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GATE – GEOLOGY ENGINEERING

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GG Geology

Part-A: Common Section

A1 EARTH AND PLANETARY SYSTEM

TERRESTRIAL PLANETS AND MOONS OF THE SOLAR SYSTEM; SIZE, SHAPE, INTERNAL STRUCTURE AND COMPOSITION OF THE EARTH; CONCEPT OF ISOSTASY; ELEMENTS OF SEISMOLOGY – BODY & SURFACE WAVES, PROPAGATION OF BODY WAVES IN THE EARTH'S INTERIOR; HEAT FLOW WITHIN THE EARTH; GRAVITATIONAL FIELD OF THE EARTH; GEOMAGNETISM & PALEOMAGNETISM; CONTINENTAL DRIFT; PLATE TECTONICS – RELATIONSHIP WITH EARTHQUAKES, VOLCANISM AND MOUNTAIN BUILDING; CONTINENTAL % OCEANIC CRUST – COMPOSITION, STRUCTURE AND THICKNESS.

CHAPTER 1

EARTH AND PLANETARY SYSTEM

PREVIOUS YEAR EXAM QUESTIONS

Topic Cover: *Terrestrial planets and moons of the solar system, size, shape, internal structure and composition of the earth, concept of isostasy, elements of seismology, body and surface waves, propagation of body waves in the earth's interior, Heat flow within the earth, Gravitational field of the Earth, geomagnetism and paleomagnetism, continental drift, plate tectonics, relationship with earthquakes, volcanism and mountain building, continental and oceanic crust, composition, structure and thickness.*

Multiple Choice Questions (MCQ)

[2007: 1 MARK]

1. Latitude correction applied for gravity data reduction is maximum at the latitude of:
(A) 0° (B) 30°
(C) 45° (D) 60°

[2007: 1 MARK]

2. The ratio of the Earth's total magnetic field at the Equator to that at the North Pole is:
(A) 1/3 (B) 1/2
(C) 2/3 (D) 3/4

[2007: 1 MARK]

3. Deep earthquakes are associated with:
(A) mid-oceanic ridges (B) rift zones
(C) subduction zones (D) transform faults

[2007: 1 MARK]

4. The average P-wave velocity in the continental crust is:
(A) 3.5 km/s (B) 4.5 km/s
(C) 5.5 km/s (D) 6.5 km/s

[2007: 1 MARK]

5. The amplitude of ground motion generated by an earthquake of magnitude 8 is greater than that of an earthquake of magnitude 5 by a factor of:
(A) 3 (B) 100
(C) 300 (D) 1000

[2007: 1 MARK]

6. P-wave is NOT a:
(A) dilatational wave (B) irrotational wave
(C) longitudinal wave (D) rotational wave

[2007: 1 MARK]

7. Low velocity zone (LVZ) occurs globally at the base of the:
(A) asthenosphere (B) crust
(C) lithosphere (D) outer core

[2007: 1 MARK]

8. The fastest spreading divergent plate boundary is the:
(A) Carlsberg ridge (C) East Pacific rise
(B) Central-Indian ridge (D) Mid-Atlantic ridge

[2007: 2 MARK]

9. A seismic reflection segment after migration:
(A) shallows and steepens
(B) deepens and steepens
(C) lengthens and deepens
(D) shortens and deepens

[2008: 1 MARK]

10. The planet having density less than 1.0 gm/cm^3 is:
(A) Jupiter (B) Neptune
(C) Saturn (D) Uranus

[2008: 1 MARK]

11. In the plate tectonic theory, the "ring of fire" around the Pacific ocean is related to:
(A) convergent plate boundary
(B) divergent plate boundary
(C) hot spots
(D) transform fault

[2008: 1 MARK]

12. The shear wave is:
(A) longitudinal (B) dilatational
(C) irrotational (D) equivoluminal

[2008: 1 MARK]

13. The dominant process of heat transport in the lithosphere is:
(A) advection (B) conduction
(C) convection (D) radiation

[2008: 1 MARK]

14. The geophysical method that provided a convincing evidence of sea floor spreading is:
(A) gravity (B) magnetic
(C) electric (D) seismic

[2008: 1 MARK]

15. The difference in the gravity value (in mgal) between the equator and pole is close to:
(A) 3786 (B) 4586
(C) 5186 (D) 5986

[2008: 1 MARK]

16. With respect to the Earth-Moon axis, the tidal deformation of the Earth produced by the Moon has the shape of:

(A) oblate ellipse (B) oblate ellipsoid
(C) prolate ellipse (D) prolate ellipsoid

17. A successful combination of geophysical methods for exploration of kimberlite pipe is: (2008, MARK - 1)

(A) gravity and radiometric
(B) radiometric and magnetic
(C) magnetic and electromagnetic
(D) radiometric and seismic

[2008: 1 MARK]

18. Liquid outer core is evidenced by shadow zone for direct P-wave in the epicentral distance of:

(A) 92°-132° (B) 92°-142°
(C) 102°-132° (D) 102°-142°

[2008: 2 MARK]

19. In a gravity survey, if the observation point lies below the datum plane, then for gravity data reduction:

(A) Free-air and Bouguer corrections are positive
(B) Free-air correction is positive and Bouguer correction is negative
(C) Free-air correction is negative and Bouguer correction is positive
(D) Free-air and Bouguer corrections are negative

[2008: 2 MARK]

20. If the Earth's magnetic field at the north pole is 60,000 y and the radius of Earth is R, at what height above the north pole will its magnitude be 30,000 y?

(A) 0.26 R (B) 0.52 R
(C) 0.78 R (D) 1.04 R

[2008: 2 MARK]

21. The relation between magnetic latitude (0) and the magnetic inclination (i) is:

(A) 2 tan i = tan θ (B) tan i = 2 tan θ
(C) tan i = 2 $\tan^2\theta$ (D) 2 tan i = cos θ

[2008: 2 MARK]

22. To derive magnetic field from gravity field, the Poisson's relation can be used only when the direction of magnetization is:

(A) horizontal (0°) (B) 45°
(C) 60° (D) vertical (90°)

[2008: 2 MARK]

23. The amplitude of seismic wave varies due to spherical spreading as a function of:

(A) radius of sphere (B) 1/(radius of sphere)
(C) (radius of sphere)^2 (D) 1/(radius of sphere)^2

[2008: 2 MARK]

24. In a linear inverse problem having rectangular system matrix that is rank deficient, the inverse solution is:

(A) unique solution
(B) least square solution
(C) minimum norm solution
(D) minimum norm least square solution

[2008: 1 MARK]

25. The Gutenberg discontinuity is located at a depth of around:

(A) 35 km (B) 150 km
(C) 2900 km (D) 5000 km

[2009: 1 MARK]

26. Which of the following parameters is uniquely resolved by residual gravity anomaly data?

(A) lateral density contrast
(B) excess/deficit mass
(C) absolute density
(D) geometric dimensions of geophysical model

[2009: 1 MARK]

27. If a planet revolves around the Sun with a period of 8 years, then its distance from the Sun would be (in terms of distance between Earth and Sun):

(A) two times (B) four times
(C) six times (D) eight times

[2009: 1 MARK]

28. A vast majority of earthquake sources are often linked to:

(A) inner core
(B) outer core
(C) brittle part of the earth's crust
(D) molten part of earth's mantle (0)

[2009: 2 MARK]

29. The boundary between the Indian and Eurasian plates is the:

(A) Main Central Thrust
(B) Main Boundary Thrust
(C) South Tibetan Detachment Zone
(D) Indus-Tsangpo Suture Zone

[2010: 1 MARK]

30. Earth's dipole field originates mainly from:

(A) mantle (B) outer core
(C) inner core (D) crust

[2010: 1 MARK]

31. Sunspots are regions of:

(A) high pressure (B) low magnetic field
(C) high temperature (D) high magnetic field

[2010: 1 MARK]

32. Bode's law expresses the approximate distance between:

(A) earth and other planets (B) moon and sun
(C) planets and sun (D) moon and earth
[2011: 1 MARK]

33. The increase in the length of a day on the earth at a rate of 2.4 milliseconds/100 years is due to:
(A) prolate tidal bulge (B) tidal friction
(C) spring tide (D) bodily earth tide
[2011: 1 MARK]

34. Which of the following rocks contributes the highest amount of radioactive heat in the earth's crust?
(A) basalt (B) gabbro
(C) dunite (D) granite
[2011: 1 MARK]

35. The P-wave velocity of the earth's mantle at the Mohorovicić discontinuity is:
(A) 5.5 km/s (B) 6.0 km/s
(C) 7.0 km/s (D) 8.0 km/s
[2011: 1 MARK]

36. Variation of the geomagnetic field observed over the last 500 years indicates that the dipole moment of earth's magnetic field has been:
(A) decreasing (B) increasing
(C) constant (D) fluctuating randomly
(2011, MARK-1)

37. Which of the following statements is TRUE for the temperature variation with altitude in the earth's atmosphere?
(A) Temperature increases in both stratosphere and mesosphere
(B) Temperature decreases in stratosphere and increases in mesosphere
(C) Temperature increases in stratosphere and decreases in mesosphere
(D) Temperature decreases in both stratosphere and mesosphere
[2011: 1 MARK]

38. The planet which contributes maximum to the angular momentum of the solar system is:
(A) Earth (B) Mars
(C) Jupiter (D) Saturn
[2011: 1 MARK]

39. In a formation, if the density increases and elastic constants remain unchanged, then:
(A) both P and S wave velocities increase
(B) P wave velocity increases and S wave velocity decreases
(C) both P and S wave velocities decrease
(D) P wave velocity decreases and S wave velocity increases
[2011: 1 MARK]

40. In seismic exploration, 'ground roll' represents:
(A) direct wave (B) surface wave
(C) Stonely wave (D) shear wave
[2012: 2 MARK]

41. In Mohs' scale of hardness, how many minerals are of silicate composition?
(A) 4 (B) 5
(C) 6 (D) 7
[2012: 1 MARK]

42. During its orbital motion around the Sun, the Earth is nearest to the Sun on:
(A) March 21 (B) July 4
(C) September 23 (D) January 3
[2013: 1 MARK]

43. Amongst the following, which one will have the highest P-wave velocity?
(A) Granite (B) Diamond
(C) Shale (D) Talc
[2013: 1 MARK]

44. The acceleration due to gravity, 'g' is maximum at:
(A) equator (B) poles
(C) mid-latitudes (D) sub-tropical regions
[2013: 1 MARK]

45. Acoustic impedance is the _____ of density and velocity.
(A) sum (B) difference
(C) product (D) ratio
[2013: 1 MARK]

46. The type of wave that arrives first at a station from an earthquake hypocenter is:
(A) P-wave (B) S-wave
(C) Rayleigh wave (D) Love wave
[2013: 1 MARK]

47. Which of the following physical properties of rocks has the widest range of variation?
(A) Magnetic permeability (B) Dielectric permittivity
(C) Seismic velocity (D) Electrical resistivity
[2013: 1 MARK]

48. Which of the following is NOT an inverse square law?
(A) Newton's law of gravitation
(B) Coulomb's law of electrostatics
(C) Coulomb's law of magnetostatics
(D) Hooke's law
[2014: 1 MARK]

49. Which one of the following planets has the highest bulk density?
(A) Jupiter (B) Venus
(C) Saturn (D) Mars

[2014: 1 MARK]

50. From the surface to the Earth's interior, the velocity of P-wave decreases and the material density increases at the boundary between:

(A) Outer core and inner core
(B) Mantle and outer core
(C) Crust and mantle
(D) Upper crust and lower crust

[2014: 1 MARK]

51. The International Gravity Formula predicts the theoretical gravity value at a given point assuming a:

(A) non-rotating homogeneous spherical earth model
(B) rotating inhomogeneous spherical earth model
(C) rotating homogeneous oblate spheroidal earth model
(D) rotating inhomogeneous oblate spheroidal earth model

[2014: 1 MARK]

52. The diurnal variation of geomagnetic elements is due to a system of electric currents flowing in the:

(A) ionosphere (B) Earth's outer core
(C) inter-planetary medium (D) oceans

[2014: 1 MARK]

53. In seismic refraction surveys, the critical distance:

(A) is always less than the crossover distance
(B) is always more than the crossover distance
(C) is always equal to the crossover distance
(D) cannot be compared with the crossover distance

[2014: 1 MARK]

54. As compared to large earthquakes, small earthquakes are:

(A) more frequent and caused by short fault slip and long rupture lengths
(B) more frequent and caused by long fault slip and short rupture lengths
(C) less frequent and caused by short fault slip and short rupture lengths
(D) more frequent and caused by short fault slip and short rupture lengths

[2014: 1 MARK]

55. The velocity discontinuity between the upper crust and the lower crust is known as _____ discontinuity.

(A) Lehmann (B) Gütenberg
(C) Mohorovičić (D) Conrad

[2015: 1 MARK]

56. The shape of the earth is best described as:

(A) spheroid (B) prolate ellipsoid
(C) ellipsoid (D) oblate spheroid

[2015: 1 MARK]

57. Which one amongst the following is the CORRECT attitude of a bed?

(A) 221°,95° (B) N45°W,40°SE
(C) 090°/20°W (D) 089°,75°S

[2015: 1 MARK]

58. PcP and SCS phases are reflected from:

(A) crust - mantle boundary
(B) core mantle boundary
(C) inner core outer core boundary
(D) lithosphere - asthenosphere boundary

[2015: 1 MARK]

59. Amongst the different gases in the atmosphere, which one of the following pairs DOES NOT contribute to heating of the atmosphere?

(A) CO_2,H_2O (B) N_2,O_2
(C) H_2O,CH_4 (D) H_2O,O_3

[2015: 1 MARK]

60. Gardner's formula relates the seismic P-wave velocity (V_P) to:

(A) density (B) porosity
(C) permeability (D) lithology

[2015: 1 MARK]

61. In a seismic section, paraconformity is marked by:

(A) onlap (B) downlap
(C) erosional truncation (D) concordance

[2015: 1 MARK]

62. On the Earth, all conditions being same, the time period of a simple pendulum will be maximum at the:

(A) Poles (B) Tropic of Cancer
(C) Tropic of Capricorn (D) Equator

[2015: 1 MARK]

63. The two most abundant elements in the Earth are:

(A) oxygen and iron (B) iron and magnesium
(C) oxygen and silicon (D) iron and silicon

[2016: 1 MARK]

64. Which one of the following layers of the Earth has the largest volume?

(A) Upper Mantle (B) Lower Mantle
(C) Outer core (D) Inner Core

[2016: 1 MARK]

65. The S-wave shadow zone of the Earth ranges from _____.

(A) 103° to 180° (B) 103° to 160°
(C) 103° to 153° (D) 103° to 143°

[2016: 1 MARK]

66. According to Airy's model, gravity anomalies for fully isostatically compensated topography are characterized by:

[2023: 1 MARK]

21. In a seismic reflection survey over a two-layered Earth model having densities and seismic velocities for the first layer and for the second layer, the normal incidence P-wave reflection coefficient is _____ [round off to 3 decimal places]

[2023: 2 MARK]

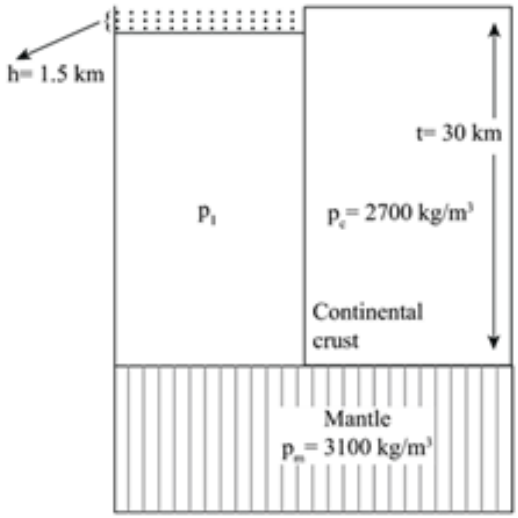
22. The resistivity of a rock, 100% saturated with water of resistivity is 60 . Assuming tortuosity and cementation exponents to be 1 and 2, respectively, the porosity of the rock is _____ (in %). [round off to 2 decimal places]

[2023: 2 MARK]

23. Let us consider that a student misses cancelling the self-potential between potential electrodes before injecting current into the subsurface, in a Wenner electrical resistivity survey using DC resistivity meter over a horizontally stratified Earth. In direct and reverse modes of measurement (when current flows from C1 to C2 and C2 to C1, respectively) with the same magnitude of current flow, the potential differences recorded are +158 mV and -214 mV, respectively. The self-potential between the potential electrodes before injecting current was _____ mV. [in integer]

[2023: 2 MARK]

24. For the given figure, considering Pratt's model of isostatic compensation at the crust mantle boundary, the crustal density that explains the 1.5 km deep lake is _____ . (Consider density of water) [round off to 2 decimal places]



[2023: 2 MARK]

25. The rate of spreading about a symmetric spreading center at the middle of a 4000 km wide sea is 40 mm/year. The spreading began _____ million years before present. [in integer]

[2024: 2 MARK]

26. Assume heat producing elements are uniformly distributed within a 16 km thick layer in the crust in a heat flow province. Given that the surface heat flow and reduced heat flow are 54 mW/m^2 and 22 mW/m^2, respectively, the radiogenic heat production in the given crustal layer in µW/m^3 is _____ (in integer).

[2025: 2 MARK]

27. If the lowest Digital Number (DN) value in an image of 10-bit radiometric resolution is 0, then the maximum DN value of that image is _____(Answer in Integer)

[2025: 2 MARK]

28. A 3×3 image (Image A) has been linearly stretched to get the maximum contrast in an 8-bit display system. Digital Number (DN) values of the pixels in Image A are shown. The value of the pixel Marked as '?' in the output Image B after linear stretching is _____.

30	40	80
75	60	180
90	100	110

Image A

Linear contrast Stretching →

	?	

Image B

(Answer in integer)

ANSWER KEY

Multiple Choice Questions (MCQ)

1	2	3	4	5	6	7	8	9	10
A	A	C	D	D	D	C	C	D	C
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A	D	B	B	A	D	C	D	C	B
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
A	D	B	D	C	A	B	C	D	B
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
D	C	B	D	D	A	C	C	C	B
41	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
A	D	B	B	C	A	D	D	B	B
51	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
C	**A**	**A**	**D**	**D**	**D**	**D**	**B**	**B**	**A**
61	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**
D	**D**	**A**	**B**	**A**	**A**	**B**	**C**	**C**	**D**
71	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
B	**C**	**B**	**D**	**B**	**C**	**B**	**C**	**C**	**C**
81	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**
C	**B**	**C**	**A**	**C**	**B**	**B**	**A**	**B**	**C**
91	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**
B	**C**	**A**	**B**	**B**	**A**	**B**	**A**	**A**	**B**
101									
D									

Multiple Select Question (MSQ)

1	2	3	4
A,B,C,D	A,C	A,B	A,C
5	**6**	**7**	
B,C	A,B	A,C,D	

Numerical Answer Type Questions (NAT)			
1	**2**	**3**	**4**
1 to 10	8.32	1.668	0.25
5	**6**	**7**	**8**
11.9	12	85	2660 to 2670
9	**10**	**11**	**12**
2.9 to 3.1	0.71 to 0.81	6367.44 to 6367.46	4 to 4
13	**14**	**15**	**16**
0.03	24	16.3 to 17.3	26.2 to 27.0
17	**18**	**19**	**20**
3.0	80.0	62610 to 6266.0	20000
21	**22**	**23**	**24**
0.272 to 0.274	6.45 to 6.46	-28	2789.00 to 2790.00
25	**26**	**27**	**28**
100	0.002	1023	3500 to 4000

EXPLANATIONS

Multiple Choice Questions (MCQ)

1. Explanation: (A)

Latitude correction accounts for Earth's oblate shape, with gravity weaker at the equator (0°) and stronger at the poles due to centrifugal force. The correction is maximum at 0° latitude, decreasing towards the poles.

2. Explanation: (A)

The Earth's magnetic field varies with location. At the equator, the horizontal component dominates, while the vertical component is zero. At the poles, the field is entirely vertical and stronger. The field strength at the equator is about one-third that at the poles, giving a ratio of 1:3.

3. Explanation: (C)

Deep earthquakes occur in subduction zones, where one tectonic plate sinks into the mantle, causing earthquakes at depths of 300–700 km. In contrast, mid-oceanic ridges, rift zones, and transform faults are associated with shallow-focus earthquakes near the Earth's surface.

4. Explanation: (D)

The average P-wave velocity in the continental crust is about 6.5 km/s, reflecting typical rock types like granite, basalt, and metamorphic rocks. Lower velocities (3.5–5.5 km/s) occur in unconsolidated sediments, while higher velocities indicate mantle material.

5. Explanation: (D)

Earthquake amplitude is measured on a logarithmic scale. Each magnitude increase by 1 corresponds to a 10-fold increase in ground motion. A magnitude 8 earthquake has an amplitude 10^3 = 1000 times greater than a magnitude 5 earthquake.

6. Explanation: (D)

P-waves are compressional waves that are dilatational, irrotational, and longitudinal, traveling by compressing and expanding the medium. They are not rotational waves, as they lack twisting motion, unlike S-waves, which involve shear deformation.

7. Explanation: (C)

The low-velocity zone (LVZ) occurs at the base of the lithosphere, within the upper asthenosphere. It features reduced seismic wave velocities due to partial melting and lower rock rigidity, enabling lithospheric plate movement. It is unrelated to the crust or outer core.

8. Explanation: (C)

The East Pacific Rise is the fastest spreading divergent boundary, with rates up to 15 cm/year, much faster than the Carlsberg, Central-Indian, or Mid-Atlantic ridges (1–6 cm/year). Its rapid spreading creates smoother topography compared to slower ridges.

9. Explanation: (D)

Seismic migration repositions reflection events to their true subsurface locations, correcting distortions caused by dipping reflectors. Before migration, reflections are spread out and appear shallower due to incorrect velocity assumptions. After migration, reflections shorten as they are repositioned closer to their true locations and deepen to reflect their actual depth.

Other Option

Shallows and steepens: Migration does not make reflections shallower; instead, it deepens them to correct for mispositioning.

Deepens and steepens: While migration deepens reflectors, it does not necessarily steepen the reflections significantly.

Lengthens and deepens: Migration does not lengthen the reflections; it shortens them due to the repositioning.

10. Explanation: (C)

Density is a measure of mass per unit volume. The density of a planet determines whether it would float or

sink in water (density = 1.0 g/cm³). Among the planets in our solar system: **Jupiter**: **1.33 g/cm³, Neptune**: **1.64 g/cm³, Uranus**: **1.27 g/cm³, Saturn**: **0.69 g/cm³.** Since **Saturn's density is less than 1.0 g/cm³**, it is the **only** planet in the solar system that would theoretically float in water. This low density is due to its large size and gaseous composition, primarily made of hydrogen and helium.

11. Explanation: (A)

The **Ring of Fire** is a **horseshoe-shaped zone** of intense **seismic and volcanic activity** around the **Pacific Ocean**, caused by **convergent plate boundaries** where **oceanic plates subduct under continental or oceanic plates**. This leads to earthquakes, volcanic eruptions, and deep-sea trenches. Subduction zones around the Pacific Plate. Volcanic arcs and deep-sea trenches (e.g., Andes Mountains, Cascade Range, Japan Trench, Philippine Trench). Frequent earthquakes and volcanic activity.

Other Option

Divergent Plate Boundary → Incorrect, as divergent boundaries create **mid-ocean ridges**, not subduction zones (e.g., Mid-Atlantic Ridge).

Hot Spots → Incorrect, as hot spots (e.g., **Hawaii**) are localized volcanic regions **not linked to plate boundaries**.

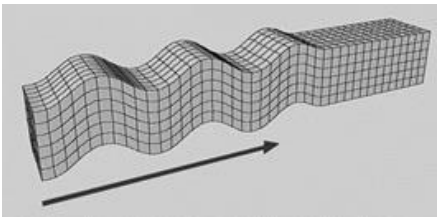
Transform Fault → Incorrect, as transform faults (e.g., **San Andreas Fault**) cause earthquakes but do not create a volcanic arc like the Ring of Fire.

12. Explanation: (D)

A **shear wave (S-wave)** is a type of **seismic wave** that moves **perpendicular** to the direction of wave propagation. These waves **do not change volume** but instead cause a **change in shape (shear deformation)** of the material they pass through. "Equivoluminal" means **constant volume**. **S-waves do not change the volume** of the material, only its shape.

Other Option

Longitudinal waves (e.g., **P-waves**) cause **compression and expansion** along the direction of propagation. Shear waves are **transverse**, not longitudinal. Dilatational waves involve **changes in volume** (expansion and contraction), which occur in **P-waves**, not S-waves. Shear waves **do involve rotational movement** of particles in a plane perpendicular to wave motion, making them **rotational, not irrotational**.



13. Explanation: (B)

The **lithosphere**, being a **rigid solid**, primarily transfers heat by **conduction**, as it lacks fluid movement for convection or advection. **Thermal energy moves via atomic vibrations**, making conduction a **slow process** compared to convection in the asthenosphere. The **geothermal gradient (~25–30°C per km)** drives heat flow from the **hot interior to the cooler surface**.

Other Option

Advection → Advection requires the bulk movement of material (e.g., magma or fluids), which is **not** the dominant heat transfer process in the rigid lithosphere. **Convection** → Convection occurs in the **asthenosphere** and **mantle**, not in the rigid lithosphere. **Radiation** → Radiation is significant in **space** and for heat transfer from the Earth's surface, but it is **not** the primary heat transfer mechanism inside the lithosphere.

14. Explanation:(B): The **magnetic method** provided the most convincing evidence for **sea-floor spreading** by revealing **symmetrical magnetic stripes** on the ocean floor. As new **oceanic crust** forms at **mid-ocean ridges**, iron-rich minerals (e.g., **magnetite**) align with Earth's **magnetic field**. Earth's **magnetic field reverses polarity** over time, creating **alternating bands** of **normal and reversed magnetism**. These **parallel magnetic stripes** on both sides of the ridge confirm that a new crust is continuously formed and pushed outward, supporting **plate tectonic theory**.

15. Explanation: (A)

Earth's Rotation: Centrifugal force reduces gravity at the **equator**, making it weaker than at the **poles**.

Earth's Shape: The **equatorial bulge** increases the Earth's radius at the **equator (6378 km)** compared to the **poles (6357 km)**, further decreasing gravity.

Gravity Difference Calculation: Gravity at the **equator**: **978,032 mGal,** Gravity at the **pole**: **981,818 mGal. Difference**: **3,786 mGal.**

16. Explanation: (D)

The Moon's gravitational pull creates tidal bulges along the Earth-Moon axis. Stronger pull on the near side and

weaker pull on the far side cause the Earth to elongate. The equatorial region remains unchanged, forming a prolate ellipsoid (elongated shape along one axis).

17. Explanation: (C)

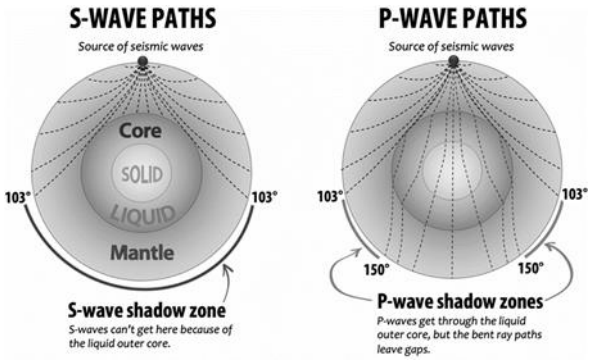
Magnetic Method: Kimberlites contain magnetite and ilmenite, creating magnetic anomalies. Electromagnetic Method: Kimberlites can be conductive due to weathering and clay alteration, allowing detection of conductivity contrasts with surrounding rock.

Other Option

Gravity and Radiometric → Incorrect; while gravity surveys can sometimes detect density contrasts, radiometric methods are **not effective** because kimberlites lack significant radioactive elements.
Radiometric and Magnetic → Incorrect; radiometric surveys are not useful as kimberlites do not emit strong radioactive signals.
Radiometric and Seismic → Incorrect; seismic methods are expensive and less effective for detecting small kimberlite bodies.

18. Explanation: (D)

P-waves refract sharply at the **core-mantle boundary (CMB)** due to the **liquid outer core**. This refraction creates a **shadow zone (102°-142°)** where **no direct P-waves** are detected.



19. Explanation: (C)

In gravity surveys, if the observation point is **below the datum**, the **free-air correction is negative** (because gravity is stronger at lower elevations) and the **Bouguer correction is positive** (to account for the mass above the observation point).

20. Explanation: (B)

The magnetic field strength decreases with the square of the distance from the Earth's center. This relationship can be described using the inverse square law for magnetic fields: **Where:** is the magnetic field strength at the surface (60,000 y), is the Earth's radius (), is the magnetic field strength at height (30,000 y), is the distance from the Earth's center to the point where the field strength is , which is .

We are given that: B_1 = 60,000y, B_2 = 30,000y

Substitute these values into the inverse square law equation: $60{,}000 \times R^2 = 30{,}000 \times (R+h)^2$

Simplify the equation: $2 \times R^2 = (R+h)^2$

Expanding $(R+h)^2$: $2 \times R^2 = R^2 + 2Rh + h^2$

Now, subtract R^2 from both sides: $R^2 = 2Rh + h^2$

For small heights compared to the Earth's radius, we can ignore the term. So the equation simplifies to: $R^2 = 2Rh$.

Solving for : $h \approx \frac{R}{2}$, Thus, the height is approximately 0.52 R.

21. Explanation: (A)

The relationship between magnetic inclination (i) and magnetic latitude (θ) is expressed as: $\tan i = 2 \tan \theta$. This equation means that the tangent of the magnetic inclination is twice the tangent of the magnetic latitude, derived from the dipole model of the Earth's magnetic field.

22. Explanation: (D)

Poisson's relation provides a mathematical relationship between the magnetic and gravitational potential fields. This relationship is valid only when certain conditions are met, one of which is the direction of magnetization. Specifically, Poisson's relation can be used to derive the magnetic field from the gravity field when the magnetization direction is vertical, i.e., at 90°.

23. Explanation: (B)

The amplitude of a seismic wave decreases inversely with the radius of the sphere due to spherical spreading. This means the amplitude varies as seismic energy spreads out over a larger area.

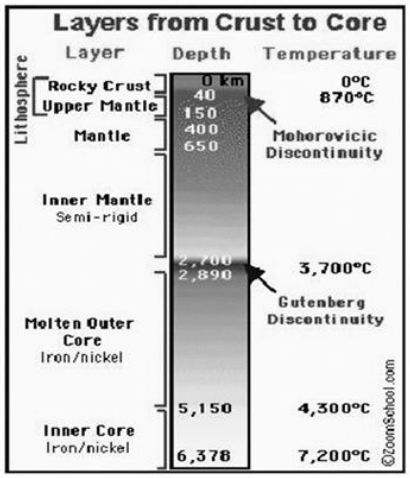
24. Explanation: (D)

In linear inverse problems with a rank deficient rectangular system matrix, we use the least squares method to find a solution. Among all possible solutions, the minimum norm least square solution is preferred, as it not only fits the data well but also has the smallest magnitude, ensuring stability and reliability.

25. Explanation: (C)

The **Gutenberg discontinuity** is a major boundary within the Earth's interior. It marks the transition between the Earth's mantle and the outer core. This discontinuity is located at a depth of approximately 2900 kilometers

beneath the Earth's surface. **Mantle:** The layer between the Earth's crust and the core, consisting mainly of silicate rocks. **Outer Core:** A layer of molten iron and nickel surrounding the solid inner core. At the Gutenberg discontinuity, there is a significant change in seismic wave velocities due to the difference in material properties between the solid mantle and the liquid outer core. Seismic waves slow down as they pass from the solid mantle into the liquid outer core, which helps geologists identify this boundary.



26. Explanation: (A)

Residual gravity anomaly data reveals variations in Earth's gravitational field by removing regional trends. It highlights lateral density contrast, which helps in mapping subsurface structures like faults, intrusions, and sedimentary variations by detecting changes in density.

27. Explanation: (B)

We need to use Kepler's Third Law of Planetary Motion, which states: Where: is the orbital period of the planet, is the average distance of the planet from the Sun (semi-major axis), is a constant that is the same for all planets orbiting the Sun. Given the Earth's orbital period is 1 year and its distance from the Sun is 1 astronomical unit (AU), we can set up the following relationship for the new planet: Given years and years, we get So, the planet's distance from the Sun would be four times the distance between Earth and the Sun.

28. Explanation: (C)

Earthquakes are primarily caused by the sudden release of energy due to the movement of tectonic plates. This movement usually occurs in the brittle part of the Earth's crust. Here's **Why: Brittle Part of the Earth's Crust:** The Earth's crust is divided into tectonic plates that float on the semi-fluid asthenosphere beneath them. The brittle nature of the crust allows it to fracture and deform when stress exceeds the strength of rocks. Most earthquakes occur along faults, which are fractures in the Earth's crust where blocks of crust have moved relative to each other.

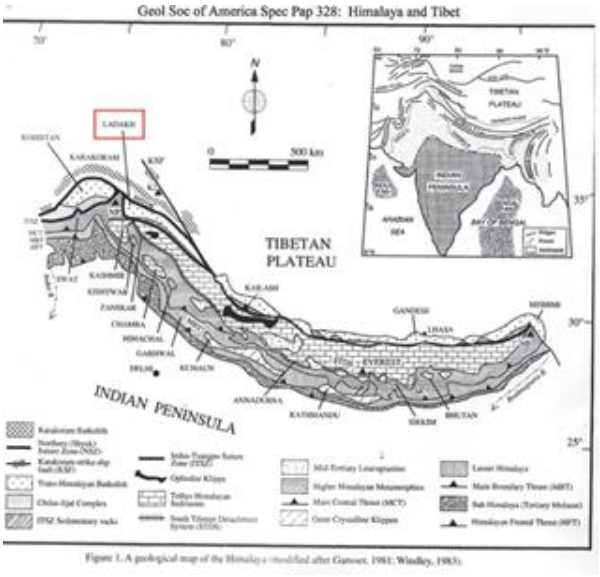
Other Option

Inner Core: The inner core is solid and composed primarily of iron and nickel. It does not generate earthquakes. **Outer Core:** The outer core is a fluid layer composed mainly of molten iron and nickel. It does not experience the brittle failure needed to generate earthquakes.

Molten Part of Earth's Mantle: The mantle is mostly solid but behaves plastically over long time scales. While mantle convection drives plate tectonics, it is not the direct source of earthquakes.

29. Explanation: (D)

The boundary between the **Indian Plate** and the **Eurasian Plate** is the **Indus-Tsangpo Suture Zone**. This is a major geological feature formed by the **collision** of the Indian and Eurasian tectonic plates around **50 million years ago**. The collision caused the uplift of the **Himalayas** and the **Tibetan Plateau**. The **Indus-Tsangpo Suture Zone** marks the location where the **Indian oceanic crust** was subducted beneath the **Eurasian continental crust**. It is where the two plates have been converging, and it can be seen as the **zone of contact** between the Indian and Eurasian plates.



Other Option

Main Central Thrust: A fault in the Himalayas, not the plate boundary, marking the boundary between the High and Lesser Himalayas.

Main Boundary Thrust: A fault in the Himalayas, but not the plate boundary; it marks the first major deformation of the Indian plate.

South Tibetan Detachment Zone: A fault zone related to vertical movement of the Indian plate, but not the direct boundary between the plates

30. Explanation: (B)

The Earth's **dipole magnetic field** originates from the **outer core**, composed of liquid iron and nickel. The **geodynamo** process, driven by convection currents in the outer core, generates electric currents that produce the magnetic field.

Other Option

Mantle: The **mantle** consists of solid rock and does not contribute significantly to the generation of the Earth's magnetic field.

Inner core: The **inner core** is solid and made mostly of iron and nickel. While it influences the magnetic field indirectly, the actual generation of the magnetic field occurs in the liquid outer core.

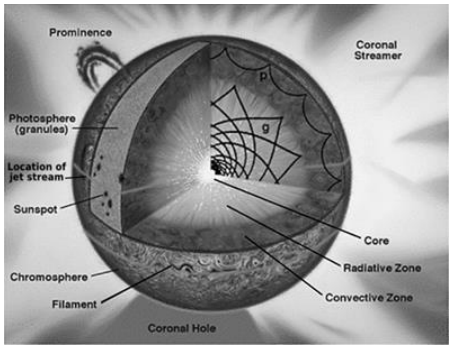
Crust: The **crust** is not involved in the generation of the Earth's magnetic field. It is too thin and not electrically conductive like the outer core.

31. Explanation: (D)

Sunspots are cooler, darker regions on the Sun's surface, caused by **strong magnetic fields**. These magnetic fields inhibit heat flow from the Sun's interior, making the sunspot areas cooler. Sunspots often occur in pairs and can lead to solar phenomena like **solar flares** and **coronal mass ejections**.

Other Option

High pressure: Sunspots are not associated with high pressure. In fact, the areas of the sunspots are cooler due to magnetic activity, and not high pressure. **Low magnetic field:** Sunspots are precisely regions of **high magnetic field**, not low magnetic field. **High temperature:** Sunspots have a **lower temperature** than the surrounding photosphere, which is why they appear darker.



32. Explanation: (C)

Bode's Law approximates the **distances of planets from the Sun** in our solar system using the formula: $a_n = 0.4 + 0.3 \times 2^{n}$, where a_n is the distance of the n-th planet from the Sun, and n is an integer starting at 0 for Mercury. It provides approximate distances, though not perfectly accurate.

Other Option

Earth and other planets: Bode's Law does not directly express the distances between Earth and other planets, but rather the distances of all planets from the Sun.
Moon and Sun: Bode's Law is not used to describe the distance between the Moon and the Sun. The Moon's distance from the Earth, not the Sun, is used in other contexts like tides.
Moon and Earth: Bode's Law is not related to the distance between the Moon and Earth.

33. Explanation: (B)

The **increase in Earth's day length (2.4 ms per 100 years)** is due to **tidal friction**, caused by the gravitational interaction between Earth and the Moon. The Moon's gravity creates tidal bulges, which are offset due to Earth's rotation. This offset leads to friction with the seafloor, transferring angular momentum from Earth to the Moon. As a result, Earth's rotation slows, lengthening the day, while the Moon drifts away at 3.8 cm per year.

Other Option

Prolate Tidal Bulge – The tidal bulge (elongated shape of the Earth due to gravitational forces) exists, but it alone does not explain the **gradual lengthening of the day**. The key factor is **friction**, not just the bulge itself.

Spring Tide – Spring tides occur due to the combined gravitational pull of the Sun and Moon during full and new moons, leading to higher tides. However, this is a periodic effect and does not cause a long-term increase in the Earth's day length.

Bodily Earth Tide – This refers to the deformation of Earth's solid body due to gravitational forces. While it contributes to Earth's shape and movement, it is not the primary reason for the increasing length of a day.

34. Explanation: (D)

Granite generates the highest radioactive heat in the Earth's crust due to its high uranium (U), thorium (Th), and potassium (K) content. As a felsic intrusive igneous rock, it contains quartz, feldspar, and mica, which hold trace radioactive elements. The radioactive decay of U-238, Th-232, and K-40 releases significant radiogenic

heat, making granite the primary heat-producing rock in the continental crust.

Other Option

Basaltic rocks are mafic and contain lower amounts of radioactive elements than granite. They contribute less radiogenic heat.

Gabbro is another mafic intrusive rock, similar in composition to basalt but formed deeper. It also has low uranium, thorium, and potassium, so its heat contribution is low.

Dunite is an ultramafic rock, rich in olivine, with very low radioactive element content. It contributes the least to radiogenic heat production.

35. Explanation: (D)

The Mohorovičić discontinuity (Moho) marks the boundary between the Earth's crust and mantle, where P-wave velocity increases sharply due to the transition from lower-density crustal rocks to higher-density ultramafic mantle rocks. In the crust, P-wave velocity ranges from 5.5 to 7.0 km/s, but at the Moho, it abruptly jumps to ~8.0 km/s, indicating the presence of dense mantle peridotite, which allows seismic waves to travel faster.

Other Option

5.5 km/s – Represents the P-wave velocity in the upper crust (granitic rocks).

6.0 km/s– Typical for lower crustal rocks (e.g., basaltic/gabbroic rocks), not the mantle.

7.0 km/s– Found in the deepest parts of the lower crust, just above the Moho, but does not represent mantle velocities.

36. Explanation: (A)

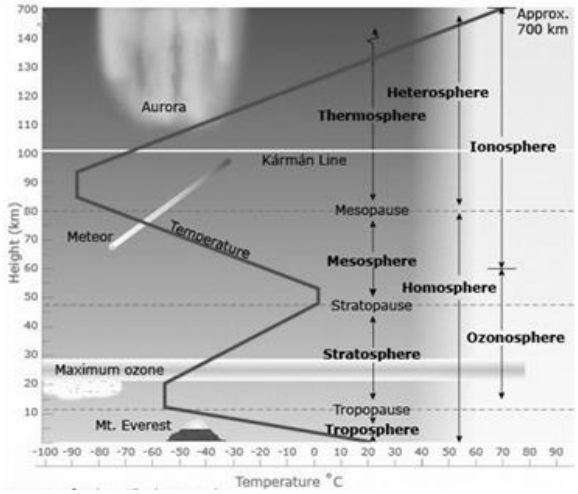
The **dipole moment of Earth's magnetic field** has been **decreasing over the last 500 years**, with a decline of **~5% per century**, based on historical and modern geomagnetic data. This **long-term weakening** suggests a potential **geomagnetic reversal**, where the north and south magnetic poles switch places. Paleomagnetic records show that such reversals have occurred multiple times in Earth's history, though over thousands to millions of years.

Other Option

Increasing – Modern data and historical records show a decrease, not an increase, in the Earth's magnetic field strength. **Constant**–The magnetic field strength fluctuates over time and is not constant, as shown by paleomagnetic studies and satellite observations. **Fluctuating Randomly**–While there are short-term variations, the overall trend shows a steady decrease rather than random fluctuations.

37. Explanation: (C)

The Earth's atmosphere has four layers based on temperature variations:



- **Troposphere (0–12 km):** Temperature **decreases** with altitude due to reduced heat from the Earth's surface.
- **Stratosphere (12–50 km):** Temperature **increases** with altitude due to **UV absorption by ozone (O_3)**.
- **Mesosphere (50–85 km):** Temperature **decreases** with altitude as there is **minimal heat absorption**, making it the **coldest layer**.
- **Thermosphere (85 km+):** Temperature **increases** due to absorption of **high-energy solar radiation (X-rays and UV)**.

38. Explanation: (C)

Angular momentum in the Solar System depends on **planetary mass** and **orbital radius**. The formula is: $L=m\times v\times r$, where **m** = mass, **v** = orbital velocity, and **r** = distance from the Sun. Jupiter, the most massive planet in the Solar System (~318 times Earth's mass), has a large orbital radius (~5.2 AU). Due to its huge mass and distant orbit, Jupiter contributes the maximum angular momentum to the Solar System. Studies estimate that Jupiter alone holds over 60% of the total angular momentum of the planetary system.

39. Explanation: (C)

The velocity of seismic waves depends on the elastic properties and density (ρ) of the rock. The wave velocities are given by:

1. **P-wave velocity (Vp):** $Vp = \sqrt{\frac{K\frac{4}{3}\mu}{P}}$

Where: K = Bulk modulus (elastic constant, remains unchanged), **μ =** Shear modulus (elastic constant, remains unchanged), **ρ =** Density (increases)