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 evidence suggests that during the last glacial maximum (Pleistocene), 1/3 of the Earth's surface was covered with ice. The most recent event of maximum glaciation occurred 18,000 years ago, it ended about 10,000 years ago when ice covered only 10% of the Earth's surface.

Q.1) Which of the following is / are **correct**? (one or more correct answers possible).

a) The global ocean level during the Pleistocene was higher than it is today.
b) The global ocean level during the Pleistocene was the same as it is today.
c) The global ocean level during the Pleistocene was lower than it is today.
d) Global ocean level was determined by the rate of ocean ice melt.
e) The change in global ocean level was determined by the thickness of ice on the continents.

Q.2) Which statement below best describes a glacial depositional environment? (only one answer possible).

a) Poorly sorted deposits, slightly rounded particles; moderately marked strata.
b) Very poorly sorted deposits, very angular pebbles, fine and angular particles.
c) Very poorly sorted deposits, moderately angular pebbles, rounded sand particles.
d) Moderately sorted deposits, moderately angular pebbles, rounded sand particles.
e) Well sorted deposits, well rounded pebbles, moderately rounded sand particles and silt.

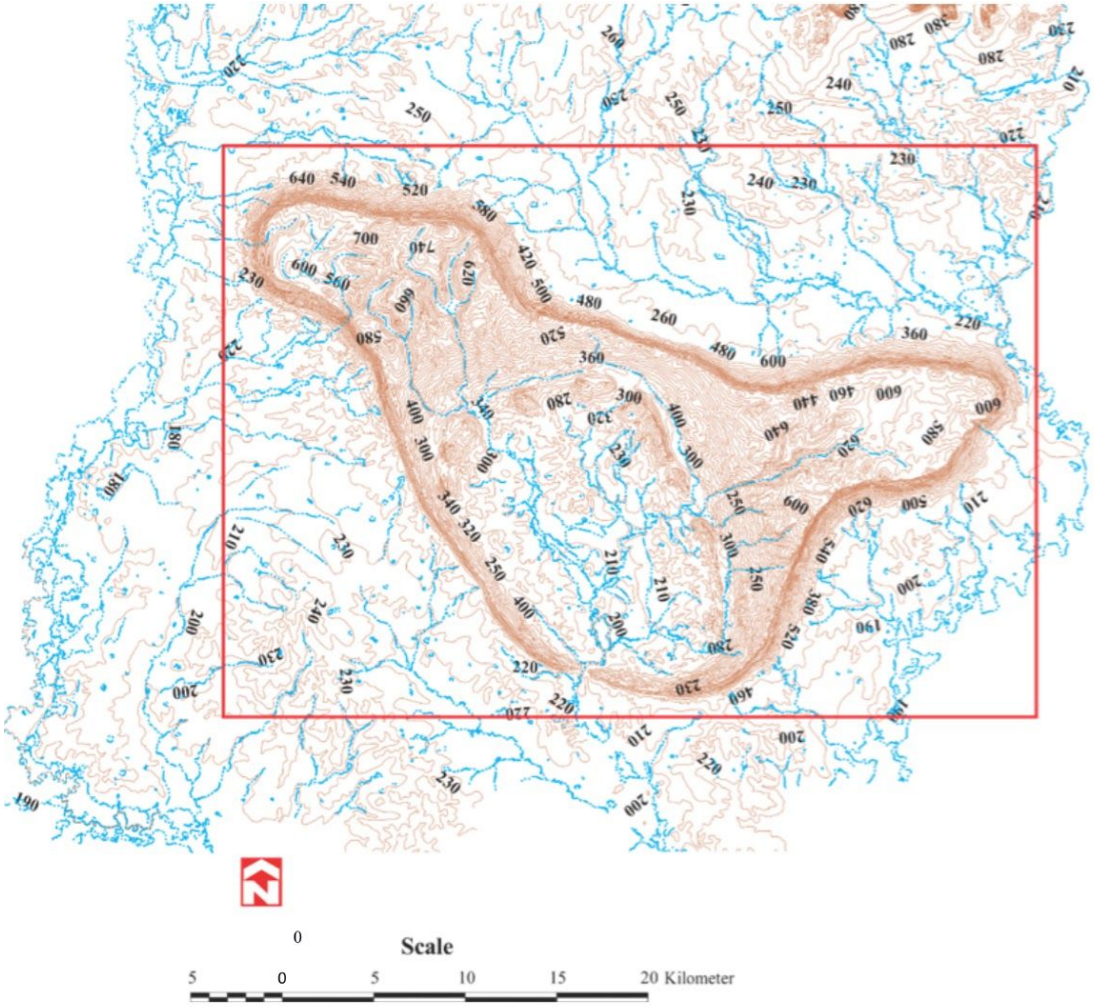
Q.3) When exploring an area, which of the following may indicate the presence of a Pleistocene glacier? (one or more correct answers possible).

a) Alpine type vegetation.
b) Parallel joints which may be observed on the surface.
c) Valleys completely snow-covered.
d) Parallel streaks which may be visible on the surface.
e) V-shaped valleys.
f) Arctic climate.
g) U-shaped valleys.

Q.4) Which of the following statements is / are correct: (one or more correct answers possible).

a) Melting glaciers are the result of a change in temperature on the Earth's surface.
b) Melting glaciers influence the temperature at the Earth's surface.
c) Melting glaciers influence the hydrosphere.
d) Melting glaciers will cause global cooling in the short term.
e) Melting glaciers will accelerate global warming in the short term.

Q.5) The topographic map below shows the contour lines (in meters) of a geomorphological structure developed in a subtropical climate. What is the geological structure contained in the red rectangle? (one or more correct answers possible).



a) A unique volcanic crater
b) Meteorite impact crater
c) Erosional anticline
d) Erosional syncline
e) Plateau

Introduction to questions 6 to 8:

In Thailand, a small open cave is discovered inside carbonate rocks. It is located right on an old river bed. The floor of the cave is covered with travertines and tuffs about ten centimeters thick; the maximum height of the ceiling is approximately 3.5 meters. During the wet season, the cave floor is about 20 meters higher than the current river water level. During the dry season, the difference between the two is increased to about 25 meters.

The characteristic structures of the cave, including stalactites, stalagmites and others (speleothems) can easily be observed. Breathing is easy at the entrance to the cave; however, 60 meters from the entrance to the cave, as it narrows, it becomes both difficult to pass and to breathe. Breathing becomes almost impossible near the cave floor due to the presence of a certain gas. The concentration of this gas seems to increase from the ceiling to the floor of the cave.

A simple method was used to identify this gas, and here is what we found:

(i) You cannot light a lighter flame near the cave floor. But we can light it easily near the ceiling, and the flame burns well.

(ii) When the lit lighter is moved slowly towards the ground, the flame tends to move away from the lighter. The distance between the lighter and the flame gradually increases as you approach the ground. Eventually the flame goes out at ground level.

Q.6) Considering the conditions of the experiment and all the factors involved, this gas is probably (only one answer possible):

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

Q.7) When is the increase in the concentration of this gas likely? (only one answer possible)

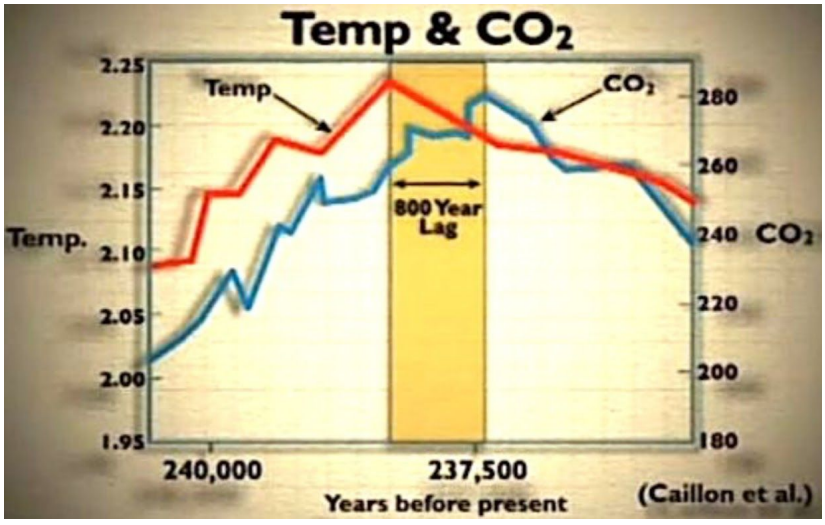
a) Throughout the year.
b) The first six months of the year.
c) Mainly during the dry season.
d) Mainly during the wet season.
e) Randomly.

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

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

Introduction to question 9:

The graph below shows the evolution of temperature (degrees Celsius) and atmospheric concentration (ppm) of carbon dioxide (CO_2) during a warm interglacial period.



Q.9) Which of the following best explains the 800-year lag in the graph above? (only one answer possible).

a) CO_2 is not responsible for climate change as many people think. If this were the case the maximum CO_2 concentration would rather have occurred at the same time, or preceded the maximum temperature.
b) The oceans act as a buffer for both temperature and the level of CO_2 in the atmosphere.
c) A change in the respiration of all plants caused this 800-year gap.
d) Changes in sea level caused this 800-year gap.

Q.10) Which of the following statements is / are correct? (one or more correct answers possible).

a) The warming of ocean water increases the dissolution of carbonates.
b) Warming ocean water reduces the dissolution of carbonates.
c) Warming of ocean water increases global warming.
d) Warming of ocean water reduces global warming.
e) Warming ocean water reduces carbonate sedimentation.
f) Warming ocean water increases the sedimentation of carbonates.

Q.11) Which of the following statements could explain why there were more desert areas on the earth's surface during the Ice Ages than today? (one or more correct answers possible).

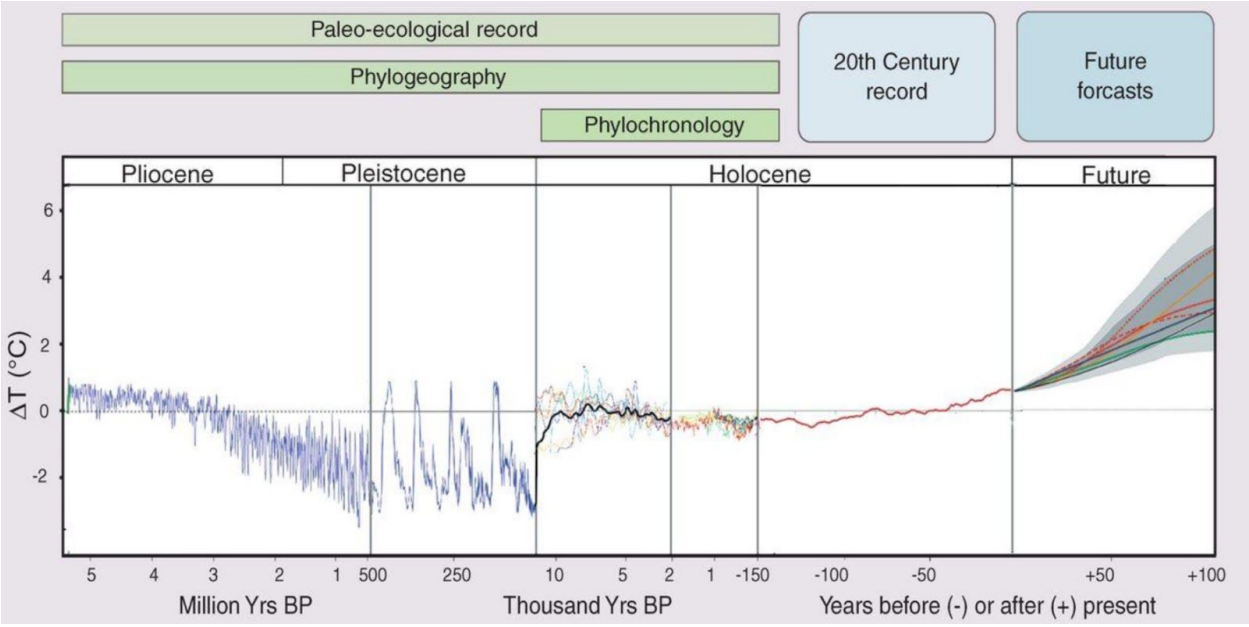
a) During these times the Earth's atmosphere contained less water vapor.
b) During these times the amount of precipitation on Earth is less than the precipitation today.
c) During these times there was less evaporation in cooler areas.
d) During these times there was less ocean evaporation.

Q.12) Which of the following is the most correct explanation possible? (only one answer possible).

a) The increasing desertification of the Earth tends to increase the local albedo making the region warmer.
b) The increasing desertification of the Earth tends to reduce the local albedo making the region warmer.
c) The increasing desertification of the Earth tends to increase the local albedo making the region colder.
d) The increasing desertification of the Earth tends to decrease the local albedo making the region colder.

Use the graph below for questions 13 and 14.

The x-axis represents time, B.P stands for "Before present". The y-axis represents the relative temperature anomaly compared to the average temperature of the last 150 years.



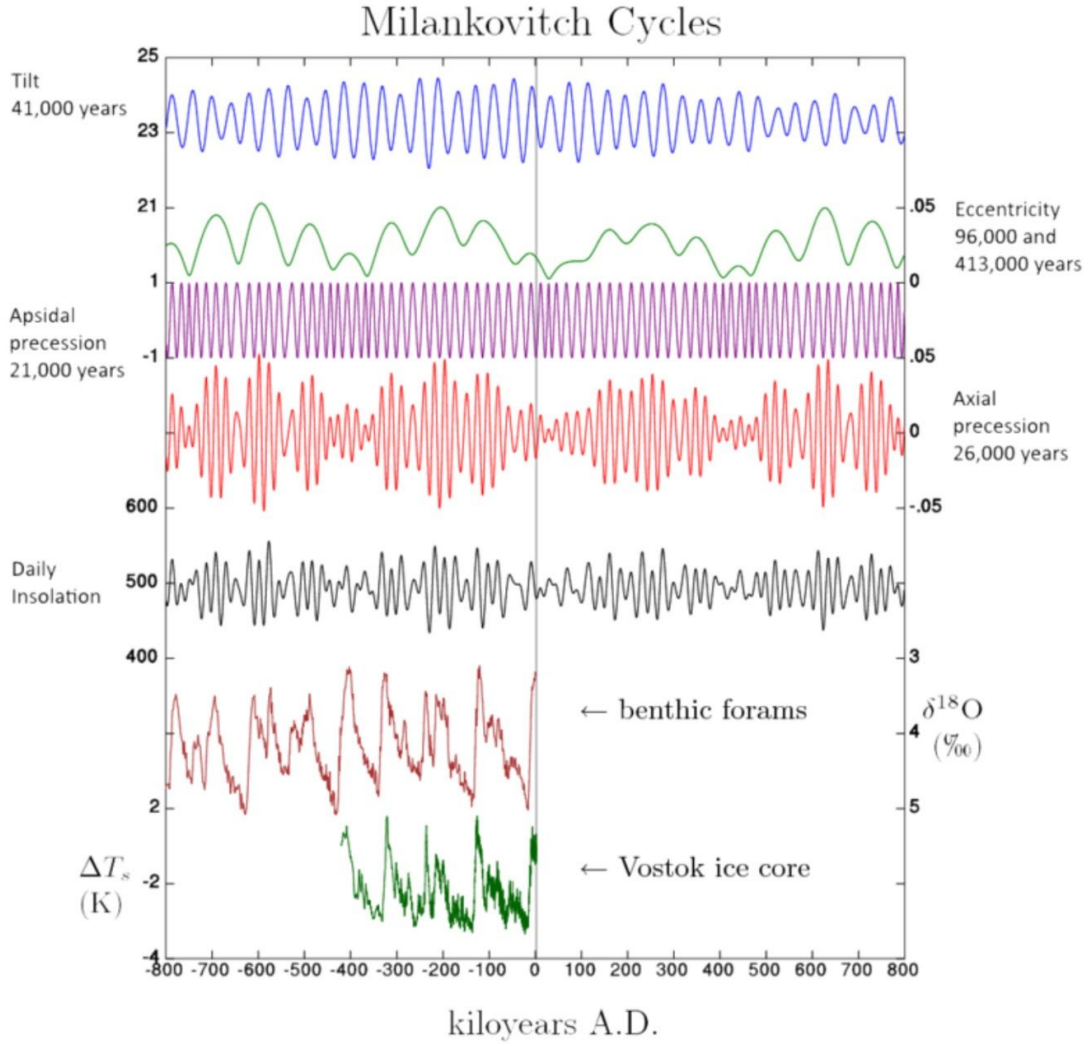
Q.13) Which of the following statements best explains the previous graph? (one or more correct answers possible).

a) There are periods between the Ice Ages that are 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 last 5 million years has been global cooling.

Q.14) Which of the following best explains the above graph? (one or more correct answers possible).

a) During the past two million years each ice age has lasted shorter than each warm period.
b) During the last two million years, warm interglacial periods have lasted shorter than ice ages.
c) Looking at the past two million years, ice ages will no longer happen to Earth.
d) The temperature change over the next 100 years is likely to be up to 4°C higher than in the last century.

Q.15) From the Milankovitch cycle diagram below, which of the following is the best interpretation of temperature variations? (only one correct answer).



a) For the past 400,000 years, the Earth's global temperature has changed in a cycle of approximately 25,000 years.
b) For the past 400,000 years, the Earth's global temperature has changed in a cycle of approximately 50,000 years.
c) For the past 400,000 years, the Earth's global temperature has changed in a cycle of approximately 75,000 years.
d) For the past 400,000 years, the Earth's global temperature has changed in a cycle of approximately 100,000 years.

Introduction to question 16.
According to the standard solar model, about 4 billion years ago, the energy radiated by the sun was only 70% of today's level. If all other variables were under today's conditions, the result would have been a totally frozen planet. Geological data shows that during this period a relatively warm temperature prevailed at the surface with the presence of liquid water.

Q.16) Which of the following statements could explain Earth's warmer (than expected) climate 4 billion years ago? (one or more correct answers possible).

a) There were more greenhouse gases in the original atmosphere.
b) In the past, the geothermal energy released by radioactive decay was considerably greater than it is today.
c) The moon had much more rock than Earth billions of years ago, which explains why the release of energy from tidal forces was much higher.
d) Lack of vegetation was the cause of higher planetary albedo.
e) The smaller continental area area billions of years ago was the cause of a lower planetary albedo.

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

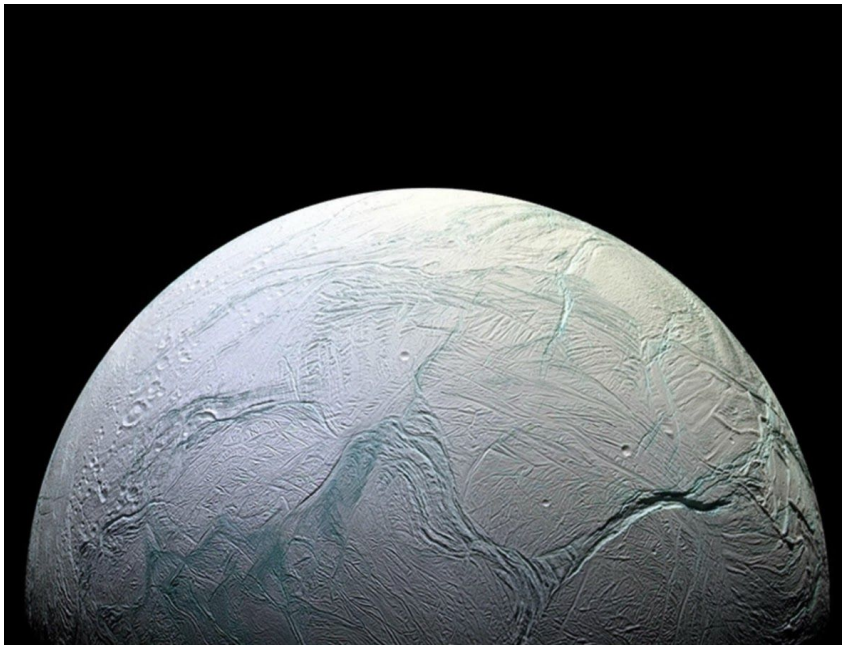


Figure Q.17: The dimension of Enceladus is 513.2 km x 502.8 km x 496.6 km

Q.17) What can we learn from observing the surface structures of Enceladus? (one or more correct answers possible).

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 hydrological system on Enceladus.

Q.18) What could be a reasonable explanation for the local temperature differences at the surface of Enceladus? (one or more correct answers possible).

a) The variation in the energy intensity of solar radiation as a function of latitude.
b) The atmosphere of Enceladus traps thermal energy.
c) Crustal formation processes release heat from the depths into some regions.
d) The subduction zones are cooler than the crustal expansion zones.

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? (one or more correct answers possible).

Figure Q.19: The width of the photo is about 4km.

a) The wind was blowing from the right side of the photo.
b) The wind was blowing from the left side of the photo.
c) Aeolian erosion processes are active on the surface of Mars.
d) Water-related erosion processes are active on the surface of Mars.
e) Aeolian deposition processes are active on the surface of Mars.
f) Mars had, but no longer has, an atmosphere.
g) Deposition processes caused by water are active on the surface of Mars.
h) Mars has an atmosphere.
i) Mars currently has a hydrosphere.
j) Mars had, but no longer has, an active hydrosphere.
k) Erosion processes caused by meteorites are active on the surface of Mars.
l) The surface of Mars has experienced hydrosphere-geosphere interactions.
m) The surface of Mars has experienced atmosphere-geosphere interactions.
n) Mars has stratigraphic layers just below its surface.

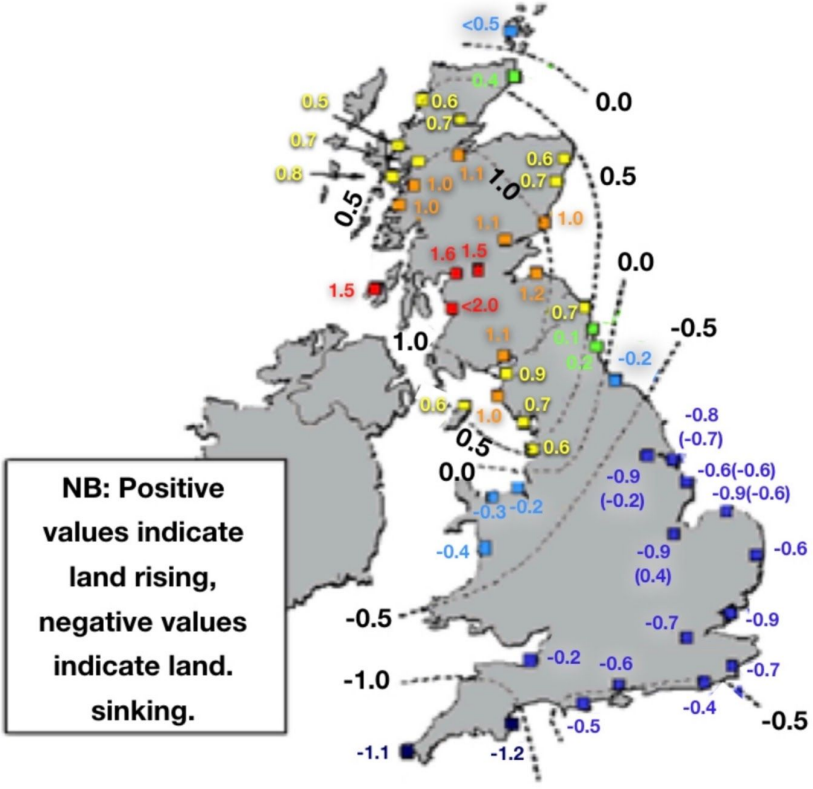
Q.20) The photo below is another image of the surface of Mars. Which of the following offers a reasonable interpretation of this image? (one or more correct answers possible).

Figure Q.20: The width of the photo is approximately 2 km.

a) The wind was blowing from the right side of the photo.
b) The wind was blowing from the left side of the photo.
c) Aeolian erosion processes are active on the surface of Mars.
d) Aeolian deposition processes are active on the surface of Mars.
e) Mars had, but no longer has, an atmosphere.
f) Mars currently has a hydrosphere.
g) Mars had, but no longer has, an active hydrosphere.
h) Erosion processes caused by water are active on the surface of Mars.
i) Water-caused deposition processes were / are active on the surface of Mars.
j) Erosion processes caused by meteorites are active on the surface of Mars.
k) Mars has stratigraphic layers.

Introduction to questions 21-22:

The document below is a map of Great Britain. It presents the speeds of the vertical movements of the crust (in mm / year). Negative values indicate sinking and positive values indicate lifting. Analysis of this data shows that the movements are remarkably fast over a large area.



Q.21) Which of the following offers the best explanation for regional variations in elevation? (only one answer possible).

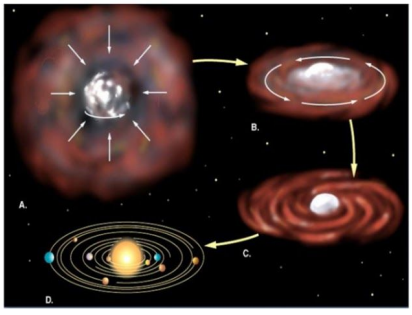
a) Tectonic activity caused by an active plate margin.
b) England is positioned above a mantle hot spot.
c) Local changes in sea level affect the elevation of the land.
d) The return to isostatic equilibrium of the crust after the last ice age.

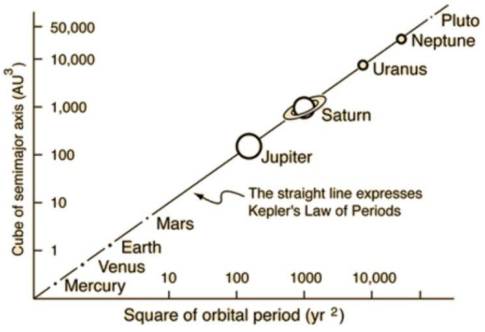
Q.22) Which of the following offers the best explanation for the sinking areas? (only one answer possible).

a) The sinking area is located near a subduction zone.
b) The sinking area is the result of an isostatic phenomenon.
c) The area was sinking because the sea level rose faster there.
d) This area was sinking because the pumping of groundwater caused regional subsidence.

Introduction to question 23:

The left figure below explains the formation and evolution of the solar system which has started 4.6 billion years ago with the gravitational collapse of a small part of a giant molecular cloud. Most of the matter collapsed in the center to form the sun, while the rest, flattened into a protoplanetary disc, produced the planets, moons, asteroids and other small bodies of the solar system. Keplers' laws describe the movements of the planets around the sun. The graph on the right below shows the relationship between the average distance of a planet from the sun and its orbital period known as Kepler's 3rd law.



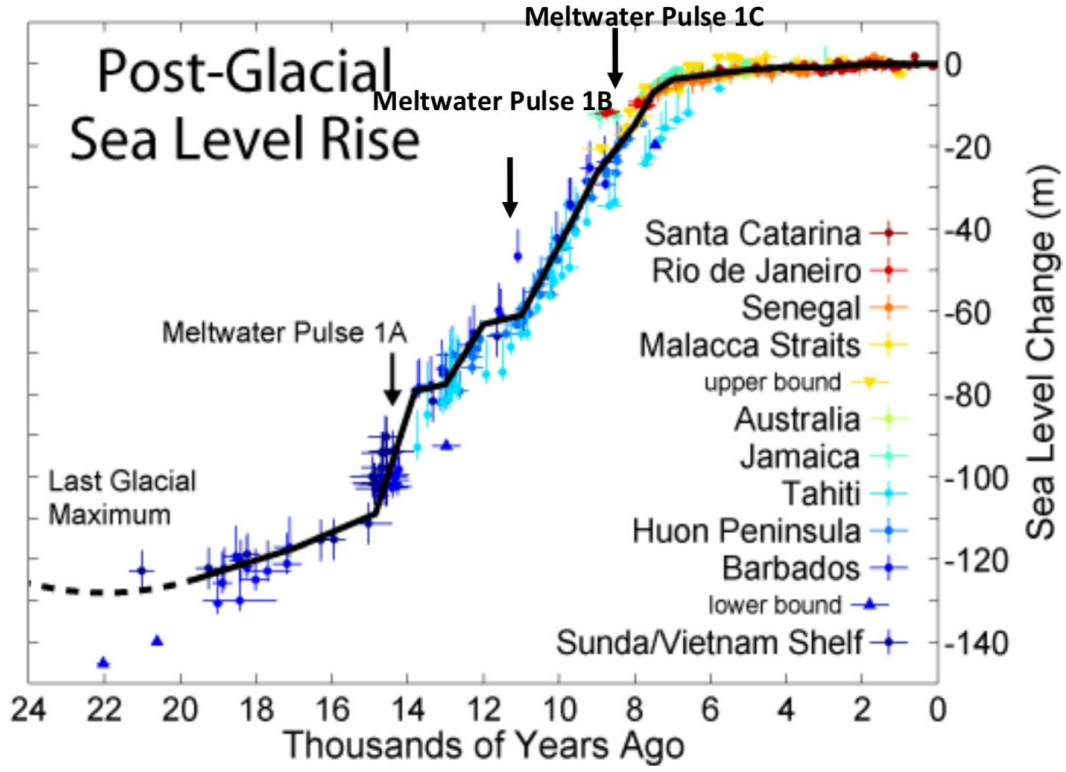


Q.23) Which of the following statements could serve as a reasonable interpretation for data shown above? (one or more correct answers possible).

a) All the planets in the solar system orbit in the same direction.
b) The direction of the axial rotation of the sun is the same as the direction of the orbital motion of the planets.
c) The direction of the axial rotation of all the planets in the solar system is the same as the direction of 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 data on the rise in global ocean levels for the past 24,000 years. The data indicates a peak in liquid water level (1A in the figure) representing 13.5 m of rise in 290 years about 14,200 years ago and another peak in liquid water level representing 7.5 meters rise in 160 years about 11,000 years ago (1B).

There is a sharp contrast with the period between -14,300 and -11,100 years, which includes the period of the Younger Dryas, for which there is an interval of reduction in the rate of ocean rise to about 6.0 at 9.9 mm / year. Subsequently, a peak in the liquid water level around 8,000 years ago (1C) corresponds to a rise of 6.5 meters in less than 140 years.



Q.24) Which of the following correctly describes the above graphic and the information given? (one or more correct answers possible).

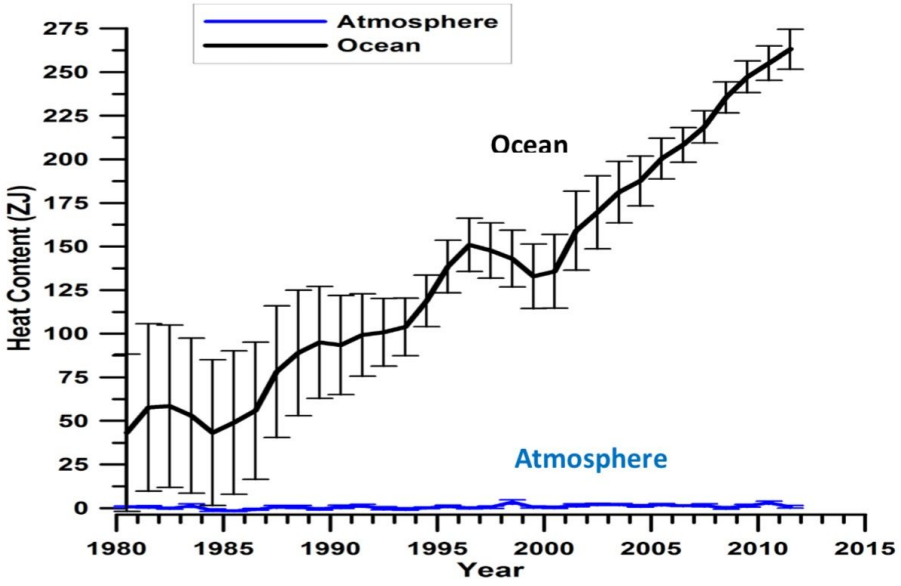
a) Sea level has been relatively stable for the past 6,000 years.
b) Sea level has risen rapidly over the past 6,000 years.
c) Sea level began to rise gradually at the end of the last maximum of glaciation 14,000 years ago.
d) Over the past 20,000 years, the rate of sea level rise has been very constant.
e) The rate of sea level rise has exceeded 4m / 100 years several times in the past 20,000 years.
f) The rate of sea level rise has exceeded 10m / 100 years several times in the past 20,000 years.

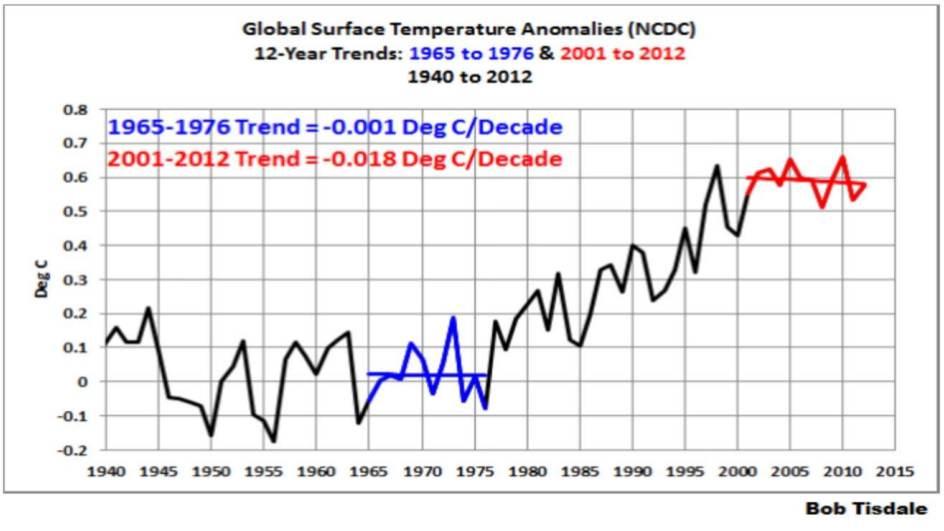
Q.25) Which of the following best explains why periods of rapid sea level rise have occurred in the past 24,000 years? (only one answer possible)

a) Rapid melting of ocean ice.
b) Periods of rapid warming of ocean water.
c) Melting glaciers in the ocean.
d) The melting sea ice already floating in the ocean.

Introduction to question 26:

The two graphs below show the atmospheric and oceanic climate changes of Earth.
The top graph shows the annual oceanic (black) and atmospheric (blue) thermal energy anomalies between 1985 and 2015. Note that the unit ZJ on the y-axis represents 10^{21} joules.
The bottom graph shows the global mean temperature as a function of time over the period 1940 - 2015. The red and blue sections show specific time intervals.





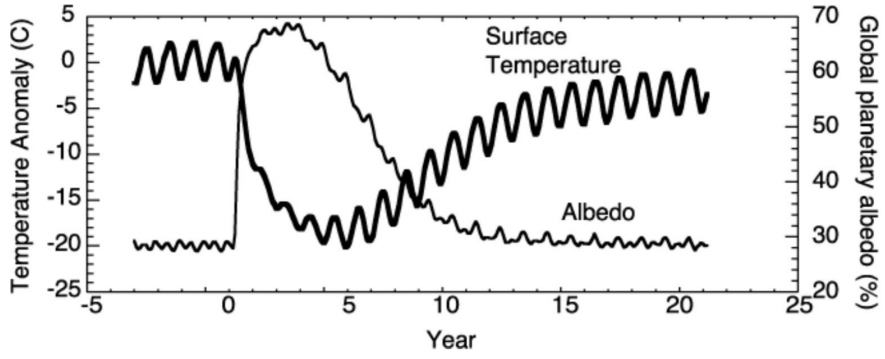
Q.26) Which of the following offers a reasonable interpretation based on the two graphs above? (one or more correct answers possible).

a) Comparison of the two graphs shows a general tendency towards increasing temperature and thermal energy in the atmosphere and hydrosphere.
b) Comparison of the two graphs shows no general tendency for temperature and thermal energy increase in the atmosphere and hydrosphere.
c) During the period 1980-2012, a large majority of the energy increase in the Earth system took place in the hydrosphere.
d) During the period 1980-2012, a large majority of the increase in energy in the Earth system took place in the atmosphere.
e) When the temperature of the atmosphere decreases, the thermal energy contained in the oceans increases.

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 magmatic material were spilled among which 800 km^3 were deposited in the form of ash falls. This eruption changed the planetary albedo.

The graph below presents a model of interaction between the global planetary albedo and the surface temperature anomaly as a function of time. The time '0' indicates the moment of the eruption.



Q.27) Which of the following could be a reasonable explanation for the modification of the planetary albedo after the Toba eruption? (one or more correct answers possible)

a) A layer of volcanic ash covers a large area of soil.
b) The ashes serve as condensation nuclei thus increasing the cloud cover.
c) The ashes serve as condensation nuclei thus reducing the cloud cover.
d) A large amount of volcanic sulfur dioxide in the atmosphere causes the albedo to increase.
e) The drop in temperature has caused an increase in snow cover.

Q.28) Which of the following could be a reasonable explanation for the return from the overall albedo level to its level prior to the Toba eruption? (one or more correct answers possible)

a) Vegetation began to grow on the ashes.
b) Ashes are gradually removed from the atmosphere.
c) Sulfur dioxide has been vented from the atmosphere.
d) The state of snow cover has returned to normal.

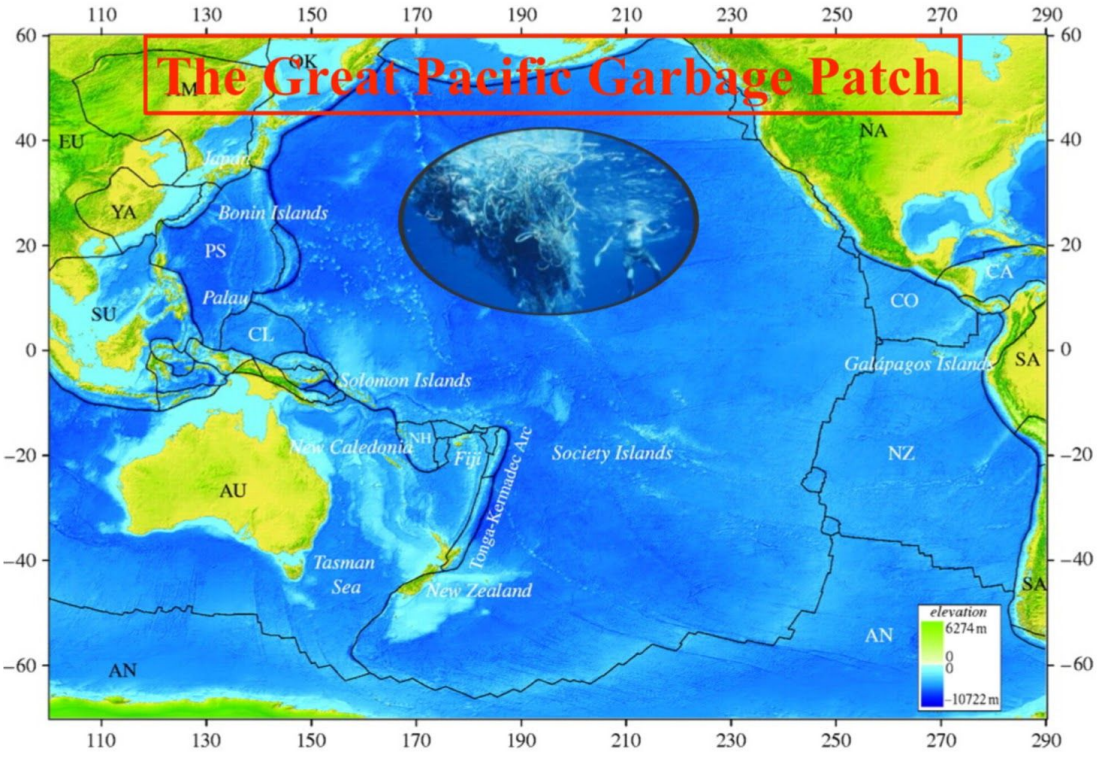
Q.29) As a result of the ocean temperature increase over the past 100 years there has been less ocean ice during most of the year near the North Pole. Which of the following possibilities is the most likely outcome of this process? (only one answer possible).

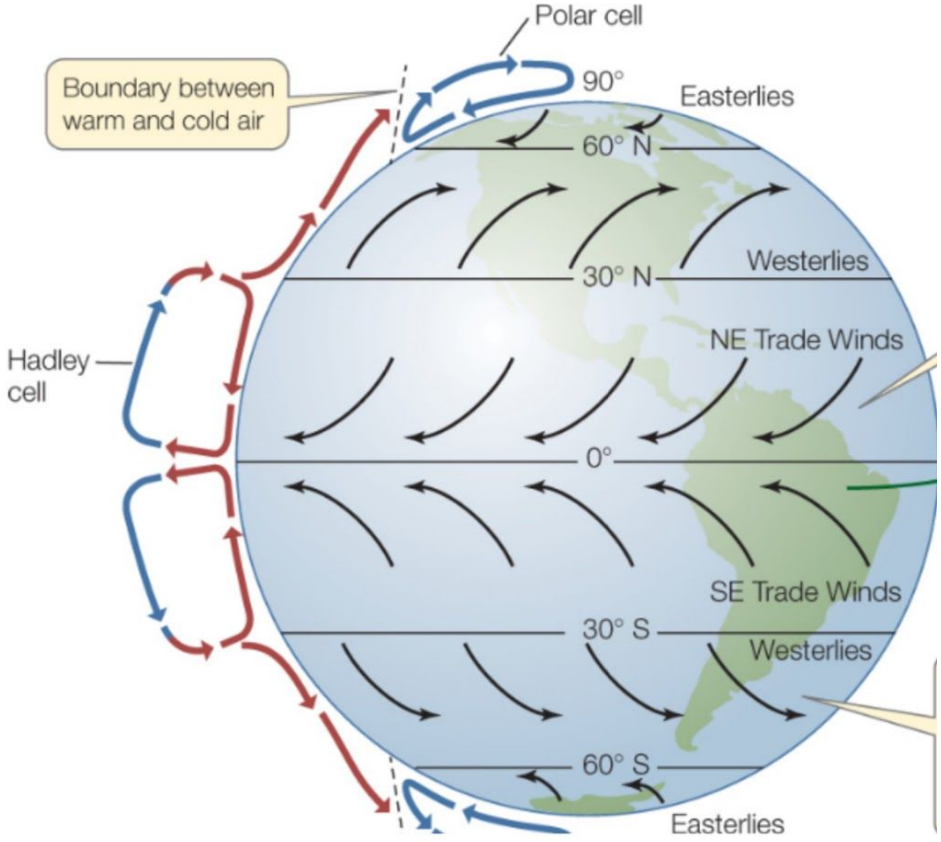
a) The acceleration of global warming because more energy has been absorbed.
b) A slowing of global warming caused by less energy uptake.
c) No impact on the rate of climate change.
d) It is impossible to know how this will affect the future climate.

Introduction to questions 30 and 31:

In the figures below, the top one indicates the location of the Great Pacific Garbage Patch (GPGP). This patch of litter is a collection of marine debris in the central North Pacific discovered between 1985 and 1988. It ranges between approximately 135 - 155°W and 35 - 42°N. The cluster of plastics and floating waste halfway between Hawaii and California extends over an area of widely varying size depending on the concentration of plastic used to define that area.

The lower figure shows the general diagram of an atmospheric circulation organized into 3 convection cells on each hemisphere: Hadley cell, Ferrell cell and polar cell. The majority of atmospheric movement takes place in the Hadley cell. High pressure systems acting on the Earth's surface are compensated by low pressure systems in other places. There is thus a balance of forces acting on the surface of the Earth.


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) Based on the diagrams above, which of the following statements could serve as a reasonable interpretation of the existence of the Great Pacific Garbage Patch at the position shown in the diagram above? (one or more correct answers possible).

a) The Garbage Patch is created by the North Pacific Gyre.
b) The patch of waste cannot be created in the Atlantic and Indian Oceans.
c) The patch of waste will gradually shrink over time.
d) Waste from land traveled along ocean currents to aggregate at the same location.

Q.31) Which of the following statements is/are correct? (one or more correct answers possible).

a) The currents in the North Pacific are related to the trade winds (NE trade winds on the diagram) and the prevailing westerly winds (Westerlies on the diagram).
b) The prevailing westerly winds (Westerlies) create ocean currents going from east to west.
c) The path of the trade winds and the westerly winds are bent because the Earth turns.
d) The Hadley cell moves south through the Northern Hemisphere in the summer.
e) At 30°N, there is a low pressure system.
f) General atmospheric circulation and ocean currents serve to transport energy.

Introduction to question 32:

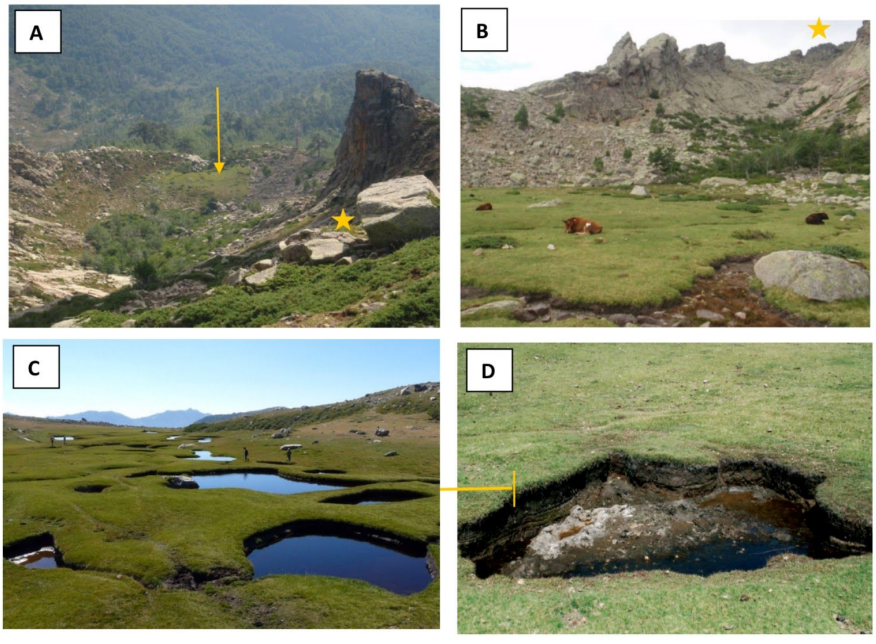
The four photos (A-D) below were taken in Corsica. They represent landscapes with different morphologies.

Photo (A) Point of view at the top of the pass (yellow star).

Photo (B) Point of view at the bottom of the pass.

Photo (C) Landscapes found at the bottom of the pass (arrow in A).

Photo (D) Zoomed-in part of photo C.



Q.32) From the information given above, choose the correct proposal(s) relating to the morphology of the landscape. (one or more correct answers possible)

a) The landscape results from an interaction between atmosphere, hydrosphere and geosphere.
b) The landscape results from an interaction between atmosphere and geosphere only.
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 highly probable that a glacier was present during the last glaciation.

Introduction to question 33:

There are two varieties of black pine in Corsica. Photo A shows the Corsican pine (*Pinus nigra Corsicana*) and photo B shows the Calabrian pine (*Pinus nigra calabrica*).

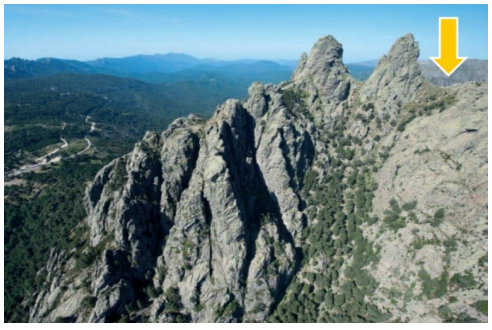
Corsican pine (photo A) needs the following conditions: **temperature**: 9-13°C, **altitude**: 900-1800 m, **rainfall**: 800-1200 mm / year, **soil**: acidic and sandy magmatic soil. It does not tolerate hydromorphic soil (a soil often saturated with water).

Calabrian pine (photo B) needs the following conditions: **temperature**: 0-9°C, **altitude**: 900-1800 m, **rainfall**: 800-1200 mm / year, **soil**: limestone soil. It tolerates hydromorphic soil.

Photo A :

Photo B :

Photo C (left) is a panorama of a specific area of Corsica. Photo D (right) is a section of the rock which forms the most pointed reliefs (marked by the yellow arrow in photo C).



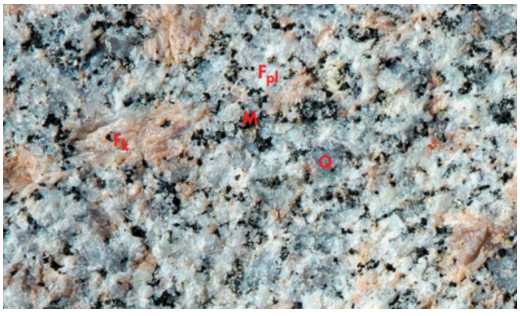


Photo D shows the minerals of granite. Q = quartz, M = biotite mica, F_k = potassium feldspar, F_{pl} = plagioclase feldspar.

Q.33) Based on the information given above, which of the following is correct for black pine from Corsica? (only one answer possible).

a) We have the best chance of finding the Corsican pine in the highest area of photo C.
b) We have the best chance of finding the Calabrian pine in the highest area of photo C.
c) The highest area of photo C is an acceptable environment for the growth of Calabrian pine thanks to the nature of the soil.
d) Both varieties of black pine can be found in a karst 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:

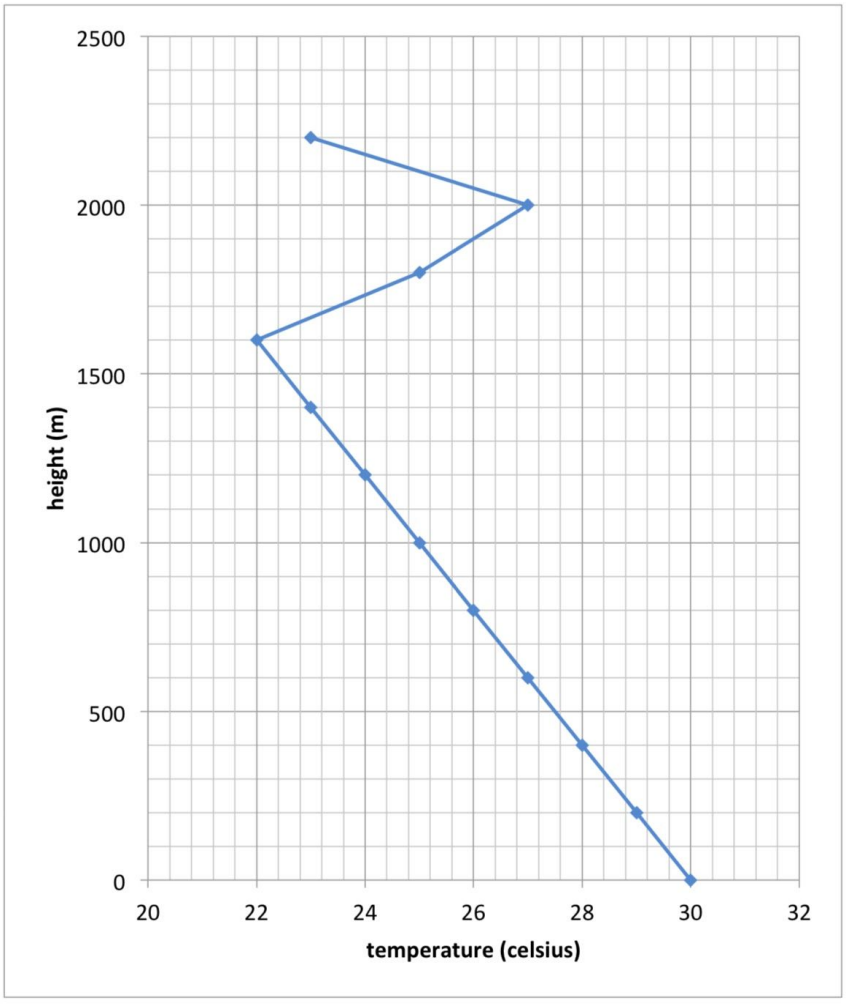
On February 8, 2018, the concentration of fine particles in the atmosphere reached unhealthy levels in several districts of Bangkok. The concentrations of fine particles (2.5 microns in diameter or less) have reached values in the order of 63 to 82 micrograms per cubic meter of air, which is significantly above the health standards set at 50 micrograms per cubic meter.
Levels beyond sanitary standards were recorded at four air quality monitoring stations in Bangkok. Pollution is a serious problem in an urbanized area like Bangkok, but regulating pollution can decrease it to acceptable levels.

Q.34) Given the adiabatic vertical lapse rate is fixed at 10 degrees Celsius per kilometer, and we consider that the temperature of a mass of polluted air released by a car or a factory is 35 degrees Celsius. What will be the temperature of this mass of air at an altitude of 2 km? (Only one answer possible).

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 evolution of the environmental temperature at different heights. The adiabatic vertical lapse rate is set at 10 degrees Celsius per kilometer.

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 adiabatic vertical lapse rate from question 34, what is the highest altitude that the polluted air mass of 35 degrees is likely to reach? (Only one answer possible.)

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

Q.36) During the middle of summer, the ground is heated by the mass of polluted air. If the temperature of this mass of polluted air is 40 degrees Celsius on the ground, what will be the maximum altitude that this mass of air can reach? Use the adiabatic vertical lapse rate given in question 34. (Only one answer possible).

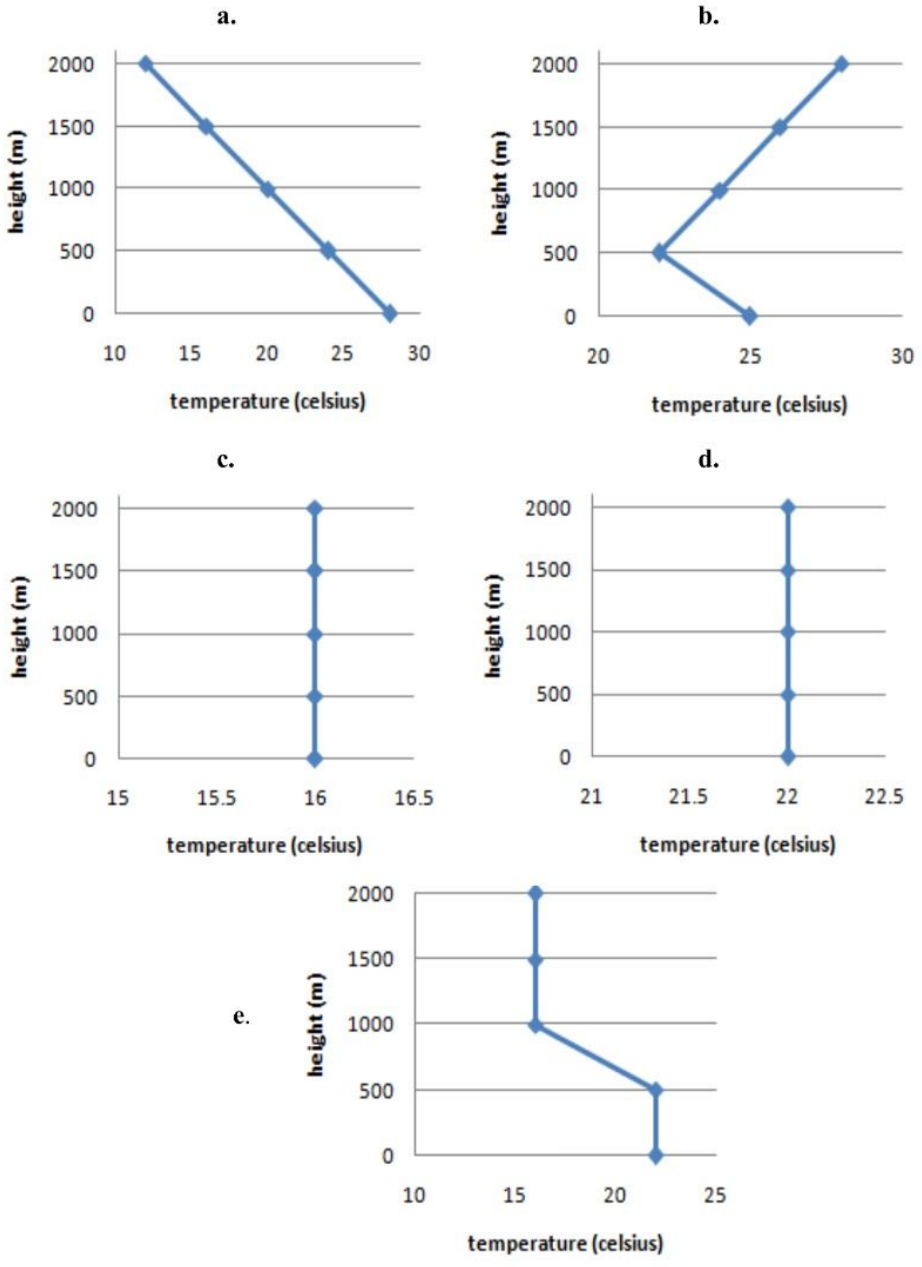
a) between 1200 m and 1400 m
b) between 1400 m and 1600 m
c) between 1600 m and 1800 m
d) between 2000 m and 2200 m
e) Beyond 2200 m

Q.37) Considering a hypothetical situation where the mass of polluted air is 50 degrees Celsius on the ground, what will be the maximum altitude that this mass of air can reach? Use the adiabatic vertical lapse rate given in question 34. (Only one answer possible).

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) Beyond 2200 m

Q.38) Given below are five thermal profiles: height in meters as a function of temperature in degrees Celsius. What is the thermal profile that represents the most severe case of pollution?

a) Thermal profile a
b) Thermal profile b
c) Thermal profile c
d) Thermal profile d
e) Thermal profile e



Q.39) Considering the thermal profile of question 38, what is generally the time of day when the air pollution is most severe? It is also considered that the emission of pollutants remains constant. (Only one answer possible)

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

Q.40) In order to reduce pollution, what can be done to reduce the local concentration of pollutants on the ground? (One or more correct answers possible).

a) Release the polluted air at a temperature above 30 degrees Celsius.
b) Release the polluted air at a temperature below 30 degrees Celsius.
c) Release the polluted air from a chimney higher than 80 meters.
d) Release the polluted air from a chimney lower than 80 meters.

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

a) The middle of summer.
b) The middle of winter.
c) When the mass of cold air replaces the mass of moist air.
d) When the mass of hot air replaces the mass of cold air.
e) When the mass of moist air replaces the mass of hot air.

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

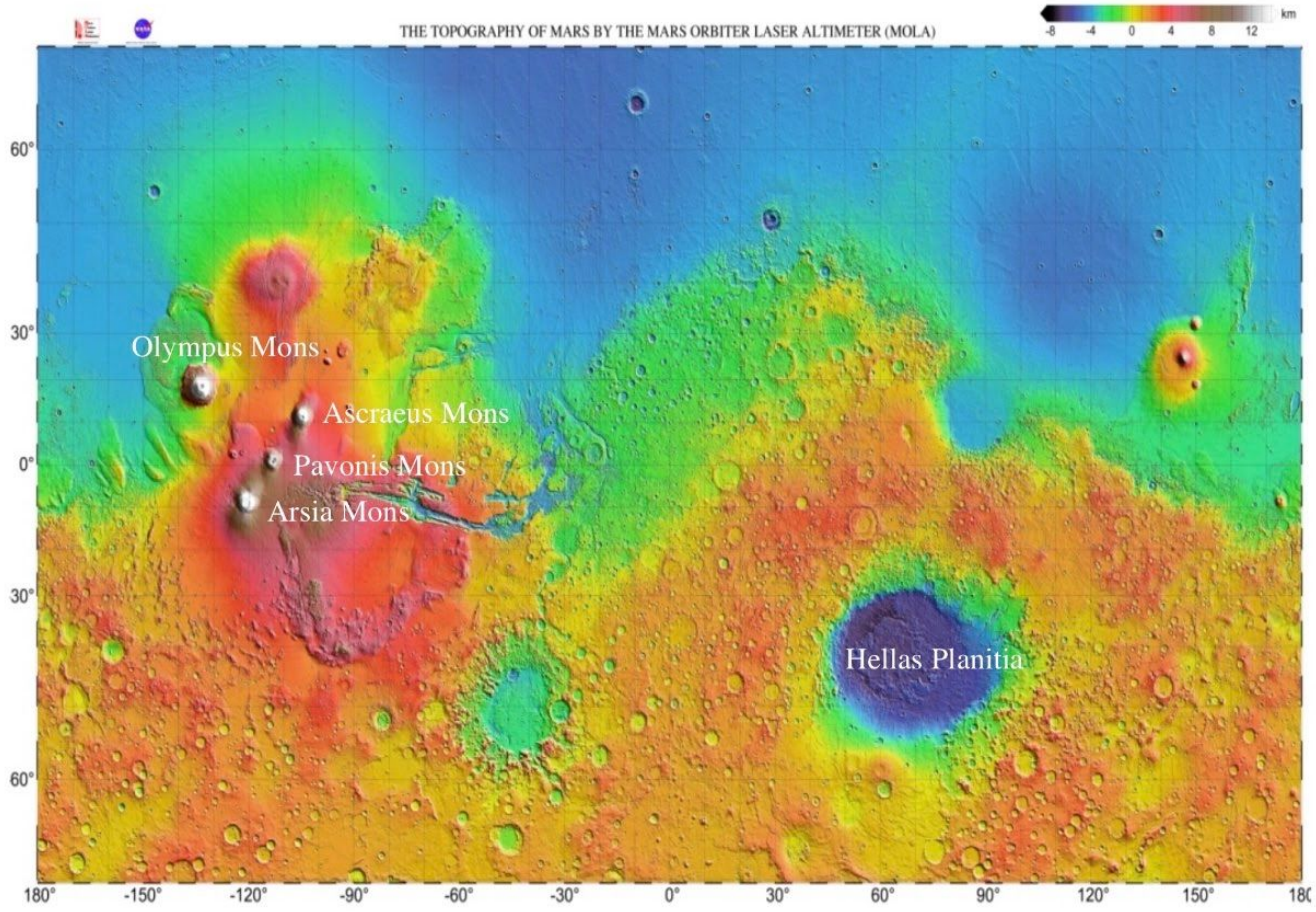


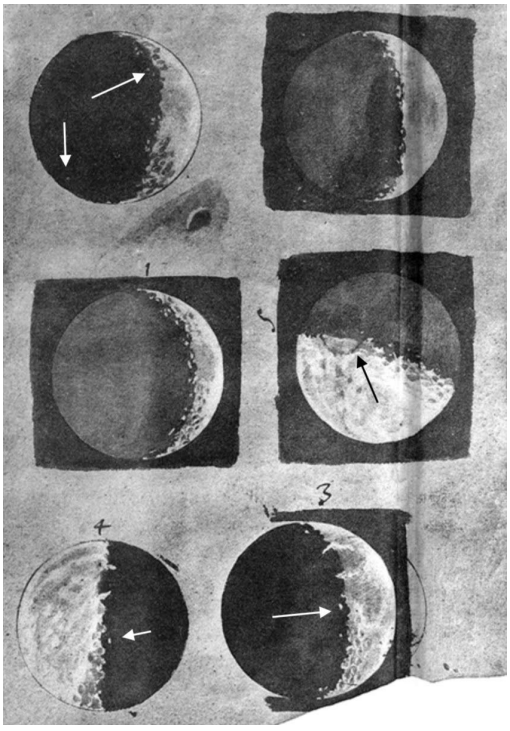
Figure: The global topography of Mars. (Credit: The Mars Orbiter Laser Altimeter)

Q.42) Choose from the following statements, the statement that CANNOT explain why Mars has more craters than Earth. (Only one answer possible).

a) There has been little or no water on Mars for a very long time.
b) The Martian atmosphere is much thinner than that of Earth.
c) Earth is larger than Mars.
d) Mars' orbit around the Sun is closer to the asteroid belt.

Q.43) Mount Olympus is the highest mountain and volcano in the solar system. Its altitude is two and a half times greater than Mount Everest on Earth. The Arsia, Pavonis and Ascraeus Mountains are also higher than Mount Everest.
What is the following statement that explains the phenomenon described above? (Only one answer possible)

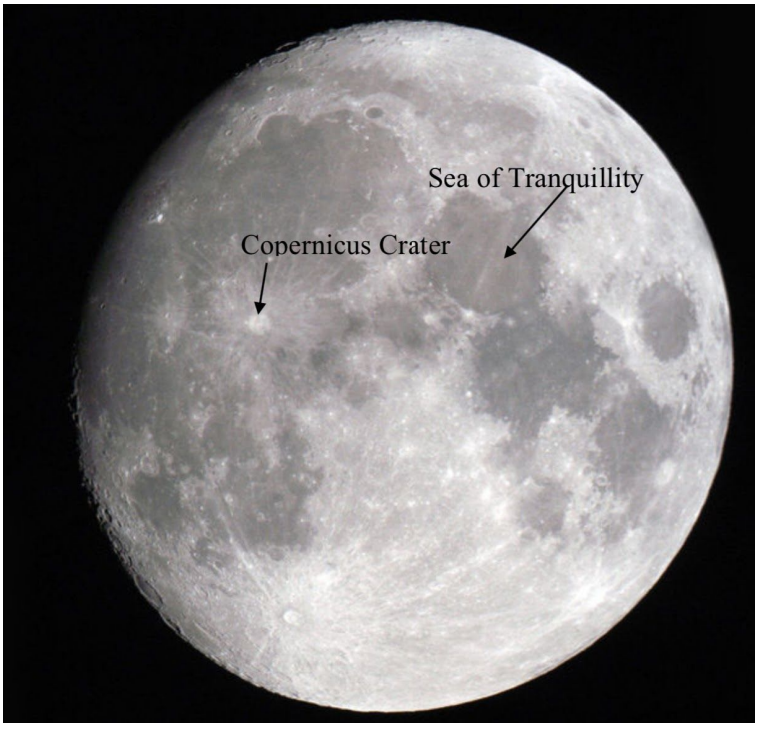
a) The lower gravity on Mars allows the formation of volcanoes higher than on Earth.
b) Earth has a larger moon than the planet Mars.
c) The difference in composition of the mantle between the Earth and Mars allowed the formation of Mount Olympus.
d) The erosion caused by solar winds on Mars is intense.



Q.44) The drawings of the Moon above were drawn by Galileo Galilei. Notice the lightest spots on the dark areas (indicated by a white arrow) and the dark circles inside the light areas (indicated by a black arrow). Galileo saw the light spots grow larger over the month and concluded that they must correspond to mountains and that the dark circle (one of those he discovered) corresponds to a shadow at a lower elevation.
Through Galileo's work, which of the following phenomena contributes to the monthly phases of the Moon? (only one correct answer).

a) The Earth obscures the sunlight and thus casts a shadow on the Moon.
b) The rotation of the Moon around its axis creates the monthly phases.
c) The fact that the Moon is orbiting the Earth creates the monthly phases of the Moon.
d) The fact that the Earth is orbiting around the sun creates the monthly phases of the Moon.

Introduction to question 45:



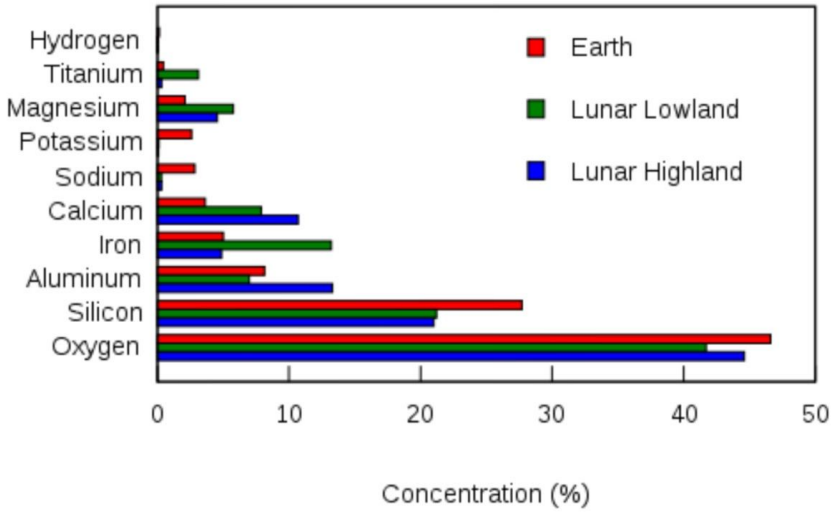
Q.45) Given above is a modern photograph of the visible side of the Moon, which is constantly facing the Earth. This highlights the multiple craters scattered on its surface (the Copernicus crater is pointed out for example). We can also note that there is a distinction between the lightest surfaces, corresponding to mountains, and the darkest, corresponding to plains or seas (the sea of tranquility is pointed for example). Compared with the time of Galileo, we also know today that the average density of the Moon is 3.344 g/cm^3 (or about 60% of the average density of the Earth) and that the gravity of the Moon is about 1/6 that of Earth.
Which of the following best explains why only one side of the moon is visible from Earth? (only one correct answer).

a) The time it takes for the Moon to revolve around the Earth is equal to its time of rotation around its axis.
b) The other side of the Moon is made up of rocks with a low albedo.
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 possible).

a) The absence of an atmosphere on the Moon.
b) The Earth's intense magnetic field protects it from meteoric impacts.
c) The low density of the Moon attracts objects from space.
d) The Moon's orbit passes through more asteroids than Earth's orbit.

Composition of chemical elements on the mountains of the moon, the plains of the moon and the crust:



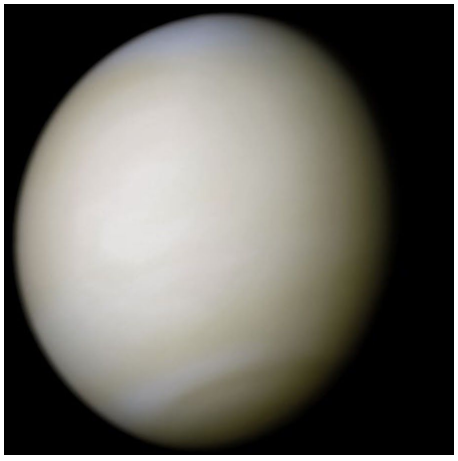
Q.47) The above graph shows the chemical element composition of the surface rocks that make up the mountains and plains of the Moon as well as the surface rocks of the Earth. In relation to the data provided above, which of the following statements is / are correct? (one or more correct answers possible).

a) The high iron concentration of the plains of the Moon indicates that they contain a high level of iron-rich sandstones.
b) The high iron concentration of the plains of the Moon indicates that they are mainly made of basalt.
c) The iron, magnesium, and titanium composition of the lunar plains would indicate that they contain a rock or rocks that do not exist in the other two regions (lunar mountain and earth's crust).
d) The difference in potassium and sodium composition between the Earth and the Moon indicates that the Earth contains a rock or rocks which do not exist on the surface of the Moon.
e) The higher concentration of aluminum and calcium in the lunar mountains compared to other regions indicates that they contain a high level of carbonates and clays.
f) The low lunar sodium and potassium concentration shows a greater degree of crustal differentiation on Earth than on the Moon.

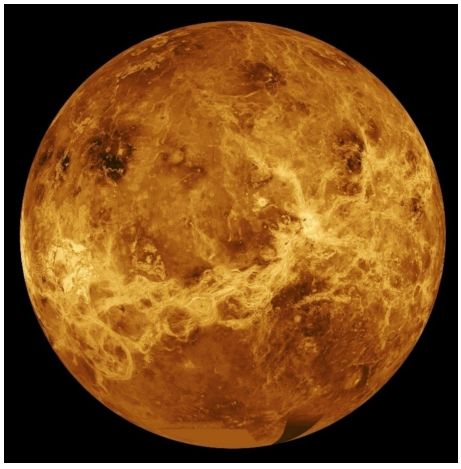
Q.48) What could be the reason(s) for the absence of a magnetic field on the Moon when the rocks of the lunar plains have a weak residual magnetism? (one or more correct answers possible)

a) Since the surface of the Moon has a lower concentration of iron compared to the Earth, a global magnetic field could not be created.
b) In relation to the low density of the Moon, the iron concentration of the lunar core is not sufficient for the creation of a magnetic field.
c) The Moon's gravitational field weakens its magnetic field.
d) The moon cooled rapidly due to its size and this influenced the amount of liquid iron in the nucleus.

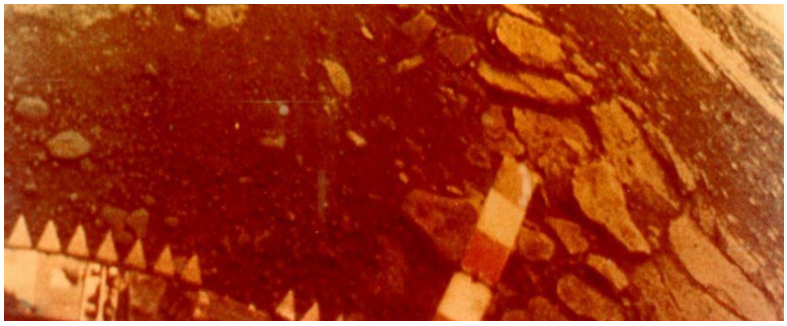
Q.49) The visible light photograph of Venus shown below was taken by the Mariner-10 space probe. It shows a thick atmosphere mainly composed of CO_2.



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

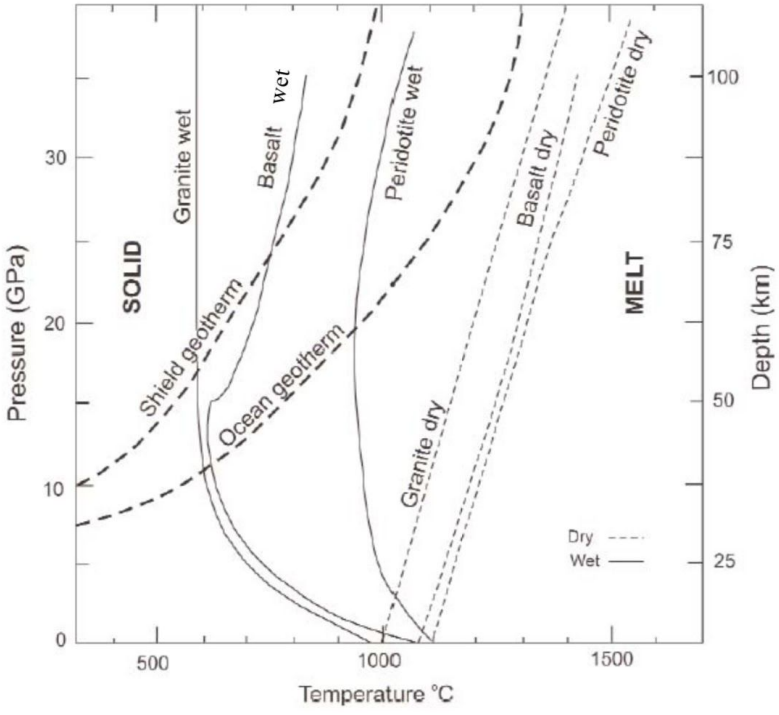


Bright shades indicate high altitudes and dark shades indicate low altitudes. This image highlights the rarity of craters on Venus compared to the moon.
The photograph below was obtained by the Venera-13 probe and it shows the basaltic surface of the planet of Venus.



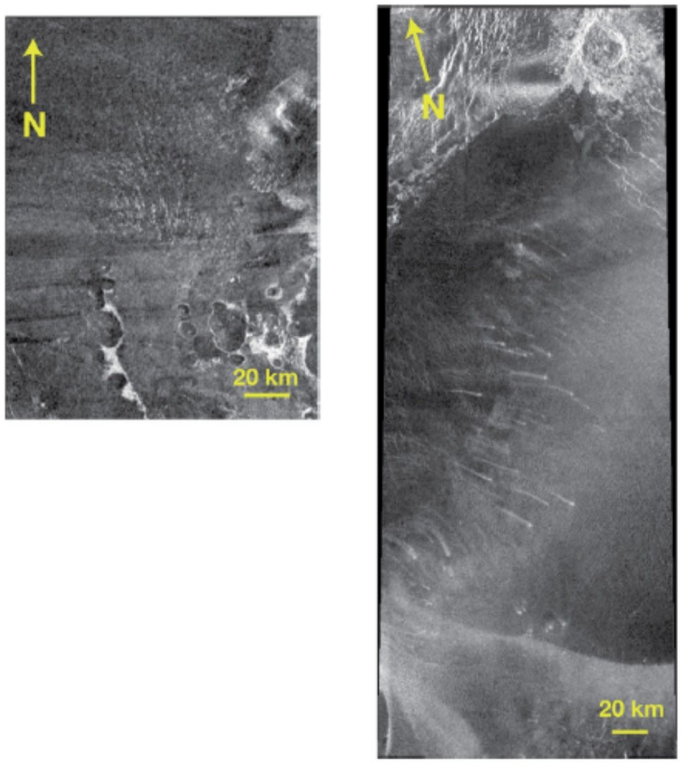
Based on the data presented in the 3 images above, which of the following statements could explain the rarity of impact craters on Venus? (one or more correct answers possible)

a) The thick atmosphere of Venus influences the surface of Venus.
b) The orbit of Venus does not cross regions rich in asteroids.
c) Erosion on the surface of Venus has erased ancient craters.
d) Magmatic activities covered ancient craters.
e) The interaction between the magnetosphere and the atmosphere of Venus.



Q.50) The atmosphere of Venus contains mostly CO_2 with virtually no water. The graph shown above is a phase diagram illustrating the effects of water on the genesis of magma.
The rocks of the mantle of Venus are considered to be anhydrous.
Based on the information given above, what is the mechanism that can initiate magmatic activity on Venus? (only one correct answer possible).

a) Subduction of tectonic plates.
b) Heat releasing water.
c) Comets that can regularly impact Venus.
d) Decompression of the basalt material in a plume.

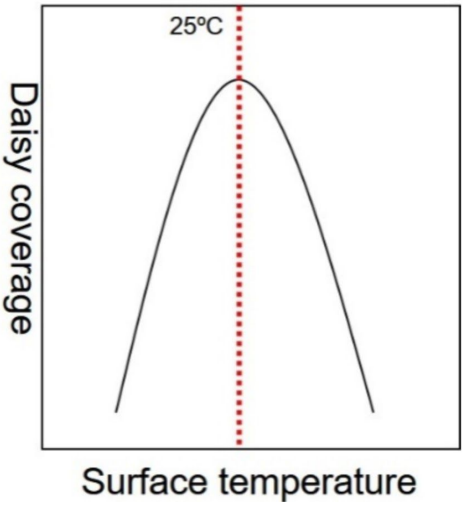


Q.51) The photos shown above were taken by the Magellan probe, showing sand dunes on Venus. White hues denote dune ridges and fronts.
Based on the information presented above and in the previous questions, what can you deduce about the composition of the grains of sand? (only one correct answer possible).

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

Introduction to questions 52-54:

The Gaia hypothesis proposes that living things interact with their environment and form a self-regulating system. In the Gaia hypothesis, the surface of the Earth is covered with white daisies and black soil. Albedo (reflection from the surface of the Earth, for example 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 is 0.7 and 0.3 respectively. The daisy has an optimum temperature of 25°C (temperature at which the Earth has the greatest coverage of daisies). The relationship between the daisy cover and the surface temperature is shown in the figure below:



Q.52) Suppose the initial surface temperature was 20°C. A temperature increase of 6°C will result in ..... (only one correct answer).

a) The surface temperature will stabilize at 26°C.
b) Daisy coverage will increase.
c) Daisy coverage will decrease.
d) All the daisies will disappear.

Q.53) Suppose the initial surface temperature was 30°C. A temperature increase of 1°C will cause ..... (only one correct answer).

a) The temperature will stabilize at 31°C.
b) The temperature will return to 30°C.
c) All the daisies will disappear.
d) Coverage of daisies will increase.

Q.54) Suppose the initial surface temperature was 20°C and the temperature will decrease by 5°C. Which of the following possibilities IS NOT likely to happen? (one or more correct answers possible).

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

Q.55) With the evolution of vascular plants, forests begin to cover the surface of the continents since the Upper Paleozoic (350 Ma), before the continents were covered by sand. A direct consequence of the vegetation on the 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 correct? (only one correct answer possible).

a) The Earth has absorbed more solar radiation over the past 350 million years.
b) The Earth has absorbed less solar radiation over the past 350 million years.
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 question 55, assume that oceans cover 70% of the Earth's surface with an albedo of 0.1 while continents cover 30%. After the continents were covered by forests, which of the following statements is correct? (only one correct answer possible).

a) Solar radiation absorbed by the Earth's surface will increase by 7%.
b) Solar radiation absorbed by the Earth's surface will decrease by 7%.
c) Solar radiation absorbed by the Earth's surface will increase by 30%.
d) Solar radiation absorbed by the Earth's surface will decrease by 30%.

Q.57) Diamictite is an unsorted or poorly sorted sediment, containing particles varying in size from clay to conglomerates, in a clay or sandstone matrix.
Geologists have discovered numerous diamictites in India, Australia and South Africa in layers dating from the Upper Carboniferous to the Lower Permian, suggesting the occurrence of glaciation. Which of the following statements is correct? (one or more correct answers possible).

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

Q.58) The Carboniferous is the oldest and most important period of coal formation. Which of the following describes the potential impact of significant coal formation on Earth? (one or more correct answers possible).

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

Q.59) Another characteristic of the Carboniferous is the presence of giant insects, such as the giant dragonfly, one meter in size. What could be the reason for the presence of giant insects? (only one correct answer possible)

a) High temperature.
b) Low temperature.
c) A high level of O_2 in the atmosphere.
d) A low level of CO_2 in the atmosphere.

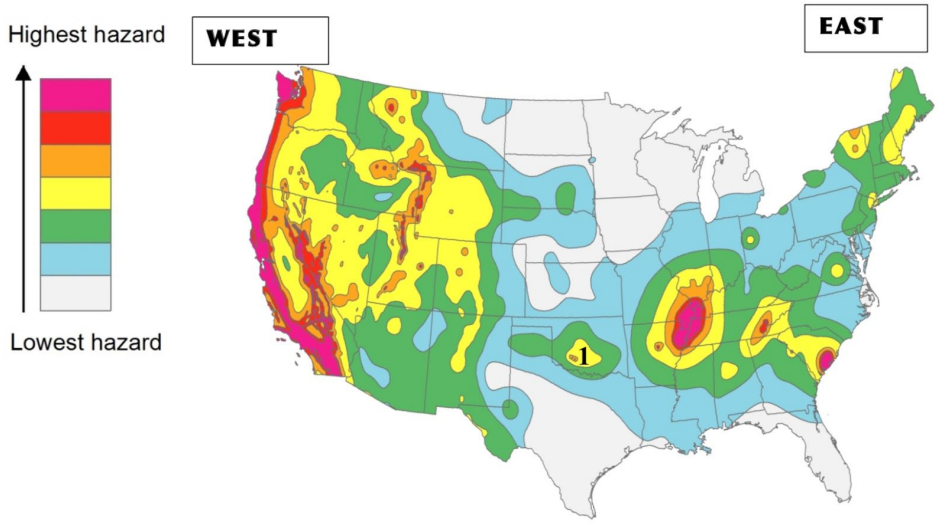
Introduction to question 60:
Bauxite is a sedimentary rock with a relatively high level of aluminum.
Carbonate bauxites are formed by the lateritization of clays deposited in carbonates. Before lateritization, these clays are concentrated by the dissolution of carbonates.
Lateritic bauxites are found mainly in tropical regions. They are formed by the intense weathering of silicate rocks which has removed all minerals except hydrated aluminum oxides.
The Carboniferous is also the time of the first deposits of bauxite.

Q.60) According to the above text, which of the following statements is correct? (one or more correct answers possible).

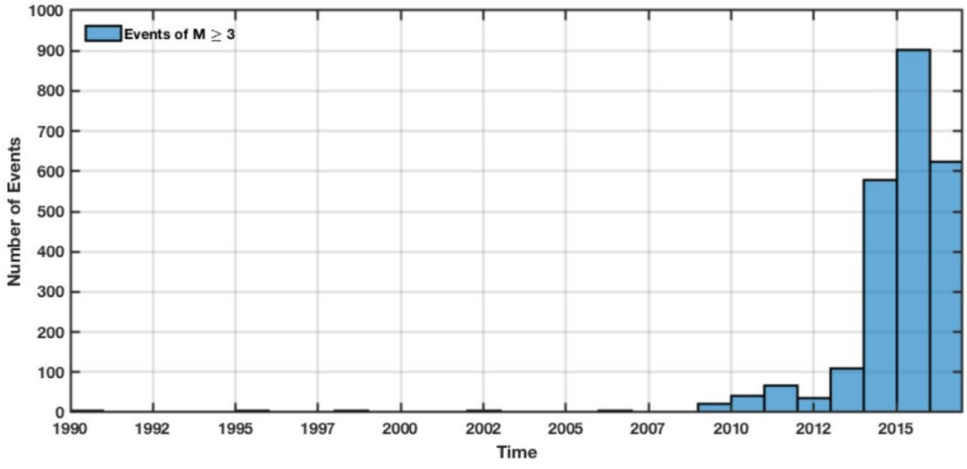
a) Vegetation played a key role in the formation of both types of bauxite.
b) Glaciation increased chemical weathering and may be responsible for the formation of bauxite.
c) The formation of carbonate bauxite is more dependent on the interaction with the biosphere than lateritic bauxites.
d) The formation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

Introduction to question 61:

The map below shows a USGS (United States Geological Survey) long-term seismic risk forecast for part of the USA. The region indicated by the number "1" is the state of Oklahoma. Oklahoma and Texas are well known for their oil and gas reservoirs. Since 2007, the petroleum industry has implemented a hydraulic fracturing technique to increase the permeability of rocks and thus increase oil production. The waste water produced during this fracturing process is then returned to the aquifers.



The Oklahoma geological survey documented more than 125 years of seismicity in the state of Oklahoma. The graph below shows the number of earthquakes of magnitude 3 and above during the period 1990-2017.



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

a) The state of Oklahoma is located on an active tectonic plate boundary.
b) The pattern of high seismic risk areas from Oklahoma to the east coast indicates that the North American plate is moving from west to east.
c) The increase in seismicity in the state of Oklahoma is likely due to human activities.
d) The increase in seismicity in the state of Oklahoma is due to interactions between the 4 Earth systems (geosphere, hydrosphere, atmosphere and biosphere).
e) The increase in seismicity in the state of Oklahoma is only due to interactions between the geosphere and the hydrosphere.
f) The increase in seismicity in the state of Oklahoma is only due to interactions between the geosphere and the biosphere.
g) The increase in seismicity in the state of Oklahoma is only due to interactions between 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