Written Test, Part 1 (3 hours)

Grading of Questions

Each question with only one correct answer will be scored as follows:
- if the correct answer is chosen: +1 point.
- if the incorrect answer is chosen: 0 point.
- if several answers are chosen: 0 point.

Each question where one or more correct answers possible will be scored as follows:
- each correct answer: +1 point.
- each incorrect answer: -0.5 point.
- if the combination of answers includes correct answers and incorrect answers, the minimum grade received is 0.

Introduction to questions 1 to 4:
Geological lines of evidence suggest that during the last glacial maximum (Pleistocene), 1/3 of the land surface was covered by glacial ice. The most recent glacial maximum event was 18,000 years ago and was considered to end ~10,000 years ago when the ice covered only 10% of the Earth's surface.

Q.1) Which of the following statements below is / are **correct**? (There might be more than one correct answer.)

a) The global ocean level during the Pleistocene was *higher* than that of the present day.
b) The global ocean level during the Pleistocene and that of the present day are *the same*.
c) The global ocean level during the Pleistocene was *lower* than that of the present day.
d) The global sea level was determined by the rate of ice melting.
e) The change in global ocean level was determined by the thickness of ice on continents.

Q.2) Which description below **best** describes a glacial deposit? (Only one correct answer.)

a) poorly sorted, moderately rounded particles; moderate graded bedding.
b) very poorly sorted, pebbles with very high angularity, angular and fine pebbles.
c) very poorly sorted, moderate angularity pebbles and rounded sand particles
d) moderately sorted, moderate angularity pebbles and rounded sand particles
e) well sorted, well rounded pebbles and moderately rounded sand and silt particles.

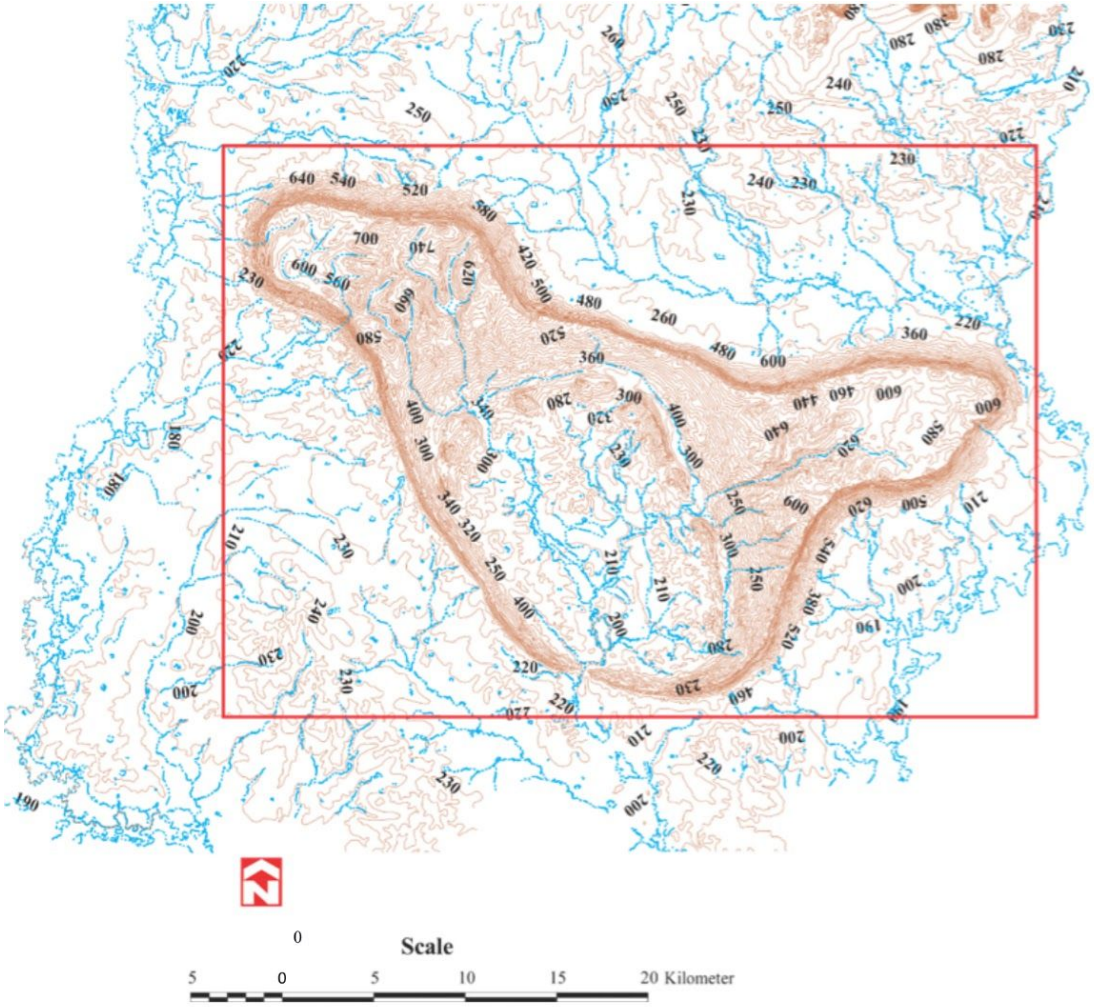
Q.3) When exploring an area, which of the following features might indicate the presence of a Pleistocene glacier? (There might be more than one correct answer.)

a) An Alpine type vegetation.
b) Parallel joints that can be seen on the surface.
c) Valleys full of snow.
d) Parallel scratches that can be seen on the surface.
e) V-shaped valleys.
f) Arctic weather.
g) U-shaped valleys.

Q.4) Which of the following statements is / are correct: (There might be more than one correct answer.)

a) The melting of glaciers is the result of a change in the Earth’s temperature.
b) The melting of glaciers influences the Earth’s temperature.
c) The melting of glaciers influences the hydrosphere.
d) The melting of glaciers will cause global cooling.
e) The melting of glaciers will increase global warming.

Q.5) The topographic map below shows spot elevations in meters of a morphological feature developed in a subtropical climate. What is the geological structure inside the red rectangle? (There might be more than one correct answer.)



a) Volcanic crater
b) Meteorite impact crater
c) Erosional anticline
d) Erosional syncline
e) Plateau

Introduction to questions 6 to 8:

A small, open cave is found within carbonate rocks. It is located right on the erosional bank of the river. The cave floor is paved with travertine and tufa of a few tens of centimeters thickness; the maximum height of the roof is around 3.5 meters. In the wet season, the cave floor is ~ 20 meters higher than the water level in the river. In the dry season, however, the difference between them increases to ~ 25 meters.

The characteristic structures of the cave, including stalactite, stalagmite and other types of cave formations (speleothems), can easily be observed. Breathing near the cave entrance is easy; however, 60 meters from the cave entrance, where it narrows down, it is both difficult to pass through and breathe. Breathing is nearly impossible near the cave floor due to the presence of a certain gas. The concentration of this gas seems to increase from the cave roof towards the cave floor.

A simple method has been used to identify this gas, and here are the findings:

(i) A flame cannot be lit using a lighter at or near the cave floor. But at or near the cave roof, a flame could be lit and the flame burned nicely.

(ii) When the lighter with the flame was moved downward slowly, the flame tended to move away from the lighter. The gap between the lighter and the flame progressively increased. Finally the flame extinguished at the cave-floor.

Q.6) Considering the setting and all the factors involved, this gas is probably (Only one correct answer.):

a) NO_2
b) He
c) SO_2
d) CO_2
e) CO

Q.7) When is the gas concentration most likely to increase? (Only one correct answer.)

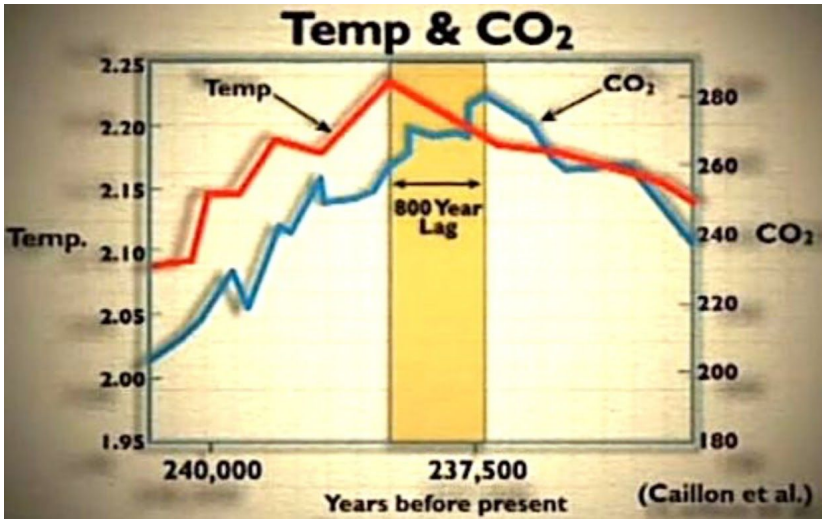
a) All year round.
b) The first six months of the year.
c) Mainly in the dry season.
d) Mainly in the wet season.
e) At random times.

Q.8) Which of the following statements is correct in relation to the heavier gas in the cave? (Only one correct answer.)

a) The appearance of this gas in the cave is the result of human activity.
b) The appearance of this gas in the cave is the result of only the hydrosphere - geosphere interaction.
c) The appearance of this gas in the cave is the result of only the atmosphere - hydrosphere - geosphere interactions.
d) The appearance of this gas in the cave is the result of direct interactions between the biosphere - hydrosphere - geosphere.
e) The appearance of this gas in the cave is the result of direct interactions between the atmosphere - biosphere - hydrosphere - geosphere.

Introduction to question 9:

The graph below shows the change in temperature (degree centigrade) and atmospheric carbon dioxide (CO_2) concentration (ppm) during a warm interglacial period.



Q.9) Which of the statements below best explains the 800-year lag in the graph above? (Only one correct answer.)

a) CO_2 is not the climate driver that many people think it is. If it was, the maximum CO_2 concentration would either occur at the same time as the maximum temperature, or precede it.
b) The oceans of the Earth act as a buffer for both temperature and CO_2 levels in the atmosphere.
c) Change in total plant respiration caused this lag of 800 years.
d) Changes in sea level caused this lag of 800 years.

Q.10) Which of the following statements are correct? (There might be more than one correct answer.)

a) The warming of the ocean waters increases carbonate dissolution.
b) The warming of the ocean waters decreases carbonate dissolution.
c) The warming of the ocean waters increases global warming.
d) The warming of the ocean waters decreases global warming.
e) The warming of the ocean waters decreases sedimentation of carbonates in the ocean.
f) The warming of the ocean waters increases sedimentation of carbonates in the ocean.

Q.11) Which of the following statements might explain why during ice ages there were more desert areas on the Earth's surface than there are today? (There might be more than one correct answer.)

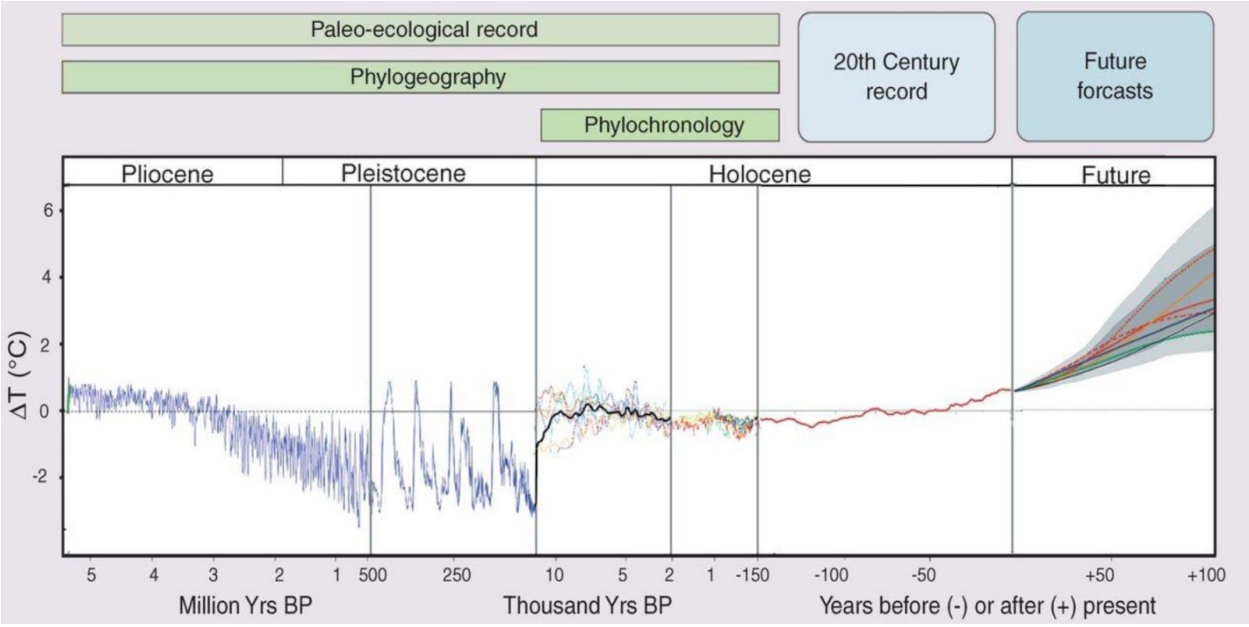
a) During those periods Earth's atmosphere held less water vapor.
b) During those periods the amount of precipitation on Earth was less than today.
c) During those periods there was less evaporation in cooler areas.
d) During those periods there was less evaporation directly from the oceans.

Q.12) Which of the statements below is the most correct explanation? (Only one correct answer.)

a) Increased desertification of the Earth tends to raise the local albedo, making the region warmer.
b) Increased desertification of the Earth tends to lower the local albedo, making the region warmer.
c) Increased desertification of the Earth tends to raise the local albedo, making the region colder.
d) Increased desertification of the Earth tends to lower the local albedo, making the region colder.

Use the graph below for questions 13 and 14.

The x-axis shows the time, B.P stands for "Before present". The y-axis shows temperature anomaly relative to the average temperature in the past 150 years.



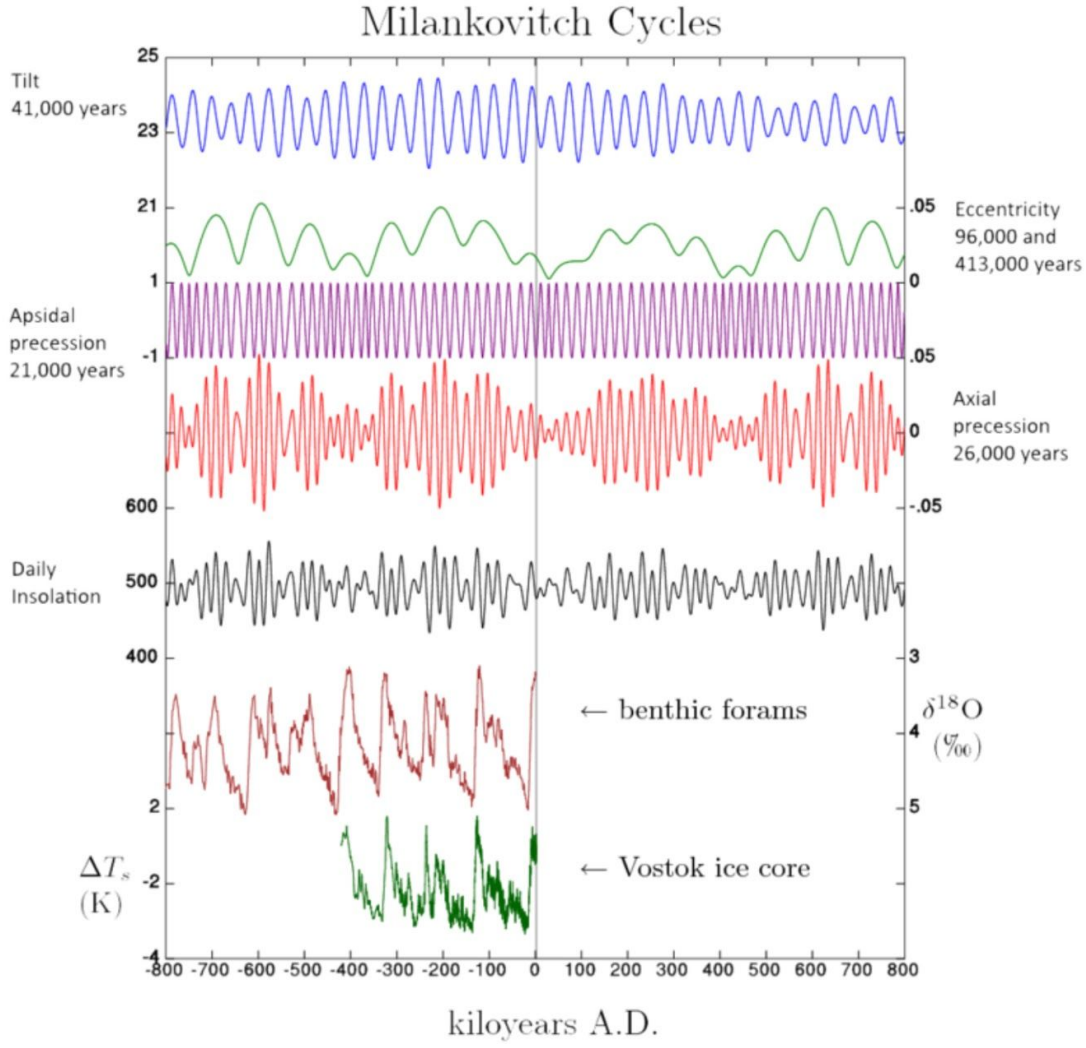
Q.13) Which of the following statements best explains the previous graph? (There might be more than one correct answer.)

a) There were periods between ice ages that were warmer than the average temperature of the past 150 years.
b) Ice ages end faster than they start.
c) Ice ages start faster than they end.
d) The general trend for the past 5 million years has been global cooling.

Q.14) Which of the following statements best explains the previous graph? (There might be more than one correct answer.)

a) During the past two million years, ice ages lasted longer than warm periods between them.
b) During the last two million years, warm interglacial periods have lasted longer than ice ages.
c) Considering the past two million years, ice ages will never occur again on Earth.
d) The change in temperature during the next 100 years will probably be up to 4 degrees Celsius warmer than the past century average.

Q.15) Using the Milankovitch Cycles chart below, which of the following statements is the best interpretation of temperature fluctuations? (Only one correct answer.)



a) For the past 400,000 years, the Earth's temperature has fluctuated with a ~25,000-years cycle.
b) For the past 400,000 years, the Earth's temperature has fluctuated with a ~50,000-years cycle.
c) For the past 400,000 years, the Earth's temperature has fluctuated with a ~75,000-years cycle.
d) For the past 400,000 years, the Earth's temperature has fluctuated with a ~100,000-years cycle.

Introduction to question 16.
According to the standard solar model, about 4 billion years ago, the sun's energy output was only 70% of its current level. If all other variables were the same as the present day conditions, this would have resulted in a totally frozen planet. The geological record shows a relatively warm surface with liquid water at that time.

Q.16) Which of the following statements might explain Earth's warmer (than expected) climate 4 billion years ago? (There might be more than one correct answer.)

a) There were more greenhouse gases in the early atmosphere.
b) In the past, the geothermal heat emitted from the decay of radioactive isotopes was considerably greater than it is today.
c) The moon was much closer to the Earth billions of years ago, and therefore, produced considerably more tidal heating.
d) Lack of vegetation caused a higher planetary albedo.
e) Less continental area billions of years ago caused a lower planetary albedo.

Introduction to questions 17 and 18.
The photo below is a visible light image of Enceladus, a moon of Saturn.

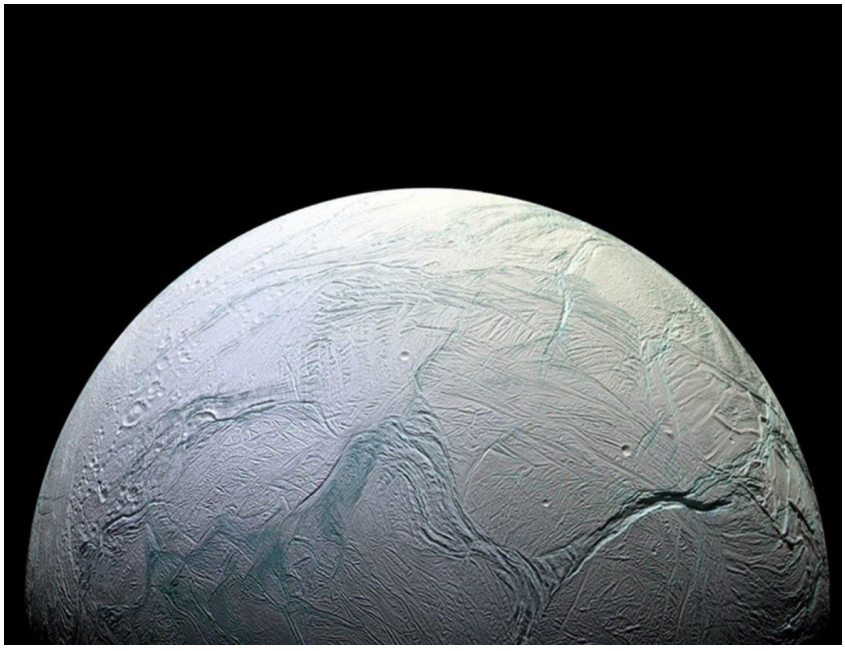


Figure Q.17: The dimension of Enceladus is 513.2 km x 502.8 km x 496.6 km

Q.17) What can be learnt from the observable surface structures of Enceladus? (There might be more than one correct answer.)

a) The crust of Enceladus is active.
b) The crust of Enceladus is static.
c) There are crustal plate boundaries on Enceladus.
d) There have been recent meteorite impacts on Enceladus.
e) There is no evidence of recent meteorite impacts on Enceladus.
f) There is a hydrologic system on Enceladus.

Q.18) What could be a reasonable explanation for the localized temperature differences on the surface of Enceladus? (There might be more than one correct answer.)

a) Variability of energy intensity of solar radiation in relation to latitude.
b) Enceladus' atmosphere trapping heat energy.
c) Crustal formation processes release heat from depth into some areas.
d) Areas of crustal subduction are colder than areas of crustal spreading.

Q.19) The photo below is an image of the sand dunes on the surface of Mars. Which of the following offers a reasonable interpretation of this image? (There might be more than one correct answer.)

Figure Q.19: The scale across the bottom of the photo is about 4 km.

a) Winds blew from the right hand side of the photo.
b) Winds blew from the left hand side of the photo.
c) Aeolian erosional processes are active on the surface of Mars.
d) Water-based erosional processes are active on the surface of Mars.
e) Aeolian depositional processes are active on the surface of Mars.
f) Mars used to, but no longer has, an atmosphere.
g) Water-based depositional processes are active on the surface of Mars.
h) Mars has an atmosphere.
i) Mars has a current hydrosphere.
j) Mars used to, but no longer has, an active hydrosphere.
k) Meteorite based erosional processes are active on the surface of Mars.
l) Mars' surface has experienced hydrosphere-geosphere interactions.
m) Mars' surface has experienced atmosphere-geosphere interactions.
n) Mars has layered subsurface stratigraphy.

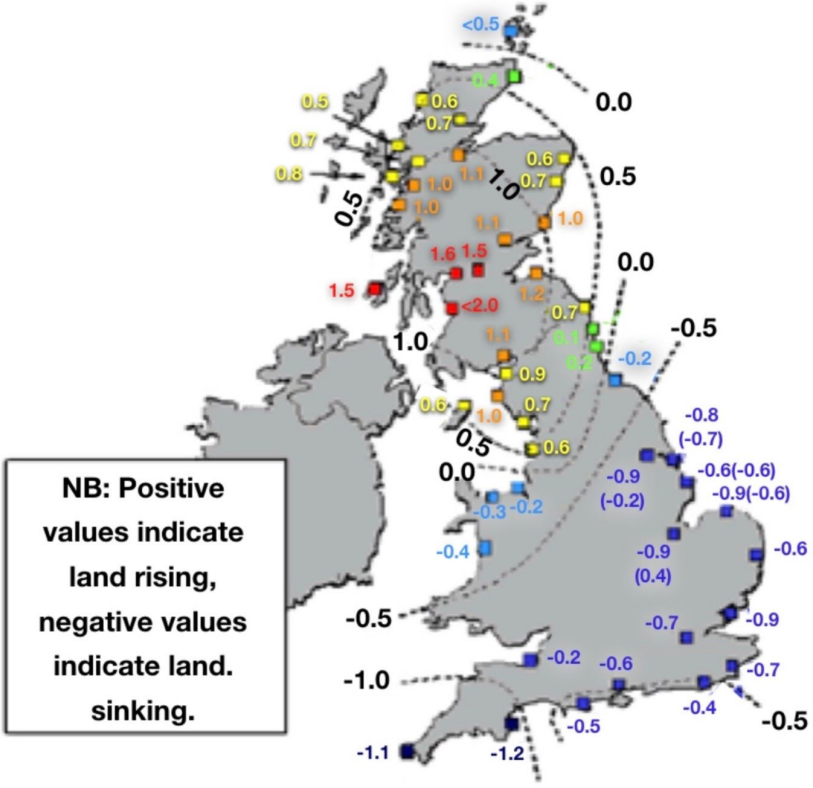
Q.20) The photo below is another image of the surface of Mars. Which of the following statements present a reasonable interpretation of this image? (There might be more than one correct answer.)

Figure Q.20: The scale across the bottom of the photo is about 2 km.

a) Winds blew from the right hand side of the photo.
b) Winds blew from the left hand side of the photo.
c) Aeolian erosional processes are active on the surface of Mars.
d) Aeolian depositional processes are active on the surface of Mars.
e) Mars used to, but no longer has, an atmosphere.
f) Mars has a current hydrosphere.
g) Mars used to, but no longer has, a significant hydrosphere.
h) Water-based erosional processes were/are active on the surface of Mars.
i) Water-based depositional processes are active on the surface of Mars.
j) Meteorite-based erosion processes are active on the surface of Mars.
k) Mars has layered subsurface stratigraphy.

Introduction to questions 21-22:

Given below is an elevation map of Great Britain. It presents the rates of crustal elevation changes (in mm / year). Negative values indicate rates of sinking and positive values rates of uplift (or land rising). Analysis of this data shows that changes in elevation are remarkably rapid over a large area.



Q.21) Which of the following statements presents the best explanation for this regional elevation change? (Only one correct answer.)

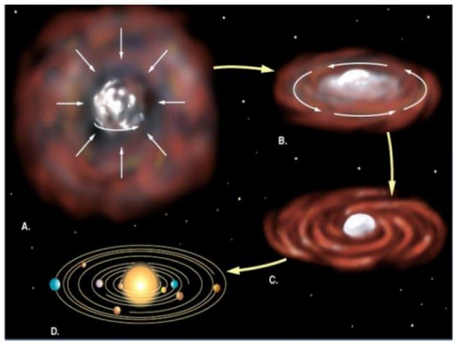
a) Tectonic activity caused by an active plate margin.
b) England is located above a mantle hot spot.
c) Changes in nearby sea level affecting land elevation.
d) Return to isostatic equilibrium of the crust after the last ice age.

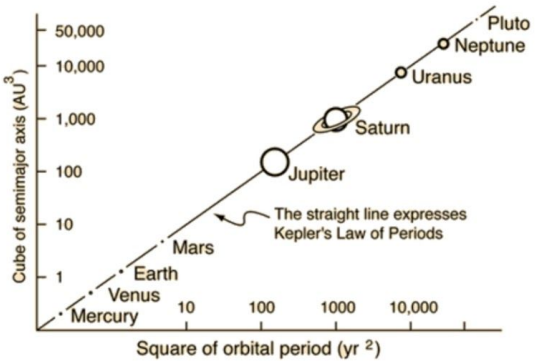
Q.22) Which of the following presents the best explanation for the area that is sinking? (Only one correct answer.)

a) The sinking area is located near a subduction zone.
b) The sinking area is the result of isostasy phenomenon.
c) The area sank as the sea level was rising faster there.
d) This area sank as groundwater pumping caused regional subsidence.

Introduction to question 23:
The left hand side figure below demonstrates the formation and evolution of the Solar System that began 4.6 billion years ago with the gravitational collapse of a small part of a giant molecular cloud. Most of the collapsing mass collected in the center, forming the Sun, whereas the rest flattened into a protoplanetary disk, out of which the planets, moons, asteroids, and other small bodies of the Solar System formed.

Kepler's laws of planetary motion describe the motion of planets around the Sun. The right hand side graph below shows the relationship between the average distance of a planet and its orbital period, which is Kepler's third law.



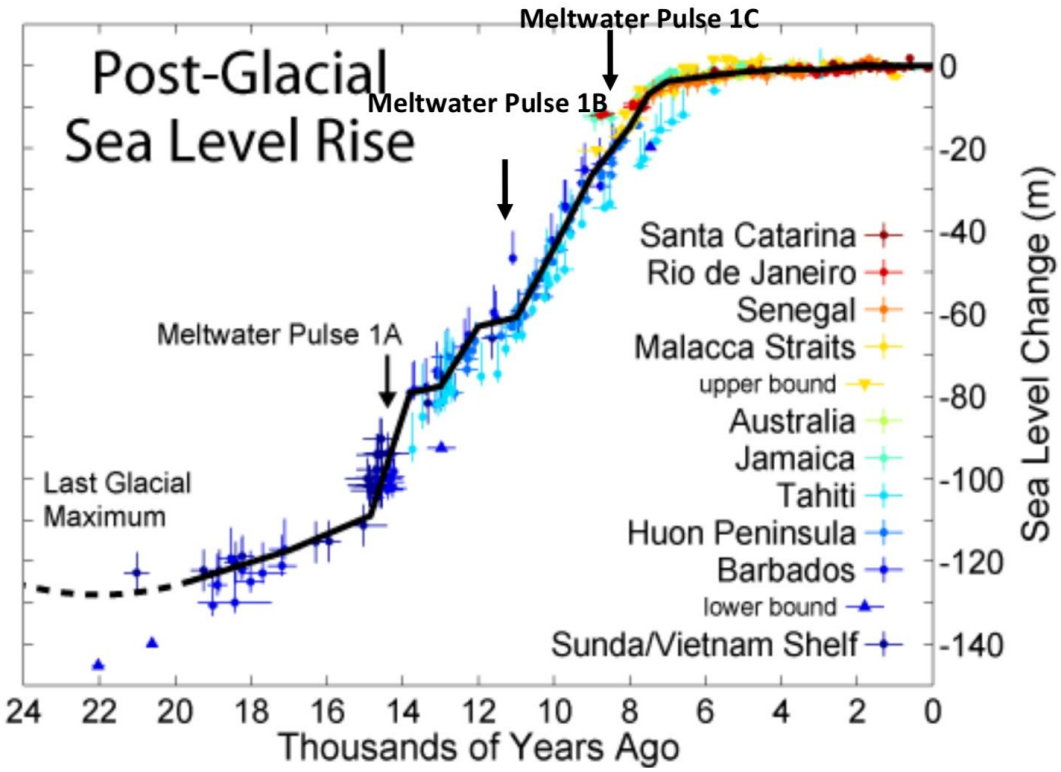


Q.23) Which of the following statements might serve as a reasonable interpretation of the data provided above? (There might be more than one correct answer.)

a) All the planets in the solar system orbit in the same direction.
b) The direction of axial rotation of the sun is the same as the direction of orbital motion of the planets.
c) The direction of axial rotation of all planets in the solar system is in the same direction as their orbital motion.
d) Planets farther from the sun have longer orbital periods.
e) An asteroid with an average orbital distance of 2 AU will orbit slightly faster than Mars.

Introduction to questions 24-25:
The graph below presents the global sea level rise data for the past 24,000 years. The data indicate a melt-water pulse of 13.5 m rise over 290 years about 14,200 years ago (1A) and another melt-water pulse of 7.5 m rise over 160 years about 11,000 years ago (1B).

In sharp contrast, during the period 14,300-11,100 years ago, which includes the Younger Dryas interval, there was an interval of reduced rate of sea level rise of about 6.0-9.9 mm/yr. Then, a melt-water pulse about 8,000 years ago (1C) indicates a rise of 6.5 m in less than 140 years.



Q.24) Which of the following statements describes correctly the above graph and the information provided above? (There might be more than one correct answer.)

a) Sea level has been relatively stable for the past 6,000 years.
b) Sea level has been rising rapidly over the past 6,000 years.
c) Sea level started to rise gradually at the end of the last glacial maximum until 14,000 years ago.
d) During the past 20,000 years the rate of sea level rise has been very consistent.
e) The rate of sea level rise has exceeded 4 meters per 100 years several times in the past 20,000 years.
f) The rate of sea level rise has exceeded 10 meters per 100 years several times in the past 20,000 years.

Q.25) Which of the following statements best explains why periods of rapid sea level rise have occurred in the past 24,000 years? (Only one correct answer.)

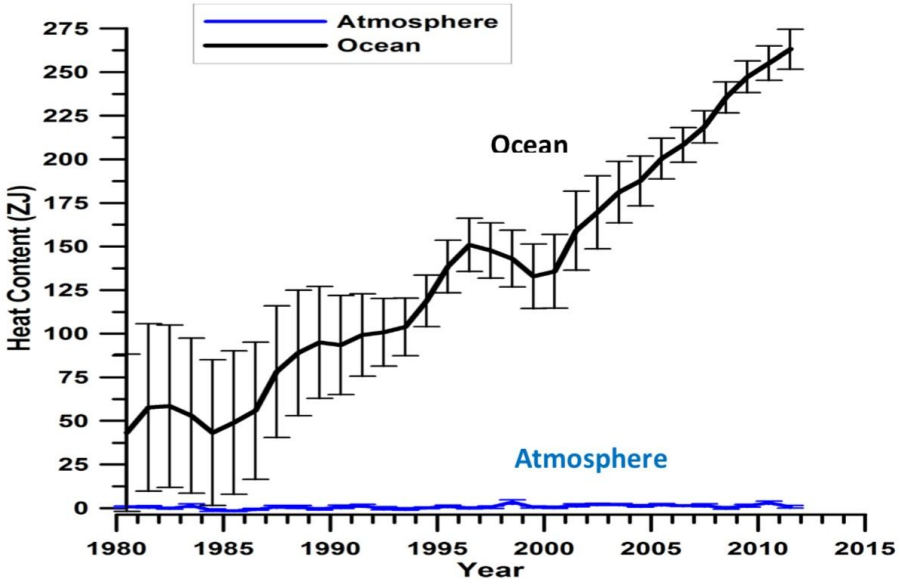
a) Fast melting of ocean ice.
b) Periods of rapid warming of ocean waters.
c) Release of glacial melt water into the ocean.
d) Melting of ice shelves already floating on the ocean water.

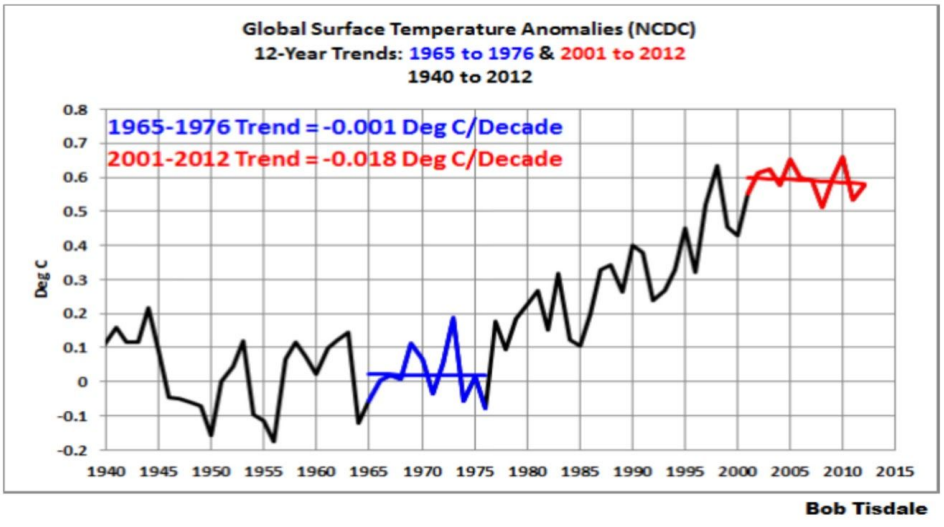
Introduction to question 26:

The two graphs below relate to climatic changes in the Earth's atmosphere and oceans.

The top figure presents the annual ocean (black) and atmosphere (blue) heat content between 1985 and 2015. Note that the unit ZJ on the y-axis is 10^{21} joules.

The bottom graph presents the average global temperature as a function of time (1940-2015). The red and blue sections show specific time intervals.





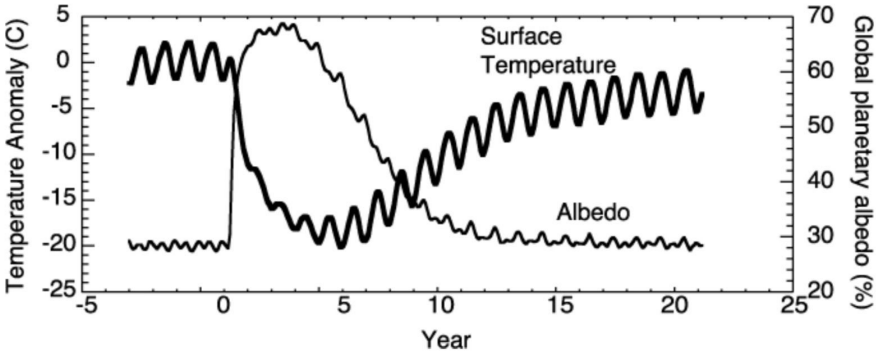
Q.26) Which of the following statements present a reasonable interpretation based on the two graphs above? (There might be more than one correct answer.)

a) Both graphs show a general trend of increased heat and temperature in the atmosphere and hydrosphere.
b) Both graphs do not show a general trend of increased heat and temperature in the atmosphere and hydrosphere.
c) During the time interval of 1980-2012, the vast majority of the energy increase in the earth system occurred in the hydrosphere.
d) During the time interval of 1980-2012, the vast majority of the energy increase in the earth system occurred in the atmosphere.
e) When the temperature of the atmosphere decreased, the heat in the oceans decreased.
f) When the temperature of the atmosphere decreased, the heat in the oceans increased.

Introduction to questions 27-28:

The Toba volcano, located in Indonesia, erupted about 75,000 years ago. At least 2,800 km^3 (or about 7 x 10^{15} kg) of magma erupted, of which 800 km^3 were deposited as ash fall. This huge eruption changed the planetary albedo.

The graph below presents a model of the inter-relationships between the global planetary albedo and the surface temperature anomaly as a function of time. Time "0" indicates the time of eruption.



Q.27) Which of the following statements might be a reasonable explanation for the planetary albedo changes following the eruption of Toba? (There might be more than one correct answer.)

a) A layer of volcanic ash covering a large land area.
b) The ash providing condensation nuclei, thus increasing the cloud cover.
c) The ash providing condensation nuclei to decrease the cloud cover.
d) Large amounts of volcanic sulfur dioxide in the atmosphere raising the albedo.
e) The drop in temperature caused an increase in snow cover.

Q.28) Which of the following statements might be a reasonable explanation for restoring the global albedo level to its pre-(Toba) eruption levels? (There might be more than one correct answer.)

a) Vegetation started to grow on the ash.
b) The ash fell out of the atmosphere.
c) The sulfur dioxide was flushed out of the atmosphere.
d) The changes in on-ground snow cover returned to normal.

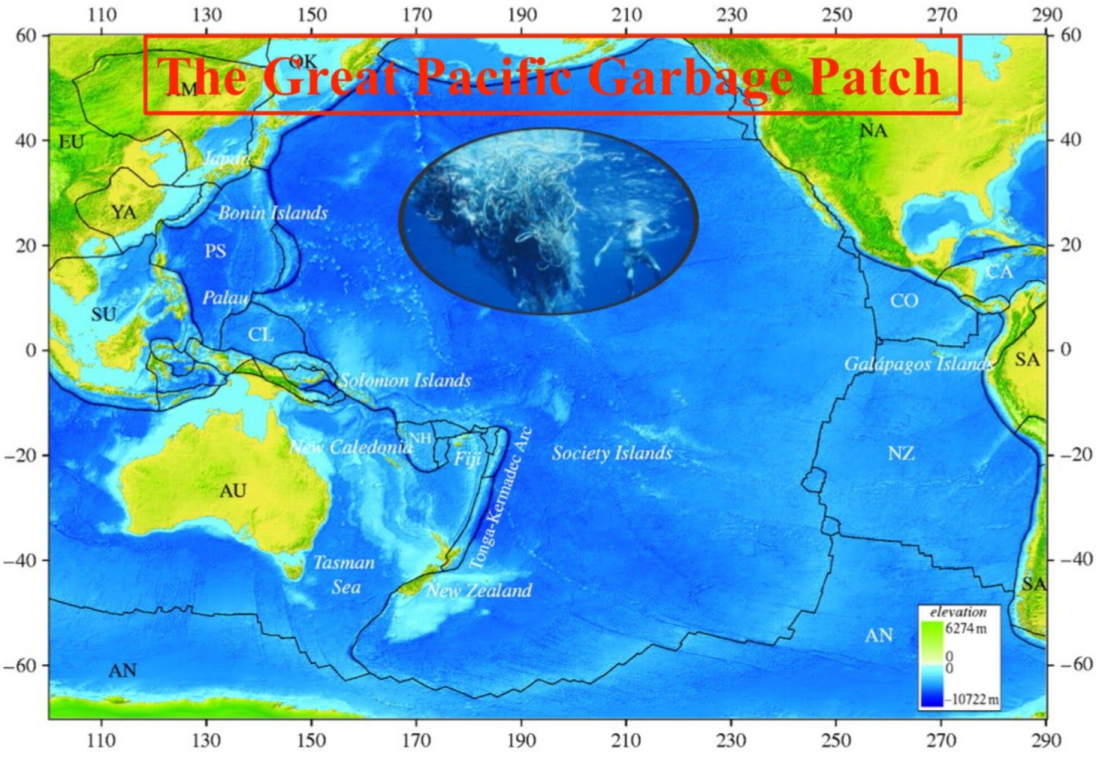
Q.29) Following the oceans getting warmed over the next 100 years, there will be less sea ice for much of the year near the North Pole. Which of the following possibilities is most likely following this process? (Only one correct answer.)

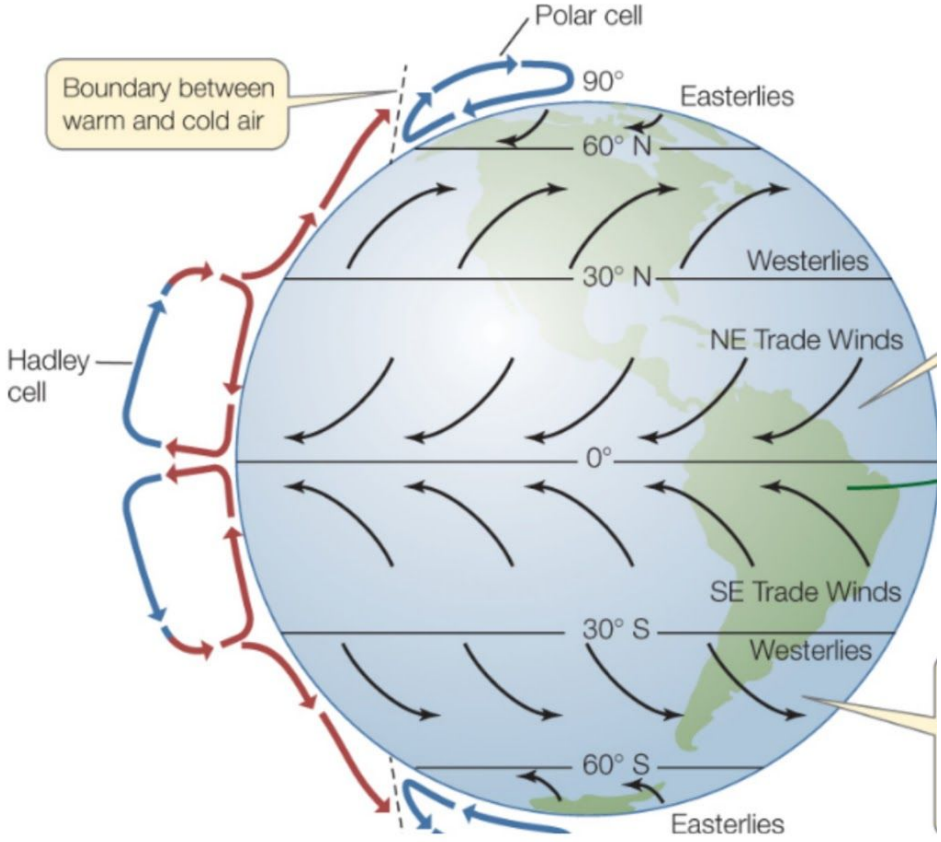
a) accelerated global warming because more energy will be absorbed.
b) slow global warming because less energy will be absorbed.
c) no impact on the rate of climate change.
d) not possible to say how this will impact climate in the future.

Introduction to questions 30 and 31:

The top figure indicates the location of the Great Pacific Garbage Patch (GPGP). This patch is a collection of marine debris in the central North Pacific discovered between 1985 and 1988. It is located from ~ 135 - 155°W and 35 - 42°N. The collection of plastic, floating trash halfway between Hawaii and California, extends over an indeterminate area of widely varying range depending on the degree of plastic concentration used to define the affected area.

The lower figure shows the general pattern of an atmospheric circulation, which is organized into three cells in each hemisphere: the Hadley cell, the Ferrell cell, and the polar cell. The bulk of atmospheric motion occurs in the Hadley cell. High pressure systems acting on the Earth's surface are balanced by low pressure systems elsewhere. As a result, there is a balance of forces acting on Earth’s surface.


The Great Pacific Garbage Patch
110
130
150
170
190
210
230
250
270
290
60
40
20
0
−20
−40
−60
OK
JM
EU
Japan
YA
Bonin Islands
PS
Palau
SU
CL
Solomon Islands
New Caledonia
NH
Fiji
Tonga-Kermadec Arc
Society Islands
AU
Tasman Sea
New Zealand
AN
NA
CA
CO
Galápagos Islands
SA
NZ
elevation
6274 m
0
0
−10722 m


Polar cell
Boundary between warm and cold air
90°
Easterlies
60° N
Westerlies
30° N
NE Trade Winds
Hadley cell
0°
SE Trade Winds
30° S
Westerlies
60° S
Easterlies

Q.30) From the above charts, which of the following statements might serve as a reasonable interpretation of the existence of the Great Pacific Garbage Patch at the location shown in the top chart? (There might be more than one correct answer.)

a) The garbage patch was created by the North Pacific gyre.
b) The garbage patch cannot be created in the Atlantic and Indian Oceans.
c) The garbage patch will gradually become smaller over time.
d) The garbage from land traveled along ocean currents and gathered in one place.

Q.31) Which of the following statements are correct? (There might be more than one correct answer.)

a) The currents in the North Pacific Ocean are related to the Northeast trade winds and Westerly winds.
b) The Westerlies create ocean currents going from east to west.
c) The reason why the path of the Northeast Trade Wind and Westerly Wind are bent is because the earth rotates.
d) The Hadley cell moves south through the Northern Hemisphere in the summer.
e) At 30°N, a low pressure system is formed.
f) The general atmospheric circulation and ocean currents serve to transport energy.

Introduction to question 32:

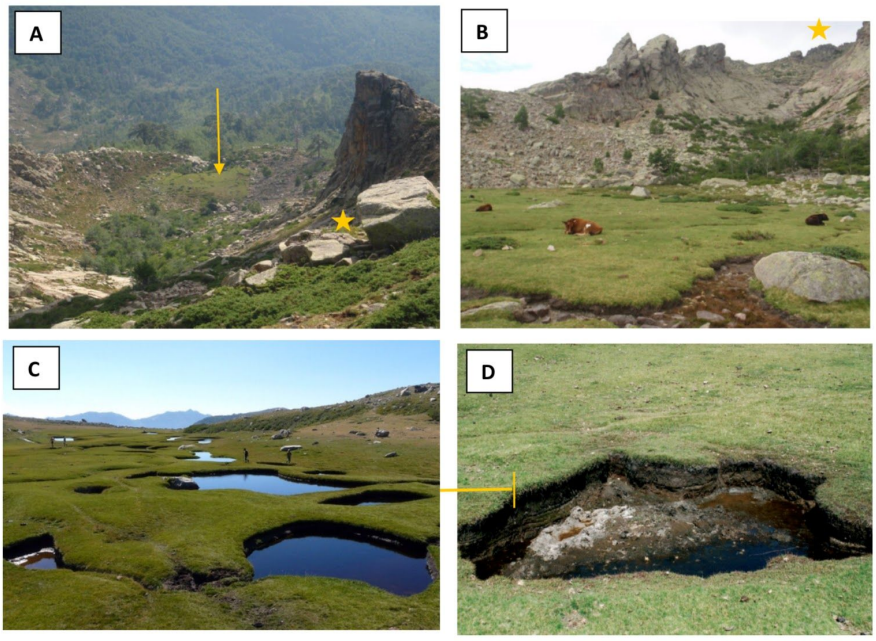
The four photos (A-D) below were taken in Corsica. They present landscapes with different morphologies.

Photo (A) Viewpoint on the top of the pass (yellow star).

Photo (B) Viewpoint on the bottom of the mountain pass.

Photo (C) Landscape on the bottom of the mountain corresponding to the yellow arrow in photo A.

Photo (D) A close-up of photo C.



Q.32) Based on the information provided above, which of the following statements are correct regarding the landscape morphology? (There might be more than one correct answer.)

a) The landscape has been formed by interactions between atmosphere, hydrosphere and geosphere.
b) The landscape has been formed by an interaction only between atmosphere and geosphere.
c) Moraines can be found on the edge of the valley.
d) The morphology of the trough valley indicates erosion by a river.
e) It is likely that a glacier was there during the last glaciation.

Introduction to question 33:

There are two varieties of black pine in Corsica. Picture A presents the *Pine de Corse* (*Pinus nigra corsicana*) and Picture B presents the *Pine de Calabre* (*Pinus nigra calabrica*).

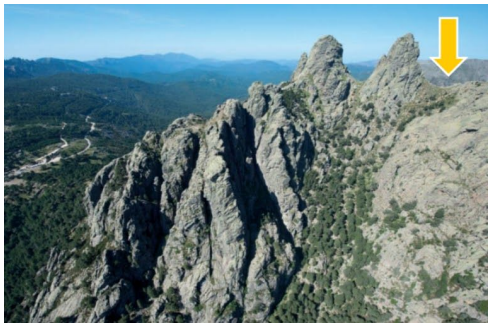
Pine de Corse (Picture A) needs the following conditions: **temperature**: 9-13°C, **altitude**: 900-1800 m, **precipitation**: 800-1200 mm/year, **soil**: felsic igneous-derived soil. It does not tolerate hydromorphic soil (a soil often saturated with water).

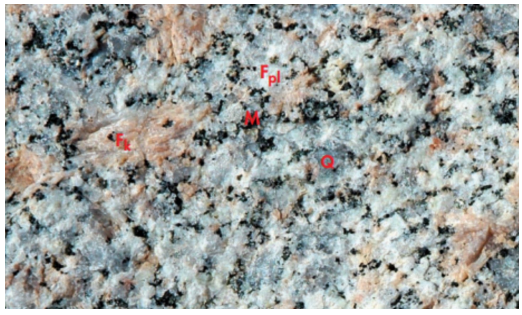
Pine de Calabre (Picture B) needs the following conditions: **temperature**: 0-9°C, **altitude**: 900-1800 m, **precipitation**: 800-1200 mm/year, **soil**: calcareous soil. It tolerates hydromorphic soil.

Photo A : 

Photo B : 

Picture C (left) is a panorama of a specific area of Corsica. Picture D (right) is the photo of a slide of the rock that makes up the higher sharp morphology (marked by the yellow arrow in picture C).





Q = quartz, M = biotite mica, F_k = potassium feldspar, F_{pl} = plagioclase feldspar.

Q.33) Based on the information given above, which of the following statements is correct regarding the black pine of Corsica? (Only one correct answer.)

a) The Pine de Corse variety is likely found in the higher area of picture C.
b) The Pine de Calabre variety is likely found in the higher area of picture C.
c) The higher area of picture C is a suitable environment for growing Pine de Calabre because of the soil there.
d) Both varieties of black pine can be found in a karstic system.

Written Test, Part 2 (2 hours)

Grading of Questions

Each question with only one correct answer will be scored as follows:
- if the correct answer is chosen: +1 point.
- if the incorrect answer is chosen: 0 point.
- if several answers are chosen: 0 point.

Each question where one or more correct answers possible will be scored as follows:
- each correct answer: +1 point.
- each incorrect answer: -0.5 point.
- if the combination of answers includes correct answers and incorrect answers, the minimum grade received is 0.

Introduction for questions 34-41:

On February 8, 2018, the concentration of fine particulate matter (PM) in the atmosphere reached unhealthy levels in many areas of Bangkok. Fine particles 2.5 microns or less in diameter have reached concentrations of 63-82 micrograms per cubic meter of air, which is well above the safe level of 50 micrograms per cubic meter.

Unhealthy levels were recorded at four air quality monitoring stations in Bangkok. Pollution is a big problem in an urbanized area like Bangkok, but through regulation, the pollution can be brought down to safe levels.

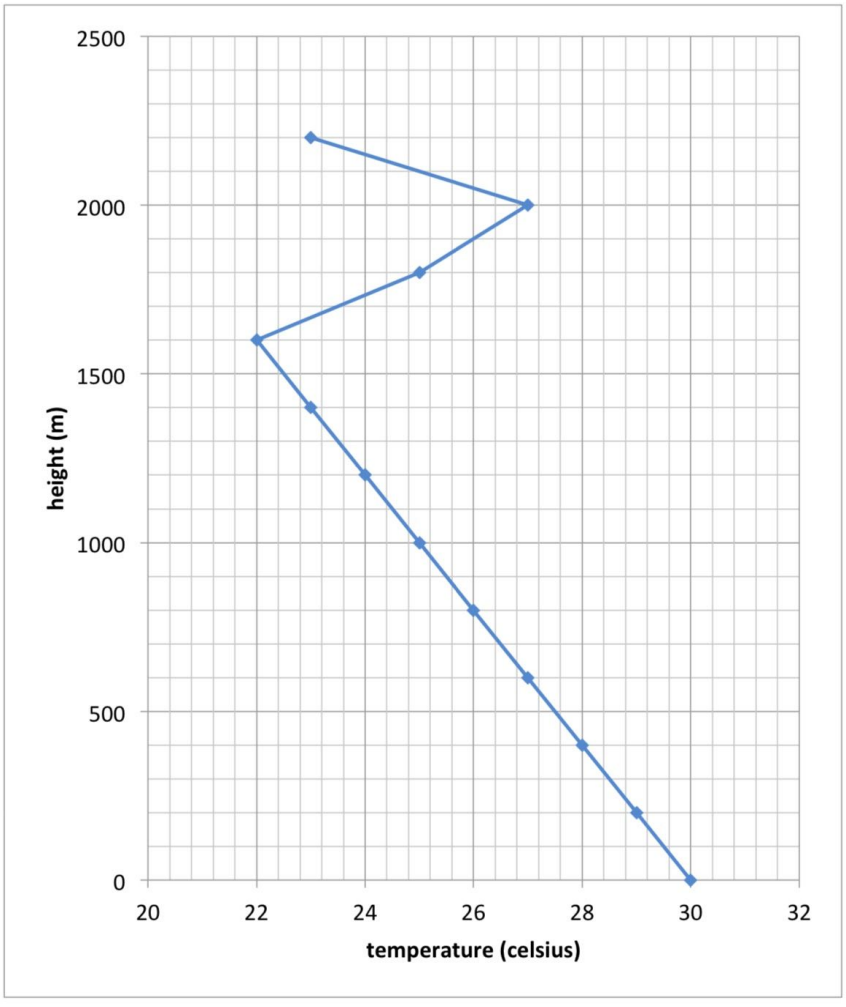
Q.34) Let the dry adiabatic lapse rate be 10 degrees Celsius/km, and the temperature of the polluted air parcel upon being released from a car or a factory, 35 degrees Celsius. What will its temperature be at a height of 2 km? (Only one correct answer.)

a) 25 degrees Celsius.
b) 15 degrees Celsius.
c) 10 degrees Celsius.
d) 5 degrees Celsius.
e) 0 degrees Celsius.

Use the table and graph below to answer questions 35 to 36.

The following table and graph show the temperature of the environment at different heights. The dry adiabatic lapse rate is 10 degrees Celsius/km.

Height (m)	Temperature (^{o}C)	Height (m)	Temperature (^{o}C)
0	30	1200	24
200	29	1400	23
400	28	1600	22
600	27	1800	25
800	26	2000	27
1000	25	2200	23



Q.35) Using the dry adiabatic lapse rate from question 34, what is the highest altitude to which the polluted air parcel of 35 degrees Celsius most likely to rise up? (Only one correct answer.)

a) 200 m
b) 600 m
c) 1000 m
d) 1200 m
e) 1600 m
f) 2000 m

Q.36) During mid-summer, the ground is heated up along with the polluted air parcel. If the temperature of the polluted air parcel at the ground level is 40 degrees Celsius, using the dry adiabatic lapse rate given in Q34, what is the highest altitude to which the polluted air parcel in the last question most likely to rise up to? (Only one correct answer).

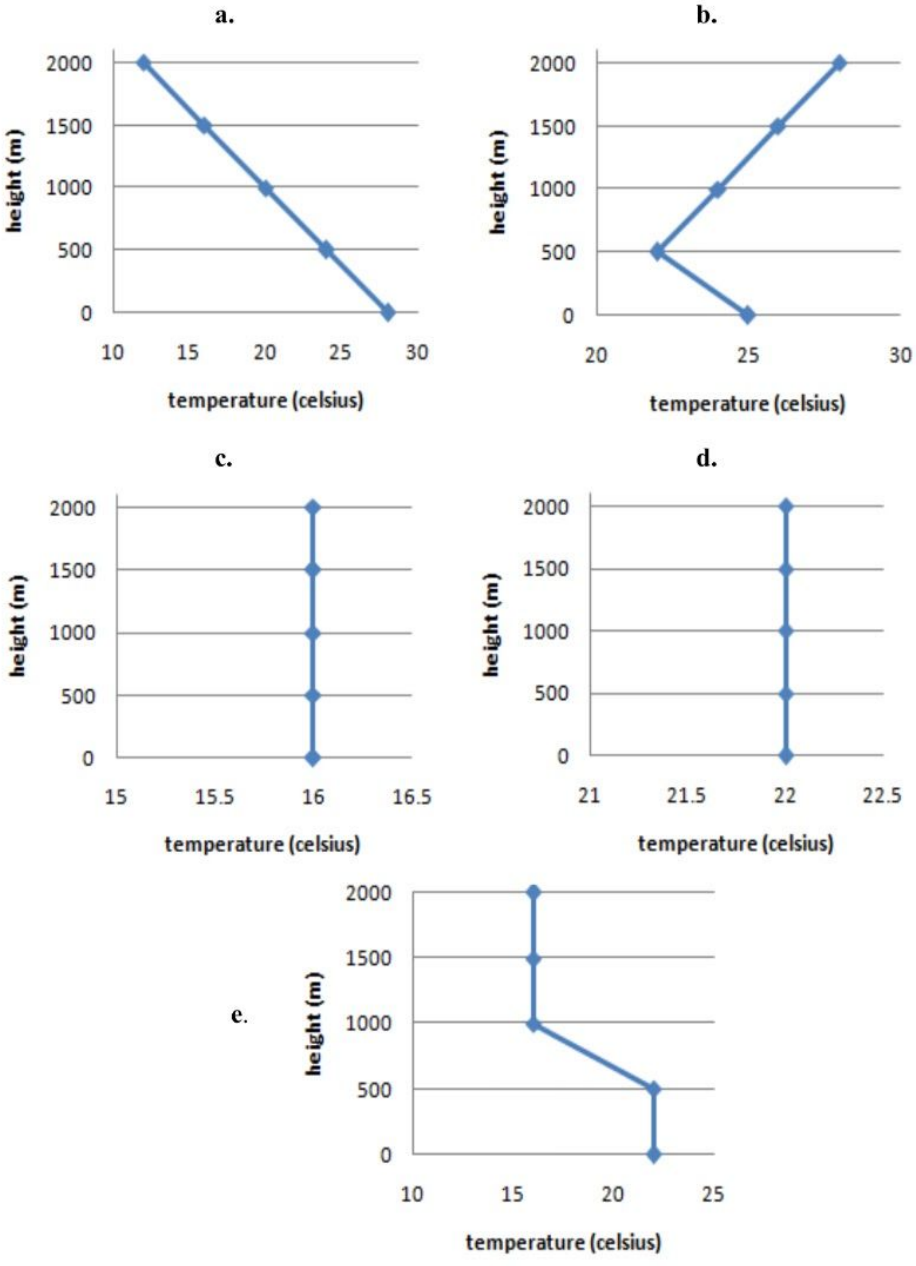
a) between 1200 m and 1400 m
b) between 1400 m and 1600 m
c) between 1600 m and 1800 m
d) between 2000 m and 2200 m
e) above 2200 m

Q.37) Consider a hypothetical situation when the temperature of the polluted air parcel at the ground is as high as 50 degrees Celsius. Using the dry adiabatic lapse rate given in Q34, what is the highest altitude to which the polluted air parcel in the last question most likely to rise up? (Only one correct answer).

a) between 1400 m and 1600 m
b) between 1600 m and 1800 m
c) between 1800 m and 2000 m
d) between 2000 m and 2200 m
e) above 2200 m

Q.38) Given below are five temperature profiles [Temperature in degrees Celsius (x-axis) plotted against height in meters (y-axis)]. Which temperature leads to the most severe case of pollution?

a) Temperature profile a
b) Temperature profile b
c) Temperature profile c
d) Temperature profile d
e) Temperature profile e



Q.39) Considering the temperature profile of question 38, what time of day is air pollution the most severe? Assume that the pollution emission remains constant. (Only one correct answer.)

a) 12am - 3am
b) 5am - 8am
c) 12pm - 3pm
d) 4pm - 7pm
e) 9pm - 12am

Q.40) In addition to reducing emissions, what else can we do to reduce the surface concentration of pollutants locally? (There might be more than one correct answer.)

a) Releasing the polluted air parcel at a temperature higher than 30 degrees Celsius.
b) Releasing the polluted air parcel at a temperature lower than 30 degrees Celsius.
c) Releasing the polluted air parcel from a smokestack taller than 80 meters.
d) Releasing the polluted air parcel from a smokestack shorter than 80 meters.

Q.41) In a tropical country like Thailand, at what time of the year is the problem of pollution at its worst, given that the source of pollution is constant throughout the year? (Only one correct answer.)

a) The middle of summer.
b) The middle of winter.
c) Around the time the cool air mass moves in to replace the moist air mass.
d) Around the time the hot air mass moves in to replace the cool air mass.
e) Around the time the moist air mass moves in to replace the hot air mass.

Use the map of the planet Mars to answer questions 42 - 43:

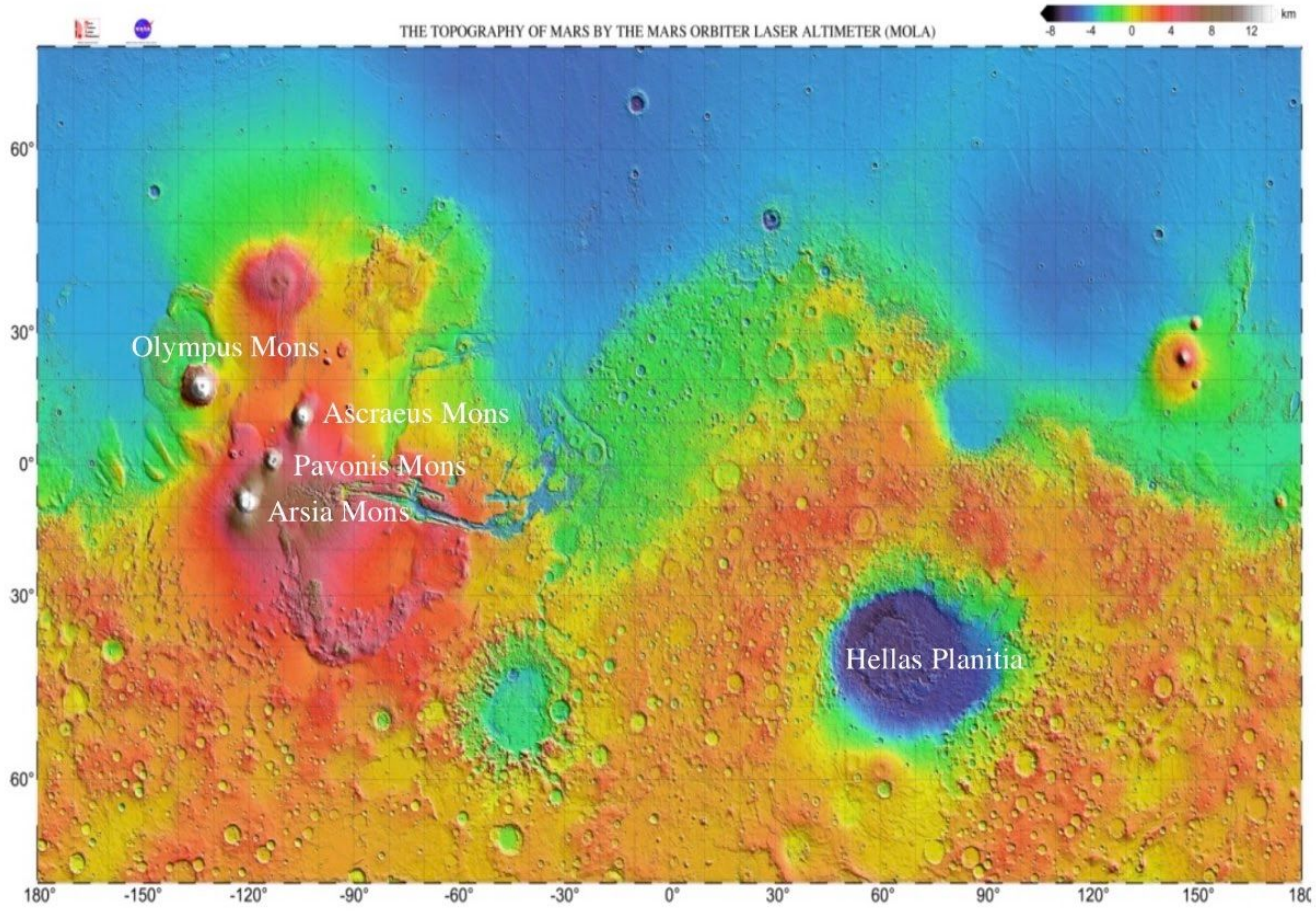


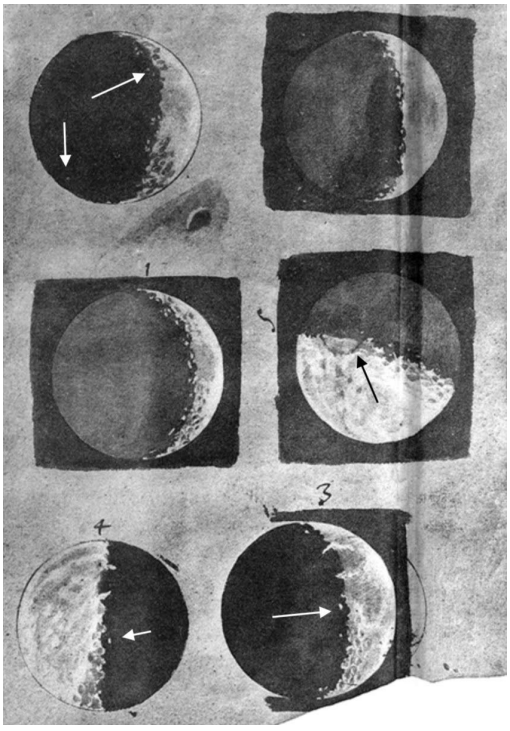
Figure: The global topography of Mars. (Credit: The Mars Orbiter Laser Altimeter)

Q.42) Which is **NOT** the reason that Mars has more craters than Earth? (Only one correct answer.)

a) There has been little or no water on the Martian surface for a long time.
b) Martian atmosphere is much thinner than that Earth's.
c) The Earth is bigger than Mars.
d) Mars orbits the Sun much closer to the inner edge of the asteroid belt.

Q.43) Olympus Mons is the highest planetary mountain and volcano in the Solar System. It stands about two and a half times as tall as Mount Everest on Earth. Arsia Mons, Pavonis Mons and Ascraeus Mons are also taller than Mount Everest.
What is the following statements might explain the phenomenon described above? (Only one correct answer.)

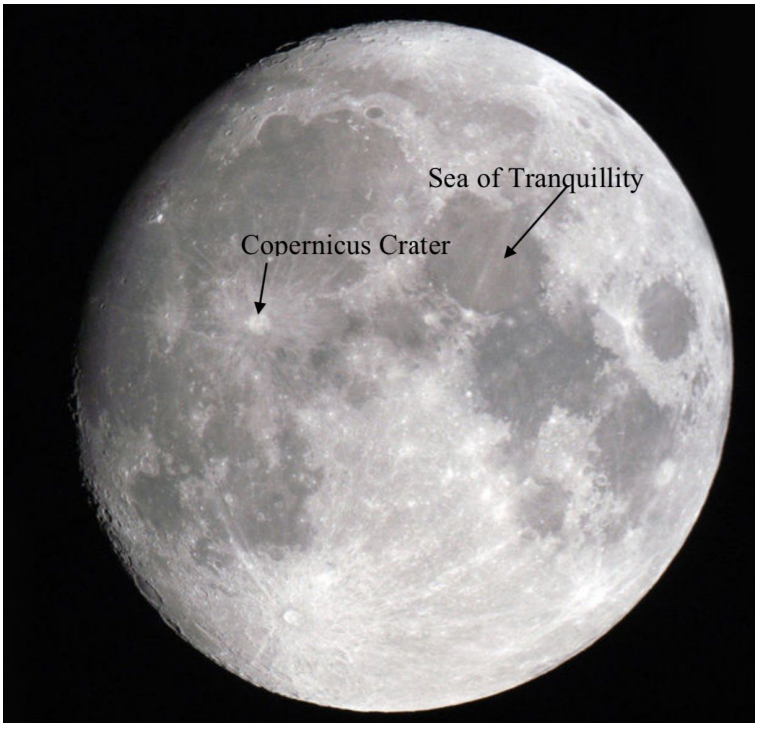
a) The lower gravity on Mars allows the formation of volcanoes higher than on Earth.
b) Earth has a larger moon than Mars.
c) The difference in mantle composition between the Earth and Mars permits the formation of Olympus Mons.
d) The solar wind erosion on Mars is intense.



Q.44) The drawings of the Moon above were drawn by Galileo Galilei. Note the lighter spots on dark areas (marked by white arrows) and the dark circle inside the light area (marked by a black arrow). Galileo saw the lighter spots growing through the month and concluded that they should be mountains and that the dark circle (one of a few that he discovered) is a shadow inside lower topography.
Following Galileo's work, which of the following phenomena contributes to the *monthly* phases of the Moon? (Only one correct answer.)

a) The Earth obstructs the light from the Sun and is thus casting a shadow on the Moon.
b) The Moon’s rotation about its axis creates the monthly phases.
c) The lunar orbit around the Earth creates the monthly phases.
d) The Earth’s orbit around the Sun creates the monthly phases.

Introduction to question 45:



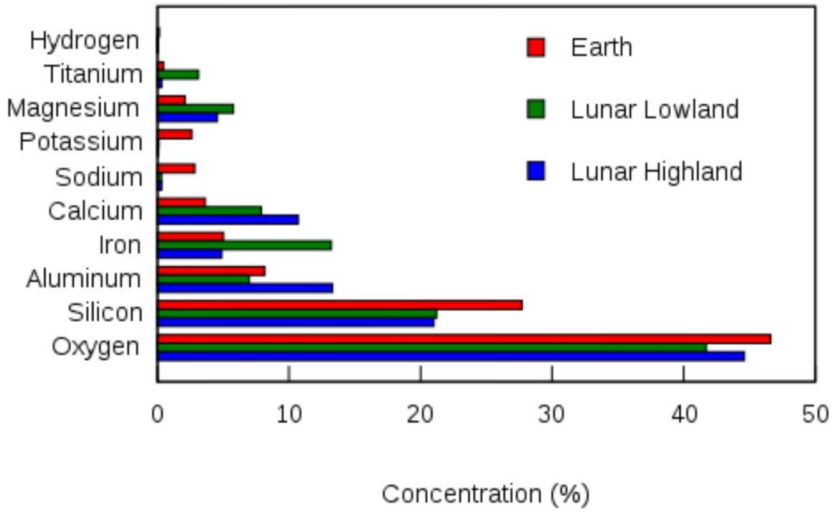
Q.45) Given above is a modern photograph of the near side of the Moon, constantly facing the Earth. It highlights the multiple craters scattered on its surface (Copernicus Crater is marked as an example). One may also notice there the distinction between the lighter surfaces, known as highlands, and the darker ones, known as lowlands or seas (Sea of Tranquility is marked as an example). Comparing to Galileo's time, we also know today that the average density of the Moon is 3.344 g/cm^3 (about 60% of the Earth's mean density) and that the Moon's gravity is about 1/6 of the Earth's gravity.
Which of the following statements best explains why only one side of the moon is visible from the Earth? (Only one correct answer.)

a) The time the Moon orbits around the Earth is equal to the time of rotation about its axis.
b) The other side of the Moon is made of low albedo rocks.
c) Only one side of the Moon faces the sun.
d) The density and gravity of the Moon influence its rotation and orbit.

Q.46) Which of the following explains the abundance of craters on the Moon relative to Earth? (Only one correct answer.)

a) The lack of the lunar atmosphere.
b) The intense magnetic field of the Earth directly shields meteoritic impacts.
c) The Moon's low density attracts space objects.
d) The Moon's orbit passes through more meteoroids than Earth's orbit.

Composition of Elements on Lunar Highlands, Lunar Lowlands, and Earth's crust:



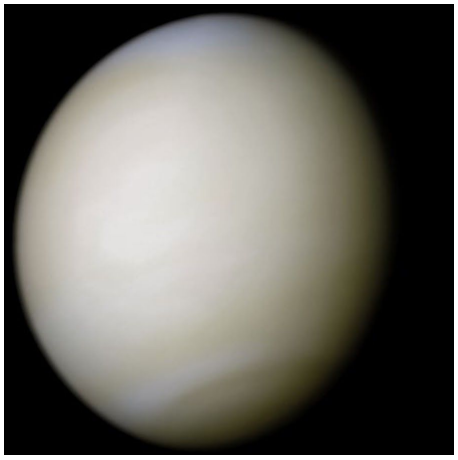
Q.47) The above graph shows the elemental composition of the Moon's lowland and highland surface rocks and Earth surface rocks. In relation to the data provided above, which of the following statements below are correct? (There might be more than one correct answer.)

a) The high iron concentration of the Moon's lowland indicates that it contains a high amount of iron-bearing sandstones.
b) The high iron concentration of the Moon's lowland indicates that it mostly contains basalts.
c) The different elemental composition of the Moon's lowland in relation to iron, magnesium, and titanium indicates that it contains rock or rocks that do not exist in the other two areas.
d) The different elemental composition of the Earth in relation to potassium and sodium indicates that it contains rock or rocks that do not exist on the surface of the Moon.
e) The higher concentration of aluminum and calcium in the Moon's highland area compared to the other areas indicates that, that area contains a high amount of carbonates and clays.
f) The low lunar concentrations of sodium and potassium elements shows that the degree of crustal differentiation on the Earth is higher than on the Moon.

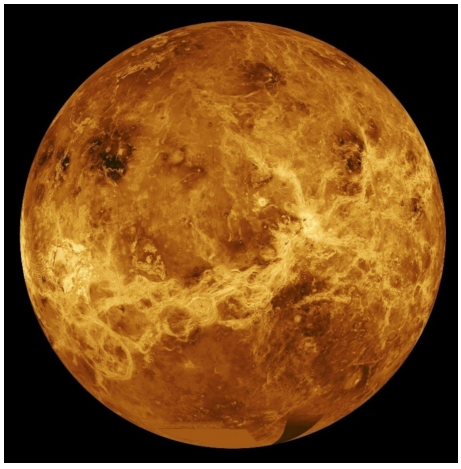
Q.48) What could be the reason(s) for the absence of a magnetic field on the Moon although the lowland rocks have weak remnant magnetism? (There might be more than one correct answer.)

a) The Moon's source has a much lower iron content compared to the Earth, thus not allowing it to create a global magnetic field.
b) The Moon's low density suggests that the concentration of iron in the Moon's core is not enough to maintain a magnetic field.
c) The gravitational field of the Moon weakens its magnetic field.
d) The Moon rapidly cooled because of its size and this influenced the amount of liquid iron in the core.

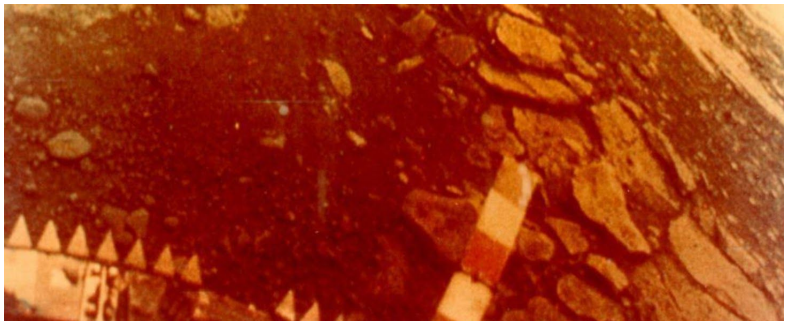
Q.49) The visible light photograph of Venus shown below was taken by the Mariner-10 spacecraft. It shows the thick, mostly CO_2 atmosphere of the planet.



The photograph below is a radar image of the surface of Venus obtained by the Magellan spacecraft in the 1990s.

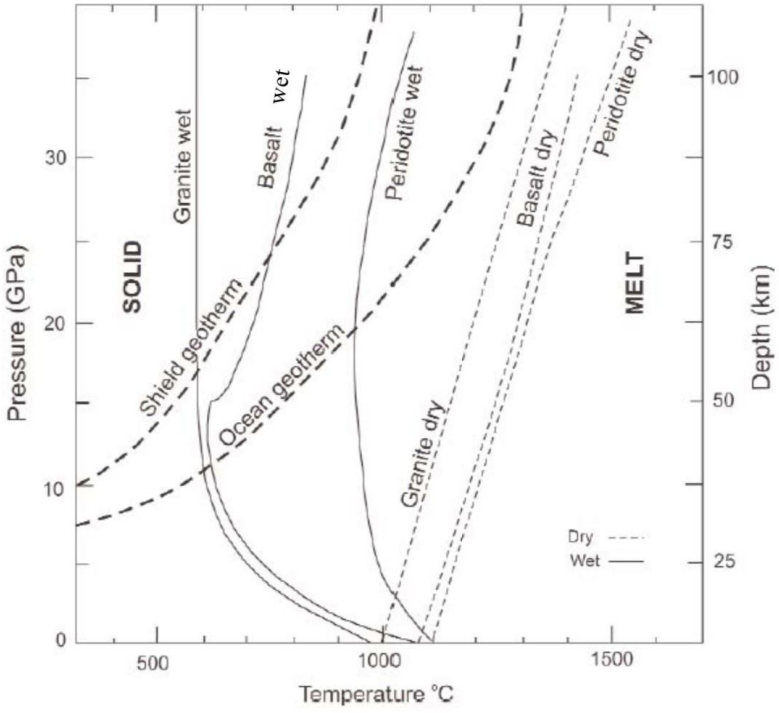


Lighter shades indicate elevated surfaces and dark shades lower surfaces. This image highlights the scarcity of craters on Venus compared to the moon.
The photograph below was obtained by the Venera-13 spacecraft, showing the basaltic surface of Venus.



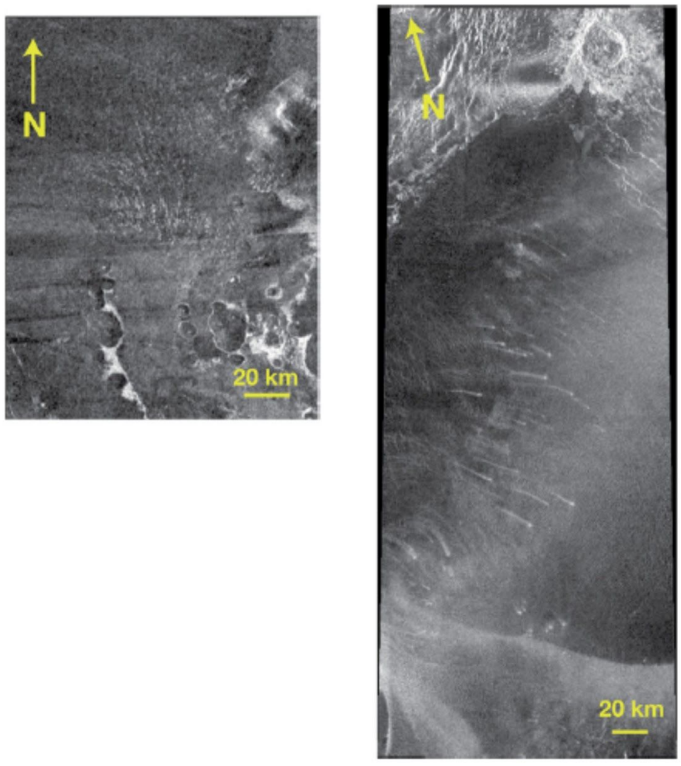
Based on the information contained in three images above, which of the following statements might explain the scarcity of impact craters on Venus? (There might be more than one correct answer.)

a) The thick atmosphere of Venus influences the surface of Venus.
b) The orbit of Venus does not cross regions rich in asteroids.
c) Erosional processes on the Venusian surface obscured past craters.
d) Igneous activity covered ancient craters.
e) Interactions between Venus' magnetosphere and atmosphere.



Q.50) The atmosphere of Venus contains mainly CO_2 with virtually no water in it. The graph presented above is a phase diagram illustrating the effects of water on magma genesis. Assume that Venus mantle rock is anhydrous. Following the information given above, what are possible mechanisms that can initiate igneous activity on Venus? (Only one correct answer.)

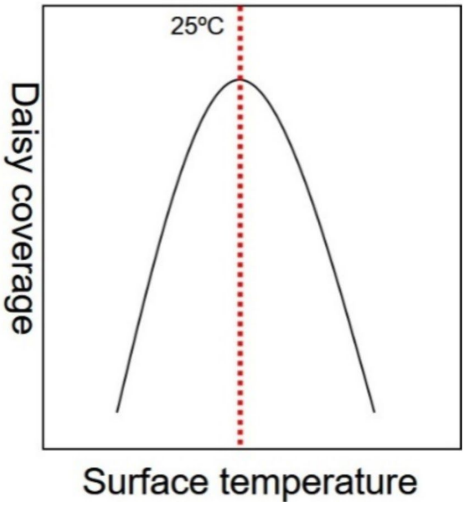
a) Subduction of tectonic plates.
b) Heating that releases water.
c) Comets that frequently hit Venus.
d) Decompressed basalt material in a plume.



Q.51) The photos shown above were taken by the Magellan spacecraft, showing sand dunes on Venus. The lighter shades denote dune crests/fronts. Based on the information presented above and in the previous questions, what would be the expected composition of the sand-sized grains? (Only one correct answer.)

a) Basaltic
b) Quartz
c) Clay minerals
d) A mixture of quartz and basalt grains

Introduction to questions 52-54:
The Gaia hypothesis proposes that living organisms interact with their living environments and form a self-regulating system. In the Gaia hypothesis, the surface of the Earth is covered with white daisies and black soil. Albedo (reflectivity of the planet's surface, e.g. 0.4 means that 40% of the solar energy is reflected back to space, while the Earth retains 60%). For white daisies and black soil the albedo are 0.7 and 0.3 respectively. The daisy flowers have an optimum temperature of 25°C (i.e., planet with the largest daisy coverage). The relationship between the daisy coverage and the surface temperature is shown in the figure below:



Q.52) Assume that the initial surface temperature was 20°C. A temperature increase of 6°C will cause ___ (Only one correct answer.)

a) the surface temperature to be stable at 26°C.
b) the daisy flowers coverage to increase.
c) the daisy flowers coverage to decrease.
d) all daisy flowers to die out.

Q.53) Assume that the initial surface temperature was 30°C. A temperature increase of 1°C will cause ___ (Only one correct answer.)

a) the temperature to be stable at 31°C.
b) the temperature to return to 30°C.
c) all daisy flowers to die out.
d) the daisy flower coverage to increase.

Q.54) Assume that the initial surface temperature was 20°C and the temperature will decrease by 5°C. Which of the following possibilities will NOT likely happen? (There might be more than one correct answer.)

a) The planet will reach a new state of equilibrium with a surface temperature of 15°C.
b) Daisy coverage will decrease.
c) The planet will absorb more solar radiation.
d) All the daisies will die out.

Q.55) With the evolution of vascular land plants, forests begin to cover the surface of continents since the Late Paleozoic (~350 Ma), before which the continents were covered by sand. One direct consequence of vegetation on continents is the change of the albedo: the albedo of a sandy desert is 0.4 and that of a forest is 0.15. Which of the following statements is true? (Only one correct answer.)

a) The Earth has absorbed more solar radiation after 350 million years ago.
b) The Earth has absorbed less solar radiation after 350 million years ago.
c) The entire system will collapse because the temperature was too high.
d) The entire system will collapse because the temperature was too low.

Q.56) Based on the facts given in Q55, assume that oceans cover 70% of the Earth's surface with an albedo of 0.1 whereas the continents account for the remaining 30%. After the continents were covered by forests, which of the following statements is correct? (Only one correct answer.)

a) Solar radiation absorbed by the Earth's surface increased by 7%.
b) Solar radiation absorbed by the Earth's surface decreased by 7%.
c) Solar radiation absorbed by the Earth's surface increased by 30%.
d) Solar radiation absorbed by the Earth's surface decreased by 30%.

Q.57) Diamictite is a non-sorted to poorly sorted sediment, containing particles that range in size from clay to boulders, suspended in a matrix of mudstone or sandstone.
Geologists have discovered numerous diamictites in India, Australia and South Africa from the Late Carboniferous to the Early Permian, suggesting the occurrence of glaciation. Which of the following statements is correct? (There might be more than one correct answer.)

a) Glaciation was triggered by a decreased absorption in solar radiation due to the evolution of forests.
b) Glaciation was enhanced by an increase in photosynthesis of forest vegetation.
c) The atmospheric CO_2 level might have decreased.
d) India, Australia and South Africa were located near the southern polar region during the Carboniferous.

Q.58) The Carboniferous is the earliest and one of the most important periods of coal formation. Which of the following statements describes the potential impact of massive coal formation on the Earth system? (There might be more than one correct answer.)

a) Coal formation was the consequence of forest evolution.
b) Coal formation was triggered by glaciations.
c) Coal formation caused a decrease in atmospheric CO_2.
d) Coal formation caused an increase in atmospheric O_2.

Q.59) Another characteristic of the Carboniferous is the occurrence of giant insects, such as the giant dragonfly of 1-meter size. What might have been one of the reasons for the gigantic nature of the insects? (Only one correct answer.)

a) High temperature
b) Low temperature
c) High O_2 level in the atmosphere
d) Low CO_2 level in the atmosphere

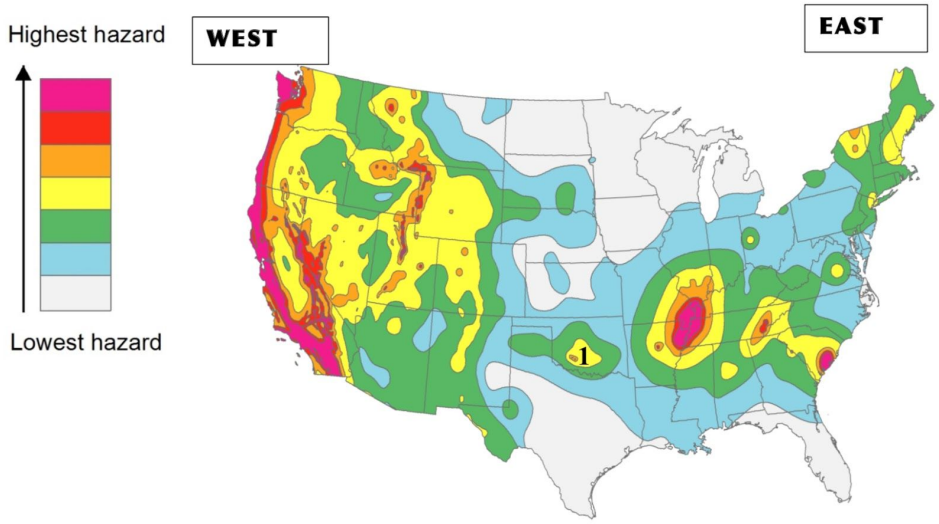
Introduction to question 60:
Bauxite is a residual rock with a relatively high aluminum content. Carbonate bauxites are formed by the lateritization of clays deposited within carbonates and later concentrated by carbonate dissolution prior to lateritization. Lateritic bauxites are found mainly in tropical regions by the intense weathering of silicate rocks that removes almost all minerals except hydrous aluminum oxides. The Carboniferous is also the age of the earliest depositional bauxite ore.

Q.60) Following the above, which of the following statements are correct? (There might be more than one correct answer.)

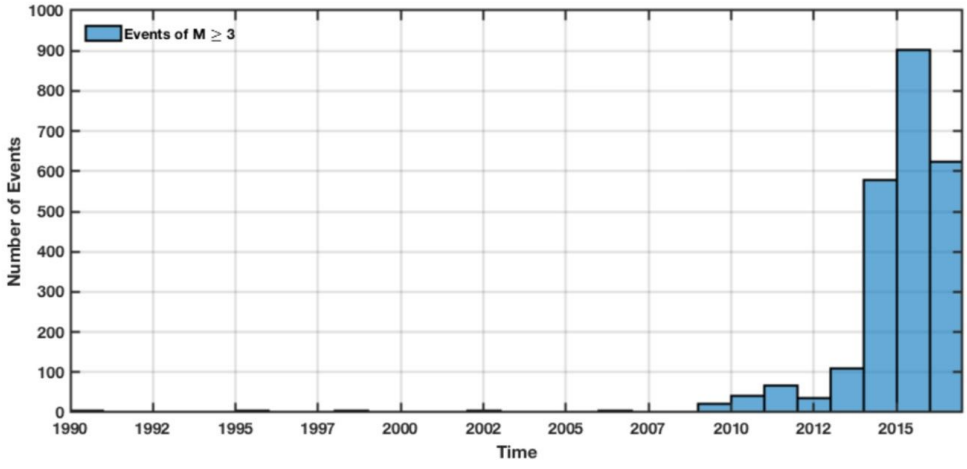
a) Vegetation played a key role in the formation of both types of bauxites.
b) Glaciation enhanced chemical weathering and may be responsible for bauxite formation.
c) The formation of carbonate bauxite is more dependent on the interaction with the biosphere than lateritic bauxites.
d) The formation of lateritic bauxite is more dependent on interaction with the biosphere than carbonate bauxites.
e) The formation of lateritic bauxite is more dependent on the interaction with the atmosphere than carbonate bauxites.
f) The formation of carbonate bauxite is more dependent on the interaction with the atmosphere than lateritic bauxites.
g) The existence of lateritic bauxite is a direct indication of a past tropical forest.

Introduction to question 61:

The map below shows the Long-Term Forecast of Seismic Hazards from the United States Geological Survey (USGS) for parts of the USA. The area marked by the number 1 is Oklahoma state. Oklahoma and Texas are well known for their oil and gas reservoirs. In 2007, the petroleum industry implemented hydraulic fracturing to increase rock permeability, thereby increasing the potential for oil production. The wastewater that is produced from this fracturing process is then pumped back into aquifers.



The Oklahoma Geological Survey has documented over 125 years of seismicity in the state. The graph below presents the number of seismic events greater than or equal to magnitude 3 that occurred between 1990-2017.



Q.61) Based on the data, which of the following statements are correct? (one or more correct answers possible).

a) Oklahoma State is located on an active plate boundary
b) The pattern of the high hazard zones from Oklahoma to the East coast indicates that the North American plate is moving from west to east.
c) The rise in seismicity in the state of Oklahoma is probably due to human activities.
d) The rise in seismicity in the state of Oklahoma is due to interaction among the four Earth systems (geosphere, hydrosphere, atmosphere and biosphere).
e) The rise in seismicity in the state of Oklahoma is due to interaction of only the geosphere and hydrosphere.
f) The rise in seismicity in the state of Oklahoma is due to interaction of only the geosphere and biosphere.
g) The rise in seismicity in the state of Oklahoma is due to interaction of only the geosphere, hydrosphere and biosphere.

Links to test (IESO 2018 Thailand, French version)

http://www.sciencesalecole.org/wp-content/uploads/2018/09/WT1-team_France.pdf
http://www.sciencesalecole.org/wp-content/uploads/2018/09/WT2-FR.pdf