



USESO 2026

Training Camp Exam

Section I

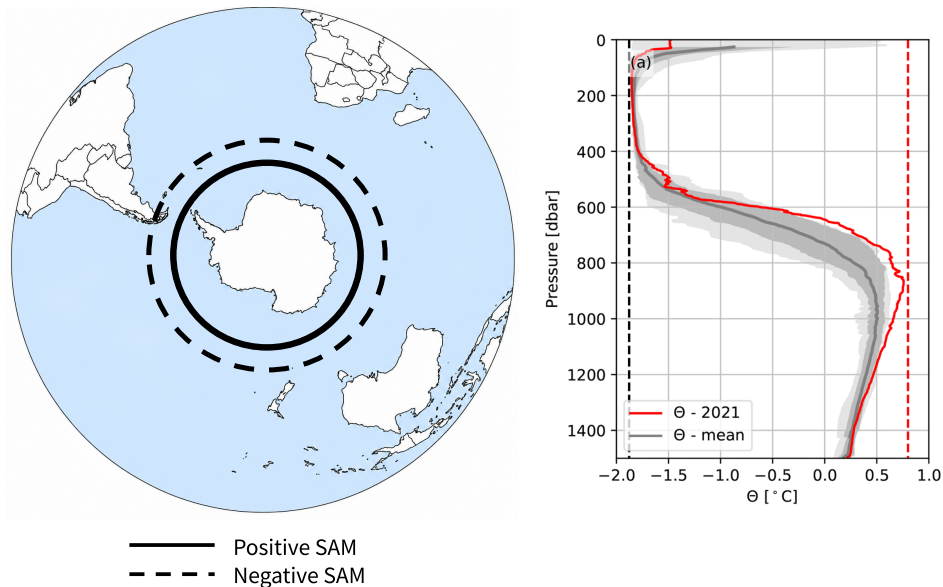
Instructions:

- Section I consists of 30 multiple choice questions. Each question is worth 2 points.
- Print your **USESO Student ID** on the ZipGrade answer sheet and bubble your answers clearly.
- You have **1 hour and 15 minutes** to complete this section.
- Any type of calculator is allowed.
- Participating in this exam is agreement to our Academic Integrity Policy.

1. The Bob River enters the Omjoe Ocean to produce a delta that is steadily growing outwards. A few thousand years later, the Bob River dries up, and the delta slowly recedes due to sea level rise. Which of the following best describes the trend in grain size for a column of the delta's sediments, from bottom to top?

A. Always increasing
 B. Always decreasing
 C. Increasing, then decreasing
 D. Decreasing, then increasing

2. The Southern Annular Mode (SAM) is a pattern of atmospheric variability in which, due to changes in atmospheric pressure above Antarctica, the Southern Westerly Winds move north or south. The figure below shows the difference in westerly wind position during the different phases of the SAM, as well as a typical potential temperature gradient with depth for the Southern Ocean. Potential temperature is the temperature a parcel of water would reach if brought to a reference pressure adiabatically.



Climate change has been predicted to cause stronger and more frequent positive phases of SAM. Which of the following are true?

- I) This would cause the Antarctic Circumpolar Current to strengthen.
 II) This would increase the melting of the Antarctic ice sheet.

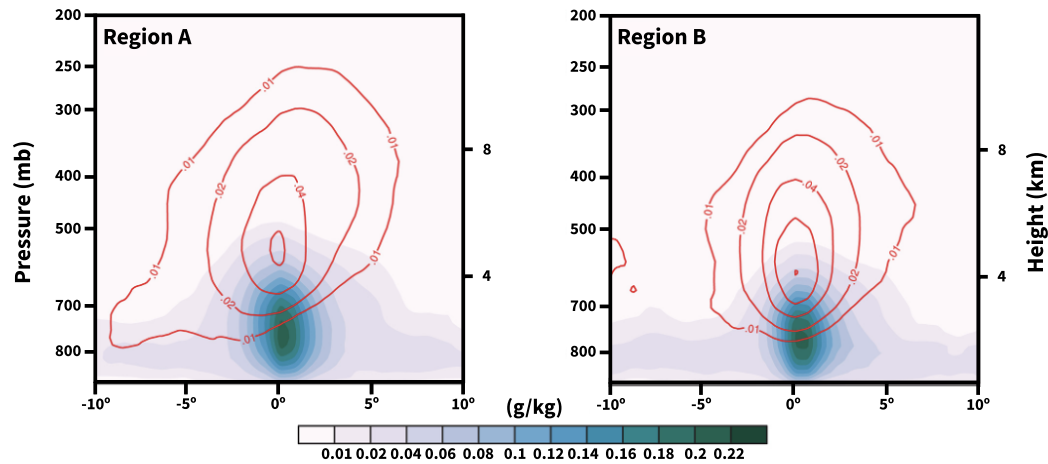
A. I only
 B. II only
 C. I and II
 D. None

3. The South American low-level jets (SALLJs) are high-speed winds traveling 1000–3000 feet off the planet's surface, typically occurring at night. They are caused by two factors: the jets are separated from surface friction, and, due to the elevation disparity between the Andes and eastern South America, the misalignment of isobaric and constant height surfaces drives movement. Identify all of the following statements that are true.

- I) SALLJs are more common on nights with extensive stratus cloud cover than on those without.
 II) SALLJs are a source of moisture for precipitation.
 III) SALLJs would be purely zonal if their flow were at the equator.

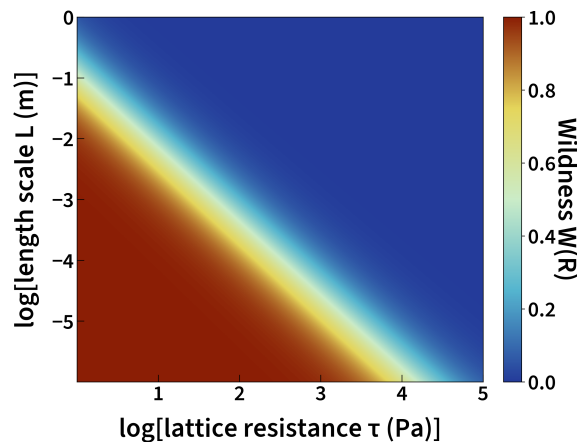
A. II only
 B. I and II
 C. II and III
 D. I, II, and III
 E. None

4. The figure below shows vertical cross-sections of liquid water content (blue/pink shading) and ice water content (red contours) in two low-pressure systems in the Northern Hemisphere. The x-axis represents the degrees of longitude from the location of interest.



Which of the following statements are true regarding the figure?

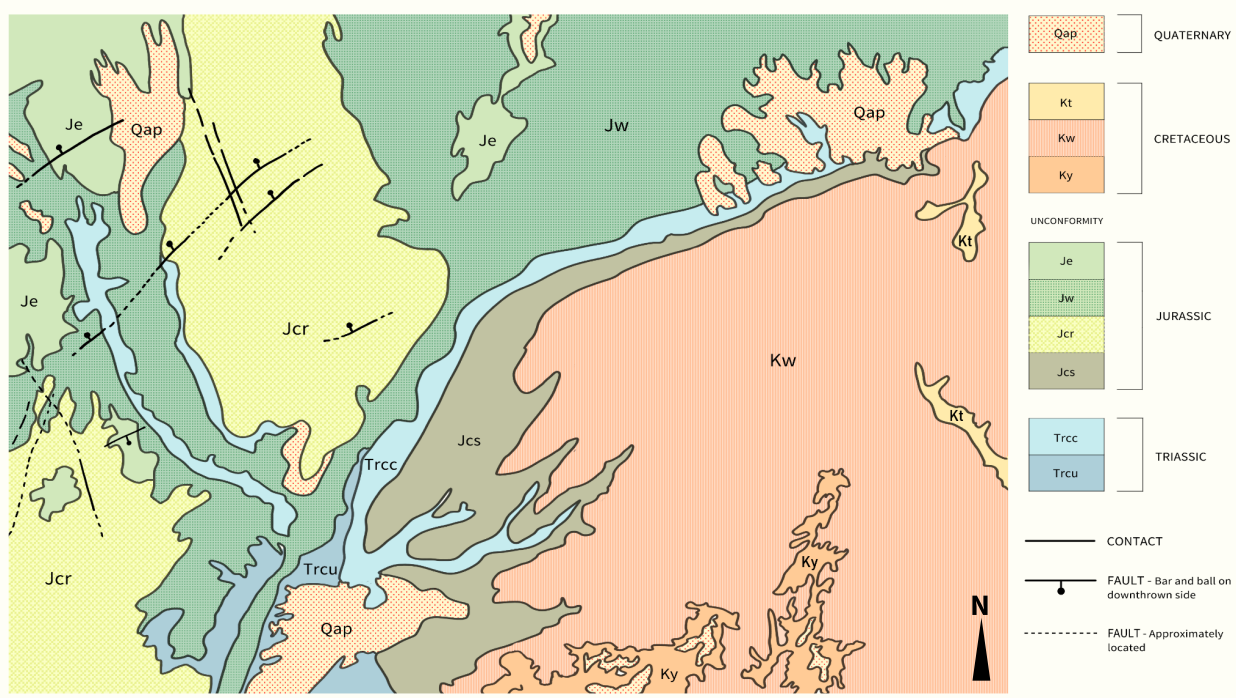
- I) Region A has more significant cloud development than region B.
 - II) The low-pressure system in region A is likely to strengthen more rapidly than the one in region B.
- A. I only B. II only C. I and II D. None
5. Below is a diagram showing the wildness of plasticity, which is the amount of dislocation that happens in bursts of high strain rate rather than gradual plastic flow.



The lattice resistance τ is a parameter that describes the resistance of a crystal lattice to the movement of dislocations, and L is the length of the system along the axis of dislocation. Based on this, which of the following best explains how these parameters influence the strengths of deep earthquakes?

- A. The lower lithosphere has a lower lattice resistance than the upper asthenosphere, which results in stronger earthquakes
- B. The lower lithosphere has a smaller length scale than the upper asthenosphere, which results in stronger earthquakes
- C. The upper asthenosphere has a lower lattice resistance than the lower lithosphere, which results in stronger earthquakes
- D. The upper asthenosphere has a larger length scale than the lower lithosphere, which results in stronger earthquakes

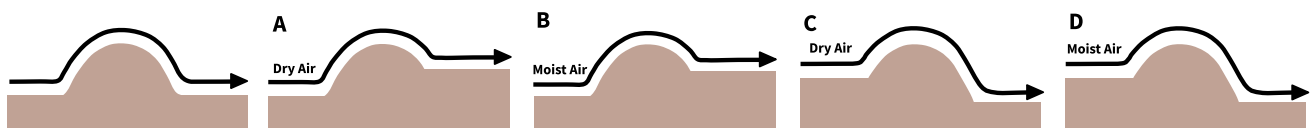
6. The geologic map pictured below shows an area of untilted strata. Which of the following statements about the area are most likely true?



- I) A river once flowed from the southwest towards the northeast.
 II) This area exhibits horst and graben topography.
 III) The area is useful for studying the Jurassic-Cretaceous transition boundary.

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

7. The diagram on the left shows the idealized path of an air parcel as it flows over a mountain, losing all moisture in the process. The next four figures show the same basic scenario, but with some changes in the mountain's topography and the air humidity. Assuming temperature is constant on either side of the mountain before the onset of the wind, in which scenario would the air parcel experience the largest increase in temperature?

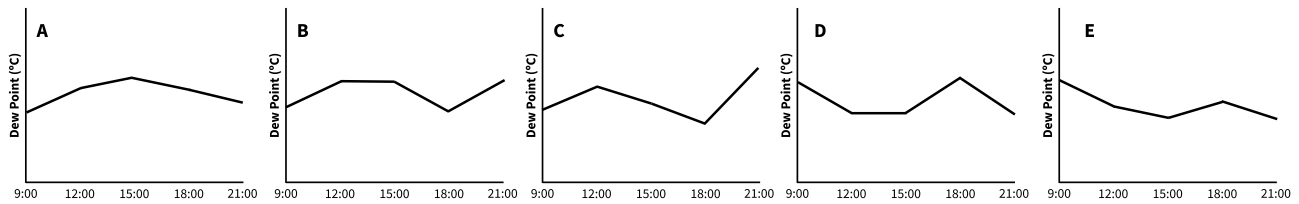
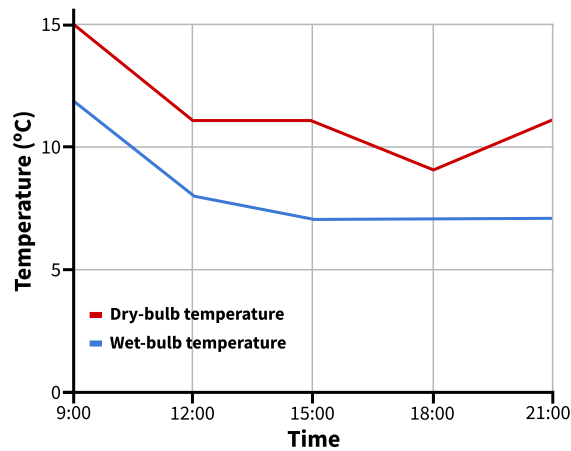


A. A B. B C. C D. D

8. A firestorm is a self-sustaining convective storm driven by massive fire events, producing clouds known as pyrocumulonimbus clouds. Which of the following statements is **least** accurate regarding firestorms?

- A. Their formation is favored by dry surface air and moist upper-level air
 B. Their strong downbursts can spawn secondary fires away from the storm front
 C. They are more likely to form in densely vegetated regions
 D. As the system develops vertically due to updrafts, the rotational speed of the central vortex decreases

9. Kat measures the dry-bulb and wet-bulb temperatures in 3-hour intervals over a day and obtains the below data. Which of the following graphs most accurately describes the dew point fluctuation throughout the day?



A. A

B. B

C. C

D. D

E. E

10. Phobos orbits Mars counterclockwise (as viewed from Mars' north celestial pole) with a sidereal orbital period of 0.319 days. Mars rotates counterclockwise with a sidereal day of 1.026 days. An observer is stationed at the Martian equator to log the motion of Phobos. Neglecting Mars' axial tilt, which of the following statements are true?

- I) From the observer's perspective, the synodic period of Phobos is 0.463 days.
 II) The observer would see Phobos rise in the east and set in the west.
 III) Over the course of a single Martian sol, the observer would witness Phobos complete more than one full cycle of phases.

A. I only

B. II only

C. I and II

D. I and III

E. I, II, and III

11. Ice streams are regions of ice sheets with increased ice velocities. Understanding the processes controlling ice streams is critical for evaluating the stabilization of ice sheets. The lateral margin growth of ice streams happens through the following process:

- Ice moves faster within a region due to topographic or geologic features.
- Increased shear stresses between the faster ice stream and the slower neighboring ice lead to weakening and warming ice.
- Subsurface sediment mobilization increases, propagating higher ice velocities.

Which of the following options accurately pairs a change made to the lateral ice stream margin with the impact on the magnitude of the ice stream velocity it would have?

A. Increased water drainage at the boundaries, increase

B. Increased bed sediment stiffening, increase

C. Shear thinning of the ice, decrease

D. Transition from sheet to channelized subsurface water flow, decrease

12. The table below shows the magnetic field strengths of several bodies as well as the predicted field strength of Triton based on a recently published model. Assuming the model is correct, which of the following is the likely cause of the magnetic field?

Body	Radius (km)	Distance from Sun (AU)	Field Strength (nT)
Venus	6050	0.73	10
Europa	1560	5.5	100
Mercury	2440	0.46	300
Triton (Predicted)	1350	30	1000
Earth	6700	1	25000

- A. Induced magnetic field in subsurface oceans
 B. Internal dynamo from subsurface saltwater ocean
 C. Induced magnetic field in its liquid outer core
 D. Internal dynamo in its liquid outer core
13. Komatiites are a rare type of rock formed by very high-temperature magmas that erupted during the Archean Eon. Which of the following statements would you expect to be true of komatiites?
- I) Present-day komatiite finds are more often in paleo-lava tube or paleo-lava pool settings rather than paleo-surface flow settings.
 II) Present-day komatiites are uniformly distributed amongst tectonic settings.
 III) Komatiite formation was primarily due to the heat generated by ^{87}Rb , a radioactive isotope with a 50 billion-year half-life.

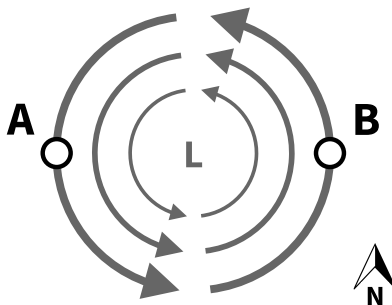
- A. I only
 B. III only
 C. I and II
 D. II and III
 E. I, II, and III

14. Which of the following properties generally describe clay-rich soils?

- I) High moisture retention rate in dry seasons
 II) High plant available water content in wet seasons

- A. I only
 B. II only
 C. I and II
 D. None

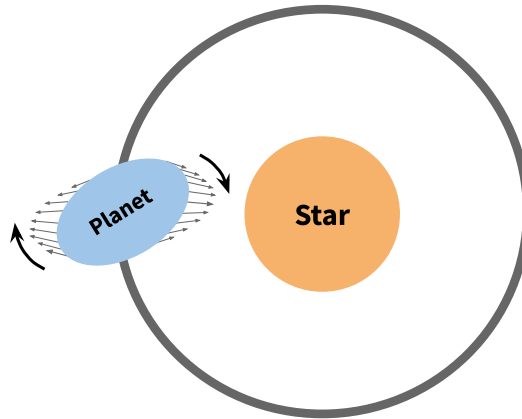
15. Consider two points A and B on the westernmost and easternmost points, respectively, of a Northern Hemisphere cyclone. Each point on the cyclone has a relative vorticity ζ and planetary vorticity f such that $\zeta + f = \eta$, where the absolute vorticity η is conserved during the movement of an air parcel.



Consider how the vorticity of air parcels located at points A and B changes when parcels follow the cyclonic wind direction at each point. How do these changes affect the motion of the cyclone?

- A. Relative vorticity increases at A and decreases at B, causing net movement to the north and west
 B. Relative vorticity increases at A and decreases at B, causing net movement to the south and east
 C. Relative vorticity decreases at A and increases at B, causing net movement to the north and east
 D. Relative vorticity decreases at A and increases at B, causing net movement to the south and west

16. Consider the tidal locking of a planet to a star. As shown in the diagram, the mechanism of tidal locking works by creating a torque on the planet's tidal bulge, which is unaligned with the planetary orbit. Identify all of the following that are true of this mechanism.



- I) Tidal locking is stable under a perturbation in planetary axial rotational velocity in either direction.
- II) Given the star's angular momentum stays constant, a planet that becomes tidally locked from a previously retrograde axial rotation will move to a closer orbital distance from its star.

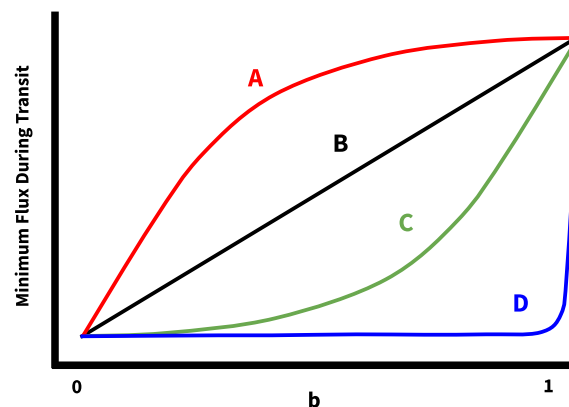
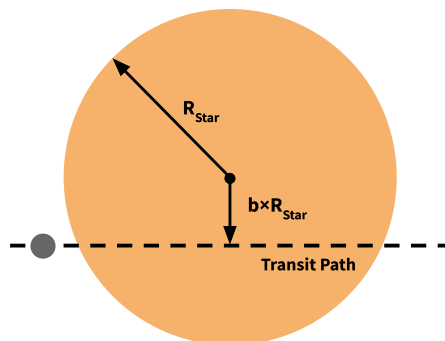
A. I only B. II only C. I and II D. None

17. Researchers have discovered coesite, a weakly metastable, high-pressure polymorph of quartz within continental crust. This finding supports the idea that continental crust can subduct deep into the mantle, forming coesite, then returning to the surface as semi-coherent continental crust where it is later exhumed. Identify all of the following statements that are true of this discovery.

- I) Coesite is often found both included within mineral grains and amongst the matrix.
- II) Coesite-hosting mineral grains can be identified by radial compression fractures.
- III) The presence of coesite provides a precise measure of subduction depth.

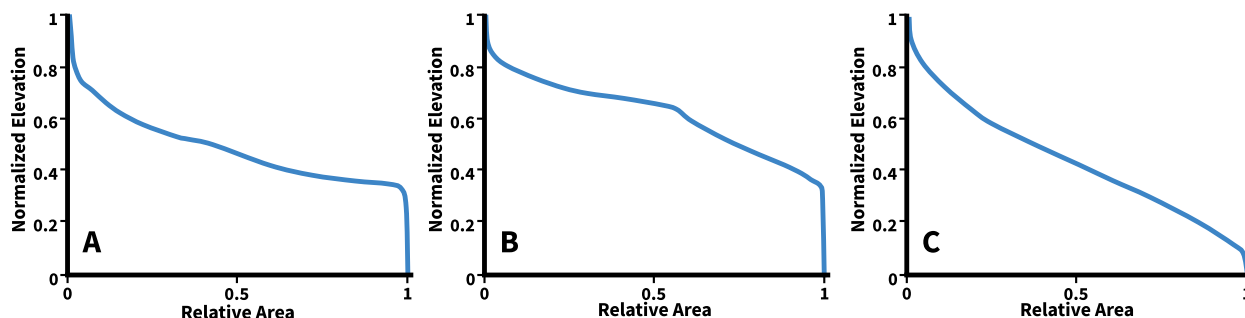
A. I only B. II only C. I and II D. II and III E. None

18. The b value of a transiting system is defined as the fraction of the transiting path's minimum distance from the center of the stellar disk out of the total radius of the star, as seen from Earth. Assuming $R_{\text{Star}} \gg R_{\text{Planet}}$, which of the following curves most accurately graphs minimum flux during transit against the value of b ?



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

19. Shown in the figure are the hypsometric curves for three different river subbasins in the Chalakudy River Basin in South India, plotting the normalized elevation versus the relative cumulative area. Identify all of the following statements that are likely true regarding these basins, assuming they have a similar age.

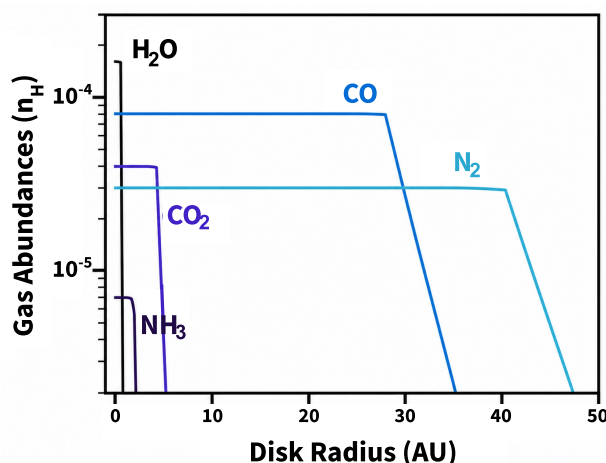


- I) A higher hypsometric integral (area under the curve) correlates with more base material eroded.
 II) Basin B is made of more resistant materials than Basin A.
 III) Basin C is closest to the mouth of the Chalakudy River Basin.
- A. I only B. II only C. I and II D. II and III E. I, II, and III
20. Which of the following are true about how climate change generally affects avalanches?
- I) Weak layers within snowpacks are less likely to form, decreasing avalanche risk, since the formation of ice layers by melting and refreezing is disfavored.
 II) Lower elevation regions are likely to have more frequent avalanches, since the amount of liquid precipitation and runoff from higher elevations increases.
 III) Higher elevation regions are expected to see more frequent avalanches, since the amount of mixed-type precipitation increases.
- A. II only B. III only C. I and II D. I and III E. II and III
21. The Froude number, a comparison between a stream's inertial and gravitational forces, can give valuable insight into fluid flow in hydrogeological systems. It is calculated by the formula below, where u is the stream velocity, g is the gravitational acceleration, and L is the stream depth. Which of the following statements are true regarding the Froude number?

$$Fr = \frac{u}{\sqrt{gL}}$$

- I) For two streams with the same volumetric flow rate and width, a more sinuous stream has a smaller Froude number.
 II) For a given location along a stream, the Froude number at that location will initially decrease, given that the location was originally a knickpoint.
- A. I only B. II only C. I and II D. None
22. Peter is studying the effect of ocean acidification on the Calcite Compensation Depth (CCD) and the Aragonite Compensation Depth (ACD). Aragonite is less stable than calcite under most conditions in the ocean. Which of the following correctly describes both the relationship between the CCD and ACD, and the Atlantic region that would experience the greatest shallowing of the CCD due to ocean acidification?
- A. The ACD is deeper than the CCD; the Western Equatorial Atlantic
 B. The ACD is deeper than the CCD; the Eastern Equatorial Atlantic
 C. The ACD is shallower than the CCD; the Western Equatorial Atlantic
 D. The ACD is shallower than the CCD; the Eastern Equatorial Atlantic

23. The figure below shows the concentration of certain compounds in a planetary disk as a function of distance from a central star.



The majority of hydrogen in space is found in compounds of H₂O and H₂, and deuterium preferentially bonds to oxygen over hydrogen. Given this information and the above figure, which of the following statements are true?

- I) As the star's surface temperature increases over time, the shown curves primarily shift up.
- II) Compounds of all phases found at the frost line for CO would have a higher D/H (deuterium to hydrogen) ratio than those found at the frost line for N₂.

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

24. The Earth's atmosphere can be modeled as an N -layer atmosphere. This model assumes each layer to be transparent to incoming solar radiation and partially opaque to outgoing radiation. Assuming each layer emits absorbed energy uniformly, which of the following statements are true for a planet in equilibrium?

- I) Higher values of N always correspond to higher surface temperature.
- II) Regardless of the value of N , the temperature at the top of the atmosphere is equal to the surface temperature of the same planet with no atmosphere.
- III) Surface temperature can be equal to the temperature of the layer directly above it.

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

25. The Volcanic Explosivity Index (VEI) measures the power of an eruption by the volume of erupted rock, including void spaces within tephra. The Dense Rock Equivalent (DRE) tephra component, on the other hand, estimates the total volume of erupted tephra excluding the air inside. Which of the following conditions would be associated with the highest discrepancy between the VEI and DRE?

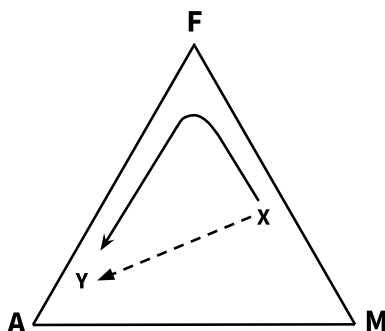
- I) Relatively slow magmatic ascent
- II) Relatively small average tephra diameters

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

26. Suppose an ocean surface buoy is blown around by a strong storm so that it is given some initial velocity in the northward direction in the Northern Hemisphere. Which of the following equations best gives the northward and eastward velocities of the buoy as a function of time?

- A. $V_n = \cos(t)$, $V_e = \sin(t)$
- B. $V_n = e^t \cos(t)$, $V_e = e^t \sin(t)$
- C. $V_n = e^t \cos(t)$, $V_e = -e^t \sin(t)$
- D. $V_n = e^{-t} \cos(t)$, $V_e = e^{-t} \sin(t)$
- E. $V_n = e^{-t} \cos(t)$, $V_e = -e^{-t} \sin(t)$

27. Aashray is studying a relatively oxidized initial melt X enriched in Fe^{3+} compared to Fe^{2+} . They found it evolved from its initial composition to melt Y through the fractional crystallization of mafic minerals. The diagram below plots melts by the relative weight percents of MgO, FeO, and $\text{Na}_2\text{O} + \text{K}_2\text{O}$, shown by letters M, F, and A, respectively. Two possible melt evolution paths are shown below. Which of the following statements is true?



- I) Based on iron ion ratios, magnetite (Fe_3O_4) crystallization is expected to be more favorable than ilmenite ($\text{FeTi}^{4+}\text{O}_3$) crystallization.
 - II) Melt X is likely from a subduction arc.
 - III) Simultaneous crystallization of magnetite and forsterite (Mg-rich olivine) would result in evolution along the dashed line from X to Y.
- A. I only B. II only C. I and II D. II and III E. I, II, and III
28. Uranus is unique among the giant planets in that it has relatively little heat transport out of its interior, equal to about one-eighth of the energy it absorbs from the Sun. Identify all of the following statements that are true of Uranus as a result of this effect:

- I) Its surface atmospheric circulation is highly seasonal.
- II) Its surface atmospheric circulation extends far into its interior.

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

29. Emmanuel is studying a geological structure he found on a horizontal outcrop. As he walks from north to south, he notes the composition of each layer he comes across, as well as the dip direction of some of the layers. In order, they are: composition Z, dipping north; composition X, unknown dip; composition W, dipping east; composition X, unknown dip; composition Z, dipping south. Assuming the outcrop is not overturned, what type of feature did Emmanuel encounter?

- A. Syncline D. Plunging Anticline
- B. Anticline E. Unable to determine
- C. Plunging Syncline

30. The heterosphere occurs in the upper atmosphere, where composition changes as some gases begin to separate due to their chemical properties. Which of the following statements are true as altitude increases in the heterosphere?
- I) Ionized atoms appear more frequently from photoionization.
 - II) The ratio of the concentration of all phases of oxygen to that of nitrogen increases.
 - III) Hydrogen and helium mole fractions decrease.

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

END OF SECTION I