KCG COLLEGE OF TECHNOLOGY
DEPARTMENT OF MECHANICAL ENGINEERING
ME 6403-ENGINEERING MATERIALS AND METALLURGY
QUESTION BANK
SEMESTER: 4
UNIT –I –ALLOYS AND PHASE DIAGRAMS

PART -A

1) Define an alloy.

An alloy is defined as a combination of two or more elements of which one of the elements should be a metal in major proportion. The other may be a metal or non-metal e.g.Brass(cu-zn) and steel(fe-c)

2) What is solid solution?

Solid solution is an alloy in which solute atoms are distributed in the solvent matrix and has the same structure of solvent.

3) Differentiate substitional and interstitial solid solution with examples?

In a substitution solid solution, the atoms of the solvent metal are replaced in the crystal lattice by atoms of the solute e.g.in Au-Cu, the cu atoms replace the Au atoms.

In an interstitial solid solution the atoms of the solute fit into the interstitial space of the solvent,e.g.fe-c.The carbon atoms fit into the interstitial space of iron.

4) Whatis the effect of crystal structure and atomic radii on formation of solid solution between two metallic elements?

If two metal are of same crystal lattice,it is possible for complete solid solubility to occur over the whole composition range. If the atomic ratio of solute and solvent differ by less than 15%,conditions are favorable for the formation of solid solution. if the difference exceeds 15%, Solid solution formation is extremely limited.

5) What are intermediate phases or compounds?

Intermediate phases or chemical compounds are formed between two dissimilar elements having widely divergent electrochemical properties. The crystal structure of a compound is different from those of the parent metals.

6) Define term phase.

A phase is a chemically and structurally homogeneous portion of the microstructure.

7) What is phase diagram?

A phase diagram is a graphical representation of phase present in a system at various temperature,pressure and composition.

8) Write the equation for Gibbs phase rule and define each of the term.

Gibbs phase rule is given by

$$P+F=C+2$$

P-Number of phases existing in a system under consideration

F-Degree of freedom

C-Number of components in the system

9) What is a binary isomorphous alloy system?

An alloy system,which consists of two components that are completely soluble both in the liquid solid states, is called binary isomorphism system. in this system, only a single type of crystal structure exist for all the compositions of components and therefore it is the system.

10) What is a phase or equilibrium diagram? What information may be obtained from an equilibrium diagram?

Phase or equilibrium diagrams are maps or plots that give the relationships between the phases in equilibrium in a system as a function of temperature, pressure and composition. Information concerning the phase changes in many alloy systems can be had from equilibrium diagram.

11) State lever rule.

The lever rule is a convenient method of calculating the relative proportions of different phases (solid and liquid) at any given temperature for a given alloy composition. According to the lever rule the tie-line (horizontal line to a given temperature in a phase diagram) is treated as a lever arm, with the fulcrum at the overall composition. The weight at each end corresponds to the amount of the phase at that end of tie-line phase diagram.

12) What is an alloy?

An alloy is a mixture of two or more metals, or a mixture of metal and a non-metal, with the mixture exhibiting metallic properties.

13) Define eutectic reaction

A reaction wherein, upon cooling, one liquid phase transforms isothermally and reversibly into two new solid phases that are intimately mixed is called eutectic reaction.

14) Define eutectoid reaction

A reaction wherein, upon cooling, one solid phase transforms isothermally and reversibly into two new solid phases that are intimately mixed is called eutectoid reaction.

15) What is meant by solidus?

In a constitution or equilibrium diagram, the locus of points representing the temperature at which the various compositions finish freezing on cooling or begin to melt on heating is called solidus.

16) What is meant by liquids?

In a constitution or equilibrium diagram, the locus of points representing the temperature at which the various compositions in the system begin to freeze on cooling or to finish melting on heating is called liquids.

17) What are the possible microstructures of iron and steel?

The possible microstructures of iron and steel which reveal the arrangement, size and shape of the grains and molecules are
a) Ferrite
b) Austenite
c) Cementite
d) Martensite
f) Bainite
g) Sorbite and troostite

18) What are the three classes of plain steels?

On the basis of the iron-carbon equilibrium diagram it is possible to describe three classes of plain steels.
i) Hypo-eutectoid steels
these have carbon contents varying from 0.008% to just below 0.83%.
ii) Eutectoid steels
these have carbon contents, ideally, of 0.83%
iii) These have carbon contents greater than 0.83%

19) What are the stainless steels and what are the possible classifications based on their microstructure?

The stainless steels are iron-chromium alloys with atleast 11 wt% of chromium. Addition of nickel and molybdenum enhances the corrosion resistance. Stainless steels are divided into three classes on the basis of the microstructure

a) martensitic stainless steels
b) ferritic stainless steels and
c) austenitic stainless steels

20) What are cast irons and what are their basic types?

Any ferrous alloy made up primarily of iron with about 2% or more carbon is considered to be cast iron. Most commercial alloys contain from about 2.5% to 3.8% carbon. There are four basic types of cast iron

a) Grey cast iron
b) White cast iron
c) Malleable iron
d) Nodular iron

PART -B

1. How are solid solution classified? Give two examples for each.
2. Draw and explain unary phase diagram.
3. Draw and explain classification of binary phase diagram.
4. Draw iron-iron carbide equilibrium diagram and mention the important composition and temperature
5. Draw the microstructure of steel?

6. Explain properties and application of cast iron.

7. What are the different types of cast irons? Draw the microstructureof any four types of cast irons. Give one application for each
8. Explain with a phase diagram of eutectoid and peritectic reaction

UNIT-2 HEAT TREATMENT

PART-A

1. ***Define heat treatment.***
   Heat treatment is the controlled heating and cooling of metals for the purpose of altering their properties.
2. ***What is annealing?***
   Annealing is a heat treatment for the general purpose of softening or stress relieving a material.
3. ***What is normalising?***
   Normalising is a heat treatment obtained by austenitising and air cooling to produce a fine pearlite structure and to enhance toughness by refining the grain size.
4. ***What is quenching?***
   Quenching refers to rapid cooling. Some of the quenching medium that are widely used are caustic soda, brine solution, water, oil and air.
5. ***What is hardening?***
   Hardening refers to the heat treatment which increases the hardness by quenching.
6. ***What is tempering?***
   Tempering is a heat treatment in which martensite is reheated. In this, the ductility and toughness of martensite can be enhanced by reducing the hardness of martensite.
7. ***What is time-temperature transformation (TTT) diagram?***
   The TTT diagram, also known as isothermal transformation diagram or the C-curve, is a plot of temperature versus the logarithm of time for a steel alloy of definite composition. It is used to determine when transformation begins and ends for an isothermal heat treatment of a previously austenitized alloy.
8. ***What is continuous cooling transformation (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 transformation occurs as the initially austenitized material is continuously cooled at a specified rate. In addition, using the CCT diagram the final microstructure and mechanical characteristics may be predicted.
9. ***Define hardenability.***
   Hardenability refers to the ease with which hardness may be attained. It is a measure of ease of forming martensite. The Jominy end-quench test method is widely ised to determine the hardenability.
10. ***Define martempering.***
    Martempering is a heat treatment of steel involving a slow cool through the martensitic transformation range to reduce stresses associated with that crystallographic change.
11. ***What are the factors should be considered while selecting a quenching medium?***
    - Desired rate of heat removal.
    - Required temperature interval.
    - Boiling point.

- Viscosity.

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

Molten salt, brine, water and oil.

13. 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 time.

14. What do you mean by temper embrittlement?

The tempering of some steels/steel alloys may result in a reduction of toughness (i.e., increase in brittleness). This phenomenon is referred to as temper embrittlement.

15. What are hardenability curves? What are its uses?

- 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 practical uses of end-quench hardenability curves are:
    - If the quench rate (i.e., cooling rate) for a given part is known, the Jominy hardenability curves can predict the hardness of that part.
    - If the hardness at any point can be measured, the cooling rate at that point may be obtained from the hardenability curve for that material.

16. 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 the core should be soft. The treatments given to steels to achieve this are called surface heat treatments or surface hardening or case hardening.

17. In what ways cyaniding differs from carburizing?

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

18. What is meant by selective hardening technique?

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

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

- Flame hardening
- Induction hardening

20. 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.

PART -B

1) With neat sketches explain the mechanism of slip and twining. Also

State the differences between them.

2) Define harden ability and explain Jominy End Quench test. How to use this Jominy end quench test data?

3) Explain Brinell hardness testing and its applications

4) What is Hardening? Discuss in detail on different hardening methods and mechanism. Compare hardening and annealing.

5) Write a short note on

(i) Carburising(ii) Nitriding

(iii) Flame hardening (iv) Cyaniding

6) What is CCR? Write difference between Normalizing and Tempering

UNIT-3 FERROUS AND NONFERROUS METALS

PART-A

1. ***What are ferrous alloys?***

Ferrous alloys (steels and cast irons) are those in which iron is the prime constituent.

2. ***What are the different plain carbon steels?***

Low carbon steels – Those contain less than 0.25% carbon

Medium carbon steels – Those containing between 0.25 and 0.60% carbon

High carbon steels – Those containing more than 0.60% carbon

3. ***What are different alloys steels?***

Low alloy steels – Those contain up to 3 to 4% of alloying elements

High alloy steels – Those contain more than 5% of alloying elements

4. ***What are the effects of adding alloying elements on the mechanical properties of ferrous alloys?***

The alloying elements are added to enhance properties such as increased strength, toughness, hardenability, corrosion and wear resistance, etc.

5. ***Mention some of the commonly used alloying elements.***

Some of the commonly used alloying elements include Mn, Si, Cr, Ni, W, Mo, V, ti, Co, Cu and Pb.

6. ***What are stainless steels?***

Stainless steels are alloys of iron, chromium and other elements that resist corrosion from many environments.

7. ***What are the classes of stainless steels?***

There are three classes of stainless steels on the basis of their microstructure:

a) Austenitic stainless steels
b) Ferritic stainless steels and

c) Martensitic stainless steels

8. ***What are tool steels?***
   Tool steels are high-carbon alloys used to make tools and dies for cutting, forming or otherwise shaping a material into a component or part for a specific application.
9. ***What are HSLA steels?***
   High Strength Low Alloy steels also known as micro-alloyed steels are low carbon steels containing small amounts of alloying elements. Its primary purpose is reduced weight with increased strength.
10. ***What are maraging steels?***
    Maraging steels are low carbon, highly alloyed steels. They are used in applications where very high tensile strength is desired.

11. ***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 the last two digits indicate the carbon concentration.
12. ***What are the effects of lead and sulphur on the machinability of steels?***
    Lead improves the machinability whereas sulphur reduces it.

13. ***Which alloy elements are basically (a) carbide formers (b) graphite promoters?***

    c.) Carbide formers: Cr, W, Ti, Mo, Nb, V and Mn.
    d.) Graphite promoter: Si, Co, Al and Ni.

14. ***Why do stainless steels lose their corrosion resistance when the chromium in solution drops below 12%?***
    When the weight percentage of chromium drops below 12%, the corrosion rate increases sharply. As the corrosion rate increases, the resultant chromium-oxide protective layer becomes unable to redard oxidation, rust or corrosion effectively.
15. ***What determines whether a stainless steel is austenitic, ferritic or martensitic?***
    The predominant phase constituent of the microstructure present in a stainless steel determines whether a stainless steel is austenitic, ferritic or martensitic.
16. ***What is meant by 18-4-1 high speed steel?***
    A widely used high-speed tool steel is 18-4-1 high speed steel. This steel contains 18% tungsten, 4% chromium and 1% vanadium. It is considered to be one of the best of all purpose tool steels.
17. ***What are 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.

18. ***What are the features that make cast iron an important material?***

- Good mechanical rigidity and good strength under compression.
- Easy castability.
- Good machinability can be achieved when a suitable composition is selected.

19. ***What are the effects of carbon on the properties of cast iron?***

If the cast iron contains more of the brittle cementite, then its mechanical properties will be poor.

20. ***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.

PART –B

1. Write a short note on compositions and properties of the following steels:
    a. Austenitic stainless steels
    b. High speed steels
    c. Matensitic stainless steels
    d. Maraging steels

2. (a) How will you classify brasses on the composition of zinc? Explain the properties and applications of the main types of brasses.

(b) Explain the steps involved in precipitation hardening treatment.

3. (a) What are stainless steels? What are the main characteristics of stainless steels? Name different types of stainless steels and their main applications.

(b) What are HSLA steels? How can high strength and toughness be attained in them?

4. Discuss the influence of each of the following alloying elements on the properties of steel:

(a) Molybdenum (b) Chromium (c) Manganese (d) Vanadium (e) Titanium (f) Tungsten.

5. Discuss the characteristics of aluminium and also mention its alloys, their properties and uses.

UNIT IV- NON METALLIC MATERIALS

Part-A (2 Marks)

1. ***What are polymers?***
    - Polymers are composed of a large number of repeating units of small molecules called monomers.
    - Polymers may be defined as giant organic, chain-like molecules having molecular weight from 10000 to more than 1,000,000 $g.mol^{-1}$
2. ***List any four attractive characteristics of polymers.***
    - Low density
    - Good thermal and electrical insulation properties
    - High resistance to chemical attack
    - Ease of fabrication
    - Relative low cost
3. ***Classify polymers***
    a. Plastics
    b. Elastomers
    c. Adhesives
    d. Coatings
    e. Fibres
4. ***Define the following terms: (1) monomers, (ii) homopolymer, (iii) copolymer.***
    Monomer is a small molecule consisting of a single mer i.e., a single unit/ blocking block
    Homopolymer is a polymer 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. Such unsaturated molecules are important in the polymerization i.e., joining together of small molecules into large one having the same constituents.
7. ***What is polymerisation?***
    Polymerisation is the process of forming a polymer.
8. ***Define the term 'degree of polymerisation'?***
    Degree of polymerization is the number of repetitive units (or mers) present in one molecule of a polymer.
9. ***What is the difference between addition polymerization and condensation polymerization?***

- Addition polymerization, also known as chain reaction polymerization, is a process by which two or more chemically similar monomers are polymerized to form long chain molecules.
- Condensation polymerization, also known as step-growth polymerization, 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 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 as low price, colour range, toughness, water resistance, low electrical and thermal conductivity, ease of fabrication, etc.

12. Differentiate commodity plastics with engineering plastics.

The plastics which are not generally used for engineering applications are known as commodity plastics. The plastics which are used in engineering applications are knows as engineering plastics.

13. Name any four commodity plastics and engineering plastics.

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

Engineering Plastics: (i) Ethenic, (ii) polyamides, (iii) cellulosics, (iv) acetlas.

14. Distinguish between thermoplastics and thermosetting plastics.

S. No	Thermoplastics	Thermosetting plastics
1	They are formed by addition	They are formed by condensation polymerisation
2	They are linear polymers, so they are composed of chain molecules.	They are composed of three dimensional network of cross linked molecules.
3	Softening is possible on reheating (because of the weak secondary forces)	Softening is possible on reheating (because of strong covalent bonds)
4	They can be easily moulded on remoulded into any shape.	They cannot be remoulded into any new shape
5	They can be recycled again	They cannot be recycled.

15. Name any four thermoplastics and thermosetting plastics.

Thermoplastics: polythenes, polypropylene, polystyrenes, PVC.

Thermosetting Plastics: polyesters, phenolics, epoxides, melamine formaldehyde.

16. What are the advantages do thermoplastics polymers have over thermosetting polymers, and vice versa?

- Since thermoplastics have low melting temperature and can be repeatedly moulded and remoulded to the desired shape, they habe a good resale/scrap value.
- They thermosetting plastics are generally stronger, harder, more brittle more resistant to heat and solvents than thermoplastics.

17. What are the sources of raw materials for plastics?

- Animal and vegetable by –products.
- Coal by products
- Petroleum by-products.

18. What do the following acronyms refer: PE,PP,PS,PVC,PTFE,PMMA

PE: polyethylene; PP: polypropylene; PS: polystyrene; PVC: polyvinyl chloride; PTFE: polyterafluoro ethylene; PMMA: polymethyl methacrylate.

19. List the properties and typical applications of PVC.

- Acrylic materials are thermoplastics polymers based in the polymerization of esters of acryclic acid and/or methacrylic acid
- The most commonly used acrylic polymers are:
    i. PMMA (polymethyl methacrylate), and
    ii. PAN (polyacrylonitrile)

20. What are the bakelites? Also state their applications.

Phenolics, also known as bakelites, are the oldest family of thermosetting plastics. The most important phenolic materials ispolyformaldehydes.

Part-B (16 Marks)

1. Explain the properties and application of the PVC, PE, PTFE, and ABS
2. Give the detailed account on:
    (a) Urea formaldehydes
    (b) Fibre reinforced plastics
    (c) Cellulose nitrate.
3. Explain PMMA.
4. What is polymerization? Describe addition polymerization and condensation polymerization.
5. How plastic materials are classified? Explain each classification.
6. Write brief notes on following traditional ceramics
    (a) Clay products
    (b) Glasses

(c) Cements
(d) Refractory's

7. Describe the properties and applications of following structural ceramics
(a) Alumina
(b) Partially stabilized zirconia
(c) Silicon carbide (d) Silicon nitride (e) Sialon

8. Describe the structures, properties and applications of following commodity thermoplastic polymers
(a) Polyethylene
(b) Polyvinylchloride
(c) Polystyrene

UNIT V- MECHANICAL PROPERTIES AND TESTING

Part-A (16 Marks)

1. ***What is meant by mechanical properties of materials?***
   Mechanical properties are those characteristics of material that describe its behaviour under 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 by 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 ruptue takes place.
   - Malleability is the property of a material by 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 it can withstand deformation under compression without rupture.
   - Hardness is the property of a material by virtue of which it is 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 metal.***
   - Machinability
   - Castablity

- Weldability, and
- Formability or workability.

7. What are the factors affecting mechanical properties?

- Grain size
- Heat treatment
- Atmospheric exposure, and
- 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) hav high yield strength , high tensile strength, and more harness. Also fine grain results in better resistance to cracking and better surface finish.
- The materials having larger grains (i.e., coarse grained structure) exhibit better workability, hardenability, forgeability and creep resistance. But coarse grains results 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 a solid.

Sl no	Elastic deformation	Plastic deformation
1	It is the deformation of a body which completely disappears as soon as the external load is removed from the body.	It is the deformation of a body which remains even after removing the external load from the body
2	It obeys hook's law	It does not obey hook's law
3	The elastic deformation is the beginning of the progress of deformation	The plastic deformation takes place after the elastic deformation.

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

- Brittle fracture,
- Ductile fracture
- Fatigue fracture, and
- Creep fracture.

12. What is brittle fracture?

A brittle fracture may be defined as a fracture which takes place by the rapid propagation of crack with a negligible deformation.

13. ***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.

14. What is meant by fatigue fracture?

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

15. 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.

16. What are the factors affecting fatigue strength?

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

17. What is meant by creep fracture?

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

18. What are the factors affecting creep?

- Grain
- Thermal stability of the micro-structure.
- Chemical reaction
- Prior strain.

19. 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.

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

- Tensile test
- Impact test
- Bend test
- Fatigue test
- Torsion test and Creep test.

Part-B (16 Marks)

1. Describe with neat sketch fatigue test.

2. Describe with neat sketch creep test.

3. Explain the mechanism of plastic deformation by slip and twinning with neat sketch.

4. Describe how the torsion test is conducted and what are the properties deter from this test?

5. Explain the testing procedure for Vickers hardness test and mention the advantages and limitations.

6. Describe the procedure of Charpy impact testing and the properties obtained from it.

7. Explain the method of testing the materials for fatigue and how is the fatigue data presented.

8. Draw a typical creep curve and explain the various stages of creep.

9. What is meant by ductile fracture? Explain the mechanism of it.

10. Compare and contrast the Brinell, Vickers and Rockwell hardness tests.

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