AP PGECET 2024 Metallurgy
Question Paper with Solutions

Duration :120 minutes	**Total Marks :**120	**Total Questions :**120

Important Instructions

Read the following instructions carefully:

1. The Answer Sheet is inside this Test Booklet. Fill in the details in the provided columns with a blue or black ballpoint pen.
2. The test duration is 120 minutes, covering Metallurgy with 120 multiple-choice questions.
3. Each correct response awards 4 marks; each incorrect response deducts 1 mark. Total marks: 120.
4. Candidates should mark answers clearly on the Answer Sheet.
5. Rough work should be done on the provided rough sheets only.
6. The code for this booklet is F1. Ensure it matches the code on your Answer Sheet.
7. Do not leave the hall without handing over the Answer Sheet to the Invigilator.
8. Violation of rules will lead to disqualification.
9. Do not mark anything on the Answer Sheet other than the answers.

1. Which of the following does not have FCC crystal structure?

(1) Copper

(2) Sodium

(3) Lead

(4) Aluminium

Correct Answer: (2) Sodium

Solution: Sodium does not have an FCC (Face-Centered Cubic) crystal structure. Copper, lead, and aluminum have an FCC crystal structure, whereas sodium has a body-centered cubic (BCC) structure.

Quick Tip

FCC structures are known for high ductility and close-packed arrangements, which are characteristic of many metals.

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2. Froth flotation is most suitable for treating

(1) Iron ores

(2) Quartzite

(3) Sulphide ores

(4) Carbonates

Correct Answer: (3) Sulphide ores

Solution: Froth flotation is primarily used to separate hydrophobic materials from hydrophilic materials, which is most effective with sulphide ores.

Quick Tip

Froth flotation is a process used in mining to extract metals, especially from ores like sulphides and carbonates.

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3. Which of the following is a line defect found in metal crystal?

(1) Vacancies

(2) Grain boundaries

(3) Stacking faults

(4) Dislocations

Correct Answer: (4) Dislocations

Solution: Dislocations are a type of line defect in metal crystals, which allow for the deformation of the material.

Quick Tip

Dislocations play a key role in the plastic deformation of metals and affect the mechanical properties of materials.

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4. Softest phase in Fe-Fe_3C phase diagram is

(1) Austenite

(2) Cementite

(3) α ferrite

(4) Martensite

Correct Answer: (3) α ferrite

Solution: α ferrite is the softest phase in the Fe-Fe_3C phase diagram, as it is a relatively pure form of iron with a body-centered cubic structure.

Quick Tip

The α ferrite phase is soft and ductile, with a lower carbon content compared to other phases like cementite and martensite.

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5. At room temperature, Iron is ..... in lattice arrangement

(1) HCP

(2) BCC

(3) Tetragonal

(4) FCC

Correct Answer: (2) BCC

Solution: At room temperature, iron exists in a Body-Centered Cubic (BCC) lattice structure. This is typical of alpha iron (α-iron), which is stable at temperatures below 912°C.

Quick Tip

BCC structures are common in many metals at lower temperatures, contributing to their strength and brittleness.

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6. The term Ledeburite in steels refers to

(1) An intermetallic compound

(2) A solid solution

(3) An inclusion

(4) A mixture of two phases

Correct Answer: (4) A mixture of two phases

Solution: Ledeburite is a mixture of austenite and cementite found in steel, especially in eutectoid compositions. It plays a crucial role in the hardening process of steel.

Quick Tip

Ledeburite is important in the heat treatment of steel, where it influences the microstructure and hardness.

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7. The eutectoid reaction in steel occurs at

(1) 723°C

(2) 1146°C

(3) 1495°C

(4) 910°C

Correct Answer: (1) 723°C

Solution: The eutectoid reaction in steel occurs at 723°C, where austenite transforms into a mixture of pearlite (ferrite + cementite).

Quick Tip

The eutectoid reaction in the iron-carbon system is important for understanding the microstructure of steels at different temperatures.

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8. Peritectic reaction among the following is

(1) $\alpha + L \xrightarrow{Cooling} \beta$

(2) L $\xrightarrow{Cooling} \beta$

(3) $\alpha \xrightarrow{Cooling} \beta$

(4) L $\xrightarrow{Cooling} \beta$ + S

Correct Answer: (1) $\alpha + L \xrightarrow{Cooling} \beta$

Solution: The peritectic reaction occurs when a solid phase (α) and liquid phase (L) react to form a new solid phase (β), commonly seen in certain alloys like steel.

Quick Tip

The peritectic reaction is essential in understanding phase transformations in alloys, especially at intermediate temperatures.

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9. Carbon content in hypo eutectic cast iron is

(1) 0.08-0.8%

(2) 4.3-6.67%

(3) 2.0-4.3%

(4) 0.8-2.0%

Correct Answer: (3) 2.0-4.3%

Solution: Hypo eutectic cast iron contains carbon content in the range of 2.0-4.3

Quick Tip

In hypo eutectic cast iron, the carbon content is lower than the eutectic composition and results in a microstructure that is a combination of pearlite and proeutectic phases.

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10. Etching solution used for Copper is

(1) Nital

(2) 50% NH_4OH

(3) Picral

(4) 1% HF in water

Correct Answer: (2) 50% NH_4OH

Solution: The common etching solution used for copper is a 50% aqueous solution of ammonium hydroxide (NH_4OH), which is used to reveal microstructures in metallographic analysis.

Quick Tip

Ammonium hydroxide is commonly used in the etching process to reveal the fine structure of metals like copper and its alloys.

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11. Toughness of a material implies

(1) Impact strength

(2) Creep resistance

(3) Stress relieving

(4) Machinability

Correct Answer: (1) Impact strength

Solution: Toughness refers to a material's ability to absorb energy before fracturing, which is commonly associated with impact strength.

Quick Tip

Toughness is a critical property for materials that need to withstand sudden forces or impacts without breaking.

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12. Martensite transformation occurs by

(1) Nucleation-and-growth phenomenon

(2) Diffusionless transformation

(3) Lattice diffusion

(4) Spinodal decomposition

Correct Answer: (2) Diffusionless transformation

Solution: Martensite transformation in steel occurs through a diffusionless transformation, where the atoms do not diffuse but instead experience a shear transformation.

Quick Tip

Martensite is a hard phase formed in steels during rapid cooling, and its formation is diffusionless, meaning it occurs without atom movement.

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13. The fine austenite grain size in steel increases

(1) Corrosion resistance

(2) Hardenability

(3) Creep strength

(4) Impact toughness

Correct Answer: (4) Impact toughness

Solution: A finer austenite grain size in steel improves its impact toughness, which is the material's ability to absorb energy before fracturing.

Quick Tip

Fine-grained materials generally exhibit improved toughness and resistance to impact, making them ideal for applications requiring high strength.

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14. Which mode of size reduction is used by Jaw crushers?

(1) Impact

(2) Compression

(3) Cutting

(4) Attrition

Correct Answer: (2) Compression

Solution: Jaw crushers primarily use compression as the mechanism to reduce the size of materials, where the material is compressed between two surfaces.

Quick Tip

Compression-based crushers are highly effective in breaking hard and brittle materials, such as rocks and ores.

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15. Which of the following is a metal refining process?

(1) Roasting

(2) Smelting

(3) Vacuum arc remelting

(4) Calcination

Correct Answer: (3) Vacuum arc remelting

Solution: Vacuum arc remelting is a metal refining process that involves melting metal in a vacuum to remove impurities and improve the material's quality.

Quick Tip

Vacuum arc remelting is used in the production of high-quality steels and alloys, especially for aerospace applications.

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16. Kick's law relates to

(1) Final particle size

(2) Feed size

(3) Ore size

(4) Energy consumption

Correct Answer: (4) Energy consumption

Solution: Kick's law describes the relationship between energy consumption and the size reduction of particles, specifically stating that energy required for size reduction is proportional to the size of the material.

Quick Tip

Kick's law is commonly applied in particle size reduction, especially for materials that undergo significant changes in size during processing.

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17. Pine oil used in froth flotation technique acts as a

(1) Frother

(2) Collector

(3) Crusher

(4) Modifier

Correct Answer: (1) Frother

Solution: In froth flotation, pine oil is used as a frother to create a stable foam layer which helps separate minerals based on their hydrophobicity.

Quick Tip

Frothers like pine oil enhance the separation process in flotation by increasing the stability of the air bubbles.

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18. Leaching of ore is done in ..... method of metal extraction process

(1) Smelting

(2) Pyro metallurgical

(3) Hydro metallurgical

(4) Electro metallurgical

Correct Answer: (3) Hydro metallurgical

Solution: Leaching is a hydrometallurgical process used to extract metals from their ores by using water-based solutions.

Quick Tip

Hydrometallurgical processes like leaching are widely used for extracting metals such as gold, copper, and uranium from ores.

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19. Which of the following is not a function of coke in the blast furnace?

(1) Produce heat

(2) Generate reducing gases

(3) Act as spacer

(4) Act as a flux

Correct Answer: (4) Act as a flux

Solution: Coke in a blast furnace is used to produce heat, generate reducing gases, and act as a spacer. However, it does not act as a flux, which is typically performed by materials like limestone.

Quick Tip

Coke plays a critical role in the blast furnace, both as a fuel and a chemical reducing agent, helping to reduce iron ore to iron.

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20. The size of blast furnace coke is about

(1) 10-30 mm

(2) 25-80 mm

(3) 80-100 mm

(4) 25-40 mm

Correct Answer: (2) 25-80 mm

Solution: The size of blast furnace coke is typically between 25-80 mm, ensuring proper airflow and efficient heat transfer in the furnace.

Quick Tip

Coke of the right size is crucial for maintaining the proper conditions within the blast furnace for iron production.

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21. Which is an acidic refractory?

(1) Magnesite

(2) Dolomite

(3) Fireclay

(4) Chrome magnesite

Correct Answer: (1) Magnesite

Solution: Magnesite is an acidic refractory material, commonly used for high-temperature applications due to its resistance to basic slags.

Quick Tip

Acidic refractories are typically resistant to acidic environments and are used in applications where high resistance to corrosion is required.

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22. Which is the hardest structure that appears on the Fe-C equilibrium diagram?

(1) Ferrite

(2) Pearlite

(3) Austenite

(4) Cementite

Correct Answer: (4) Cementite

Solution: Cementite (Fe_3C) is the hardest structure that appears in the Fe-C equilibrium diagram, and it plays a critical role in the hardness of steel.

Quick Tip

Cementite is a hard, brittle phase in steel that can significantly influence the mechanical properties of steel alloys.

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23. Which of the following statement is wrong in Hume Rothery rules?

(1) Solute and solvent atoms possess almost equal diameters

(2) The crystal structure of two metals is the same

(3) The chemical affinity of the two metals is high

(4) Lower chemical valence metals will dissolve more in higher valence than vice versa

Correct Answer: (4) Lower chemical valence metals will dissolve more in higher valence than vice versa

Solution: The wrong statement is that lower chemical valence metals will dissolve more in higher valence metals. The rule actually states that metals with similar chemical valence are more likely to dissolve in each other.

Quick Tip

Hume Rothery rules explain the solubility of metals in each other, with the greatest solubility occurring when metals have similar atomic sizes, crystal structures, and valency.

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24. Segar cones are used for the determination of

(1) Electrical conductivity

(2) Softening temperature of refractories

(3) Spalling resistance

(4) Resistance to slag attack

Correct Answer: (2) Softening temperature of refractories

Solution: Segar cones are used to measure the softening temperature of refractories, which is a critical property in assessing their performance in high-temperature environments.

Quick Tip

Segar cones are commonly used in ceramics and refractory industries to determine the softening temperature at which a material will start to deform.

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25. Sillimanite is a

(1) Basic refractory

(2) Insulating refractory

(3) Neutral refractory

(4) High alumina refractory

Correct Answer: (4) High alumina refractory

Solution: Sillimanite is a high alumina refractory material, commonly used in the production of high-temperature equipment due to its resistance to heat and abrasion.

Quick Tip

High alumina refractories are highly resistant to heat and are widely used in industries that involve high-temperature processes.

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26. The structure produced by martempering of steel is

(1) Pearlite

(2) Austenite

(3) Martensite

(4) Bainite

Correct Answer: (3) Martensite

Solution: Martempering produces martensite, a hard and brittle phase formed when steel is cooled rapidly from austenitizing temperature in a controlled manner.

Quick Tip

Martempering is a heat treatment process that results in a martensitic microstructure, which increases the hardness of steel.

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27. Which of the following treatments is used for imparting ductility in the metals?

(1) Annealing

(2) Normalizing

(3) Hardening

(4) Tempering

Correct Answer: (1) Annealing

Solution: Annealing is a heat treatment process that softens metals, increases ductility, and relieves internal stresses by heating the material and then cooling it slowly.

Quick Tip

Annealing is commonly used to improve ductility and reduce hardness, making metals easier to form and work with.

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28. Sub-zero treatment is used for

(1) Bainite transformation

(2) Pearlite transformation

(3) Austenite transformation

(4) Retained Austenite transformation

Correct Answer: (4) Retained Austenite transformation

Solution: Sub-zero treatment is used to transform retained austenite into martensite in steel, improving its hardness and dimensional stability.

Quick Tip

Sub-zero treatment is often used in the final stages of heat treatment to remove retained austenite and improve the steel's properties.

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29. Hardenability of a steel is measured in terms of

(1) Its iron content

(2) Its carbon content

(3) The depth martensite from the surface

(4) The depth of Austenite from the surface

Correct Answer: (3) The depth martensite from the surface

Solution: Hardenability of steel refers to the ability of a material to form martensite at a given quenching rate. The depth of martensite from the surface is an important factor in measuring this property.

Quick Tip

A greater depth of martensite indicates better hardenability and more uniform hardness in the material after quenching.

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30. Compound formed during precipitation hardening of Al-Cu alloys is

(1) CuAl

(2) CuAl

(3) CuAl

(4) CuAl

Correct Answer: (2) CuAl

Solution: CuAl is the intermetallic compound formed during the precipitation hardening of Al-Cu alloys, which strengthens the material by preventing dislocation movement.

Quick Tip

Precipitation hardening enhances the strength of alloys, and CuAl is a key phase in Al-Cu alloys that significantly increases their strength.

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31. The structure produced by Austempering of steel is

(1) Austenite

(2) Pearlite

(3) Bainite

(4) Martensite

Correct Answer: (3) Bainite

Solution: Austempering is a heat treatment process that produces bainite, a microstructure formed when steel is quenched in a molten salt bath at a specific temperature.

Quick Tip

Bainite is a mixture of ferrite and cementite, offering a balance of strength and toughness.

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32. Sorbite is a mixture

(1) Ferrite and cementite

(2) Austenite and Ferrite

(3) Ferrite and pearlite

(4) Ferrite and martensite

Correct Answer: (1) Ferrite and cementite

Solution: Sorbite is a microstructure consisting of ferrite and cementite, formed under specific heat treatment conditions.

Quick Tip

Sorbite is a combination of ferrite and cementite, and it exhibits a balance of strength and ductility suitable for various engineering applications.

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33. Major alloying addition in spring steels is

(1) Aluminium

(2) Silicon

(3) Titanium

(4) Nickel

Correct Answer: (2) Silicon

Solution: Silicon is a major alloying element in spring steels. It is added to improve strength, hardness, and elasticity at high temperatures.

Quick Tip

Silicon in spring steels increases their ability to maintain strength at high temperatures and enhances their toughness and resistance to oxidation.

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34. Which of the following is not a mixture of ferrite and cementite?

(1) Troostite

(2) Pearlite

(3) Ledeburite

(4) Martensite

Correct Answer: (4) Martensite

Solution: Martensite is a solid solution of carbon in iron and does not contain a mixture of ferrite and cementite, unlike troostite, pearlite, and ledeburite.

Quick Tip

Martensite forms when steel is rapidly cooled (quenched) and is known for its hardness but brittleness.

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35. Malleable cast iron is obtained by controlled heat treatment of

(1) Grey cast iron

(2) Nodular cast iron

(3) White cast iron

(4) Flake graphite cast iron

Correct Answer: (2) White cast iron

Solution: Malleable cast iron is made by annealing white cast iron, which is a brittle form of cast iron, to convert the cementite phase into a more ductile structure.

Quick Tip

Malleable cast iron is more ductile than white cast iron, and it is often used for making parts that need to withstand shock and wear.

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36. The diffusion inequality of components in a binary solution of alloys is given by

(1) Cottrell effect

(2) Graham's law

(3) Fick's law

(4) Kirkendall effect

Correct Answer: (3) Fick's law

Solution: Fick's law describes the diffusion process and the relationship between the diffusion rate and the concentration gradient in a binary solution of alloys.

Quick Tip

Fick's law is fundamental in understanding how atoms move through alloys during processes such as heat treatment or alloy formation.

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37. Stress causing a deformation of ..... % is called yield strength

(1) 1.0

(2) 0.01

(3) 0.2

(4) 3.3

Correct Answer: (3) 0.2

Solution: The yield strength of a material is the stress at which it causes a permanent deformation of 0.2

Quick Tip

A material's yield strength is essential for determining how much load a material can bear before it starts to deform permanently.

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38. The diameter of the ball in BHN test for steel and other hard materials is

(1) 5 mm

(2) 10 mm

(3) 25 mm

(4) 50 mm

Correct Answer: (2) 10 mm

Solution: In the Brinell Hardness Number (BHN) test, the diameter of the ball used for testing steel and other hard materials is typically 10 mm.

Quick Tip

The 10 mm diameter ball is commonly used in the BHN test for materials with medium hardness, such as steel and cast iron.

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39. In which of the following hardness tests is the Brale indenter used for indentation?

(1) Vickers test

(2) Shore test

(3) Brinell test

(4) Rockwell test

Correct Answer: (3) Brinell test

Solution: The Brinell hardness test uses the Brale indenter, which is a steel or carbide ball, to create an impression on the material being tested.

Quick Tip

Brinell is commonly used for testing materials with coarse or uneven textures, where a larger indenter helps in forming accurate impressions.

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40. The ability of a material to withstand suddenly applied loads is called

(1) Creep strength

(2) Hardness

(3) Impact strength

(4) Fatigue strength

Correct Answer: (3) Impact strength

Solution: Impact strength refers to the ability of a material to withstand a sudden force or shock without breaking or fracturing.

Quick Tip

Impact strength is crucial for materials used in construction, automotive, and aerospace industries where sudden forces can be encountered.

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41. The fatigue limit of metals is decreased by

(1) Carburizing

(2) Nitriding

(3) Carbonitriding

(4) Decarburizing

Correct Answer: (4) Decarburizing

Solution: Decarburizing decreases the fatigue limit of metals by reducing the carbon content, which weakens the material and makes it more susceptible to fatigue failure.

Quick Tip

Decarburizing is commonly performed during heat treatment to improve surface properties, but it can reduce the overall strength of the material.

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42. Plastic deformation of metal below its recrystallization temperature is called

(1) Cold working

(2) Hot working

(3) Deep drawing

(4) Tempering

Correct Answer: (1) Cold working

Solution: Cold working involves the plastic deformation of metals at temperatures below their recrystallization temperature, leading to hardening and strengthening of the material.

Quick Tip

Cold working is used to shape and strengthen materials, but it can also cause residual stresses and reduced ductility if not followed by annealing.

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43. At what temperature grains and grain boundaries will have equal strength?

(1) Recrystallization temperature

(2) Curie temperature

(3) Absolute zero temperature

(4) Equi cohesive temperature

Correct Answer: (1) Recrystallization temperature

Solution: At the recrystallization temperature, grains and grain boundaries have equal strength, which allows for grain growth and improved ductility in metals.

Quick Tip

The recrystallization temperature is a critical point for shaping and annealing metals to relieve stresses and improve mechanical properties.

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44. Which method is not used to measure the residual stress of a given material?

(1) Magnetic particle method

(2) Radiography

(3) Dye-penetrant method

(4) Ultrasonic testing

Correct Answer: (3) Dye-penetrant method

Solution: Dye-penetrant method is used for detecting surface defects rather than measuring residual stress. Methods like radiography and ultrasonic testing are typically used to measure residual stress.

Quick Tip

Residual stress measurement is important for evaluating material integrity and performance, especially in critical engineering applications.

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45. Which of the following is not used for the manufacture of bearing materials?

(1) Steel

(2) Copper

(3) Babbit materials

(4) Pig iron

Correct Answer: (4) Pig iron

Solution: Pig iron is not used for the manufacture of bearing materials. Steel, copper, and babbit materials are commonly used in bearing manufacturing due to their specific properties.

Quick Tip

Pig iron is too brittle for bearing applications, which require materials with good wear resistance and low friction.

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46. Hooke's law holds good up to

(1) Plastic limit

(2) Proportional limit

(3) Yield point

(4) Ultimate tensile strength

Correct Answer: (2) Proportional limit

Solution: Hooke's law holds true up to the proportional limit, which is the point where stress is proportional to strain. Beyond this point, the material starts to deviate from elastic behavior.

Quick Tip

Hooke's law is fundamental in understanding elastic deformation, and it holds true until the material reaches the proportional limit.

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47. In CO moulding process ..... is used as binder

(1) Water

(2) Dextrine

(3) Sodium silicate

(4) Bentonite

Correct Answer: (3) Sodium silicate

Solution: In the CO moulding process, sodium silicate is used as a binder, which reacts with CO to form a hard mold.

Quick Tip

Sodium silicate is commonly used as a binder in sand casting processes due to its strong binding properties and the reaction with CO.

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48. Which of the following is a powder production method?

(1) Rolling

(2) Tapping

(3) Forging

(4) Atomization

Correct Answer: (4) Atomization

Solution: Atomization is a powder production method that involves breaking a liquid metal stream into fine droplets, which solidify into powder.

Quick Tip

Atomization is widely used for producing metal powders for powder metallurgy and 3D printing applications.

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49. Copper materials exhibit ..... fracture

(1) Flat

(2) Combined

(3) Cup and cone

(4) Helical

Correct Answer: (3) Cup and cone

Solution: Copper materials typically exhibit cup and cone fracture, which is a ductile fracture characterized by a conical appearance on the fractured surface.

Quick Tip

Ductile fractures like cup and cone are usually seen when the material undergoes plastic deformation before breaking.

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50. Which of the following is an ore of Titanium?

(1) Bauxite

(2) Ilmenite

(3) Chacopyrite

(4) Limonite

Correct Answer: (2) Ilmenite

Solution: Ilmenite is the primary ore of titanium. It is a titanium-iron oxide mineral commonly used to extract titanium metal.

Quick Tip

Ilmenite (FeTiO) is the most important source for titanium extraction and is often found in beach sands.

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51. Cementite (Fe_3C) crystal structure is

(1) Orthorhombic

(2) BCT

(3) HCP

(4) FCC

Correct Answer: (1) Orthorhombic

Solution: Cementite (Fe_3C) has an orthorhombic crystal structure, which is one of the important phases in the iron-carbon system.

Quick Tip

Cementite is a hard, brittle compound found in steels and cast irons, and it plays a key role in determining material properties.

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52. Most closely packed planes in face-centered cubic lattice are

(1) (110)

(2) (112)

(3) (100)

(4) (111)

Correct Answer: (4) (111)

Solution: The most closely packed planes in the face-centered cubic (FCC) lattice are the (111) planes, which are also the densest planes in terms of atomic packing.

Quick Tip

In FCC crystals, the (111) planes are the most efficient for atomic stacking, contributing to high ductility and strength in FCC metals.

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53. Stacking faults are ..... imperfections

(1) Point

(2) Line

(3) Surface

(4) Volume

Correct Answer: (3) Surface

Solution: Stacking faults are surface imperfections that occur in the crystal structure when a misalignment or shift happens during the stacking of atomic planes.

Quick Tip

Stacking faults can affect the mechanical properties of materials, particularly in metals and alloys with close-packed structures.

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54. Which of the following alloys can be strengthened by Age-hardening?

(1) Cu - Sn

(2) Cu - Zn

(3) Cu - Ni

(4) Al - Cu

Correct Answer: (4) Al - Cu

Solution: Aluminium-copper (Al-Cu) alloys are commonly strengthened by age-hardening, a process that involves the formation of precipitates that hinder dislocation motion.

Quick Tip

Age-hardening is widely used to strengthen alloys by heating them to specific temperatures, which leads to precipitation of harder phases.

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55. Surgical instruments are made of

(1) Plain carbon steels

(2) Titanium alloys

(3) Stainless steels

(4) Copper alloys

Correct Answer: (3) Stainless steels

Solution: Surgical instruments are primarily made from stainless steels due to their resistance to corrosion, strength, and biocompatibility.

Quick Tip

Stainless steels are preferred in surgical instruments because of their ability to resist rust and their non-reactivity with biological tissues.

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56. Razor blades are made with ..... % of carbon steel

(1) Low carbon steel

(2) Medium carbon steel

(3) Mild steel

(4) High carbon steel

Correct Answer: (4) High carbon steel

Solution: Razor blades are typically made from high carbon steel, which provides the hardness and sharpness required for a durable cutting edge.

Quick Tip

High carbon steel is used in razor blades due to its excellent hardness and ability to retain a sharp edge.

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57. Zirconium alloys are used in nuclear reactors as

(1) Cladding material

(2) Catalyst

(3) Moderator

(4) Fuel

Correct Answer: (1) Cladding material

Solution: Zirconium alloys are used as cladding materials in nuclear reactors due to their excellent corrosion resistance and low neutron absorption.

Quick Tip

Zirconium alloys are ideal for cladding because they provide a protective barrier between the reactor coolant and the fuel.

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58. To obtain high corrosion resistance of the steel, which of the following elements are added?

(1) Carbon, Silicon

(2) Chromium, Nickel

(3) Carbon, Tungsten

(4) Copper, Titanium

Correct Answer: (2) Chromium, Nickel

Solution: Chromium and nickel are commonly added to steel to improve its corrosion resistance, which is a characteristic of stainless steels.

Quick Tip

Chromium and nickel enhance the corrosion resistance of steel, making it ideal for use in harsh environments such as marine applications and chemical industries.

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59. Dephosphorization is favorable in the following conditions of the steel-making process

(1) Acid slag and oxidizing atmosphere

(2) Acid slag and reducing atmosphere

(3) Basic slag and oxidizing atmosphere

(4) Basic slag and reducing atmosphere

Correct Answer: (1) Acid slag and oxidizing atmosphere

Solution: Dephosphorization is most effective when acid slag is used in an oxidizing atmosphere, as this combination helps remove phosphorus from the steel.

Quick Tip

Dephosphorization improves the quality of steel by removing harmful impurities like phosphorus, which can embrittle steel.

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60. Finest particles in blast furnace gas are removed by

(1) Dust catcher

(2) Electrostatic precipitator

(3) Wet scrubber

(4) Blast furnace stoves

Correct Answer: (2) Electrostatic precipitator

Solution: Electrostatic precipitators are used to remove the finest particles from blast furnace gas by charging the particles and collecting them on electrodes.

Quick Tip

Electrostatic precipitators are highly effective in capturing fine dust and particles from exhaust gases, preventing environmental pollution.

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61. Which of the following is not an iron ore?

(1) Banded Hematite Quartzite (BHQ)

(2) Hematite

(3) Goethite

(4) Chalcopyrite

Correct Answer: (4) Chalcopyrite

Solution: Chalcopyrite is a copper ore, not an iron ore. The other options are iron ores commonly used in steelmaking.

Quick Tip

While Chalcopyrite is a significant copper ore, it does not contain iron and is not used for iron extraction.

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62. Which of the following is a chief source of sulfur entry in the blast furnace?

(1) Iron ore

(2) Coke

(3) Sinter

(4) Flux

Correct Answer: (2) Coke

Solution: Coke is the primary source of sulfur in the blast furnace due to its sulfur content. The sulfur can then be transferred into the iron produced during the smelting process.

Quick Tip

Efforts to reduce sulfur content in blast furnaces often focus on using low-sulfur coke or treating the gas streams for sulfur removal.

---

63. The favorable conditions for desulphurization of iron are

(1) Both slag basicity and temperature should be high

(2) Atmosphere should be oxidizing

(3) Slag basicity should be low and temperature should be high

(4) Slag should be viscous

Correct Answer: (1) Both slag basicity and temperature should be high

Solution: High slag basicity and temperature provide the best conditions for desulphurization of iron in the blast furnace by promoting the formation of slag that absorbs sulfur efficiently.

Quick Tip

Controlling the temperature and slag chemistry is crucial for effective desulphurization in steelmaking processes.

---

64. Blue dust is

(1) Generated during iron making

(2) Generated during steel making

(3) Generated during mining

(4) Dust collected from exhaust gases

Correct Answer: (4) Dust collected from exhaust gases

Solution: Blue dust refers to fine dust particles often collected from the exhaust gases of blast furnaces or coke ovens, which contain high levels of iron oxides.

Quick Tip

Blue dust is often recycled in steelmaking processes or used in sintering to improve the efficiency of the furnace.

---

65. Iron ore sintering employs the principle of .....

(1) Down draught sintering

(2) Up draught sintering

(3) Smelting

(4) Roasting

Correct Answer: (1) Down draught sintering

Solution: Down draught sintering is used in the sintering process for iron ores, where heat flows downward through the material, promoting uniform sintering and efficient fuel use.

Quick Tip

Down draught sintering is the most common method used for agglomerating iron ore fines, allowing for better control over the sintering process.

---

66. High alumina content in the blast furnace slag .....

(1) Increases its melting point, but decreases its viscosity

(2) Does not affect its melting point but increases its viscosity

(3) Decreases both its melting point but increases its viscosity

(4) Increases both its melting point and viscosity

Correct Answer: (4) Increases both its melting point and viscosity

Solution: High alumina content in blast furnace slag increases both the melting point and viscosity, which helps in trapping impurities but can make the slag more difficult to handle.

Quick Tip

The viscosity of slag affects the ease of its removal and the overall efficiency of the blast furnace operation.

---

67. Lever rule is used to evaluate the .....

(1) Relative amounts of two phases in equilibrium at any specified temperature

(2) Chemical composition of the phases of an alloy in equilibrium at any specified temperature

(3) Residual stresses in a given alloy

(4) Number of phases present in a given alloy

Correct Answer: (1) Relative amounts of two phases in equilibrium at any specified temperature

Solution: The lever rule is used to calculate the relative proportions of two phases in equilibrium at a given temperature, particularly in phase diagrams.

Quick Tip

The lever rule provides a simple way to estimate phase fractions in equilibrium without needing extensive calculations.

---

68. Catch carbon technique is employed in LD steel making process to produce

(1) Low carbon steel

(2) High alloy steel

(3) High carbon steel

(4) Killed steel

Correct Answer: (3) High carbon steel

Solution: The catch carbon technique is used to adjust the carbon content in steel during the LD (Linz-Donawitz) steelmaking process, primarily for producing high carbon steel.

Quick Tip

The catch carbon technique helps in controlling carbon levels to achieve the desired steel grade during the refining process.

---

69. Composites strength is evaluated by .....

(1) Hooke's law

(2) Power law

(3) Fick's law

(4) Rule of mixture

Correct Answer: (4) Rule of mixture

Solution: The strength of composites is typically evaluated using the rule of mixture, which assumes a linear relationship between the strength of individual phases and their volume fractions.

Quick Tip

The rule of mixture is a useful approximation for estimating properties like strength and stiffness of composite materials based on the properties of individual components.

---

70. Salamander tapping in blast furnace is done after

(1) Blowing out

(2) Banking

(3) Back draughting

(4) Blowing in

Correct Answer: (1) Blowing out

Solution: Salamander tapping refers to the removal of liquid iron from the blast furnace, which is typically done after blowing out the furnace to clear the system for tapping.

Quick Tip

Blowing out and tapping are critical stages in the blast furnace process to maintain proper operation and ensure consistent iron production.

---

71. Which of the following is a creep deformation mechanism?

(1) Grain sliding

(2) Grain boundary sliding

(3) Dislocations pile up

(4) Strain hardening

Correct Answer: (2) Grain boundary sliding

Solution: Grain boundary sliding is one of the primary mechanisms for creep deformation at elevated temperatures, where the grains slide past each other, leading to plastic deformation over time.

Quick Tip

Creep mechanisms like grain boundary sliding are important in materials exposed to high-temperature environments for extended periods.

---

72. Which of the following is not a metal matrix composites fabrication technique?

(1) Vortex method

(2) Squeeze casting

(3) Pultrusion

(4) Duralcan process

Correct Answer: (3) Pultrusion

Solution: Pultrusion is a fabrication technique used for making composite materials with continuous fibers and resin matrices, but it is not typically used for metal matrix composites.

Quick Tip

Pultrusion is commonly used for polymer matrix composites, while metal matrix composites are fabricated using methods like squeeze casting and vortex methods.

---

73. Critical fibre length of a composite is expressed by the following equation

(1) $L_c = [\sigma d]/[2\tau_C]$

(2) $L_c = [\sigma + d]/[2\tau_C]$

(3) $L_c = [2\tau_C]$ / $[\sigma d]/$

(4) $L_c = [\sigma - d]/[2\tau_C]$

Correct Answer: (1) $L_c = [\sigma d]/[2\tau_C]$

Solution: The critical fibre length (L_c) in a composite is calculated using the equation above, where is the stress, d is the fibre diameter, and $\tau is the interfacial shear strength.$

Quick Tip

Understanding the critical fibre length helps in evaluating the performance of composites based on their fibre-matrix bonding.

---

74. Which of the following employs a bottom blowing operation?

(1) L.D. converter

(2) Rotor

(3) OBM

(4) Kaldo furnace

Correct Answer: (3) OBM

Solution: The OBM (Oxygen Blown Furnace) process uses a bottom-blowing operation to introduce oxygen into the bath for refining steel.

Quick Tip

Bottom blowing helps in better mixing of oxygen and metal, leading to improved efficiency in refining processes.

---

75. In Basic steel making process, ... slag is prepared to remove the impurities

(1) Dry slag

(2) Wet slag

(3) Neutral slag

(4) Reducing slag

Correct Answer: (2) Wet slag

Solution: Wet slag is prepared in the basic steelmaking process to effectively remove impurities such as sulfur and phosphorus.

Quick Tip

Slag plays an important role in trapping impurities and ensuring the quality of the steel produced during the refining process.

---

76. Killing of the steel bath is aimed to remove .....

(1) Carbon

(2) Sulphur

(3) Phosphorous

(4) Oxygen

Correct Answer: (4) Oxygen

Solution: The killing of the steel bath refers to the process of removing dissolved oxygen, which is done by adding deoxidizing agents to the bath.

Quick Tip

Oxygen removal is crucial for producing high-quality steel, as excess oxygen can lead to undesirable properties in the final product.

---

77. Glass ceramics possess .....

(1) Fine grain structure

(2) Non-crystalline structure

(3) Hard and brittle

(4) Low impact strength

Correct Answer: (1) Fine grain structure

Solution: Glass ceramics typically have a fine grain structure that contributes to their excellent mechanical properties, including strength and thermal resistance.

Quick Tip

Glass ceramics are known for their combination of glassy and crystalline properties, making them suitable for various high-temperature applications.

---

78. Which of the following is an oxide ore of copper?

(1) Chalcocite

(2) Chalcopyrite

(3) Malachite

(4) Bornite

Correct Answer: (3) Malachite

Solution: Malachite is an important copper ore composed primarily of copper carbonate hydroxide ($Cu_2CO_3(OH)_2$), while the other options are copper ores containing sulfides or oxides.

Quick Tip

Malachite is commonly found in copper-rich regions and is a valuable source for copper extraction.

---

79. In Parkes process, desilvering of molten lead is affected by the addition of

(1) Carbon

(2) Copper

(3) Aluminum

(4) Zinc

Correct Answer: (4) Zinc

Solution: In the Parkes process, zinc is added to molten lead to help remove silver by forming an alloy with silver that can be easily separated.

Quick Tip

Zinc's ability to form an alloy with silver makes it effective in the desilvering process in lead refining.

---

80. The use of bacterial leaching is

(1) Refining of metals

(2) Fast recovery of metal values

(3) In situ-leaching of low-grade ores

(4) Leaching of enriched ores

Correct Answer: (3) In situ-leaching of low-grade ores

Solution: Bacterial leaching is primarily used for in situ leaching of low-grade ores, as it is a more environmentally friendly method for extracting metals.

Quick Tip

Bacterial leaching uses microorganisms to dissolve and extract valuable metals from ores, reducing the need for harsh chemical treatments.

---

81. Lead-free solders are made with

(1) Iron based alloys

(2) Tin based alloys

(3) Magnesium based alloys

(4) Aluminium based alloys

Correct Answer: (2) Tin based alloys

Solution: Lead-free solders are typically made from tin-based alloys, which are safer for the environment and human health compared to traditional lead-based solders.

Quick Tip

Tin-based alloys are commonly used for lead-free soldering due to their good melting point and excellent conductivity.

---

82. Which is the most weldable of all metals?

(1) Plain carbon steels

(2) Stainless steels

(3) Aluminium

(4) Brass

Correct Answer: (1) Plain carbon steels

Solution: Plain carbon steels are the most weldable of all metals due to their low carbon content, which makes them easier to weld without cracking.

Quick Tip

Plain carbon steels are often used in welding due to their high weldability and ease of processing compared to other metals like stainless steel or aluminum.

---

83. The formation of corrosion retarding films on metal surfaces is known as

(1) Polarization

(2) Passivation

(3) Cavitation

(4) Pitting

Correct Answer: (2) Passivation

Solution: Passivation refers to the formation of a protective oxide film on metal surfaces that prevents further corrosion, especially in materials like stainless steel.

Quick Tip

Passivation improves the corrosion resistance of metals, particularly in aggressive environments like acidic or saline conditions.

---

84. Example of a sacrificial anode which is used in the protection of underground pipelines is

(1) Steel

(2) Platinum

(3) Graphite

(4) Magnesium

Correct Answer: (4) Magnesium

Solution: Magnesium is commonly used as a sacrificial anode for corrosion protection of underground pipelines due to its higher reactivity compared to steel and other metals.

Quick Tip

Magnesium sacrificial anodes are widely used to protect steel pipelines from corrosion by acting as a more reactive material.

---

85. Enthalpy "H" is defined as

(1) H = E - PV

(2) H = E + PV

(3) H = F - TS

(4) H = F + PV

Correct Answer: (2) H = E + PV

Solution: Enthalpy (H) is defined as the sum of internal energy (E) and the product of pressure (P) and volume (V), as represented by the equation H = E + PV.

Quick Tip

Enthalpy is a state function that is used to measure the heat content of a system under constant pressure.

---

86. The main cause to exist congruent melting alloys in a given isomorphous system is

(1) Large atomic size difference between solvent and solute

(2) Variation in crystal structures of solvent and solute

(3) Variation in chemical valance factor of solvent and solute

(4) Variation in chemical composition of solvent and solute

Correct Answer: (1) Large atomic size difference between solvent and solute

Solution: The large atomic size difference between the solvent and solute is the primary factor that allows the formation of congruent melting alloys in an isomorphous system.

Quick Tip

In isomorphous alloys, a large atomic size difference promotes the solid solubility of one element in another.

---

87. Degrees of freedom at triple point will be

(1) 0

(2) 1

(3) 2

(4) 3

Correct Answer: (1) 0

Solution: At the triple point of a substance, all three phases coexist in equilibrium, and there are no degrees of freedom (0) as the temperature and pressure are fixed.

Quick Tip

The triple point is unique because all phases of a substance coexist in equilibrium at a specific temperature and pressure.

---

88. The free energy changes at equilibrium is

(1) Positive

(2) Negative

(3) Intermediate

(4) Zero

Correct Answer: (4) Zero

Solution: At equilibrium, the free energy change is zero, indicating that the system is at a state of maximum stability.

Quick Tip

In thermodynamics, when a system is in equilibrium, the Gibbs free energy is minimized, and the change in free energy is zero.

---

89. For a spontaneous process

(1) Both Free energy and entropy decrease

(2) Free energy increases

(3) Free energy decreases whereas the entropy increases

(4) Free energy is zero

Correct Answer: (3) Free energy decreases whereas the entropy increases

Solution: For a process to be spontaneous, the free energy must decrease, while entropy (a measure of disorder) typically increases.

Quick Tip

A spontaneous process tends to result in an increase in entropy, which aligns with the second law of thermodynamics.

---

90. Entropy is a measure of

(1) Disorder of a system

(2) Orderly behavior of a system

(3) Only temperature changes of the system

(4) Equilibrium of system

Correct Answer: (1) Disorder of a system

Solution: Entropy is a thermodynamic quantity that measures the level of disorder or randomness in a system.

Quick Tip

Entropy is often considered as a measure of uncertainty or disorder, and it increases in spontaneous processes.

---

91. Ellingham diagrams for M MOx reactions is a plot of

(1) ΔG vs T

(2) ΔG° vs T

(3) ΔG° vs 1/T

(4) ΔG° vs 1/T

Correct Answer: (3) ΔG° vs 1/T

Solution: Ellingham diagrams plot the Gibbs free energy (ΔG) of a reaction as a function of temperature, often expressed as ΔG° vs 1/T to show the temperature dependence of the reaction's feasibility.

Quick Tip

Ellingham diagrams are used to understand the thermodynamics of oxidation reactions and to predict which reactions are more likely to occur at different temperatures.

---

92. In Ellingham diagrams, the reaction that is parallel to the temperature axis is

(1) $2CO + O_2 = 2CO_2$

(2) $2C + O_2 = 2CO_2$

(3) $C + O_2 = CO_2$

(4) $2Zn + O_2 = 2ZnO$

Correct Answer: (4) $2Zn + O_2 = 2ZnO$

Solution: In Ellingham diagrams, the reaction that is parallel to the temperature axis typically represents a reaction where the standard free energy change does not vary significantly with temperature, such as the oxidation of zinc.

Quick Tip

Reactions that are parallel to the temperature axis on an Ellingham diagram are often those where the change in Gibbs free energy is independent of temperature.

---

93. Dental alloys are casted by ..... process

(1) True centrifugal

(2) Shell moulding

(3) CO2 moulding process

(4) Investment casting

Correct Answer: (4) Investment casting

Solution: Dental alloys are typically cast using the investment casting process, which provides high precision and is essential for creating detailed dental prostheses.

Quick Tip

Investment casting is often used for intricate shapes like dental alloys because it allows for excellent surface finish and dimensional accuracy.

---

94. The ideal theoretical shape of a Riser is

(1) Conical

(2) Rectangular

(3) Cylindrical

(4) Cubic

Correct Answer: (3) Cylindrical

Solution: The ideal theoretical shape of a riser in casting is cylindrical because this shape allows for uniform feeding of molten metal into the mold, minimizing the occurrence of defects.

Quick Tip

Risers are designed to allow molten metal to flow into the mold cavity to compensate for shrinkage during solidification, and the cylindrical shape is the most efficient for this purpose.

---

95. Plastic goods are usually produced by

(1) Shell moulding

(2) Injection moulding

(3) Wet sand moulding

(4) Dry sand moulding

Correct Answer: (2) Injection moulding

Solution: Plastic goods are commonly produced using injection moulding, a process where molten plastic is injected into a mold to form complex shapes.

Quick Tip

Injection moulding is widely used in the production of plastic parts due to its speed, accuracy, and cost-effectiveness for high-volume production.

---

96. Blow holes are casting defects caused by

(1) Excessive gaseous substances not able to escape

(2) Discontinuity in metal casting resulting from hindered contraction

(3) Two streams of metals that are too cold to figure properly

(4) Some sand shearing from the cope surface

Correct Answer: (1) Excessive gaseous substances not able to escape

Solution: Blow holes in casting are caused by the entrapment of gases, which cannot escape from the molten metal during solidification, leading to defects in the final casting.

Quick Tip

Proper venting of molds and careful control of the molten metal's temperature can help minimize the occurrence of blow holes during casting.

---

97. Which of the following is a eutectic reaction?

(1) $L \rightarrow$ Cooling α

(2) $L \rightarrow$ Cooling $\alpha + \beta$

(3) $L \rightarrow$ Cooling β

(4) $\alpha + L \rightarrow$ Cooling β

Correct Answer: (2) $L \rightarrow$ Cooling $\alpha + \beta$

Solution: A eutectic reaction involves the simultaneous solidification of two phases from a liquid phase at a specific composition and temperature, as seen in option (2).

Quick Tip

Eutectic reactions typically have a sharp melting point, and are important in alloy systems for creating materials with desirable properties.

---

98. Which is the top-down approach method for the synthesis of Nano materials?

(1) Chemical vapour deposition

(2) Sol-Gel technique

(3) High energy ball milling

(4) Chemical precipitation method

Correct Answer: (3) High energy ball milling

Solution: High energy ball milling is a top-down method for producing nanoparticles by reducing the size of bulk materials through high-energy impacts.

Quick Tip

High energy ball milling is a popular method for synthesizing nanoparticles, as it allows for the production of a variety of materials with controlled sizes and shapes.

---

99. TIG is especially useful in welding for the following alloys

(1) Stainless steels

(2) Aluminium and its alloys

(3) Titanium and its alloys

(4) Cast Irons

Correct Answer: (2) Aluminium and its alloys

Solution: Tungsten Inert Gas (TIG) welding is especially useful for welding non-ferrous metals such as aluminium and its alloys due to the precise heat control it offers.

Quick Tip

TIG welding is preferred for thin materials and alloys like aluminium because it provides high-quality, clean welds with minimal distortion.

---

100. Electrode is consumed in ..... welding process

(1) Gas

(2) TIG

(3) Thermit

(4) Arc

Correct Answer: (4) Arc

Solution: In arc welding, the electrode is consumed during the welding process, which melts the electrode to form the weld.

Quick Tip

Arc welding typically uses an electrode that melts to form a weld pool, whereas processes like TIG use a non-consumable electrode.

---

101. Cold working of metal reduces its

(1) Ductility

(2) Hardness

(3) Ultimate tensile strength

(4) Electrical resistance

Correct Answer: (1) Ductility

Solution: Cold working increases the hardness and strength of metals but decreases their ductility due to strain hardening.

Quick Tip

Cold working improves strength through strain hardening but at the cost of ductility, making the material less capable of deformation.

---

102. The collapsible toothpaste tube is produced by ..... extrusion

(1) Direct

(2) Impact

(3) Tube

(4) Indirect

Correct Answer: (2) Impact

Solution: The collapsible toothpaste tube is typically produced by impact extrusion, where the metal is forced into a mold using a high-energy impact.

Quick Tip

Impact extrusion is widely used for making hollow shapes like tubes due to its ability to create thin-walled parts efficiently.

---

103. Dislocation tangles are the regions of

(1) Defect free areas

(2) Dislocation free areas

(3) Low dislocation density areas

(4) High dislocation density areas

Correct Answer: (4) High dislocation density areas

Solution: Dislocation tangles form in regions of high dislocation density, where dislocations interact and become tangled due to plastic deformation.

Quick Tip

Dislocation tangles play a significant role in the strengthening of materials by preventing further movement of dislocations.

---

104. Critical resolved shear stress is expressed by the following equation

(1) $\tau_R = \frac{P}{A} \cos\phi \sin\lambda$

(2) $\tau_R = \frac{P}{A} \sin\phi \cos\lambda$

(3) $\tau_R = \frac{P}{A} \cos\phi \cos\lambda$

(4) $\tau_R = \frac{P}{A} \sin\phi \sin\lambda$

Correct Answer: (1) $\tau_R = \frac{P}{A} \cos\phi \sin\lambda$

Solution: The critical resolved shear stress (τ_R) is calculated based on the applied force, the area of the slip plane, and the angles of the applied force relative to the slip direction and plane.

Quick Tip

This equation is used in the Schmid law, which describes the relationship between applied stress and slip in crystalline materials.

---

105. Anti-Phase Boundaries (APB) are existing in ..... strengthening mechanism

(1) Grain boundary strengthening mechanism

(2) Solid solution strengthening mechanism

(3) Precipitation hardening strengthening mechanism

(4) Strain hardening strengthening mechanism

Correct Answer: (2) Solid solution strengthening mechanism

Solution: Anti-phase boundaries (APB) are related to the solid solution strengthening mechanism, where the addition of alloying elements leads to lattice distortions.

Quick Tip

Solid solution strengthening is achieved when solute atoms are added to a solvent, causing a distortion in the lattice that impedes dislocation movement.

---

106. Which alloying element does not shift TTT diagram or does not retard the transformation of austenite to pearlite or bainite?

(1) Cobalt

(2) Nickel

(3) Copper

(4) Aluminium

Correct Answer: (1) Cobalt

Solution: Cobalt does not significantly shift the TTT diagram, making it one of the alloying elements that does not impede the transformation of austenite into pearlite or bainite.

Quick Tip

Cobalt is often used in steel alloys because it enhances the strength and hardness without significantly altering the phase transformation behavior.

---

107. When two different metals placed in contact, when one is heated, an EMF is generated. This effect is called as

(1) Thomson effect

(2) Temperature effect

(3) Seebeck effect

(4) Junction-diode effect

Correct Answer: (3) Seebeck effect

Solution: The Seebeck effect occurs when two dissimilar metals are joined, and a temperature difference generates an electromotive force (EMF).

Quick Tip

The Seebeck effect is used in thermocouples to measure temperature by generating a voltage that is proportional to the temperature difference.

---

108. Calculate the Pilling-Bedworth ratio when Fe oxides to FeO. The atomic weight of Fe is 55.8 gm, the atomic weight of Oxygen is 16 gm, density of Fe is 7.87 gm/cc and density of FeO is 5.70 gm/cc

(1) 0.777

(2) 3.777

(3) 2.777

(4) 1.777

Correct Answer: (1) 0.777

Solution: The Pilling-Bedworth ratio is calculated by comparing the volume of the oxide produced to the volume of metal consumed. For Fe to FeO, it results in a ratio of 0.777.

Quick Tip

A Pilling-Bedworth ratio greater than 1 indicates a protective oxide layer, while a ratio less than 1 suggests the oxide may not provide protection.

---

109. Solution of the system of equations $3x + y + 2z = 3$, $2x - 3y - z = -3$, $x + 2y + z = 4$

(1) $(1, 2, 1)$

(2) $(1, 2, -1)$

(3) $(2, 3, 1)$

(4) $(4, 3, 2)$

Correct Answer: (2) $(1, 2, -1)$

Solution: The solution to this system of linear equations can be obtained by using methods like substitution or matrix operations.

Quick Tip

For systems of linear equations, matrix methods like Gaussian elimination are useful to find the solution efficiently.

---

110. If $f(x) = (x^2 - 16)^2$, where x is real, $f(x)$ has

(1) Two maxima and one minimum

(2) One maxima and 2 minima

(3) Three minima

(4) Three maxima

Correct Answer: (2) One maxima and 2 minima

Solution: The function $f(x) = (x^2 - 16)^2$ has two minima at $x = \pm 4$ and a maximum at $x = 0$.

Quick Tip

To analyze the maxima and minima of a function, find its derivative and set it equal to zero to determine critical points.

---

111. If A is an orthogonal matrix, then A^{-1} is

(1) Symmetric

(2) Skew-symmetric

(3) Orthogonal

(4) Hermitian

Correct Answer: (3) Orthogonal

Solution: The inverse of an orthogonal matrix is also orthogonal, i.e., $A^{-1} = A^T$.

Quick Tip

Orthogonal matrices preserve length and angle, making them useful in rotations and reflections in geometry and linear algebra.

---

112. If f $= f_1(y,z)\hat{i} + f_2(z,x)\hat{j} + f_3(x,y)\hat{k}$**, then** f **is**

(1) Irrotational

(2) Solenoidal

(3) Both Irrotational & Solenoidal

(4) Gradient

Correct Answer: (2) Solenoidal

Solution: A vector field that is solenoidal has zero divergence. In this case, the field satisfies the condition for being solenoidal.

Quick Tip

A solenoidal vector field has zero divergence, meaning that there is no net flow out of any region of space.

---

113. The work done in displacing a particle from $r = 0$ **to** $r = 1$ **in a curve** $x = t^2 + 1$ **and** $z = t^2 + 1$ **in a force field** $\mathbf{F} = (2xy, 3x, -5z)$ **is**

(1) $-\frac{19}{2}$

(2) $-\frac{14}{3}$

(3) $-\frac{21}{2}$

(4) 5

Correct Answer: (3) $-\frac{21}{2}$

Solution: The work done can be calculated by evaluating the line integral of the force field along the path from $r = 0$ to $r = 1$.

Quick Tip

Work is the integral of the force along a path. For vector fields, the line integral calculates the total work done by a force.

---

114. If $\mathbf{a}$ is a constant vector, then div$[\mathbf{a} \times (\mathbf{r} \times \mathbf{a})]$ is

(1) $2a^2$

(2) $3a^2$

(3) $6a^2$

(4) $4a^2$

Correct Answer: (1) $2a^2$

Solution: Using the vector calculus identity for the divergence of a cross product, we obtain div$[\mathbf{a} \times (\mathbf{r} \times \mathbf{a})] = 2a^2$.

Quick Tip

In vector calculus, the divergence of a cross product can be simplified using the vector identity to find the result.

---

115. If $\mathbf{F} = ax\hat{i} + by\hat{j} + cz\hat{k}$, where a, b, c are constants, then

(1) 0

(2) $\frac{4}{3}\pi(a+b+c)^2$

(3) $\frac{4}{3}\pi(a+b+c)$

(4) 1

Correct Answer: (3) $\frac{4}{3}\pi(a+b+c)$

Solution: The integral in this question evaluates to $\frac{4}{3}\pi(a+b+c)$, which is the surface area of a sphere with a radius defined by the constants.

Quick Tip

The integral of the force field over the surface of a sphere can be simplified based on symmetry considerations.

---

116. Solution of the differential equation $xy\frac{dy}{dx} = 1 + x + y + xy$ is

(1) $\log(x(1+y)) = c$

(2) $(y-x)\log(x(1+y)) = c$

(3) $(y+x)\log(x) = c$

(4) $\log(x(1+y)) = c$

Correct Answer: (1) $\log(x(1+y)) = c$

Solution: The solution to this differential equation is derived by separating variables and integrating both sides.

Quick Tip

To solve such differential equations, express the equation in terms of a separable form and integrate both sides.

---

117. What is the correct formula for Runge-Kutta 3rd order method?

(1) $y = y_0 + \frac{1}{6}(k_1 + 2k_2 + 3k_3)$

(2) $y = y_0 + \frac{1}{3}(k_1 + 4k_2 + k_3)$

(3) $y = y_0 + \frac{1}{6}(k_1 + 4k_2 + k_3)$

(4) $y = y_0 + \frac{1}{6}(k_1 + k_2)$

Correct Answer: (1) $y = y_0 + \frac{1}{6}(k_1 + 2k_2 + 3k_3)$

Solution: This is the formula for the 3rd order Runge-Kutta method used to solve ordinary differential equations.

Quick Tip

For higher-order Runge-Kutta methods, the weightings in the formula change depending on the order of the method.

---

118. One of the two events must occur. The chance of one is $\frac{2}{3}$ of the other, then odds in favor of the other are

(1) $3 : 2$

(2) $1 : 3$

(3) $3 : 1$

(4) $2 : 3$

Correct Answer: (1) $3 : 2$

Solution: The odds in favor are calculated by using the ratio of the probability of the event occurring to the probability of the event not occurring.

Quick Tip

Odds are often written as ”successes:failures,” where failures are the complement of the event happening.

---

119. The coefficient of correlation is independent of

(1) Change of scale only

(2) Change of origin only

(3) Both change of scale & origin

(4) No change

Correct Answer: (3) Both change of scale & origin

Solution: The coefficient of correlation is a measure of the linear relationship between two variables and is independent of both the scale and origin changes.

Quick Tip

The coefficient of correlation remains unchanged under linear transformations, meaning it is scale and origin invariant.

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120. If $x^2 - x - 4 = 0$ by bisection method, first two approximations x_1 and x_2 are 1 and 2, then x_3 is

(1) 1.2

(2) 1.3

(3) 1.4

(4) 1.5

Correct Answer: (4) 1.5

Solution: Using the bisection method, x_3 is found as the midpoint of x_1 and x_2, which gives 1.5.

Quick Tip

The bisection method is a numerical method used to find roots of continuous functions by iteratively narrowing the interval where the root lies.
