



USESO 2025

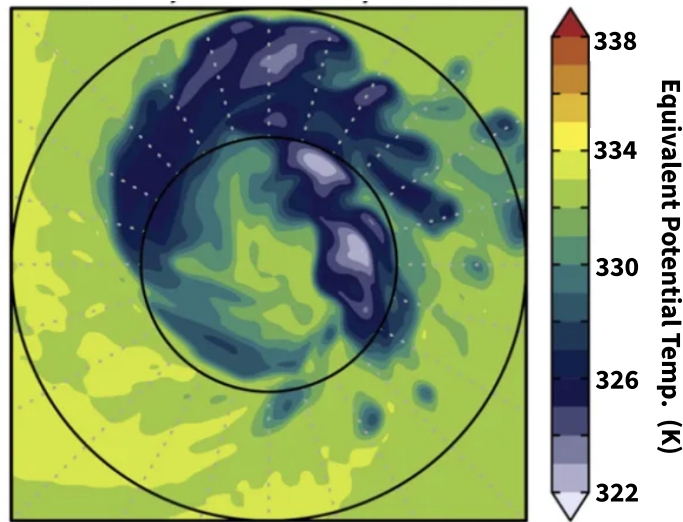
Training Camp Exam

Multiple Choice

Instructions:

- Section I consists of 30 questions that assess geoscience knowledge in the form of multiple-choice questions. Each question is worth 2 points.
- 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.

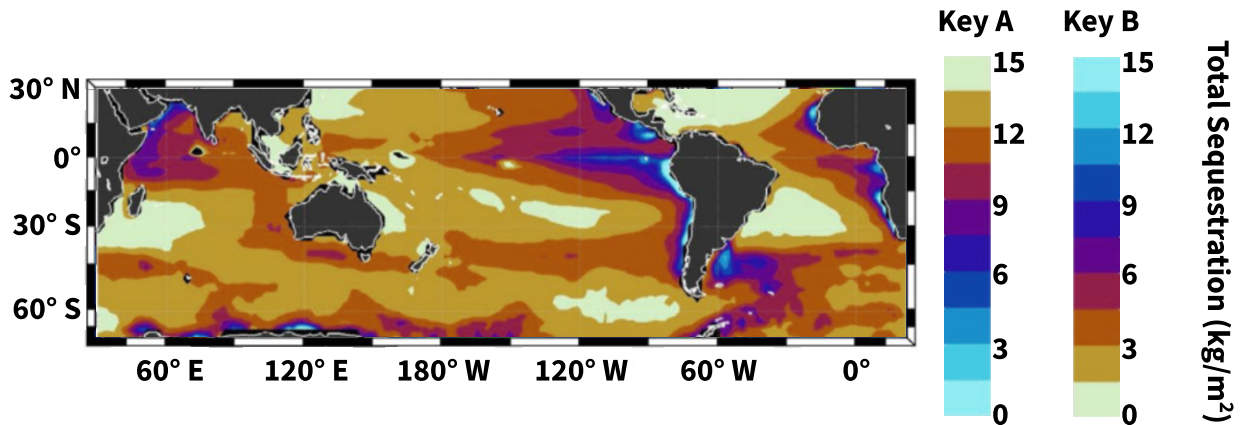
1. The following figure depicts the equivalent potential temperature (EPT) of a region on an isobaric surface; the black circles represent radii at every 50 kilometers. EPT is defined as the temperature that an air parcel would reach if all the water vapor it contained condensed and released the corresponding latent heat.



Which of the following statements is/are true regarding this region?

- I) The region is located in the Northern Hemisphere and contains a surface low
 - II) EPT likely decreases with height in the region
- A. I only
 - B. II only
 - C. I and II
 - D. None
2. In an area thought to have once been at the ocean floor, scientists find a bed of calcareous sediment overlain by siliceous sediments. Which of the following past environmental changes would **least** likely account for this change in deposited material?
- A. Sinking of the seafloor over time
 - B. Increase in subsurface ocean temperature over time
 - C. Increase in ocean acidity over time
 - D. Movement of the seafloor towards an area of coastal upwelling over time
3. During the early Pliocene, low mean sea levels resulted in the closing of the Indonesian Gateway, preventing equatorial water flow between the Pacific and Indian Oceans. A recent study used paleoclimate proxies to characterize P-E, or precipitation minus evaporation, across the Pacific Ocean during the early Pliocene. Which of the following correctly describes how the closing of the Indonesian Gateway would likely affect Pacific P-E?
- A. Higher P-E at the equator, higher P-E at mid-latitudes
 - B. Higher P-E at the equator, lower P-E at mid-latitudes
 - C. Lower P-E at the equator, higher P-E at mid-latitudes
 - D. Lower P-E at the equator, lower P-E at mid-latitudes

4. The ocean carbon pump transfers carbon from the atmosphere and ocean surface to the deep ocean. The figure below depicts a model of the spatial distribution of the amount of carbon sequestered by this pump per year.



Given that one of Key A or Key B is correct, which of the following is true regarding this figure?

- A. Key A is correct; downwelling at the center of subtropical gyres transports large amounts of CO₂ into the deep ocean
- B. Key A is correct; upwelling at the center of subtropical gyres increases productivity of biological organisms
- C. Key B is correct; downwelling at the center of subtropical gyres decreases the productivity of biological organisms
- D. Key B is correct; upwelling at the center of subtropical gyres brings CO₂ in the deep ocean back to the surface

5. At a given point, two weather models, A and B, predict the same geopotential heights for the 1000 and 500 hPa pressure levels. However, they predict different temperature **anomalies** (relative to the climatological average within each pressure level), as shown in the table below.

	1000 hPa	500 hPa
A	+3 °C	+1 °C
B	+3 °C	+5 °C

Which of the following about the 1000-500 hPa layer **must** be true given the information above?

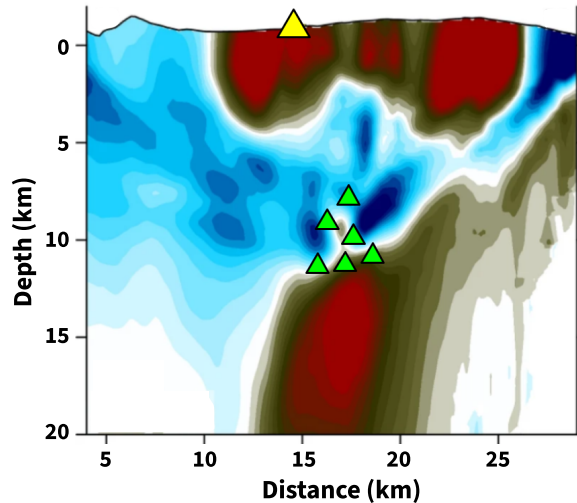
- I) A predicts a less stable atmosphere than B
- II) A predicts a conditionally unstable atmosphere
- III) B predicts an atmospheric inversion

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

6. The image below represents a two-dimensional cross section of

$$v_s/v_p$$

(the ratio of S wave velocity to P wave velocity) under La Palma, an island where a lengthy volcanic eruption occurred in 2021. The yellow triangle represents the location of the eruption, while the smaller green triangles represent locations of major earthquakes that occurred during the eruption.



Which of the following statements is/are true of the image and the geology of the region?

- I) In the image, red represents an unusually high $\frac{v_s}{v_p}$ ratio
- II) The eruption was primarily fed by magma from less than 5 kilometers beneath the surface

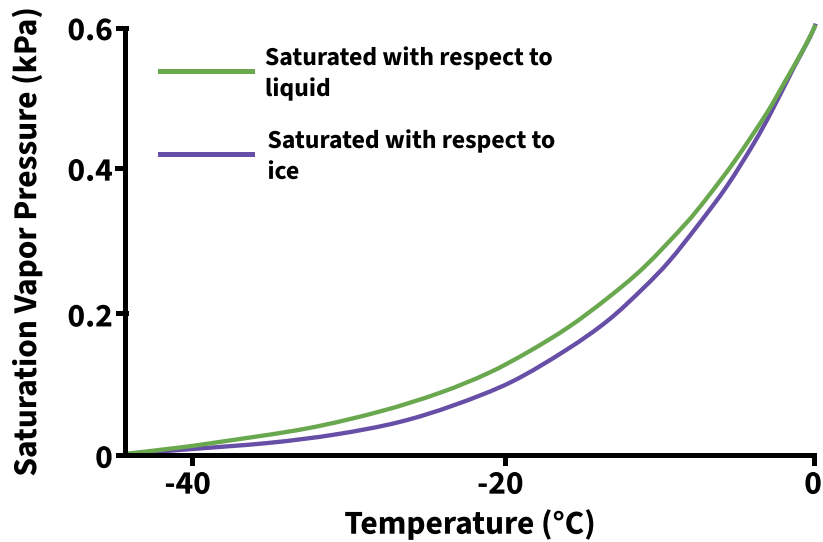
- A. I only
- B. II only
- C. I and II
- D. None

7. A total solar eclipse occurs during July. Assuming that the Sun, Moon and Earth are collinear during the height of the eclipse and using the table of values provided below, which of the following is closest to the maximum radius of the resulting umbra?

Radius of the Sun	$6.96 \cdot 10^5 \text{ km}$
Radius of Earth	6370 km
Radius of the Moon	1740 km
Perihelion of Earth	$1.47 \cdot 10^8 \text{ km}$
Aphelion of Earth	$1.52 \cdot 10^8 \text{ km}$
Perigee of Moon	$3.62 \cdot 10^5 \text{ km}$
Apogee of Moon	$4.05 \cdot 10^5 \text{ km}$

- A. 28 km
- B. 56 km
- C. 84 km
- D. 112 km

8. The graph below plots saturation vapor pressure as a function of temperature.



Which of the following best explains how the difference between the two curves contributes to precipitation formation in clouds that contain both liquid water droplets and ice crystals?

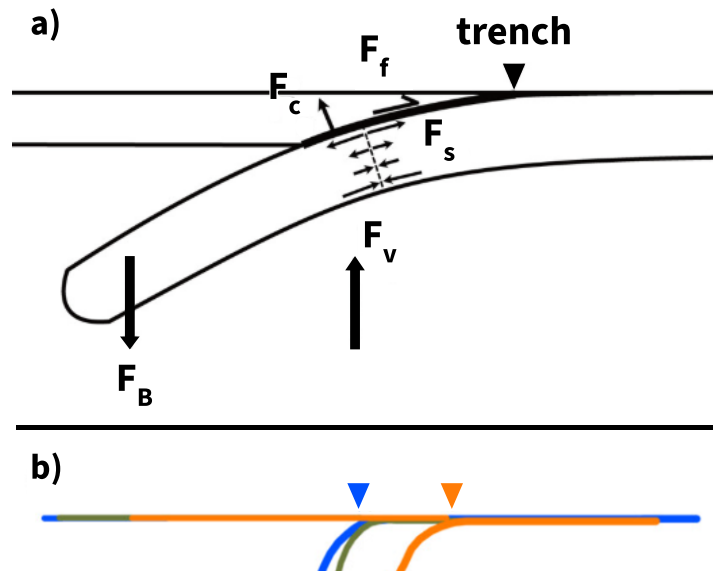
- A. Supercooled droplets grow quickly because water vapor deposits preferentially on liquid water
 - B. Ice crystals grow at the expense of surrounding water droplets because water vapor condenses preferentially on ice
 - C. Precipitation rarely forms in mixed-phase clouds because it is difficult for air to become saturated with respect to both liquid water and ice
 - D. Ice crystals do not grow until all water droplets freeze because the saturation vapor pressure of ice is lower than that of liquid water
9. Clastic dikes are discordant structures similar to igneous dikes but filled with sediment rather than igneous rock. Clastic dikes found in Badlands National Park extend up to 30 meters deep and run for a quarter of a mile at many different strikes and dips, criss-crossing at random intervals. Identify all of the following three possible formation mechanisms that could explain the formation of these structures.
- I) Large mud cracks formed and then filled with clastic material.
 - II) Large-scale extensional tectonics resulted in stretching and fracturing of crustal rock.
 - III) Liquefaction during seismic activity injected sediment into the resulting fractures.
- A. I only
 - B. III only
 - C. I and II
 - D. I and III
 - E. II and III

10. The Sun has gradually been getting brighter over time—when the Solar System formed, it was only about 70 percent as bright as it is today. Scientists hypothesize that Mars formerly had liquid water, but it is unclear how a dimmer Sun could sustain high enough temperatures to do so. One model suggests that this was possible due to processes related to hydrogen release in the atmosphere of Mars, which occurs due to the oxidation of iron with equation $2\text{FeO} + \text{H}_2\text{O} \longrightarrow \text{Fe}_2\text{O}_3 + \text{H}_2$. Which of the following statements is/are true regarding the effect of this process on the Martian surface and atmosphere?

- I) The rate of H_2 outgassing has increased over time
- II) The Martian equator likely has a higher $\text{Fe}_2\text{O}_3/\text{FeO}$ ratio than the poles

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

11. Some geologists have created a model of a subduction zone in which there is no mantle flow. As shown in panel (a) of the figure, some forces relevant to this simplified model include the slab pull force (F_B), slab bending force (F_s), the viscous force due to the mantle (F_v), friction (F_f), and the compressive force (F_c).



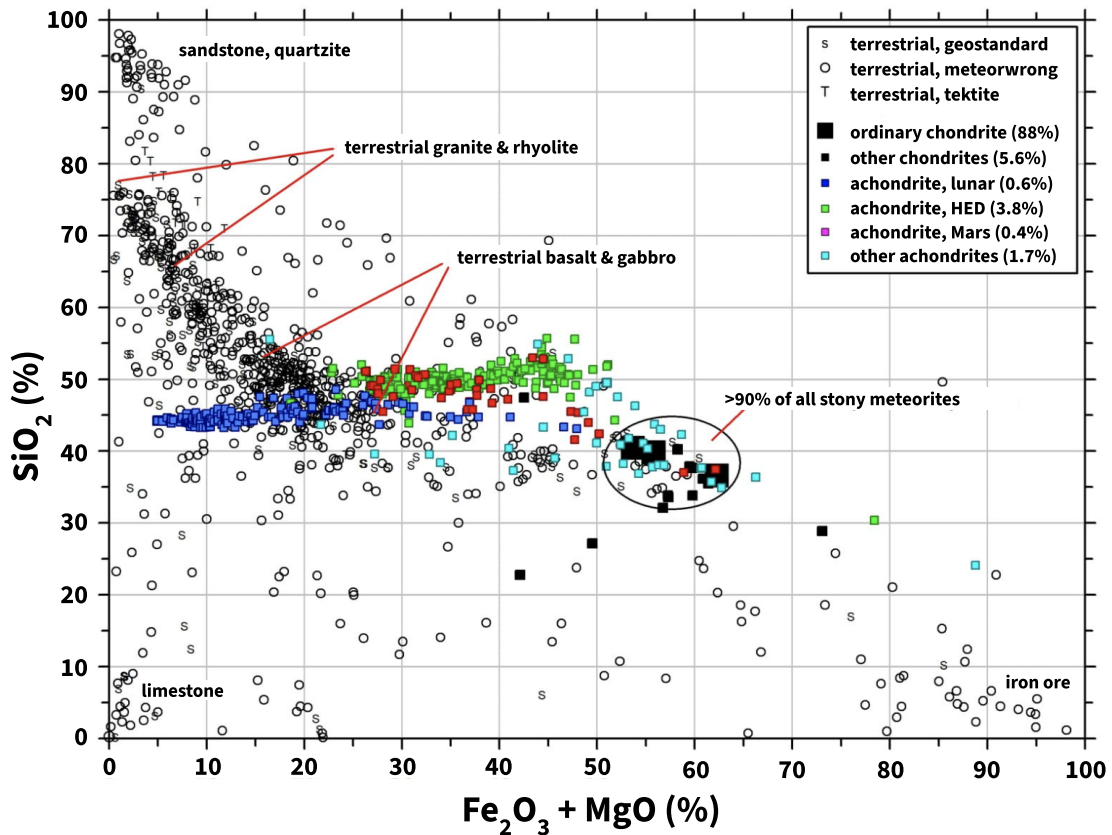
The model predicts that the trench associated with the subducting plate moves while the subduction progresses, as shown in panel b). Which of the following choices correctly gives both the direction and the dominant driving force of this movement?

- A. Blue \rightarrow Green \rightarrow Orange, F_f
- B. Blue \rightarrow Green \rightarrow Orange, F_s
- C. Blue \rightarrow Green \rightarrow Orange, F_B
- D. Orange \rightarrow Green \rightarrow Blue, F_v
- E. Orange \rightarrow Green \rightarrow Blue, F_c

12. In the Southern Ocean, coastal polynyas are areas of open water in which sea ice forms. Outside these sites, the growth of sea ice in most of the ice-covered region is restricted by a feedback involving brine rejection which results in heat mixing upwards. Which of the following statements best explains why coastal polynyas are often sites of deepwater formation while other ice-covered regions are not?

- A. Sea ice formed in coastal polynyas is typically thicker than sea ice formed elsewhere
- B. In coastal polynyas, most heat is conducted directly from the ocean to the atmosphere
- C. The salinity of sea ice formed in coastal polynyas is relatively low, so brine rejection is stronger
- D. Isopycnals are nearly horizontal at coastal polynyas, while nearly vertical in the sea ice zone

13. The figure below shows the SiO_2 and $\text{Fe}_2\text{O}_3 + \text{MgO}$ composition of a number of meteorite finds as well as a number of terrestrial or man-made samples (meteorwrongs).



Based on the diagram, which of the following conclusions may be made?

- I) The vast majority of meteorites come from undifferentiated bodies.
- II) Glass formed as a consequence of meteorite strikes usually shares a similar composition to the meteorite itself.

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

14. Which of the following entries of the table best describes the components and the formation environment of the bedform depicted below?



Entry	Dark Component	Light Component	Formation Environment
A	Basalt	Ash deposit	Volcano flank
B	Mud	Sand	Intertidal zone
C	Clay	Silt	Glacial lake
D	Blueschist	Quartzite	Region of tectonic extension

- A. Entry A
- B. Entry B
- C. Entry C
- D. Entry D

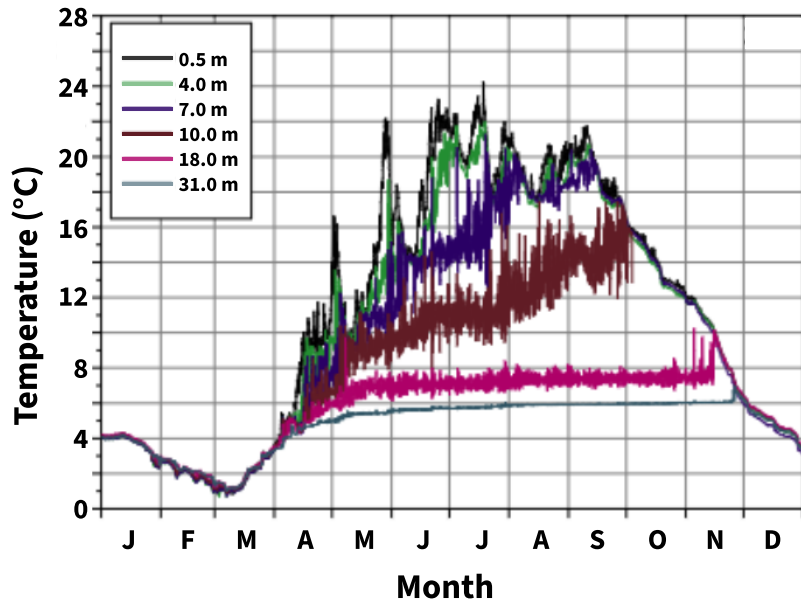
15. Venus has an orbital eccentricity of 0.21, the largest out of any planet in the Solar System. This results in Venus receiving more light from the Sun when at perihelion. In which of the following ranges does the ratio of the amount of light Venus receives at perihelion to aphelion lie?

- A. Between 1.0 and 1.4
- B. Between 1.4 and 1.8
- C. Between 1.8 and 2.2
- D. Between 2.2 and 2.6
- E. Greater than 2.6

16. Planetary equilibrium temperatures are critical for determining the potential habitability of a planet. If Earth's emissivity decreased from 0.95 to 0.9, its new albedo would need to lie in which of the following ranges to maintain a stable equilibrium temperature? Assume that Earth's current albedo is 0.3.

- A. Between 0.26 and 0.28
- B. Between 0.28 and 0.30
- C. Between 0.30 and 0.32
- D. Between 0.32 and 0.34
- E. Between 0.34 and 0.36

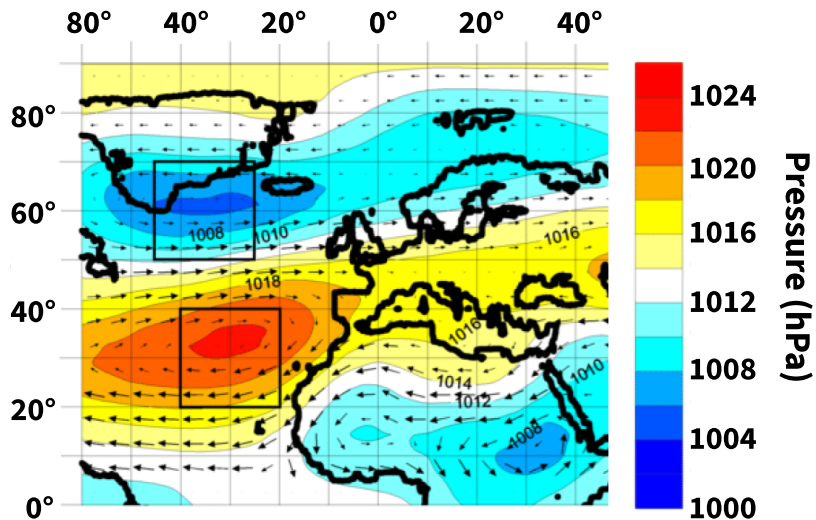
17. A hydrologist produces the figure below by sampling water at different depths and at different times of year at a lake in Germany. (Note that in areas where some lines appear to disappear, the different lines have simply converged.)



Which of the following accurately gives the lake’s mixing regime and the depth of the lake’s thermocline between August and September?

- A. Amicitic, 0.5-7 meters deep
 - B. Dimictic, 0.5-7 meters deep
 - C. Dimictic, 7-10 meters deep
 - D. Monomictic, 0.5-7 meters deep
 - E. Monomictic, 7-10 meters deep
18. Although often assumed to be constant for a given location, the moist adiabatic lapse rate (MALR) actually varies with height, primarily due to the effects of latent heat release on rising air. Which of the following accurately describes the relationship between MALR and atmospheric pressure and temperature, respectively?
- A. Direct, direct
 - B. Direct, inverse
 - C. Inverse, direct
 - D. Inverse, inverse
19. A soil located in which of the following environments would likely be most susceptible to liquefaction during a major earthquake?
- A. Above a former desert lake bed
 - B. Above a region of karst topography
 - C. In the outwash plain of a valley glacier
 - D. On the edge of a meandering river

20. The North Atlantic Oscillation (NAO) is a phenomenon involving the oscillation in pressure between the Icelandic Low and the Azores High, shown in the map below in the top left and bottom left, respectively. The NAO is defined according to the difference in air pressure between these two pressure centers, i.e. a positive NAO corresponds to higher variation in pressure between the centers.



Meteorologists have found that large CO₂ forcing is likely to make the NAO consistently more positive. Identify all of the following climate conditions that would likely be a result of more positive average NAO conditions.

- I) Stronger westerlies over the Atlantic
- II) Colder winters in western Europe

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

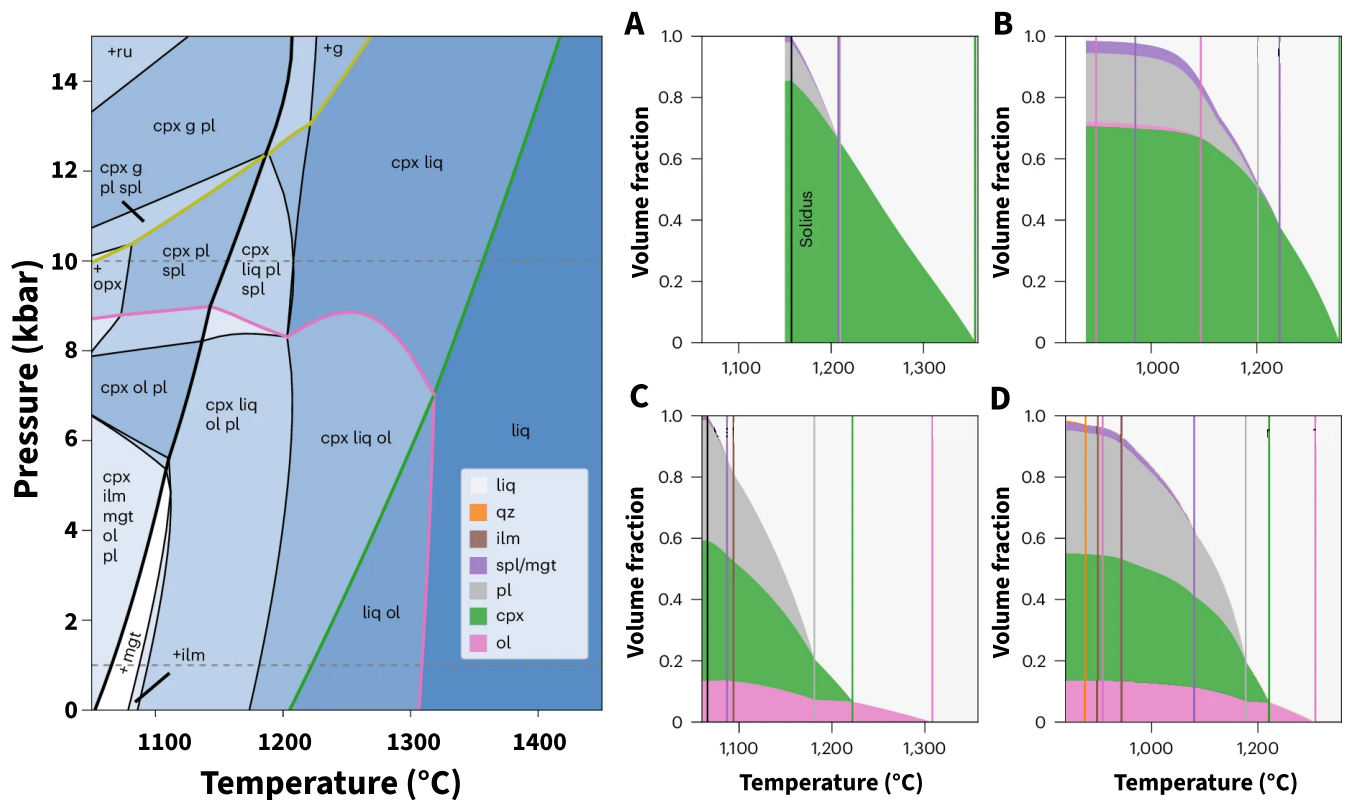
21. A major runoff event causes an influx of nutrients into the Gulf of Mexico, causing a large but short-lived algal bloom. Which of the following best describes how this event would affect the water's dissolved oxygen content at the surface and at a depth of 500 meters, respectively?

- A. Increase, then decrease; uniformly increase
- B. Increase, then decrease; uniformly decrease
- C. Decrease, then increase; uniformly increase
- D. Decrease, then increase; uniformly decrease

22. Radiation fog forms when Earth's surface cools radiatively and the surrounding air condenses. This type of fog is most likely to form when a relatively _____ layer of _____ air underlies a layer of _____ air.

- A. Shallow; moist; drier
- B. Shallow; dry; moister
- C. Deep, moist, drier
- D. Deep, dry, moister

23. The figure below depicts the results of four simulations of the evolution of a mafic magma alongside a phase diagram for this magma. Which of the simulations represents fractional crystallization at a pressure of 10 kbar?

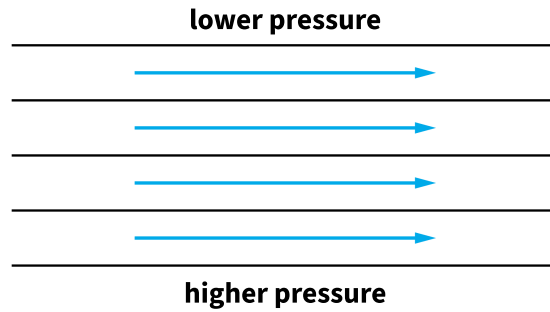


- A. Figure A
- B. Figure B
- C. Figure C
- D. Figure D

24. A geologist is analyzing two basalt samples titled “Sample A” and “Sample B.” They determine that Sample A is relatively depleted in alkali metals such as potassium. Meanwhile, Sample B is relatively enriched in alkali metals. The geologist knows that one sample is derived from a continental mantle plume while the other was found near an oceanic rift. Given only this information, which of the following choices most likely describes the origin of Sample A?

- A. Sample A was derived from magma associated with a continental mantle plume, which led to more complete melting.
- B. Sample A was derived from magma associated with a continental mantle plume, which led to less complete melting.
- C. Sample A was derived from magma associated with melting at an oceanic rift, which led to more complete melting.
- D. Sample A was derived from magma associated with melting at an oceanic rift, which led to less complete melting.

25. A planet rotates at angular velocity Ω . A uniform pressure gradient leads to geostrophic flow as shown in the figure below, in which the black contours represent isobars and the blue arrows represent velocity vectors for the resulting geostrophic wind.

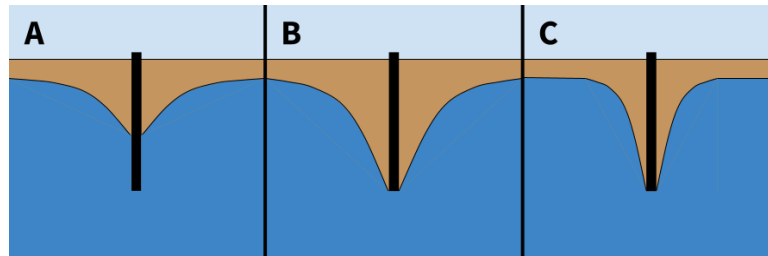


The planet then begins to rotate at 2Ω . After it has reached equilibrium, which of the following changes alone, if any, would be necessary to maintain the same magnitude and direction of the geostrophic winds?

- A. Increasing the pressure gradient
 - B. Decreasing the pressure gradient
 - C. Inverting the pressure gradient direction
 - D. Introducing a compensating friction
 - E. No change
26. The rate of groundwater flow Q is given by Darcy's law:

$$Q = -\frac{k}{\mu} \nabla P$$

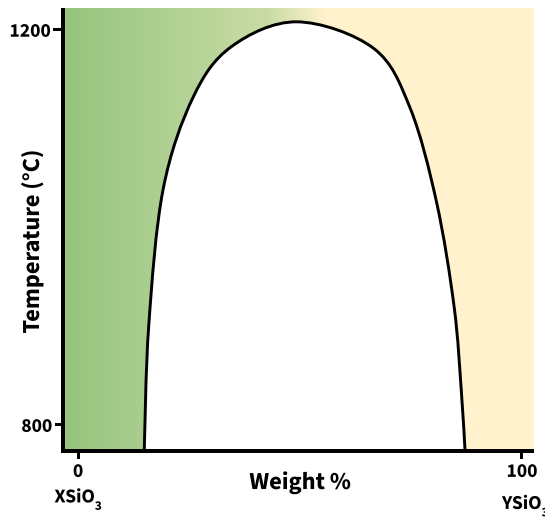
where k is the permeability of the material, μ is the viscosity of the fluid, and ∇P is the pressure gradient (equal to the change in pressure over a given distance).



The figure above shows three wells surrounded by cones of depression, regions where overpumping of groundwater has occurred. Which of the following statements correctly describe the environments of wells A, B, and C?

- I) Well A is pumping less water than well B
 - II) The ground surrounding well B has a higher permeability than the ground surrounding well C
- A. I only
 - B. II only
 - C. I and II
 - D. None

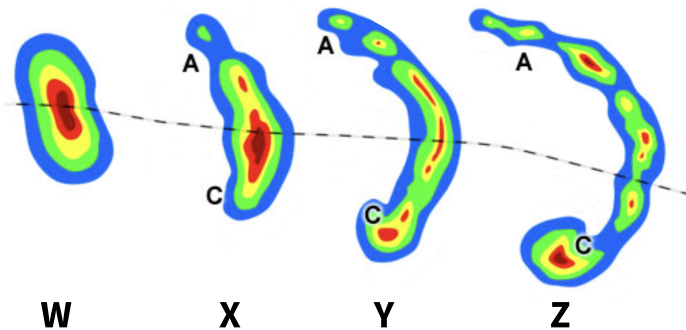
27. Show below is a temperature-composition diagram of a hypothetical solid solution series between endmembers $XSiO_3$ and $YSiO_3$, where X represents an ion with charge 2+ and ionic radius 0.91 Å and Y represents an ion with charge 2+ and ionic radius 0.73 Å.



Assume that the ionic radii of Y was instead 0.83 Å. Which of the following correctly describes the relative width of the miscibility gap and the probability of finding exsolution textures in minerals crystallized from magma of this altered solid solution?

- A. No change, greater
- B. Smaller, greater
- C. Smaller, smaller
- D. Greater, greater
- E. Greater, smaller

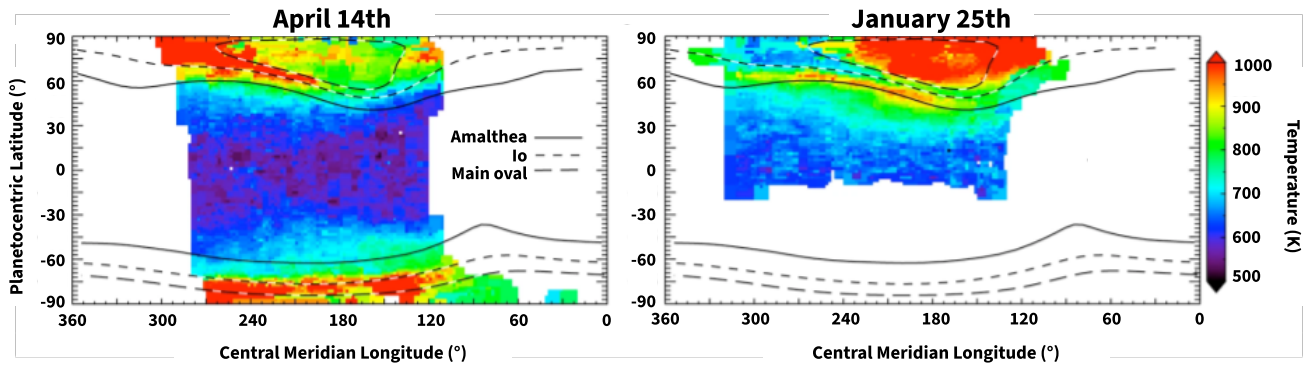
28. Certain arrangements of thunderstorms can produce a radar signature called a bow echo, which can morph into a comma echo over time. The figure below depicts a complex of thunderstorms (W) evolving into a bow echo (X and Y) and then into a comma echo (Z). The red shading indicates where the storm is most intense.



Which of the following accurately describes the evolution of the bow echo and the hemisphere in which the storm occurred?

- A. Cyclonic winds at A are weakened while anticyclonic winds at C are strengthened; Northern Hemisphere
- B. Anticyclonic winds at A are weakened while cyclonic winds at C are strengthened; Northern Hemisphere
- C. Cyclonic winds at A are weakened while anticyclonic winds at C are strengthened; Southern Hemisphere
- D. Anticyclonic winds at A are weakened while cyclonic winds at C are strengthened; Southern Hemisphere

29. Auroral heating on Jupiter plays an important role in the circulation of the planet's thermosphere. The figure below depicts the global distribution of Jupiter's upper atmosphere temperature on two dates; long-dashed lines show the main region of the aurora while short-dashed lines and solid lines show the magnetic influence of the moons Io and Amalthea, respectively.



Astronomers determine that the solar wind pressure was dramatically higher during the January 25th observations compared to the April 14th observations. Which of the following conclusions could be reasonably drawn from the data presented?

- A. The higher solar wind pressure on January 25th excited charged particles in Jupiter's atmosphere, creating warming at the equator
 - B. The higher solar wind pressure on January 25th caused a significant decrease in plasma emitted by Io, resulting in an increase in auroral heating
 - C. The higher solar wind pressure on January 25th caused an equatorward migration of Amalthea's magnetic footprint, resulting in a decrease in propagation of auroral heating throughout Jupiter's thermosphere
 - D. The higher solar wind pressure on January 25th compressed Jupiter's magnetic field, resulting in an equatorward propagation of auroral heating
30. The meandering channel of a slightly-stratified estuary has both a primary flow downstream as well as a secondary circulation that involves cross-channel flow in a helical pattern. A hydrologist determines that the secondary circulation developed due to centrifugal forces pushing the water surface toward the outer banks of meanders. Given this information, which of the following is/are true regarding the isohaline profiles of the estuary channel?
- I) Isohalines in the longitudinal profile of the estuary channel are oriented near-horizontal
 - II) Isohalines in the cross-sectional profile of a meander decrease in salinity toward the outer bank
- A. I only
 - B. II only
 - C. I and II
 - D. None

END OF MULTIPLE CHOICE