

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE TOLD TO DO SO

T.B.C. : BBSP-T-GPS

Test Booklet Series

Serial No. 1000109

TEST BOOKLET

A

PAPER—II

(Geophysics)

Time Allowed : Two Hours

Maximum Marks : 300

I N S T R U C T I O N S

1. IMMEDIATELY AFTER THE COMMENCEMENT OF THE EXAMINATION, YOU SHOULD CHECK THAT THIS TEST BOOKLET *DOES NOT* HAVE ANY UNPRINTED OR TORN OR MISSING PAGES OR ITEMS, ETC. IF SO, GET IT REPLACED BY A COMPLETE TEST BOOKLET.
2. **Please note that it is the candidate's responsibility to encode and fill in the Roll Number and Test Booklet Series A, B, C or D carefully and without any omission or discrepancy at the appropriate places in the OMR Answer Sheet. Any omission/discrepancy will render the Answer Sheet liable for rejection.**
3. You have to enter your Roll Number on the Test Booklet in the Box provided alongside. *DO NOT* write *anything else* on the Test Booklet.
4. This Test Booklet contains **120** items (questions). Each item comprises four responses (answers). You will select the response which you want to mark on the Answer Sheet. In case you feel that there is more than one correct response, mark the response which you consider the best. In any case, choose *ONLY ONE* response for each item.
5. You have to mark all your responses *ONLY* on the separate Answer Sheet provided. See directions in the Answer Sheet.
6. **All** items carry equal marks.
7. Before you proceed to mark in the Answer Sheet the response to various items in the Test Booklet, you have to fill in some particulars in the Answer Sheet as per instructions sent to you with your Admission Certificate.
8. After you have completed filling in all your responses on the Answer Sheet and the examination has concluded, you should hand over to the Invigilator *only the Answer Sheet*. You are permitted to take away with you the Test Booklet.
9. Sheets for rough work are appended in the Test Booklet at the end.
10. **Penalty for wrong answers :**
THERE WILL BE PENALTY FOR WRONG ANSWERS MARKED BY A CANDIDATE IN THE OBJECTIVE TYPE QUESTION PAPERS.
 - (i) There are four alternatives for the answer to every question. For each question for which a wrong answer has been given by the candidate, **one-third** of the marks assigned to that question will be deducted as penalty.
 - (ii) If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that question.
 - (iii) If a question is left blank, i.e., no answer is given by the candidate, there will be **no penalty** for that question.

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1. The geophysical methods used for investigating the shallow features of the Earth's crust are
 - (a) static methods only
 - (b) dynamic methods only
 - (c) static and dynamic methods both
 - (d) relaxation methods only

2. The units of magnetic field strength and magnetic flux density, respectively are
 - (a) ampere metre⁻¹ and volt second metre⁻²
 - (b) volt second metre⁻² and ampere metre⁻¹
 - (c) volt second and ampere metre⁻¹
 - (d) ampere metre⁻¹ and volt second

3. The angle of obliquity of the Earth ranges from
 - (a) 21.1° to 25.3°
 - (b) 21.9° to 24.3°
 - (c) 21.9° to 25.3°
 - (d) 21.1° to 24.3°

4. Which one of the following planets of the solar system has the highest mean orbital velocity?
 - (a) Mercury
 - (b) Venus
 - (c) Earth
 - (d) Mars

5. Which one of the following relations is correct among the radius of sphere, R , and equatorial and polar radii of the international reference of ellipsoid, a and c , respectively, if the volumes of the sphere and ellipsoid are equal?
 - (a) $R - c \approx \frac{a - R}{2}$
 - (b) $R - c \approx a - R$
 - (c) $R - c \approx 2(a - R)$
 - (d) $R - c \approx 4(a - R)$

6. The difference between geographic and geocentric latitudes is maximum at
 - (a) 0° latitude
 - (b) 23.5° latitude
 - (c) 45° latitude
 - (d) 90° latitude

7. The acceleration of a point mass m_1 due to the attraction of another point mass m_2 at distance r is equal to
 - (a) $G \frac{m_1}{r^2}$
 - (b) $G \frac{m_2}{r^2}$
 - (c) $G \frac{m_1 m_2}{r^2}$
 - (d) $-G \frac{m_1}{r}$

(where G = universal gravitational constant)

8. A circular coil having axis length L and number of turns n is wound around a magnetic core. A current of I units passes through this coil. The magnetic excitation inside the core will be
- $\frac{nI}{L}$
 - nIL
 - $\frac{nL}{I}$
 - $\frac{L}{I}$
9. The angle between magnetic north and total magnetic field is
- magnetic declination
 - magnetic inclination
 - magnetic total angle
 - magnetic vertical angle
10. Which one of the following minerals has negative magnetic susceptibility?
- Pyrrhotite
 - Ilmenite
 - Sphalerite
 - Quartz
11. The ratio of S-wave to P-wave velocities for zero Poisson's ratio value is
- $\sqrt{3}$
 - $\frac{1}{\sqrt{3}}$
 - $\sqrt{2}$
 - $\frac{1}{\sqrt{2}}$
12. What fraction of the normal incident wave energy will be transmitted into the second layer, if a layer with density 3 g/cc and wave velocity 4 km/s is overlain by a layer having density 2 g/cc and velocity 3 km/s?
- 0.11
 - 0.22
 - 0.44
 - 0.89
13. Which one of the following seismic phases results from a P-wave turning within the crust?
- P_g
 - P_mP
 - P_n
 - PP
14. The slowness vector of a 1 Hz plane P-wave propagating at 6.5 km/s velocity in $+x$ direction is
- $\left\{ \frac{1}{6.5}, 0, 0 \right\}$
 - $\left\{ 0, \frac{1}{6.5}, 0 \right\}$
 - $\left\{ 0, 0, \frac{1}{6.5} \right\}$
 - $\left\{ \frac{1}{6.5}, 0, \frac{1}{6.5} \right\}$
15. Which one of the following correctly describes the attenuation property of the Earth expressed in terms of quality factor (Q)?
- The Q value is infinite for the Earth.
 - The Q value is zero for the Earth.
 - The Q value of P-wave is lower than the Q value of S-wave in the Earth's core.
 - None of the above

16. What type of changes in the mineral phase takes place at 410 km discontinuity inside the Earth?

- (a) Olivine-type to spinel-type lattice
- (b) Graphite-type to γ -spinel-type lattice
- (c) α -spinel-type to pyrite-type lattice
- (d) γ -spinel-type to β -spinel-type lattice

17. What is the approximate pressure at the centre of the Earth?

- (a) 180 GPa
- (b) 280 GPa
- (c) 380 GPa
- (d) 480 GPa

18. A weak P-wave diffraction is observed in the epicentral distance range of

- (a) 0° - 30°
- (b) 30° - 90°
- (c) 90° - 102°
- (d) 103° - 120°

19. Which one of the following is the correct epoch sequence from 0 to 4 Ma age as estimated from normal and reverse geomagnetic data?

- (a) Brunhes, Gauss, Matuyama, Gilbert
- (b) Brunhes, Matuyama, Gauss, Gilbert
- (c) Brunhes, Matuyama, Gilbert, Gauss
- (d) Brunhes, Gilbert, Matuyama, Gauss

20. The scalar seismic moment (M_0) of an earthquake is related to density of medium ρ , seismic velocity c , hypocentral distance r and radiation pattern $U_{\phi\theta}$ as

- (a) $\frac{\rho c^3}{r U_{\phi\theta}}$
- (b) $\frac{\rho c^2}{r U_{\phi\theta}}$
- (c) $\frac{\rho c^3 r}{U_{\phi\theta}}$
- (d) $\frac{\rho c^2 r}{U_{\phi\theta}}$

21. What approximate percentage of the total annually released seismic energy is due to the intermediate focal depth earthquakes at the global level?

- (a) 85%
- (b) 20%
- (c) 12%
- (d) 3%

22. What is the ratio of the number of earthquakes having surface wave magnitudes greater than 5 and 7 occurring in a region, if the intercept, a and slope, b values of earthquake magnitude-frequency relation are 8 and 1, respectively for that region?

- (a) 1000
- (b) 100
- (c) 32
- (d) 10

23. The approximate value of free-air correction at a station located at 1 m height above the datum plane at the equator is

- (a) 0.3072 mGal
- (b) 0.3388 mGal
- (c) 0.3491 mGal
- (d) 0.3516 mGal

24. What is the ratio of maximum values of gravities directly above the centres of two spherical bodies of radii 1 m and 2 m situated in a homogeneous moraine having density contrast of 1 g/cc and 2 g/cc, respectively and depth to the centre of sphere as 2 m and 4 m, respectively?

- (a) 1
- (b) $\frac{1}{2}$
- (c) $\frac{1}{4}$
- (d) $\frac{1}{8}$

25. What is the approximate range of the Earth's magnetic field variation due to change in latitude value?

- (a) > 100 nT/km
- (b) 50–100 nT/km
- (c) 10–50 nT/km
- (d) < 6 nT/km

26. What is the approximate direction of polarization of protons with respect to the Earth's magnetic field (F) due to applied external field in proton precession magnetometer?

- (a) Parallel to F only
- (b) Antiparallel to F only
- (c) Normal to F
- (d) Both parallel and antiparallel to F

27. What is the coefficient of anisotropy for a medium having vertical and horizontal resistivities ρ_v and ρ_h , respectively?

- (a) $\left(\frac{\rho_v}{\rho_h}\right)^{\frac{1}{2}}$
- (b) $\left(\frac{\rho_h}{\rho_v}\right)^{\frac{1}{2}}$
- (c) $\frac{\rho_v}{\rho_h}$
- (d) $\frac{\rho_h}{\rho_v}$

28. What is the equivalent horizontal resistivity for a vertical stake of n beds with resistivities $\rho_1, \rho_2, \rho_3, \dots, \rho_n$ and thicknesses $z_1, z_2, z_3, \dots, z_n$ from top to bottom, respectively?

(a) $\left(\frac{\sum_{i=1}^n \rho_i z_i}{\sum_{i=1}^n z_i} \right)$

(b) $\left(\frac{\sum_{i=1}^n \frac{\rho_i}{z_i}}{\sum_{i=1}^n z_i} \right)$

(c) $\left(\frac{\sum_{i=1}^n z_i}{\sum_{i=1}^n \frac{z_i}{\rho_i}} \right)$

(d) $\left(\frac{\sum_{i=1}^n z_i}{\sum_{i=1}^n \frac{\rho_i}{z_i}} \right)$

29. What is the ratio of effective resistivity of the rock (ρ_e) to the resistivity of the groundwater (ρ_w), if the formation has 1% porosity, water saturation constant 1.0, and parameters $a = 1$, $m = 2$ and $n = 2$ are constants of Archie's formula?

(a) 10^{-4}

(b) 10^4

(c) 10^{-2}

(d) 10^2

30. Which one of the following potentials is relatively more variable electrical potential used in geophysical prospecting?

(a) Diffusion potential

(b) Nernst potential

(c) Electrokinetic potential

(d) Telluric potential

31. What is the ratio of seismic velocities of the second layer to the first layer for a seismic wave incident on a horizontal interface at an angle of 30° to the normal in the first layer and refracted at 45° angle to the normal in the second layer?

(a) $\frac{1}{\sqrt{2}}$

(b) $\sqrt{2}$

(c) 2

(d) $2\sqrt{2}$

32. The ground roll in seismic data can be attenuated by

(a) grouping of geophones

(b) reducing the number of geophones

(c) increasing geophone spacing

(d) decreasing geophone spacing

33. What is the reflection coefficient for a seismic wave incident at normal to the interface between the first and second layers characterized by densities 3 g/cc and 2.5 g/cc, and velocities 5 km/s and 4 km/s, respectively?

(a) 0.2

(b) -0.2

(c) 1.2

(d) -1.2

34. A point scatterer is observed at 2.5 km depth within a layer with a uniform velocity of 4 km/s. What is the observed two-way travel time for the source and receiver with an offset of 3 km?

(a) 1.25 s

(b) 1.35 s

(c) 1.60 s

(d) 1.95 s

35. The phase shift between ghost multiple and primary reflection in seismic data is

- (a) 90°
- (b) 180°
- (c) 270°
- (d) 360°

36. What is the Nyquist frequency for a seismic data recorded with a sampling rate of 100 Hz?

- (a) 250 Hz
- (b) 200 Hz
- (c) 100 Hz
- (d) 50 Hz

37. Which one of the following filters is used to avoid the aliasing problem in seismic data processing?

- (a) Low-pass filter
- (b) High-pass filter
- (c) Band-pass filter
- (d) Notch filter

38. The convolution of a signal with a delta function

- (a) alters the shape of the signal only
- (b) does not alter the shape of the signal but produces a time shift in the original signal
- (c) makes the signal zero at all times
- (d) alters the shape of the signal as well as produces a time shift in the original signal

39. The only non-zero Fourier series coefficients for the signal $x(t) = \sin \omega_0 t$, having fundamental frequency ω_0 , are

- (a) $\pm \frac{1}{8i}$
- (b) $\pm \frac{1}{6i}$
- (c) $\pm \frac{1}{4i}$
- (d) $\pm \frac{1}{2i}$

(where $i = \sqrt{-1}$)

40. The radix-2 fast Fourier transform requires the sequence length of the input time-domain signal to be an integral power of

- (a) 2
- (b) 3
- (c) 4
- (d) 5

41. The Laplace transform of a function $f(t)$ is given as $F(s)$. The Laplace transform of a time-domain signal $f(t) = Ae^{-at}$ ($A = \text{constant}, a > 0$) is

- (a) $\frac{A}{s}$
- (b) $\frac{A}{s^2}$
- (c) $\frac{A}{s+a}$
- (d) $\frac{A}{(s+a)^2}$

42. What would be the length of the output signal, generated after convolution of two signals of lengths D_1 and D_2 ?

- (a) $D_1 + D_2 - 1$
- (b) $D_1 + D_2 + 1$
- (c) $D_1 + D_2 - 2$
- (d) $D_1 + D_2 + 2$

43. Which one of the following is **not** correct about the Dirac delta function?
- (a) The Fourier transform of a Dirac function is equal to a nonzero constant.
 - (b) The Dirac function can be used to delay a time series function.
 - (c) The product of a function with a Dirac function gives a Dirac function of amplitude equal to the sample of that function.
 - (d) The Fourier transform of a Dirac function is equal to zero.
44. With the increase in number of input data points, the difference between the number of complex multiplications required by the radix-2 fast Fourier transform (FFT) and the discrete Fourier transform (DFT)
- (a) remains constant
 - (b) increases
 - (c) decreases
 - (d) becomes zero
45. Which one of the following microwave bands will have the maximum penetration in dry sand?
- (a) P
 - (b) S
 - (c) X
 - (d) K
46. Which of the following ground parameters are measured during field survey using thermal infrared region of electromagnetic spectrum?
- (a) Ground temperature and spectral emissivity
 - (b) Rainfall pattern and back-scattering coefficient
 - (c) Spectral emissivity and back-scattering coefficient
 - (d) Ground temperature and rainfall pattern
47. Which one of the following statements is **not** correct regarding body's emissivity?
- (a) The spectral emissivity values range from 0–1.
 - (b) Blackbody radiates a continuous spectrum.
 - (c) The Sun and the Earth as whole bodies radiate a near-continuous spectrum.
 - (d) The spectral emissivity values of a gray body are not constant at all wavelengths.
48. Consider the following statements :
1. Stefan-Boltzmann relation applies to all wavelengths of the spectrum shorter than microwaves.
 2. Rayleigh-Jeans law is valid for longer wavelengths such as microwaves.
- Which of the statements given above is/are correct?
- (a) Both 1 and 2
 - (b) 1 only
 - (c) 2 only
 - (d) Neither 1 nor 2

49. Which one of the following is the correct sequence of the electromagnetic waves in the order of their increasing frequencies?

- (a) Radio wave, Microwave, Infrared, Visible, Ultraviolet, X-ray
- (b) Radio wave, Infrared, Microwave, Visible, Ultraviolet, X-ray
- (c) Microwave, Radio wave, Infrared, Visible, X-ray, Ultraviolet
- (d) Infrared, Visible, Ultraviolet, Microwave, Radio wave, X-ray

50. A hot blackbody emits energy at the rate of $25 \text{ J m}^{-2} \text{ s}^{-1}$ with most intense radiation corresponding to wavelength of 20000 \AA . If the temperature of the body is further raised, its most intense radiation corresponds to wavelength of 10000 \AA . Then the rate at which energy is emitted is

- (a) $100 \text{ J m}^{-2} \text{ s}^{-1}$
- (b) $200 \text{ J m}^{-2} \text{ s}^{-1}$
- (c) $400 \text{ J m}^{-2} \text{ s}^{-1}$
- (d) $800 \text{ J m}^{-2} \text{ s}^{-1}$

51. The correct value of the Stefan-Boltzmann constant is

- (a) $5.6704 \times 10^{-7} \text{ W m K}^{-4}$
- (b) $5.6704 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
- (c) $4.6704 \times 10^{-8} \text{ W m K}^{-4}$
- (d) $4.6704 \times 10^{-7} \text{ W m}^{-2} \text{ K}^{-4}$

52. The energy of an oscillator of frequency ν is equal to

- (a) $\frac{h}{\nu}$
- (b) $h\nu$
- (c) $h^2\nu^{2/3}$
- (d) $h^{2/3}\nu^2$

(where h is Planck's constant)

53. The Kelvin-Planck statement of the second law of thermodynamics deals with

- (a) conservation of energy
- (b) conservation of mass
- (c) conversion of work into heat
- (d) conversion of heat into work

54. Which one of the following thermodynamic laws relates the change in internal energy of a system with the heat supplied to the system and the work done by the system on its surroundings?

- (a) Zeroth law
- (b) First law
- (c) Second law
- (d) Third law

55. An infinite plane carries a uniform surface charge σ . Its electric field is

(a) $\frac{\sigma}{2\epsilon_0} \hat{n}$

(b) $\frac{\sigma}{\epsilon_0} \hat{n}$

(c) $\frac{\sigma}{4\epsilon_0} \hat{n}$

(d) $\frac{\sigma}{8\epsilon_0} \hat{n}$

(where \hat{n} is a unit normal vector pointing away from the surface)

56. The velocity of ground-penetrating radar signals depends on

(a) electrical properties of the material only

(b) magnetic properties of the material only

(c) both electrical and magnetic properties of the material

(d) neither electrical nor magnetic properties of the material

57. The electric field in polystyrene (relative permittivity = 2.55) filling the space between the plates of a parallel-plate capacitor is 10 kV/m. The distance between the plates is 1.5 mm. The potential difference between the plates is

(a) 4 V

(b) 10 V

(c) 60 V

(d) 15 V

58. A particle of charge Q moves with speed v , in a circle of radius R , in a uniform magnetic field of magnitude B perpendicular to the plane of the circle. The momentum of the particle is

(a) QvB

(b) $\frac{QB}{R}$

(c) $\frac{QB}{v}$

(d) QBR

59. Which one of the following laws describes the force (\vec{F}) experienced by a charged particle of charge q , while moving through a magnetic field \vec{B} with velocity \vec{v} ?

(a) Faraday's law

(b) Biot-Savart law

(c) Coulomb's law

(d) Lorentz's law

60. Which one of the following statements regarding solenoid is **not** correct?

(a) The wire is wound closely in the form of a helix.

(b) The wire is coated with a conducting material.

(c) Adjacent turns of the wire physically touch each other.

(d) Ampere's law is valid.

61. According to Biot-Savart law, the magnitude of the magnetic field due to a current element is

- (a) directly proportional to the square of the distance between the current element and the point where the field is calculated
- (b) directly proportional to the cube of the distance between the current element and the point where the field is calculated
- (c) inversely proportional to the square of the distance between the current element and the point where the field is calculated
- (d) inversely proportional to the cube of the distance between the current element and the point where the field is calculated

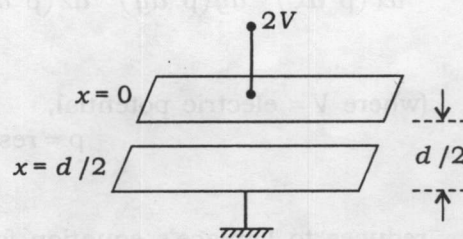
62. According to Faraday's law of electromagnetic induction, the magnetic flux through a coil can be changed by

1. changing the magnitude of the magnetic field within the coil
2. changing the portion of the area of the coil that lies within the magnetic field
3. changing the temperature of the experimental setup
4. changing the angle between the direction of the magnetic field and the plane of the coil

Select the correct answer using the code given below.

- (a) 1, 2 and 4
- (b) 2, 3 and 4
- (c) 1 and 4 only
- (d) 2 and 4 only

63. Two parallel plates are separated by a distance $d/2$ as shown in the figure below :



The surface charge density at $x = 0$ is

- (a) $\frac{4V\epsilon_0}{d}$
- (b) $\frac{V\epsilon_0}{d}$
- (c) $\frac{V\epsilon_0}{4d}$
- (d) $\frac{2V\epsilon_0}{d}$

64. Which one of the following boundary conditions is **not** satisfied by the electric potential (V) while solving Laplace's equation $\nabla^2 V = 0$ in electromagnetic method?

- (a) V is continuous.
- (b) The component of current density normal to the boundary is continuous.
- (c) The component of current density normal to the boundary is discontinuous.
- (d) V is finite at any point where there is no source or sink of current.

65. The equation

$$\frac{d}{dx} \left(\frac{1}{\rho} \frac{dV}{dx} \right) + \frac{d}{dy} \left(\frac{1}{\rho} \frac{dV}{dy} \right) + \frac{d}{dz} \left(\frac{1}{\rho} \frac{dV}{dz} \right) = 0$$

(where V = electric potential,
 ρ = resistivity)

reduces to Laplace's equation for

- (a) a homogeneous and anisotropic medium
- (b) a homogeneous and isotropic medium
- (c) an inhomogeneous and anisotropic medium
- (d) an inhomogeneous and isotropic medium

66. A uniform magnetic field B exists in a direction perpendicular to the plane of a square frame made of copper wire. The wire has a diameter of 2 mm and a total length of 40 cm. The magnetic field changes with time at a steady rate $\frac{dB}{dt} = 0.02 \text{ T s}^{-1}$. The current induced in the frame is

- (a) $4.5 \times 10^{-2} \text{ A}$
- (b) $9.3 \times 10^{-2} \text{ A}$
- (c) $2.5 \times 10^{-1} \text{ A}$
- (d) $8.5 \times 10^{-3} \text{ A}$

(Given : Resistivity of copper
 $= 1.7 \times 10^{-8} \text{ } \Omega \text{ m}$)

67. Which one of the following Maxwell's equations is generalized due to displacement current?

- (a) Gauss's law for electricity
- (b) Gauss's law for magnetism
- (c) Faraday's law
- (d) Ampere's law

68. "The parallel components of \vec{H} are discontinuous by an amount proportional to the free surface current density."

For a linear medium, which one of the following relations is the correct boundary condition for the statement given above?

- (a) $\frac{1}{\mu_1} \mathbf{B}_1^{\parallel} - \frac{1}{\mu_2} \mathbf{B}_2^{\parallel} = \mathbf{K}_f \times \hat{n}$
- (b) $\mathbf{E}_1^{\parallel} - \mathbf{E}_2^{\parallel} = 0$
- (c) $\frac{1}{\mu_1} \mathbf{B}_1^{\parallel} - \frac{1}{\mu_2} \mathbf{B}_2^{\parallel} = 0$
- (d) $\frac{1}{\mu_1} \mathbf{B}_1^{\parallel} + \frac{1}{\mu_2} \mathbf{B}_2^{\parallel} = \mathbf{K}_f \times \hat{n}$

(where the symbols have their usual meanings)

69. An electromagnetic wave propagates through a linear homogeneous medium. The speed of the wave in this medium is

- (a) $c \sqrt{\frac{\epsilon_0 \mu_0}{\epsilon \mu}}$
- (b) $c \sqrt{\frac{\epsilon \mu}{\epsilon_0 \mu_0}}$
- (c) $c \sqrt{\frac{\epsilon_0 \mu}{\epsilon \mu_0}}$
- (d) $c \sqrt{\frac{\epsilon \mu_0}{\epsilon_0 \mu}}$

(where the symbols have their usual meanings)

70. Consider the following statements regarding skin depth of electromagnetic waves in conductors :

1. It is the distance taken by the electromagnetic wave to reduce the amplitude by a factor of half.
2. It measures how far the electromagnetic wave penetrates into the conductor.
3. It is determined by the real part of the wave number.
4. It is determined by the imaginary part of the wave number.

Which of the statements given above are correct?

- (a) 1 and 3
- (b) 1 and 4
- (c) 2 and 3
- (d) 2 and 4

71. The number of inhomogeneous Maxwell's equations for a good conductor is

- (a) one
- (b) two
- (c) three
- (d) zero

72. Which one of the following pairs is an example of mirror nuclei?

- (a) ^{14}C and ^{13}C
- (b) ^{13}C and ^{14}N
- (c) ^{13}C and ^{13}N
- (d) ^{13}C and ^{12}B

73. The ground-state spin (J) and parity (P) of most of the even-even (even protons, even neutrons) nuclei, i.e., J^P , is

- (a) 3^-
- (b) 0^+
- (c) $5/2^+$
- (d) 0^-

74. The approximate radius R of ^{125}Sn nucleus is

- (a) 1.2 fm
- (b) 12.5 fm
- (c) 6 fm
- (d) 10 fm

75. According to the liquid drop model, when a nucleus is bombarded by neutrons, the compound nucleus before undergoing fission attains the shapes in the sequence of

- (a) ellipsoidal, spherical, dumbbell
- (b) spherical, ellipsoidal, dumbbell
- (c) spherical, dumbbell, ellipsoidal
- (d) dumbbell, ellipsoidal, spherical

- 76.** The total binding energy of ${}_{10}^{20}\text{Ne}$ nucleus is 160.647 MeV. The binding energy per nucleon for ${}_{10}^{20}\text{Ne}$ is
- 160.647 MeV
 - 16.064 MeV
 - 8.032 MeV
 - 5.354 MeV
- 77.** In the asymmetric fission of ${}_{92}^{235}\text{U}$, the maximum energy appears as
- kinetic energy of the emitted neutrons
 - energy of the emitted gamma rays
 - kinetic energy of the lighter fission fragments
 - kinetic energy of the heavier fission fragments
- 78.** Which one of the following nuclear fusion reactions has the highest release of energy?
- Proton-proton reaction
 - Proton-deuteron reaction
 - Deuteron-deuteron reaction
 - Deuteron-triton reaction
- 79.** The half-life of a radioactive nucleus is 6 nanosecond (ns). The decay constant of this nucleus is
- $1.16 \times 10^9 \text{ s}^{-1}$
 - $1.16 \times 10^8 \text{ s}^{-1}$
 - $1.60 \times 10^9 \text{ s}^{-1}$
 - $1.60 \times 10^8 \text{ s}^{-1}$
- 80.** ${}_{43}^{99}\text{Tc}$ nucleus decays to ${}_{44}^{99}\text{Ru}$ nucleus by a radioactive decay process. This radioactive decay is an example of
- alpha decay
 - positive beta decay
 - negative beta decay
 - orbital electron capture
- 81.** Which one of the following statements is correct for a nucleus undergoing gamma decay?
- The number of neutrons increases by one.
 - The number of protons increases by one.
 - Neither the number of protons nor the number of neutrons changes.
 - Each of the proton and neutron numbers increases by one.
- 82.** The minimum photon energy required for a pair production by a gamma ray, in the presence of a nucleus, is
- 0.511 MeV
 - 1.022 MeV
 - 937 MeV
 - 4.0 MeV
- 83.** For an incident gamma-ray energy of 1 MeV, which one of the following absorbers has the highest probability of photoelectric absorption?
- ${}_{6}^{12}\text{C}$
 - ${}_{14}^{28}\text{Si}$
 - ${}_{28}^{60}\text{Ni}$
 - ${}_{32}^{76}\text{Ge}$

84. The maximum energy that can be transferred by an incident photon of energy $h\nu$ to an electron in a single Compton interaction is

(a) $h\nu \left(\frac{2\alpha}{1+2\alpha} \right)$

(b) $h\nu \left(\frac{1}{1+2\alpha} \right)$

(c) $h\nu \left(\frac{1}{1-2\alpha} \right)$

(d) $h\nu \left(\frac{2\alpha}{1-2\alpha} \right)$

(where $\alpha = \frac{h\nu}{m_0c^2}$; m_0c^2 is the rest mass

energy of the electron)

85. Which one of the following is the correct equation to represent a pair-production process of gamma-ray interaction?

(a) $h\nu - m_0c^2 = E_{e^-} + E_{e^+}$

(b) $h\nu + m_0c^2 = E_{e^-} + E_{e^+}$

(c) $h\nu + 2m_0c^2 = E_{e^-} + E_{e^+}$

(d) $h\nu - 2m_0c^2 = E_{e^-} + E_{e^+}$

(where $h\nu$ is the energy of incident gamma ray; E_{e^-} and E_{e^+} are the electron and positron kinetic energies, respectively; m_0c^2 is the rest mass energy of the electron)

86. Which one of the following radioactive minerals has thorium (Th) element?

(a) Alunite

(b) Carnotite

(c) Monazite

(d) Muscovite

87. A radioactive source having a half-life of 5 years has an initial activity of 400 kBq. The activity (in kBq) after 15 years will be

(a) 200

(b) 100

(c) 50

(d) 25

88. The parent nuclide of the $(4n+2)$ radioactive series is

(a) ^{232}Th

(b) ^{238}U

(c) ^{210}Bi

(d) ^{227}Ra

89. Which one of the following inorganic scintillators has the maximum light yield per MeV?

(a) BaF_2

(b) BGO

(c) NaI (Tl)

(d) $\text{LaBr}_3(\text{Ce})$

90. The different regions of operation of gas-filled detectors are ion saturation, proportional region, limited proportional region and Geiger-Müller region. The region **not** used for detector operation is

(a) Geiger-Müller region

(b) ion saturation region

(c) proportional region

(d) limited proportional region

91. The de Broglie wavelength associated with an alpha particle emitted with a kinetic energy of 1 MeV by the nucleus of an atom of radon is of the order of

- (a) 10^{-14} cm
- (b) 10^{14} cm
- (c) 10^{-12} cm
- (d) 10^{12} cm

92. The magnitudes of total angular momentum given by $\vec{J} = \vec{L} + \vec{S}$ for $l = 1$ and $s = 1/2$ are

- (a) $\frac{\sqrt{3}}{4} \hbar$ and $\frac{\sqrt{15}}{4} \hbar$
- (b) $\frac{\sqrt{3}}{2} \hbar$ and $\frac{\sqrt{1}}{2} \hbar$
- (c) $\frac{\sqrt{3}}{2} \hbar$ and $\frac{\sqrt{15}}{2} \hbar$
- (d) $\frac{\sqrt{3}}{2} \hbar$ and $\frac{\sqrt{4}}{3} \hbar$

(where the symbols have their usual meanings)

93. In the X-ray spectra, the K_{β} line originates

- (a) when an $n = 4$ electron undergoes a transition to a vacant $n = 2$ state
- (b) when an $n = 3$ electron undergoes a transition to a vacant $n = 2$ state
- (c) when an $n = 3$ electron undergoes a transition to a vacant $n = 1$ state
- (d) when an $n = 2$ electron undergoes a transition to a vacant $n = 1$ state

94. A completely antisymmetric tensor $\epsilon_{\mu\nu\lambda}$ in 3-space dimensions possesses

- (a) rank = 3 and independent components = 3
- (b) rank = 1 and independent components = 1
- (c) rank = 1 and independent components = 3
- (d) rank = 3 and independent components = 1

95. Which one among the following pairs is **not** correctly matched?

- (a) $\nabla \cdot (\nabla \times \vec{A})$: 0
- (b) $\nabla \times (\nabla \times \vec{A})$: $\nabla(\nabla \cdot \vec{A}) - \nabla^2 \vec{A}$
- (c) $\nabla \times (\nabla \phi)$: 0
- (d) $\nabla \times (\phi \vec{A})$: $(\nabla \phi) \times \vec{A} - \phi(\nabla \times \vec{A})$

(Given : ϕ and \vec{A} are differentiable scalar and vector functions, respectively)

96. Let $P(4 \cos t, 4 \sin t, 4t)$ be a point on a curve, where t is some parameter. The magnitude of the tangent vector at point P is

- (a) 4
- (b) $2\sqrt{2}$
- (c) 2
- (d) $4\sqrt{2}$

97. The eigenvalues of the matrix

$$A = \begin{pmatrix} 5 & -2 \\ -2 & 2 \end{pmatrix}$$

are

- (a) 1, 2
- (b) 5, 2
- (c) 2, 6
- (d) 1, 6

- 98.** For a matrix A , the diagonal matrix A' is obtained using the similarity transformation $A' = S^{-1}AS$, where S is a transformation matrix. If $A = \begin{pmatrix} 0 & i \\ i & 0 \end{pmatrix}$, then the diagonal matrix A' is
- $\begin{pmatrix} i & 0 \\ 0 & i \end{pmatrix}$
 - $\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$
 - $\begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix}$
 - $\begin{pmatrix} i & 0 \\ 0 & -i \end{pmatrix}$
- 99.** The isostatic gravity anomaly is defined as the difference between
- Bouguer gravity anomaly and computed anomaly of the root zone
 - free-air gravity anomaly and computed anomaly of the root zone
 - Bouguer gravity anomaly and free-air gravity anomaly
 - regional gravity anomaly and residual gravity anomaly
- 100.** The gravity value on the surface of the Earth at the equator is approximately
- 6.78 m/s^2
 - 7.78 m/s^2
 - 8.78 m/s^2
 - 9.78 m/s^2
- 101.** The spherical shape model mass in the gravity method is particularly used as a first approximation in the interpretation of
- asymmetrical 2D anomalies
 - approximately symmetrical 2D anomalies
 - asymmetrical 3D anomalies
 - approximately symmetrical 3D anomalies
- 102.** Which one of the following fundamental forces is mediated by massive particles?
- Strong force
 - Electromagnetic force
 - Weak force
 - Gravitational force
- 103.** The range of weak interactions is
- 10^{-12} m
 - 10^{-15} m
 - 10^{-18} m
 - 10^{-21} m
- 104.** The engine of a rocket in outer space, far from any planet, is turned on. The rocket rejects burned fuel at a constant rate. In the first second of firing, it ejects $\frac{1}{100}$ of its initial mass m_0 at a relative speed of 2000 m/s . The initial acceleration of the rocket is
- -20 m/s^2
 - $+20 \text{ m/s}^2$
 - $-2 \times 10^5 \text{ m/s}^2$
 - $+2 \times 10^5 \text{ m/s}^2$
- 105.** In the centre of mass frame of reference, the magnitudes of the velocities of particles
- remain unchanged in an elastic collision
 - remain unchanged in an inelastic collision
 - remain unchanged in both elastic and inelastic collisions
 - change in both elastic and inelastic collisions

106. The angular speed of 3600 rpm in rad/s is equal to

- (a) 251
- (b) 277
- (c) 351
- (d) 377

107. If the kinetic energy of a proton is 3752 MeV, then its Lorentz (relativistic) factor is approximately

- (a) 5
- (b) 4
- (c) 3
- (d) 2

108. The total energy of a 3.53 MeV electron is

- (a) 3.02 MeV
- (b) 3.53 MeV
- (c) 4.04 MeV
- (d) 4.55 MeV

109. The regularization parameter in non-linear least-squares inversion technique describes a trade-off between

- (a) the best fitting and the most reasonable stabilization
- (b) the worst fitting and the most reasonable stabilization
- (c) the best fitting and the most unreasonable stabilization
- (d) the worst fitting and the most unreasonable stabilization

110. Which one of the following is the additive rule of probability $P(X \cup Y)$ for mutually exclusive events X and Y ?

- (a) $P(X \cup Y) = P(X) - P(Y) - P(X \cap Y)$
- (b) $P(X \cup Y) = P(X) - P(Y) + P(X \cap Y)$
- (c) $P(X \cup Y) = P(X) - P(Y)$
- (d) $P(X \cup Y) = P(X) + P(Y)$

111. Match List-I with List-II and select the correct answer using the code given below the Lists :

List-I (Distribution)	List-II (Probability distribution)
A. Binomial	1. $\frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$
B. Poisson	2. $q^{x-1} p$
C. Geometric	3. $\frac{\lambda^x}{x!} e^{-\lambda}$
D. Normal	4. ${}^n C_x p^x q^{n-x}$

(where the symbols have their usual meanings)

Code :

- (a) A B C D
4 2 3 1
- (b) A B C D
4 3 2 1
- (c) A B C D
1 2 3 4
- (d) A B C D
1 3 2 4

112. Consider the following differential equation :

$$\frac{d^2y}{dx^2} = y$$

The solution of this equation $y(x)$ passing through the origin and through the point $(\ln 2, \frac{3}{4})$ is

- (a) $\sinh x$
- (b) $\cosh x$
- (c) $2\sinh x$
- (d) $2\cosh x$

113. Consider the following statements regarding a system of linear equations :

1. A system of linear equations is consistent if it has one or more solutions.
2. A system of linear equations is inconsistent if it has one or more solutions.
3. A system of linear equations is consistent if it has no solution.
4. A system of linear equations is inconsistent if it has no solution.

Which of the statements given above are correct?

- (a) 1 and 3
- (b) 2 and 4
- (c) 2 and 3
- (d) 1 and 4

114. The order and degree of the differential equation

$$\left[1 + \left(\frac{dy}{dx} \right)^2 \right]^3 = \left(\frac{d^2y}{dx^2} \right)^2$$

are, respectively

- (a) 1, 2
- (b) 2, 2
- (c) 3, 1
- (d) 2, 3

115. Let $y_1 = e^{2x}$ and $y_2 = e^{3x}$ be two solutions of a linear second-order differential equation. Which one of the following is correct about the Wronskian (W), y_1 and y_2 ?

- (a) $W = 0$; y_1 and y_2 are linearly dependent
- (b) $W = e^{5x}$; y_1 and y_2 are linearly dependent
- (c) $W = 0$; y_1 and y_2 are linearly independent
- (d) $W = e^{5x}$; y_1 and y_2 are linearly independent

116. Consider the second-order partial differential equation for a function $u(x, y)$, defined by

$$\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$$

Which one of the following is correct regarding the equation given above?

- (a) Laplace equation, hyperbolic type
- (b) Laplace equation, elliptic type
- (c) Wave equation, parabolic type
- (d) Wave equation, elliptic type

117. Consider the heat flow in a two-dimensional (x, y) metal plate. The temperature $u(x, y, t)$ at any point (x, y) at time t for diffusivity d^2 of the plate is governed by

(a) $\frac{\partial^2 u}{\partial t^2} = d^2 \frac{\partial^2 u}{\partial x^2}$

(b) $\frac{\partial u}{\partial t} = d^2 \left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} \right)$

(c) $\frac{\partial^2 u}{\partial x^2} - \frac{\partial^2 u}{\partial y^2} = d^2 \frac{\partial u}{\partial t}$

(d) $\frac{\partial^2 u}{\partial t^2} = d^2 \left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} \right)$

118. The numerical value of the integral $\int_1^2 (x^3 + 1) dx$ using trapezoidal rule (considering only one interval between the end points) is

- (a) 5.50
- (b) 5.60
- (c) 5.75
- (d) 5.55

119. The Newton-Raphson method is used in numerical analysis to

- (a) solve a partial differential equation approximately
- (b) find the root(s) of nonlinear equations approximately
- (c) solve an ordinary differential equation exactly
- (d) solve an algebraic equation exactly

120. Which one of the following 'rules/methods' is used to numerically find the solutions of linear differential equations?

- (a) Trapezoidal rule
- (b) Boole's rule
- (c) Newton-Raphson method
- (d) Euler's method

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