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

令和 9 年度大学院修士課程入学試験問題（秋季入試）

令和 8 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 19, 2026

Environmental Science

Question 1 Read the following text and answer questions (1) to (6).

"Despite bountiful production, some [①] million people in the world today are considered chronically undernourished, getting less than the minimum [②] kcal per day. Chronic hunger is especially widespread in [③] and in South Asia—which includes India, the second most populous country on earth.

Although chronic hunger and malnutrition have declined steadily since the 1960s, in recent years this tendency has slowed or even reversed in some areas. This change is driven by a convergence of overlapping crises—specifically (i)escalating armed conflicts, accelerating climate change, and persistent food price inflation.

According to the FAO, food security involves the physical and economic access to enough nutritious food to meet the dietary needs for a healthy and active lifestyle. Ending hunger is therefore also a serious global health challenge because it requires not just access to enough food but to nutritious foods. The FAO estimates that 3 billion people, nearly [④] of the world's population, was unable to afford a healthy diet in 2019. A healthy diet contains (ii)a good balance of six essential nutrients."

(1) Choose the appropriate figure for [①] and [②] from the following options provided. 【 200, 800, 2200, 10000 】

(2) Choose the appropriate word for [③] from the options provided below.
【 Latin America, Oceania, sub-Saharan Africa, Europe 】

(3) Choose the appropriate figure for [④] from the options provided below.
【 10%, 40%, 75%, 90% 】

(4) Concerning the part underlined (i), briefly explain in about ten lines how these three factors are affecting global progress against chronic hunger and malnutrition in developing, low-income regions. Use each of the following terms at least once.
【 food supply chain, agricultural yields, food costs, low-income countries 】

(5) Concerning the part underlined (ii), list the six essential nutrients required for a healthy diet and indicate which ones are defined as macro and micronutrients. Furthermore, briefly describe the main nutritional role of one macronutrient of your choice in about five lines.

(6) Genetically modified (GM) crops can provide important benefits for food production and security including resistance to drought, frost or disease, as well as nutritional enrichment among others. However, GM crops are also source of important environmental concerns. Two key issues include threats to biodiversity and the creation of tolerant weed and insect pests. Explain in about ten lines how GM crops can cause these two issues using each of the following terms at least once.
【 genetic swamping, herbicide tolerant, pest resistant 】

Environmental Science

Question 2 Answer all the questions (1) through (8).

(1) The theory of evolution through natural selection was originally established by Charles Darwin and has become a cornerstone of biological sciences. Describe how the evolution of species through natural selection works in about eight lines. Include the following words in your response at least once.

【 mutations, genes, traits, dominant, natural selection, evolutionary adaptation, generations 】

(2) Explain the difference between point and nonpoint sources of water pollution and give an example of each type in about four lines.

(3) It is estimated that if Earth's atmosphere consisted solely of nitrogen and oxygen, the global average surface temperature would be approximately -18°C. However, the actual average temperature of the Earth is about 15°C. Explain the reason for this in about six lines. Include the following words in your response at least once.

【 greenhouse gases, infrared radiation, lower atmosphere 】

(4) Environmental pollution caused by persistent organic pollutants (POPs) is a growing source of concern. Name a representative example and explain three of their distinctive characteristics as environmental pollutants in about four lines.

(5) The following Figure 1 shows trends in global renewable energy generation by source. Describe these trends in relation to the temporal trends in the share of solar, wind, and hydropower relative to the total energy. Also, explain the reason why trends in global electricity generation are strongly linked to the need for developing electricity storage infrastructure. Your response should be approximately eight lines in total.

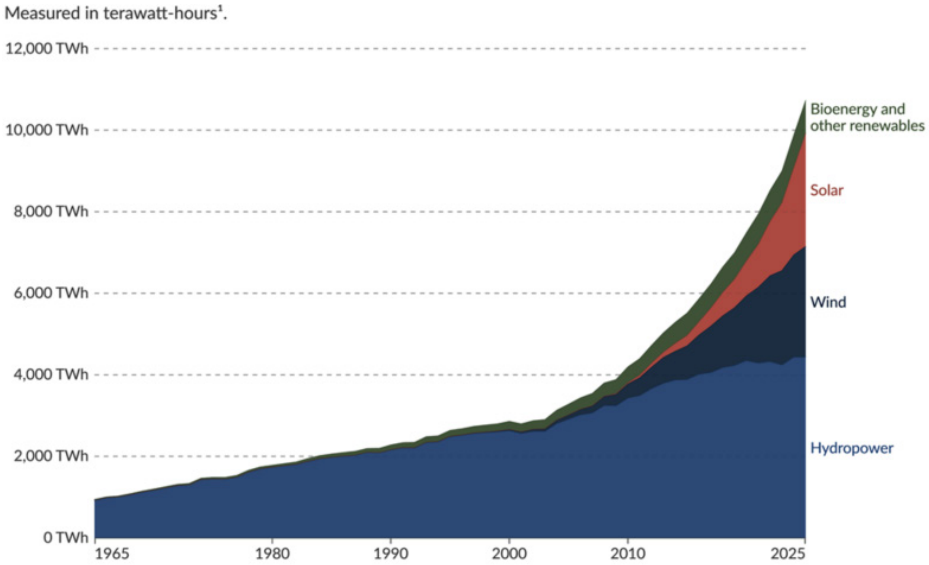


Figure 1: Trends in electricity generation (vertical axis, unit: terawatt-hours) over time (horizontal axis, unit: years). Data is color-coded by source. (Source: Our World in Data; https://ourworldindata.org/renewable-energy)

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(6) Explain what the Montreal Protocol and the Convention on International Trade in Endangered Species (CITES) address and how they contribute to solving specific environmental problems in about five lines in total.

(7) Explain what are "super bugs" and give a specific example in about four lines.

(8) The following Figure 2 shows a classic example of resource partitioning of woodland warblers, studied by ecologist Robert MacArthur. By reference to the example, explain each of the following ecological principles: **competitive exclusion**, **resource partitioning** and **niche specialization** in about eight lines in total.

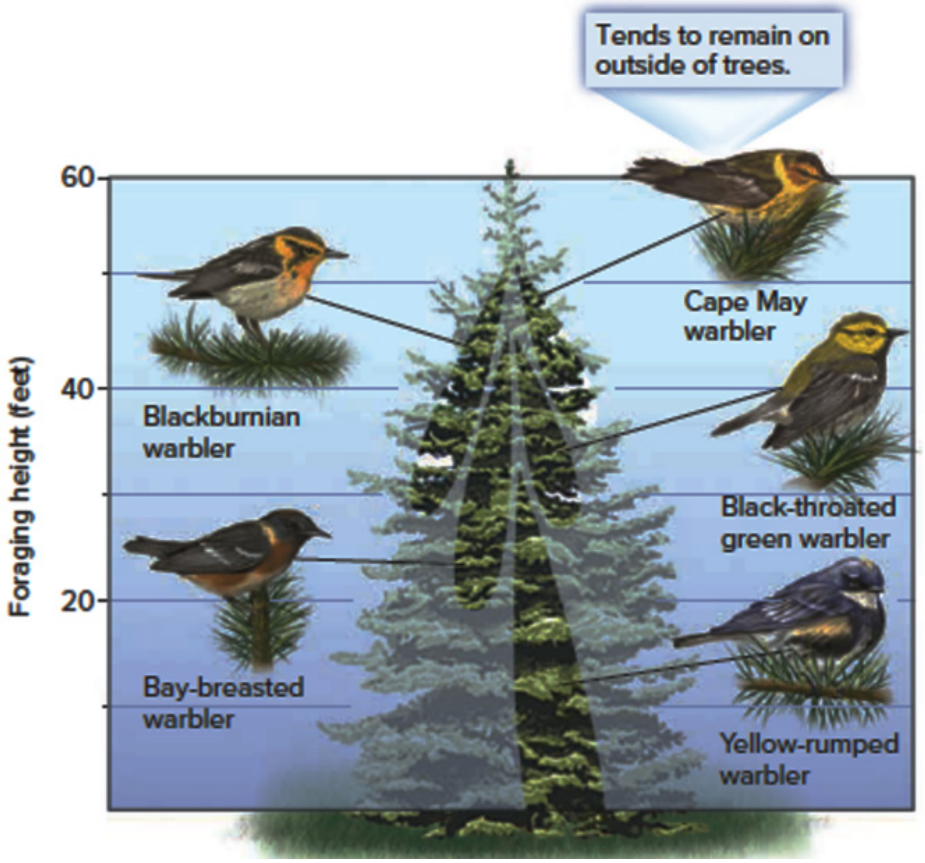


Figure 2: A schematic diagram showing the approximate spatial distribution of five warbler species in relation to a tree. (Source: Cunningham and Cunningham, 2024).

Physics

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

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

【 Relative humidity, Atmosphere-ocean coupled model, Spiral band, Wind profiler 】

(2) Figure 1 illustrates the radiative equilibrium of the Earth. Answer the following questions.

(a) A portion of the solar radiation incident on the Earth is scattered or reflected. The ratio of the total scattered and reflected radiation (dashed line in Fig. 1) to the incident solar radiation passing through the hatched area in Fig. 1 is called albedo (for example, if the albedo is 0.3, 30 % of the solar radiation is scattered or reflected). Over land, deserts and snow cover have high albedo. Provide one example of a high-albedo feature in each of the following environments: the atmosphere and ocean.

(b) Let the intensities of solar and terrestrial radiation be I_0 and I_e, the albedo be A, and the radius of Earth be r_e. When the Earth is in radiative equilibrium, the incoming solar radiation balances the thermal loss due to radiation from the Earth's surface. Express this balance using a mathematical equation. You may assume that the Earth is a perfect sphere. Include the derivation process in your answer.

(c) Given the solar radiation intensity $I_0 = 1370$ W m^{-2}, the Earth albedo $A = 0.3$, and the radius of the Earth $r_e = 6400\times10^3$ m, calculate the value of the terrestrial radiation intensity I_e using the equation derived in (b). Round to the nearest integer.

(d) The Stefan-Boltzmann law governs the relationship between radiation intensity and temperature. Explain this law in approximately three lines.

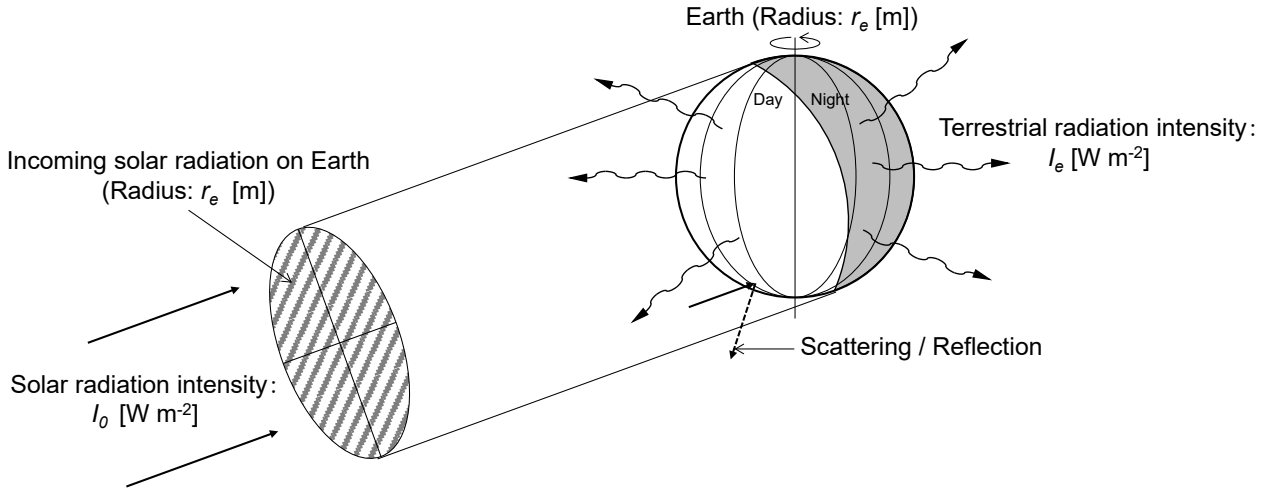


Figure 1: Schematic diagram of radiative equilibrium of the Earth. Solid arrows represent solar radiation, wavy arrows represent terrestrial radiation, and dashed arrows represent scattered and reflected solar radiation.

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(3) Answer the following questions about the large-scale circulation of air and the global water cycle on the Earth.

(a) Choose the appropriate terms from the list below to fill ①, ②, ③, and ④ in Fig. 2.
(Rayleigh, Ferrel, Hadley, Rossby, high pressure, low pressure, convergence, divergence)

(b) Explain in about three lines why the northeasterly trade winds have an easterly component.

(c) The thermal wind equation is shown below. Insert the appropriate variables (x, y, z, or t) into blanks ⑤ and ⑥. Here, U_g denotes the zonal component of the geostrophic wind, g the acceleration due to gravity, f the Coriolis parameter, and T the air temperature. x, y, z, and t represent longitudinal distance, latitudinal distance, height, and time, respectively.

$$\frac{\partial U_g}{\partial \boxed{⑤}} = \frac{g}{fT}\left(-\frac{\partial T}{\partial \boxed{⑥}}\right)$$

(d) Using the thermal wind equation, explain in about four lines why a westerly jet stream forms in the upper troposphere of the midlatitudes as shown in Fig. 2.

(e) Figure 3 shows the latitudinal distribution of precipitation and evaporation. Choose the appropriate combination of lines in the figure from either (i) or (ii) below. Then, based on Fig. 2, explain in about four lines why you made that choice.
(i) ⑦ represents precipitation and ⑧ represents evaporation
(ii) ⑦ represents evaporation and ⑧ represents precipitation

(f) Using Fig. 3, explain in about three lines the latitudinal distribution of salinity in the ocean surface water.

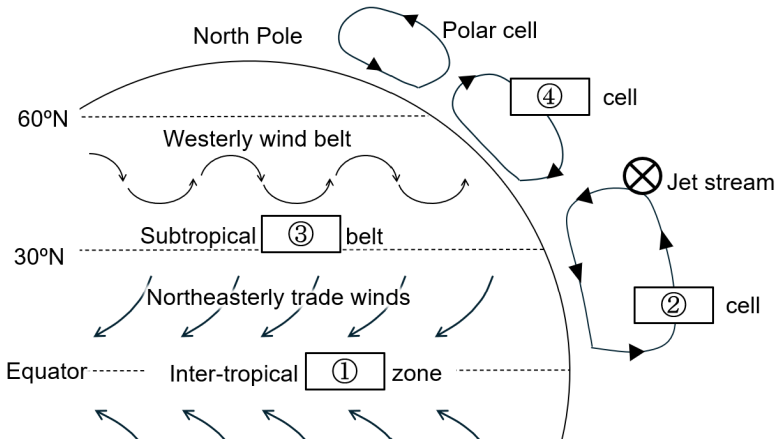


Figure 2: Schematic diagram of the large-scale circulation of winds around the Earth. The cross-in-circle symbol (⊗) indicates the westerly jet stream.

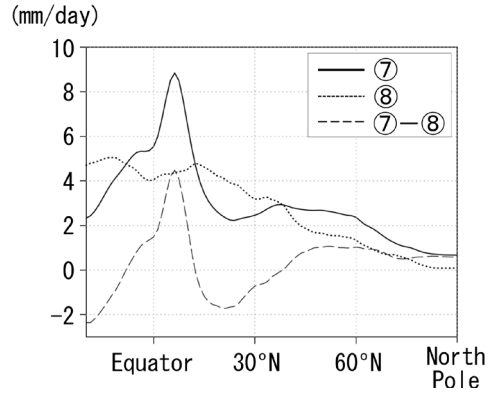


Figure 3: Latitudinal distribution of precipitation and evaporation. Lines ⑦ and ⑧ represent either precipitation or evaporation. JRA-55 reanalysis data provided by Japan Meteorological Agency is used.

Ecology and Geography

Question 4 Answer all of the following questions (1) to (2).

(1) Explain each of the following terms (a) to (d), related to natural landforms, in approximately two lines each.

(a) Fluvial terrace

(b) Delta

(c) Alluvial cone

(d) Caldera volcano

(2) Read the following figure and passage, and answer all of the following questions (a) to (f).

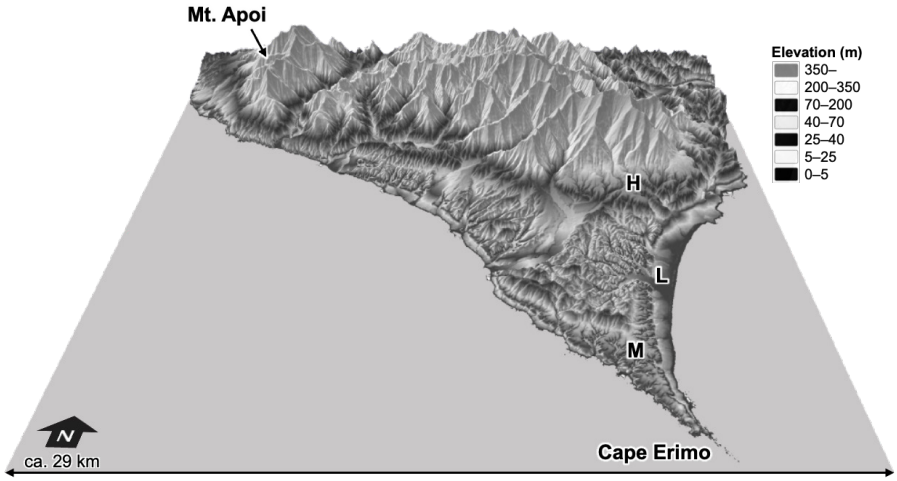


Figure. Bird's-eye view of the area around Cape Erimo (vertical exaggeration ×3; created using GSI Maps 3D, Geospatial Information Authority of Japan).

Around Cape Erimo, at the southern tip of the Hidaka Mountains in Hokkaido, three clear marine terrace surfaces have developed. From the highest to the lowest, these are known as the Toyoni surface (elevation 350–200 m, labeled H in the figure), the Yankebetsu surface (elevation 70–40 m, labeled M), and the Ogoshi surface (elevation 25–5 m, labeled L). A mammoth tooth fossil, dated more than 20,000 years ago, which corresponds to the coldest period of the last glacial period, has been found in the stratigraphic unit that erodes into the Yankebetsu surface. These terrace surfaces, particularly the mid-level Yankebetsu surface, are characterized by gently undulating slopes. This is mainly the result of (i)periglacial action during the glacial period, which continued until roughly 12,000 years ago.

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Around Mt. Apoi (elevation 810 m) in the southern Hidaka Mountains, there is an area where mantle material, known as the Horoman peridotite body, is exposed at the surface in an almost unmetamorphosed state. Soils formed by the weathering of this rock are rich in magnesium and heavy metals (such as nickel and chromium) and poor in calcium. This area was formerly part of the Hidaka Mountains–Erimo Quasi-National Park, but in June 2024, a broad area of more than 250,000 hectares, extending from the Hidaka Mountains, including Mt. Apoi, to the coastal region of Cape Erimo, (ii)was designated as the Hidakasanmyaku–Erimo–Tokachi National Park.

In principle, entry to Japan's national parks is free of charge. As exceptions, some areas effectively collect fees under names such as a "mountain entry fee" or a "cooperation fee," and in some regions, institutional frameworks for future admission charges are being developed. Outside Japan, by contrast, entrance fees are common at many national parks. In the national parks of the United States, for example, a fee of approximately $35 per private vehicle is charged. Furthermore, starting January 1, 2026, the fee structure was revised: at 11 major national parks, non-U.S. residents aged 16 and older are now charged (iii)an additional $100 per person on top of the standard entrance fee.

(a) Among the Toyoni, Yankebetsu, and Ogoshi surfaces, which was formed earliest? State your answer with reasoning in approximately three lines.

(b) The formation of marine terraces such as these is thought to involve both crustal movement and glacial–interglacial sea-level change. Explain, in approximately five lines, how each factor contributes to terrace formation.

(c) Regarding underline (i), explain in approximately three lines the process by which periglacial action smooths and rounds slopes.

(d) Despite its relatively low elevation of 810 m, Mt. Apoi supports alpine plant communities. Explain, in approximately four lines, how geological and soil conditions are thought to be related to this.

(e) Regarding underline (ii), what advantages are there in having a national park managed directly by the national government, compared with a quasi-national park for which the prefectural government was the managing body? State your answer in approximately three lines.

(f) Regarding underline (iii), explain in approximately four lines the reasons for, and the effects of, setting different entrance fees for residents and non-residents of a country.

Ecology and Geography

Question 5 Answer all the following questions (1)–(3).

(1) For each of (a) and (b), explain the meanings of the two ecological terms and describe the relationship between them in about three lines.

(a) Individuals and populations
(b) Primary producers and primary consumers

(2) Read the passage below and answer questions (a)–(c).

In recent decades, the Earth has been warming rapidly due to increasing concentrations of greenhouse gases. Global warming affects (i)the distribution of organisms as well as their phenology and population size in various ways. However, even within the same region, (ii)the effects of warming differ among species. Consequently, global warming often alters interspecific interactions within biological communities. For example, in the Netherlands, during warm springs, both the budburst of the pedunculate oak (*Quercus robur*) and the hatching of eggs of the winter moth (*Operophtera brumata*), whose larvae feed on oak leaves, occur earlier. However, the winter moth shows a stronger response to warming than the pedunculate oak. As a result, under warmer conditions, (iii)winter moth eggs hatch before the pedunculate oak begins budburst.

(a) Regarding the underlined section (i), the center of a species' geographic distribution may shift northward as the climate warms. Explain, in about four lines, why the center of a species' distribution shifts northward due to global warming. Your answer must include the terms "local extinction" and "establishment."

(b) Regarding the underlined section (ii), explain, in about four lines, why the effects of climate warming on species' distributions, phenology, and population dynamics differ among species even within the same region, focusing on differences in their physiological and ecological traits.

(c) The great tit (*Parus major*) initiates breeding in response to changes in day length and feeds primarily on winter moth larvae. Based on this information, explain, in about four lines, how the phenomenon described in the underlined section (iii) is expected to affect the breeding success of the great tit.

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(3) Originally, a certain island supported a large breeding population consisting only of native ground-nesting seabirds. Subsequently, feral cats and rats were introduced and became established. Cats prey on both seabirds and rats, whereas rats prey on seabirds. Assuming this predator–prey relationship, answer questions (a)–(c).

(a) In one year, the rat population increased dramatically due to some factor, and the seabird population subsequently declined sharply. Explain, in about four lines, the direct and indirect effects that could account for this decline.

(b) After cats were eradicated from the island, the seabird population declined. Explain, in about four lines, why this occurred.

(c) The island's seabirds are at risk of extinction in the near future. If the goal is to eradicate both cats and rats to prevent seabird extinction, state the most appropriate order to eradicate cats and rats in no more than two lines.

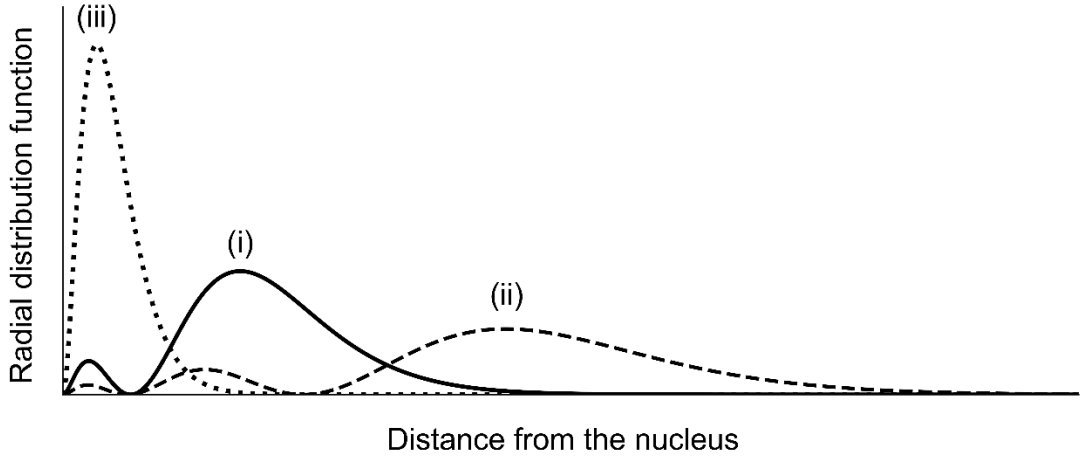
Chemistry

Question 6 Answer the following questions (1) to (3). In the case of numerical calculations, describe the calculation processes without omission. If necessary, use the following atomic weights, H: 1, C: 12, N: 14, O: 16.

(1) The curves labeled i-iii below represent the radial distribution functions of the 1s, 2s, and 3s orbitals of the hydrogen atom.

(a) Identify which orbital (1s, 2s, and 3s) corresponds to each curve, i-iii.

(b) Focusing on the characteristics of the radial distribution functions, explain the differences among these three orbitals in about five lines.



(2) Answer the following questions about ozone.

(a) The two O–O bond lengths in an ozone molecule are identical. Explain the reason in about seven lines by drawing the resonance structures.

(b) Ozone undergoes the following decomposition reaction in the stratosphere:

$$2O_3 \rightarrow 3O_2$$

(b-1) Express the relationship between the rate of disappearace of ozone, v_{O3}, and the rate of formation of oxygen, v_{O2}. Show all steps in the derivation of the equation.

(b-2) At a certain time, the rate of formation of oxygen was 3.0×10^{-5} mol L^{-1} s^{-1}. Calculate the rate of disappearance of ozone at that time.

(b-3) Under standard conditions (0 ºC and 1 atm), 96.0 g of ozone was completely decomposed. Calculate the volume of oxygen produced under standard conditions.

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(3) There are five structural isomers of aromatic compounds having the molecular formula C_7H_8O.

(a) Draw the structural formulas and names of all five isomers.

(b) Identify the isomers that are positional isomers of one another.

(c) Identify the isomers that exhibit weak acidity, and explain the reason for their acidic behavior in about four lines.