Harvard Undergraduate Science Olympiad India
2024 Open Round
Earth Science (9th-10th Grade) Exam

Format of Earth Science Section: The Earth Science section will contain only single-select multiple choice questions with 4 answer choices each. The section will have 45 multiple choice questions.

Scoring: Each correct answer will give you 1 point. You will lose 0.25 points for an incorrect answer. You will receive 0 points for a question left blank.

Allowed Materials:
You must bring:

- #2 pencil
- Eraser

You are allowed:

- Non-programmable, non-graphing calculator
- Wrist-watch (not a smart watch)

You may not bring

- Smart watch
- Books or notes
- Electronic devices

1. Peridotite is a rock composed primarily of pyroxene and olivine. In which layer of the earth is peridotite mostly found?
   a) Crust
   b) Mantle
   c) Outer core
   d) Inner core

2. Convection in which layer of the Earth is responsible for tectonic movement? Select the best answer.
   a) Lithosphere
   b) Mantle
   c) Asthenosphere
   d) Crust

3. What is the primary mechanism behind the sudden release of energy that causes most earthquakes?
   a) Gravitational attraction between the Earth and Moon
   b) Subduction of an oceanic plate beneath a continental plate
   c) Tectonic stress overcoming friction along fault lines
   d) Volcanic activity along divergent boundaries

4. Faults are linked to many geological features. Which statement about faults is true?
   a) Strike-slip faults do not affect the landscape.
   b) Normal faults indicate tensional forces
   c) All types of faults produce the same geological features
   d) Strike-slip faults are solely responsible for creating earthquakes, while normal and reverse faults have little impact on seismic activity.

5. A sedimentary rock called bauxite is the world's primary source of aluminum ore. In what environment is bauxite formed?
   a) Near the surface in tropical regions
   b) In high-altitude environments
   c) Deep in the earth, near the mantle
   d) Antarctic regions

6. Which of the following phenomena is least likely to occur at a convergent plate boundary?
   a) Earthquakes
   b) Volcanic eruptions
   c) Creation of oceanic ridges
   d) Formation of mountain ranges

7. At a continental-oceanic convergent boundary, the oceanic plate subducts under the continental plate. Which of the following statements about oceanic crust is true?
   a) Oceanic crust is thinner and denser than continental crust
   b) Oceanic crust is primarily composed of granite
   c) The uniform density of oceanic crust prevents tectonic activity
   d) Oceanic crust is thicker and less dense than continental crust

8. Which of the following is NOT true of mafic rocks compared to felsic rocks?
   a) Darker in color
   b) Higher concentration of iron and magnesium
   c) More viscous lava
   d) Denser

9. According to Bowen's Reaction Series, which mineral crystallizes last from a mafic magma?
   a) Quartz
   b) Feldspar
   c) Olivine
   d) Biotite

10. Which of the following sedimentary structures most likely formed in a high-energy river environment?
    a) Mud cracks
    b) Ripple marks
    c) Cross-bedding
    d) Graded bedding

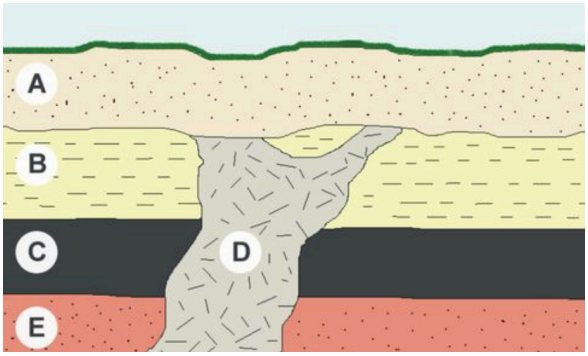
11. An igneous rock with a porphyritic texture likely formed under which conditions?
    a) Very rapid cooling on the Earth's surface
    b) Very slow cooling deep in the Earth’s crust
    c) Initial slow cooling followed by rapid cooling
    d) Repeated heating and cooling cycles

12. Which metamorphic facies would you expect to find in a region that experienced high pressure but relatively low temperature?
    a) Greenschist facies
    b) Blueschist facies
    c) Amphibolite facies
    d) Granulite facies

13. What is the primary component of soil that is responsible for its ability to retain moisture?
    a) Sand
    b) Silt
    c) Clay
    d) Organic matter

14. A volcano erupts with felsic, high-viscosity lava. Which of the following is most likely to form?
    a) Cinder cone (steep slopes)
    b) Shield volcano (gentle slopes)
    c) Caldera (collapsed top)
    d) Stratovolcano (medium slopes)

15. The following image depicts a geological cross-section. Which of the following statements is incorrect?



    a) E was the last to form
    b) Significant time passed between the formation of B and A
    c) A formed before D
    d) C formed before B

16. Which weather phenomenon is typically associated with a warm front?
    a) Sudden thunderstorms
    b) Long periods of rain
    c) Heavy snowfall
    d) Tornadoes

17. What are the characteristics of a continental tropical (cT) air mass?
    a) Warm and dry
    b) Cold and dry
    c) Warm and moist
    d) Cold and moist

18. What type of pressure system is associated with clear skies and calm weather?
    a) Low pressure
    b) High pressure
    c) Cyclonic pressure
    d) Frontal pressure

19. What effect does a mountain range have on the local climate?
    a) It prevents rainfall entirely.
    b) It can create a rain shadow effect.
    c) It has no effect on climate.
    d) It causes uniform temperatures.

20. What does the term "lapse rate" refer to?
    a) The rate at which pressure increases with altitude
    b) The rate at which temperature decreases with altitude
    c) The rate of humidity change with altitude
    d) The rate of wind speed change with altitude

21. In a scenario where a significant temperature gradient exists between land and ocean, what weather phenomenon is likely to develop?
    a) Stable, clear skies
    b) Storm systems, such as hurricanes or tropical storms
    c) Mild temperatures with little wind
    d) Uniform weather conditions across the region

22. What is the primary cause of the La Niña phenomenon?
    a) Volcanic activity
    b) Changes in atmospheric pressure
    c) cool ocean surface temperatures in the Pacific ocean
    d) warm ocean surface temperatures in the Pacific ocean

23. What is the primary driver of ocean currents?
    a) Wind patterns
    b) Earth's rotation
    c) Differences in water temperature and salinity
    d) Tidal forces

24. An air parcel rises from sea level, where the temperature is 20°C, to an altitude of 3,000 meters. Assume the air parcel undergoes adiabatic cooling as it rises and it follows the dry adiabatic lapse rate.

    What is the temperature of the air parcel at 3,000 meters?
    a) -10°C
    b) -5°C
    c) 0°C
    d) 5°C

25. If this air parcel then descends back to sea level, undergoing adiabatic heating with the wet adiabatic lapse rate of around 5°C, what will be its final temperature?
    a) -10°C
    b) -5°C
    c) 0°C
    d) 5°C

26. Which of the following factors most significantly contributes to the formation of trade winds?
    a) Earth's gravitational pull
    b) Differences in atmospheric pressure between the poles and equator
    c)The rotation of Earth (Coriolis effect)
    d) The seasonal variations in solar radiation

27. If Earth's rotation slowed down by half, what would most likely happen to the direction and strength of trade winds?
    a) Trade winds would remain the same in direction and strength.
    b) Trade winds would become stronger but continue blowing from east to west.
    c) Trade winds would weaken and have a less defined east-west direction.
    d) Trade winds would reverse direction, blowing from west to east.

28. Lakes that have little to no inflow or outflow are referred to as:
    a) Oligotrophic
    b) Endorheic
    c) Eutrophic
    d) Thermocline

29. If a sedimentary rock contains well-sorted, fine-grained sand and shell fragments, it most likely formed in which environment?
    a) Deep ocean
    b) Desert dune
    c) Nearshore marine environment
    d) Mountain stream

30. A river experiences increased discharge due to heavy rainfall. What is the most likely ecological impact of this change?
    a) Increased biodiversity in river ecosystems
    b) Decreased water temperature
    c) Erosion of riverbanks leading to habitat loss
    d) Stabilization of sediment transport

31. Which factor is most crucial in determining whether a river will exhibit more erosional or depositional features over time?
    a) The presence of tributaries
    b) The river's discharge and sediment load
    c) The length of the river
    d) Seasonal changes in temperature

32. If a glacier is retreating due to climate change, what is one likely consequence for nearby rivers?
    a) Increased sedimentation rates in the river
    b) Decreased river discharge during dry seasons
    c) Higher water temperatures in the river
    d) Decreased biodiversity in the river ecosystem

33. Why does the ocean absorb more solar radiation at the equator than at the poles?
    a) The Earth's surface is less smooth at the poles.
    b) The ocean is deeper at the poles.
    c) There is more atmospheric reflection at the poles.
    d) The angle of sunlight is less direct at the poles.

34. Why do polar regions have higher salinity than might be expected, despite low evaporation rates?
    a) Ice formation excludes salt from the ice
    b) Increased wind-driven mixing of surface waters
    c) Higher rates of volcanic activity
    d) Greater rates of precipitation

35. If you observe neap tides (lower than usual) on a particular day, which of the following would most likely describe the alignment of the Earth, Moon, and Sun?

    a) The Earth, Moon, and Sun are in a straight line, with the Moon between the Earth and Sun (new moon phase).
    b) The Earth, Moon, and Sun are in a straight line, with the Earth between the Moon and Sun (full moon phase).
    c) The Moon is at a 90-degree angle to the line connecting the Earth and Sun (first or third quarter moon phase).
    d) The Earth, Moon, and Sun are all aligned at a 45-degree angle.

36. Which landform is created by glacial deposition?
    a) Moraine
    b) Rift valley
    c) Delta
    d) Sand dune

37. Imagine a region with a consistent flow of slightly acidic groundwater, but with varying layers of limestone and impermeable rock like shale. Which of the following would most likely lead to the development of karst features in this region over time?
    a) The limestone layer is located above the shale
    b) The limestone layer is located below the shale
    c) The limestone and shale layers are interbedded
    d) The region has a low amount of groundwater and minimal precipitation

38. What happens to a wave as it approaches shallow water near the coast?
    a) Its height increases and speed decreases.
    b) Its height decreases and wavelength increases.
    c) It dissipates without change
    d) Its speed increases and wavelength decreases.

39. How does increased atmospheric CO_2 affect the oceans?
    a) CO_2 dissolves in seawater and decreases pH by forming carbonic acid.
    b) CO_2 displaces oxygen in the water, reducing pH.
    c) CO_2 increases temperature, causing evaporation and higher salinity.
    d) CO_2 reacts with calcium carbonate, increasing pH levels.

40. Which of the following is most likely to decrease over the course of a river?
    a) Channel roughness
    b) Discharge
    c) Channel Size
    d) Velocity

41. Acid rain forms when sulfur dioxide (SO_2) and nitrogen oxides (NO_x) react with water vapor in the atmosphere to create sulfuric and nitric acids. Which of the following rock types would be most susceptible to chemical weathering in an area frequently affected by acid rain?
    a) Mafic igneous rocks
    b) Felsic igneous rocks
    c) Clastic sedimentary rocks
    d) Organic sedimentary rocks

42. A geologist wants to estimate the age of a rock sample by using a radioactive isotope with a half-life of 1,250 years. If 12.5% of the original isotope remains in the rock, approximately how old is the rock?
    a) 1,250 years
    b) 2,500 years
    c) 3,750 years
    d) 5,000 years

43. Lichens are known as “pioneer species” because they can colonize bare rock surfaces. Which process carried out by lichens contributes to soil formation?

    a) Photosynthesis, which produces sugars and nutrients that enrich the soil.
    b) Symbiosis, which allows them to inhabit regions with other plants.
    c) Mechanical weathering, where lichens physically break down rock through root penetration.
    d) Chemical weathering, where acids produced by lichens dissolve minerals in the rock

44. In a landslide, rocks accelerate down a slope. Which factor would most significantly affect the speed of the rocks at the bottom of the slope before they slide?
    a) The mass of the rocks
    b) The color of the rocks
    c) The shape of the rocks
    d) The temperature of the environment

45. A river has a total discharge of 120,000 cubic meters over 4 hours. If the river is flowing at a rate of 10 meters per second, what is the cross-sectional area of the river?
    a) 10 m^2
    b) 50 m^2
    c) 100 m^2
    d) 120 m^2