OJEE LE Tech (BSc) Sample Paper 03

A) Mode and Time: The exam is a Computer Based Test (CBT) lasting 60 minutes.
B) Total Questions: The exam contains 60 questions.
C) Marking Scheme & Rules:

- +4 marks for each correct answer; -1 mark for each incorrect answer.

Q1. What is the value of the limit $\lim_{x\to 0} \frac{\tan x - x}{x^3}$?

A. 1

B. 1/3

C. 1/6

D. 0

Q2. The trace of an orthogonal matrix of order n must always lie in the interval:

A. $[0, n]$

B. $[-n, n]$

C. $[-1, 1]$

D. $[0, 1]$

Q3. The integrating factor for the first-order linear differential equation $x\frac{dy}{dx} - y = x^2$ is:

A. $1/x$

B. $-1/x$

C. x

D. e^{-x}

Q4. The complex function $f(z) = \frac{1}{\sin(1/z)}$ has what type of singularity at $z = 0$?

A. Removable singularity

B. Simple pole

C. Non-isolated essential singularity

D. Isolated essential singularity

Q5. Stokes' theorem mathematically connects which two types of vector integrals?

A. Line and Surface integrals

B. Surface and Volume integrals

C. Line and Volume integrals

D. Contour and Double integrals

Q6. The number of generators of a finite cyclic group of prime order p is:

A. 1

B. p

C. $p-1$

D. $p/2$

Q7. In numerical integration, the local truncation error of the Trapezoidal rule is of the order:

A. $O(h)$

B. $O(h^2)$

C. $O(h^3)$

D. $O(h^4)$

Q8. The complete integral of the non-linear partial differential equation $p^2+q^2=1$ (where $p=\frac{\partial z}{\partial x}, q=\frac{\partial z}{\partial y}$) is given by:

A. $z=ax+ay+c$

B. $z=ax+y\sqrt{1-a^2}+c$

C. $z=x\sqrt{1-a^2}+ay+c$

D. $z=a^2x+b^2y+c$

Q9. What is the Laplace transform of the function $f(t)=e^{at}$?

A. $\frac{1}{s+a}$

B. $\frac{a}{s^2+a^2}$

C. $\frac{1}{s-a}$

D. $\frac{s}{s^2-a^2}$

Q10. For a Binomial probability distribution with parameters n and p, the relationship between its mean and variance is:

A. Mean $<$ Variance

B. Mean $=$ Variance

C. Mean $>$ Variance

D. Mean $=$ Variance^2

Q11. According to the fundamental theorem of calculus, the derivative $\frac{d}{dx}\int_0^x e^{-t^2}dt$ is equal to:

A. $2xe^{-x^2}$

B. e^{-x^2}

C. $-e^{-x^2}$

D. 0

Q12. The nullity (dimension of the null space) of a 4×4 identity matrix is:

A. 4

B. 1

C. 0

D. -1

Q13. The Cauchy-Riemann equations for an analytic function $f(z) = u(r,\theta) + iv(r,\theta)$ in polar coordinates are:

A. $u_r = \frac{1}{r}v_\theta, v_r = -\frac{1}{r}u_\theta$

B. $u_r = v_\theta, v_r = -u_\theta$

C. $u_r = -\frac{1}{r}v_\theta, v_r = \frac{1}{r}u_\theta$

D. $u_r = rv_\theta, v_r = -ru_\theta$

Q14. For any continuously differentiable scalar field ϕ, the curl of its gradient $(\nabla \times (\nabla\phi))$ is:

A. $\nabla^2\phi$

B. $\mathbf{1}$

C. $\mathbf{0}$

D. $\nabla\phi$

Q15. If the auxiliary equation of a second-order linear homogeneous ODE has real and distinct roots m_1 and m_2, the general solution is:

A. $y = (c_1 + c_2 x)e^{m_1 x}$

B. $y = c_1 e^{m_1 x} + c_2 e^{m_2 x}$

C. $y = e^{m_1 x}(c_1 \cos m_2 x + c_2 \sin m_2 x)$

D. $y = c_1 \cos m_1 x + c_2 \sin m_2 x$

Q16. The rate of convergence of the Bisection method for finding the root of an equation is:

A. Quadratic

B. Cubic

C. Super-linear

D. Linear

Q17. The determinant of a real skew-symmetric matrix of odd order is always:

A. 1

B. -1

C. 0

D. A purely imaginary number

Q18. The residue of the complex function $f(z) = \frac{e^z}{(z-1)^2}$ at the pole $z = 1$ is:

A. 1

B. e

C. $e/2$

D. 0

Q19. The Fourier series of a purely even periodic function consists entirely of:

A. Sine terms only

B. Cosine terms and a constant

C. Both sine and cosine terms

D. Odd harmonics only

Q20. In abstract algebra, Lagrange's theorem implies that any group of prime order must necessarily be:

A. Non-abelian

B. Cyclic

C. A symmetric group

D. An alternating group

Q21. A differential equation of the specific form $y = px + f(p)$, where $p = \frac{dy}{dx}$, is known as:

A. Bernoulli's equation

B. Euler-Cauchy equation

C. Clairaut's equation

D. Riccati equation

Q22. In differential calculus, the radius of curvature of a perfectly straight line is:

A. 0

B. 1

C. π

D. ∞

Q23. What is the inverse Laplace transform of $\frac{1}{s^2+a^2}$?

A. $\cos(at)$

B. $\frac{1}{a}\sin(at)$

C. $\sin(at)$

D. $\frac{1}{a}\cos(at)$

Q24. In classical probability theory, the probability of an impossible event is universally defined as:

A. -1

B. 0.5

C. 1

D. 0

Q25. The one-dimensional heat conduction equation $u_t = c^2 u_{xx}$ is mathematically classified as a:

A. Parabolic partial differential equation

B. Hyperbolic partial differential equation

C. Elliptic partial differential equation

D. Linear ordinary differential equation

Q26. A fundamental property of a real orthogonal matrix is that its inverse is identically equal to its:

A. Adjugate

B. Determinant

C. Transpose

D. Cofactor matrix

Q27. A vector field $\mathbf{V}$ that satisfies the condition $\nabla \cdot \mathbf{V} = 0$ everywhere is termed:

A. Irrotational

B. Conservative

C. Solenoidal

D. Harmonic

Q28. In numerical methods, the classic 4th-order Runge-Kutta method has a local truncation error of the order:

A. $O(h^2)$

B. $O(h^3)$

C. $O(h^4)$

D. $O(h^5)$

Q29. The principal value of the complex expression i^i evaluates to a:

A. Purely imaginary number

B. Complex number with non-zero real and imaginary parts

C. Purely real number $(e^{-\pi/2})$

D. Zero

Q30. The absolute maximum value of the function $f(x) = \sin x + \cos x$ is:

A. 1

B. 2

C. $\sqrt{2}$

D. 0

Q31. In electromagnetism, Gauss's law for electric fields in dielectric media is most conveniently expressed using which vector field?

A. Electric field **E**

B. Electric displacement **D**

C. Magnetic induction **B**

D. Polarization **P**

Q32. The zero-point energy of a quantum particle of mass m confined in a one-dimensional box of length L is:

A. 0

B. $\frac{h^2}{8mL^2}$

C. $\frac{h^2}{4mL^2}$

D. $\frac{3h^2}{8mL^2}$

Q33. The theoretical maximum efficiency of a Carnot heat engine operating between a hot reservoir at T_1 and a cold reservoir at T_2 is:

A. $1 - \frac{T_1}{T_2}$

B. $1 - \frac{T_2}{T_1}$

C. $\frac{T_1 - T_2}{T_1 + T_2}$

D. $\frac{T_2}{T_1}$

Q34. In solid-state physics, the effective number of atoms per unit cell in a Body-Centered Cubic (BCC) crystal lattice is:

A. 1

B. 2

C. 4

D. 6

Q35. The resolving power of a diffraction grating is directly proportional to the:

A. Wavelength of incident light

B. Width of the grating lines

C. Total number of rulings and the order of the spectrum

D. Distance to the screen

Q36. The moment of inertia of a uniform solid sphere of mass M and radius R about an axis passing through its center is:

A. $\frac{2}{3}MR^2$

B. $\frac{1}{2}MR^2$

C. $\frac{2}{5}MR^2$

D. MR^2

Q37. The magnetic susceptibility (χ_m) of an ideal diamagnetic material is typically:

A. Large and positive

B. Small and positive

C. Small and negative

D. Zero

Q38. In quantum mechanics, the linear momentum operator in the x-direction ($\hat{p}_x$) is represented by:

A. $i\hbar\frac{\partial}{\partial x}$

B. $-i\hbar\frac{\partial}{\partial x}$

C. $\hbar^2\frac{\partial^2}{\partial x^2}$

D. $-i\hbar\nabla$

Q39. Fermi-Dirac quantum statistics apply specifically to particles that are identical, indistinguishable, and possess:

A. Zero spin

B. Integer spin

C. Half-integer spin

D. No electric charge

Q40. In the Newton's rings interference experiment, the central spot observed in the reflected light system is:

A. Bright

B. Dark

C. Colored

D. Transparent

Q41. The First Law of Thermodynamics is essentially a specific formulation of the universal law of conservation of:

A. Mass

B. Momentum

C. Charge

D. Energy

Q42. The speed of an electromagnetic wave in a perfect vacuum (c) is related to the vacuum permittivity (ε_0) and permeability (μ_0) by the equation:

A. $c = \mu_0 \varepsilon_0$

B. $c = \sqrt{\mu_0 \varepsilon_0}$

C. $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

D. $c = \frac{1}{\mu_0 \varepsilon_0}$

Q43. According to the theory of Special Relativity, the invariant rest mass of a photon is strictly:

A. 3×10^8 kg

B. Defined by E/c^2

C. 0

D. Infinite

Q44. What is the degeneracy of the first excited energy state of a three-dimensional isotropic quantum harmonic oscillator?

A. 1 (Non-degenerate)

B. 2

C. 3

D. 6

Q45. In crystallography, the reciprocal lattice of a Body-Centered Cubic (BCC) real-space lattice is a:

A. Simple Cubic (SC) lattice

B. Base-Centered Cubic lattice

C. Body-Centered Cubic (BCC) lattice

D. Face-Centered Cubic (FCC) lattice

Q46. What is the correct SI unit for the rate constant (k) of a first-order chemical reaction?

A. $mol \cdot L^{-1} \cdot s^{-1}$

B. s^{-1}

C. $L \cdot mol^{-1} \cdot s^{-1}$

D. $L^2 \cdot mol^{-2} \cdot s^{-1}$

Q47. According to VSEPR theory and hybridization concepts, the central Phosphorus atom in PCl_5 undergoes which type of hybridization?

A. sp^3

B. dsp^2

C. sp^3d

D. sp^3d^2

Q48. In the Reimer-Tiemann reaction (conversion of phenol to salicylaldehyde), the reactive electrophilic intermediate generated from chloroform and base is:

A. Carbocation

B. Dichlorocarbene ($:CCl_2$)

C. Chloronium ion

D. Free radical

Q49. Hess's Law of Constant Heat Summation is a direct consequence of the fact that enthalpy is a:

A. Path function

B. Intensive property

C. State function

D. Kinetic property

Q50. What is the formal oxidation state of Chromium (Cr) in Potassium dichromate ($K_2Cr_2O_7$)?

A. +3

B. +4

C. +6

D. +7

Q51. When a primary aliphatic amine is heated with chloroform and ethanolic potassium hydroxide, it produces a foul-smelling compound. This is the:

A. Liebermann's nitroso test

B. Carbylamine (Isocyanide) test

C. Hinsberg's test

D. Iodoform test

Q52. Colligative properties of dilute solutions (like boiling point elevation and osmotic pressure) depend strictly upon the:

A. Chemical nature of the solute

B. Physical state of the solvent

C. Number of solute particles relative to solvent molecules

D. Molecular weight of the solvent

Q53. Which element in the periodic table exhibits the highest electronegativity?

A. Oxygen (O)

B. Chlorine (Cl)

C. Fluorine (F)

D. Nitrogen (N)

Q54. Natural rubber is a linear addition polymer fundamentally composed of repeating units of which monomer?

A. Chloroprene

B. Isoprene (2-methyl-1,3-butadiene)

C. Styrene

D. Ethylene glycol

Q55. For any chemical system that has reached thermodynamic equilibrium at constant temperature and pressure, the change in Gibbs free energy (ΔG) is:

A. Maximum

B. 0

C. Less than 0

D. Greater than 0

Q56. Despite its sp^3 hybridization, the molecular geometry of Ammonia (NH_3) is not perfectly tetrahedral due to a lone pair. Its actual shape is:

A. Square planar

B. Trigonal planar

C. Trigonal pyramidal

D. Bent/V-shaped

Q57. According to IUPAC nomenclature rules, the systematic name for acetic acid (CH_3COOH) is:

A. Methanoic acid

B. Ethanoic acid

C. Propanoic acid

D. Formic acid

Q58. In electrochemistry, the Nernst equation mathematically links the actual cell potential to the standard cell potential and the:

A. Temperature and Reaction Quotient (Q)

B. Activation energy of the electrodes

C. Volume of the electrolyte

D. Atmospheric pressure

Q59. What is the coordination number of the central Cobalt ion in the complex $[Co(en)_3]^{3+}$ (where 'en' is ethylenediamine)?

A. 3

B. 4

C. 6

D. 8

Q60. The Lucas test, which uses a reagent of anhydrous $ZnCl_2$ and concentrated HCl, is primarily used in organic chemistry to distinguish between:

A. Aldehydes and Ketones

B. Alkanes and Alkenes

C. Primary, Secondary, and Tertiary amines

D. Primary, Secondary, and Tertiary alcohols

Solutions

1. B
Explanation: Expand $\tan x = x + x^3/3 + 2x^5/15 + \dots$ Substituting this into the limit gives $\frac{(x+x^3/3+\dots)-x}{x^3} = \frac{x^3/3}{x^3} = 1/3$.

2. B
Explanation: The eigenvalues of a real orthogonal matrix have an absolute value of 1 (they are of the form $e^{i\theta}$). The trace is the sum of these n eigenvalues. The maximum sum occurs if all are $+1$ (trace n), and the minimum if all are -1 (trace $-n$). Thus, it lies in $[-n, n]$.

3. A
Explanation: Rewrite the equation in standard linear form: $\frac{dy}{dx} - \frac{1}{x}y = x$. The integrating factor is $e^{\int P(x)dx} = e^{\int(-1/x)dx} = e^{-\ln x} = e^{\ln(x^{-1})} = 1/x$.

4. C
Explanation: The function $f(z) = 1/\sin(1/z)$ has poles where $\sin(1/z) = 0$, which occurs at $1/z = n\pi \implies z = 1/(n\pi)$. As $n \to \infty$, these poles accumulate at $z = 0$. Therefore, $z = 0$ is a non-isolated essential singularity.

5. A
Explanation: Stokes' theorem equates the surface integral of the curl of a vector field over a surface Σ to the line integral of the vector field over its closed boundary curve $\partial\Sigma$.

6. C
Explanation: For a finite cyclic group of order n, the number of generators is given by Euler's totient function $\phi(n)$. If $n = p$ (a prime number), then $\phi(p) = p - 1$.

7. C
Explanation: The local truncation error for a single interval in the Trapezoidal rule is $-\frac{h^3}{12}f''(\xi)$, which is mathematically of the order $O(h^3)$. (The global error is $O(h^2)$).

8. B
Explanation: For an equation of the form $f(p, q) = 0$, the complete integral is $z = ax + by + c$ where $a^2 + b^2 = 1$. Thus $b = \sqrt{1 - a^2}$, giving $z = ax + y\sqrt{1 - a^2} + c$.

9. C
Explanation: By definition, the Laplace transform of e^{at} is $L\{e^{at}\} = \int_0^\infty e^{-st}e^{at}dt = \int_0^\infty e^{-(s-a)t}dt = \frac{1}{s-a}$ (for $s > a$).

10. C
Explanation: For a Binomial distribution, the Mean is np and the Variance is npq (where $q = 1 - p$). Since p is a probability ($0 < p < 1$), q is also a fraction less than 1. Therefore, $np > npq$, meaning Mean ¿ Variance.

11. B
Explanation: The First Fundamental Theorem of Calculus states that if $F(x) = \int_a^x f(t)dt$, then $F'(x) = f(x)$. Applying this gives $\frac{d}{dx}\int_0^x e^{-t^2}dt = e^{-x^2}$.

12. C
Explanation: The identity matrix has full rank. For a 4×4 identity matrix,

the Rank is 4. By the Rank-Nullity Theorem (Rank + Nullity = Dimension), $4 + \text{Nullity} = 4$, so Nullity $= 0$.

13. A
Explanation: In polar coordinates, the Cauchy-Riemann equations ensuring complex differentiability are $u_r = \frac{1}{r}v_\theta$ and $v_r = -\frac{1}{r}u_\theta$.

14. C
Explanation: A fundamental vector calculus identity establishes that the curl of the gradient of any twice-differentiable scalar field is identically zero ($\nabla \times (\nabla \phi) = \mathbf{0}$).

15. B
Explanation: When the auxiliary equation yields real and distinct roots ($m_1 \neq m_2$), the fundamental independent solutions are $e^{m_1 x}$ and $e^{m_2 x}$, making the general solution $y = c_1 e^{m_1 x} + c_2 e^{m_2 x}$.

16. D
Explanation: The Bisection method halves the interval at each step. The error at step $n+1$ is directly proportional to the error at step n ($e_{n+1} \approx 0.5 e_n$), which defines Linear convergence.

17. C
Explanation: For a skew-symmetric matrix A, $A^T = -A$. Taking the determinant: $|A^T| = |-A| \implies |A| = (-1)^n |A|$. If n is odd, $|A| = -|A| \implies 2|A| = 0 \implies |A| = 0$.

18. B
Explanation: For a pole of order $m = 2$ at $z = 1$, the residue is $\lim_{z\to 1} \frac{1}{(2-1)!}\frac{d}{dz}\left[(z-1)^2 \frac{e^z}{(z-1)^2}\right] = \lim_{z\to 1} \frac{d}{dz}(e^z) = \lim_{z\to 1} e^z = e^1 = e$.

19. B
Explanation: An even function satisfies $f(-x) = f(x)$. Its product with $\sin(nx)$ (an odd function) is odd, so all sine coefficients $b_n = 0$. The series contains only cosine terms and the constant a_0.

20. B
Explanation: A corollary to Lagrange's theorem states that any group with a prime number of elements has no non-trivial subgroups and can be generated by any non-identity element, thus it is always Cyclic.

21. C
Explanation: The differential equation $y = x\frac{dy}{dx} + f(\frac{dy}{dx})$, written as $y = px + f(p)$, is the standard form of Clairaut's equation. Its general solution is simply $y = cx + f(c)$.

22. D
Explanation: Curvature (κ) measures how sharply a curve bends. A straight line does not bend, so its curvature is exactly 0. The radius of curvature ($R = 1/\kappa$) is therefore infinite (∞).

23. B
Explanation: The standard Laplace transform formula is $L\{\sin(at)\} = \frac{a}{s^2+a^2}$. Therefore, the inverse Laplace transform of $\frac{1}{s^2+a^2}$ requires dividing by a, giving $\frac{1}{a}\sin(at)$.

24. D

Explanation: By Kolmogorov's axioms of probability, the probability of an event that cannot possibly occur (an impossible event) is exactly 0.

25. A
Explanation: For a second-order linear PDE $Au_{xx} + Bu_{xy} + Cu_{yy} \ldots$, the discriminant is $B^2 - 4AC$. For the heat equation $u_{xx} - \frac{1}{c^2}u_t = 0$, $A = 1, B = 0, C = 0$. The discriminant is $0^2 - 0 = 0$, classifying it as Parabolic.

26. C
Explanation: By definition, an orthogonal matrix Q satisfies $QQ^T = Q^TQ = I$. Therefore, multiplying by the inverse yields $Q^{-1} = Q^T$.

27. C
Explanation: A vector field with zero divergence ($\nabla \cdot \mathbf{V} = 0$) means it acts like a continuous loop with no sources or sinks. Such a field is termed a Solenoidal field (like a magnetic field).

28. D
Explanation: The classical 4th-order Runge-Kutta method (RK4) has a local truncation error per step of $O(h^5)$. The accumulated global truncation error over the entire interval is $O(h^4)$.

29. C
Explanation: Write i in exponential form: $i = e^{i\pi/2}$. Then $i^i = (e^{i\pi/2})^i = e^{i^2\pi/2} = e^{-\pi/2}$. Since e and π are real, $e^{-\pi/2}$ is a purely real number (approx 0.207).

30. C
Explanation: To maximize $f(x) = \sin x + \cos x$, take the derivative $f'(x) = \cos x - \sin x = 0 \implies \tan x = 1 \implies x = \pi/4$. Evaluating $f(\pi/4) = \frac{\sqrt{2}}{2} + \frac{\sqrt{2}}{2} = \sqrt{2}$.

31. B
Explanation: In dielectric media, polarization effects make the total electric field complex. Gauss's law is modified to $\nabla \cdot \mathbf{D} = \rho_{\text{free}}$, where $\mathbf{D}$ is the electric displacement vector.

32. B
Explanation: The energy levels for a particle in a 1D box are $E_n = \frac{n^2h^2}{8mL^2}$. The lowest possible state (zero-point energy) corresponds to $n = 1$, giving $E_1 = \frac{h^2}{8mL^2}$.

33. B
Explanation: The Carnot efficiency formula relies solely on the absolute temperatures of the hot (T_1) and cold (T_2) reservoirs, defined mathematically as $\eta = 1 - \frac{T_2}{T_1}$.

34. B
Explanation: A BCC unit cell has 1 atom at the center (wholly inside) and 8 atoms at the corners (each shared by 8 adjacent cells). Total atoms $= 1 + (8 \times 1/8) = 2$.

35. C
Explanation: The resolving power of a diffraction grating is given by $R = \lambda/\Delta\lambda = nN$, where n is the order of the spectrum and N is the total number of lines (rulings) on the grating.

36. C
Explanation: By integrating the moment of inertia of infinitesimally thin disks from pole to pole, the moment of inertia for a uniform solid sphere about its central

axis evaluates to $\frac{2}{5}MR^2$.

37. C
Explanation: Diamagnetic materials weakly oppose applied magnetic fields due to induced orbital electron currents. Thus, their magnetic susceptibility χ_m is slightly less than zero (small and negative).

38. B
Explanation: In the position representation of quantum mechanics, the momentum operator for the x-coordinate is postulated as $\hat{p}_x = -i\hbar\frac{\partial}{\partial x}$.

39. C
Explanation: Fermi-Dirac statistics describe the statistical distribution of fermions—particles that obey the Pauli exclusion principle and have half-odd-integer spin (like electrons, protons, and neutrons).

40. B
Explanation: In Newton's rings (reflected light), the air film thickness at the exact center is zero. A 180° (π) phase change occurs upon reflection from the denser glass boundary, creating perfectly destructive interference (a dark spot).

41. D
Explanation: The First Law of Thermodynamics ($\Delta U = Q - W$) is the application of the universal physical law of conservation of energy to thermodynamic systems.

42. C
Explanation: Maxwell derived that electromagnetic waves travel at the speed of light, mathematically linking mechanics and optics through the relation $c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$.

43. C
Explanation: According to Special Relativity, a photon travels precisely at the speed of light c. To have a finite energy and momentum at this speed, its invariant rest mass must be exactly zero.

44. C
Explanation: For a 3D isotropic harmonic oscillator, energy is $E_{nx,ny,nz} = (n_x + n_y + n_z + \frac{3}{2})\hbar\omega$. The ground state is $(0, 0, 0)$. The first excited state has total $n = 1$, which can be $(1, 0, 0)$, $(0, 1, 0)$, or $(0, 0, 1)$. This gives a degeneracy of 3.

45. D
Explanation: Through Fourier transform definitions of crystal lattices, the reciprocal lattice vectors generated from a Body-Centered Cubic (BCC) direct lattice mathematically construct a Face-Centered Cubic (FCC) lattice in reciprocal (momentum) space.

46. B
Explanation: The rate law for a first-order reaction is Rate $= k[A]$. Rate has units of M/s, and $[A]$ has units of M (Molarity). Therefore, k must have units of $1/s$ or s^{-1} to balance the equation.

47. C
Explanation: Phosphorus in PCl_5 utilizes 5 valence electrons to form 5 single bonds with Chlorine atoms. There are no lone pairs. A steric number of 5 requires 5 hybridized orbitals, which is sp^3d.

48. B
Explanation: In the Reimer-Tiemann reaction, chloroform ($CHCl_3$) reacts with a strong base like KOH to undergo alpha-elimination, forming the highly electron-deficient dichlorocarbene ($:CCl_2$) which acts as the electrophile.

49. C
Explanation: Hess's Law states that the total enthalpy change of a reaction is the same regardless of the pathway taken. This is fundamentally because Enthalpy (H) is a thermodynamic state function.

50. C
Explanation: In $K_2Cr_2O_7$, Potassium is $+1$ and Oxygen is -2. Let Cr be x. The net charge is 0, so $2(1)+2(x)+7(-2)=0 \implies 2+2x-14=0 \implies 2x=12 \implies x=+6$.

51. B
Explanation: The Carbylamine reaction (or isocyanide test) is a specific chemical test for primary amines. When heated with chloroform and ethanolic base, primary amines synthesize highly foul-smelling isocyanides.

52. C
Explanation: By strict definition in physical chemistry, colligative properties depend uniquely on the ratio or absolute number of solute particles in a solution, regardless of their chemical identity.

53. C
Explanation: Fluorine (F) sits at the top-right of the halogen group and has the strongest pull on shared electrons in a chemical bond, giving it the highest electronegativity (3.98 on the Pauling scale).

54. B
Explanation: Natural rubber is a highly elastic polymer consisting almost entirely of long chains of cis-1,4-polyisoprene, meaning its constituent monomer unit is isoprene (2-methyl-1,3-butadiene).

55. B
Explanation: At chemical equilibrium, the system is at its lowest possible free energy state. There is no longer any driving force in either the forward or reverse direction, meaning $\Delta G = 0$.

56. C
Explanation: While NH_3 has 4 electron domains (sp^3 geometry = tetrahedral), one of those is a lone pair. The molecular geometry (which only counts atoms) is thus Trigonal pyramidal, with bond angles compressed to $\approx 107°$.

57. B
Explanation: Acetic acid (CH_3COOH) contains two carbon atoms. In IUPAC nomenclature, a two-carbon alkane is ethane. Dropping the 'e' and adding the carboxylic acid suffix '-oic acid' makes it Ethanoic acid.

58. A
Explanation: The Nernst equation is $E = E° - \frac{RT}{nF}\ln Q$. It shows how the actual cell potential (E) depends on the standard potential ($E°$), the absolute Temperature (T), and the Reaction Quotient (Q).

59. C

Explanation: Ethylenediamine (en) is a bidentate ligand, meaning each 'en' molecule forms 2 coordinate bonds with the metal ion. Since there are 3 'en' ligands, $3 \times 2 = 6$. The coordination number is 6.

60. D

Explanation: The Lucas test differentiates primary, secondary, and tertiary alcohols based on their reactivity (via an S_N1 mechanism) with a solution of anhydrous zinc chloride in concentrated hydrochloric acid.