COMBINED GEO-SCIENTIST (P) EXAM-2022 205/09

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T.B.C. : FTRE–T–GPH **Test Booklet Series**

Serial No. 1005725

TEST BOOKLET

A

PAPER—II

(Geophysics)

Time Allowed : Two Hours **Maximum Marks : 300**

INSTRUCTIONS

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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.**
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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.
    (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. Which of the following methods is/are appropriate for archaeological investigation?

1. Ground-penetrating radar method
2. Electrical resistivity method
3. Electromagnetic method
4. Gravity method

Select the correct answer using the code given below.

(a) 1 and 2 only

(b) 2 and 3 only

(c) 4

(d) 1, 2 and 3

2. Which one of the following is ***not*** a principal subdivision of geophysics?

(a) Seismology

(b) Meteorology

(c) Terrestrial magnetism

(d) Petrology

3. According to the nebular hypothesis of the origin of the solar system, the sun, planets and other components of the solar system originated from

(a) objects in the Kuiper belt

(b) a white dwarf star

(c) a rotating cloud of hot, primordial gas and dust

(d) a red giant star

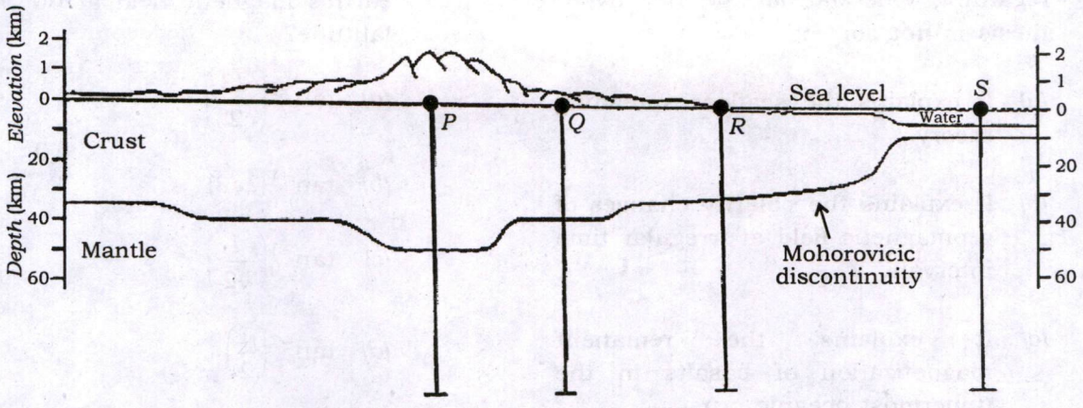
4. Match List–I with List–II and select the correct answer using the code given below the Lists :

List–I (Solar system body)	*List–II (Category)*
A. Uranus	1. Dwarf planet
B. Pluto	2. Natural satellite
C. Mercury	3. Jovian planet
D. Moon	4. Terrestrial planet

Code :

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

5. Consider the following diagram :



Assuming that the measured gravity is equal to the normal gravity value, which point in the above diagram has zero Bouguer gravity value?

(a) Point *P*

(b) Point *Q*

(c) Point *R*

(d) Point *S*

6. Consider the following statements regarding shape of the earth :

Statement 1 :

The ellipsoidal shape of the earth is a result of its rotation.

Statement 2 :

The ellipsoidal shape affects the rate of rotation and the orientation of rotational axis of the earth.

Which one of the following is correct in respect of the above statements?

(a) Both Statement 1 and Statement 2 are true and Statement 2 is the consequence of Statement 1

(b) Both Statement 1 and Statement 2 are true and Statement 2 is not the consequence of Statement 1

(c) Statement 1 is true but Statement 2 is false

(d) Statement 1 is false but Statement 2 is true

7. Which one of the following statements regarding Vine-Matthews-Morley hypothesis is ***not*** correct?

(a) It explains the seafloor spreading theory.

(b) It explains the polarity changes of geomagnetic field at irregular time intervals.

(c) It explains the remanent magnetization of basalts in the uppermost oceanic crust.

(d) It explains the solar wind interaction with the magnetic field of the earth.

8. Which one of the following magnetometers is used to study the remanent magnetization of rocks?

(a) Proton precession magnetometer

(b) Optically pumped magnetometer

(c) SQUID magnetometer

(d) Spinner magnetometer

9. Which one of the following represents the correct order of magnetic susceptibilities of various rocks?

(a) Schist < Pegmatite < Peridotite

(b) Pegmatite < Schist < Peridotite

(c) Pegmatite < Peridotite < Schist

(d) Schist < Peridotite < Pegmatite

10. What is the angle of inclination of the earth's magnetic field at 60° magnetic latitude?

(a) $\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$

(b) $\tan^{-1}(2\sqrt{3})$

(c) $\tan^{-1}\left(\frac{1}{\sqrt{2}}\right)$

(d) $\tan^{-1}\left(\frac{1}{2}\right)$

11. For an earth material with both the Lamé parameters equal ($\lambda = \mu$), the ratio of P-wave to S-wave velocities is

(a) $\frac{1}{2}$ *(b)* 2

(c) $\frac{1}{\sqrt{3}}$ *(d)* $\sqrt{3}$

12. The decrease in the intensity (energy density) of surface wave and body wave respectively, with distance r from the source, is proportional to

(a) $\frac{1}{r}, \frac{1}{r}$ *(b)* $\frac{1}{r}, \frac{1}{\sqrt{r}}$

(c) $\frac{1}{r}, \frac{1}{r^2}$ *(d)* $\frac{1}{\sqrt{r}}, \frac{1}{r}$

13. A class of seismic waves observed only on coastal and island seismic stations, which travel at very low phase velocities and correspond to sound waves trapped in the oceanic water layers, is known as

(a) primary waves

(b) Love waves

(c) tertiary waves

(d) Rayleigh waves

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

List–I (Seismic phase)	*List–II (Propagating medium)*
A. P_g, S_g	1. Compressional and shear waves travelling along the Moho discontinuity
B. P^*, S^*	2. Compressional and shear waves reflected at Moho
C. P_n, S_n	3. Compressional and shear waves travelling along the Conrad discontinuity
D. PmP, SmS	4. Compressional and shear waves in the granitic layer of the crust

Code :

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

15. The seismological Moho is commonly defined as the depth at which P-wave velocity exceeds

(a) 8·4 km/s

(b) 6·3 km/s

(c) 7·6 km/s

(d) 5·5 km/s

16. Which one of the following is the correct relation among the stresses for a strike-slip fault regime?

(where σ_1 = maximum principal stress, σ_2 = intermediate principal stress and σ_3 = least principal stress in a region)

(a) $\sigma_1 > \sigma_2 > \sigma_3$

(b) $\sigma_2 > \sigma_3 > \sigma_1$

(c) $\sigma_3 > \sigma_2 > \sigma_1$

(d) $\sigma_2 > \sigma_1 > \sigma_3$

17. The depth range of the transition zone associated with mineralogical phase changes in the mantle of the earth is

(a) 35 km–150 km

(b) 150 km–410 km

(c) 410 km–670 km

(d) 720 km–860 km

18. The average value of oceanic heat flow for an oceanic lithosphere of age 36 Ma is

(a) 65 mW/m^2

(b) 75 mW/m^2

(c) 85 mW/m^2

(d) 105 mW/m^2

19. The surface wave magnitude of an earthquake was misreported as 5 with seismic energy E. If the correct magnitude of the earthquake is 7, then the seismic energy generated by the earthquake will be

(a) $1024E$

(b) $3276E$

(c) $1000E$

(d) $3200E$

20. The slope of the Wadati plot obtained using P-wave and S-wave arrival times for an earthquake is 0·77. What will be the corresponding $\frac{V_P}{V_S}$ ratio?

(where V_P = velocity of P-wave and V_S = velocity of S-wave)

(a) 0·77

(b) 1·77

(c) 2·00

(d) 2·77

21. Which one of the following statements regarding the earth as a dynamic planet is ***not*** correct?

(a) The earth's surface is constantly altered by endogenic processes resulting in volcanism and tectonism.

(b) The earth's surface is altered by exogenic processes such as erosion and deposition.

(c) Europe and most of the Arabia plate formed a single continent called Laurasia.

(d) Laurasia and Gondwanaland split apart in the Early Mesozoic.

22. Which one of the following statements regarding interplate events is ***not*** correct?

(a) Majority of seismic moment release occurs during interplate events.

(b) Recurrence interval of interplate events is generally much longer than intraplate events.

(c) Interplate events have much lower stress drops than intraplate events.

(d) Interplate faults are weaker in some sense than intraplate faults.

23. Which one of the following equations is true, if a vector field $\vec{A}$ is irrotational?

(a) $\oint_{\partial S} \vec{A} \cdot d\vec{r} = 0$

(b) $\int_{S} \vec{A} \cdot d\vec{S} = 0$

(c) $\vec{\nabla} \cdot \vec{A} = 0$

(d) $\nabla^2 \vec{A} = 0$

24. Consider the following vectors :

1. $\vec{A} = 3\hat{i} + 7\hat{j} - 4\hat{k}$
2. $\vec{B} = 7\hat{i} - 4\hat{j} + 3\hat{k}$
3. $\vec{C} = 4\hat{i} + 3\hat{j} + 7\hat{k}$
4. $\vec{D} = 4\hat{i} - 7\hat{j} + 3\hat{k}$

Which one of the following statements is true in respect of the above vectors?

(a) Vector $\vec{A}$ has a larger magnitude than the other three vectors.

(b) Vector $\vec{B}$ has a larger magnitude than the other three vectors.

(c) Vector $\vec{C}$ has a larger magnitude than the other three vectors.

(d) Vectors $\vec{A}$, $\vec{B}$, $\vec{C}$ and $\vec{D}$ have equal magnitudes.

25. The components of a vector remain unchanged if

(a) it is rotated through an arbitrary angle

(b) it is multiplied by an arbitrary scalar

(c) its cross product with a unit vector is computed

(d) it is moved parallel to itself

26. Two functions $f(x)$ and $g(x)$ are related by a matrix (M) equation $Mf = g$. If $f(x)$ is an eigenfunction of M, then

(a) $g(x)$ should always be equal to $f(x)$

(b) $g(x)$ is directly proportional to $f(x)$

(c) $g(x)$ is inversely proportional to $f(x)$

(d) $g(x)$ is independent of $f(x)$

27. What will be the approximate values of principal stresses in MPa for a 2D stress tensor $\tau = \begin{bmatrix} -3 & -1 \\ -1 & -5 \end{bmatrix}$ MPa?

(a) –1, 1·2

(b) –2, 4·1

(c) –0·8, –3·1

(d) –2·6, –5·4

28. Consider the following statements regarding eigenvalues of matrices :

1. The product of the eigenvalues of a matrix is equal to the determinant of the matrix.
2. A matrix has the same eigenvalues as its transpose.
3. A real symmetric matrix has real eigenvalues only.
4. The eigenvalues of a triangular matrix are equal to those of its equivalent diagonal matrix.

Which of the statements given above are correct?

(a) 1, 3 and 4 only

(b) 2 and 4 only

(c) 1, 2 and 3 only

(d) 1, 2, 3 and 4

29. Which one of the following correctly represents the relation between gravitational potential (U) and gravity attraction (g_r) at a distance r from the source mass?

(a) $g_r = -\dfrac{\partial U}{\partial r}$

(b) $g_r = r^2 \dfrac{\partial U}{\partial r}$

(c) $g_r = \dfrac{1}{r^2} \dfrac{\partial U}{\partial r}$

(d) $g_r = r^2 \dfrac{\partial^2 U}{\partial r^2}$

30. A spaceship is moving in vacuum of outer space, which is far from any star or planet. When its engine dies, the spaceship will

(a) come to rest instantly

(b) move with an increasing velocity

(c) move with a decreasing velocity

(d) continue to move with a uniform velocity

31. Which one of the following types of interactions is insignificant between elementary particles but becomes prominent in the study of astrophysics and cosmology?

(a) Strong interaction

(b) Weak interaction

(c) Electromagnetic interaction

(d) Gravitational interaction

32. A disk of mass M and radius R rotates with an angular velocity $\vec{\omega_0}$. Another disk of equal mass M and radius r is placed on top of the rotating disk such that their centres coincide. Both the disks now rotate with an angular velocity $\vec{\omega}$ which is given by

(a) $\frac{r^2\vec{\omega_0}}{R^2+r^2}$

(b) $\frac{R^2\vec{\omega_0}}{R^2+r^2}$

(c) $\frac{(R^2+r^2)\vec{\omega_0}}{r^2}$

(d) $\frac{(R^2+r^2)\vec{\omega_0}}{R^2}$

33. Two bodies of equal mass m are connected by a massless rigid rod of length $2l$ lying in the x-y plane with the centre of the rod at the origin. If this system is rotating about the z-axis with an angular velocity $\vec{\omega}$, then its angular momentum is

(a) $4ml^2\vec{\omega}$

(b) $2ml^2\vec{\omega}$

(c) $0\cdot5ml^2\vec{\omega}$

(d) $0\cdot25ml^2\vec{\omega}$

34. The moment of inertia I of a thick spherical shell of uniform density ρ, with internal radius r and external radius R, is given by

(a) $I=\left(\frac{2}{5}\right)\pi\rho\,(R^2-r^2)$

(b) $I=\left(\frac{8}{4}\right)\pi\rho\,(R^3-r^3)$

(c) $I=\left(\frac{8}{3}\right)\pi\rho\,(R^5-r^5)$

(d) $I=\left(\frac{8}{15}\right)\pi\rho\,(R^5-r^5)$

35. The proper time interval $d\tau$ in special theory of relativity is expressed via a relation $d\tau^2=-dt^2+d\vec{x}^2$, where t is the time and $\vec{x}$ is the space vector. Then time-like and space-like separations between events are respectively given by

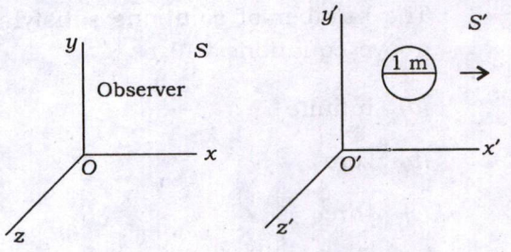
(a) $d\tau^2>0$ and $d\tau^2<0$

(b) $d\tau^2<0$ and $d\tau^2>0$

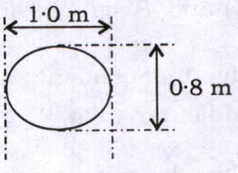
(c) $d\tau^2>0$ and $d\tau^2=0$

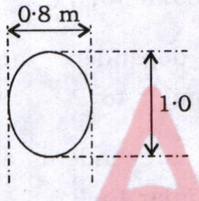
(d) $d\tau^2<0$ and $d\tau^2=0$

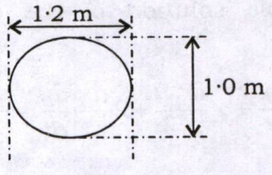
36. A sphere of 1 m diameter is in S' frame that is moving in x' direction with a speed of 0·6 times the speed of light in vacuum with respect to S frame :

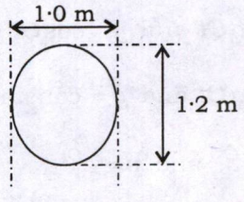


How will an observer at rest in frame S see the object?

(a) 

(b) 

(c) 

(d) 

37. Two meteorites are moving towards each other with speeds of 0·9c and 0·3c, respectively with respect to the laboratory frame of reference, where c is the speed of light in vacuum. Their relative speed is

(a) 0·49c

(b) 0·94c

(c) 0·74c

(d) 0·67c

38. According to the special theory of relativity

(a) the speed of light in vacuum is dependent on the direction of propagation

(b) the speed of light in vacuum is dependent on the relative velocity of source and the observer

(c) the speed of light in vacuum is independent of the direction of propagation

(d) the laws of physics are dependent on the frame of reference

39. Consider a linear inverse problem $Gm = d$, where G is a matrix of size $N \times M$; m and d are model and data vectors of lengths M and N, respectively. The least square solution for this problem is

(a) $[G^T G]^{-1} Gd$

(b) $[GG^T]^{-1} Gd$

(c) $[G^T G]^{-1} G^T d$

(d) $[GG^T]^{-1} G^T d$

40. Consider three identical boxes *I*, *II* and *III*, each containing two coins. In box *I*, both are gold coins, in box *II*, both are silver coins and in box *III*, there is one gold and one silver coin. A person chooses a box at random and takes out a coin. If the coin is of gold, what is the probability that the other coin in the box is also of gold?

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

(b) $\frac{1}{4}$

(c) $\frac{4}{7}$

(d) $\frac{2}{3}$

41. If the standard deviation of a data set is 3·28, then what would be the approximate mean deviation assuming Gaussian distribution of the data?

(a) 1·08

(b) 2·61

(c) 3·08

(d) 4·61

42. What is the probability that a red ball and a blue ball are respectively picked up in succession from a bag containing 6 red balls and 9 blue balls?

(a) $\frac{5}{18}$

(b) $\frac{1}{54}$

(c) $\frac{6}{25}$

(d) $\frac{9}{35}$

43. Consider the following set of equations :

$$3x - 6y = -15$$
$$-x + 2y = 5$$

The number of solutions satisfying the above equations will be

(a) infinite

(b) zero

(c) three

(d) two

44. The three vectors $\vec{M} = (2\hat{i} + \hat{j} + \hat{k})$, $\vec{N} = 2(\hat{j} - \hat{k})$ and $\vec{P} = (\hat{i} + \hat{k})$ are

(a) linearly independent and $\vec{M}$ is perpendicular to $\vec{N}$

(b) linearly dependent and $\vec{M}$ is perpendicular to $\vec{N}$

(c) linearly dependent and $\vec{M}$ is perpendicular to $\vec{P}$

(d) linearly independent and $\vec{M}$ is perpendicular to $\vec{P}$

45. A possible solution of the differential equation

$$y\frac{d^2x}{dt^2} + x\frac{d^2y}{dt^2} + 2\frac{dx}{dt}\frac{dy}{dt} = -Q^2xy$$

(where Q is a non-zero constant) is

(a) $x = \sin Qt$ and $y = \cos Qt$

(b) $x = \sin Qt$ and $y =$ constant

(c) $x = e^{-Qt}$ and $y = e^{Qt}$

(d) $x = e^{-Qt}$ and $y = e^{-Qt}$

46. The relation among total amount of heat flowing out of the earth per second $\left(\frac{dQ}{dt}\right)$, the mean heat flow per unit area per second (q) and the earth's surface area (A) is

(a) $\left(\frac{dQ}{dt}\right) = \frac{q}{A}$

(b) $\left(\frac{dQ}{dt}\right) = -qA$

(c) $\left(\frac{dQ}{dt}\right) = \frac{A}{q}$

(d) $\left(\frac{dQ}{dt}\right) = A - q$

47. A standing wave $\psi(x, t)$ satisfies the wave equation $\frac{\partial^2\psi}{\partial x^2} = \frac{1}{c^2}\frac{\partial^2\psi}{\partial t^2}$, which is a/an

(a) elliptic partial differential equation

(b) hyperbolic partial differential equation

(c) elliptic ordinary differential equation

(d) parabolic ordinary differential equation

48. A river is 80 m wide. The depth d at a distance x from the bank is given by the following table :

x (m)	0	10	20	30	40	50	60	70	80
d (m)	0	4	7	9	12	15	14	8	3

What will be the approximate area of the cross-section of the river by using Simpson's $\frac{1}{3}$rd rule?

(a) 610 m^2

(b) 690 m^2

(c) 710 m^2

(d) 740 m^2

49. What will be the Taylor series expansion of a polynomial $f(x) = x^4 + 1$, when expanded around $x = 0$ up to third order?

(a) 1

(b) 0

(c) -1

(d) ∞

50. Consider the following Rodrigues' formula for a Hermite polynomial :

$$H_n(x) = (-1)^n e^{x^2}\left(\frac{d}{dx}\right)^n e^{-x^2}$$

What will be the second-order Hermite polynomial from the equation given above?

(a) $2x^2 - 4$

(b) $4x^2 - 2$

(c) $4x^2 - 1$

(d) $2x^2 - 1$

51. Heun's method for solving ordinary differential equations is an example of

(a) first-order Runge-Kutta method

(b) second-order Runge-Kutta method

(c) third-order Runge-Kutta method

(d) fourth-order Runge-Kutta method

52. The process of inducing a charge on a metal ball by bringing an electrically charged plastic rod near it, without actually touching it, is called

(a) electrostatic friction

(b) electrostatic induction

(c) electrostatic conduction

(d) charge transfer

53. The magnetic field inside a uniformly magnetized sphere is

(a) radial, unlike the electric field inside a uniformly polarized sphere

(b) uniform, unlike the electric field inside a uniformly polarized sphere

(c) radial, like the electric field inside a uniformly polarized sphere

(d) uniform, like the electric field inside a uniformly polarized sphere

54. Two point charges of equal mass m and charge Q are suspended at a common point by two threads of negligible mass and length l. At equilibrium, if α is the angle of each thread to the vertical, the charge Q is given by the relation

(a) $Q = 16\pi\varepsilon_0 mgl \sin^2\alpha$

(b) $Q = \sqrt{16\pi\varepsilon_0 mgl^2 \sin^2\alpha \tan\alpha}$

(c) $Q = \sqrt{4\pi\varepsilon_0 mgl \tan\alpha}$

(d) $Q = 2\pi\varepsilon_0 mgl^2 \cos\alpha$

55. An electron moving with a uniform speed enters into a long current-carrying solenoid along its axis. Which one of the following statements is correct in this regard?

(a) The electron will be repelled back.

(b) The electron will be deflected by an angle of 45° from the axis of the solenoid.

(c) The electron will continue moving with the same speed along the axis of the solenoid.

(d) The electron's path will become circular about the axis of the solenoid.

56. A light beam travelling in the x-direction is described by the electric field

$$E_y = (300\ \text{V m}^{-1}) \sin\omega\left(t - \frac{x}{c}\right)$$

An electron is constrained to move along the y-direction with a speed of $2{\cdot}0\times10^{7}$ m/s. The maximum magnetic force on the electron is

(a) $4{\cdot}8\times10^{-17}$ N

(b) $3{\cdot}2\times10^{-18}$ N

(c) $7{\cdot}8\times10^{-15}$ N

(d) $8{\cdot}2\times10^{-12}$ N

57. A cubical region of space, with an edge l, is filled with uniform electric and magnetic fields. Now an electron enters into this region across one of its faces with a certain velocity $\vec{v}$. At the same instant, a positron enters the cubical region via the opposite face with velocity $-\vec{v}$. The following statements are given in this regard for the instant when both the particles enter the cubical space :

1. Both the particles will experience the same accelerations due to the electric force.
2. Both the particles will experience the same accelerations due to the magnetic force.
3. Both the particles will gain (or lose) energy at the same rate.
4. The magnetic field alone will determine the motion of centre of mass of the two particles.

Which of the statements given above are correct?

(a) 1, 3 and 4

(b) 1 and 4 only

(c) 2 and 3 only

(d) 2, 3 and 4

58. A charged particle moves with a uniform speed of 4 m/s along the x-axis in a region of uniform electromagnetic field with $\vec{E} = 28\hat{j}$ V/m and $\vec{B} = B_0\hat{k}$. If the particle keeps on moving with the same uniform speed in the field, then the value of B_0 (in Wb/m^2) is

(a) 5

(b) 7

(c) 10

(d) 15

59. Consider the following four surfaces placed in uniform electric fields :

1. A flat oval surface with vector area $\vec{A} = (8{\cdot}0\ \text{m}^2)\hat{j} + (17\ \text{cm}^2)\hat{k}$ in a uniform electric field $\vec{E} = (4{\cdot}2\ \text{N/C})\hat{i}$
2. A flat circular surface with vector area $\vec{A} = (8{\cdot}0\ \text{m}^2)\hat{i} - (17\ \text{cm}^2)\hat{k}$ in a uniform electric field $\vec{E} = (4{\cdot}2\ \text{N/C})\hat{i}$
3. A flat rectangular surface with vector area $\vec{A} = (8{\cdot}0\ \text{m}^2)\hat{i} + (17\ \text{cm}^2)\hat{j}$ in a uniform electric field $\vec{E} = (2{\cdot}4\ \text{N/C})\hat{i} - (7{\cdot}6\ \text{N/C})\hat{j}$
4. A flat square surface with vector area $\vec{A} = (8{\cdot}0\ \text{m}^2)\hat{j} + (17\ \text{m}^2)\hat{k}$ in a uniform electric field $\vec{E} = (7{\cdot}6\ \text{N/C})\hat{k} + (3{\cdot}4\ \text{N/C})\hat{j}$

Rank these surfaces in increasing order of electric flux through them.

(a) $1 < 2 < 3 < 4$

(b) $2 < 4 < 1 < 3$

(c) $1 < 3 < 2 < 4$

(d) $4 < 2 < 3 < 1$

60. A 0·20 m long current-carrying solenoid has 4·0 cm inner diameter. It consists of four close-packed layers of 100 turns along its length. What is the magnetic field strength at the centre of the solenoid, if the current through it is 5 A ? ($\mu_0 = 4\pi \times 10^{-7}$ T m/A)

(a) $3{\cdot}14 \times 10^{-3}$ T

(b) $3{\cdot}14 \times 10^{-5}$ T

(c) $12{\cdot}6 \times 10^{-7}$ T

(d) $12{\cdot}6 \times 10^{-3}$ T

61. Two parallel plane current sheets placed at planes given by $z = 0$ and $z = 4$ carry currents with densities equal to $-10\hat{i}$ A/m^2 and $10\hat{i}$ A/m^2, respectively. What is the magnetic field strength $\vec{H}$ at the point (1, 1, 1)?

(All distances are in metres)

(a) 0 A/m

(b) $10\hat{j}$ A/m

(c) $5\hat{j}$ A/m

(d) $-5\hat{j}$ A/m

62. Which one of the following expressions of a scalar function V satisfies the Laplace equation?

(a) $V = x^2 + y^2 - 2z^2$

(b) $V = x^2 + y^2 - z^2$

(c) $V = x^2 + y^2 + 2z^2$

(d) $V = x^2 + y^2 + z^2$

63. A parallel-plate capacitor with plate area of 10 cm^2 and plate separation of 3 mm has a voltage 30*t* V applied to its plates. What will be the displacement current, if the permittivity of the medium $\varepsilon = 2\varepsilon_0$? $\left(\frac{1}{4\pi\varepsilon_0} = 9\times10^9\ N\,m^2\,C^{-2}\right)$

(a) 1·47 nA

(b) $1\cdot77\times10^{-10}$ A

(c) 50×10^{-5} A

(d) 8×10^{-7} A

64. The existence of displacement current in a capacitive circuit is due to an inconsistency in

(a) Ampere's law

(b) Faraday's law

(c) Gauss' law

(d) Coulomb's law

65. Which of the following circuit elements oppose(s) any change in the current through it?

(a) Resistor only, as it offers resistance to the flow of charges in the conductor

(b) Inductor only, by developing a voltage across it proportional to the rate of change of the current

(c) Capacitor only, as it stores energy by maintaining a voltage between the two plates

(d) Both inductor and capacitor

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

List–I (Law)	*List–II (Explanation)*
A. Gauss' law for electricity	1. Relates induced electric field to changing magnetic flux
B. Gauss' law for magnetism	2. Relates net magnetic flux to net enclosed magnetic charge
C. Faraday's law	3. Relates induced magnetic field to changing electric flux and to current
D. Ampere-Maxwell law	4. Relates net electric flux to net enclosed electric charge

Code :

(a) A 4 B 1 C 2 D 3

(b) A 3 B 1 C 2 D 4

(c) A 3 B 2 C 1 D 4

(d) A 4 B 2 C 1 D 3

67. The intensity of an electromagnetic radiation at a point is

(a) the instantaneous value of the electromagnetic energy flow rate $(= \vec{E} \times \vec{B})$ at that point

(b) the average value of the electromagnetic energy flow rate $(= \vec{E} \times \vec{B})$ at that point

(c) the average value of the electromagnetic energy flow rate $\left(= \frac{1}{\mu_0} \vec{E} \times \vec{B}\right)$ at that point

(d) the instantaneous value of the electromagnetic energy flow rate $\left(= \frac{1}{\mu_0} \vec{E} \times \vec{B}\right)$ at that point

68. In an electronic communication system, which one of the following correctly represents the sequence of phenomena taking place?

(a) The generation of waves, their propagation, their reception and their reflection

(b) The propagation of waves, their generation, their reflection and their reception

(c) The generation of waves, their propagation, their reflection and their reception

(d) The generation of waves, their reflection, their propagation and their reception

69. An electromagnetic radiation having an energy flux of 20 W/cm^2 falls on a completely absorbing surface, having 25 cm^2 area, at an incidence angle of 0°. What is the total momentum delivered to the surface in 10 minutes?

(a) $3{\cdot}60 \times 10^{-3}$ kg m/s

(b) $3{\cdot}00 \times 10^{-3}$ kg m/s

(c) $1{\cdot}00 \times 10^{-3}$ kg m/s

(d) $1{\cdot}80 \times 10^{-2}$ kg m/s

70. Which one of the following statements is true about Maxwell's equations?

(a) These equations can be used to show that a point charge at rest produces static electric and magnetic fields.

(b) There are exceptions, where these equations are not able to explain the behaviour of electromagnetic waves.

(c) With the help of these equations, the entire electromagnetic theory can be explained.

(d) These equations explain the existence of electric as well as magnetic monopoles.

71. What will be the approximate skin depth of electromagnetic waves of frequency 1 kHz in a conductor having conductivity 100 S/m?

(a) 16 metres

(b) 1·6 metres

(c) 0·16 metre

(d) 0·016 metre

72. Which one of the following statements regarding second vertical derivative of gravity data is correct?

(a) It enhances the deeper anomalies.

(b) It enhances the near surface anomalies.

(c) It increases the vertical resolution.

(d) It estimates the gravity at datum.

73. Which one of the following electrode configurations produces the most pronounced peak in the resistivity curve over a thin dike?

(a) Full Wenner configuration

(b) Half Wenner configuration

(c) Double-dipole configuration

(d) Half Schlumberger configuration

74. The amplitude of magnetic diurnal variation is highest

(a) in the Equatorial regions

(b) in the Polar regions

(c) at 45° latitude

(d) at 23·5° latitude

75. Which one of the following logs is most reliable for coal identification?

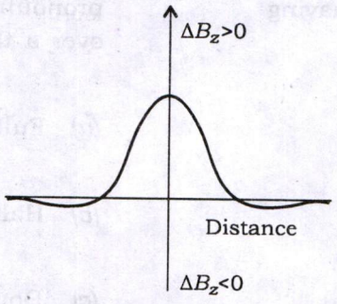
(a) Gamma ray log

(b) Density log

(c) Neutron log

(d) NMR log

76. Consider the following schematic vertical component of the magnetic anomaly for a vertical dike with infinite horizontal extent :



Which one of the following statements regarding depth extent and induced magnetic field of the dike is correct with respect to the above diagram?

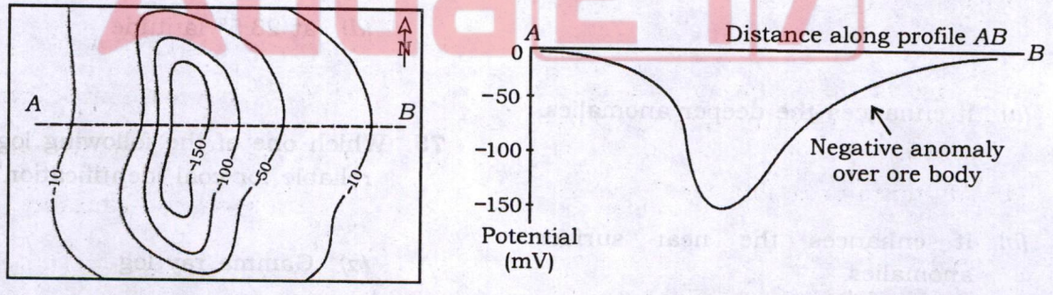
(a) The dike has infinite depth extent and is induced by the vertical component of the earth's magnetic field.

(b) The dike has finite depth extent and is induced by the vertical component of the earth's magnetic field.

(c) The dike has infinite depth extent and is induced by the horizontal component of the earth's magnetic field.

(d) The dike has finite depth extent and is induced by the horizontal component of the earth's magnetic field.

77. Consider the following diagram with hypothetical contour lines of a negative self-potential anomaly over an ore body :



Which one of the following statements explains the asymmetry of the anomaly along the profile *AB*?

(a) The ore body dips perpendicular to the profile in the North direction.

(b) The ore body dips perpendicular to the profile in the South direction.

(c) The ore body dips towards *B* of the profile.

(d) The ore body dips towards *A* of the profile.

78. Which one of the following statements regarding Gardner's equation for various rock types is correct?

(a) It relates P-wave velocity with density.

(b) It relates S-wave velocity with density.

(c) It relates P-wave velocity with porosity.

(d) It relates S-wave velocity with porosity.

79. Which one of the following methods is ***not*** used for removing the effect of attenuation?

(a) Deconvolution

(b) Time-variant spectral whitening

(c) Migration

(d) Inverse *Q* filtering

80. Which one of the following is a source of coherent noise in the seismic data?

(a) Multiples or multiple reflections

(b) Wind blowing on trees near geophone locations in a seismic survey

(c) Passing traffic near geophone locations in a seismic survey

(d) Movement of streamers in a marine seismic survey

81. The foldage of a 2D common depth point (CDP) reflection profiling conducted using a 72-channel digital recording unit with a geophone interval of 50 m and a shot interval of 100 m is

(a) 18

(b) 36

(c) 72

(d) 144

82. In a seismic refraction survey, the inferred upper and lower layer velocities are 2 km/s and 6 km/s, respectively. The depth of the refractor is 0·5 km. What will be the crossover distance?

(a) 2828 m

(b) 1414 m

(c) 707 m

(d) 353·5 m

83. Which one of the following statements regarding linear, time-invariant system is ***not*** correct?

(a) It follows commutative property.

(b) It follows distributive property.

(c) It follows associative property.

(d) It follows non-causality property.

84. Which one of the following is a minimum phase wavelet?

(a) {6, – 1, – 1}

(b) {3, – 5, – 2}

(c) {–2, – 5, 3}

(d) {–1, – 1, 6}

85. A signal with input frequency 625 Hz is sampled at every two milliseconds. What will be the folding-back frequency in the output after aliasing?

(a) 100 Hz

(b) 125 Hz

(c) 250 Hz

(d) 370 Hz

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

List–I (Function)	*List–II (Fourier transform)*
A. Real and even	1. Imaginary
B. Real and odd	2. Imaginary and odd
C. Real even plus imaginary odd	3. Real
D. Real odd plus imaginary even	4. Real and even

Code :

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

87. Consider the following statements regarding Fourier transformation :

1. It may be used to convert a time function into its amplitude and phase spectra.
2. The Fourier transform of impulse response is known as transfer function.
3. Fast Fourier transform (FFT) is used to transform continuous waveform in time domain to its equivalent frequency domain.
4. The Fourier transform of Dirac function consists a continuous frequency spectrum from zero to infinity.

Which of the statements given above are correct?

(a) 1, 2 and 4

(b) 1, 2 and 3

(c) 1, 3 and 4

(d) 2, 3 and 4

88. The discrete-time Fourier transform (DTFT) of a discrete-time signal $x[n]$ is represented as $X(e^{j\omega})$. What will be the DTFT for $x[n-n_0]$?

(a) $e^{-j\omega n_0} X(e^{j\omega})$

(b) $e^{-j\omega n_0/n} X(e^{j\omega})$

(c) $\dfrac{X(e^{j\omega})}{e^{-j\omega n_0}}$

(d) $\dfrac{X(e^{j\omega})}{e^{-j\omega n_0/n}}$

89. The Laplace transform of unit step function is

(a) 1

(b) $1/s$

(c) $1/s^2$

(d) $1/s^3$

90. Which one of the following statements regarding convolution operator is ***not*** correct?

(a) It describes the change of shape of waveform while passing through a filter.

(b) Convolution in time domain is equivalent to multiplication in frequency domain.

(c) Convolved waveform output is shorter than the input waveform.

(d) Convolution involves both folding and shifting of one waveform while keeping other waveform fixed.

91. Consider the following statements regarding autocorrelation function (ACF) :

1. The ACF of a periodic waveform is also periodic.
2. The ACF of a cosine wave is a cosine wave.
3. The ACF contains all the amplitude information of the original waveform.
4. The ACF contains all the phase information of the original waveform.

Which of the statements given above are correct?

(a) 1, 2 and 4

(b) 1, 3 and 4

(c) 2 and 4 only

(d) 1, 2 and 3

92. The frequency domain of a time domain delta function contains

(a) zero frequency range

(b) unit frequency range

(c) –1 Hz to +1 Hz frequency range

(d) infinite frequency range

93. The derivative of unit step function is

(a) sinc function

(b) comb function

(c) unit step function

(d) impulse function

94. Which one of the following represents the active remote sensing system?

(a) Aerial photography

(b) Visible/near infrared imaging

(c) Thermal infrared imaging

(d) Real aperture radar

95. In remote sensing technique, we use the properties of

(a) seismic waves

(b) sound waves

(c) gravity waves

(d) electromagnetic waves

96. Non-selective scattering occurs if the size of effective atmospheric particles is

(a) smaller than the wavelength of radiation

(b) of same size as the wavelength of radiation

(c) larger than the wavelength of radiation

(d) independent of the wavelength of radiation

97. Which band of the electromagnetic spectrum can penetrate the clouds?

(a) Infrared wave band

(b) Thermal infrared wave band

(c) Microwave band

(d) Ultraviolet band

98. What is the approximate value of impedance of free space (Z_0) required to calculate flux density of electro-magnetic waves?

(a) 170 Ω

(b) 377 Ω

(c) 445 Ω

(d) 520 Ω

99. What percent of the incident radiant flux is reflected back by the earth?

(a) 17

(b) 25

(c) 35

(d) 46

100. A blackbody is at a temperature of 5796 K. What will be the wavelength at which the peak spectral radiance occurs?
(where displacement constant $= 2 \cdot 898 \times 10^{-3}$ m K)

(a) 0·3 μm

(b) 0·5 μm

(c) 1·0 μm

(d) 1·5 μm

101. The relative magnetic permeability of water is close to

(a) 1

(b) 9

(c) 83

(d) 377

102. Which one of the following statements is correct according to Planck's radiation law?

(a) Cold bodies emit more energy at shorter wavelengths.

(b) Warm bodies emit more energy at shorter wavelengths.

(c) Cold bodies emit more energy at longer wavelengths.

(d) Warm bodies emit more energy at longer wavelengths.

103. The phase boundary at 660 km depth in the mantle is due to

(a) exothermic transition

(b) endothermic transition

(c) entropy change being negative

(d) temperature change being positive

104. What is the Reynolds' number for convection in the entire mantle having a thickness = 2900 km, speed of flow = $1 \cdot 5 \times 10^{-9}$ m/s, density = 5000 kg/m^3 and viscosity = $1 \cdot 5 \times 10^{21}$ Pa s?

(a) $1 \cdot 45 \times 10^{-20}$

(b) $1 \cdot 45 \times 10^{-25}$

(c) $3 \cdot 5 \times 10^{-30}$

(d) $3 \cdot 5 \times 10^{-20}$

105. Which one of the following represents a pair of mirror nuclei?

(a) $^{15}_{7}N$ and $^{15}_{8}O$

(b) $^{16}_{8}O$ and $^{17}_{8}O$

(c) $^{60}_{27}Co$ and $^{66}_{30}Zn$

(d) $^{14}_{6}C$ and $^{16}_{8}O$

106. The total angular momentum of a nucleus is a

(a) scalar quantity and is the sum of the angular momenta of all the nucleons

(b) vector quantity and is the vector sum of the angular momenta of all the charged nucleons only

(c) vector quantity and is the vector sum of the angular momenta of all the nucleons

(d) scalar quantity and is the sum of the angular momenta of all the charged nucleons only

107. The electrons in an atom are bound to the nucleus due to

(a) weak nuclear force

(b) electrostatic force

(c) strong nuclear force

(d) gravitational force

108. Which one of the following statements best describes the *Q*-value of a nuclear reaction?

(a) It is the energy required to start the reaction.

(b) It is the difference in the total kinetic energies of the system after and before a reaction.

(c) It is defined only for β-decay.

(d) It is the kinetic energy of a neutron which is produced in a nuclear reaction.

109. Among the protium, deuterium and tritium isotopes of hydrogen, which one has the largest value of the ratio of binding energy to rest mass energy?

(a) Protium

(b) Deuterium

(c) Tritium

(d) Same for all the three isotopes of hydrogen

110. Consider ^{3}He and ^{3}H nuclei which have equal number of nucleons. Which one of the following energy terms will ***not*** be the same for both the nuclei in the semi-empirical mass formula?

(a) Volume energy term

(b) Surface energy term

(c) Coulomb energy term

(d) Pairing energy term

111. Consider the following nuclear reactions :

1. $p \rightarrow n + e^{-} + \bar{\nu}_e$
2. $n \rightarrow p + e^{-} + \bar{\nu}_e$
3. $p \rightarrow n + e^{+} + \bar{\nu}_e$
4. $n \rightarrow p + e^{+} + \bar{\nu}_e$

Which of the nuclear reactions given above represent(s) a β-decay?

(a) 1 only

(b) 2 only

(c) 1 and 2

(d) 3 and 4

112. The half-life of a radioactive element

(a) does not depend on the time elapsed but depends on the quantity of the element

(b) depends both on the time elapsed and on the quantity of the element

(c) increases with time but is independent of the quantity of the element

(d) is independent of both the elapsed time and the quantity of the element

113. $^{238}_{92}U$ nucleus decays into $^{234}_{90}Th$ through alpha particle emission. The atomic masses of $^{238}_{92}U$, $^{234}_{90}Th$ and $^{4}_{2}He$ atoms are 238·05079 u, 234·04363 u and 4·00260 u, respectively. The energy released during the decay is

(where $1\,u \equiv 931 \cdot 5$ MeV/c^2, c is the speed of light in vacuum)

(a) 7·76 MeV

(b) 4·25 MeV

(c) 6·67 MeV

(d) 3·73 GeV

114. Alkali metals are generally preferred to be used as photosensitive metals as

(a) they have low work functions

(b) they have very low rest mass

(c) they have low stopping potential

(d) they are shiny

115. Consider the following statements regarding pair-production process :

1. A third body is necessarily required for momentum conservation.
2. A third body is necessarily required for energy conservation.
3. The threshold energy for pair-production is less when a gamma ray interacts with a heavy target nucleus and is more when it interacts with a light target nucleus.

Which of the statements given above is/are correct?

(a) 1 only

(b) 2 only

(c) 1 and 3

(d) 2 and 3

116. Which one of the following statements is best suited with regard to carbon dating technique, used to determine the time of death of an organism?

(a) ^{14}N converts into ^{14}C through β^+ decay with a half-life of 5730 years.

(b) ^{14}N converts into ^{14}C through β^- decay with a half-life of about 375 years.

(c) ^{14}C converts into ^{14}N through β^+ decay with a half-life of about 375 years.

(d) ^{14}C converts into ^{14}N through β^- decay with a half-life of 5730 years.

117. A radioactive material decays with time with a certain half-life. Which one of the following laws is generally followed in this decay?

(a) Inverse-cube law

(b) Linear law

(c) Exponential law

(d) Inverse-square law

118. Which of the following nuclear detectors are based on the principle of ionization of a gas when radioactive radiation passes through it?

(a) Scintillation and proportional counters only

(b) Geiger-Müller and proportional counters only

(c) Scintillation and Geiger-Müller counters only

(d) Geiger-Müller, proportional and scintillation counters

119. The wavelength of a neutron with kinetic energy 1 eV is closest to

(where Planck's constant $h = 6 \cdot 626 \times 10^{-34}$ J s and mass of neutron $= 1 \cdot 674 \times 10^{-27}$ kg)

(a) 10^{-2} cm

(b) 10^{-4} cm

(c) 10^{-6} cm

(d) 10^{-9} cm

120. Which one of the following could be the possible reason of helium atom having more spectral transitions than hydrogen atom?

(a) Helium atom is smaller in size as compared to hydrogen atom

(b) Helium is inert while hydrogen is not

(c) Helium atom has more number of electrons than hydrogen atom

(d) Helium is less abundant than hydrogen

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