Earth and Environmental Sciences: Second-round sample tasks for the Open Doors Postgraduate Track

The demo test comprises 44 tasks, categorized as follows: 27 entry-level tasks, each with a single correct answer and valued at 1 point per task; 13 intermediate-level tasks, each with multiple correct answers and valued at 3 points per task; and 4 advanced-level tasks requiring detailed responses, each valued between 8 and 10 points. Assessment criteria and standard answers are provided for the complex advanced-level tasks to ensure consistency in evaluation.

Water resources

Task 1
Entry level (1 point)

If the ice, which is lighter than water and floats on the surface, melts, what will happen to the water level in the vessel?

a) It will increase
b) It will decrease
c) It won't change
d) It will first decrease and then increase

Answer: c.

Task 2
Entry level (1 point)

Choose ONE answer and continue the sentence: "The composition of municipal wastewater differs from runoff because it contains…":

a) more suspended solids
b) surfactants
c) a large amount of microflora
d) salts and minerals

Answer: c.

Task 3
Entry level (1 point)

Choose ONE answer and continue the sentence: "The UV spectroscopy method is used to determine the concentration of pollutants and is based on the measurement of…":

a) excitation spectrum
b) optical density
c) atomic spectrum
d) radiation waves

Answer: b.

Task 4
Intermediate level (3 points)

Numerous experiments by scientists confirm the existence of "water memory" due to the formation of "clathrate hydrates." What plays a key role in building these structures?
Select TWO answers:

a) The ability of water to dissolve salts
b) Polarity of water molecules
c) The presence of a covalent bond in a molecule
d) Formation of hydrogen bonds between molecules
e) Dimensions of a water molecule
f) Flat molecular structure

Answer: b, d.

Geology

Task 1
Entry level (1 point)

What are the different types of existing rocks?

a) Igneous, sedimentary, metamorphic
b) Volcanic, clastic, crystalline
c) Stratified, folded, faulted
d) Effusive, intrusive, extrusive

Answer: a.

Task 2
Entry level (1 point)

Which processes are related to geodynamic ones?

a) Movement of lithospheric plates, earthquakes, volcanism
b) Formation of rocks, relief formation

c) Change in the chemical composition of the atmosphere
d) Sedimentation

Answer: a.

Task 3
Entry level (1 point)

Which rock contains a mineral consisting of calcium carbonate ($CaCO_3$)?

a) Granite
b) Basalt
c) Limestone
d) Labradorite

Answer: c.

Task 4
Intermediate level (3 points)

Which TWO rocks can contain organic remains?

a) Limestone
b) Basalt
c) Marble
d) Granite
e) Argillite
f) Gabbro

Answer: a, e.

Task 5
Intermediate level (3 points)

Which TWO methods are related to the methods of relative geochronology?

a) Steno's principle
b) Rubidium-strontium dating
c) Potassium-argon dating
d) Radiocarbon dating
e) Uranium–lead dating
f) Biostratigraphic method

Answer: c, e.

Geochemistry and geophysics

Task 1
Entry level (1 point)

Please, select the predominant gas in Mars' atmosphere

a) CO_2
b) CO
c) H_2O
d) Xe

Answer: a.

Task 2
Entry level (1 point)

What is the term used to describe the ability of atoms within a molecule to attract electrons to themselves?

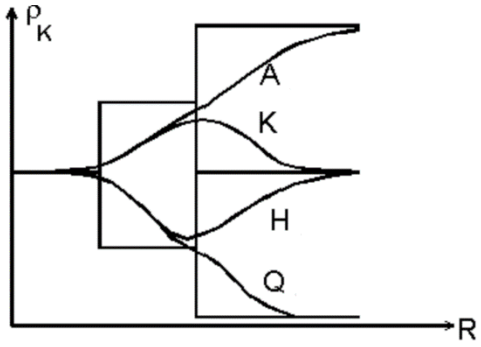
a) Electron affinity
b) Electrical conductivity
c) Conductivity
d) Electronegativity

Answer: d.

Task 3
Entry level (1 point)

What layer resistance ratio corresponds to a type Q curve?

a) $\rho_1<\rho_2<\rho_3$
b) $\rho_1<\rho_2>\rho_3$
c) $\rho_1>\rho_2<\rho_3$
d) $\rho_1>\rho_2>\rho_3$



Answer: d.

Task 4
Intermediate level (3 points)

Which TWO nuclear reactions are classified as exothermic?

a) Fission of heavy nuclei by neutrons
b) Fission of virtual particles
c) Formation of molecules
d) Formation of virtual particles
e) Elastic scattering
f) Synthesis of the lightest nuclei

Answer: a, f.

Task 5
Intermediate level (3 points)

Select TWO main formats of seismic data storage:

a) SEG-B
b) SEG-C
c) SEG-D
d) SEG-X
e) SEG-Y
f) SEG-Z

Answer: c, e.

Meteorology and Atmosphere Science

Task 1
Entry level (1 point)

Which climate zone is characterized by a hot and humid climate throughout the year?

a) Equatorial
b) Tropical
c) Temperate
d) Arctic

Answer: a.

Task 2
Entry level (1 point)

What climate zones is Pakistan located in?

a) Tropical to equatorial
b) Arctic to subtropical
c) Antarctic to tropical
d) Subtropical to temperate

Answer: d.

Task 3
Entry level (1 point)

What is the name of the atmospheric layer that acts as the boundary between the stratosphere and the mesosphere?

a) The Karman line
b) Exobase
c) Stratopause
d) The Mohorovičic discontinuity

Answer: c.

Task 4
Intermediate level (3 points)

Which of the following does NOT belong to atmospheric phenomena?

a) Thunderstorm
b) Aurora
c) Wind speed
d) Squall
e) Drought

f) Landslide

Answer: c, f.

Task 5
Advanced level (8 points)

Why is mercury preferred over water in liquid barometers?
Provide a detailed explanation, including the reasons behind the choice of mercury and the advantages it offers compared to water. Your response should address the key physical and chemical properties that make mercury suitable for this application.
Note that the evaluation will consider both the depth of the explanation and the clarity of the response; simply stating the answer is insufficient.

Solution:
The size of the barometer depends on the density of the liquid used in it.
The higher the density of the barometric liquid, the smaller the size of the device is.
Mercury is a liquid that has one of the highest densities in nature (13595.1 kg/m³ at 0°C), which is 13.5 times higher than the density of water.
Due to this, the barometer has smaller dimensions.

Answer: The higher the density of the barometric liquid, the smaller the size of the device is.
Mercury has a higher density than water.

Assessment criteria:

1. Understanding the reasons for choosing mercury and Its density relative to water (up to 4 points):
- A clear understanding of why mercury is preferred over water in liquid barometers.
- Correct explanation of the importance of mercury's higher density (13.6 g/cm³) compared to water (1 g/cm³), emphasizing how this difference influences the barometer's design and effectiveness.

2. Logical justification for the choice of mercury (up to 4 points):
- coherent and logical explanation for the selection of mercury, focusing on its physical properties.
- discussion of the advantages of mercury, such as its low vapor pressure, non-wetting characteristics, and wide liquid temperature range, and connects these properties to the practical benefits they offer in the context of barometric measurements.

Mineralogy

Task 1
Entry level (1 point)

Which of the following is a mica?

a) Olivine
b) Quartz
c) Halite
d) Muscovite

Answer: d.

Task 2
Entry level (1 point)

Select a rock that is typical of local metamorphism

a) Hornfels
b) Cataclasite
c) Magnesian skarn
d) Green shale

Answer: a.

Task 3
Entry level (1 point)

What of the following is a rock-forming mineral for andesite?

a) Fluorite
b) Calcite
c) Plagioclase
d) Olivine

Answer: c.

Task 4
Intermediate level (3 points)

Which TWO minerals are part of the upper mantle?

a) Olivine
b) Goethite
c) Kaolinite
d) Zeolite
e) Clinopyroxene
f) Hornblende

Answer: a, e.

Environmental Sciences

Task 1
Entry level (1 point)

Choose ONE answer and continue the sentence: “The first aerial remote sensing photograph was taken…”.

a) From an airplane
b) From a hang glider
c) From a balloon
d) From a satellite

Answer: c.

Task 2
Entry level (1 point)

What is selective scattering?

a) Light scattering, which occurs when the particle size is significantly smaller than the wavelength of radiation
b) Coherent light scattering without changing the wavelength of particles
c) Scattering of light with changes in wavelength
d) Light scattering, which occurs when the particle size is significantly larger than the wavelength of radiation

Answer: d.

Task 3
Entry level (1 point)

What are the main functions of a GIS?

a) Collection, storage, analysis, and visualization of spatial information
b) Studying the surface of the Earth with the help of radio waves
c) Studying natural resources using aerial photography
d) Obtaining data about objects using reflected sunlight

Answer: a.

Task 4

Intermediate level (3 points)

How are quantitative characteristics displayed on the map?

a) Geometric figure
b) Number of icons
c) Size of icons
d) Line thickness
e) Number
f) Quantitative characteristics are not displayed on the maps

Answer: c, d.

Physical geography

Task 1
Entry level (1 point)

Which lake is described in this text?
"This lake is a relic of an ancient sea basin. Its waters are well mixed by the wind in shallow water. Due to this, the waters become saturated with oxygen and silty particles from the bottom. All of the above contributes to the development of fauna".

a) Balaton
b) Baikal
c) Caspian
d) Lake Onega

Answer: c.

Task 2
Entry level (1 point)

What is a facies as an element of the landscape?

a) An element of the landscape defined by a specific set of natural conditions.
b) The fundamental unit within the hierarchy of a natural-territorial complex, distinguished by the highest uniformity of natural conditions.
c) The uppermost level in the hierarchy of a natural-territorial complex, marked by the greatest representation of typical natural conditions.
d) The most basic level in the hierarchy of a natural-territorial complex, noted for the highest degree of typical natural conditions.

Answer: b.

Task 3
Entry level (1 points)

Which of the following types of maps exist?

a) Political map
b) Physical map
c) Geological map
d) All of the above

Answer: d.

Task 4
Intermediate level (3 points)

What animals live in South America?
Select TWO answers:

a) Wombat, echidna
b) Hamadryas baboon, hyrax
c) Kinkajou, sloth
d) Sloth bear, macaque
e) Shoebill, giraffe
f) Hoatzin, llama

Answer: c, f.

Task 5
Intermediate level (3 points)

What is a map scale?

a) The ratio of the length of a line on the map to the length of the corresponding line on the ground
b) Map legend
c) The degree of reduction of the image on the map
d) Width of the object on the map
e) Distance between objects on the map
f) Length of the line on the map

Answer: a, c.

Task 6
Advanced level (8 points)

Describe the pseudocylindrical projection according to the following criteria: characteristics of distortions, type of projection grid, and its primary uses.
Note: the assessment will take into account the progress of the solution; writing only the answer is not enough.

Solution:
Pseudocylindrical projections are categorized based on the nature of distortions into equal-area and arbitrary types. These projections are not equidistant, and they do not preserve lengths along meridians. In the normal projection grid, the parallels are straight, parallel lines, while the central meridian is a line perpendicular to the parallels. The remaining meridians are either broken lines or curves that are symmetrical relative to the central meridian. Pseudocylindrical projections are commonly used for world maps and maps of the Pacific Ocean.

Answer:
1) Types: equal-area and arbitrary projections;
2) They cannot be equidistant;
3) Type of projection map grid: the parallels of the normal grid are parallel lines; the middle meridian is a line perpendicular to the parallels; the remaining meridians are broken lines or curves symmetrical about the middle meridian.
4) Using: maps of the world and the Pacific Ocean

Assessment criteria:
The types of pseudocylindrical projections are correct – 4 points.
The type of projection map grid is correct – 2 points.
Correct identification of the type of maps pseudocylindrical projections are used for – 2 points.

Ecology

Entry level (1 point)

Choose ONE answer and continue the sentence: “The vertical structure of communities is determined by…”.

a) Layering of vegetation cover
b) The size of adults
c) Location on vertical surfaces
d) Helio- and geotropism of individuals

Answer: a.

Task 2
Entry level (1 point)

What is the name of the transition zone between the two communities?

a) Ecotone
b) Ecocline
c) Ecotope
d) Coenocline

Answer: a.

Task 3
Entry level (1 point)

What level of biological diversity is alpha diversity?

a) Genetic
b) Ecosystem
c) Biome
d) Species

Answer: d.

Task 4
Intermediate level (3 points)

Which TWO cycles are of the sedimentary type?

a) Hydrogen cycle
b) Nitrogen cycle
c) Oxygen cycle
d) Phosphorus cycle
e) Carbon cycle
f) Sulfur cycle

Answer: d, e.

Task 5
Advanced level (8 points)

Water treatment of drinking water is carried out in several stages, depending on the source and intended use of the water. Suggest a water treatment procedure if the water is taken from a surface source (river, reservoir) and will be used in the municipal water supply system.
Note: the assessment will take into account the progress of the solution; writing only the answer is not enough.

Solution and answer choices:
Water taken from surface sources contains various mechanical impurities, dissolved gases, bacteria, viruses, salts, heavy metals, and other substances. To be safe for consumption, water must undergo water treatment to improve its quality. Water treatment should include several main stages, in the case of taking water from a surface source [1]:

1. Mechanical purification (sedimentation and/or filtration process);
2. Softening (in the case of hard water) (ion-exchange resins replace Ca Mg ions with Na ions);
3. Removal of heavy metal ions, salts, and various chemical compounds;
4. Clarification and odorization (removal of foreign odors).
5. Disinfection.

A complex fine water purification system is used for clarification, odorization, and removal of heavy metal ions — microfiltration, sorption on coals, membranes and/or electrochemical methods. To disinfect water in the water supply system, reagent treatment with chlorine or UV irradiation is used.

Reference:
1. Drinan J.E., Spellman F. Water and Wastewater Treatment: A Guide for the Nonengineering Professional. 2nd Edition. CRC Press, 2012. 300 p.

Assessment criteria:
Stages of water preparation are correctly indicated – 4 points.
Possible methods used at each stage are correctly indicated – 4 points.

Mining and Mineral Processing

Entry level (1 point)

The collar of the vertical exploration well is located at an altitude of 733 m above sea level. The depth of the well is 834 m. Please, find the absolute elevation of the well bottom.

a) 1567 m
b) Insufficient data to solve the task
c) -101 m
d) 101 m

Answer: c.

Task 2
Entry level (1 point)

Which of the listed models consists of points and line segments connecting them?

a) Block model
b) Statistical model
c) Wireframe model
d) Vector model

Answer: c.

Task 3
Entry level (1 point)

What is the skin factor in a well?

a) A hydrodynamic parameter that characterizes additional filtration resistance to fluid flow in the near-wellbore zone of a formation.
b) A characteristic of downhole equipment operation at increasing water cut of production.
c) A characteristic of fluid flow between formations inside the well.
d) A thermodynamic parameter reflecting formation cooling during its operation.
Answer: a.

Task 4
Intermediate level (3 points)

How do surfactants affect the deposit?
Select TWO answers:

a) Alteration in surface tension at the oil-water interface
b) Enhancement of the rock's hydrophilicity
c) Variation in water viscosity
d) Modification in rock permeability
e) Alteration in oil viscosity
f) Enhancement of the rock's hydrophobicity
Answer: a, b.

Task 5
Intermediate level (3 points)

Select TWO correct statements:

a) Wireframe models are primarily used for mine planning within mining and geological information systems.
b) A wireframe model cannot be created without an existing block model.
c) In mining and geological information systems, a block model is represented as a collection of points with associated attributes.
d) Ore bodies are typically contoured in sections to create wireframe models.

e) A block model may exclusively store information on the concentration of a valuable component.
f) The quantity of mineral resources delineated by a wireframe model is always greater than that indicated by a block model constructed within the same wireframe.
Answer: c, d.

Task 6
Advanced level (10 points)

During the exploration of the deposit, borehole drilling employs a drilling fluid with a density of 1100 kg/m³, composed of technical water and bentonite clay. Upon reaching Cretaceous-age rocks, it becomes necessary to increase the fluid density to 1250 kg/m³ by adding dolomite. The total volume of the weighted fluid required is 160 m³.
Calculate the volumes of bentonite clay, dolomite, and water required to produce 160 m³ of the weighted drilling fluid.
Provide each answer in the format XX.XX m³.
The necessary data for the calculations are given in Table 1.

Table 1. Densities of Drilling Fluid Components

Component	**Density, kg/m³**
Technical water	1002
Bentonite clay	1780
Dolomite	2800

Calculation formulas:

$$\rho_{component} = \frac{m_{component}}{V_{component}}$$

$$m_{component} = \frac{\rho_{component} \cdot (\rho_{liquid\ mixed\ with\ component} - \rho_{liquid})}{\rho_{component} - \rho_{liquid}}$$

Note: the assessment will take into account the progress of the solution; writing only the answer is not enough.

Solution:
1. Amount of bentonite clay to prepare 1 cubic meter of the drilling fluid:

$$q_{clay} = \frac{\rho_{clay} \cdot (\rho_{drilling\ fluid} - \rho_{water})}{\rho_{clay} - \rho_{water}} = \frac{1780 \cdot (1100 - 1002)}{1780 - 1002} = 224.2\ kg$$

The volume of bentonite clay in 1 cubic meter of drilling fluid is:

$$V_{clay} = \frac{q_{clay}}{\rho_{clay}} = \frac{224.2}{1780} = 0.126\ m^3$$

Then, to prepare 160 cubic meters of weighted drilling fluid **the needed volume of clay** is:

$$V_{clay}^{160\ m3} = V_{clay} \cdot 160 = 0.126 \cdot 160 = \mathbf{20.16\ m^3}$$

(4 points)

2. Amount of dolomite to weigh up the drilling fluid from a density of 1100 kg/m^3 to a density of 1250 kg/m^3:

$$q_{dolomite} = \frac{\rho_{dolomite} \cdot (\rho_{weigh\ drilling\ fluid} - \rho_{drilling\ fluid})}{\rho_{dolomite} - \rho_{weigh\ drilling\ fluid}} = \frac{2800 \cdot (1250 - 1100)}{2800 - 1250} = 271.0 kg$$

The volume of dolomite in 1 cubic meter of the weighted drilling fluid is:

$$V_{dolomite} = \frac{q_{dolomite}}{\rho_{dolomite}} = \frac{271.0}{2800} = 0.097\ m^3$$

Then, to prepare 160 cubic meters of weighted drilling fluid **the needed volume of dolomite** is:

$$V_{dolomite}^{160\ m3} = V_{dolomite} \cdot 160 = 0.097 \cdot 160 = \mathbf{15.52\ m^3}$$

(4 points)

3. The **needed volume of water** in the weighted drilling fluid:

$$V_{water}^{160\ m3} = V_{weigh\ drilling\ fluid} - V_{clay}^{160\ m3} - V_{dolomite}^{160\ m3} = 160 - 20.16 - 15.52 = \mathbf{124.32\ m^3}$$

(2 points)

Answer:

$$V_{clay}^{160\ м3} = 20.16\ м^3$$
$$V_{dolomite}^{160\ м3} = 15.52\ м^3$$
$$V_{water}^{160\ м3} = 124.32\ м^3$$

Assessment criteria:

1. The amount of bentonite clay required to prepare 160 cubic meters of weighted drilling fluid is calculated correctly – 4 points.
2. The amount of dolomite needed to prepare 160 cubic meters of weighted drilling fluid is calculated correctly – 4 points.
3. The volume of water in the weighted drilling fluid is calculated correctly – 2 points.