ferrous metals, and 2. Non-ferrous metals.

2. What are ferrous metals? Classify ferrous materials.

The metals, which contain iron as their main constituent, are called **ferrous metals.**

Type s of ferrous metals: 1. Steels, and 2. Cast irons.

3. Sta te three reasons why ferrous alloys are used extensively.

1. Iron-based components are relatively abundant and are widely distributed throughout the world.
2. Ferrous materials can be produced very economically.
3. Ferrous materials are versatile. Therefore wide range of mechanical and physical properties of ferrous materials can be achieved.

4. Sta te three characteristic s of ferrous alloys that limit their utilization.

Heavy in weight, Lower electrical and thermal conductivity, lower resistance to corrosion.

5. How can you specify a steel? What is the difference between 4140 steel and 4340 steel?

The AISI/SAE designation for the steels is a four digit number: First two digits indicate the alloy content, and Last two digits indicate the carbon concentration.

4140 steels is alloy of Cr-Mo with 0.40% C, where as 4340 steel is an alloy of Mo-Cr-Ni with 0.40% C.

6. What are three primary groups of plain carbon steels?

1. Low-carbon steels: Those contain less than 0.25% carbon.
2. Medium-carbon steels: Those containing between 0.25 and 0.60% carbon.
3. High-carbon steels: Those containing more than 0.60% carbon.

7. What are alloy steels? How are alloy steels classified?

Alloy steels mean ma y steels other than carbon steels.

Alloy steels ca n be divided into two main groups as:

1. Low alloy steels: These contain up to 3 to 4% of alloying elements.
2. High alloy steels: These contain more than 5% of alloying elements.

8. List four important alloying elements added in alloy steels.

The most commonly used alloying elements are chromium, nickel, molybdenum, vanadium, tungsten, cobalt, boron, copper and others.

9. Why is alloying done?

The alloying steel is generally done:

To increase its strength.
To improve hardness.
To improve toughness.
To improve resistance to abrasion and water.
To improve machinability.
To improve ductility.

10. What are the primary effects of chromium, and copper as alloying elements in steel?

Effects of alloying chromium: Increases corrosion and oxidation resistance, increases hardenability, increases high-temperature strength, and resists abrasion and wear (with high carbon).

Effects of alloying copper: Increases strength, and increases corrosion resistance.

11. What are the effects of lead and sulphur on the machinability of steels?
Lead improves the machinability whe reas sulphur reduces it.

12. Which alloy e leme nts are basically a) carbide formers, and b) graphite promoters?
a) Carbide formers: Cr, W, Ti, Mo, Nb, V, and Mn.
b) Graphite promoter: Si, Co, Al, and Ni.

13. What makes a stainle ss steel "stainless"?
The chromium oxide (extremely dense-thin) protective layer acts as a barrier to retard further oxidation, rust or corrosion. As this steel c annot be stained easily, it is calle d stainless steel.

14. Why do stainless steels lose their corrosion resistance when the chromium in solution drops below 12%?
When the weight% of chromium drops below 12% the corrosion rate increases sharply. As the corrosion rate increases, the resultant chromium-oxide protective la yer unable to retard oxidation, rust or corrosion effectively.

15. What determines whether a stainless steel is austenitic ferritic, or martenistic?
The predominant phase constituent of the microstructure present in a stainless steel determines whether a stainless steel is austenitic, ferritic, or martenistic.

16. What are the required properties of a tool steel?
Tool steels should have the following requirements:
1. Good toughness, 2. Good wear resistance, 3. Very good machinability,
4. Slight change of form during hardening, 5. Little risk of cracking during hardening.
5. Resistance to softening on heating.

17. How can you classify tool steels?
1. Cold work tool steels, 2. Shock resisting tool steels, 3. Hot work tool steels,
4. High speed tool steels, 5. Plastic mold tool steels and 6. Special purpose tool steels.

18. What is meant b y 18-4-1 high speed steel?
A widely used high-speed tool steel is 18-4-1 high speed steel. This ste el contains 18% tungsten, 4% chromium, and 1% vanadium. It is considered to be one of the best of a ll purpose tool steels.

19. What are HSLA steels? Where are the y used?

HSLA steels are nothing but **high-strength low-alloy steels.** HSLA steels, also known as **micro alloyed steels,** are low-carbon steels containing small amounts of alloying elements.

These HSLA steels are widely used as **structural or constructional alloy steels.**

20. What are maraging steels? Give its composition.

Maraging steels are low-carbon, highly alloyed steels. These are very high-strength materials that can be hardened to obtain tensile strengths of up to 1900 Mpa.

Composition: Maraging steels conta in 18% nickel, 7% cobalt, and small amounts of other elements such as titanium. The carbon content is low, generally less tha n 0.05%.

21. What are the heat resisting steels and free-machining steels?

Steels which can resist the creep and oxidation at high temperatures and retain sufficient strength are called **heat resisting steels.**

Free-machining steels, also known as free cutting steels, machine readily and form small chips so as to reduce the rubbing against the cutting tool and associated friction and wear.

22. What are the features that make cast iron an important material?
1. It is a cheap metallurgical substance, 2. Good castability,
3. Good mechanical rigidity and good strength under compression.
4. Good machinability cn achieved when a suitable composition is selected.

23. What are the effects of carbon on the properties of ca st iron?
If a c ast iron contains more of the brittle cementite, then its mechanical properties will be poor.

24. What is the influence of cooling rate on the properties of a cast iron?
High rate of cooling results in a weak and brittle cast iron. Slow cooling rate results in tough and strong cast iron.

25. How can you classify cast irons?

Cast Iron

Alloy cast irons
(Special-purpose)

Grey (General-Purpose)

White (Hard and wear resistant)

Malleable (Heat-treated for ductility)

Spheroidal Graphite (Some ductility)

26. What is the chemical composition of grey cast iron?
Typical composition of grey cast iron is given below:
Carbon – 2.5 to 4%.
Silicon – 1 to 3%.
Manga nese – o.4 to 1%.
Phosphorus – 0.15 to 1%.
Sulphur – 0.02 to 0.15%. Remaining is iron.

27. Where are white cast irons used?
1. White cast iron is used as a raw material in the production of malleable cast iron.
2. The typical applications of white cast irons include rolls, wear plates, pump linings, balls, etc.
3. It is also used for inferior casting and in places where hard coating is required as in the outer surface of car wheels.

28. What is the difference between malleable cast iron and ductile cast iron?

- Malleable cast iron is produced by he at treating unalloyed white iron. The ductile (or SG or nodular) cast iron is produced by adding magnesium and/or cerium to molten cast iron.
- Both malleable and ductile cast irons have the nodules, also called spheroids. But the nodules of ductile cast irons are more perfect spheres.

29. What are alloy ca st irons?

- The alloy cast irons, like alloy steels, can be produced by adding alloying elements like Ni, Cr, Mo, Cu, Si, and Mn.
- Allo y cast irons have bee n produced to give high-strength materials, hard and abrasion-resistant materials, corrosion resistant irons, and irons for high-temperature service.

30. What are the primary effects of adding Ni, and Mo in cast irons?

S.No.	**Alloying element**	**General effects**
1.	Nickel (Ni)	It has graphitizing effect on cementite . So intends to produce a grey iron. It has a grain-refining effect, which helps to prevent the formation of coarse grain. It also toughens thin sections.
2.	Molybdenum (Mo)	It increases the hardne ss of thick sections. It also improves toughness.

31. What properties do non-ferrous alloys have that usually are not associated with ferrous alloys?
1. Lighter in weight. 2. Higher electrical and thermal conductivity.
3. Better resistance to corrosion. 4. Ease of fabrication (casting, rolling, forging, welding, and machining). 5. Colour.

32. Write some characteristics of non-ferrous alloys that limit their utilization.
Non-ferrous materials are not produced in as great tonnages a nd are more costly than ferrous materials.

33. List the outstanding properties of copper and some typical applications.

The copper posses the following properties:

1. Copper possess very high electrical conductivity.
2. It also has very high thermal conductivity.
3. It exhibits excellent resistance to corrosion.
4. It is very soft, ductile and malleable.

Copper is extensive ly used for manufacturing power cables, telephone cables, cables for computer networks, printed circuit boards, connectors, etc.

34. What is the main difference between a brass and a bronze?

Brass is an alloy of copper and zinc whereas bronze is a n alloy of copper and tin.

35. List at least four types of brasses used.

Gliding metal (or commercial bronze), cartridge brass, standard brass (or cold working brass), Muntz metal (or yellow metal), Naval brass, Admira lty bra ss.

36. List some bronze alloys.

Bell bronze, phosphor bronze , aluminium bronze, silicon bronze, coinage bronze and leaded bronze.

37. What are gun metals? Give its composition.

Gun metals are alloys of copper, tin, and zinc.

Composition of admiralty gun metal: 88 Cu, 10 Sn, 2 Z n, 2 (max) Ni.

38. What are cupronickels? What is the use of monel metal?

Cupronickels are alloys of copper and nickel.

Uses of monel metal: For making propellers, pump fittings, condenser tubes, steam turbine blades, sea water exposed parts, tanks, and chemical a nd food handling plants.

39. What properties have made aluminium and its alloys the most important non-ferrous metal?

i) Light-weight (one-third the weight of steel), ii) High thermal and electrical conductivity, iii) Excellent corrosion resistanc e, iv) Non-toxic ity, v) Soft and ductile, vi) Low specific gra vity, vii) High strength-to-weight ratio, and viii) High reflectivity.

40. Why does the aluminium replace the copper as an electrical conductor?

i) The price of the aluminium is much lower than that of copper.

ii) The specific gravity of aluminium.

iii) The electrical conductivity of EC-grade (electrical conductor) aluminium is 61% of the conductivity of standa rd copper, based on equal cross sections.

iv) If equal weights of aluminium a nd copper conductors of a give n length are compared, it is found that aluminium conducts 201% as much current as does copper.

41. What are the two types of aluminium alloys?

1. Heat-treatable aluminium alloys, and
2. Non-heat treatable aluminium alloys.

42. What is duralumin? Give its composition and applications.

Duralumin is an alloy of aluminium and copper.

Composition: 94 Al, 4Cu, 0.5 Mg, 0.5 Mn, 0.5 Si, 0.5 Fe.
Typical applications: For aircraft and automobile industries; for making electric cables, in surgical and orthopaedic implements or gadgets, etc.

43. What is meant b y precipitation hardening?

Precipitation hardening, also known as age hardening, is the most important method of improving the physical properties of some of the non-ferrous alloys by solid state reaction.

44. Differentiate between natural ageing and artificial a geing.

The ageing process done at room temperature is often called **natural ageing.** Natural ageing takes a prolonged period of time in terms of several days to reach maximum strength.

Ageing at high temperature of 190° C to 260° C accelerates the precipitation process and the time required is reduced considerably. This process is called **artificial ageing.**

45. What is the effect of ageing temperature and time on the material strength?

The strengthening process accelerates with the increase in the ageing temperature. The maximum strength increases as the ageing temperature decreases.

46. What are the required characteristics of a be aring material?

1. Bearing material should possess sufficient hardness and wear resistance.
2. It should have a low coefficient of friction.
3. It should be tough, shock-resistant, and sufficiently ductile.
4. It should have a sufficient melting point, and high thermal conductivity.
5. It should have good casting qualities, and good resistance to corrosion.

47. List the bearing materials that are commonly used.

1. White metals, 2. Copper-base alloys, 3. Aluminium-base alloys,
4. Plastic materials, and 5. Ceramics.

48. What are super alloys?

Super alloy is a general term used to describe the nickel-base and cobalt-base alloys which have been developed for use at elevated temperatures.

Super alloys produce a combination of high strength as elevated temperature, resistance to creep at temperatures up to 1000° C, and resistance to corrosion.

Unit – IV
ROTO DYNAMIC NON-METALLIC MATERIALS
PART – A

1. What are polymers?

Polymers are composed of a large number of repeating units of small molecule s called manometers.

Polymers may be defined as giant organic, chain-like molecules having molecula r weight from 10000 to more than 1,000,000 $g.mol^{-1}$.

2. List any four attractive characteristics of polymers.
1. Low density. 2. Good thermal and electrical insulation properties.
3. High resistance to chemical attack. 4. Ease of fabrication. 5. Relatively low cost.

3. Classif y polymers.
1. Plastic s, 2. Elastomers, 3. Adhesives, 4. Coatings, 5. Fibres.

4. Define the following terms: i) Monometer, ii) Homopolymer, and iii) Copolymer.
Monomer is a small molecule consisting of a single mer i.e., a single unit/blocking block.

Homopolymer is a polyme r made out of identical monomer.
Copolymer is a polymer which is obtained by adding different types of monomers.

5. What is meant by isomerism?
Isomerism is a phenomenon wherein different atomic configurations are possible for the same configuration.

6. What is meant by the term 'unsaturated molecule'? State its significance in plastics.
A compound in which the valence bonds of the carbon atoms are not satisfied is said to be unsaturated. Such unsaturated molecules are important in the polymerization i.e., joining together of small molecules into large one ha ving the same constituents.

7. What is polymerisation?
Polymerisation is the process of forming a polymer.

8. Define the term 'degree of polymerisation'?
Degree of polymerisation is the number of repetitive units (or mers) present in one molecule of a polymer. Mathematica lly,
Molecular weight of a polymer
Degree of polymerisation = --
Molecular weight of a single monomer

9. What is the difference between addition polymerisation and condensation polymerisation?
Addition polymerisation, a lso known as chain reaction polymerisation, is a process by which two or more chemically similar monomers are polymerized to form long c hain molecules.
Condensation polymerisation, also known as step-growth polymerisation, is the formation of polymers by stepwise intermolecular chemical reactions that normally involve at least two different monomers.

10. Why are additives added to polymers?
The various polymer additives include:
1. Filler materials, 2. Plasticizers, 3. Stabilizers, 4. Colorants, 5. Flame retardants,
6. Reinforcements, and 7. Lubricants.

11. What are the characteristics of plastics which account for their wide use as engineering materials?
Plastics are extensively used in engineering applications due to their important properties such a s low price, colour range, toughness, water resistance, low electrical and thermal conductivity, ease of fabrication, etc.

12. Why are the fillers a nd plasticizers added to polymers?

S.No.	Additive Nam	Purpose
1.	Fillers	To improve tensile and compressive strengths. To improve dimensional and thermal stability, and other properties. To reduce the cost of the fina l product.
2.	Plasticizers	To improve the flexibility, ductility, and toughness. To reduce the hardness a nd stiffness. To increase a nd control the flow of the polymer during molding.

13. Differentiate commodity plastics with engineering plastics.
The plastics which are not generally used for engineering applications are known as commodity plastics. H plastic s which are used in engineering applications are kno wn as engineering plastics.

14. Name any four commodity plastics and engineering plastics.

Commodity plastics: i) Polyethylene (PE), ii) Polypropylene (PP), iii) Polystyrene (PS), iv) Polyvinyl chloride (PVC).

Engine ring Plastics: i) Ethenic, ii) Polyamides, iii) Cellulosics, iv) Acetals.

15. Distinguish between thermoplastics and thermosetting plastic s.

S. No.	Thermoplastics	Thermosetting plastics
1.	The y are formed addition polymerisation.	The y are formed by condensation polymerisation.
2.	The y are linear polymers, so they are composed of chain molecules.	The y are composed of three dimensional networks of cross-linked molecules.
3.	Softe ning is possible on re heating (because of the weak secondary forces).	Softening is not possible on reheating (because of strong covalent bonds).
4.	The y can be ea sily moulded on remoulded into any shape.	The y cannot be remoulded into any new shape.
5.	The y ca n be recycled again.	The y cannot be recyc led.

16. Name any four thermoplastics and thermosetting plastics.
Thermoplastics: Polythenes, Polypropylene, Polystyrenes, PVC.
Thermosetting plastics: Polyesters, phenolics, epoxides, melamine formaldehyde.

17. What advantage s do thermoplastic polymers have over thermosetting polymers, and vic e versa?

- Since thermoplastics have low melting temperature and can be repeatedly molded and remolded to the desired shape, they have a good resale/scrap value.
- The thermosetting plastics are generally stronger , harder, more brittle, more resistant to heat and solve nts than thermoplastics.

18. What are the sources of raw materials for plastics?
1. Animal and vegetable by-products, 2. Coal by-products, 3. Petroleum by-products.

19. What do the following 'acronyms' refer: PE, PP, PS, PVC, PTFE, PMMA.
PE: Polyethylene; PP: Polyprop ylene; PS: Polystyrene; PVC; Polyvinyl chloride;
PTFE: Polytetrafluro ethyle ne; PMMA: Polymethyl methacrylate.

20. List the properties and typical applications of PVC.

Properties: Good low-cost, general purpose materials; ordinary rigid, but can be made flexible with plasticizers; susceptible to heat distortion.

Typical applications: Pipes, valves, fittings, floor tiles, wire insulations, toys, phonograph records, safety glass interlayer's.

21. What are acrylic materials? Name two of them.

Acrylic materials are thermoplastic polymers based on the polymerization of esters of acrylic acid and/or methacrylic acid.

The most commonly used acrylic polymers are:

1. PMMA (Polymethyl methacrylate), 2. PAN (Polyacrylonitrile).

22. Write short notes on nylons.

Polyamides (PA), also known as **nylons,** are the products of condensation reactions between an amine and an organic acid.

There are number of common polyamides. The y are usually designated as nylon 6, nylon 6/6, nylon 6/10, nylon 6/12, nylon 11, and nylon 12. These suffixes re fer to the number of carbon atoms in eac h of the reacting substances involved in the condensation polymerization process.

23. What are bakelites? Also state the ir applications.

Phenolics, also known as **Bakelites,** are the oldest family of thermosetting plastics. The most important phenolic materials is the polyformaldehydes.

Typical applications include electrical plugs, sockets, switches, telephones, door knobs and handles, adhesives, coatings, and laminates.

24. List the characteristic s of urea-formaldehyde.
1. They are similar to the phenolics. 2. They are hard and rigid thermo sets.
3. They have good electrical insulation properties. 4. They are light in colour.
5. They e xhibit good resistance to most chemicals.

25. What are engineering ceramics?

Engineering ceramics are also known as **technical/industr ial ceramics,** are those ceramics that are specially used for engineering applications or in industries.

26. List some of the distinct characteristics of engineer ing cera mics.
1. High resistance to abrasion and wear. 2. High strength at high temperature.
3. Good chemical stability. 4. Good electrical insulation characteristics.

27. What are the main classifications of ceramic materials?

Engineering ceramics can be classified into oxides, carbides, sulphides, nitrides, metalloids, or intermetallics.

28. Name any four engineering ceramics.

1. Alumina (Al_2O_3). 2. Selicon carbide (SiC). 3. Silicon nitride (Si_3N_4).
4. Partially stabilized zirconia (PSZ), and 5. Sialons.

29. Compare the fracture toughness of alumina, silicon carbide, and silicon nitride.

Property	**Al_2O_3**	**SiC (Sintered)**	**Si_3N_4 (Reaction bonded)**	**Si_3N_4 (Hot pressed)**	**PSZ**	**Sialon**
Fracture toughness, MPa $m^{-1/2}$	5.5	4	3	5.5	11	10

30. What is meant b y PSZ?

Partially stabilized zirconia (PSZ) is nothing but a zirconium oxide (ZrO_2) that has been blended and sintered with some other oxide such as magnesium oxide (MgO), calcium oxide (CaO), and yttria (Y_2O_3), to control cr ystal structure transformations.

31. What are sialons? State the ir applications.

The name sialon is an acronym derived from the ingredients involved, namely Si

formed when aluminium and oxygen partially substitute for silicon and nitrogen in silicon nitride.

Sialons are used for cutting tool materials, dies for drawing wire and tubes, rock-cutting and coal-cutting equipment, nozzles and welding shields.

32. What are composites?

Composites are produced when two or more materials are joined to give a combination of properties that cannot be attained in the original materials.

33. What are the constituents of composites?

Composites are composed of two phases. They are:

1. Matrix phase, and 2. Dispersed phase.

34. How are composite materials classified?

Composites

- Particle-reinforced
  - Dispersion-strengthened
  - Large-particle
- Structural
  - Laminates
  - Sandwich panels
- Fibre-reinforced
  - Continuous (aligned)
  - Discontinuous (short)
    - Aligned
    - Randomly y oriented

35. What is the role of matrix material in a composite?

The matrix usually provide s the major control over electrical properties, chemical behavior, and elevated-temperature use of the composite.

36. List the various matrix materials used.

1. Thermosetting resins: Polyester resins, epoxide resins.
2. Thermoplastics: PA, PAI, PBT, PET, PES, PPS, PEEK
3. Metal matrices: Al, Ti, Mg, Cr and Ni, together with their alloys.
4. Composite materials.

37. List the various matrix materials used.

1. Polymers: Kevlar, nylon, polyethylene. 2. Metals: Be, Boron, W.

3. Glass: E-glass, S-glass. 4. Carbon: HS (high strength), HM (high modulus).

5. Ceramics: Al_2O_3, B_4C, SiC, ZrO_2. 6. Whiskers: Al_2O_3, Cr, graphite, SiC, Si_3N_4.

38. What are cermets? What are two common uses of cermets?

The term 'cermet' refers to ceramic-metal composite containing between 80 and 90 % of ceramic. Cermets are composed of ceramic particles in metallic matrix.

Typical applications: Cutting tools, slip gauge, wire-drawing dies, rocket motor and jet-engine parts.

Unit – V

MECHANICAL PROPERTIES ANS TESTING

PART – A

1. What is meant by mechanical properties of materials?

Mechanical properties are those characteristics of material that describe its behaviour unde r the action of external forces.

2. Distinguish between elasticity and plasticity.

Elasticity is the property of a material by virtue of which it is able to retain its original shape and size after the removal of the load.

Plasticity is the property of a material b y virtue of which a permanent deformation (without fracture) takes place, whenever it is subjected to the action of external forces.

3. Differentiate between ductility and malleability.

Ductility is the property of a material by virtue of which it can be drawn into wires before rupture takes place.

Malleability is the property of a material b y virtue of which it can withstand deformation under compression without rupture.

4. Define the terms brittleness and hardness.

Brittleness is the property of a material by virtue of which it can withstand deformation under compression without rupture.

Hardness is the property of a material by virtue of which it able to resist abrasion, indentation (or penetration), machining, and scratching.

5. What do you mean by toughness and stiffness?

Toughness is the property of a material by virtue of which it can absorb maximum energy before fracture takes place .

Stiffness is the property of a material by virtue of which it resists deformation.

6. List any four technological properties of me tals.

1. Machinability, 2. Castability, 3. Weldability, and 4. Formability or workability.

7. What are the factors affecting mec hanical properties?

1. Grain size , 2. Heat treatment, 3. Atmospheric exposure, and
4. Low and high temperatures.

8. What is the effect of the grain size on the mechanical properties of the materials?

The materials having smaller grains (i.e., fine grained structure) have high yield strength, high tensile strength, and more hardness. Also fine grain results in better resistance to cracking and better surface finish.

The materia ls having grains (i.e., coarse grained structure), exhibit better workability, hardenability, forgeability and creep resistance. But coarse gra ins result in poor surface finish, less tough and have greater tendency to cause distortion.

9. What is the effect of heat treatment on the mechanical properties of the materials?

The heat treatment improves mechanical properties like tensile strength, toughness, hardness, ductility, shock resistance and resistance to corrosion. It also improves workability, forgeability and machinability of metals.

10. Distinguish between elastic and plastic deformation of solid.

S. No.	Elastic deformation	Plastic deformation
1.	It is the deformation of a body with completely disappears as soon as the external load is removed from the body.	It is the deformation of a body which remains eve n after removing the external load from the body.
2.	It obeys Hook's law.	It does not obe y Hook's law.
3.	The e lastic deformation is the beginning of the progress of deformation.	The plastic deformation takes pla ce after the elastic deformation has stopped.

11. Define the terms slip and twinning.

Slip may be defined as the sliding of blocks of the crystal over one another along definite a mirror image of the other part.

Twinning is the process in which the atoms in a part of a crystal subjected to stress, rearrange themselves so that one part of the crystal becomes a mirror image of the other part.

12. State the Schmid's law.

The stress required at a given temperature to initiate slip in a pure and perfect single crystal, for a material is constant. This is known as Schmid's law.

13. What are the causes of twins?

1. Mechanical twins: Twins that are produced by mechanical deformation are called mechanical twins.

2. Annealing twins: T wins that are produced by annealing are called annealing twins.

14. What is meant b y fracture?

Fracture is the mechanic al failure of the material which will produce the separation or fragmentation of a solid into two or more parts under the action of stresses.

15. List the different types of fracture in a material.

1. Brittle fracture, 2. Ductile fracture, 3. Fatigue fracture, and 4. Creep fracture.

16. What is brittle fracture?

A brittle fracture may be defined as a fracture which take s place by a slow propagation of crack with appreciable plastic deformation.

17. What is ductile fracture?

Ductile fracture may be defined as the fracture which takes place by a slow propagation of crack with appreciable plastic deformation.

18. Distinguish between brittle fracture and ductile fracture.

S. No.	**Brittle fracture**	**Ductile fracture**
1.	It occurs with negligible plastic deformation.	It occurs with large plastic deformation.
2.	It occurs at the point where micro crack is more.	It occurs in some localized region where the deformation is very large.
3.	The rate of crack propagation is rapid.	The rate of crack propagation is slow.
4.	Failure is due to the direct stress.	Failure is due to the shear stress.

19. How can you prevent the ductile fracture?

In order to prevent the ductile fracture, the material should have the following characteristics:

The material should have fine grains.
It should have higher hardness value.
It should have higher Young's modulus and cohesive energy.
It should not have any defects/dislocations.

20. What is meant b y fatigue fracture?

A fatigue fracture is defined as the fracture which takes place under repeatedly applied fatigue stresses.

21. What is S-N diagram? What is the significance of it?

The S-N diagram is a graph obtained by plotting the number of cycles of stress reversals (N) required to cause fracture against the applied stress level (S). Using S-N diagram, the fatigue life of a material can be determined.

22. What are the factors affecting fatigue strength?

1. Fatigue strength is influenced b y many factors such as chemical composition, grain size, and amount of cold working.
2. Fatigue strength is high at low temperature s and gradually decrease s with rise in temperature.
3. Environmental effects such as corrosion of the product by moisture decreases the fatigue strength.
4. The design of the product also influences the fatigue strength.

23. How can you prevent fatigue fracture?

The following methods can be adopted to prevent the fatigue failure.

1. Use of good design to avoid stress concentration by eliminating sharp recesses and severe stress raisers.
2. Control of the surface finish b y avoiding damage to surface machining, punching, stamping, shearing, etc.
3. Reduction of corrosion environmental effects by surface heat treatments like polishings, coatings, carburizing, nitriding, etc.
4. The material should have fine grain structure and also it should be free from residual stresses and dislocations.

24. What is meant b y creep fracture?

The creep is defined as the property of a material by virtue of which it deforms continuously under a stead y load.

25. What are the factors affecting creep?

1. Grain, 2. Thermal stability of the micro-structure,
3. Chemic al reactions, 4. Prior strain.

26. How can you prevent the creep fractures?

The following methods can be adopted to prevent the creep failure.

1. Use of coarse grained materials will avoid creep fracture.
2. Strain hardening ca n be done to avoid creep fracture.
3. The material should be free from any residual stresses and dislocations.
4. Precipitation-hardened alloys can be used to avoid creep fracture.

27. Differentiate between destructive and non-destructive tests.

In destructive type of testing, the component or specimen to be tested is destroyed and cannot be reused.

In non-destructive type of testing, the component or specimen to be tested is not destroyed and can be reused after the test.

28. List some important destructive tests carried out on a material.

1. Tensile test, 2. Impact test, 3. Bend test,
4. Fatigue test, 5. Torsion test, and 6. Creep test.

29. List the main parameters which may be determined in a tensile test.

1. Limit of proportionality, 2. Yield point or yield strength, 3. Brea king strength,
4. Maximum tensile strength, 5. Percentage elongation, 6. Modulus of elasticity, and
7. Percentage reduction in area.

30. How does the Rockwell test differ from that of the others?

The principle of the Rockwell test differs from that of the others in that the depth of the impression is related to the hardness rather than the diameter or diagonal of the impression.

31. Why must Rockwell test numbers always include a letter, such as A, B, or C?

The Rockwell scales such A, B, or C are used to denote the type and size of the indenter used and the total indenting load to be applied.

32. What is the difference between Izod and Charpy impact testing methods?

Based on the types of specimen used on impact testing machine, the impact tests can be classified into: 1. Izod test, and 2. Charpy test.

Izod test uses a cantilever specimen of size 75 mm×10mm×10mm. The Charpy test uses a simply-supported test specimen of size 55mm×10mm×10mm.

33. Define the term notch sensitivity.

The notch sensitivity refers to the tendency of some normal ductile materials to behave like brittle materials in the presence of notches.