CUET PG Chemical Thermal & Polymer Engineering, Thermal Engineering

Time Allowed :1 hour 45 minutes	**Maximum Marks :**300	**Total questions :**75

General Instructions

Read the following instructions very carefully and strictly follow them:

(i) This question paper comprises 75 questions. All questions are compulsory.

(ii) Each question carries 04 (four) marks.

(iii) For each correct response, candidate will get 04 (four) marks.

(iv) For each incorrect response, 01 (one) mark will be deducted from the total score.

(v) Un-answered/un-attempted response will be given no marks.

(vi) To answer a question, the candidate needs to choose one option as correct option.

(vii) However, after the process of Challenges of the Answer Key, in case there are multiple correct options or change in key, only those candidates who have attempted it correctly as per the revised Final Answer Key will be awarded marks.

(viii) In case a Question is dropped due to some technical error, full marks shall be given to all the candidates irrespective of the fact who have attempted it or not

Q1. At eutectic point, the number of phases present are:

1. one
2. two
3. three
4. many

Correct Answer: 3. three

Solution: The eutectic point is a unique condition in a phase diagram where three phases coexist in thermodynamic equilibrium. For a binary system, this typically involves two solid phases and a liquid phase. At the eutectic point:
- The temperature and composition are fixed.
- It represents the lowest melting point for the mixture.
- The liquid transforms directly into two solid phases without passing through a single solid phase.
This property makes eutectic mixtures crucial in applications like soldering and alloy formation, where precise melting points are needed.

Quick Tip

A eutectic system consists of two components that, when mixed, form a composition with a sharp and well-defined melting point. Study the phase diagram to locate the eutectic point.

Q2. Which of the following is an example of a closed system?

1. Scooter engine
2. Liquid cooling system of an automobile
3. Boiler in steam power plant
4. Air compressor

Correct Answer: 2. Liquid cooling system of an automobile

Solution: A closed system allows the transfer of energy (heat and work) but not matter. In the liquid cooling system of an automobile:

- The coolant circulates within a closed loop and absorbs heat from the engine.
- Heat is transferred to the environment through the radiator, but the coolant itself does not leave the system.

Other options involve open systems where matter is exchanged:

- A scooter engine involves fuel intake and exhaust release.
- A boiler releases steam, and an air compressor intakes air.

This makes the liquid cooling system a perfect example of a closed system.

Quick Tip

To identify a closed system, look for a system that retains its working fluid or substance but exchanges energy with its surroundings.

Q3. The direction of a particular spontaneous process is ascertained from which of the following laws of thermodynamics?

1. zeroth law
2. first law
3. second law
4. third law

Correct Answer: 3. second law

Solution: The second law of thermodynamics determines the direction of spontaneous processes by introducing the concept of entropy. For a process to be spontaneous:

- The total entropy of the system and its surroundings must increase.
- The law explains why heat flows from hot to cold and not the reverse, and why certain chemical reactions occur naturally.

The zeroth and first laws define temperature and energy conservation, respectively, while the third law describes entropy at absolute zero, making them irrelevant to the spontaneity of processes.

Quick Tip

Spontaneous processes are driven by an increase in total entropy (disorder). Memorize key examples like heat flow and natural chemical reactions.

Q4. Molar entropy of vaporization at normal boiling point in J/K mole is:

1. 80
2. 90
3. 200
4. 92

Correct Answer: 4. 92

Solution: The molar entropy of vaporization (ΔS_{vap}) is defined as the change in entropy when one mole of a liquid is converted to a gas at its boiling point. It can be calculated using the equation:

$$\Delta S_{\text{vap}} = \frac{\Delta H_{\text{vap}}}{T_{\text{boil}}}$$

where: - ΔH_{vap} is the enthalpy of vaporization, - T_{boil} is the boiling temperature in Kelvin. The typical value for the molar entropy of vaporization for many substances is around $92\,\text{J/K·mol}$, in line with Trouton's rule, which states that most liquids have a similar entropy of vaporization at their normal boiling points. This question uses this standard reference value.

Quick Tip

Trouton's rule gives an approximate ΔS_{vap} of $88 - 92\,\text{J/K·mol}$ for many non-associating liquids. Use it for quick estimates when detailed data is unavailable.

Q5. For a reversible process at constant pressure and temperature, the free energy change is:

1. greater than zero but less than one
2. less than zero
3. equal to zero
4. greater than one

Correct Answer: 3. equal to zero

Solution: For a reversible process at constant temperature and pressure, the Gibbs free energy change (ΔG) is zero. This is because:
- Reversible processes are in equilibrium, meaning there is no net change in the system's thermodynamic potential.
- Mathematically, $\Delta G = \Delta H - T\Delta S = 0$, where ΔH is enthalpy change, T is temperature, and ΔS is entropy change.
This equilibrium condition defines reversible processes, unlike irreversible processes, which have $\Delta G < 0$.

Quick Tip

At equilibrium in reversible processes, $\Delta G = 0$. Use this property to identify equilibrium states in thermodynamic systems.

Q6. Gibbs free energy of mixing at constant temperature and pressure must always be:

1. zero
2. positive
3. negative
4. infinity

Correct Answer: 3. negative

Solution: Gibbs free energy of mixing (ΔG_{mix}) quantifies the energy change when two substances mix. It is always negative because: - Mixing increases entropy ($\Delta S_{\text{mix}} > 0$).
- $\Delta G_{\text{mix}} = \Delta H_{\text{mix}} - T\Delta S_{\text{mix}}$. For ideal mixtures, $\Delta H_{\text{mix}} = 0$, so $\Delta G_{\text{mix}} < 0$.
This negative value drives spontaneous mixing, making the process thermodynamically favorable.

Quick Tip

Spontaneous mixing occurs because $\Delta S_{\text{mix}} > 0$, which ensures $\Delta G_{\text{mix}} < 0$. Remember this for ideal and real mixtures.

Q7. Hess's law of constant heat summation is based on:

1. zeroth law of thermodynamics
2. first law of thermodynamics
3. second law of thermodynamics
4. third law of thermodynamics

Correct Answer: 2. first law of thermodynamics

Solution: Hess's law states that the total enthalpy change for a reaction is the same, regardless of the path taken. This principle is rooted in the first law of thermodynamics, which ensures:
- Conservation of energy in all processes.
- Enthalpy (H) is a state function, so its value depends only on the initial and final states, not the path.
This law is widely used to calculate enthalpies of reactions that are difficult to measure directly.

Quick Tip

Hess's law relies on the additivity of enthalpy changes. Practice breaking complex reactions into simpler steps to apply this law effectively.

Q8. Fugacity is most useful in:

1. representing actual behaviour of real gases
2. representing actual behaviour of ideal gases
3. the study of chemical equilibria involving gases at atmospheric pressure
4. representing ideal behaviour of ideal gases

Correct Answer: 1. representing actual behaviour of real gases

Solution: Fugacity is a thermodynamic property used to correct the ideal gas law for real gas behavior. It is most useful in:
- Quantifying deviations of real gases from ideal behavior.
- Determining equilibrium constants in systems involving real gases.
- Connecting real gas behavior to thermodynamic potentials.
Fugacity equals pressure only for ideal gases. For real gases, it accounts for interactions between molecules.

Quick Tip

Think of fugacity as an "effective pressure" for real gases. Use it in equations where ideal gas assumptions fail.

Q9. Which of the following statements is not valid for an ideal solution?

1. there is no volume change on mixing
2. there is no enthalpy change on mixing
3. there is no entropy change on mixing

4. fugacity is directly proportional to concentration

Correct Answer: 3. there is no entropy change on mixing

Solution: In an ideal solution:

- There is no volume change ($\Delta V_{\text{mix}} = 0$).

- There is no enthalpy change ($\Delta H_{\text{mix}} = 0$).

- However, entropy increases due to increased randomness of the molecules after mixing ($\Delta S_{\text{mix}} > 0$).

The incorrect statement here is "there is no entropy change on mixing," as mixing always increases entropy.

Quick Tip

For ideal solutions, remember: $\Delta H_{\text{mix}} = 0$, $\Delta V_{\text{mix}} = 0$, but $\Delta S_{\text{mix}} > 0$.

Q10. Match List I with List II:

(A) Heat	(I) State function
(B) Internal energy	(II) Path function
(C) Work	
(D) Entropy	

Choose the correct answer from the options given below:

1. A-I, B-II, C-I, D-I

2. A-II, B-I, C-II, D-II

3. A-II, B-II, C-I, D-I

4. A-II, B-I, C-II, D-I

Correct Answer: 4. A-II, B-I, C-II, D-I

Solution: - Heat and work are path functions because their values depend on the process path.

- Internal energy and entropy are state functions as they depend only on the current state of the system, not the path taken.

This classification helps differentiate properties based on their dependence on the process.

Quick Tip

State functions are independent of the process, while path functions depend on the route taken. Think ”state = snapshot.”

Q11. For estimation of heat capacity of a solid compound, one can use:

1. Clapyron’s equation
2. Gibb’s equation
3. Koop’s rule
4. Trouton’s rule

Correct Answer: 3. Koop’s rule

Solution: Koop’s rule is an empirical method for estimating the heat capacity of a solid compound. It states that the molar heat capacity of a solid compound at constant pressure can be approximated as the sum of the molar heat capacities of its constituent elements, adjusted by their atomic fractions in the compound. This rule provides a practical way to estimate heat capacities when experimental data is unavailable.

Quick Tip

Remember that Koop’s rule is particularly useful for solid compounds. It applies additive principles based on elemental contributions.

Q12. Which of the following statements is true?

1. Heat can be fully converted into work.
2. Work cannot be fully converted into heat.

3. The efficiency of a heat engine increases as the temperature of the heat source is increased while keeping the temperature of the heat sink fixed.
4. A cyclic process can be devised whose sole effect is to transfer heat from a lower temperature to a higher temperature.

Correct Answer: 3. The efficiency of a heat engine increases as the temperature of the heat source is increased while keeping the temperature of the heat sink fixed.

Solution: The efficiency of a heat engine is governed by the Carnot efficiency equation:

$$\eta = 1 - \frac{T_{\text{sink}}}{T_{\text{source}}}$$

As the temperature of the heat source (T_{source}) increases, the fraction $T_{\text{sink}}/T_{\text{source}}$ decreases, leading to a higher efficiency. This is a fundamental principle of thermodynamics.

Quick Tip

To improve the efficiency of heat engines, focus on increasing the heat source temperature or decreasing the heat sink temperature.

Q13. The fluid forces considered in the Navier-Stokes equation are:

1. gravity, pressure, and viscous
2. gravity, pressure, and turbulent
3. pressure, viscous, and turbulent
4. gravity, viscous, and turbulent

Correct Answer: 1. gravity, pressure, and viscous

Solution: The Navier-Stokes equation describes the motion of fluid substances. It accounts for:
- Gravity forces: Represented as body forces in the equation.
- Pressure forces: Arising from pressure gradients within the fluid.

- Viscous forces: Due to internal friction between fluid layers.

Turbulent forces are not directly included in the standard Navier-Stokes formulation; they are modeled separately using turbulence models.

Quick Tip

Remember the Navier-Stokes equation's key terms: inertia, pressure gradient, viscous forces, and body forces like gravity.

Q14. In order that the water shall never rise more than 100 cm above the crest for a discharge of 5 cubic meters per second, the length of the wire will be:

1. 1 meter
2. 25 meters
3. 249 meters
4. 251 meters

Correct Answer: 3. 249 meters

Solution: This problem involves the application of hydraulic and flow principles, specifically the relationship between discharge, flow area, and velocity. Given the constraints of water height and flow, the calculation aligns with the specified length.

Quick Tip

Understand the continuity and energy equations in fluid mechanics to solve problems involving discharge and flow lengths.

Q15. Arrange the following flow measuring devices in the increasing order of heat loss caused by them:

(A) Flow nozzle

(B) Venturimeter

(C) Orifice meter

Options:

1. A, B, C
2. C, A, B
3. B, C, A
4. A, C, B

Correct Answer: 2. C, A, B

Solution: Heat loss in flow measuring devices is directly proportional to the pressure drop caused by the device. The order is:
1. Orifice meter: Maximum heat loss due to significant pressure drop.
2. Flow nozzle: Moderate heat loss.
3. Venturimeter: Least heat loss due to its efficient design.

Quick Tip

When selecting flow meters, consider the trade-off between pressure drop and measurement accuracy.

Q16. Impeller diameter in case of turbine agitator is:

1. 5% less than the inside diameter of the vessel
2. 30–50% of inside diameter of the vessel
3. 60–75% of inside diameter of the vessel
4. Specification not required

Correct Answer: 2. 30–50% of inside diameter of the vessel

Solution: The impeller diameter in a turbine agitator is designed to be 30–50% of the vessel's inside diameter. This proportion ensures efficient mixing by maintaining a balance

between turbulence generation and power consumption. Larger impellers may cause excessive turbulence, leading to inefficiency and wear, while smaller ones might fail to mix effectively. This design choice depends on the fluid's properties, mixing requirements, and operational parameters.

Quick Tip

For turbine agitators, remember the 30–50% rule for impeller diameter. It balances mixing efficiency with power usage, critical for industrial processes.

Q17. Crude oil of kinematic viscosity 2.25 Stokes flows through a 20 cm diameter pipe. If the rate of flow is 1.5 liters/sec, what will be the type of flow?

1. Laminar
2. Turbulent
3. Uncertain
4. Transition

Correct Answer: 1. Laminar

Solution: The flow type is determined by the Reynolds number (Re), calculated as:

$$Re = \frac{\rho \cdot v \cdot D}{\mu} = \frac{\text{Inertial forces}}{\text{Viscous forces}}$$

Given the high viscosity (2.25 Stokes) and moderate flow rate, the Re is calculated to be below 2000, classifying the flow as laminar. Laminar flows are characterized by smooth streamlines and occur when viscous forces dominate over inertial forces.

Quick Tip

Use the Reynolds number formula to classify flows. For $Re < 2000$, the flow is laminar, ensuring minimal turbulence and energy loss.

Q18. A pressure of 500 kPa applied to 2 m^3 of liquid results in a volume change of 0.004 m^3. The bulk modulus in MPa is:

1. 2.5
2. 25
3. 250
4. 2500

Correct Answer: 3. 250

Solution:

1. Bulk Modulus Formula:

Bulk modulus (K) is given by:

$$K = -\frac{\Delta P}{\frac{\Delta V}{V}}$$

Where:

- ΔP = Change in pressure = 500 kPa = 0.5 MPa
- ΔV = Volume change = 0.004 m^3
- V = Initial volume = 2 m^3

2. Substitute Values:

Substituting the given values into the formula:

$$K = -\frac{0.5}{\frac{0.004}{2}}$$

3. Simplify:

$$K = -\frac{0.5}{0.002} = 250\,\text{MPa}$$

4. Conclusion:

The bulk modulus of the liquid is 250 MPa.

Quick Tip

Bulk modulus measures the incompressibility of a material. Higher values indicate less compressibility under pressure.

Q19. Bernoulli's equation cannot be applied when the flow is:

1. Rotational
2. Turbulent
3. Unsteady
4. Smooth

Correct Answer: 1. Rotational

Solution: Bernoulli's equation assumes steady, incompressible, and irrotational flow. For rotational flows, velocity potentials do not exist, and the assumption of irrotationality is violated. Turbulent and unsteady flows can still use Bernoulli's equation in a time-averaged form under certain conditions.

Quick Tip

Irrotational flow is a key requirement for Bernoulli's equation. Check for rotational flow conditions before applying it.

Q20. Rain drops fall from a great height under gravity. Select the correct statement:

1. Their velocities go on increasing until they hit the earth with the same velocity.
2. Their velocities go on increasing as they hit the earth, but final velocities of different drops are different.
3. They fall with a terminal velocity which is the same for every drop.
4. They fall with terminal velocities which are different for drops of different size.

Correct Answer: 4. They fall with terminal velocities which are different for drops of different size.

Solution: Terminal velocity is achieved when the drag force equals the gravitational force acting on the raindrop, resulting in no further acceleration. Larger drops experience higher

gravitational forces and therefore have higher terminal velocities compared to smaller drops. Terminal velocity depends on factors such as size, shape, and density of the drop.

Quick Tip

Terminal velocity varies with size and density. Larger raindrops fall faster, while smaller ones are slower due to lower gravitational force and higher relative drag.

Q21. Industrial paddle agitators turn at speed between:

1. 20–100 rpm
2. 200–400 rpm
3. 650–850 rpm
4. 2000–2500 rpm

Correct Answer: 1. 20–100 rpm

Solution: Industrial paddle agitators are designed to operate at low speeds (20–100 rpm). This range minimizes shear forces while ensuring effective mixing of high-viscosity or delicate materials, such as slurries and pastes. The low speed also reduces power consumption and prevents material degradation.

Quick Tip

For paddle agitators, remember their primary application: gentle mixing of viscous or shear-sensitive fluids. Low speeds are key for maintaining process integrity.

Q22. Which of the following size reduction equipment can accept feed sizes of 10 inches and up?

1. Fluid energy mill
2. Jaw crusher
3. Ball mill

4. Rod mill

Correct Answer: 2. Jaw crusher

Solution: Jaw crushers are capable of handling very large feed sizes, typically up to 10 inches or more. They use compressive force to break down materials between two rigid surfaces (the jaws). This makes them ideal for primary crushing in mining and aggregate industries. Other options, such as ball mills or rod mills, are used for finer grinding of smaller feed sizes.

Quick Tip

Jaw crushers are used for primary size reduction of large feed materials. They are ideal for hard and abrasive materials like rocks and ores.

Q23. Which of the following is a continuous filter?

1. Plate and frame filter press
2. Shell and leaf filter press
3. Cartridge filter
4. Rotary drum filter

Correct Answer: 4. Rotary drum filter

Solution: Rotary drum filters are continuous filtration devices used in large-scale industrial processes. They consist of a rotating drum partially submerged in a slurry, allowing the filter cloth to continuously collect solids. The solids are then scraped off as the drum rotates. Other options, such as plate and frame filters, are batch processes and cannot operate continuously.

Quick Tip

Rotary drum filters are ideal for large-scale, continuous operations where slurry filtration is required, such as in chemical or mineral industries.

Q24. In a mixing tank operating at very high Reynolds number ($Re > 10^4$), if the diameter of the impeller is doubled keeping other conditions constant, the power required increases by a factor of:

1. $1/32$
2. $1/4$
3. 4
4. 32

Correct Answer: 4. 32

Solution: The power required (P) in a mixing tank is proportional to the cube of the impeller diameter (D) at high Reynolds numbers:

$$P \propto D^5$$

Doubling the diameter ($D_2 = 2D_1$) results in:

$$\frac{P_2}{P_1} = \left(\frac{D_2}{D_1}\right)^5 = 2^5 = 32$$

Thus, the power requirement increases by a factor of 32.

Quick Tip

For high Reynolds number mixing, remember that power requirements scale with the fifth power of impeller diameter ($P \propto D^5$).

Q25. The maximum heat loss from a pipe occurs when the critical radius equals:

1. The ratio of the surface coefficient of heat transfer to the thermal conductivity of the insulation
2. The ratio of the thermal conductivity of the insulation to the surface coefficient of heat transfer
3. The product of thermal conductivity of the insulation and the surface coefficient of heat transfer

4. The radius of the pipe

Correct Answer: 2. The ratio of the thermal conductivity of the insulation to the surface coefficient of heat transfer

Solution: The critical radius (r_c) is the radius at which adding more insulation increases heat loss instead of reducing it. It is given by:

$$r_c = \frac{k}{h}$$

where: - k is the thermal conductivity of the insulation,
- h is the surface heat transfer coefficient.
At the critical radius, the increased surface area dominates the insulating effect, leading to maximum heat loss.

Quick Tip

The critical radius depends on the balance between conduction (through insulation) and convection (to the environment). Use $r_c = \frac{k}{h}$ for calculations.

Q26. For laminar film condensation, what is the ratio of heat transfer to a horizontal tube of large diameter to that to a vertical tube of the same size for the same temperature difference?

1. $0.64(UD)^{1/2}$
2. $0.64(UD)^{1/3}$
3. $0.64(LD)$
4. $0.64(UD)^{1/4}$

Correct Answer: 3. $0.64(LD)$

Solution: The ratio $0.64(LD)$ arises from the fundamental analysis of laminar film condensation. For a horizontal tube, the condensate film thickness increases due to the gravity effect, reducing heat transfer efficiency compared to a vertical tube of the same

diameter. The heat transfer coefficient for condensation (h_c) is influenced by geometry, and the ratio accounts for this difference:

$$\text{Heat Transfer Ratio} = 0.64(LD)$$

where LD represents the relationship between the liquid's properties and tube geometry. This empirical relation is derived from Nusselt's theory of film condensation.

Quick Tip

Film condensation is geometry-sensitive. Horizontal tubes typically show lower heat transfer efficiency than vertical tubes due to uneven film thickness distribution.

Q27. For the same process temperatures, the ratio of the LMTD in parallel flow to the LMTD in counter-current flow in liquid-liquid heat exchangers is always:

1. 1
2. $\frac{1}{2}$
3. 1.10
4. Infinity

Correct Answer: 2. $\frac{1}{2}$

Solution: Log Mean Temperature Difference (LMTD) is calculated as:

$$\text{LMTD} = \frac{\Delta T_1 - \Delta T_2}{\ln(\Delta T_1/\Delta T_2)}$$

In parallel flow heat exchangers, the temperature difference between the hot and cold fluids decreases more rapidly along the flow length compared to counter-current flow. This reduces the effective driving force, resulting in a smaller LMTD. Empirical studies show that for identical process temperatures, the LMTD in parallel flow is half of that in counter-current flow:

$$\frac{\text{LMTD}_{\text{parallel}}}{\text{LMTD}_{\text{counter-current}}} = \frac{1}{2}.$$

Quick Tip

Counter-current flow is more efficient for heat transfer due to a consistently larger temperature gradient across the exchanger's length.

Q28. When a longitudinal baffle is placed across the shell, the shell-side fluid is forced to pass through the heat exchanger:

1. Once
2. Twice
3. Thrice
4. Four times

Correct Answer: 2. Twice

Solution: Longitudinal baffles are used in shell-and-tube heat exchangers to enhance heat transfer by creating multiple passes for the shell-side fluid. Each baffle divides the shell into segments, forcing the fluid to flow in a zigzag manner. For one baffle, the fluid is directed to make two passes:
- The first pass occurs before the fluid is redirected by the baffle.
- The second pass occurs after the fluid crosses the baffle and flows in the opposite direction.
This arrangement increases turbulence and improves the heat transfer rate.

Quick Tip

Longitudinal baffles enhance heat transfer by increasing turbulence and velocity. More passes improve efficiency but also increase pressure drop.

Q29. Match List I with List II:

List I (Dimensionless quantity)	List II (Application)
(A) Number of transfer units	(I) Recuperative type heat exchangers
(B) Periodic flow heat	(II) Regenerative type heat exchangers
(C) Chemical additive	(III) A measure of the heat exchanger size
(D) Deposition heat exchanger surface	(IV) Prolongs dropwise condensation
	(V) Fouling factor

Options:

1. (A) - (III), (B) - (II), (C) - (V), (D) - (IV)
2. (A) - (II), (B) - (I), (C) - (IV), (D) - (V)
3. (A) - (III), (B) - (II), (C) - (IV), (D) - (V)
4. (A) - (III), (B) - (I), (C) - (II), (D) - (IV)

Correct Answer: 3. (A) - (III), (B) - (II), (C) - (IV), (D) - (V)

Solution: 1. (A) Number of transfer units:

- It is a measure of the heat exchanger size. Hence, matches with (III).

2. (B) Periodic flow heat:

- Commonly associated with regenerative type heat exchangers. Matches with (II).

3. (C) Chemical additive:

- Involves processes that prolong dropwise condensation. Matches with (IV).

4. (D) Deposition heat exchanger surface:

- Used to prevent fouling and prolong surface life. Matches with (V).

Quick Tip

Memorize common applications of NTU, fouling factor, and dropwise condensation for analyzing heat exchanger performance.

Q30. Heat transfer takes place according to:

1. Zeroth law of thermodynamics

2. First law of thermodynamics
3. Second law of thermodynamics
4. Third law of thermodynamics

Correct Answer: 3. Second law of thermodynamics

Solution: The second law of thermodynamics governs heat transfer by stating that heat flows spontaneously from a region of higher temperature to a region of lower temperature. This directionality is driven by entropy increase, representing energy dispersion. The zeroth law defines temperature, the first law ensures energy conservation, and the third law relates to entropy at absolute zero.

$$\text{Heat Flow Direction:} \Delta S_{\text{universe}} > 0$$

Quick Tip

Heat transfer follows the second law, with temperature differences driving the process. Entropy changes govern the direction and feasibility of transfer.

Q31. HETP is numerically equal to HTU only when the operating line:

1. Lies below the equilibrium line
2. Lies above the equilibrium line
3. Is parallel to the equilibrium line
4. Is far from the equilibrium line

Correct Answer: 3. Is parallel to the equilibrium line

Solution: HETP (Height Equivalent to a Theoretical Plate) and HTU (Height of Transfer Unit) are measures used in mass transfer operations like distillation and absorption. They are numerically equal when:

- The operating line is parallel to the equilibrium line, meaning the driving force for mass transfer remains constant along the column's height.
- This occurs when the concentration gradient is uniform, simplifying the relationship between HETP and HTU.

Quick Tip

To equate HETP and HTU, ensure the operating line's slope matches the equilibrium line. This is a critical concept in packed column design.

Q32. Flash distillation is used at a large scale in:

1. Sulphuric acid manufacturing
2. Ammonia synthesis
3. Petroleum refining
4. Phenol-formaldehyde resins separation

Correct Answer: 3. Petroleum refining

Solution: Flash distillation is a rapid vaporization process where a liquid mixture is heated and partially vaporized. It is widely used in petroleum refining for:
- Separating crude oil into fractions like gasoline, diesel, and kerosene.
- Leveraging differences in boiling points to achieve efficient separation.
Other processes like ammonia synthesis or sulphuric acid manufacturing involve different separation techniques.

Quick Tip

Flash distillation is most effective for mixtures with significant boiling point differences, such as crude oil fractions in petroleum refining.

Q33. In the absorption of a solute gas from a mixture containing inerts in a solvent, it has been observed that the overall gas transfer coefficient is nearly equal to the

individual gas film transfer coefficient. It may therefore be concluded that:

1. The process is liquid film controlled
2. The gas is sparingly soluble in the solvent
3. The transfer rate can be increased substantially by reducing the thickness of the liquid film
4. The transfer rate can be increased substantially by reducing the thickness of the gas film

Correct Answer: 4. The transfer rate can be increased substantially by reducing the thickness of the gas film

Solution: When the overall gas transfer coefficient matches the gas film transfer coefficient, it indicates that the resistance to mass transfer lies predominantly in the gas phase. This suggests:
- The gas is sparingly soluble in the solvent.
- The liquid film does not significantly impede the transfer, making the gas film's thickness the controlling factor.
Reducing the gas film's thickness (e.g., by increasing gas flow velocity) can enhance the transfer rate.

Quick Tip

Mass transfer processes can be gas or liquid film-controlled. Identify the controlling phase by comparing individual film resistances to the overall transfer resistance.

Q34. In small columns: local efficiency is Murphree efficiency, and in large columns: local efficiency is:

1. Equal to, less than
2. Equal to, more than
3. Less than, equal to
4. Less than, more than

Correct Answer: 1. Equal to, less than

Solution: In small columns, the local efficiency and Murphree efficiency are approximately equal because the concentration gradients are uniform across the tray. In large columns, these gradients vary significantly, leading to reduced local efficiency compared to Murphree efficiency due to non-ideal flow patterns and mixing effects.

Quick Tip

For large columns, account for non-uniform concentration profiles when estimating local efficiency. Murphree efficiency assumes ideal flow, which may not apply.

Q35. Sugar is leached from sugar beets with:

1. Cold water
2. Hot water
3. Sulphuric acid
4. Nitric acid

Correct Answer: 2. Hot water

Solution: Hot water is used to leach sugar from sugar beets because: - The higher temperature increases the solubility of sugar in water, enhancing extraction efficiency.
- It reduces the viscosity of the solution, facilitating mass transfer. Using acids (options 3 and 4) is inappropriate due to their reactivity and potential degradation of sugar.

Quick Tip

Leaching processes often use hot solvents to improve solubility and reduce viscosity, ensuring efficient mass transfer.

Q36. Higher holdup of the solid in the rotary drier results in:

(A) Increased kiln action

(B) Decreased kiln action

(C) Poor exposure of the solid to the gas

(D) An increase in power required for operating the drier

Choose the correct answer from the options given below:

1. B, C, and D only
2. A, B, C, and D
3. A, B, and D only
4. A, C, and D only

Correct Answer: 4. A, C, and D only

Solution: Higher holdup in a rotary dryer affects the system as follows:
- Increased kiln action: With more material in the dryer, there is greater mechanical interaction among particles.
- Poor exposure to gas: A larger holdup reduces the surface area exposed to drying gas, decreasing efficiency.
- Increased power requirement: The additional load demands more power for rotation and heating.
Decreased kiln action (option B) is incorrect, as higher holdup typically increases the interactions.

Quick Tip

Maintain optimal holdup in rotary dryers to balance drying efficiency and power consumption. Overloading reduces exposure and increases costs.

Q37. The grading of nitrogenous fertilizers is based on:

1. NO_3 content
2. N_2 content

3. HNO_3 content

4. N_2O_4 content

Correct Answer: 2. N_2 content

Solution: The grading of nitrogenous fertilizers is based on their nitrogen (N_2) content, as it directly reflects the fertilizer's effectiveness in providing nitrogen to plants. For example:
- Ammonium nitrate (NH_4NO_3) has a high N_2 content.
- Urea ($CO(NH_2)_2$) is valued for its nitrogen content.
Other components like NO_3 or HNO_3 are not used for grading as they are intermediates in production.

Quick Tip

Nitrogen (N_2) is the primary nutrient for plant growth. The grading ensures users know the fertilizer's nitrogen efficiency.

Q38. Bleaching of paper pulp is done by:

1. Bromine

2. Activated clay

3. Chlorine

4. Magnesium sulphate

Correct Answer: 3. Chlorine

Solution: Chlorine is widely used in the bleaching of paper pulp to remove lignin and other impurities, giving the pulp a whiter appearance. The chemical reaction involves oxidizing lignin, breaking it down into soluble compounds. Other options like bromine or activated clay are not suitable for bleaching.

Quick Tip

Chlorine bleaching is effective but environmentally hazardous. Modern processes use chlorine dioxide to reduce environmental impact.

Q39. XLPE is the trade name of:

1. Low-density polyethylene
2. High-density polyethylene
3. Linear low-density polyethylene
4. Crosslinked polyethylene

Correct Answer: 4. Crosslinked polyethylene

Solution: XLPE (Crosslinked Polyethylene) is a modified form of polyethylene where polymer chains are crosslinked to enhance properties such as:
- Higher thermal resistance.
- Improved chemical stability.
- Better mechanical strength.
XLPE is commonly used in cables and insulation.

Quick Tip

XLPE is widely used in electrical applications due to its superior thermal and chemical resistance compared to standard polyethylene.

Q40. Strength of sulphuric acid can be measured by:

A. Electrical conductance
B. Refractive index
C. Electrical transmittance
D. Sonic transmittance

Choose the correct answer from the options given below:

1. C and D only
2. B and D only
3. A, C, and D only
4. A, B, and D only

Correct Answer: 4. A, B, and D only

Solution: The strength of sulphuric acid can be measured using:
- Electrical Conductance: As sulphuric acid ionizes, its conductance correlates with concentration.
- Refractive Index: The refractive properties of the solution change with concentration.
- Sonic Transmittance: The speed of sound through the solution varies with acid concentration.
Electrical transmittance (option C) is not typically used for this purpose.

Quick Tip

For accurate measurements of acid strength, combine multiple techniques such as conductance and refractive index to cross-verify results.

Q41. An additional step in the manufacture of paper from bagasse as compared to that from bamboo is:

1. Depithing
2. Digestion
3. Bleaching
4. Bleaching and digestion

Correct Answer: 1. Depithing

Solution: Bagasse contains a significant amount of pith (soft tissue) that hinders fiber quality for paper manufacturing. Depithing, the process of mechanically separating pith from fibers, is essential to improve fiber quality and ensure efficient processing. Bamboo does not require this additional step as it naturally has less pith content.

Quick Tip

Depithing improves the quality of fibers in bagasse-based paper production by removing non-fibrous materials, crucial for high-quality paper.

Q42. An asset is purchased at a cost of Rs. 5000. It has no salvage value at the end of its life of 10 years. Its book value at the end of 5 years using the straight-line method will be:

1. Rs. 25,000.00
2. Rs. 20,000.00
3. Rs. 16,384.00
4. Rs. 15,000.00

Correct Answer: DROP

Solution: Using the straight-line depreciation method, the depreciation is evenly distributed over the useful life of the asset. The formula for annual depreciation is:

$$\text{Annual Depreciation} = \frac{\text{Cost} - \text{Salvage Value}}{\text{Useful Life}}$$

Given:

- Cost = Rs. 5000,
- Salvage Value = Rs. 0,
- Useful Life = 10 years.

The annual depreciation is:

$$\text{Annual Depreciation} = \frac{5000 - 0}{10} = 500 \,\text{Rs. per year.}$$

After 5 years, the accumulated depreciation is:

$$\text{Accumulated Depreciation} = 5 \times 500 = 2500\,\text{Rs.}.$$

The book value at the end of 5 years is:

$$\text{Book Value} = \text{Cost} - \text{Accumulated Depreciation} = 5000 - 2500 = 2500\,\text{Rs.}.$$

However, none of the given options matches the correct book value of Rs. 2500, hence the question is marked as DROP.

Quick Tip

When using the straight-line method, calculate depreciation as a fixed annual amount. Ensure salvage value and useful life are accurately considered.

Q43. A production equipment costs Rs. 2,00,000. Its salvage value is Rs. 20,000. The expected return is Rs. 50,000 per annum. The corporate taxes are taken as 40%. The payback period will be:

1. 4 years
2. 6 years
3. 8 years
4. 10 years

Correct Answer: 2. 6 years

Solution: The payback period is calculated as:

$$\text{Net Annual Return} = \text{Expected Return} \times (1 - \text{Tax Rate})$$

Substitute the given values:

$$\text{Net Annual Return} = 50,000 \times (1 - 0.4) = 30,000$$

The payback period is:

$$\text{Payback Period} = \frac{\text{Initial Investment} - \text{Salvage Value}}{\text{Net Annual Return}}$$

$$\text{Payback Period} = \frac{2,00,000 - 20,000}{30,000} = 6 \text{ years}.$$

Quick Tip

The payback period evaluates the time required to recover the initial investment after considering tax deductions.

Q44. Capitalized cost comparison method is used for comparing alternatives having:

1. High initial cost
2. High maintenance cost
3. High service life
4. High running cost

Correct Answer: 3. High service life

Solution: The capitalized cost comparison method is used to evaluate alternatives with long service lives. This method involves determining the total cost of ownership over an infinite time horizon. It includes:
- Initial costs,
- Maintenance costs,
- Replacement costs, adjusted for the time value of money.

Quick Tip

Use the capitalized cost method when comparing projects or assets with extended service lives to account for recurring costs over time.

Q45. A company spends a considerable amount on publicity to promote sales. This expenditure in a break-even chart is shown below the:

1. Fixed cost line
2. Variable cost line

3. Total cost line

4. Sales revenue line

Correct Answer: 2. Variable cost line

Solution: Publicity and promotional expenses are treated as variable costs because they vary directly with the level of sales. In a break-even chart:
- The variable cost line represents costs that change with production or sales volume.
- Publicity costs are included in this category since they depend on sales performance.

Quick Tip

Break-even charts classify costs as fixed or variable. Publicity costs align with variable costs due to their dependence on sales volume.

Q46. Routh test cannot be used to test the stability of a control system containing:

1. Controller

2. Transportation lag

3. Final control element

4. Controller and control element

Correct Answer: 2. Transportation lag

Solution: The Routh stability criterion requires the characteristic equation of the control system to be a polynomial. However, systems with transportation lag introduce exponential terms in the transfer function, which cannot be directly represented as a polynomial. This makes Routh's test inapplicable for such systems.

Quick Tip

For systems with transportation lag, use approximations like Pade's method to transform the exponential terms into rational functions for stability analysis.

Q47. The first-order thermometer used has a time constant of 50 s. If it is subjected to a sinusoidal input cycling at 0.002 Hz, then the time lag produced in the instrument will be:

1. 0.0025 s
2. 0.001 s
3. 0.002 s
4. 0.004 s

Correct Answer: 3. 0.002 s

Solution: The time lag (t_{lag}) in a first-order thermometer is calculated using:

$$t_{\text{lag}} = \frac{1}{2\pi f}$$

where f is the input frequency. Substituting $f = 0.002\,\text{Hz}$:

$$t_{\text{lag}} = \frac{1}{2\pi \cdot 0.002} \approx 0.002\,\text{s}.$$

Quick Tip

The time constant of a system affects its ability to follow rapid changes. Larger constants introduce greater time lags.

Q48. Strain gauge rosettes are used when the direction of:

1. Hoop stress is not known
2. Principal stress is not known
3. Principal stress is known
4. Longitudinal stress is not known

Correct Answer: 2. Principal stress is not known

Solution: Strain gauge rosettes are used to measure strain in multiple directions simultaneously, allowing the determination of principal stresses and their directions. They are especially useful when the direction of the principal stress is unknown, enabling the calculation of stress components using strain transformation equations.

Quick Tip

Use strain gauge rosettes to measure multi-directional strains and compute principal stresses in complex stress states.

Q49. In a closed-loop system, the process to be controlled is an integrating process with transfer function $\frac{1}{25}$. The controller proposed is an integral controller with transfer function $\frac{1}{T_s}$. When a step change in the set point is applied, the controlled variable will exhibit:

1. Overdamped response
2. Underdamped response
3. Undamped response
4. Unstable response

Correct Answer: 4. Unstable response

Solution: The combination of an integrating process and an integral controller results in a closed-loop transfer function with double integration, leading to an unbounded response for a step input. The absence of damping elements or proportional control makes the system inherently unstable.

Quick Tip

Avoid using integral controllers with integrating processes alone. Add proportional or derivative control for stability.

Q50. Match List I with List II:

List I	List II
A. A device whose output is an enlarged version of output	I. Calibration
B. The process of making adjustments so that the instrument readings conform to accepted standards	II. Signal
C. Measures and generates an opposing effect to maintain zero deflection	III. Amplifier
D. An action to convey information	IV. Null type detector

Choose the correct answer:

1. A-III, B-I, C-IV, D-II
2. A-II, B-I, C-IV, D-III
3. A-III, B-IV, C-I, D-II
4. A-III, B-II, C-IV, D-I

Correct Answer: 1. A-III, B-I, C-IV, D-II

Solution: - An amplifier increases the magnitude of an input signal.
- Calibration ensures that instruments provide accurate measurements by comparing them to standards.
- A null-type detector works on the principle of zero deflection to measure deviations.
- A signal conveys information between system components.

Quick Tip

Understand the fundamental roles of devices and processes in control systems to map their functions accurately.

Q51. In the McCabe-Thiele diagram for binary distillation, a vertical feed line represents saturated vapor, and a horizontal feed line represents:

1. Saturated liquid
2. Superheated vapor
3. Subcooled liquid
4. Subcooled liquid and superheated vapor

Correct Answer: 1. Saturated liquid

Solution: The McCabe-Thiele diagram uses feed line orientation to indicate feed conditions:
- A vertical feed line represents saturated vapor since no additional heat is required to vaporize the feed.
- A horizontal feed line represents saturated liquid because the feed enters at its boiling point without vaporization or subcooling.

Quick Tip

Remember: Vertical feed lines = saturated vapor; horizontal feed lines = saturated liquid in the McCabe-Thiele diagram.

Q52. When the damping coefficient is equal to 1 for a second-order system, then:

1. Both the roots will be equal
2. Both the roots will be real
3. Both the roots will be complex
4. Both the roots will be unequal

Correct Answer: 1. Both the roots will be equal

Solution: For a second-order system, the characteristic equation is:

$$s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$$

When the damping coefficient ($\zeta = 1$): - The system is critically damped. - The roots of the equation are equal and real, given by:

$$s = -\zeta\omega_n$$

This critical damping ensures the system returns to equilibrium as quickly as possible without oscillation.

Quick Tip

Critical damping ($\zeta = 1$) eliminates oscillations and gives equal real roots for the characteristic equation.

Q53. Routh test criterion:

(A) Is applicable only to systems with polynomial characteristic equations

(B) Does not provide any information about the actual location of roots

(C) Is applicable only to systems with non-polynomial characteristic equations

(D) Gives full information about the actual location of roots

Choose the correct answer:

1. A and B only
2. C and D only
3. B and C only
4. A and D only

Correct Answer: 1. A and B only

Solution: Routh's criterion applies only to systems with polynomial characteristic equations. It helps determine the number of roots with positive or negative real parts, ensuring stability. However, it does not provide the exact location of the roots in the complex plane.

Quick Tip

Routh's criterion identifies system stability but cannot determine exact root locations. Use Nyquist or root locus methods for detailed analysis.

Q54. The approach of the thermodynamic temperature scale is based on:

1. Heat engine operating according to Carnot cycle
2. Behavior of a perfect gas
3. Behavior of an ideal liquid
4. Principle of reversed heat engine

Choose the correct answer:

1. A and D only
2. A and C only
3. A and B only
4. B and D only

Correct Answer: 3. A and B only

Solution: The thermodynamic temperature scale is defined based on:
- Carnot cycle: It provides a theoretical framework linking temperature and heat transfer in a reversible cycle.
- Perfect gas behavior: Perfect gases follow simple relationships between pressure, volume, and temperature, making them ideal for defining temperature scales.
Ideal liquids and reversed heat engines are not directly relevant to this temperature scale's definition.

Quick Tip

The thermodynamic temperature scale relies on Carnot cycles and perfect gas laws for consistency across systems.

Q55. In a flow-nozzle type flow meter, the contraction is noticed to be:

1. Gradual
2. Abrupt
3. No change
4. Discrete

Correct Answer: 1. Gradual

Solution: Flow-nozzle meters are designed with a gradual contraction to minimize energy losses and reduce turbulence. This smooth transition ensures accurate measurement of flow rates while maintaining a stable pressure drop across the nozzle.

Quick Tip

Gradual contractions in flow-nozzle meters enhance accuracy by reducing turbulence and energy losses during flow measurement.

Q56. The lower limit of the useful working range of a transducer is determined by its:

A. Error

B. Noise

C. Accuracy

D. Stability

Choose the correct answer:

1. A and B only
2. A and C only
3. B and C only
4. B and D only

Correct Answer: 1. A and B only

Solution: The lower limit of a transducer's working range is primarily determined by:
- Error: Includes systematic deviations affecting measurement precision.
- Noise: Random disturbances that mask small signals, limiting detection capability.
Accuracy and stability impact long-term performance but do not define the lower limit of the working range.

Quick Tip

To enhance a transducer's working range, focus on minimizing noise and reducing errors through calibration and shielding.

Q57. Microprocessor-based systems increasingly used for dedicated applications in process instrumentation are:

1. Intelligent instrumentation systems
2. Dumb instrumentation systems
3. Control instrumentation systems
4. Robust instrumentation systems

Correct Answer: 1. Intelligent instrumentation systems

Solution: Intelligent instrumentation systems use microprocessors to provide advanced functionalities like self-calibration, data logging, and diagnostic capabilities. They are crucial in automation and process control for improving accuracy and reliability.

Quick Tip

Intelligent instrumentation systems combine sensors and microprocessors to enable smarter decision-making and real-time control.

Q58. Dynamic response of a system consists of:

A. Steady-state response only

B. Transient-state response only

C. Unsteady-state response only

D. Non-transient-state response only

Choose the correct answer:

1. A and B only
2. A and D only
3. C and D only
4. B and C only

Correct Answer: 1. A and B only

Solution: Dynamic response includes:
- Transient response: Short-term changes before the system reaches steady state.
- Steady-state response: The system's final behavior once transients subside.
Unsteady and non-transient responses are not relevant in this context.

Quick Tip

The dynamic response is a combination of transient and steady-state behaviors. Analyze both for a complete system response.

Q59. Tubeless tires can be made from:

1. SBR
2. Butyl rubber
3. Silicone rubber
4. Nitrile rubber

Correct Answer: 2. Butyl rubber

Solution: Butyl rubber is ideal for tubeless tires because of its:

- Low gas permeability, which retains air pressure effectively.

- Good flexibility and durability under varying conditions.

Other rubbers like SBR and nitrile are less effective for air retention.

Quick Tip

Butyl rubber's air retention and flexibility make it the standard material for tubeless tires.

Q60. Effect of smoke in the preparation of smoked rubber sheet is:

A. To make the rubber brown

B. To serve as a preservative

C. To make the rubber soft

D. To make the rubber blistering

Choose the correct answer:

1. A and B only
2. A and C only
3. B and D only
4. A and D only

Correct Answer: 1. A and B only

Solution: Smoke imparts:

- Color: Makes rubber brown, improving its appearance.

- Preservation: Acts as an antioxidant to prevent aging and degradation.

It does not soften rubber or cause blistering.

Quick Tip

Smoking rubber improves its shelf life and imparts a characteristic brown color while maintaining mechanical properties.

Q61. The characteristic that deteriorates when more styrene is added in butadiene to get SBR during polymerization is:

1. Resilience
2. Strength
3. Elongation
4. Freezing point

Correct Answer: 1. Resilience

Solution: 1. Understanding SBR Composition:
Styrene-Butadiene Rubber (SBR) is a copolymer where styrene provides rigidity, and butadiene contributes to elasticity.
2. Effect of Increased Styrene:
Adding more styrene increases rigidity, reducing resilience — the material's ability to recover its shape after deformation.
3. Conclusion:
Resilience deteriorates with higher styrene content; strength and elongation are less affected.

Quick Tip

Balancing styrene content is critical for achieving the desired properties in SBR, particularly for applications like tires requiring flexibility.

Q62. Bicycle paddle is an example of:

1. Blow moulding

2. Injection moulding

3. Thermoforming

4. Compression moulding

Correct Answer: 2. Injection moulding

Solution: 1. Injection Moulding Process:
Injection moulding involves injecting molten material into a mold, cooling it, and solidifying it to create complex shapes.
2. Application to Bicycle Paddles:
Bicycle paddles require high precision, durability, and strength — properties well-suited for injection moulding.
3. Alternative Processes:
Blow moulding and thermoforming are unsuitable as they primarily handle hollow or flat structures.

Quick Tip

Injection moulding is ideal for producing high-strength, durable, and complex geometries like bicycle paddles.

Q63. In extrusion, the primary function of the transition zone is to:

A. Compress the polymer

B. Melt the polymer

C. Support the screen pack

D. Contribute to the back pressure

Choose the correct answer:

1. A and B only

2. A and C only

3. B and D only

4. A and D only

Correct Answer: 1. A and B only

Solution: 1. Role of the Transition Zone:
- Compresses the polymer to eliminate air pockets.
- Melts the polymer to prepare it for shaping in the die.
2. Functions of Other Zones:
- Screen pack support and back pressure are handled in different zones, not the transition zone.

Quick Tip

The transition zone ensures uniform melting and compression, critical for consistent extrusion quality.

Q64. Diglycidyl ether of bisphenol-A and 4,4-diamino diphenyl sulfone system can be used to obtain glass-reinforced composites by the process of:

1. Wet-lay-up technique

2. Dry-lay-up technique

3. Dry-wet-up technique

4. Wet-dry-up technique

Correct Answer: 2. Dry-lay-up technique

Solution: 1. Dry-Lay-Up Technique:
- Dry fibers are placed in a mold.
- Resin (e.g., diglycidyl ether of bisphenol-A) is applied with curing agents under controlled conditions.
2. Advantages:

- Ensures high-strength, lightweight composites with precision molding.

3. Comparison:

- Wet-lay-up involves direct application of resin, less suitable for controlled precision applications.

Quick Tip

Dry-lay-up techniques are preferred for applications requiring high strength and lightweight composites, like aerospace components.

Q65. Self-polymerization of reactive styrene at room temperature can be prevented by the addition of:

1. Dicumyl peroxide
2. p-Tetra butyl catechol
3. Diazo carbonamide
4. Chromium oxide

Correct Answer: 2. p-Tetra butyl catechol

Solution: 1. Self-Polymerization of Styrene:

- Uncontrolled reaction due to radical formation.
- Requires inhibitors to prevent chain propagation.

2. Role of p-Tetra Butyl Catechol:

- Acts as a stabilizer by scavenging free radicals.
- Prevents undesired polymerization reactions.

3. Comparison with Alternatives:

- Dicumyl peroxide is a radical initiator, not an inhibitor.

Quick Tip

To inhibit self-polymerization, always add radical scavengers like p-Tetra butyl catechol to the monomer mixture.

Q66. Polymer having high tensile strength, tensile modulus, stiffness, melting point, and heat distortion temperature combined with low specific gravity and excellent resistance to environmental stress cracking is:

1. LDPE
2. Polypropylene
3. HDPE
4. Styrene-butadiene rubber

Correct Answer: 2. Polypropylene

Solution:

1. Properties of Polypropylene:
- High tensile strength and stiffness.
- High melting point and resistance to environmental stress cracking.

2. Comparison with Alternatives:
- HDPE and LDPE have lower stiffness and tensile modulus.
- Styrene-butadiene rubber is not thermoplastic, making it unsuitable.

Quick Tip

Polypropylene is widely used for applications requiring lightweight, high-strength materials, such as automotive parts.

Q67. The polymer —A–A–A–B–B—AAA—B—B represents:

1. Block copolymer
2. Graft copolymer
3. Random copolymer
4. Alternate copolymer

Correct Answer: 1. Block copolymer

Solution: 1. Definition of Block Copolymer:
- Block copolymers have long sequences of one monomer (A) followed by another monomer (B).
- The pattern shown, —AAA—BBB—, matches the structure of a block copolymer.

2. Comparison with Other Types:
- Graft copolymer: Has a main polymer chain with branches of another polymer.
- Random copolymer: Monomers are randomly distributed (e.g., ABABAB).
- Alternate copolymer: Monomers alternate strictly (e.g., ABABAB).

Quick Tip

Block copolymers are versatile materials combining properties of both monomers, widely used in elastomers and adhesives.

Q68. The kinetics and degree of polymerization during emulsion polymerization depend upon:

1. Time of process, quality of initiator
2. Quantity of initiator, intensity of agitator
3. Intensity of agitator, temperature of process
4. Temperature and time of process, quantity of initiator, and intensity of agitator

Correct Answer: 4. Temperature and time of process, quantity of initiator, and intensity of agitator

Solution: 1. Key Factors in Emulsion Polymerization:
- Temperature: Controls the rate of polymerization.
- Time: Determines the degree of polymerization.
- Quantity of initiator: Affects the number of radicals formed, influencing reaction rate.
- Agitation intensity: Ensures uniform mixing and dispersion of monomers and emulsifiers.

2. Significance:

- These factors collectively determine the final polymer properties, such as molecular weight and particle size.

Quick Tip

Optimize initiator, temperature, and agitation for desired polymerization kinetics and high-quality emulsion polymers.

Q69. For the manufacture of Nylon-6 by condensation polymerization of caprolactam, the temperature maintained in the reactor is about:

1. 60–80°C
2. 130–140°C
3. 240–280°C
4. 400–450°C

Correct Answer: 3. 240–280°C

Solution: 1. Manufacturing Nylon-6:

- Caprolactam undergoes ring-opening polymerization.
- A high temperature (240–280°C) is required to promote the reaction and achieve polymerization.

2. Significance of Temperature:

- Lower temperatures result in incomplete polymerization.
- Excessively high temperatures can degrade the polymer.

3. Conclusion:

- 240–280°C is the optimal range for efficient production of high-quality Nylon-6.

Quick Tip

Temperature control is crucial in condensation polymerization to ensure high molecular weight and minimal defects in Nylon-6.

Q70. Catalyst used during the condensation of phenol and formaldehyde to achieve the highest electrical properties is:

1. Liquid ammonia
2. Caustic soda solution
3. Sulphuric acid
4. Hydrochloric acid

Correct Answer: 2. Caustic soda solution

Solution: 1. Phenol-Formaldehyde Condensation:
- Phenol reacts with formaldehyde in the presence of acidic or basic catalysts.
- Caustic soda (NaOH) promotes high cross-link density, improving electrical insulation properties.

2. Comparison of Catalysts:
- Acidic catalysts (e.g., HCl, H_2SO_4): Produce thermosetting resins with different mechanical properties.
- Alkaline catalysts (e.g., NaOH): Enhance electrical properties, making them suitable for insulating materials.

Quick Tip

Use alkaline catalysts like caustic soda to produce phenolic resins with superior electrical properties for circuit boards and insulating materials.

Q71. If the function $f(z) = x^3 + axy + by^3 + i(cx^3 + dxy + y^3)$ is analytic, then the values of a, b, c, d are:

1. $a = 2, b = -1, c = 1, d = -2$
2. $a = 2, b = 1, c = -1, d = 2$
3. $a = 2, b = 1, c = 1, d = 2$

4. $a = 2, b = -1, c = -1, d = 2$

Correct Answer: 4. $a = 2, b = -1, c = -1, d = 2$

Solution: 1. Analytic Function Condition: A function $f(z) = u(x, y) + iv(x, y)$ is analytic if it satisfies the Cauchy-Riemann equations:

$$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}, \quad \frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}.$$

2. Substitute $u(x, y)$ and $v(x, y)$: Here, $u(x, y) = x^3 + axy + by^3$ and $v(x, y) = cx^3 + dxy + y^3$.

3. Partial Derivatives: Compute the partial derivatives:

$$\frac{\partial u}{\partial x} = 3x^2 + ay, \quad \frac{\partial u}{\partial y} = ax + 3by^2,$$

$$\frac{\partial v}{\partial x} = 3cx^2 + dy, \quad \frac{\partial v}{\partial y} = dx + 3y^2.$$

4. Apply Cauchy-Riemann Equations: From $\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}$:

$$3x^2 + ay = dx + 3y^2.$$

From $\frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}$:

$$ax + 3by^2 = -(3cx^2 + dy).$$

5. Solve for a, b, c, d: Equating coefficients gives:

$$a = 2, \; b = -1, \; c = -1, \; d = 2.$$

Quick Tip

To check analyticity, compute partial derivatives and substitute them into the Cauchy-Riemann equations for verification.

Q72. Which of the following is not correct?

1. If A and B are two matrices of order 2×3 and 3×4, then their product AB is of order 2×4.

2. If A and B are square matrices of the same order, then $AB = BA$.

3. The augmented matrix of the system of linear equations in matrix form $Ax = B$ is given by $[A|B]$.

4. Any homogeneous system of linear equations has at least one solution.

Correct Answer: 2. If A and B are square matrices of the same order, then $AB = BA$.

Solution: 1. Matrix Multiplication Order: The product AB is generally not equal to BA because matrix multiplication is not commutative.

2. Examples to Validate: Consider:

$$A = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, \quad B = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}.$$

Here:

$$AB = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}, \quad BA = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}.$$

3. Conclusion: The claim $AB = BA$ is false. All other statements are true: - AB dimensions follow matrix order rules. - Augmented matrices include $[A|B]$. - Homogeneous systems always have at least the trivial solution.

Quick Tip

Remember, matrix multiplication is not commutative. Verify results when swapping the order of operations.

Q73. The first-order partial derivatives of the function $\log(\sin x + \cos y)$ with respect to x and y, respectively, are:

1. $\frac{\cos x}{\sin x + \cos y}, \frac{-\sin y}{\sin x + \cos y}$
2. $\frac{\sin x}{\sin x + \cos y}, \frac{\cos y}{\sin x + \cos y}$
3. $\frac{-\cos x}{\sin x + \cos y}, \frac{-\sin y}{\sin x + \cos y}$
4. $\frac{\cos x}{\sin x + \cos y}, \frac{\sin y}{\sin x + \cos y}$

Correct Answer: 1. $\frac{\cos x}{\sin x+\cos y}, \frac{-\sin y}{\sin x+\cos y}$

Solution: 1. Function Given:

$$f(x, y) = \log(\sin x + \cos y).$$

2. Derivative w.r.t. x:

$$\frac{\partial}{\partial x}\log(\sin x + \cos y) = \frac{1}{\sin x + \cos y} \cdot \frac{\partial(\sin x + \cos y)}{\partial x}.$$
$$= \frac{\cos x}{\sin x + \cos y}.$$

3. Derivative w.r.t. y:

$$\frac{\partial}{\partial y}\log(\sin x + \cos y) = \frac{1}{\sin x + \cos y} \cdot \frac{\partial(\sin x + \cos y)}{\partial y}.$$
$$= \frac{-\sin y}{\sin x + \cos y}.$$

Quick Tip

When differentiating logarithmic functions, use the chain rule: $\frac{\partial \log(u)}{\partial x} = \frac{1}{u} \cdot \frac{\partial u}{\partial x}$.

Q74. The complementary function of the differential equation $y'' + 16y = x\sin px, p = +4$ is given by:

1. $a\cos 16x + b\sin 16x$, where a and b are constants
2. $a\cos 4x + b\sin 4x$, where a and b are constants
3. $a\cos 8x + b\sin 8x$, where a and b are constants
4. $a\cos 2x + b\sin 2x$, where a and b are constants

Correct Answer: 2. $a\cos 4x + b\sin 4x$

Solution: 1. Identify the Differential Equation: The equation is:

$$y'' + 16y = x\sin px, \quad p = 4.$$

2. Find the Characteristic Equation: Solve the homogeneous part $y'' + 16y = 0$:

$$r^2 + 16 = 0.$$

3. Solve the Characteristic Equation:

$$r^2 = -16 \implies r = \pm 4i.$$

4. Write the Complementary Function: The general solution for the complementary function is:

$$y_c = a\cos 4x + b\sin 4x,$$

where a and b are constants.

Quick Tip

For equations of the form $y'' + k^2 y = 0$, the complementary function is $\cos(kx) + \sin(kx)$, where $k = \sqrt{\text{coefficient of } y}$.

Q75. Which of the following is correct?

1. The Cauchy-Riemann equations are given by $\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}, \frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}$.
2. The function $f(z) = z$ is analytic everywhere.
3. If $f(z)$ is analytic inside and on a simple closed curve C, then $\int_C f(z)dz = 0$.
4. If $f(z)$ is analytic inside and on a simple closed curve C except at a finite number of points, then the integral around C equals $2\pi i \times$ (sum of residues).

Correct Answer: 4. If $f(z)$ is analytic inside and on a simple closed curve C except at a finite number of points, then the integral around C equals $2\pi i \times$ (sum of residues).

Solution:

1. Residue Theorem:

- The Residue Theorem states that if $f(z)$ is analytic in a region except at a finite number of singularities within a closed contour C, then:

$$\int_C f(z)\,dz = 2\pi i \sum (\text{residues of } f(z) \text{ at singularities inside } C).$$

2. Analysis of Options:

- Option 1: The correct Cauchy-Riemann equations are:

$$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}, \quad \frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}.$$

Thus, this statement is correct.

- Option 2: The function $f(z) = z$ is analytic everywhere, as it satisfies the Cauchy-Riemann equations globally. This statement is also correct.

- Option 3: If $f(z)$ is analytic inside and on C, then the integral is zero. This is true, but the statement does not account for singularities.

- Option 4: Matches the Residue Theorem precisely and is the most comprehensive statement.

3. Conclusion:

- Option 4 best captures the essence of analytic functions with singularities, as it incorporates the Residue Theorem.

Quick Tip

The Residue Theorem is a powerful tool for evaluating contour integrals involving analytic functions with isolated singularities.
