

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

平成 26 年度 4 月入学大学院修士課程入学試験問題（秋季入試）

平成 25 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]

- Environmental Science is a compulsory subject, and all 3 questions must be answered.
- Two questions are given in each of the 4 specific subject areas of (1) Mathematics and Physics, (2) Ecology and Geography, (3) Environment and Society, and (4) Chemistry and Biology. Candidates are required to answer 1 question out of 8 questions.
- The required 3 questions for Environmental Science and the 1 question for the chosen subject area are equivalent in score.
- Use one answer sheet for each question.
- Specify the subject name and the question number on each answer sheet.

August 26, 2013

Environmental Science (Compulsory)

Question 1 Read the sentences below and answer the questions.

Desertification is defined as "land degradation in the arid regions", which occupy 41% of the earth land surface. It is presumed that 10 to 20% of the arid land regions are under desertification, and about 1 to 6% of people on the arid region are living under the desertification. The cause of desertification includes human-caused and natural factors, the former include deforestation by over cultivation and grazing, and excessive firewood and coal material extraction, fires and ⁽ⁱ⁾unsuitable irrigation, the latter includes climatic warming and drying. The human-caused factors have socio-economic background, such as increase in population, poverty, and ⁽ⁱⁱ⁾development of market economy. ⁽ⁱⁱⁱ⁾Recovery from desertification and ^(iv)prevention of desertification require bird's-eye view of these various factors.

- (1) On the part of underline (i), explain how unsuitable irrigation alters the soil characteristics in around one line.
- (2) On the part of underline (ii), explain why development of market economy results in desertification in around four lines. Include both words of "commons (shared pasture)" and "management" in your explanation.
- (3) On the part of underline (iii), describe technological means to recover from desertification in around three lines.
- (4) On the part of underline (iv), describe community-based social system (measures) to prevent desertification in around three lines.

Environmental Science (Compulsory)

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

- (1) Explain what kind of information you can know from PRTR (Pollutant Release and Transfer Register) data in about five lines.
- (2) Explain what kind of property is the advantage of asbestos as building materials. Explain effects of asbestos to human health in about four lines.
- (3) Chemical substances control law in Japan requires to test three properties for new chemicals. These are also harmful properties of PCB. List up the three properties.
- (4) Environmental risk of chemical substances is estimated by a degree of harmful effect and exposure. Explain methods to predict a degree of exposure of a chemical substance in about four lines.

Environmental Science (Compulsory)

Question 3 Answer the questions (1) to (5), based on the following sentences.

(i) Biodiversity has been obviously decreasing. The direct factors of decreasing biodiversity are summarized into four categories in Japan: the first crisis owing to human activities including landuse, the second crisis occurring in (ii) satoyama (village forest), the third crisis induced by (iii) exotic species and chemical substances, and the forth crisis is so-called as "the crisis of (iv) global warming" by increasing greenhouse effect gases. We are now finding out ways out of global warming, by promoting (v) afforestation and other efforts.

- (1) On the underlined term (i), write the three levels.
- (2) On the underlined section (ii), explain why the high biodiversity was maintained in about four lines.
- (3) On the underlined section (iii), show each of the animals and plants on Japanese river reservations in English, Japanese or scientific names.
- (4) On the underlined section (iv), the effect is conspicuous in the alpine zones of terrestrial regions. Explain the reason(s) in about three lines.
- (5) On the underlined section (v), it has the effects of weakening global warming. In addition, it is expected that biodiversity is conserved. Show an example of the effects, and explain the reason(s) in about four lines.

Mathematics and Physics

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

(1) Answer the following questions:

(A) Calculate
$$\begin{vmatrix} 1 & \sin x & \cos x \\ 0 & \cos x & -\sin x \\ 1 & -\sin x & -\cos x \end{vmatrix}.$$

(B) Calculate
$$\begin{vmatrix} x & 1 & 1 & 1 \\ 1 & x & 0 & 0 \\ 1 & 0 & x & 0 \\ 1 & 0 & 0 & x \end{vmatrix}.$$

(C) Obtain the eigenvalues and eigenvectors of matrix $\mathbf{A} = \begin{pmatrix} 1 & 0 & -1 \\ 1 & 2 & 1 \\ 2 & 2 & 3 \end{pmatrix}.$

(2) Answer the following questions on the differential equation $\frac{dx}{dt} = ax(1-x)$ ($a > 0$):

(A) Obtain two fixed points of x (x_1 and x_2) such that $\frac{dx}{dt} = 0$.

(B) Set $x = x_i + y_i$ and obtain differential equations of y_1 and y_2 assuming y_1 and y_2 are infinitesimal, which means $y_i^2 = 0$.

(C) Solve the differential equations obtained in (B). The initial condition is that $y_i = 1$ when $t = 0$.

(D) y_i means the difference from fixed point. Explain the meaning of the solutions in (C) using the phrase of “the difference from fixed point”.

(Continued to the following page)

(3) In a bag of n balls, n_1 are red and the rest are black. A group of r balls is chosen at random from the bag. Answer the following questions.

(A) In how many different ways can r balls be chosen from n balls?

(B) In how many different ways can k red balls and $r-k$ black balls be chosen from n_1 red balls and $n-n_1$ black balls?

(C) Let $q_k(n)$ be the probability that r chosen balls contain exactly k red balls. Obtain $q_k(n)$.

(D) In a lake population of n fish, n_1 are red fish and the rest are black. A group of r fish is caught at random from the lake. Then, the probability that r caught fish contain k red fish is exactly $q_k(n)$. Answer the following questions.

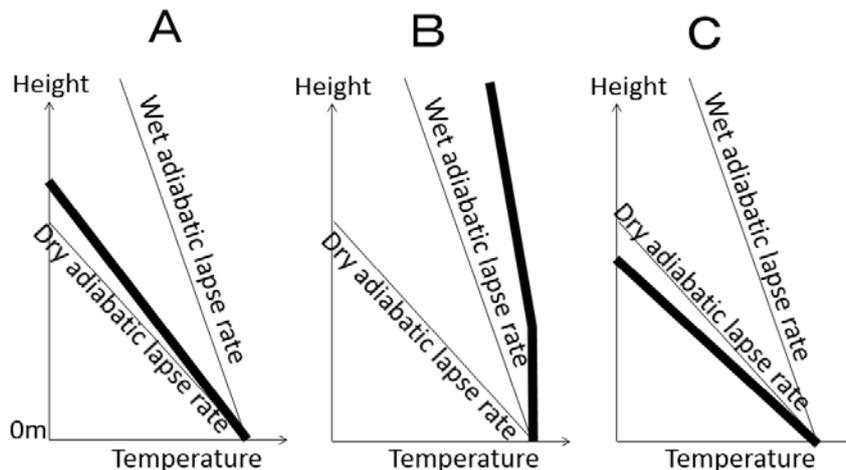
(i) Obtain the condition that $q_k(n)$ decreases with n , i.e., $\frac{q_k(n+1)}{q_k(n)} < 1$.

(ii) When $\frac{q_k(n^*+1)}{q_k(n^*)}$ is less than one at the first n^* , then $q_k(n^*)$ is maximum. Obtain

n^* such that the probability that r caught fish contain 300 red fish is maximum when $n_1=r=1000$.

Mathematics and Physics

Question 2 The following figures show the atmospheric vertical temperature structures. Thick lines indicate the observed temperatures in calm days. Thin lines indicate dry adiabatic lapse rate and wet adiabatic lapse rate, respectively. Answer the following questions.



(1) Choose appropriate words from the choices below to fill parentheses **【a】** to **【j】** .

The atmospheric pressure **【a】** with altitude. When dry air parcel is lifted without any heat exchange with circumstance, the temperature of the air parcel decreases with the rate of **【b】** °C per 100m altitude as a result of adiabatic **【c】** . In case of the lifting of air parcel that contains water vapor, the water vapor undergoes condensation to make liquid cloud droplets when the temperature of air parcel is equal to the **【d】** . The temperature lapse rate for saturated air parcel is approximately **【e】** °C per 100m altitude. Therefore, after the adiabatic lifting, the wet air parcel tends to have **【f】** temperature than the dry air parcel if the initial temperatures are the same. The temperature difference is attributed to the **【g】** released during the condensation.

The situations of air temperature in figure A and B correspond to **【h】** and **【i】** , respectively. The strongly stable stratification is often observed in the **【j】** .

Choices: expansion, compression, condensation, evaporation, latent heat, higher, lower, dew point temperature, freezing temperature, decreases, increases, cold season, warm season, stable, conditionally unstable, unstable, lifting condensation level, 0.5, 0.976, 12.5, 273, radiative heat, greenhouse heat

(2) Explain the behaviors of air parcels that are adiabatically displaced upward from near surface under the situations of A and B in about five lines, respectively.

(Continued to the following page)

(3) Describe the vertical movement of air pollutants in the smoke released from the industrial chimney under the situations of figures B and C in about four lines, respectively. Assume chemical reaction can be ignored.

(4) Read the following sentences and answer the questions (A) to (C).

Horizontal transport of air pollutants in the smoke can be described with the following equation.

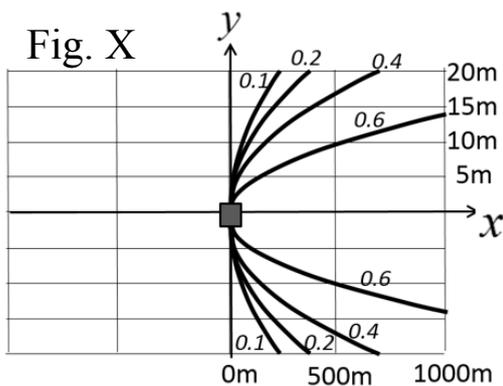
$$\frac{\partial C(x, y, t)}{\partial t} = -U \frac{\partial C(x, y, t)}{\partial x} + K \left(\frac{\partial^2 C(x, y, t)}{\partial x^2} + \frac{\partial^2 C(x, y, t)}{\partial y^2} \right) + Q,$$

where x -axis is along the constant wind direction and y -axis is horizontal right angle to the x -axis, $C(x, y, t)$ is the concentration of the air pollutants at time t , Q is the constant emission rate from the chimney, U is the wind speed, and K is the diffusion coefficient. Assume U and K are horizontally uniform constants.

(A) Explain the horizontal distribution of air pollutants when $K=0$ in about two lines.

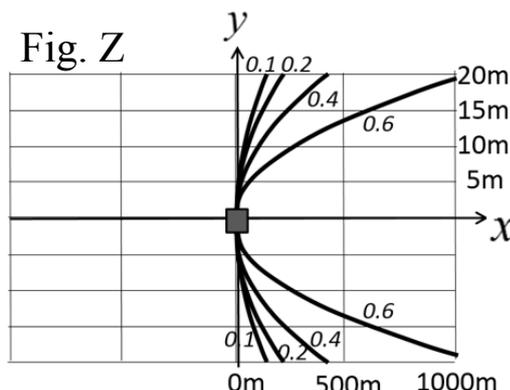
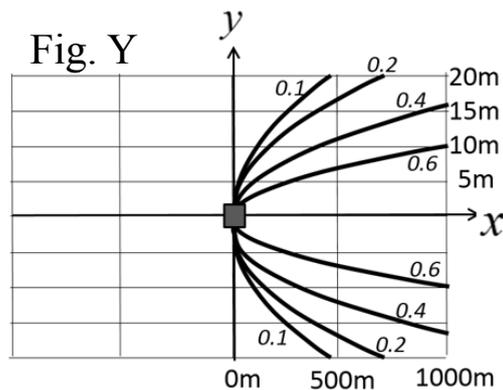
(B) Explain the horizontal distribution of air pollutants when $U=0$ in about two lines.

(C) Figure X shows the horizontal distribution of the concentration of air pollutants under the condition of $U=5.0$ (m sec^{-1}) and $K=1.0$ ($\text{m}^2 \text{sec}^{-1}$). Choose a figure corresponding to the condition of $U=3.0$ (m sec^{-1}) and $K=1.0$ ($\text{m}^2 \text{sec}^{-1}$) from figures Y and Z, and explain the reason why you choose it in about two lines.



Figures X-Z

Horizontal distributions of the concentration of air pollutants (g m^{-3} ; thick line) after a long period of emission from the chimney. Boxes in the center indicate the location of the chimney.



Ecology and Geography

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

(1) Answer the questions (A) and (B).

(A) Describe each of the five ecological words (i) to (v) in about 3 lines.

- (i) life table
- (ii) density dependence
- (iii) competitive exclusion rule
- (iv) ecotone
- (v) acid rain

(B) Answer the questions (i) to (iii) related to ecological succession, based on the figure.

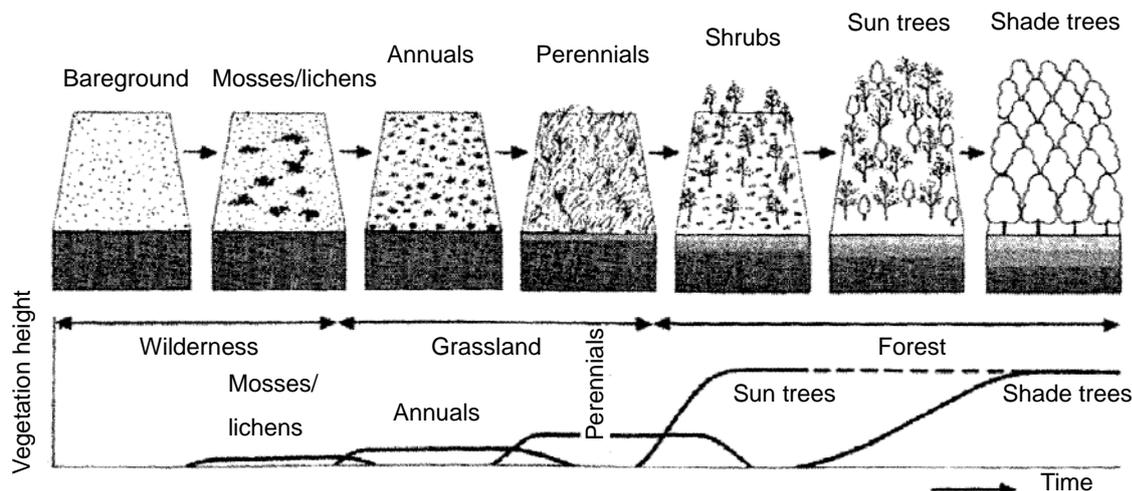


Fig 1. Pattern diagram on xeric primary succession in temperate and cool temperate regions.

- (i) Explain why seed plants do not establish on bareground in the early stages of succession in about 2 lines.
- (ii) Explain the mechanisms of successional changes from sun-tree forest to shade-tree forest in about 5 lines.
- (iii) There are three hypotheses on succession – facilitation, inhibition and tolerance. Select one hypothesis that explains most on the successional sere shown in Figure 1. Explain why you select the hypothesis in about 5 lines.

(Continued to the following page)

Answer the following questions (A) to (E) after carefully examining the figure and paragraph below.

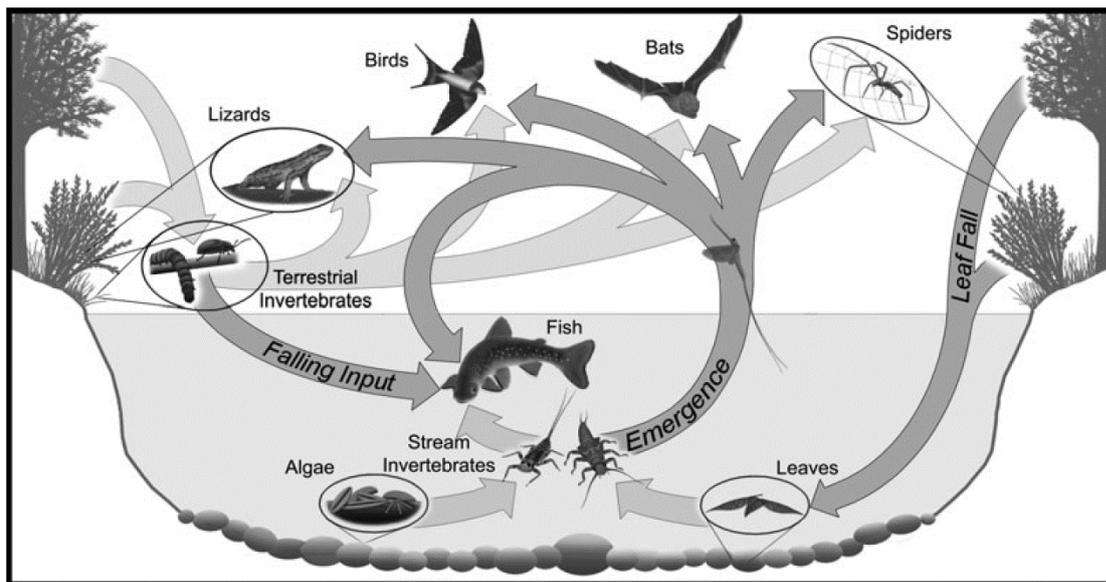


Fig 2. A schematic diagram showing the major pathways of energy through food-web in a forested river. Darkest gray arrows denote directions of energy flux across the boundary between aquatic and terrestrial ecosystems. (Source: Baxter et al. 2005 Freshwater Biology 50: 201-220).

Complex relationships between the constituents of one trophic level and others of adjacent trophic level through the process of eating and being eaten are referred to as food chain (or food web). Trophic levels comprise primary producers, which acquire energy from the process of [a], and consumers dependent on primary producers. In Fig. 2, primary consumers include algae and [b], while an example of consumers is birds. As seen in the figure, river ecosystems can be seen as a composite of aquatic and terrestrial ecosystems. For aquatic ecosystem, algae is called as [c] resources because it is produced within it, whereas [b] are referred to as allochthonous resources because it is provided from outside of it. Reciprocal energy fluxes across neighboring ecosystems have been found to have strong influences on quality and quantity of basal resources in respective ecosystems. Such a concept can be applied to a lake fringed by trees along its shore line. For example, when two lakes having shore vegetation that are characterized with similar tree height and width from the shore are compared, (i) it is predicted that aquatic organisms in the smaller lake are more dependent on allochthonous resources compared with those in the larger lake.

(A) Provide words suitable to fill the blanks [a] to [c].

(B) Describe reasons why such a prediction in the underlined (i) can be made in about three lines.

(Continued to the following page)

- (C) Algal production on the riverbed is typically lower in shallow rivers compared to deep rivers. Explain the reason for such a pattern by referring to Beer's law relationship in about three lines.
- (D) Abundance of organisms shown in the figure can be regulated by bottom-up control. Assuming such a case, list the names of two taxonomic groups that are affected by the decrease in algal production. Also, articulate the pathways and consequences regarding how those groups are affected in about five lines.
- (E) Explain the reason why it is important to protect trees around rivers when attempting to conserve fish abundance in about three lines.

Ecology and Geography

Question 2 Answer the following all questions, (1) and (2).

(1) Read the following and answer the questions below the text.

A glacier is characterized by both flow and mass balance, i.e., the change in the ice body in **【a】** area and **【b】** area. In other words, an extended mass of ice formed from snow in **【a】** area in the upper area moves slowly downward to reach **【b】** area in the lower area. (i) Currently perennial snow patches exists in Japan; however, they are not regarded as glaciers because their **【a】** area and **【b】** area cannot be distinguished and because they do not flow. Processes of erosion, transportation and deposition caused by glacier flow are in general referred to as **【c】**. Glaciers are rapidly melting in the recent years due to the global warming, which are observed for example in the Himalaya, where lakes that are formed by melt-water are burst to cause flood. (ii) This leads to great social issues.

【d】 is defined by ground that remains frozen for at least two consecutive years, and is in general observed in the areas with the annual mean air temperature below -2°C . The top layer of soil thaws during summer and freezes again during the autumn. Such a seasonally thawing surface layer is called **【e】**. In the cold environments even without **【d】**, ground surface with seasonal freeze-thaw cycles experiences (iii) frost heave (frost heaving), i.e., an uplift of ground surface due to the freezing of internal moisture. It also experiences **【f】**, i.e., a slow downslope movement of water-saturated sediment due to recurrent freezing and thawing of the ground surface. Landforms formed by periglacial processes are called (iv) periglacial landforms.

(A) Select appropriate terms in **【a】** to **【f】** from the following terms.

permafrost, deglaciation, ice cap, circulation, ablation, abrasion, point bar, accumulation, gravity flow, gravitational drainage, active layer, solifluction, turbidite, glaciation, U-shape valley formation, weathering

(B) On the part of underline (i), some scientists have recently claimed the current existence of glaciers in Japan. Do you support the idea of no-existence of current glaciers or the idea of existence of current glaciers currently in Japan? Also provide the reasons why you think so in about four lines.

(C) On the part of underline (ii), discuss social issues to be raised when a lake outbursts and cause flood in about four lines.

(Continued to the following page)

(D) On the part of underline (iii), explain problems that frost heaving causes in daily life in about three lines.

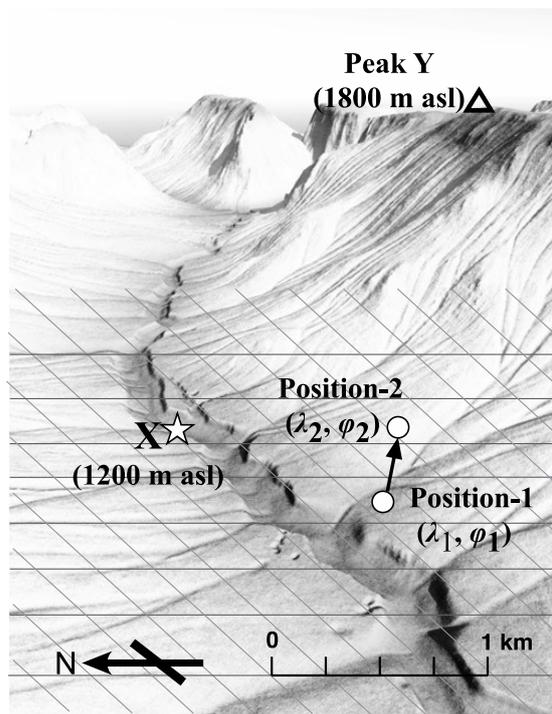
(E) On the part of underline (iv), list five names of periglacial landforms, excluding 'solifluction'.

(Continued to the following page)

- (2) Answer the following questions, (A) to (D), supposing the situation to investigate a certain valley as shown in the right figure using a small GPS receiver equipped with a barometric altimeter and a magnetic compass.

There is a river flowing westward at the bottom of the valley. Now, you are going to survey cross sections of the valley perpendicular to the river.

Parallel rulings (EW and NS directions) are plotted in the figure. Note that those lines are on the horizontal projection plane at the position of X, but are not necessarily on the whole land surface in the figure.



λ : latitude, φ : longitude

- (A) The following is an incomplete sentence including blanks marked as **[a]** to **[r]** which should be filled with a term or a symbol given beneath the sentence. Choose one term or symbol that would best keep the meaning of the sentence.

The magnetic compass equipped in the GPS has accidentally been nonfunctional. So, you need to deduce the direction to go without the magnetic compass. GPS coordinates were measured while walking toward position-2 from position-1 as plotted in the figure. Using these values, you may calculate the traveling direction between the two points. Then you may know how many degrees you should turn to follow the course of the traverse survey.

Since you are standing on the **[a]**, the survey direction to go should be **[b]**. In order to follow the survey line, you may thus turn in just the counterclockwise angle of the moving direction. The moving direction is calculated by a simplified computational procedure described below. Although the actual Earth is bulging at the **[c]**, we assume here that the Earth has a simple **[d]** body of the radius R . The two positions in this case are close enough to assume that both points are on the same tangent plane at the latitude of position-1.

The GPS coordinates of the position-1 and 2 are memorized on your filed note in **[e]** scale as dd°mm' ss". These values should be converted into **[f]** scale for the calculation. **[f]** degree is obtained by the formula,

$$\mathbf{[f]} \text{ [degree]} = \text{dd} + \text{mm} / \mathbf{[g]} + \text{ss} / \mathbf{[g]}^2.$$

(Continued to the following page)

In addition, the angle unit should be converted from degree to the unit of circular measure **【h】** , multiply by **【i】** .

When (λ_1, φ_1) and (λ_2, φ_2) are the converted geographic coordinates of position-1 and 2 respectively,

(longitudinal difference between 1 and 2) $\Delta\lambda = \mathbf{【j】} - \mathbf{【k】}$, and,

(latitudinal difference between 1 and 2) $\Delta\varphi = \mathbf{【l】} - \mathbf{【m】}$.

The distance between two points is along the circumference of the Earth. The circumferential length along the meridian (NS component) is constant, and the circumferential length along the parallels (EW component) varies depending on latitudinal locations. Thus,

(EW component of the distance between 1 and 2) $\Delta x = R * \mathbf{【n】} * \cos \varphi_1$, and,

(NS component of the distance between 1 and 2) $\Delta y = R * \mathbf{【o】}$.

Using the above values, the azimuth of the position-2 as viewed from the position-1 is

azimuth $\theta = \tan^{-1} (\mathbf{【p】} / \mathbf{【q】})$.

Finally, the unit of the angle θ is calculated in **【g】** , convert it to the **【f】** degrees.

Incidentally, by the **【r】** , the distance L between the two points is calculated by the following formula:

$$L^2 = \mathbf{【q】}^2 + \mathbf{【p】}^2.$$

Words and symbols:

arabian, atmosphere, binary, crust, cubic, cuboidal, decimal, downstream, equator, Euler's theorem in geometry, flat surface, gradian, law of cosines, law of sines, left bank of the river, mantle, meridian, north face slope, ocean, Pythagorean theorem, radian, radius, right bank of the river, sexagesimal, south face slope, spherical, summit, triangulation, true-eastward, true-northward, true-southward, true-westward, upstream, valley bottom, Δx , Δy , $\Delta\lambda$, $\Delta\varphi$, θ , λ_1 , λ_2 , π , $\pi/2$, $\pi/180$, φ_1 , φ_2 , 2π , 30, 60, 120, 180, $180/\pi$, R , L

- (B) What should you take notice when you determine altitudes by a barometric altimeter equipped in the GPS? Explain in about five lines.
- (C) What should you keep in mind when you determine the direction of traverse courses using a magnetic compass equipped in the GPS? Explain in about five lines.
- (D) Draw a cross section you may expect prior to the actual measurement, which is passing the position "X" perpendicularly to the river.

Environment and Society

Question 1 Refer to the following statement and answer the questions (1) to (5) below.

Notable achievements of the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol are the establishment of a global response to the climate problem, stimulation of an array of national policies, the creation of an international carbon market and the establishment of new institutional mechanisms that may provide the foundation for future mitigation efforts.

(Source: IPCC AR4, Summary for Policy Makers)

- (1) There is a wide variety of national environmental policy instruments. Take one instrument and explain its features from such viewpoints as environmental effectiveness, cost-effectiveness in about three lines.
- (2) It is mentioned that the international tradable permits, one of the market mechanisms introduced by Kyoto Protocol, can save the total costs of emissions reduction to achieve the reduction targets. By using an example presented in Figure 1 and Table 1 on the next page, calculate the total costs of the reduction in two cases, namely the case with 50 tCO₂ of international trading of emission permits and the case without the trading, that is each of the countries A and B reduces emissions by 100 tCO₂ respectively, when Country A and Country B conduct emission reductions by 200 tCO₂ in total. Then by comparing the two cases, present that the total reduction costs decreases by using the international tradable permits.
- (3) Explain the outline and features of the two market mechanisms other than international tradable permits stipulated by Kyoto Protocol in about five lines respectively.
- (4) It is pointed out that climate change policy is one of the important elements to achieve the sustainable development. Explain the meaning of the sustainable development, including its relation to climate change policy in about five lines.
- (5) There are some cases that climate change policies have potential synergies (positive effects) and trade-offs (negative effects) with sustainable development. Give one example and explain the case in about five lines.

(Continued to the following page)

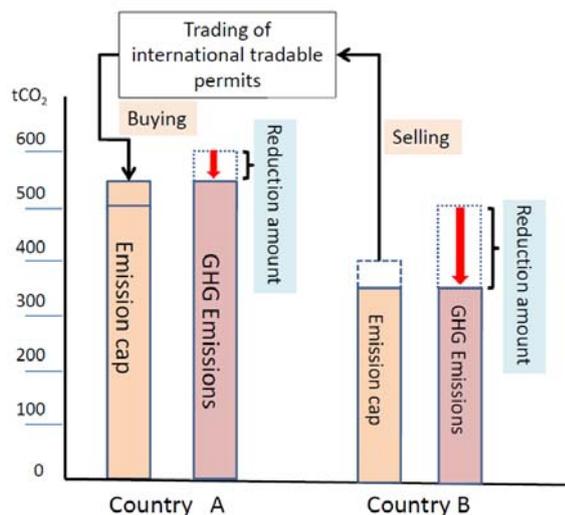


Figure 1 Emissions reduction and emission cap with trading of permits

Table 1 Emission trading between Country A and Country B

Items	A	B
Emissions amount before reduction (tCO ₂)	600	500
Emission permits after reduction (without emission trading, (tCO ₂))	500	400
Emissions amount after reduction (emission cap with emission trading, tCO ₂)	550	350
Amount of International tradable permits (tCO ₂)	50 buying	50 selling
Unit cost of reduction (USD/tCO ₂) in each country	200	100
Price of emissions permits (USD/tCO ₂)	150	150

Environment and Society

Question 2 Refer to Table 2 and answer the following questions. Note that Countries A through E include: Japan, China, United States of America, Denmark, and Germany.

Table 2 Recent population, area, ratio of forest area to the country area, installed capacity of wind power, installed capacity of wind power per population, installed capacity of wind power per area, and fish catches in Countries A through E.

Country	A	B	C	D	E
Population (million people)	1,349	6	82	127	310
Area (thousand km ²)	9,600	40	360	380	9,630
Ratio of forest area (%)	22	13	30	69	33
Installed capacity of wind power (MW)	62,733	3,871	29,060	2,501	46,919
Installed capacity of wind power per population (MW/million people)	46	697	353	20	151
Installed capacity of wind power per area (MW/thousand km ²)	6.5	89.8	81.4	6.6	4.9
Fish catches (thousand ton)	15,670	830	220	4,140	4,380

(Data modified from FAO Global Forest Resources Assessment 2010 Country Report and OECD Environmental Data Compendium)

- (1) Write down the name of Countries A through E.

- (2) In Countries B and C, installed capacity of wind power is significantly large in both per population and per area, compared to the other countries. Explain about the reason, including the political aspects, in about five lines.

- (3) Country A has a huge area and the installed capacity of wind power has rapidly been increasing. On the other hand, there exist many problems in increasing the wind power. Pick up one of the problems and explain about the problem in about three lines.

- (4) Country E has many problems that hinder the entire country from increasing the wind power and other renewable energy. Pick up one of the problems and explain about the problem in about three lines.

- (5) Pick up one of the reasons why the wind power has not been grown popular in Country D in about three lines. Also, describe what kinds of problems are required to be settled to increase the wind power in future in this country in about three lines. You may refer to any data in Table 2 to answer this question if necessary.

Chemistry and Biology

Question 1 Answer the following questions (1) to (4).

(1) Two isotopes, A and B, exist in the element E of the atomic number Z . The isotopic ratios of two isotopes, A and B, are 25% and 75%, respectively. The sum of the atomic mass number of A and B is $2m$. The atomic mass number of A is larger by $2n$ than that of B. Answer the following questions (a) to (c) with the above signs: (a) the number of extranuclear electron in isotope B; (b) the number of neutron in nucleus of isotope A; (c) atomic weight of element E.

(2) Explain why putting some citron juice or vinegar on dead fish can greatly reduce the fishy smell in two or three lines. The disagreeable odor of dead fish is mainly due to organic compounds containing an amino group.

(3) In the human body the blood plasma has a normal pH of 7.4. One of the major buffer systems in the blood is the carbonic acid-bicarbonate system with the following equilibrium equation:



Answer the following questions (A) to (C) with the equation.

(A) Calculate the ratio $[\text{HCO}_3^-]/[\text{H}_2\text{CO}_3]$ in blood at pH 7.4 using the Henderson–Hasselbalch equation on the assumption that the second dissociation can be ignored. Remember that $\log 2 = 0.30$.

(B) The carbonic acid-bicarbonate system is involved in pH control but it is acting as a true buffer system in blood. Explain why the system could not be a chemical buffer of any reasonable efficiency at the normal pH in one or two lines.

(C) Explain how the change of pH of blood can occur due to rapid expulsion of carbon dioxide in cases of hyperventilation during extreme fevers or hysteria in around four lines.

(4) Answer the following questions (A) to (C), assuming that one calorie is equivalent to 4.2 joules and it is the amount of energy needed to raise the temperature of one gram of water by one degree Celsius. Write in calculated values with two significant digits and don't omit the calculation process and the reasons in the description.

(Continued to the following page)

- (A) Metabolic activity of an adult human releases averagely 100 W (J/s) of heat. Assuming the body is 60 kg of water, answer how much would the body temperature rise if it were an isolated system.
- (B) Assume that perspiration function of the body eliminates a half of the heat to maintain the normal body temperature. Answer how much water must the body eliminate as perspiration to maintain the normal body temperature. The heat of vaporization of water is taken as 2.4 kJ/g .
- (C) The adult human lounged at 27°C in water of an indoor pool for one hour. During the time, heat of 100 W (J/s) transferred from the body to the pool water. Calculate the lower limit of an increase in the entropy (kJ/K) of the water pool by the process of the heat transfer for the hour.

Chemistry and Biology

Question 2 Answer the following questions (1) to (4). In the case of a numerical calculation, write calculated values with 3 significant digits and do not omit calculation process and the reasons in the description in your answer sheet.

(1) Explain meanings of the following terms from (A) to (E) within three lines.

- (A) exon
- (B) plasmid
- (C) genetic code
- (D) poly A tail
- (E) mRNA precursor

(2) Answer about (A) and (B) after reading the following sentences.

A cylinder calorimeter has been used to measure the calories of food. When 8.00 g of dry cereal in a cylinder calorimeter was completely oxidized into CO_2 and H_2O , the temperature of 2400 g of water in the water jacket raised from 15.0°C to 29.1°C . The percentage by weight of protein in the dry cereal was measured as 18.0%.

- (A) Calculate the caloric value per 1.00 g of cereal. The answer should be shown as kcal/g.
- (B) If the dry cereal is comprised of only protein, carbohydrate and lipid, calculate the percentage by weight of carbohydrate and lipid in the cereal. You can use following data for the calculation; caloric values of protein, carbohydrate and lipid are 4.30, 4.20 and 9.50 kcal/g, respectively.

(3) Answer (A) to (D) after reading the following sentences.

An enzyme X catalyzes hydrolysis of glycerol phosphoric acid. One mL stock solution including enzyme X was added to glycerol phosphate buffer solution (0.110 mM, 9.00 mL), and the mixture was kept at 25°C . A part of the reaction mixture was taken at every minute. The concentration of inorganic phosphate in the mixture was measured after addition of trichloroacetic acid. The results are listed in the following table.

(Continued to the following page)

Chemistry and Biology

Time after addition of enzyme (min)	Concentration of inorganic phosphate in the reaction mixture ($\mu\text{mol/mL}$)
0	0.000
1	0.210
2	0.420
3	0.630

- (A) When K_M value of glycerol phosphoric acid is $3.00 \mu\text{M}$, answer whether the substrate is saturated on this condition after the calculation of substrate concentration in the reaction solution.
- (B) Why was trichloroacetic acid added into the reaction mixture? Answer it in one line.
- (C) Calculate the concentration of the enzyme in the reaction mixture (units/mL). It is defined that one unit hydrolyzes $1.00 \mu\text{mol/mL}$ of substrate for one minute.
- (D) Answer name of this enzyme X.

(4) Answer the questions (A) and (B) after reading the following sentences.

The remediation method using the plant (phytoremediation) is used as one of remediation methods in the polluted soil with heavy metal. It is known that (i) phytoremediation is suitable for remediation of low concentration pollution in the wide area. In addition, when phytoremediation has been carried out, (ii) a plant which accumulates heavy metals in a leaf and stem has been selected as compared with that accumulates metals in the root.

- (A) On the part of underline (i), explain the reason in around three lines.
- (B) On the part of underline (ii), explain the reason in around three lines.