

The Written Test
(Norwegian translation)
(Norsk oversettelse)

The 9th
International Earth Science Olympiad
Pocos de Caldas
Brazil

September, 2015

INSTRUCTIONS

1. Please write your name and nationality in English and in capitals on the cover page.
2. The time allocated for this examination is 3 hours.
3. Read the entire question group carefully before starting to answer. Each question has a point value assigned, for example, (1 point).
4. Pay attention to questions that seek more than one correct answer. Such questions carry negative points for wrong answers.
5. Any inappropriate examination behavior will result in your withdrawal from the IESO.

1. The rock unit (bergartsenheten) in the picture below consists of rounded grains (korn) ranging in size from sand to small pebbles (småstein). In which sedimentary environment (avsetningsmiljø) did this rock form? (Correct answer = 1 point)



- a. Dune (vinddyne)
- b. River
- c. Lake
- d. Beach

2. The surface wind is a result of the balance between the pressure gradient force, Coriolis force, and frictional force. If the surface wind blows from west to east in the Northern Hemisphere (nordlige halvkule), in which direction would the pressure gradient force point? (Correct answer = 1 point)

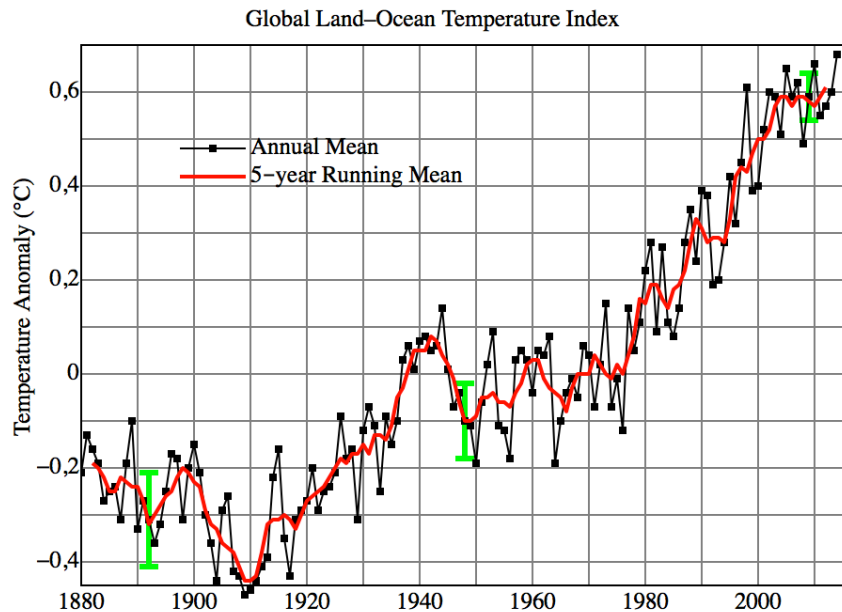
- a) Northeast
- b) Southeast
- c) Southwest
- d) Northwest

3. Choose the correct description for the evidence that the Earth's outer core is liquid (flytende). (Correct answer = 1 point)

- a) In some places, the first arriving seismic waves are refracted (avbøyde) waves instead of direct waves.
- b) There is a seismic shadow zone.
- c) S-waves do not reach the opposite side of an epicenter.
- d) Weak P-waves are detected in the P-wave shadow zone.

4. The figure below shows the global mean surface temperature anomaly (avvik) and the 5-year running mean (gjennomsnitt). The green bars show uncertainty estimates (anslag). The Earth's temperature has remained relatively constant for the past 15 years. Which one of the following options (valgmulighetene) would possibly cause this warming slowdown (or warming pause)?

(Correct answer = 1 point)



- a) Amount of cirrus cloud cover and an increase in the amount of water vapor (damp)
- b) Concentration of tropospheric ozone has increased
- c) An increase in the number of sunspots
- d) The frequency of La Nina events (hendelser) has increased.

5. According to the Big Bang theory, approximately (omtrent) how many years ago was the universe at a very high density state (tilstand) and then expanded? (Correct answer = 0.5 point)

- a) $130 \cdot 10^6$
- b) $1.3 \cdot 10^9$
- c) $13.8 \cdot 10^9$
- d) $138 \cdot 10^9$

6. Which of the following statements (uttalelsene) is correct and only related to the study of seismic waves that pass through the Earth and based on rock rheology characteristics (the response of rock to stress)? (Correct answer = 1 point)

- a) The asthenosphere lies entirely within the mantle and behaves in a semi-fluid(delvis flytende) (plastic) manner on which the lithosphere slips.
- b) The theory of plate tectonics states that the crust is segmented (delt opp) into several pieces of a spherical jigsaw puzzle (runde puslespillbiter).
- c) The crust(jordskorpa) and the outermost mantle comprise (utgjør) the asthenosphere that behaves plastically.
- d) The crust and mantle define a plate that moves relative to one another by floating on and gliding over the liquid (flytende) outer core.

7. The figures below represent two different types of cyclones. Which of the statements (utsagnene) below is correct?
(Correct answer = 1 point)

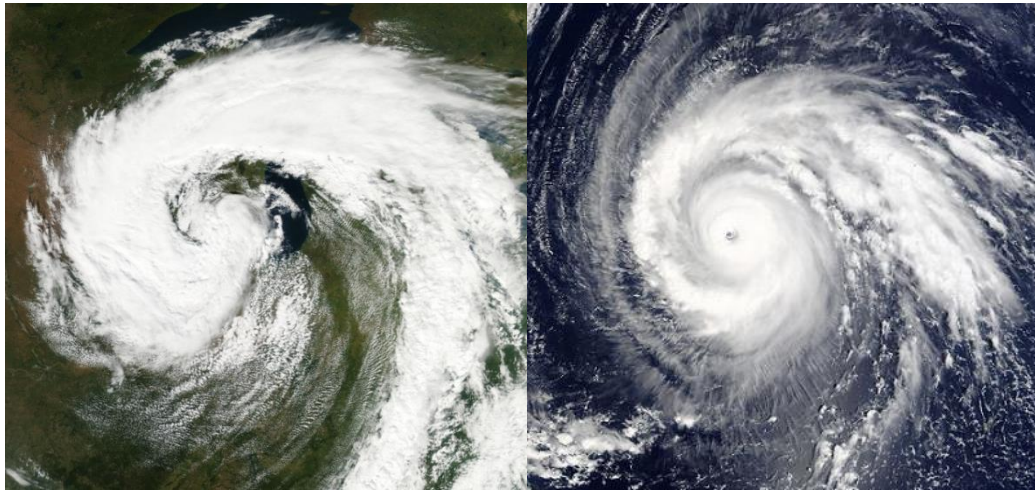


Figure 1

Figure 2

- a) Fig. 1 cyclone forms over cold tropical water.
- b) Fig. 2 cyclone gains energy from condensation.
- c) Fig. 1 cyclone is caused (forårsakes) by upper air convergence (beveger seg mot hverandre).
- d) Fig. 2 cyclone has boundaries separating air masses of different temperatures.

8. Which of the statements (utsagnene) below describe the interaction (samspillet) among CaCO_3 , CO_2 and H_2O ?

(EACH correct answer = 1 point; EACH wrong answer = -1 point)

- a) The formation of limestone (kalkstein).
- b) The dissolution of limestone (kalkstein).
- c) The interaction (samspillet) between atmosphere and geosphere.
- d) The interaction among biosphere, hydrosphere and geosphere.

9. How many years ago did the solar system form due to the gravitational collapse of a giant interstellar molecular cloud? (Correct answer = 0.5 point)

- a) $46 \cdot 10^6$
- b) $460 \cdot 10^6$
- c) $4.6 \cdot 10^9$
- d) $46 \cdot 10^9$

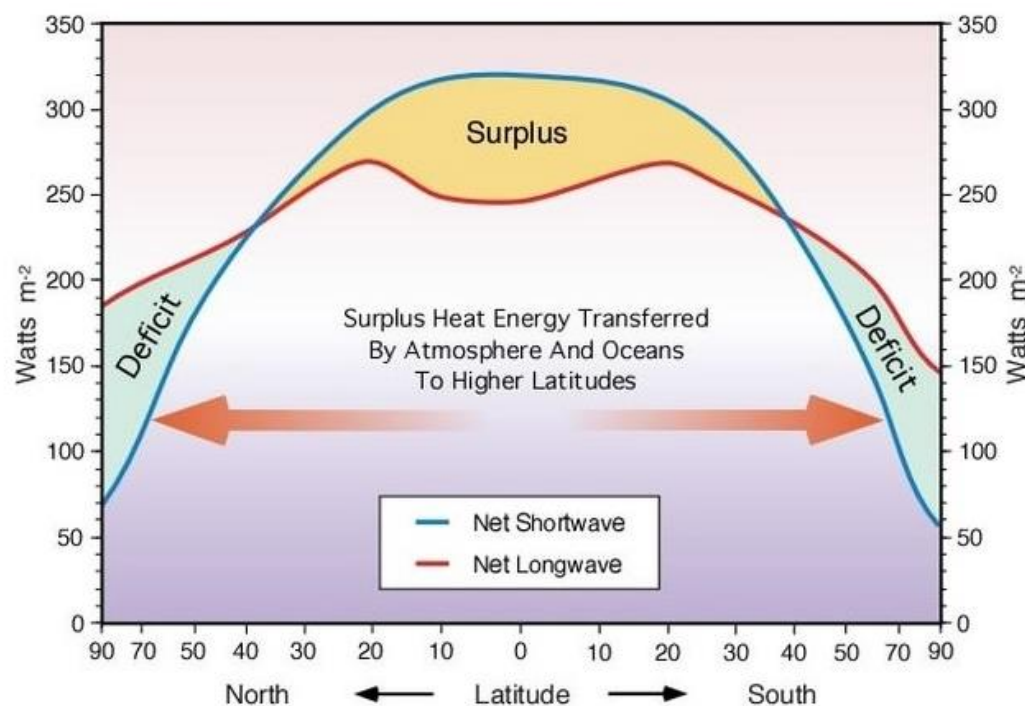
10. If a massive formation of stalactites takes place in caves, which of the statements below describe the outcome?

(**EACH** correct answer = 1 point; **EACH** wrong answer = -1 point)

- a) Accelerate the present climate change.
- b) Slow down the present climate change.
- c) Accelerate the precipitation rate (utfellingshastigheten) of limestone in the ocean.
- d) Slow down the precipitation rate of limestone in the ocean.

11. The figure below shows the annual (årlig) mean of solar (shortwave) and terrestrial (fra jorda)(long-wave) radiation. In the tropics, incoming solar radiation exceeds (overgår) the outgoing terrestrial radiation and, hence, a surplus (overskudd) of energy exists. The reverse holds good (Det motsatte er tilfellet) for the high latitudes (breddegrader). Thus, tropical surplus heat (overskuddsvarme) should be transferred towards the poles to balance the energy budget.

Which one of the following statements (utsagn) does **NOT** reduce the latitudinal energy imbalance? (Correct answer = 1 point) (Deficit = underskudd)



- a) Hurricanes (orkaner) move poleward.
- b) Cold currents (strømmer) flow towards the equator
- c) Atmospheric circulation in the mid-latitudes
- d) Cyclones (annet ord for orkaner) develop in mid-latitudes (midlere breddegrader)

12. For a given gas, a decrease in temperature increases its solubility (løsbarehet) in water.

How will global warming influence (påvirke) the carbonate rocks on Earth?

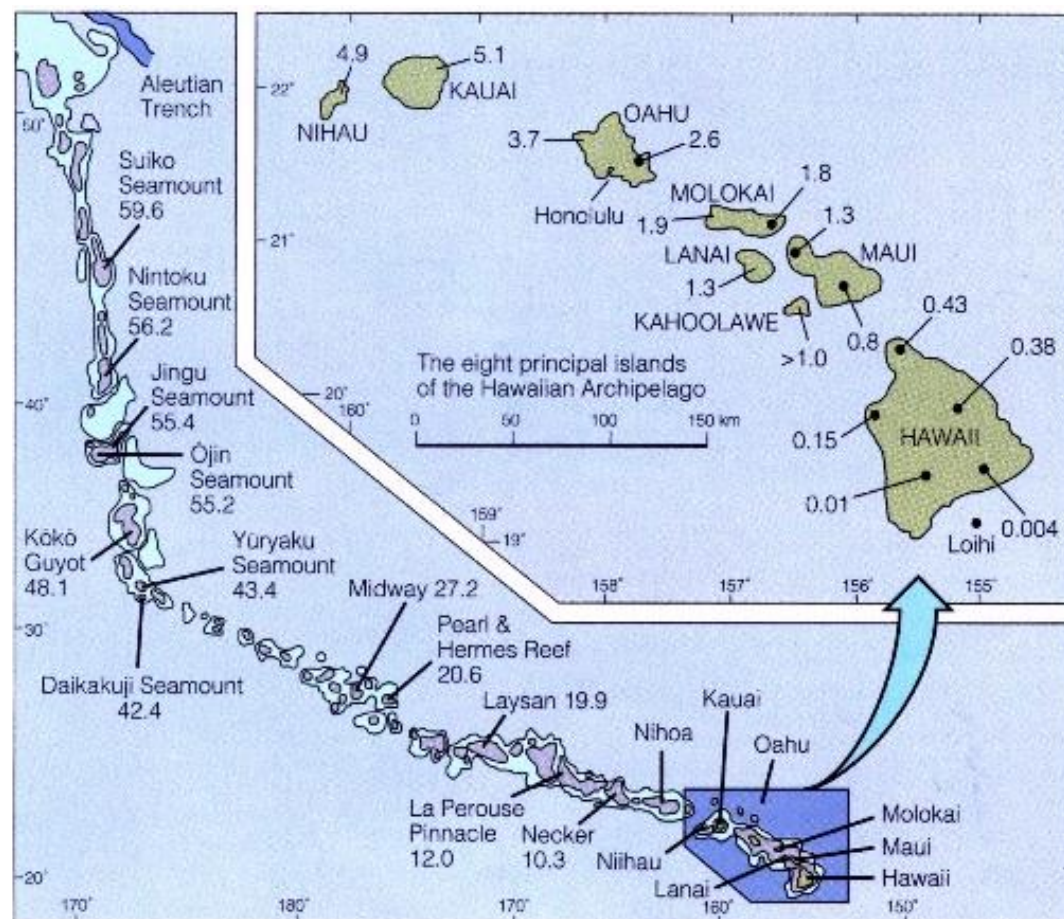
Choose the correct statement below. (Correct answer = 1 point)

- a) It will only increase the dissolution (oppløsning) of limestone.
- b) It will increase the dissolution of all the carbonate rocks.
- c) It will have no effect on the dissolution or formation of carbonate rocks.
- d) It will increase the formation of carbonate rocks.

13. The figure below shows the distribution (fordeling) of the Hawaiian and Emperor chains with the geological age of volcanic rocks (unit: 10^6 years).

What is the velocity (hastigheten) of the Pacific plate movement at present on the basis of this distribution (fordeling)? Choose the correct statement (utsagnet) from the list below:

(Correct answer = 1 point)



- a) 6 cm/year
- b) 60 cm/year
- c) 3 cm/year
- d) 30 cm/year

14. Which of the statements below describe the outcome of the increase of CO₂ in the atmosphere? (**EACH** correct answer = 1 point; **EACH** wrong answer = -1 point))

- a) A decrease in the formation of CaCO₃ in the oceans.
- b) The formation of CaCO₃ in the oceans.
- c) Acidification (Forsuring) of the oceans.
- d) An increase in the growth of coral reefs.

15 –16. The following paragraph (deloppgaven)(concerning sunspots) contains (inneholder) numbered blanks (nummererte blanke felt). Please match the numbered blanks with the correct letters from the word bank (ordbanken) provided below. (Correct answer = 0.5 point)

A sunspot (solflekk) is a relatively colder part on the sun's surface. The number of sunspots typically changes with a periodicity of **(15)** years; solar activity is **(16)** when there are many sunspots.

Word bank:

(a) 11 (b) 110 (c) 1100 (d) low (e) high (f) constant

| Blank number in the paragraph | The matching letter from the word bank |
|-------------------------------|--|
| 15 | |
| 16 | |

17. How many times bigger is the diameter of the Sun compared to that of the Earth? (Correct answer = 0.5 point):

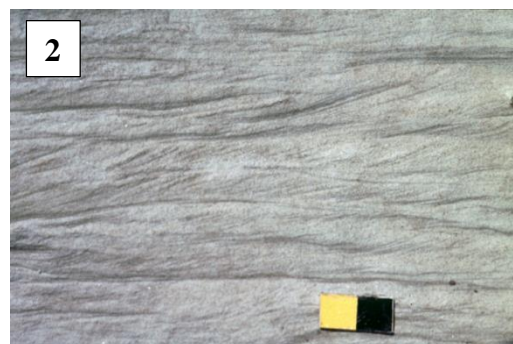
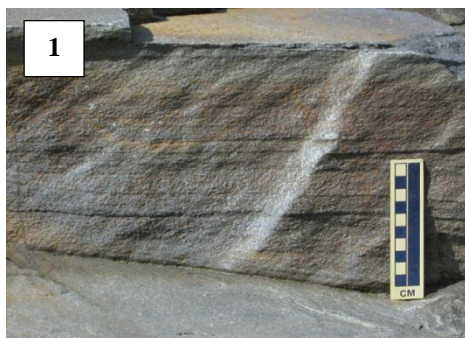
- a) About 100 times
- b) About 1,000 times
- c) About 10,000 times
- d) About 100,000 times

18. Both the figures below show medium-grained (medium kornet) sandstone.

Figure (1) shows horizontal lamination (findelt lagdeling) and Figure (2) shows ripple cross (kryss)-lamination

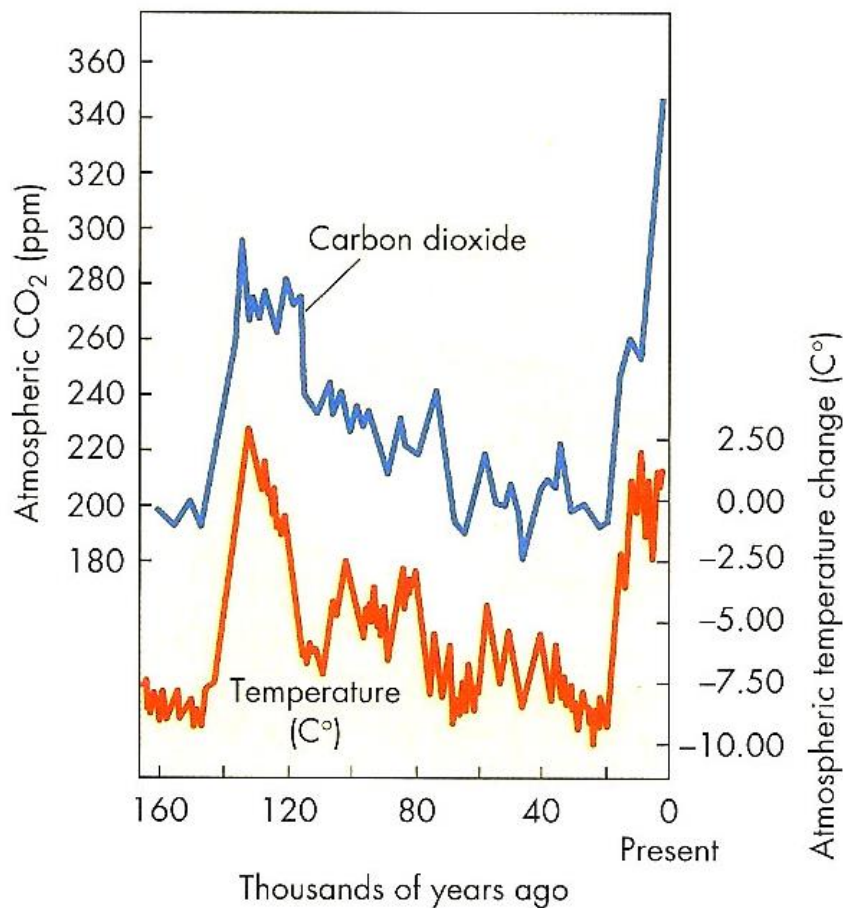
Choose the correct answer that explains these sedimentary structures?

(Correct answer = 1 point).



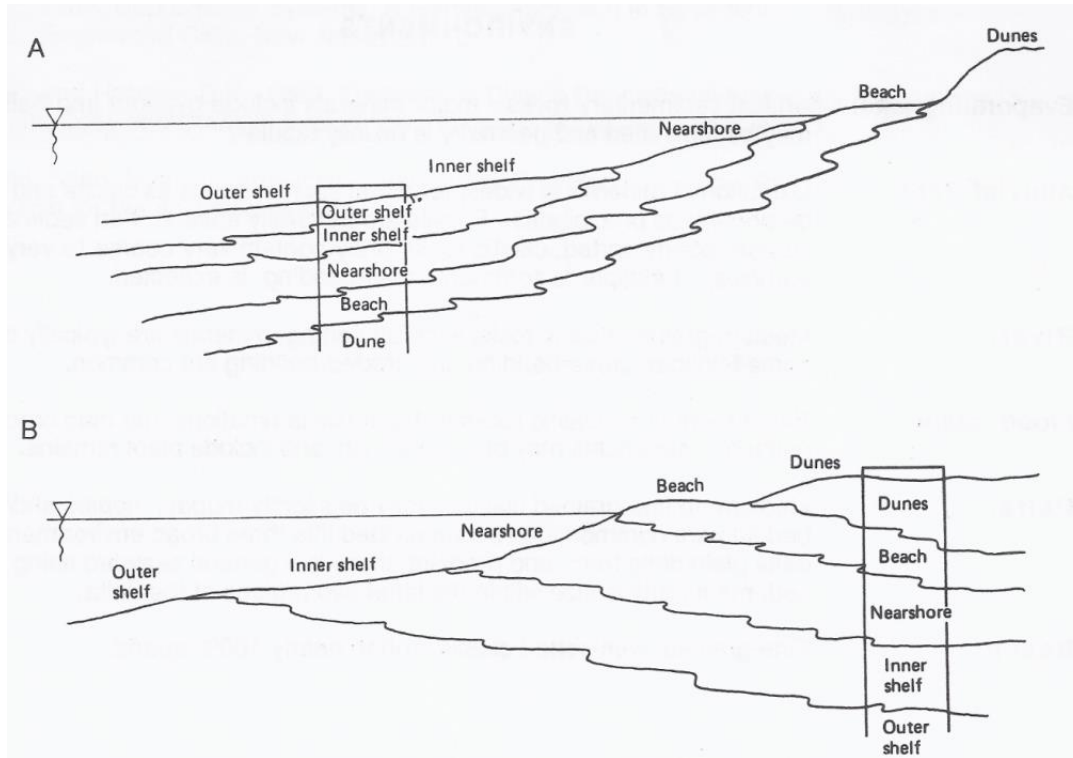
- a) The water depth to form sedimentary structure (2) is deeper than that to form sedimentary structure (1).
- b) Sedimentary structure (2) is formed in a delta.
- c) Sedimentary structure (1) is formed by the settling of grains in water (korn som felles ut fra vannkolonnen).
- d) Sedimentary structure (1) requires water flow of a higher velocity (hastighet) when compared to that needed for sedimentary structure (2).

19. The following figure shows the inferred (antatte) changes in the concentration of atmospheric carbon dioxide and temperature during the past 160,000 years. Choose the correct answers to explain the geologic processes related to this figure. (EACH correct answer = 1 point; EACH wrong answer = -1 point)



- a) The high concentration of atmospheric CO₂ at present is mainly caused by global warming.
- b) Ocean acidification (forsuring) is expected and already recorded at present due to an increase of atmospheric CO₂.
- c) Development of glaciers (breer) in polar regions is expected when the atmospheric CO₂ concentration is below 220 ppm.
- d) Dissolution (oppløsning) of limestone exposed (eksponert) on continents is thought to have occurred (skjedd) more effectively 20,000 years ago than 120,000 years ago.

20. Diagrams A and B show the development pattern (mønster) of sequences (sekvenser) in a coast-to-continental shelf (koninentalhylle) setting (miljø). Choose the correct answer to explain the balance between the rate of sea level rise (havnivåendring) and the rate of sediment supply (mengde sedimenter tilført) to the sea to form the sequences in (A) and (B). (Choose the correct answer = 1 point)



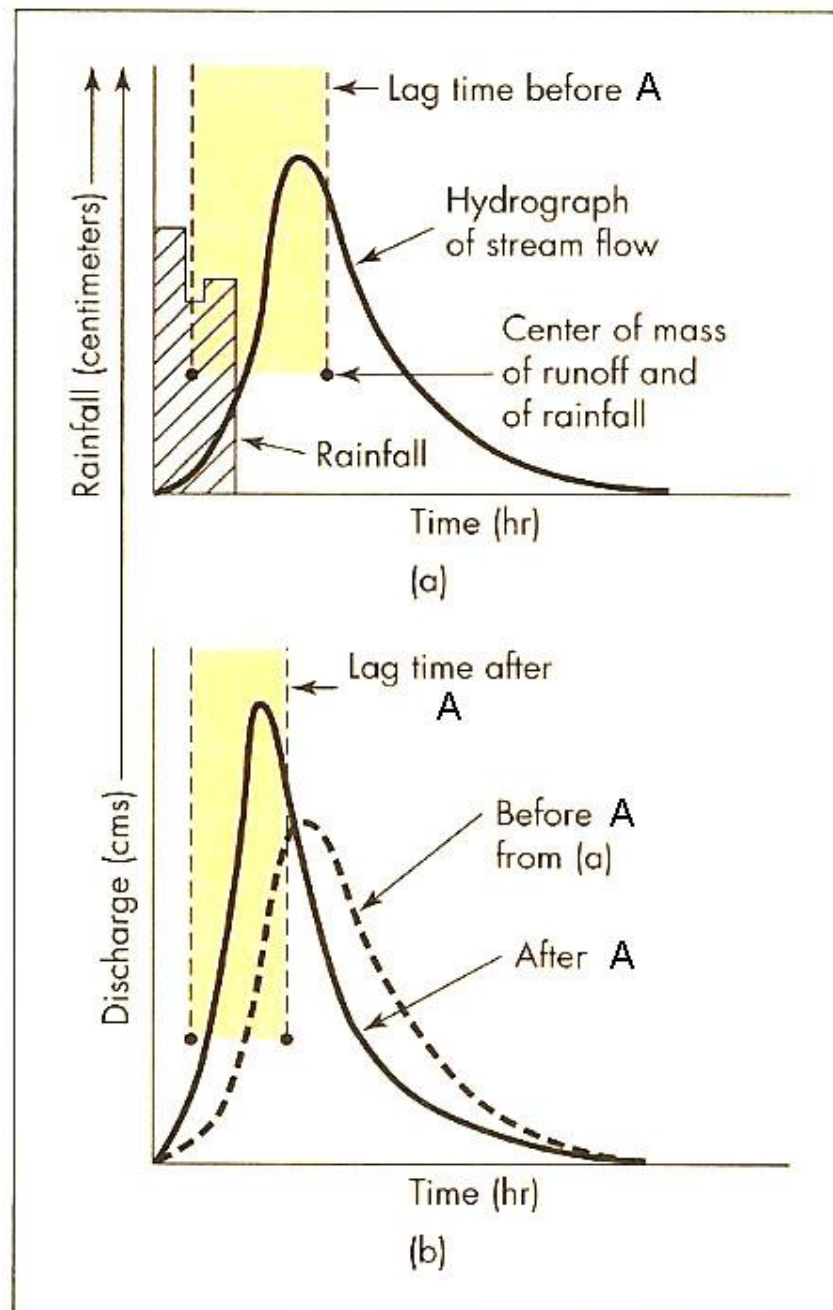
Forklaring/legend til forskjellige avsetningsmiljø: dunes – dyner; beach – strand; nearshore – grunnmarint/i havet men nær strand; inner shelf – indre del av kontinentalhylle; outer shelf – ytre del av kontinentalhylle)

- a) In section A: rate of sea level rise = rate of sediment supply (tilførsel)
In section B: rate of sea level rise < rate of sediment supply
- b) In section A: rate of sea level rise > rate of sediment supply
In section B: rate of sea level rise = rate of sediment supply
- c) In section A: rate of sea level rise > rate of sediment supply
In section B: rate of sea level rise < rate of sediment supply
- d) In section A: rate of sea level rise < rate of sediment supply
In section B: rate of sea level rise > rate of sediment supply

21. The Sun produces nuclear fusion by converting (omgjøre) _____. (Correct answer = 0.5 point)

- a) Helium to Hydrogen,
- b) Hydrogen to Lithium,
- c) Helium to Carbon,
- d) Hydrogen to Helium

22. A hydrograph shows the rate of flow (discharge)(avrenning) versus (kontra) time past a specific point in a river. The unit cms is cubic meters per second. Figure (a) is a hydrograph showing the typical lag (forsinkelsen) between the time when most of the rainfall occurs and the time when the stream (elva) floods (flommer over). “A “ in the hydrographs below represents a factor which influences lag time. In Figure (b) there is a decrease in lag time (forsinkelsen blir mindre) with the same amount of rainfall as in figure (a). What is the correct reason for this decrease? (Correct answer = 1 point).



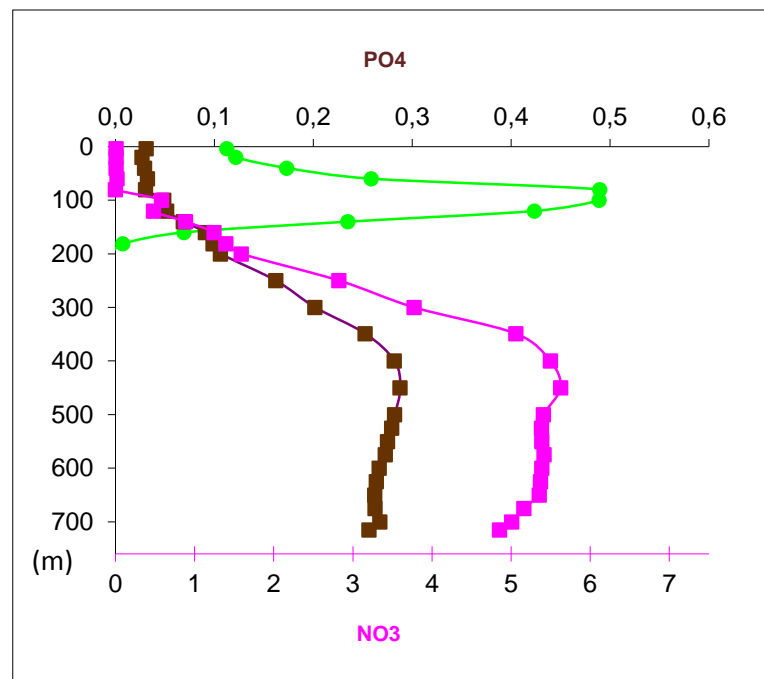
- a) Construction of upstream retention) ponds (flomdempende demninger)
- b) Storm
- c) Urbanization
- d) Restoration (gjenoppbygning) of catchment forestation (flomdempende skog)

23. Which of the statements (utsagnene) below correctly describes the outcome (resultatet) of the formation of limestone and chalk (kritt)? (Correct answer = 1 point)

- a) An increase in the amount of CO₂ in the hydrosphere and in the atmosphere.
- b) An increase in the amount of CO₂ in the atmosphere only.
- c) A decrease in the amount of CO₂ in the atmosphere and in the hydrosphere.
- d) A decrease in the amount of CO₂ in the hydrosphere only.

24. The green line in the graph below presents the chlorophyll content (water depth-wise) in the Gulf of Aqaba (Rødehavet) (latitude 29°). Which of the items below is related to the high amount of chlorophyll at shallow depth (~ 100 m)?

(Correct answer = 1 point)



- a) The concentration of CO₂ in the atmosphere
- b) The sun light and water
- c) The salinity of the water
- d) The amount of nitrate and phosphate

25. Which of the options below do **NOT** reflect the interrelationships (forholdet til hverandre) between the earth systems (de forskjellige sfærene) in the formation of limestone and chalk (kritt)?

(**EACH** correct answer = 1 point; **EACH** wrong answer = -1 point)

- a) Geosphere, atmosphere, hydrosphere and biosphere.
- b) Only the geosphere, atmosphere and hydrosphere.
- c) Only the biosphere, hydrosphere and geosphere.
- d) Only the biosphere, atmosphere and geosphere.

26. What is the average surface temperature of the Sun? (Correct answer = 0.5 point)

- a) 3750°C
- b) 4750°C
- c) 5750°C
- d) 6750°C
- e) 7750°C

27 – 40. The following paragraph (concerning our solar system) contains numbered blanks (tomme, nummererte ruter). Please match the numbered blanks (Fyll inn de tomme rutene) with the correct letters from the word bank provided below. (Correct answer = 0.5 point for hvert riktige svar)

The four inner planets - Mercury, Venus, Earth and Mars - are called (27), which are made up of (28) and (29). The four outer planets are (30).

Jupiter and Saturn, are (31), and are mainly composed of (32) and (33). Uranus and Neptune are (34), and are mainly composed of (35), (36) and (37).

Smaller objects also exist in the Solar System, mostly between (38) and (39), which is called (40).

Word bank:

| | |
|-------------------------|-------------------------------|
| a) Rock | m) Ice giants |
| b) Ice giant | n) Scattered disc |
| c) Methane | o) Water |
| d) Mars | p) Venus |
| e) Neptune | r) Saturn |
| f) Kuiper belt | s) Ammonia (ammoniakk) |
| g) Metal | t) Earth |
| h) Hydrogen | u) Uranus |
| i) Helium | v) Gas giants |
| j) Giant planets | w) Asteroid belt |
| k) Mercury | x) Rocky planets |
| l) Jupiter | y) Planetesimals |

| Blank number in the paragraph | The matching letter from the word bank |
|--------------------------------------|---|
| 27 | |
| 28 | |
| 29 | |
| 30 | |
| 31 | |
| 32 | |
| 33 | |
| 34 | |
| 35 | |
| 36 | |
| 37 | |
| 38 | |
| 39 | |

41. Which of the options (alternativene) below is the correct order (viser den riktige rekkefølgen) of the size of carbon reservoirs on Earth? (Correct answer = 1 point).

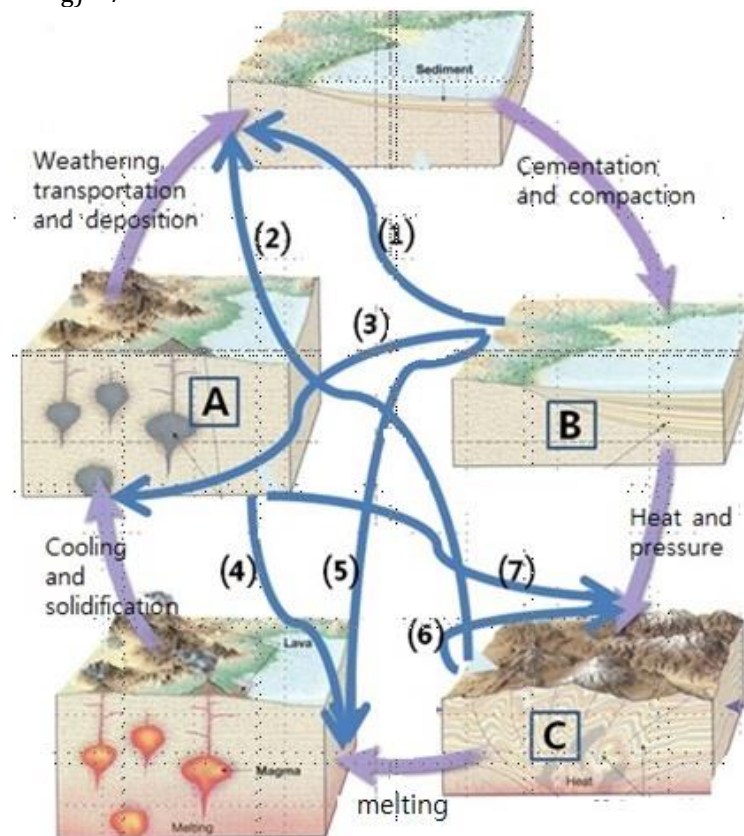
- a) Atmosphere (the largest).
Biosphere
Hydrosphere
Geosphere (the smallest)
- b) Atmosphere (the largest).
Biosphere
Geosphere
Hydrosphere (the smallest)
- c) Biosphere (the largest).
Atmosphere
Geosphere
Hydrosphere (the smallest)
- d) Geosphere (the largest).
Atmosphere
Biosphere
Hydrosphere (the smallest)
- e) Geosphere (the largest).
Hydrosphere
Biosphere
Atmosphere (the smallest)

42. Which of the following statements is true about the conditions under which carbonate sedimentation occurs in oceans? (Under hvilket forhold skjer det karbonatsedimentering i havet?) (Correct answer = 1 point).

- a) The formation of carbonate sediments is promoted through respiration (celleånding) of living organisms.
- b) Carbonate sedimentation is relatively high in oceans with conditions for rapid (rask) photosynthesis.
- c) Oceanic carbonate sediments are primarily derived (dannet gjennom) from the erosion of limestone deposits (avsetninger) in continents.
- d) Carbonate sedimentation is relatively high in warmer oceans.

43. Which of the pathways (number) (1-7 in the diagram below) cannot occur in nature?
(Correct answer = 1 point)

- a) 1
- b) 2
- c) 3
- d) 4
- e) 5
- f) 6
- g) 7



44. While walking in a mountain range, you find a fossil reef in a limestone layer. What might you conclude based on this field observation?
(Correct answer = 1 point)

- a) It is most likely that this area was an ancient deep ocean floor.
- b) It is most likely that this area was a continental shelf (kontinentalsokkel) located in an area with rather warm water.
- c) It is most likely that this area was a continental shelf located in a rather cold area.
- d) It is most likely that this area was a former continental slope (kontinentalskråning) beneath which detrital (klastiske) sediments have been accumulating (samlet seg).

45 - 47. In the photograph below, the darker units are metamorphic (metamorfe) rocks with some igneous (magmatiske) intrusions (ganger) and the lighter unit consists of limestone, dolomite, chalk (kritt) and chert (kiselstein (fra kiselalger)). Question numbers 45, 46 and 47 are related to this photograph.



45. Which of the structures below is most likely the reason (mest sannsynlige og enkleste forklaringen) for this appearance of the rocks units (for hvordan bergartsenhetene fremstår)? (Correct answer = 1 point)

- a) Syncline (synklinal)
- b) Anticline (antiklinal)
- c) Horst
- d) Graben

46. What are the geologic processes that took place in the area? Choose the correct answers. (**EACH** correct answer = 1 point, **EACH** wrong answer = -1 point)

- a) Sedimentation
- b) Metamorphism
- c) Volcanic eruptions (vulkanutbrudd)
- d) Magmatic intrusions (inntrengning av magmatiske ganger)
- e) Erosion
- f) Chemical weathering (kjemisk forvitring)
- g) Lithification (forsteining)
- h) Melting
- i) Burial (begravning)
- j) Uplift

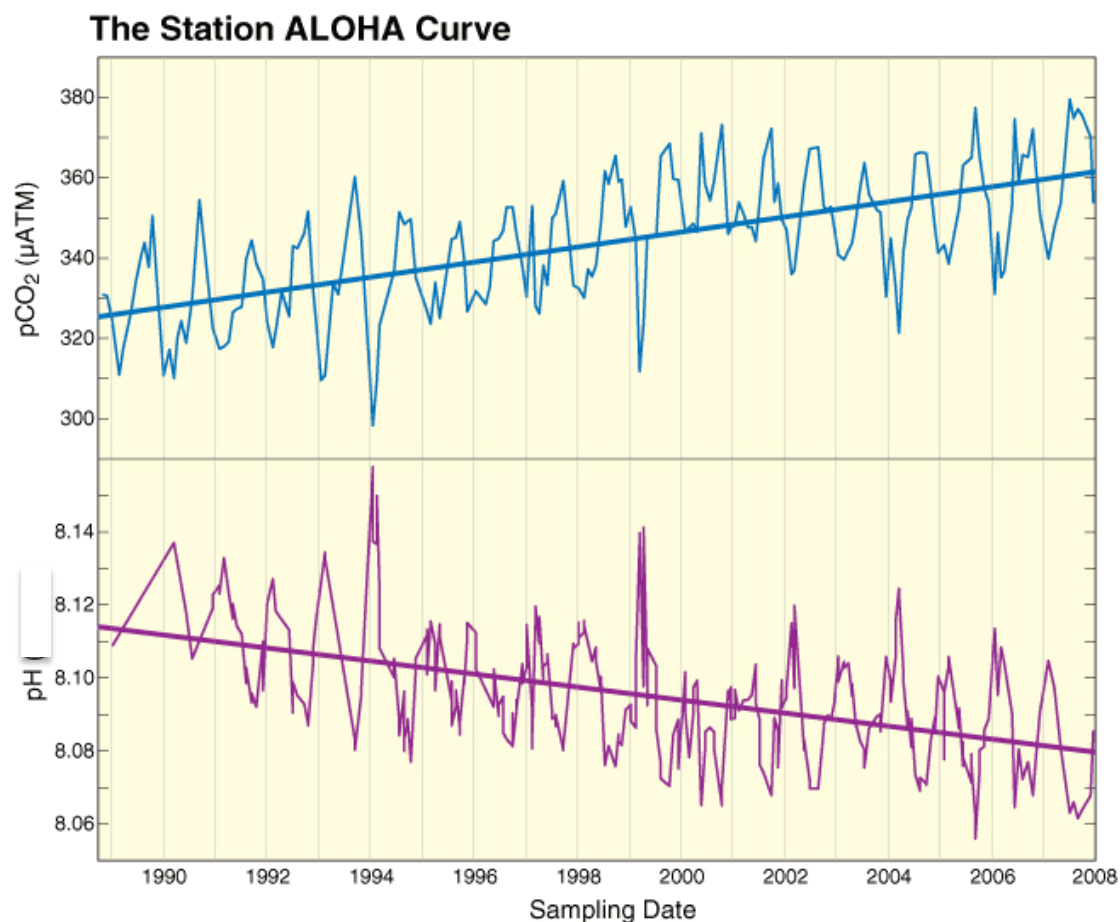
47. Which of the sequences given below best describes the order of the geological processes that took place in the area? (Correct answer = 1 point)

- a) Metamorphism, erosion, magmatic intrusions, sedimentation, erosion.
- b) Metamorphism, magmatic intrusions, erosion, sedimentation, erosion.
- c) Metamorphism, sedimentation, magmatic intrusions, erosion.
- d) Metamorphism, magmatic intrusions, volcanic eruptions, sedimentation, erosion.

48. The graph below depicts (gjengir) the changes of atmospheric CO₂ concentration and the pH of the Pacific Ocean water. The measurements were made in Hawaii from 1990 to 2008.

Based on the graph, mark the correct statements in the list below.

(EACH correct answer = 1 point; EACH wrong answer = -1 point)



- When the pH increases, (øker) CO₂ is released (frigitt) from the ocean to the atmosphere.
- Global warming causes an increase in atmospheric CO₂ concentration and the ocean water becomes more acidic (surere).
- When atmospheric CO₂ concentration increases, CO₂ gets into the ocean and the ocean water becomes more acidic.
- If only the atmospheric CO₂ concentration was increasing and the oceanic pH was constant, global warming would be more rapid (skje i et raskere tempo).
- If only atmospheric CO₂ concentration was increasing and the oceanic pH was constant, global warming would be slower.
- An increase in oceanic CO₂ concentration can affect (påvirke) coral reefs.
- The annual (den årlige) variation of the atmospheric CO₂ concentration is a result of biological activity.
- The common explanation for the increase of atmospheric CO₂ concentration is human activity, mostly fossil fuel burning and forest fires. (skogbranner).
- The atmospheric CO₂ data shown represent only the changes in the Pacific Ocean.

49. What is the dated age of the rocks in which the first evidence of life forms appeared? (Correct answer = 0.5 point):

- a) Approximately $380 \cdot 10^6$ years ago.
- b) Approximately $550 \cdot 10^6$ years ago.
- c) Approximately $3.8 \cdot 10^9$ years ago.
- d) Approximately $4.6 \cdot 10^9$ years ago.

50. Which of the statements below correctly describe the change in the CO₂ concentration in the primitive atmosphere of the Archaean Earth (i urtiden i jordas historie)?

(**EACH** correct answer = 1 point; **EACH** wrong answer = -1 point):

- a) Increased following the appearance of life on earth.(livets opprinnelse)
- b) Decreased following the appearance of photosynthetic organisms.(organismer som driver fotosyntese).
- c) Decreased following the formation (dannelsen) of calcium carbonate by living organisms.
- d) Increased following the formation of calcium carbonate by living organisms.
- e) Decreased following the weathering (forvitring) of igneous (magmatiske) minerals.
- f) Increased following the weathering of igneous minerals.

51 - 52. The following paragraph (concerning the Sun) contains numbered blanks. Please match the numbered blanks with the correct letters from the word bank provided below. (Correct answer = 0.5 point)

The Sun ejects (skyter ut) charged particles,(ladde partikler) referred to as (**51**), with the speed of several (**52**) of km/s

Word bank:

- a) Corona
- b) Solar wind
- c) Solar flare
- d) Tens
- e) Hundreds
- f) Thousands
- g) Ten thousands

| Blank number in the paragraph | The matching letter from the word bank |
|-------------------------------|--|
| 51 | |
| 52 | |

53 – 56. The following paragraph (concerning fossil fuels) contains numbered blanks. Please match the numbered blanks with the correct letters from the word bank provided below. (Correct answer = 0.5 point)

Fossils of (**53**), which use energy from (**54**), existed (eksisterte) in the ocean and produced (**55**). This created (**56**) in the Archaean oceans. (havene i jordas urtid)

Word bank:

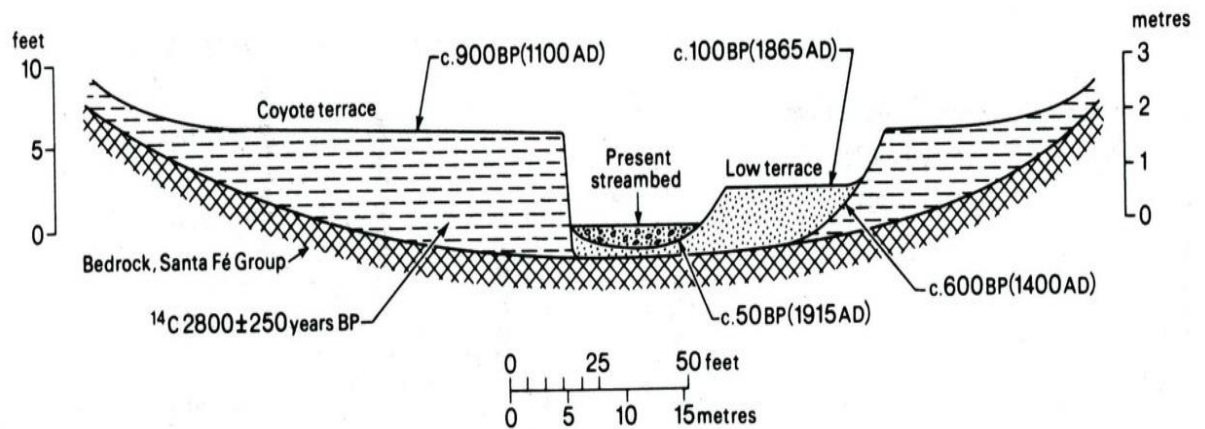
- a) Cyanobacteria (blågrønne alger)
- b) Burgess Shale
- c) Oxygen
- d) Brachiopoda
- e) Zooplankton (dyreplankton)
- f) Nickel ore (nikkel malm)
- g) Photosynthesis (fotosyntese)
- h) Trilobites
- i) Uranium ore (uran malm)
- j) Stromatolites
- k) Nitrogen
- l) Banded Iron Formation (jernoksider)
- m) Crinoids

| Blank number in the paragraph | The matching letter from the word bank |
|-------------------------------|--|
| 53 | |
| 54 | |
| 55 | |
| 56 | |

57. Which of the statements below correctly describe the tendency of weathering of feldspars (forvitring av feltspat)? (**EACH** correct answer = 1 point; **EACH** wrong answer = -1 point)

- a) Decreases the amount (mengden) of CO₂ in the atmosphere.
- b) Increases the amount of CO₂ in the atmosphere.
- c) Enhances the acidification (forsuringen) of the oceans.
- d) Limits the acidification of the oceans.
- e) Increases the formation of calcium carbonate.
- f) Decreases the formation of calcium carbonate.

58 – 59. The cross section (snittet) below represents terraces in a desert (ørken). The terraces were dated and their ages are presented in the figure. Question numbers 58 and 59 are related to (knyttet opp mot) this diagram.



58. What is the rate of deposition (avsetningshastighet) in the older terrace? (Correct answer = 1 point)

- a) One meter in 1000 years.
- b) One meter in 100 years.
- c) One meter in 300 years.
- d) Three meters in 1000 years.

59. What can be the reasons for the incision of the valley (nedskjæringen av dalen)? Choose the correct answers. (**EACH** correct answer = 1 point; **EACH** wrong answer = -1 point)

- a) Change in the base level. (endring av dalens grunnnivå)
- b) Climate became drier.
- c) Climate became wet.
- d) Changes in the drainage basin (nedbørsfeltet) over time.

60 – 67. The following paragraph (concerning the Earth's early evolution) contains numbered blanks. Please match the numbered blanks with the correct letters from the word bank provided below. (Correct answer = 0.5 point)

The Earth formed (**60**) years ago by accretion from the solar nebula. (ved at soltåken trakk seg sammen) The early Earth was (**61**) from the surface to the core (kjernen) and heavy (**62**) sunk, leading to the formation of the (**63**). The surface (overflaten) was covered with a (**64**) and volcanic outgassing created the primordial (førstegenerasjons) atmosphere with (**65**) oxygen.

Then Earth cooled and formed a crust (skorpe), with the ocean at the surface. This is the beginning of the (**66**) age, which occupies the (**67**) span of time (tidsperioden) in the Earth's history.

Word bank:

| | |
|----------------------------|------------------|
| a) hydrogen | l) iron |
| b) oxygen | m) mantle |
| c) reductive (reduserende) | n) core |
| d) nitrogen | o) magma ocean |
| e) water | p) set of plates |
| f) $460 \cdot 10^6$ | q) plenty of |
| g) $4.6 \cdot 10^9$ | r) no |
| h) $46 \cdot 10^9$ | s) smallest |
| i) solid (fast) | t) largest |
| j) molten (smeltet) | u) Cambrian |
| k) silicon | v) Precambrian |

| Blank number in the paragraph | The matching letter from the word bank |
|-------------------------------|--|
| 60 | |
| 61 | |
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