北海道大学大学院環境科学院
環境起学専攻

Division of Environmental Science Development
Graduate School of Environmental Science, Hokkaido University
Course in Human and Ecological Systems, Course in Environmental Adaptation Science, and Course in Global Environmental Management

令和 **5** 年度大学院修士課程入学試験問題（秋季入試）

令和 **4** 年度 **10** 月入学大学院修士課程入学試験問題

Entrance Examination

専門科目

Specialized Subjects

[留学生用**]**
For international students

- **Six questions are given in the subjects of Environmental Science (2 questions), Physics (1 question), Ecology and Geography (2 questions), and Chemistry (1 question). Candidates are required to answer 2 questions out of 6 questions.**
- **Use one answer sheet for each question.**
- **Backside of answer sheet can be used if necessary.**
- **Specify the subject name and the question number on each answer sheet.**

August 23, 2022

Environmental Science

Question 1. Answer the questions (1) and (2) below.

(1) Select two sets of acronyms from (a)-(c) below. For each set of the selection, explain the terms and their relationship in about five lines.

(a) CFC, HFC

(b) UNEP, IPCC

(c) IUCN, RLE

(2) Select two sets of terms from (a)-(c) below. For each set of the selection, explain the terms and their relationship in five lines.

(a) Mangrove, Wetlands, Tidal flat

(b) Ogallala Aquifer, Center pivot irrigation, Fossil groundwater (Paleo-groundwater)

(c) The Ramsar Convention, The Washington Convention, The Convention on Biological Diversity

Environmental Science

Question 2. Answer all the questions below.

(1) State the word applied to ① in the following paragraph "When water is considered as a natural resource, freshwater released to the atmosphere through evaporation and transpiration by plants, as well as that supplied to forests, grasslands, and rainfed crops, is called green water. Freshwater extracted by humans such as groundwater and river water is called ①. Wastewater used by the household without fecal matter is called gray water."

(2) ① is mainly used in agricultural, industrial and urban sectors. In the agricultural sector, its consumption relative to supply is larger than in the industrial and urban sectors. Describe the reason(s) in about two lines.

(3) DO is one of the indices of water quality. Explain what DO is and give an example of how DO can represent environmental/ecological conditions by referring to a specific value(s) of DO in mg/L in about five lines.

(4) Disposal of dumped garbage is essential to eliminate water pollution. There are two methods of waste disposal: landfilling and incineration. Explain advantages and disadvantages of each method in about five lines.

(5) Along coasts, apart from natural sand deposits, one may find marine litter such as wastes and unnecessary materials washed on the beach. Describe the impacts of marine litter on the surrounding environment in about three lines.

(6) Describe impacts of coastal erosion caused by global climate change and regional factors in about three lines in total.

Physics

Question 3. Answer the following questions (1) to (3).

(1) Explain the terms below in about three lines each.

【Terms】Virtual temperature, Thermohaline circulation, Rossby wave, Greenhouse effect

(2) Figure 1 illustrates the distributions of precipitation and lower atmospheric wind in January and July. Answer the following questions.

(a) Suggest one method for observing precipitation distribution over oceans. Explain it within four lines addressing the strength and weakness of the method.

(b) Explain the seasonal change of lower atmospheric winds around Japan within four lines using the word “monsoon”.

(c) Explain the relationship between Hadley circulation and precipitation distribution as presented in the figure within four lines.

(d) Easterly (i.e., westward) wind component is dominant over the equatorial region. Explain within five lines how this wind pattern affects horizontal and vertical motion of sea water. You must use the terms “wind stress” and “Ekman drift” in the answer.

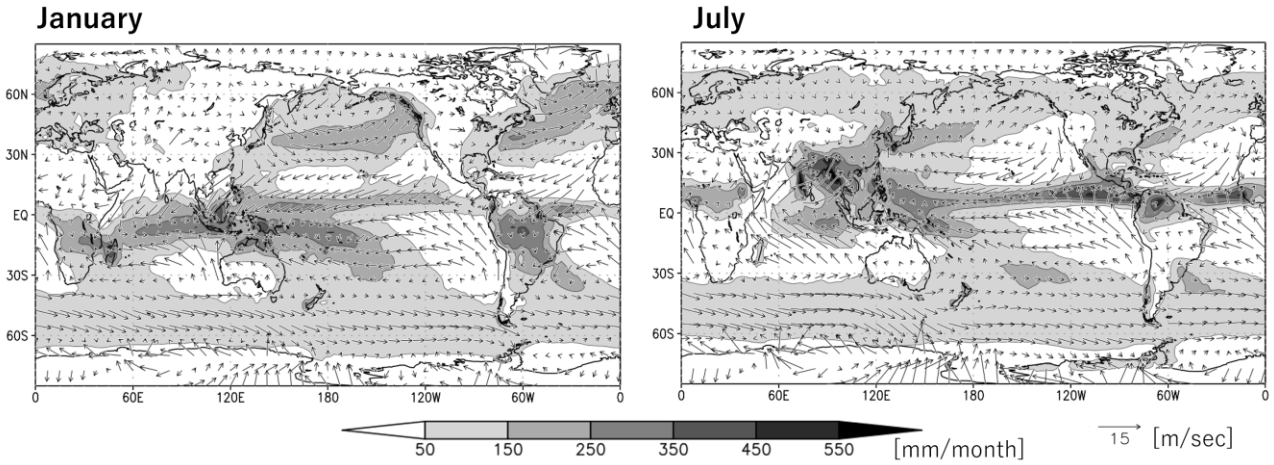

Figure 1: Distributions of precipitation and lower atmospheric wind in January and July. (Data source: GPCPv2.3 for precipitation and JRA-55 reanalysis for winds)

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(3) Figure 2 shows vertical temperature profiles of ocean water and atmosphere around Japan. Answer the following questions.

(a) Satellite-based measurements of sea surface temperature have been conducted as an application of the Stefan-Boltzmann law. Explain the methodology in about three lines.

(b) Which summer or winter, is the subsurface mixed layer of the ocean in the figure thicker? Provide the answer and explain the reason in about three lines.

(c) Explain the possible influence of vertical water mixing on aquatic ecosystems. Answer in about four lines suggesting one example of the influence.

(d) Two inversion layers, near surface and at 1400 m, exist in the atmospheric temperature profile. Explain the possible formation mechanism of each inversion layer. The answer should be summarized within two lines for each.

(e) The dash arrow in the figure denotes the temperature change (dT) of the air parcel according to the vertical displacement (dz), whose decreasing rate is approximately 0.98℃ per 100 m, when the air parcel is lifted adiabatically from the 0 m height. Prove that this temperature lapse rate (−0.98℃/100 m) can be written as $\frac{dT}{dz} = -\frac{g}{C_p}$, where C_p is the specific heat of the dry air at constant pressure and g is the acceleration due to gravity. All calculation steps must be described. You may draw a figure in the answer sheet if necessary.

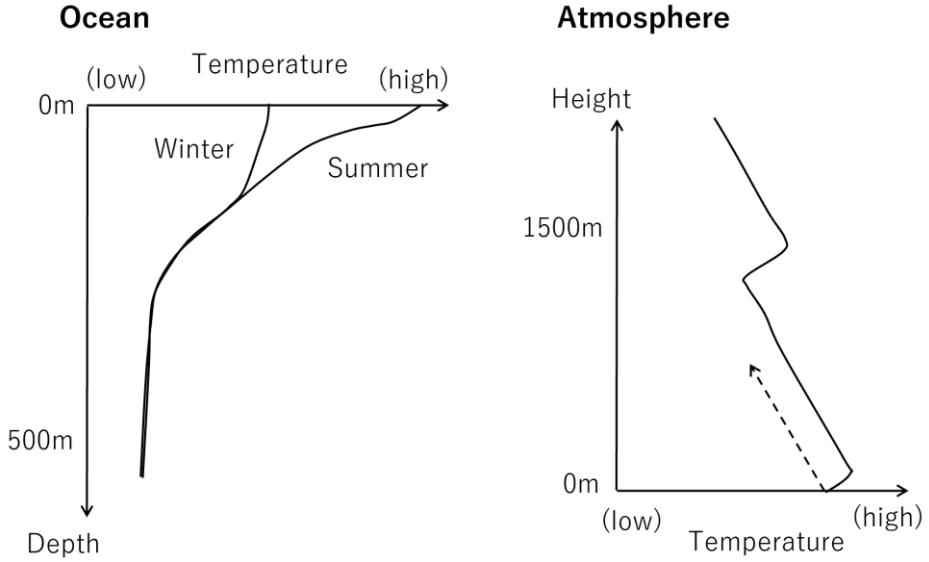

Figure 2: (Left) Idealized vertical temperature profiles of ocean water for winter and summer. (Right) Atmospheric temperature profile observed in November. Dash arrow indicates the temperature change of the air parcel lifted from the 0 m height.

Ecology and Geography

Question 4. Answer all the questions (1) to (3).

(1) Two relevant ecological terms are described in (i) to (iii). Explain the ecological definition or meaning of each term from (i) to (iii) to understand the difference between the two terms.

(i) competition, facilitation
(ii) gross primary productivity (GPP), net biome productivity (NEP)
(iii) community, population

(2) Answer the questions (a) to (e), based on the text.

When (i)soil movement is large and (ii)direct sunlight is strong on coastal dunes in Hokkaido, Japan, a community dominated by species adapted to these environments is developed. In addition, from the coast to the inland, the communities often change to (iii)bare ground, grassland, [(A)] and (iv)forest. Like this, in this example, the development of a community or vegetation along a certain environmental gradient related to the distance from the coast is called [(B)]. However, at present, the natural coastal ecosystems have been reduced greatly due to human activities, and research on conservation and restoration such as (v)reforestation by afforestation is being conducted.

(a) On the underline (i), explain what characteristics of plants are adaptive on such sand dunes.

(b) On the underline (ii), explain what photosynthetic type is advantageous for the growth of plants, including the reasons. The terms “strong light”, “photorespiration”, “evapotranspiration” and “temperature" should be used in the explanation. Underline these terms in your answer.

(c) On the underlines (iii) and (iv), show a representative species of each category.

(d) Fill appropriate words in (A) and (B).

(e) On the underline (v), explain what we should pay attention when the reforestation is conducted.

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(3) Answer the questions (a) to (c).

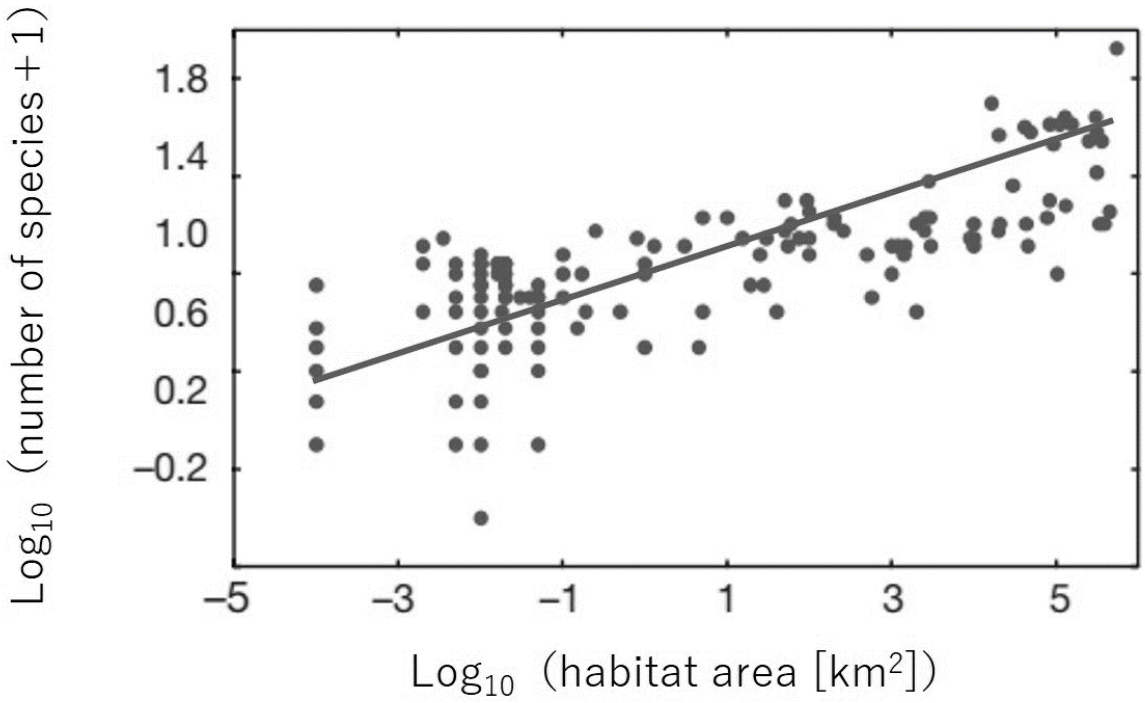

Figure. The species numbers of earthworms in areas ranging from 0.0001 km^2 to 600,000 km^2 across Europe. There is a significant positive correlation between the log-transformed number of species and the log-transformed habitat area. (modified from Gaston 2000).

(a) Concerning the figure, what term is used in representing the positive correlation between habitat area and the number of species? Additionally, describe an equation between the number of species (S) and habitat area (A).

(b) It is essential to conserve species-rich areas to lessen ongoing biodiversity loss. Conserving habitats of a species with particular ecological features is a promising way to identify areas with higher species richness. Explain what kind of species is appropriate to pinpoint such species-rich areas. Make sure to use the term “trophic cascade” in your answer.

(c) On the other hand, conservation of areas with higher species richness is not always enough for comprehensive biodiversity conservation. Provide a reason behind this idea. Make sure to use the term “species evenness” or “β-diversity” in your answer.

Ecology and Geography

Question 5. Provide answers to both questions (1) and (2).

(1) Define each of the following terms in about three lines.

(a) U-shaped valley
(b) solifluction
(c) active layer
(d) frost heave

(2) Read the following description in relation to a map and a cross-sectional profile of the earth's surface and answer questions (a) to (g) below.

Maps on the portal site of the Japan's Geospatial Information Authority (GSI) are seamlessly displayed on a computer screen. In addition, the maps can be displayed on a computer screen at the required (i) scale for research, and then (ii) cross-sectional profiles can be created. If the horizontal and vertical scales are the same, the cross-sectional profile will be almost entirely flat and will not be able to show the features of the ground surface. For example, if the horizontal and vertical scales are the same and if a horizontal distance of 10 km is represented by 1 cm on a cross-sectional profile, the summit of Japan's highest mountain (Mt. Fuji, 3,776 m) is represented by [(A)] cm on the cross-sectional profile. For this reason, a cross-sectional profile is usually drawn with vertical emphasis. For example, a horizontal distance of 10 km is represented by 1 cm on the cross-sectional profile, and 1,000 m is represented by 1 cm with vertical emphasis. In other words, the vertical emphasis is [(B)] times in this case. The vertical magnification can be freely set on the website.

You can also create 3D topographic maps and simultaneously superimpose (iii) aerial photographs taken in different years on the topographic map. Furthermore, you can superimpose geospatial information offered by organizations other than the GSI, such as governmental statistical data and distribution maps of active volcanoes by the Japan Meteorological Agency.

(a) Fill in (A) and (B) in the description above.

(b) In relation to underline (i), there are various types of paper-based maps published by the Geographical Survey Institute (GSI), including (1) topographic maps at 1/500,000 scale, (2) topographic maps at 1/50,000 scale, and (3) topographic maps at 1/25,000 scale. Which of these three types of topographic maps is the largest in scale?

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(c) In relation to underline (ii), the following cross-sectional profile shows a surface topography of Toya Lake in Hokkaido and its surrounding land surface in an approximately north-south direction. The lake with a small island (N) in the center shown in this profile is surrounded by a landform called a somma or an outer crater rim (S). Read the description about the topography of the lake and its surroundings below and fill in the blanks (C) through (G) in the description below.

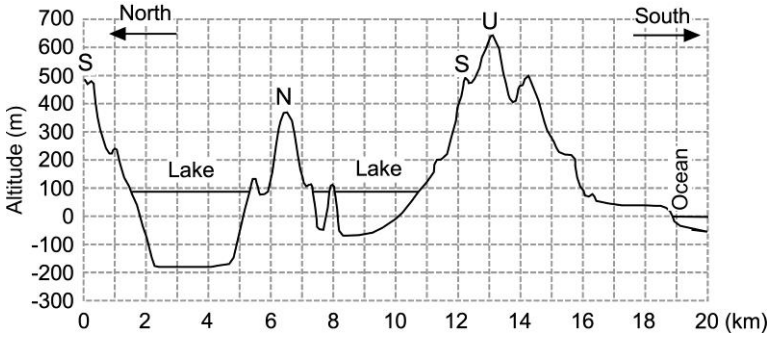


Figure: Cross-sectional profile of Toya Lake in Hokkaido and its surrounding area (the profile was created with the map on the portal site of GSI, with some additions)

This lake (Toya Lake) was formed after a huge volcanic eruption and is geomorphologically called [C] lake: [D] Lake and [E] Lake are examples of [C] lakes. When the present [C] lake was formed, a large amount of [F], i.e., 'a mixture of hot volcanic ash, pumice, and volcanic rocks, flowed down at a high velocity', was erupted and created a plateau around the lake. The small island (N) in the center of the lake is geomorphologically called [G], which is round-shaped when viewed from the sky and which was formed by the extrusion of highly viscous lava.

(d) As shown in the profile above, this lake is shallow on the south side and deep on the north side. Explain the reasons for the difference in the lake-bottom topography in about four lines.

(e) For each of the three landforms of the outer crater rim S, island N, and volcano U shown in the profile above, list the order of their formation from oldest to newest.

(f) List three potential volcano-related hazards of concern in the area near the coast in the cross-sectional profile, excluding those written in the text above (including 'F').

(g) In relation to underline (iii), describe in about one line each about the advantages and disadvantages of using the aerial photographs over the Landsat images when you conduct research.

Chemistry

Question 6. Answer the following questions (1) to (4). In the case of numerical calculations, describe the calculation processes. If necessary, use the following atomic weights, H: 1, C: 12, Na: 23, Cl: 35.5 and Avogadro constant, 6.0×10^{23} mol^{-1}.

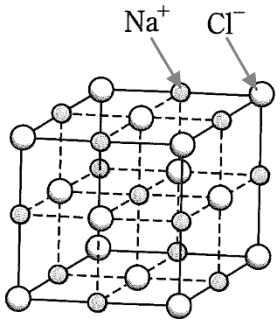
(1) Write ground state electron configurations of Ne, Si, and Cu^+ by following the example.

Example: He $1s^2$

(2) Draw all structural isomers of the alkane, C_5H_{12}.

(3) Sodium chloride has a rock salt type structure in the solid state. The figure below shows the unit cell of sodium chloride. When only sodium ion or chloride ion is focused, each ion arranges in the [(i)] lattice and [(ii)] interaction mainly acts between sodium and chloride ions.

(a) Describe the number of sodium and chloride ions in the unit cell.
(b) Describe appropriate terms in [(i)] and [(ii)].
(c) When the ionic radii of sodium and chloride ions are 0.1 and 0.18 nm, respectively, calculate the density of sodium chloride crystal. Answer with a unit and two significant digits.



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(4) Ammonia reacts with oxygen to form nitrogen monoxide and water.

(a) Describe this reaction formula.

(b) Explain whether this reaction spontaneously progresses at 25 °C using a standard reaction Gibbs' energy change. The following are standard enthalpy changes of formation and standard molar entropies of reactants and products.

$\Delta_f H°$[ammonia(g)] = –46.1 [kJ/mol]
$\Delta_f H°$[nitrogen monoxide(g)] = 90.3 [kJ/mol]
$\Delta_f H°$[water(g)] = –241.8 [kJ/mol]
$S°$[nitrogen monoxide(g)] = 210.8 [J/(K·mol)]
$S°$[water(g)] = 188.8 [J/(K·mol)]
$S°$[ammonia(g)] = 192.5 [J/(K·mol)]
$S°$[oxygen(g)] = 205.1 [J/(K·mol)]