Earth and Environmental Sciences: Second-round Sample Tasks for the Open Doors Undergraduate Track

The variant includes 30 tasks, 19 of which are entry-level tasks with one correct answer (a correctly completed task is 2 points), 8 are intermediate-level tasks with several correct answers (a correctly completed task is 4 points), 3 are high-level tasks with a detailed answer (the correctly completed task is 10 points).
In test tasks, correct answers are highlighted in bold.
For complex tasks with a detailed answer, assessment criteria and a standard answer are provided.

1. Water recourses

Task 1
Entry level (2 points)

Which of the following pollutants that enter water are formed only as a result of human activity?

a) Oil
b) Salts
c) **Dibenzofurans**
d) Hydrogen sulfide

Answer: c

Task 2
Entry level (2 points)

Lakes are more likely than rivers undergo to eutrophication. This is due to the fact that lakes have

a) less depth
b) **lower water flow speed**
c) higher water salinity
d) less sediment

Answer: b

Task 3
Intermediate level (4 points)

Choose two valid statements that can be used to characterize Lake Victoria.

a) The lake is located on the territory of four African States: Tanzania, Kenya, Uganda, Rwanda. The lake is the third largest freshwater lake in the world.
b) **The lake is located on the territory of three African States: Tanzania, Kenya, Uganda. It is the second largest freshwater lake in the world by area.**
c) The lake is the third largest freshwater lake in the world by reserves.
d) The lake is the first largest freshwater lake in the world by reserves.
e) **The lake is characterized by severe storms caused by hurricane winds during tropical thunderstorms. The lake is fed mainly by precipitation and river waters.**

f) The lake basin is characterized by calm conditions. The lake is powered mainly by groundwater

Answer: b, e

Task 4
Advanced level (10 points)

Task. It is known that approximately 3.8 billion years ago the concentration of sodium chloride in the primordial ocean was 0.9% by weight NaCl, so it was the same as the concentration of salt in human blood. Currently the average salt concentration in the World Ocean has increased and is 3.47%. Explain why the concentration of salt in the World Ocean has changed. Calculate how much salt entered the World Ocean during this time, if the mass of sea water remained unchanged and is $1.34 \cdot 10^{21}$ kg.

Note: the assessment takes into account the progress of the solution; writing the answer only is not enough for getting points.

Solution:
1. The concentration of salts in the World Ocean gradually increased due to the neutralization reaction between acids that were formed in water during volcanic eruptions and alkaline elements (sodium, magnesium, potassium, calcium, etc.), which were formed due to the destruction of rocks and entered into water. Alkaline elements combined with chlorine, fluorine, bromine and neutralized the solution.
2. The concentration of salts in the World Ocean increased by: 3.47-0.9=2.57%, i.e. at 2.57 g/100 g sea water
3. Consequently, the mass of salts in the World Ocean increased by: $2.57 \cdot 1.34 \cdot 10^{21} =$ **$3.44 \cdot 10^{21}$ kg**

Answer: 3.44·1021 kg of salt entered the World Ocean

Assessment criteria:
Criterion 1 – 4 points.
Criterion 2 – 3 points.
Criterion 3 – 3 points.

Scientific field 2. Geology

Task 1
Entry level (2 points)

Which rock group does granite belong to?

a) Sedimentary rocks
b) **Magmatic rocks**
c) Metamorphic rocks
d) It is not a rock

Answer: b.

Task 2

Entry level (2 points)

Geologists are planning a field trip and have drawn straight lines on a map that lie in the same plane and do not intersect. What are these lines called?

a) Intersecting
b) Perpendicular
c) **Parallel**
d) Crossed

Answer: c.

Task 3
Intermediate level (4 points)

Select from the listed countries the two countries that are the leaders (the largest quantity) in reserves of uranium in the subsoil of the Earth.

a) **Australia**
b) Japan
c) **Namibia**
d) China
e) USA
f) Russia

Answer: a, c.

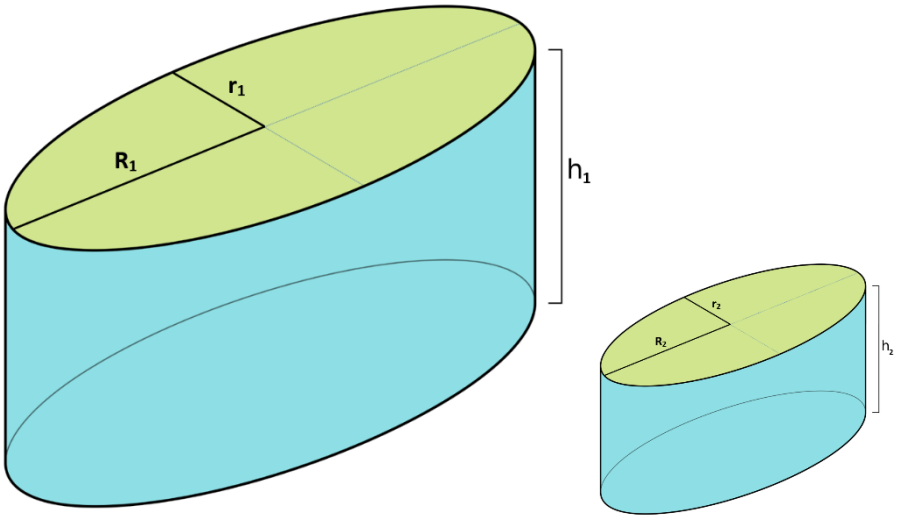
Task 4
Advanced level (10 points)

The major area of the continent is located in the southern and eastern hemisphere. Part of the continent is surrounded by the Atlantic and Indian Oceans, and the climate is predominantly tropical and to a lesser extent subtropical. Several countries in this part of the continent have huge reserves (accounting for a significant portion of the world's reserves) of non-metallic minerals. The raw material value of this mineral is large. Geologists have found a new deposit of this mineral and investigated it. It consists of two ore bodies of the same shape but different sizes. The ore bodies have the shape of an elliptical (oval) cylinder, and the oval side is on the surface of the Earth. The first ore body has the following parameters: the depth of mineralization is 400 m, along the strike on the Earth's surface the ore body has the shape of an oval with the radius of the long semi-major axis of 1000 m and the radius of the short semi-major axis of 500 m. The second ore body has a volume of 628 000 m^3. Note: the geometric shape of the ore bodies remains constant, the values of radiuses and depths change proportionally. The value of π is assumed to be equal to 3.14.

1) Identify the continent and the specific region for which the information is provided.
2) Determine the mineral being described.
3) Calculate how many times the area of occurrence of the second ore body on Earth's surface is smaller than the area of the first.

Note: the assessment takes into account the progress of the solution; writing the answer only is not enough for getting points.

Solution: The two continents of Africa and Antarctica are surrounded by the Atlantic and Indian Oceans. Given a type of climate and the existence of countries, the continent searched for is Africa. Southern Africa (or southern part of Africa) has a predominantly tropical and to a lesser extent subtropical climate and two countries (South Africa and Botswana) have huge diamond reserves (more than 20% of the world's reserves). Diamonds belong to non-metallic minerals and are an expensive type of raw material. The shape of ore bodies is an elliptical (oval) cylinder. The volume of such a shape is calculated by the formula $\mathbf{V} = \boldsymbol{\pi} \cdot \mathbf{R} \cdot \mathbf{r} \cdot \mathbf{h}$. Based on the dimensions of the first ore body, specified in the task h is the depth of mineral distribution and is equal to 400 m, radius R of the long semi-major axis of the oval 1000 m, radius r of the short semi-major axis 500 m, the volume is calculated as $\mathbf{V_1} = 3.14 \cdot 1000\ \text{m} \cdot 500\ \text{m} \cdot 400\ \text{m} = 628\,000\,000\ \text{m}^3$. The volume of the second ore body is 1000 times smaller than the first ($\mathbf{V_1}/\mathbf{V_2} = 628\,000\,000\ \text{m}^3 / 628\,000\,000\ \text{m}^3 = 1000$). Provided that the ore bodies have the same geometric shape, then when the volume changes, all quantities (radii and heights) will change proportionally. Using the rule of similarity of geometric figures, linear quantities will change relative to volumetric quantities as the root of the cubic degree. It means that linear quantities (**R**, **r**, **h**) of the second figure (ore body) will be $\sqrt[3]{1000} = 10$ times smaller than the first one. Accordingly, $\mathbf{R_2} = 100$ m, $\mathbf{r_2} = 50$ m, $\mathbf{h_2} = 40$ m. Thus, the area of distribution of the second ore body on the surface of the Earth is less than the area of the first in 100 times and calculated as $\mathbf{S_1}/\mathbf{S_2} = (\boldsymbol{\pi} \cdot \mathbf{R_1} \cdot \mathbf{r_1}) / (\boldsymbol{\pi} \cdot \mathbf{R_2} \cdot \mathbf{r_2}) = (\mathbf{R_1} \cdot \mathbf{r_1}) / (\mathbf{R_2} \cdot \mathbf{r_2}) = (1000\ \text{m} \cdot 500\ \text{m}) / (100\ \text{m} \cdot 50\ \text{m}) = 100$.
The graphical representation of the figure is shown in the figure.



Answer:
1) Africa, southern Africa (or southern part of Africa)
2) Diamonds
3) 100 (the area of distribution of the second ore body on the Earth's surface is 100 times less than the area of the first one)

Assessment criteria:
Criterion 1 – 3 points.
Criterion 2 – 3 points.
Criterion 3 – 4 points.
Scientific field 3. Geochemistry & geophysics

Task 1
Entry level (2 points)

Which class of minerals does zircon ($ZrSiO_4$) belong to?

a) Sulfides
b) Sulfates
c) Silicates
d) Arsenides

Answer: c.

Task 2
Entry level (2 points)

Geophysicists are conducting an experiment. The voltage in the electric power line is 220 V, the resistance of the ore sample is 88 Ohm (Ω). What is the electric current in the ore sample?

a) 0,25 A
b) 0.4 A
c) 2.5 A
d) 25 A

Answer: c.

Task 3
Intermediate level (4 points)

Which two of the following materials (substances) are not attracted to a magnet or are attracted the least?

a) Glass
b) Cast iron
c) Steel
d) Cobalt
e) Diamond
f) Copper

Answer: a, e.

Scientific field 4. Meteorology & atmospheric sciences

Task 1
Entry level (2 points)

Determine which layer of the atmosphere has the specified properties: This is the lowest and densest layer of the atmosphere; almost all air and water vapor are concentrated here, fog clouds and precipitation are formed:

a) Stratosphere
b) Troposphere
c) Asthenosphere
d) Mesosphere

Answer: b

Task 2
Entry level (2 points)

Climate change is associated with the presence of greenhouse gases in the atmosphere. However, their contribution to global warming varies. Which greenhouse gas has the maximum global warming potential?

a) CO_2
b) H_2O
c) **SF_6**
d) CH_4

Answer: c

Task 3
Intermediate level (4 points)

Choose two correct statements that characterize the Los Angeles-type smog.

a) This is a wet smog that is formed with the participation of fog.
b) **This is a dry smog resulting from photochemical reactions.**
c) **Los Angeles-type smog contains gases and aerosols of increased concentration.**
d) Los Angeles-type smog contains mainly solid particles entering the atmosphere from natural sources.
e) Los Angeles-type smog does not have a significant impact on human health due to its short duration.

Answer: b, c.

Scientific field 5. Mineralogy

Task 1
Entry level (2 points)

Which class of minerals does arsenopyrite (FeAsS) belong to?

a) Sulfides
b) Sulfates
c) Silicates

d) Arsenides

Answer: a.

Task 2
Entry level (2 points)

When studying minerals under the microscope, an optical phenomenon is observed: when light travels from an optically rarer medium (less optically dense) to optically denser medium (more optically dense), the angle of refraction of the light ray always

a) is less than the angle of incidence
b) is equal to the angle of incidence
c) is greater than the angle of incidence
d) does not depend on the angle of incidence

Answer: a.

Task 3
Intermediate level (4 points)

Which mineral or mineral raw material refers to non-ferrous metals? Choose 2 answers.

a) Tin ore
b) Iron ore
c) Copper ore
d) Gold ore
e) Marble
f) Peat

Answer: a, c.

Scientific field 6. Environmental sciences

Task 1
Entry level (2 points)

What is the main energy source for living organisms?

a) Sunlight
b) Movement of air masses
c) Electromagnetic field
d) Minerals

Answer: a

Task 2
Entry level (2 points)

Renewable natural resources include …

a) Coal
b) Wood
c) Oil
d) Gas

Answer: b

Task 3
Intermediate level (4 points)

What organisms are the pioneers colonizing lifeless substrates during primary succession? Choose 2 answers.

a) Methanogenic bacteria
b) Lichens
c) **Mosses**
d) Diatoms
e) Perennial herbs
f) Trees

Answer: b, c.

Scientific field 7. Physical geography

Task 1
Entry level (2 points)

A consequence of the Earth's axial rotation is

a) change of day and night
b) existence of a date line
c) wind deflection to the left
d) wind deflection to the right

Answer: a

Task 2
Entry level (2 points)

The world ocean consists of the following parts:

a) oceans, seas, bays and straits

b) oceans, seas, islands, bays and continents
c) oceans, islands, peninsulas and mountains

Answer: a

Task 3
Intermediate level (4 points)

Fill the gaps with the words given. Choose the correct sequence: “A cyclone is a _____rotating air vortex with _____atmospheric pressure in the center, which increases towards its periphery. Cyclones originate in the temperate and polar latitudes of the two hemispheres when different air masses collide and under the influence of the Earth's rotation.”

a) descending
b) moderate
c) ascending
d) high
e) low
f) medium

Answer: c, e.

Scientific field 8. Ecology

Task 1
Entry level (2 points)

_____ are the representatives of non-cellular life forms. Indicate the missing word.

a) Fungi
b) Viruses
c) Bacteria
d) Protozoa

Answer: b

Task 2
Entry level (2 points)

The share of higher plants in the phytomass of the biosphere is

a) 0,2%
b) 68%
c) 99,8%
d) 32

Answer: c

Task 3
Intermediate level (4 points)

Select two human viral diseases.

a) AIDS
b) Giardiasis
c) Tetanus
d) Polio
e) Plague

Answer: a, d

Task 4
Advanced level (8 points)

Task. Black fur color is dominant over white for guinea pigs. Two heterozygous males and females were crossed. What will the first-generation hybrids be like?

Note: the assessment takes into account the progress of the solution; writing the answer only is not enough for getting points.

Solution:
Given: A — black, a — white
P: ♀ – Aa; ♂ – Aa

P: ♀ Aa × ♂ Aa
G: A a A a
F1 –?
F1: AA, Aa, Aa, aa
b b b w

Answer: ¾ of the first-generation hybrids will be black, ¼ will be white.

Assessment criteria:
Criterion 1 – 2 points.
Criterion 2 – 4 points.
Criterion 3 – 2 points.

Scientific field 9. Mining & mineral processing

Task 1
Entry level (2 points)

Which element increases a metal's resistance to corrosion?

a) Hydrogen

b) Aluminum
c) Nickel
d) Iron

Answer: c.

Task 2
Entry level (2 points)

The mine workings are shaped like a cube. The area of the base of the cube is 36 cm^2. Find its volume.

a) 1296 cm^3
b) 108 cm^3
c) 72 cm^3
d) 216 cm^3

Answer: d.

Task 3
Intermediate level (4 points)

Choose two countries from the listed countries that are leaders in gold production.

a) Ghana
b) Russia
c) Saudi Arabia
d) Brazil
e) China
f) South Africa

Answer: b, e.