

Test Booklet Series



Test Booklet
(Physics)

Test Booklet No.

Name of Applicant

Answer Sheet No.

Applicant ID/Roll No. :

Signature of Applicant :

Date of Examination :

Signature of the Invigilator(s)

Time of Examination :

1.

2.

Duration : 2 Hour]

[Maximum Marks : 100

IMPORTANT INSTRUCTIONS

- (i) The question paper is in the form of Test-Booklet containing **100 (Hundred)** questions. All questions are compulsory. Each question carries four answers marked (A), (B), (C) and (D), out of which only one is correct. Choose the correct option or the most appropriate option.
- (ii) On receipt of the Test-Booklet (Question Paper), the candidate should immediately check it and ensure that it contains all the pages, i.e., **100** questions. Discrepancy, if any, should be reported by the candidate to the invigilator immediately after receiving the Test-Booklet.
- (iii) A separate Answer-Sheet is provided with the Test-Booklet/Question Paper. On this sheet there are **100** rows containing four circles each. One row pertains to one question.
- (iv) The candidate should write his/her Application ID/Roll number at the places provided on the cover page of the Test-Booklet/Question Paper and on the Answer-Sheet and **NOWHERE ELSE**.
- (v) No second Test-Booklet/Question Paper and Answer-Sheet will be given to a candidate. The candidates are advised to be careful in handling it and writing the answer on the Answer-Sheet.
- (vi) For every correct answer of the question **One (1) mark will be awarded**.
- (vii) Marking shall be done only on the basis of answers responded on the Answer-Sheet.
- (viii) To mark the answer on the Answer-Sheet, candidate should darken the appropriate circle in the row of each question with Blue or Black pen.
- (ix) For each question only **one** circle should be **darkened** as a mark of the answer adopted by the candidate. If more than one circle for the question are found darkened or with one black circle any other circle carries any mark, the answer will be treated as incorrect.
- (x) The candidates should not remove any paper from the Test-Booklet/Question Paper. Attempting to remove any paper shall be liable to be punished for use of unfair means.
- (xi) Rough work may be done on the blank space provided in the Test-Booklet/Question Paper only.
- (xii) *Mobile phones (even in Switch-off mode) and such other communication/programmable devices are not allowed inside the examination hall.*
- (xiii) No candidate shall be permitted to leave the examination hall before the expiry of the time.

DO NOT OPEN THIS QUESTION BOOKLET UNTIL ASKED TO DO SO.

PART-A
(Research Methodology)

1. The main objective of fundamental/basic research is:
(A) To solve an immediate practical problem
(B) To discover new facts and develop theories
(C) To evaluate existing social programs
(D) To study historical events

2. The scientific method of research is characterized by:
(A) Subjectivity and intuition
(B) Empiricism, objectivity, and replicability
(C) Relying solely on authority
(D) Lack of logical reasoning

3. While selecting a research topic, which of the following is the LEAST important consideration?
(A) Feasibility of the study
(B) Researcher's interest
(C) Availability of funds and time
(D) Personal biases of the researcher

4. The ethical principle of "Informed Consent" implies that:
(A) Participants must be forced to participate for the greater good
(B) Participants must be fully aware of the research procedures and agree voluntarily
(C) Researchers can hide the true purpose of the study to avoid bias
(D) Data can be shared publicly without participant knowledge

5. Fabrication, falsification, and plagiarism in research are collectively known as:
(A) Research misconduct
(B) Sampling error
(C) Ethical compliance
(D) Research methodology

6. Which research design is primarily concerned with describing the characteristics of a population or phenomenon?
(A) Exploratory research design
(B) Descriptive research design
(C) Experimental research design
(D) Diagnostic research design

7. In an experimental research design, the variable that is intentionally manipulated by the researcher is the:
(A) Dependent variable
(B) Extraneous variable
(C) Independent variable
(D) Control variable

8. Research conducted to find out the causes of an event that has already happened, without manipulating variables, is known as:
- (A) Action research (B) Ex-post facto research
(C) Applied research (D) Pure research
9. The "Control Group" in an experimental design is used to:
- (A) Introduce the experimental treatment
(B) Serve as a baseline for comparison with the experimental group
(C) Eliminate the dependent variable
(D) Increase the sample size
10. Deductive reasoning in the scientific method moves from:
- (A) Specific observations to general theories
(B) General theories to specific hypotheses
(C) Empirical data to conceptualization
(D) Null hypothesis to alternative hypothesis
11. Internal validity in an experimental design refers to:
- (A) The generalizability of the findings to the real world
(B) The certainty that the independent variable caused the changes in the dependent variable
(C) The consistency of the measuring instrument
(D) The representativeness of the sample
12. If every member of the population has an equal and independent chance of being selected, the sampling technique is called:
- (A) Purposive sampling (B) Convenience sampling
(C) Simple random sampling (D) Quota sampling
13. When the population is heterogeneous with distinct subgroups (strata), the most appropriate probability sampling technique is:
- (A) Simple random sampling (B) Stratified random sampling
(C) Cluster sampling (D) Snowball sampling

- 14.** In cluster sampling, the sampling units selected are:
- (A) Individual elements
 - (B) Natural groupings or categories (e.g., districts, schools)
 - (C) Homogeneous subgroups
 - (D) Volunteers
- 15.** Snowball sampling is specifically used when:
- (A) The population size is very large
 - (B) The sampling frame is readily available
 - (C) The population is hidden, rare, or difficult to access
 - (D) The researcher needs a perfectly representative sample
- 16.** The difference between a sample statistic and the true population parameter is termed as:
- (A) Systematic error
 - (B) Sampling error
 - (C) Measurement error
 - (D) Non-sampling error
- 17.** Which measurement scale classifies data into mutually exclusive categories without any order or ranking?
- (A) Ordinal scale
 - (B) Interval scale
 - (C) Nominal scale
 - (D) Ratio scale
- 18.** A Likert scale (Strongly Disagree to Strongly Agree) is technically an example of:
- (A) Nominal scale
 - (B) Ordinal scale
 - (C) Interval scale
 - (D) Ratio scale
- 19.** Which scaling technique asks respondents to rate an object on a series of bipolar adjectives (e.g., Good-Bad, Fast-Slow)?
- (A) Likert scale
 - (B) Guttman scale
 - (C) Semantic Differential scale
 - (D) Thurstone scale

- 20.** The key difference between a questionnaire and a schedule is:
- (A) A questionnaire is filled by the enumerator, a schedule is filled by the respondent
 - (B) A questionnaire is filled by the respondent, a schedule is filled by the enumerator/interviewer
 - (C) A schedule is mailed, a questionnaire is given face-to-face
 - (D) There is no difference between them
- 21.** Data collected by the researcher themselves for the specific purpose of the current study is called:
- (A) Secondary data
 - (B) Primary data
 - (C) Official data
 - (D) Documentary data
- 22.** The process of checking the raw data to ensure completeness, accuracy, and consistency before analysis is called:
- (A) Coding
 - (B) Editing
 - (C) Tabulation
 - (D) Classification
- 23.** Assigning numerical values or symbols to the responses for computational purposes is known as:
- (A) Editing
 - (B) Coding
 - (C) Transcription
 - (D) Tabulation
- 24.** A histogram is used to graphically represent the distribution of:
- (A) Discrete/categorical data
 - (B) Continuous data grouped into class intervals
 - (C) Qualitative characteristics
 - (D) Proportions of a whole
- 25.** A pie chart is most effective for representing:
- (A) Trends over time
 - (B) The relationship between two continuous variables
 - (C) The percentage breakdown of a whole
 - (D) Frequency distribution of continuous data

26. A hypothesis that states there is no significant difference or relationship is called:
- (A) Directional hypothesis
 - (B) Non-directional hypothesis
 - (C) Null hypothesis
 - (D) Alternative hypothesis
27. "Students who study using method A will score significantly higher than those who study using method B." This is an example of:
- (A) Null hypothesis
 - (B) Directional alternative hypothesis
 - (C) Non-directional alternative hypothesis
 - (D) Ex-post facto hypothesis
28. A Type I error in hypothesis testing occurs when:
- (A) We fail to reject a true null hypothesis
 - (B) We reject a true null hypothesis
 - (C) We fail to reject a false null hypothesis
 - (D) We reject a false null hypothesis
29. The probability of committing a Type I error is denoted by:
- (A) Beta (β)
 - (B) Alpha (α)
 - (C) P-value
 - (D) Standard error
30. A statistical test that makes assumptions about the population parameters (like normal distribution, homogeneity of variance) is called:
- (A) Non-parametric test
 - (B) Parametric test
 - (C) Chi-square test
 - (D) Distribution-free test
31. The Chi-square (χ^2) test is primarily used to test:
- (A) The difference between means of two groups
 - (B) The association between two categorical variables
 - (C) The significance of regression coefficients
 - (D) The variance within a single group

32. In a Chi-square test of independence, if the calculated value of χ^2 is greater than the critical/ table value at the 0.05 level, we:
- (A) Accept the null hypothesis
 - (B) Reject the null hypothesis
 - (C) Conclude the variables are independent
 - (D) Conclude the sample is biased
33. The formula for calculating expected frequency (E) in a Chi-square contingency table cell is:
- (A) (Row Total $\times$ Column Total) / Grand Total
 - (B) (Row Total + Column Total) / Grand Total
 - (C) Grand Total / (Row Total $\times$ Column Total)
 - (D) Row Total / Column Total
34. Analysis of Variance (ANOVA) is used instead of multiple t-tests to compare the means of three or more groups because:
- (A) ANOVA is easier to calculate
 - (B) Multiple t-tests increase the risk of Type I error
 - (C) ANOVA does not require normal distribution
 - (D) ANOVA uses nominal data
35. In a one-way ANOVA, the "one way" refers to:
- (A) One dependent variable and one independent variable with multiple levels
 - (B) One independent variable and multiple dependent variables
 - (C) Only one sample being tested
 - (D) One-tailed test of significance
36. The F-ratio in One-way ANOVA is calculated as:
- (A) Within-group variance / Between-group variance
 - (B) Between-group variance / Within-group variance
 - (C) Total variance / Residual variance
 - (D) Mean square error / Mean square total
37. The degrees of freedom for "Between Groups" in a One-Way ANOVA with 'k' groups is:
- (A) $N - 1$
 - (B) $N - k$
 - (C) $k - 1$
 - (D) $(N - 1) - (k - 1)$

38. Which of the following is a non-parametric alternative to One-way ANOVA?
(A) Kruskal-Wallis test (B) Mann-Whitney U test
(C) Wilcoxon signed-rank test (D) Chi-square goodness of fit
39. A multivariate statistical technique used to reduce a large number of interrelated variables to a smaller set of unobservable factors is:
(A) Cluster Analysis (B) Factor Analysis
(C) Discriminant Analysis (D) Conjoint Analysis
40. In Factor Analysis, the proportion of variance in a specific variable explained by the common factors is called:
(A) Communality (B) Eigenvalue
(C) Factor loading (D) Uniqueness
41. Which concept in Factor Analysis represents the total variance explained by a specific factor across all variables?
(A) Communality (B) Eigenvalue
(C) Factor score (D) Rotation
42. Multiple Regression is used to:
(A) Classify objects into groups
(B) Predict the value of a dependent variable based on two or more independent variables
(C) Reduce the number of variables
(D) Determine the association between two categorical variables
43. In Multiple Regression, the coefficient of multiple determination (R^2) represents:
(A) The correlation between two independent variables
(B) The proportion of variance in the dependent variable explained by all independent variables
(C) The regression coefficient of the strongest predictor
(D) The standard error of the estimate
44. Pearson's correlation coefficient (r) measures:
(A) The causal relationship between two variables
(B) The linear association between two continuous variables
(C) The association between two categorical variables
(D) The variance of a single variable

45. If the Pearson correlation coefficient between X and Y is -0.85 , it indicates:
- (A) A weak positive relationship (B) A strong positive relationship
(C) A strong negative relationship (D) No relationship
46. Which multivariate technique is used to group objects or individuals so that objects in the same group are highly similar to each other but different from objects in other groups?
- (A) Discriminant Analysis (B) Factor Analysis
(C) Cluster Analysis (D) Conjoint Analysis
47. The main difference between Cluster Analysis and Discriminant Analysis is that:
- (A) Cluster analysis requires predefined groups, discriminant analysis does not
(B) Discriminant analysis requires predefined groups, cluster analysis does not
(C) Cluster analysis uses metric data, discriminant analysis uses non-metric
(D) Discriminant analysis is for data reduction, cluster analysis is for prediction
48. Conjoint Analysis is primarily used in marketing research to:
- (A) Determine the optimal number of clusters
(B) Measure how consumers value different features of a product by analyzing trade-offs
(C) Reduce the dimensions of product features
(D) Classify customers into predefined demographic groups
49. The standard format for writing a quantitative research report is generally known by the acronym:
- (A) IMRAD (Introduction, Method, Results, And Discussion)
(B) PEST (Political, Economic, Social, Technological)
(C) SWOT (Strengths, Weaknesses, Opportunities, Threats)
(D) APA (American Psychological Association)
50. Which section of the research report contains a brief summary of the entire study, including the problem, methodology, major findings, and conclusions?
- (A) Introduction (B) Abstract/Executive Summary
(C) Literature Review (D) Discussion

PART-B

(Physics)

- 51.** Which of the following crystal structures has the highest atomic packing factor (APF)?
(A) Simple Cubic (SC) (B) Body-Centered Cubic (BCC)
(C) Face-Centered Cubic (FCC) (D) Diamond Cubic
- 52.** According to the Free Electron Theory of metals, how does the electrical conductivity σ (sigma) change with an increase in temperature?
(A) Increases linearly (B) Decreases
(C) Remains completely unchanged (D) Increases exponentially
- 53.** The energy gap (band gap) between the valence band and conduction band for a typical semiconductor is of the order of:
(A) 0 eV (B) 1 eV
(C) 10 eV (D) 100 eV
- 54.** Above the Curie temperature (T_c), a ferromagnetic material transitions into which state?
(A) Diamagnetic (B) Paramagnetic
(C) Antiferromagnetic (D) Superconducting
- 55.** The expulsion of a magnetic field from the interior of a superconductor when it is cooled below its critical temperature is known as the:
(A) Hall Effect (B) Meissner Effect
(C) Seebeck Effect (D) Peltier Effect
- 56.** In the context of Hilbert space and Dirac notation, if an operator A represents a physical observable, which mathematical property must it satisfy to ensure that measurement outcomes are real numbers?
(A) It must be Orthogonal (B) It must be Hermitian
(C) It must be Idempotent (D) It must be Unitary

57. The energy of the first excited state(s) for a particle of mass (m) in a two-dimensional square infinite potential well of side length (L) is

(A) $\frac{5\hbar^2\pi^2}{2mL^2}$

(B) $\frac{4\hbar^2\pi^2}{mL^2}$

(C) $\frac{8\hbar^2\pi^2}{3mL^2}$

(D) $\frac{5\hbar^2\pi^2}{3mL^2}$

58. As the operating frequency of an alternating current (AC) passing through a solid cylindrical copper conductor increases toward radio frequencies, how do the skin depth and the AC resistance of the wire change?

(A) Skin depth decreases; AC resistance increases

(B) Skin depth increases; AC resistance increases

(C) Skin depth decreases; AC resistance decreases

(D) Skin depth increases; AC resistance decreases

59. In an intrinsic semiconductor at $T = 300$ K, the effective densities of states in the conduction and valence bands are $N_c = 2.5 \times 10^{19} \text{ cm}^{-3}$ and $N_v = 1.5 \times 10^{19} \text{ cm}^{-3}$ respectively. If the bandgap energy is $E_g = 1.1$ eV, what is the intrinsic carrier concentration n_i ? (Take $k_B T = 0.026$ eV at 300 K).

(A) $1.5 \times 10^{11} \text{ cm}^{-3}$

(B) $1.2 \times 10^{10} \text{ cm}^{-3}$

(C) $4.5 \times 10^9 \text{ cm}^{-3}$

(D) $2.3 \times 10^{12} \text{ cm}^{-3}$

60. An inverting operational amplifier circuit has an input resistor $R_{in} = 10 \text{ k}\Omega$ and a feedback resistor $R_f = 100 \text{ k}\Omega$. If the op-amp is ideal and an input voltage of $V_{in} = 0.5$ V is applied, determine the output voltage V_{out} .

(A) +5.0 V

(B) -0.05 V

(C) -5.0 V

(D) +0.05 V

61. A 1D system has a potential $V(x) = -1/2 x^2 + 1/4 x^4$. What is the nature of the phase space fixed point at $(x, p) = (0, 0)$?

(A) Stable Center

(B) Unstable Saddle Point

(C) Stable Node

(D) Unstable Focus

62. A particle moves under an attractive central force $F(r) = -k/r^n$. For what values of n are circular orbits stable against minor radial perturbations?

- (A) $n > 3$ (B) $n < 3$
 (C) $n = 3$ only (D) Stable for all values of n

63. A rigid body has a moment of inertia tensor

$$I = ma^2 \begin{pmatrix} 4 & 0 & 0 \\ 0 & 3 & -\sqrt{3} \\ 0 & -\sqrt{3} & 5 \end{pmatrix}$$

What is the largest principal moment of inertia?

- (A) $4 ma^2$ (B) $5 ma^2$
 (C) $6 ma^2$ (D) $(4 + \sqrt{3}) ma^2$

64. For what value of the constant α is the transformation $Q = q^\alpha \cos(2p)$ and $P = q^\alpha \sin(2p)$ canonical?

- (A) $\alpha = 1$ (B) $\alpha = 1/2$
 (C) $\alpha = 2$ (D) $\alpha = -1$

65. In Hamilton-Jacobi theory, the transformed Hamiltonian K is set identically to zero. The generating function $S(q_i, \alpha_i, t)$ (Hamilton's Principal Function) acts as a transformation to coordinates that are:

- (A) Purely oscillatory coordinates (B) Constants of motion
 (C) Rectilinear cartesian positions (D) Action-angle variables

66. A system with 2 degrees of freedom has normal mode frequencies $\omega_1 = \omega_0$ and $\omega_2 = \sqrt{3}\omega_0$. If the system is initialized from rest with a configuration corresponding entirely to the first normal eigenvector, the resulting motion will be:

- (A) Chaotic
 (B) A superposition demonstrating classic beat phenomena
 (C) Strictly periodic at a single frequency ω_0
 (D) Viscously damped to zero over time

67. According to the single-particle nuclear shell model, what are the spin and parity (J^π) of the ground state of the oxygen isotope ^{17}O ?
- (A) $1/2^-$ (B) $5/2^+$
(C) $3/2^-$ (D) $5/2^-$
68. A heavy unstable particle A of rest mass m_A decays at rest into two particles B and C with masses m_B and m_C respectively. What is the total relativistic energy E_B of particle B in the rest frame of A?
- (A) $\{m_A^2 + m_B^2 - m_C^2/2m_A\}.c^2$ (B) $\{m_A^2 - m_B^2 + m_C^2/2m_A\}.c^2$
(C) $\{m_A^2 + m_B^2 + m_C^2/2m_B\}.c^2$ (D) $\{m_A^2 + m_B^2 - m_C^2/2m_B\}.c^2$
69. Which of the following particle decay modes is allowed via the weak interaction?
- (A) $\mu^- \rightarrow e^- + \gamma$ (B) $\pi^0 \rightarrow \gamma + \nu + \bar{\nu}$
(C) $\tau^- \rightarrow e^- + \bar{\nu}_e + \nu_\tau$ (D) $p \rightarrow e^+ + \pi^0$
70. If a nucleus has a static electric quadrupole moment Q that is strictly less than zero ($Q < 0$), what does this indicate about the spatial charge distribution of the nucleus?
- (A) It is perfectly spherical
(B) It is an oblate ellipsoid (flattened like a pancake)
(C) It is a prolate ellipsoid (stretched like a rugby ball)
(D) The nucleus possesses no net intrinsic spin ($J = 0$)
71. A strongly interacting hadronic resonance is found to have an electric charge $Q = -1$ and a strangeness quantum number $S = -1$. Assuming its charm, bottom, and top quantum numbers are zero, what is its third component of isospin (I_3)?
- (A) $+1/2$ (B) $-1/2$
(C) -1 (D) 0
72. Which of Newton's laws of motion is most directly associated with the concept of inertia (the tendency of an object to resist changes in its state of motion)?
- (A) Newton's First Law of Motion (B) Newton's Second Law of Motion
(C) Newton's Third Law of Motion (D) Newton's Law of Universal Gravitation

73. If no external forces act on a system of colliding objects, what happens to the total momentum of the system?
- (A) It increases due to the kinetic energy of the collision
 (B) It decreases because of friction during impact
 (C) It remains constant (is conserved)
 (D) It becomes zero immediately after the collision
74. A particle of mass m moves in a central potential of the form $V(r) = -k/r^n$ (where $k > 0$). For what values of the exponent n are stable circular orbits possible?
- (A) $n > 2$ (B) $n < 2$
 (C) $n = 2$ only (D) Orbits are stable for all values of n
75. If a 3×3 matrix, M has a trace equal to 11 and a determinant equal to 36, and one of its eigenvalues is 2, what are the other two eigenvalues?
- (A) 3 and 6 (B) 4 and 5
 (C) 3 and 8 (D) 1 and 8
76. A wave function is defined as $\psi(x) = A \exp(-\alpha x^2)$, where $-\infty < x < +\infty$. Then value of A such that ψ is normalized
- (A) $(2\alpha/\pi)^{1/4}$ (B) $(2\alpha/\pi)^{1/2}$
 (C) $(2\alpha/\pi)$ (D) $(\alpha/\pi)^{1/2}$
77. A sample of Si has electron and hole mobility as 0.13 and 0.05 at 300 K. It is doped with N and Ga with doping densities $1.5 \times 10^{21} \text{ m}^{-3}$ and $2.5 \times 10^{21} \text{ m}^{-3}$. Then the conductivity $(\Omega \text{ m})^{-1}$ of doped silicon is
- (A) 4 (B) 8
 (C) 12 (D) 0
78. A particle describing simple harmonic motion executes 100 complete vibrations per minute and its speed at its mean position is 15 cm/sec. What is its velocity when it is half way between its mean position and extreme position of its path?
- (A) 25 cm/sec (B) 13 cm/sec
 (C) 5 cm/sec (D) 30 cm/sec

79. A particle moves in a straight line according to the law $x = t^3 - 75t$, where x denotes the distance in meters and t is time in seconds. If the particle weighs 6 kg, what is the resultant force on it at 4 seconds?
- (A) 144 N (B) 4 N
(C) 125 N (D) Zero
80. A particle describes an ellipse under a force μ/r^2 to a focus. The velocity at the end of the minor axis being geometric mean between the greatest (v_1) and the least velocities (v_2) is
- (A) $\sqrt{v_1 v_2}$ (B) $\sqrt{v_1/v_2}$
(C) $\sqrt{v_2/v_1}$ (D) $\sqrt{v_1 + v_2}$
81. Atom is placed in a 6T magnetic field and suitably excited. How far apart are the Zeeman components of the 650 nm spectral line of this element?
- (A) 0.12 nm (B) 1.18 nm
(C) 1.97 nm (D) 2.25 nm
82. An electron collides with a hydrogen atom in its ground state and excites it to a state of $n = 3$. How much energy was given to the hydrogen atom in this inelastic collision?
- (A) 6.8 eV (B) 12.1 eV
(C) 1.8 eV (D) 13.2 eV
83. Consider the transition of liquid water to steam as water boils at a temperature of 100°C under a pressure of 1 atmosphere. Which one of the following quantities does not change discontinuously at the transition?
- (A) The Gibbs free energy (B) The internal energy
(C) The entropy (D) The specific volume
84. If the number density of a free electron gas in three dimensions is increased eight times, its Fermi temperature will
- (A) Increase by a factor of 4 (B) Decrease by a factor of 4
(C) Increase by a factor of 8 (D) Decrease by a factor of 8

85. In low density oxygen gas at low temperature, only the translational and rotational modes of the molecules are excited. The specific heat per molecule of the gas is
- (A) $\frac{1}{2} \text{ KB}$ (B) $\frac{3}{2} \text{ KB}$
 (C) KB (D) $\frac{5}{2} \text{ KB}$
86. Which of the following atoms cannot exhibit Bose-Einstein condensation, even in principle?
- (A) $^1\text{H}_1$ (B) $^4\text{H}_2$
 (C) $^{23}\text{Na}_{11}$ (D) $^{30}\text{K}_{19}$
87. A Carnot cycle operates on a working substance between two reservoir at temperatures T_1 and T_2 with $T_1 > T_2$. During each cycle, an amount of heat Q_1 is extracted from the reservoir at T_1 and an amount Q_2 is delivered in the reservoir at T_2 . Which of the following statements is INCORRECT?
- (A) Work done in one cycle is $Q_1 - Q_2$
 (B) $Q_1 / T_1 = Q_2 / T_2$
 (C) Entropy of the hotter reservoir decreases
 (D) Entropy of the universe (consisting of the working substance and the two reservoirs) increases
88. The semi-empirical mass formula for the binding energy of nucleus contains a surface correction term. This term depends on the mass number A of the nucleus as
- (A) $A^{-1/2}$ (B) $A^{2/3}$
 (C) $A^{1/2}$ (D) A
89. Which of the following statements is NOT correct?
- (A) A deuteron can be disintegrated by irradiating it with gamma rays of energy 4 MeV
 (B) A deuteron has no excited states
 (C) A deuteron has no electric quadrupole moment
 (D) The $^1\text{S}_0$ state of deuteron cannot be formed

90. A 10 V Zener diode is used to regulate the voltage across a variable load resistor. The input voltage varies between 13 V and 16 V and the load current varies between 10 and 85 mA. The minimum Zener current is 15 mA. The value of series resistance R_s is
- (A) 15 Ω (B) 5 Ω
(C) 20 Ω (D) 30 Ω
91. In a common base connection, $\alpha = 0.95$. The voltage drop across 2 k Ω resistance which is connected in the collector is 2 V. Then the base current is
- (A) 0.05 mA (B) 5 mA
(C) 50 mA (D) 10 mA
92. The voltage gain of an amplifier without feedback is 1000. Calculate the voltage gain of an amplifier if negative voltage feedback is introduced in the circuit. Given that feedback fraction $\beta = 0.02$
- (A) 25 (B) 48
(C) 12 (D) 18
93. A large circular coil of N turns and radius R carries a time varying current $I(t) = I_0 \sin \omega t$. A small circular coil of n turns and radius r ($r \ll R$) is placed at the center of the large coil such that the coils are concentric and coplanar. The induced emf in the small coil
- (A) Leads the current in the large coil by $\pi/2$
(B) Lags the current in the large coil by π
(C) In phase with the current in the large coil
(D) Lags the current in the large coil by $\pi/2$
94. A particle of mass m carrying charge q is moving in a circle in a magnetic field B. According to Bohr's model energy of particle in the nth level is
- (A) $n(\hbar qB/\pi m)$ (B) $n(\hbar qB/4\pi m)$
(C) $n(\hbar qB/3\pi m)$ (D) $n(2\hbar qB/\pi m)$

95. Which of Maxwell's equations directly implies that magnetic monopoles do not exist in nature?
- (A) $\nabla \cdot \mathbf{E} = \rho/\epsilon_0$ (Gauss's Law for Electricity)
 (B) $\nabla \cdot \mathbf{B} = 0$ (Gauss's Law for Magnetism)
 (C) $\nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$ (Faraday's Law of Induction)
 (D) $\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \epsilon_0 \partial \mathbf{E}/\partial t$ (Faraday's Law of Induction)
96. In a vacuum, what is the relationship between the directions of the Electric field vector ($\mathbf{E}$), the Magnetic field vector ($\mathbf{B}$), and the direction of wave propagation ($\mathbf{k}$)?
- (A) $\mathbf{E}$ and $\mathbf{B}$ are parallel to each other, and perpendicular to $\mathbf{k}$
 (B) $\mathbf{E}$ is parallel to $\mathbf{k}$, while $\mathbf{B}$ is perpendicular to both
 (C) $\mathbf{E}$, $\mathbf{B}$ and $\mathbf{k}$ are all mutually perpendicular to each other
 (D) $\mathbf{E}$ and $\mathbf{B}$ can be at any angle, but both must be perpendicular to $\mathbf{k}$
97. Two particles come towards each other, each moving with a speed $0.9c$ with respect to the laboratory as a frame of reference. Their relative speed is
- (A) $0.994c$ (B) $0.336c$
 (C) $0.9c$ (D) $1.114c$
98. A radioactive particle travels with a speed of $0.99c$ for a distance of 5.4 km before decaying. The life time of the given radioactive particle as measured by the particle itself and distance covered by itself is
- (A) 419.1 m (B) 761.8 m
 (C) 513.1 m (D) 611.1 m
99. A proton has rest mass energy 1 GeV and total energy of 50 GeV . Then its linear momentum (in units of kg ms^{-1}) is
- (A) 5.3×10^{-14} (B) 4.8×10^{-17}
 (C) 2.7×10^{-17} (D) 5.3×10^{-12}
100. What will be the increase in mass of 1 kg of copper metal having specific heat of $0.20\text{ cal/g}^\circ\text{C}$ when heated through 1000°C ?
- (A) $5.63 \times 10^{-6}\text{ kg}$ (B) $6.91 \times 10^{-17}\text{ kg}$
 (C) $9.33 \times 10^{-12}\text{ kg}$ (D) $7.11 \times 10^{-9}\text{ kg}$

ROUGH WORK