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 7 年度大学院修士課程入学試験問題（秋季入試）

令和 6 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 20, 2024

Environmental Science

Question 1 Answer the questions below.

(1) Read the paragraph below and answer the following questions (a) to (c).

In relation to global environmental issues, the United Nations held a conference called [①] in Rio de Janeiro, Brazil, in June 1992 with the aim of integrating environment and development to achieve sustainable development. As outcomes of the conference, the Rio Declaration on Environment and Development, the Agenda 21, and the Statement of Principles on Forests were adopted. In addition, the international conventions on the natural environment called [②], as well as on the ecosystem called [③] were adopted.

(a) Write the appropriate words for each of ① to ③.

(b) The convention ② is closely related to the greenhouse effect. Explain the greenhouse effect in approximately four lines.

(c) The convention ③ describes ecosystem characteristics that contribute to ecosystem services. Ecosystem services can be classified mainly into provisioning services, regulating services, supporting services, and cultural services. Please name one example of the supporting services and explain why it belongs to this category in approximately four lines.

(2) Historically, a global environmental problem called ozone depletion has occurred, and an associated phenomenon called the ozone hole has been observed in Antarctica. Explain why the depletion of the ozone layer is problematic for humans and other lives in approximately four lines.

(3) Pesticides such as DDT and BHC may be included as soil contaminants. These substances can affect the lives of organisms that are not targeted by the pesticides. Explain why this happens in approximately four lines.

(4) Explain what the concept of "3R" (three-R) in waste management denotes in approximately four lines.

Environmental Science

Question 2 Answer the questions below based on the following text.

Plastics are widely used in modern society and provide significant benefits to social activities. Demand has increased due to their convenience, and (i) production and disposal volumes have increased significantly from the 1980s to the 1990s in Japan. After use, plastic waste is bulky and a major burden for (ii) waste disposal. (iii) When scattered in the natural environment, it is difficult for them to corrode, and (iv) they remain in the environment for an extremely long time. The EU has mandated the reduction of single-use plastic bags, and (v) recycling of plastics is being promoted.

(1) Concerning the underlined text (i), choose the appropriate number from those listed below that applies to each of A to D in the following text:
Of the 83 billion tons of plastic produced worldwide from 1950 to 2015, [A] billion tons were directly in use, [B] billion tons were directly discarded without being recycled, and [C] billion tons were recycled. Of the discarded materials, those discharged into the ocean amounted to [D] billion tons.
[1.5 5 25 53]

(2) Concerning the underlined text (ii), list two main ways for the disposal of plastics.

(3) For the underlined text (iii), select all inappropriate impacts resulting from this issue from options a) to d) below. If none of them apply, write "None".

a) Effects on the marine environment, including ecosystems
b) Effects on tourism and fisheries
c) Impediments to marine navigation
d) Effects on coastal residential environment

(4) Fine plastic debris of less than 5 mm in size are known as microplastics, while larger pieces of plastic are classified as macroplastics. Concerning the underlined text (iv), explain the impact of the remaining microplastics and macroplastics on the marine ecosystem in approximately four lines, respectively.

(5) Concerning the underlined texts (iii) and (iv), plastics spilled into the ocean become concentrated and floating in certain areas. As a typical example, explain the characteristics of the "Great Pacific Garbage Patch" in approximately six lines using all the following four keywords. Underline the keywords used.

[land Hawaii North Pacific Current wind system]

(6) Concerning the underlined text (v), there are two main methods for plastic recycling: "mechanical recycling" and "feedstock recycling". Explain what each of them is, giving specific examples of plastics, in approximately four lines each.

Physics

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

(1) Explain the four terms below within three lines each.
【Potential temperature, Baroclinic instability, Vertical P velocity, Latent heat flux】

(2) Answer the following questions about observation of the Earth environment using satellite remote sensing.

(a) Figure 1 provides images taken by a meteorological satellite. This satellite observes the Earth from a geostationary orbit. Explain the characteristics of the geostationary satellite in approximately three lines.

(b) Choose the most appropriate altitude at which this satellite flies from the choices below.
【36 km, 360 km, 3600 km, 36000 km】

(c) In approximately three lines, explain how this satellite is able to maintain its altitude. Your answer must include the term "gravity".

(d) Describe the possible limitation(s) of using the visible image when observing clouds in two lines.

(e) The two images in Figure 1 show the significant difference in the area indicated by circles. In approximately four lines, describe the reason for this difference.

(f) As an application of infrared imaging, what information about the Earth environment can be monitored besides the characteristics of clouds? Suggest one example and explain how it is possible in approximately three lines.

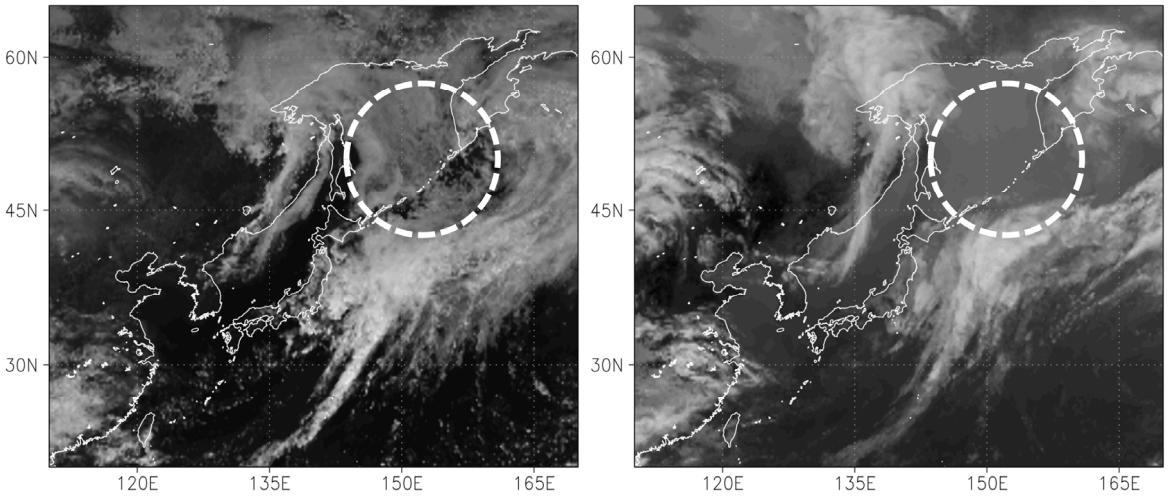

Figure 1: Meteorological satellite image capturing the area around Japan (from a day in May). (left) Visible image, (right) Infrared image.

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(3) Obtaining accurate position information is essential for environmental surveys and the operation of advanced transportation systems, including automatic piloting. Answer the following questions regarding the position measurement. For (c)-(f), do not omit calculation steps in your answer sheet.

(a) Positioning using GNSS (Global Navigation Satellite System) often experiences significant errors around steep terrain or high buildings. Explain the reason for this in approximately two lines.

(b) In May 2024, it was noted worldwide that there could be positioning errors. Explain, in approximately two lines, the characteristic of solar activity anticipated to cause this and its potential impact on GNSS.

(c) To correct errors in altitude measurements using GNSS, measuring atmospheric pressure is effective. Figure 2 illustrates the relationship between atmospheric pressure and altitude. Given a column of air above the base of area A, calculate the mass of the air volume indicated by the gray color in Figure 2. Assume that the density of air ρ is constant with height. Here, z represents altitude and P represents atmospheric pressure.

(d) Given the gravity acceleration g, derive the equation for hydrostatic balance based on Figure 2.

(e) Given that the temperature is T and the gas constant for dry air is R, the state equation for dry air can be written as $P = \rho RT$. Using this and your answer for (d), complete the below equation by filling in the missing part in【 】.

$$\frac{1}{P}\Delta P = \text{【 \quad 】}\,\Delta z$$

(f) From a point K at the sea level (0 m altitude), you climb a slope to point L at an altitude of H. Given that the atmospheric pressure at point K is P_k and at point L is P_L, derive the equation to determine H (the altitude of point L). Assume that temperature T and air density ρ are constant with altitude.

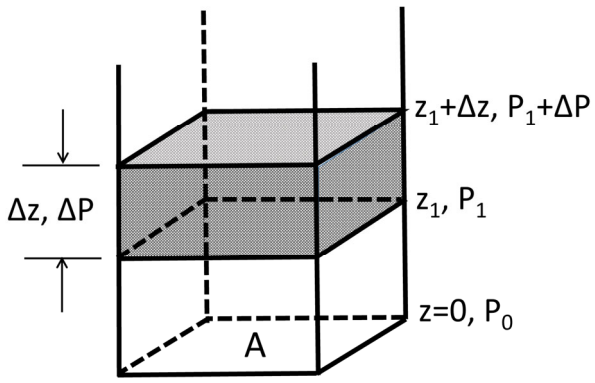

Figure 2: Relationship between atmospheric pressure and altitude.

Ecology and Geography

Question 4 Provide answers to both questions (1) and (2).

(1) Weathering refers to the process of breaking down rocks, soil and minerals, and is the first stage in landscape changing. Answer the following questions (a) and (b) about weathering.

(a) There are three types of weathering: physical (mechanical) weathering, chemical weathering, and biological weathering. Describe each weathering process and the characteristics of the debris produced.

(b) Climate (temperature and precipitation) is an important factor in determining the type of weathering. Explain the differences in weathering types according to climate. You may draw a diagram to explain.

(2) Provide answers to following questions (a) and (b) regarding relation between geological structure and stream network.

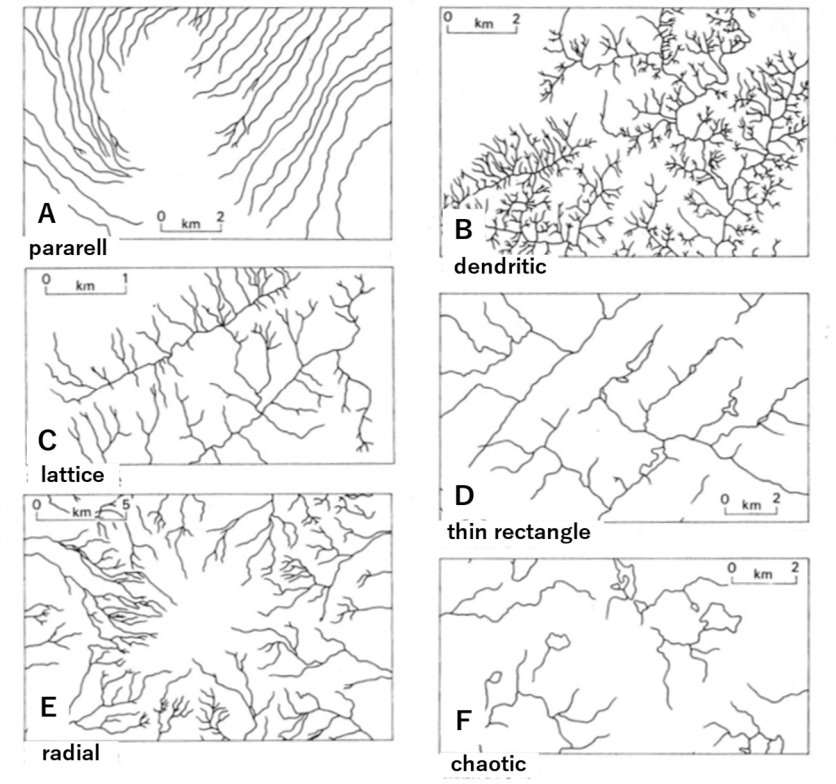

Figure. Descriptive classification of stream network

(a) Select four of the A through F in the figure above that are constrained by geological structures and explain the rationale for each.

(b) Explain the following words or phrases related to river adaptation.

(i) river capture
(ii) antecedent valley
(iii) superposed valley

Ecology and Geography

Question 5 Answer all the questions (1) to (3).

(1) Explain ecological relationships between the two terms in each of (i) to (iii).

(i) climatic climax and edaphic climax
(ii) net primary production (NPP) and net biome productivity (NBP)
(iii) species diversity and environmental heterogeneity

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

[(A)] is one of the methods to examine succession after [(B)]. For example, to obtain the successional sere after a wildfire, vegetation is surveyed 1, 5, 10, 20 and 40 years after the wildfires and the successional sere is estimated by examining the change in species composition over time since the fire. This method showed that, (i)in central Alaska, (ii)the succession patterns were different between the north and south slopes of the wildfire sites. However, this method does not estimate succession accurately unless all fires are of the same (iii)intensity and scale. Therefore, this method is effective in understanding the sequence of succession but additional monitoring is required to understand the details of succession. The permanent plot method overcomes the disadvantages of the [(A)] method but requires (iv)long-term monitoring.

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

(b) Regarding the underline (i), the vegetation is dominated by spruce (*Picea*) trees. Answer what we call this forest in one word? Also, describe the vegetation characteristics in terms of diversity, biomass and productivity.

(c) Regarding the underline (ii), explain the reasons using the three terms “permafrost”, “soil” and “light”.

(d) Regarding the underline (iii), explain how succession patterns differ between low and high fire severity scenarios.

(e) Regarding the underline (iv), to continue research effectively, points of note are proposed. Explain the content using the two terms "research objectives" and "research period”.

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

Individuals reproduce or die, which affects their (i)population sizes. The degree to which populations affect ecosystems can be quantified as the product of the average rate of an individual's interactions with the environment (e.g., (ii)exchanges of energy and matter) and population size. In natural environments, population size does not usually grow exponentially over a long period. This is because (iii)the carrying capacity of ecosystems sets the upper limits of population growth. Various human activities also affect population size and species distribution. Therefore, habitat conservation, which can ameliorate the impact of (iv)climate change and habitat fragmentation, has become an important topic.

(a) Regarding the underline (i), explain the ecological definition of "population".

(b) Regarding the underline (i), explain the differences between "population size" and "population density". In addition, describe a common method of field measurements of "population density" using an example organism group of your choice (e.g., grasshoppers).

(c) Regarding the underline (ii), describe two major energy budget components using secondary consumers in the ecosystem as an example.

(d) Regarding the underline (iii), explain the mechanisms of this relationship; each of two terms "density-dependent effects" and "resources" must be used at least once.

(e) Regarding the underline (iv), the effects of climate change on ecosystems are concerned. Describe major reason(s); each of two terms "extinction risk" and "species interaction" must be used at least once.

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, N: 14, O: 16 and Avogadro constant, 6.0×10^{23} mol^{-1}.

(1) Write the names of three quantum numbers in the general solution of the Schrödinger equation for a hydrogen atom and write what they specify for orbitals.

(2) Draw one structure of a chiral molecule and one structure of an achiral molecule among the molecules with the chemical formula C_4H_9Cl. Also, mark * on an asymmetric carbon.

(3) In the following reaction,
$NH_4^+ + NO_2^- \rightarrow N_2 + 2H_2O$,
the data of initial reaction rates at 25 °C are shown below.

Experiment	Initial concentration (mol L^{-1})		Initial reaction rate of NH_4^+ (mol L^{-1} s^{-1})
	$[NH_4^+]$	$[NO_2^-]$	
1	0.24	0.10	7.2×10^{-6}
2	0.12	0.10	3.6×10^{-6}
3	0.12	0.15	5.4×10^{-6}

(a) Calculate the reaction rate constant. Answer with a unit and two significant digits.
(b) Calculate the initial reaction rate when the initial concentrations are $[NH_4^+] = 0.39$ (mol L^{-1}) and $[NO_2^-] = 0.052$ (mol L^{-1}). Answer with a unit and two significant digits.

(4) Carbon dioxide and water are produced when ethanol is burned, which can be written by the following thermochemical equation.

$$C_2H_5OH\,(l) + 3O_2\,(g) \rightarrow 2CO_2\,(g) + 3H_2O\,(l)$$
$$\Delta H^\circ = \boxed{\text{(i)}}\,1368\ (kJ)$$

(a) Describe the Lewis structures for ethanol and carbon dioxide.
(b) This reaction is exothermic. Give the appropriate sign for (i).
(c) How many grams of ethanol must be burned to obtain a calorific value of 700 (kJ) from this combustion reaction? Answer with two significant digits.