USESO 2023

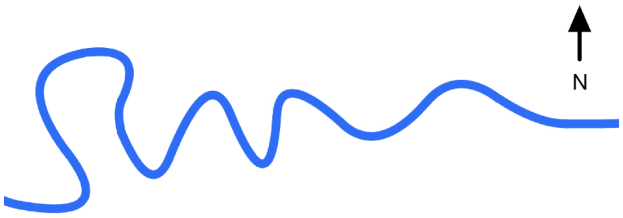
Open Exam

Section I

Instructions:

- Section I consists of 30 multiple choice questions. Each question is worth 2 points.
- Questions are **not** ordered by difficulty.
- Print your name on the ZipGrade answer sheet and the cover of this test.
- Bubble your answers clearly on the ZipGrade answer sheet. **Ignore the Student ID field**; the answer bubbles start below this section.
- You have **2 hours** to complete both sections in any order, and you may flip back and forth between sections.

1. Consider the following map of the main channel of a graded stream segment. Tributaries are hidden and the width of the stream on the map is **not** proportional to its discharge. The top of the map is north.



It can be inferred that the stream gradient is higher near the _____ end of the stream segment, and the discharge is higher near the _____ end of the segment.

A. Western, western B. Western, eastern C. Eastern, eastern D. Eastern,western

2. A sediment core is taken from the abyssal plain and layers of different sediments are marked. From top to bottom, in what order would you expect to find the following three layers?

I) Coarse-grained sandstone

II) Well-sorted sandstone

III) Laminated mudstone

A. I, II, III B. I, III, II C. III, II, I D. II, III, I E. I, III, II

3. Which of the following conditions would most favor cloud formation?

A. An increase in humidity and a decrease in temperature

B. An increase in both humidity and temperature

C. A decrease in humidity and an increase in saturation vapor pressure

D. A decrease in both humidity and saturation vapor pressure

4. The Bonneville Salt Flats are an extremely flat plain in northern Utah with extensive evaporite deposits. Considering the formation of salt flats, which of the following is likely **not** true of the location's geology?

A. Terraces can be found surrounding the area

B. The bedrock has relatively high permeability

C. The flats are at a lower elevation than the surrounding area

D. The flats are thinner during the wet season

5. The coast of Antarctica is notable for producing the Antarctic Bottom Water, a dense water mass that rapidly sinks to the bottom of the ocean. Which of the following changes in the coastal ocean would most likely **inhibit** the formation of this water mass?

A. Increase in ice formation rate around Antarctica

B. Rainfall over open water surrounding Antarctica

C. Strengthening of warm equatorial currents moving towards Antarctica

D. Strengthening of cold winds blowing away from Antarctica

6. Ephemeral streams are characterized by flow almost exclusively after precipitation events. After a storm, the stream's discharge is typically lowest downstream because:

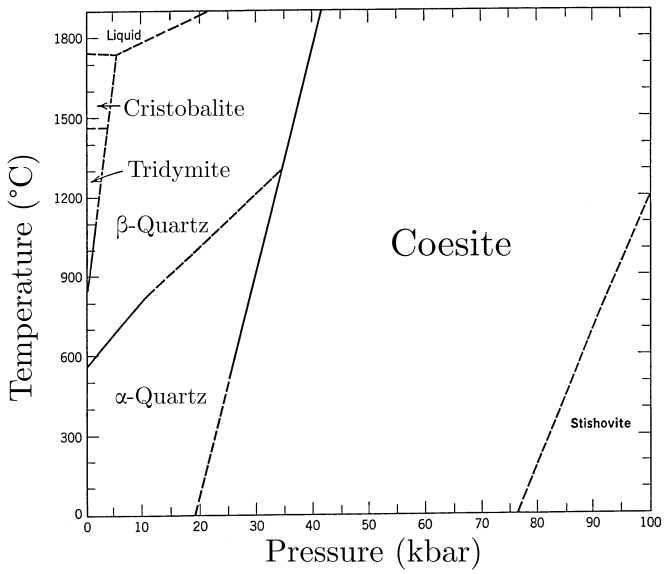
A. The water table is located below the stream
B. Water evaporates quickly in arid environments
C. Average flow velocity increases downstream
D. Capacity decreases downstream

7. Volcanic explosivity can evolve over time due to various internal and external mechanisms. Which of the following conditions would likely increase the probability of a highly explosive eruption?

I) A decrease in overburden pressure due to rapid snow melt
II) Assimilation of felsic country rock in the associated magma chamber
III) The exposure of confined groundwater to hot magma

A. I only
B. I and II
C. II and III
D. I, II, and III

8. Pictured below is a phase diagram for SiO_2. Lunar regolith sampled during the Apollo missions was found to have high proportions of SiO_2 in the metastable coesite phase. Which of the following processes best explains the occurrence of this mineral?

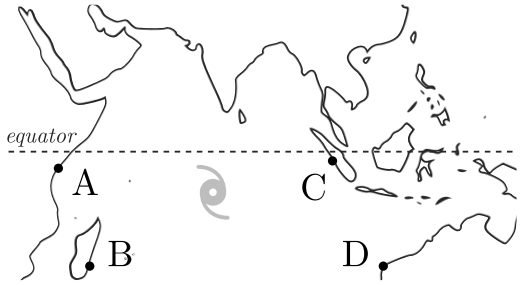


A. Compression at thrust faults on the surface of the moon
B. Subduction and subsequent uplifting from the moon's mantle
C. Shock from meteorite impacts during the late heavy bombardment
D. Strong heating of the moon's surface by the early earth

9. The addition of carbon dioxide to the atmosphere results in a series of reactions that create carbonic acid in seawater, resulting in ocean acidification. Which of the following correctly explains the feedback loop that ocean acidification creates in its interactions with oceanic organisms?

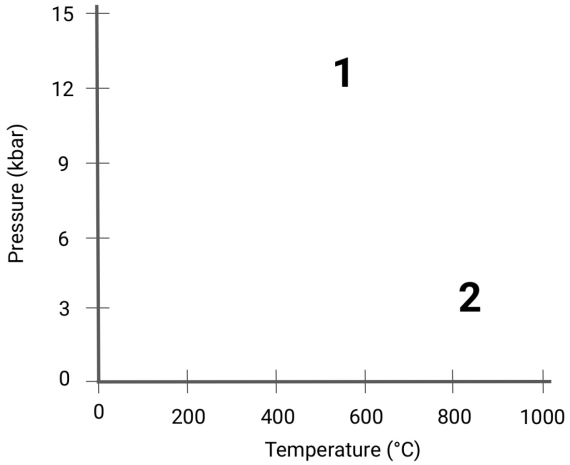
A. Positive, because it promotes carbon sequestration
B. Positive, because it inhibits carbon sequestration
C. Negative, because it promotes carbon sequestration
D. Negative, because it inhibits carbon sequestration

10. The map below shows the position of a tropical cyclone in the Indian Ocean with the equator marked by the dashed line. At which of the labeled points on the map would the cyclone most likely make landfall?



A. A B. B C. C D. D

11. Two metamorphic rocks, labeled 1 and 2, were sampled from a mountain range near an active tectonic margin. They contain index minerals that formed in the pressure-temperature conditions plotted below.



Which of the following statements can be inferred about the two rocks?

I) Rock 1 is more likely to have formed within the subducting slab than Rock 2

II) Rock 1 is more likely to have formed by contact metamorphism than Rock 2

III) Neither Rock 1 nor Rock 2 is slate

A. I only B. II only C. I and II D. I and III E. II and III

12. The biggest effect that airplanes have on the climate is surprisingly not from CO_2 emissions, but from generating long cirrus-like clouds known as contrails. Which of the following effects on the radiative budget are the primary way by which contrails cause net warming?

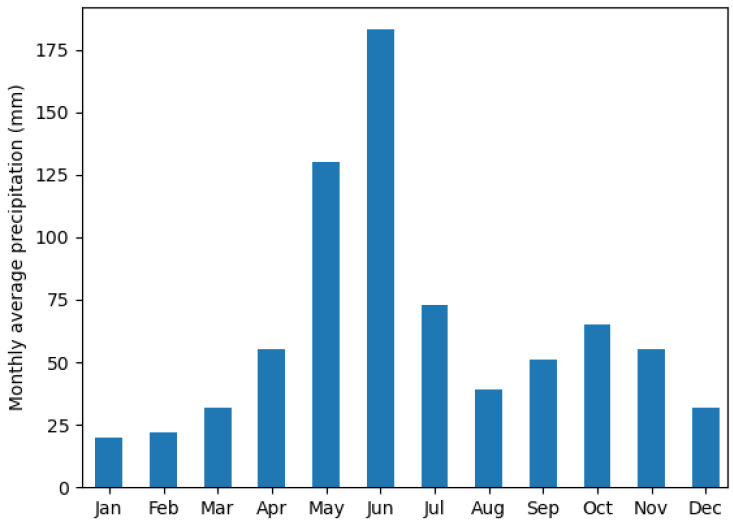
A. Contrails reflect more shortwave radiation from the Sun than clear sky

B. Contrails absorb more shortwave radiation from the Sun than clear sky

C. Contrails radiate less longwave radiation to space than clear sky

D. Contrails radiate more longwave radiation to space than clear sky

13. Consider the following precipitation climatograph. Which of the descriptions below best matches the location it represents?



A. A point at 5°N within the zone of annual ITCZ migration

B. An inland point at 20°N subject to regional monsoon circulation

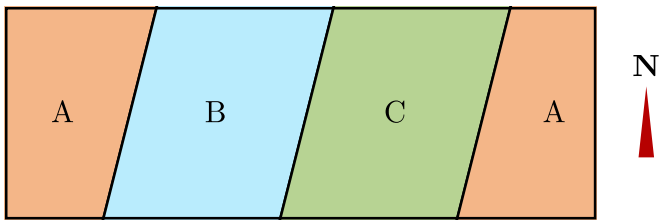
C. A point at 35°N with a semi-arid climate at the edge of the Hadley cell during summer

D. A point at 60°N sensitive to jet stream shifts caused by the El Niño-Southern Oscillation

14. Mercury's surface shows extensive faulting due to cooling and contraction rather than plate tectonics. Which of the following types of faults are prevalent on the surface of Mercury?

A. Normal B. Reverse C. Strike-slip D. Both normal and reverse E. Both reverse and strike-slip

15. The surface map below shows a partially eroded geological structure that includes multiple strata (A is youngest, C is oldest) and a reverse fault. Towards what direction does the fault dip?



A. WNW B. NNE C. ESE D. SSE E. SSW

16. A student is trying to identify where a thunderstorm could take place on a weather map using only pressure and temperature data. Which of the following conditions should the student look for?

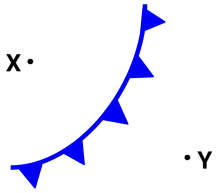
A. Low-pressure system and cold air

B. Low-pressure system and warm air

C. High-pressure system and cold air

D. High-pressure system and warm air

17. Consider the following surface weather map. Assume X and Y are both at sea level. Which of the following can be inferred?



I) X likely has denser air than Y

II) X likely has a higher relative humidity than Y

III) At Y, the air pressure is expected to increase, then decrease

A. I only B. I and II C. I and III D. II and III E. None

18. Which of the following depositional environments typically have well-sorted, rounded sediment?

I) Mountain stream

II) Glacial outwash

III) Sandy desert

A. I only B. III only C. I and III D. I, II, and III E. None

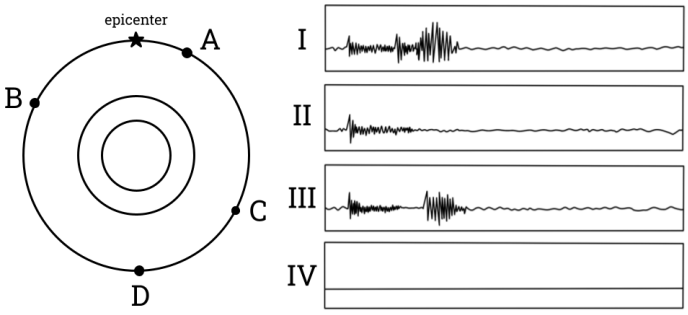
19. Jaime finds a carbon film with the following isotopic composition:

Isotope	mol %
^{12}C	98.1%
^{13}C	1.03%
^{14}C	0.522%
^{14}N	0.347%
^{15}N	<0.001%

He knows that the half-life of one of the isotopes is around 5,700 years but cannot remember which! Which of the following is closest to the age of the sample?

A. <100 years B. 2400 years C. 4200 years D. 7500 years

20. An earthquake was recorded at four seismic stations around the globe, A, B, C, and D. The diagram below represents a cross-section of the Earth with the locations of the stations and the epicenter of the earthquake, as well as an excerpt from a seismogram produced by each station.



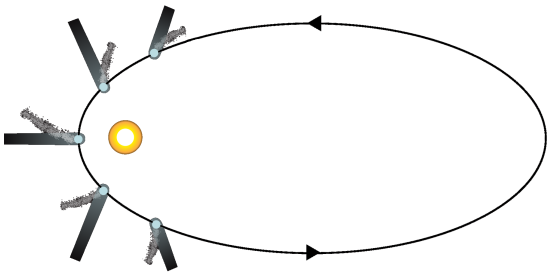
Which list best matches each seismogram, ordered from I to IV, with the seismic station at which it was recorded?

A. A, C, B, D B. B, A, C, D C. A, B, D, C D. A, D, B, C

21. As climate change melts the Greenland ice sheet, the resulting meltwater enters the northern Atlantic Ocean and remains at the surface instead of sinking to form the North Atlantic Deep Water. Which of the following best explains why glacial meltwater typically does not sink?

A. It has a low heat capacity
B. It has a low sediment capacity
C. It has very low salinity
D. It has very low viscosity

22. The following diagram describes the orbit of a comet:



Which of the following statements is true about the comet?

I) The acceleration of the comet due to gravity is **always** perpendicular to its velocity

II) Radiation pressure directs the gas tail away from the Sun

III) If the comet's velocity at perihelion is instantaneously bumped up by Δv, the eccentricity of the resultant orbit will be greater than that of the original orbit

A. I only B. II only C. III only D. II and III E. I, II, and III

Questions 23 and **24** consider a hypothetical planet that is identical to Earth but has a day length of six hours.

23. On this planet, which of the following would likely be the most similar to Earth?

A. Number of atmospheric circulation cells
B. Position of the intertropical convergence zone
C. Strength of equatorial trade winds
D. Strength of the Coriolis effect at the poles

24. The increased rotational speed of this planet would cause water to move outward towards the equator, where it would submerge most of the land in the region. What effect would the resulting change in albedo and in atmospheric water vapor content have on the planet's climate, respectively?

A. Warming; warming B. Warming; cooling C. Cooling; warming D. Cooling; cooling

25. Chlorofluorocarbons (CFCs) contribute to the depletion of Earth's ozone layer, believed to be the main cause of the 'ozone hole' in the 1990s. However, the ozone layer is found in Earth's stratosphere, and CFCs are heavier than other gases in air. Which of the following statements correctly explain why CFCs reach the stratosphere?

I) CFCs are insoluble in water

II) CFCs are relatively unreactive in the troposphere

III) Most rising air parcels move from the troposphere into the stratosphere

A. I only B. II only C. I and II D. II and III E. I, II, and III

26. A researcher inserts two devices at the top of a glacier and 100 meters below its surface to measure its flow speed at different levels. Which of the following changes would likely increase the difference in flow speed between these two devices?

I) Increase in temperature throughout

II) Decrease in valley floor roughness

III) Influx of meltwater beneath the glacier

A. I only B. II only C. I and III D. II and III E. I, II, and III

27. The frost line is the distance from the Sun at which a volatile compound can condense into a solid phase. Which of the following statements are true?

I) The frost line for water during planetary formation was closer to the Sun than it is today.

II) In other star systems, Jovian planets cannot be found within the frost line.

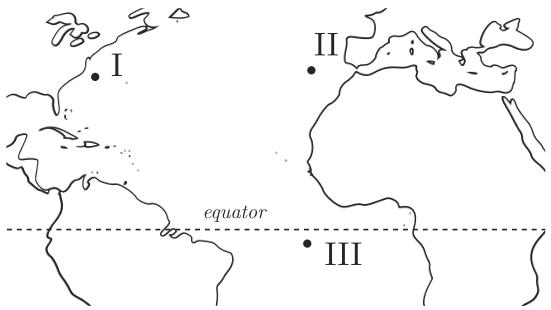
III) The frost line for carbon dioxide is closer to the Sun than the frost line for water.

A. I only B. II only C. III only D. II and III E. I, II, and III

28. At which of the following boundaries in Earth's interior is there an increase in density and a sharp decrease in seismic velocity?

A. Between the crust and upper mantle
B. Between the upper mantle and lower mantle
C. Between the lower mantle and outer core
D. Between the outer core and inner core

29. Pictured below is a map of the Atlantic Ocean with the equator marked by a dashed line. Which of the following correctly orders the average surface flow speed at the three marked points from **least to greatest**?



A. I, II, III B. I, III, II C. II, III, I D. II, I, III

30. Martian dust storms are not as strong as Earth's and are unlikely to damage any major equipment. Which of the following differences between the two planets contribute to this discrepancy?

I) There is relatively little water vapor in the Martian atmosphere

II) The Martian atmosphere is much thinner than the Earth's atmosphere

III) Mars has a higher temperature difference between the equator and poles

A. I only B. I and II C. II and III D. I, II, and III

END OF SECTION I