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 **28** 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 **27** 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 (Questions 1 through 3) 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 (Questions 4 through 11).**
- **The total score of 3 questions for Environmental Science (Compulsory) is equal to the score of 1 question for the chosen subject area.**
- **Use one answer sheet for each question.**
- **Backside of answer sheet can be used if necessary.**
- **Specify the question number on each answer sheet.**

**August 24, 2015**

**Environmental Science (Compulsory)**

**Question 1**    Answer the following questions.

(1) Biodiversity is generally discussed on three different levels. List those three diversities. Describe them to clarify their difference in about four lines.

(2) Read the following sentences on the past biodiversity and write adequate words for (A) to (D)

   There have probably been   (   A   )   mass extinctions during the past 500 million years. A famous mass extinction was caused by  (   B   )   about  (   C   )   years ago. Then, dinosaurs were wiped out and about   (   D   ) % of families are considered to extinct.

(3) The present ecosystem is composed of food chain including many species. The species are classified into several trophic levels, such as producers, primary consumers, secondary consumers and decomposers. Explain "producers", "primary consumers" and "decomposers" on the role in ecosystem and write the species name, for each word in about two lines.

(4) Describe the reasons why biodiversity is important, from both view points of utilization of ecosystem service by human and maintenance of ecosystem, in about four lines.

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## Environmental Science (Compulsory)

**Question 2**   Read the following explanations of four air pollutants and answer the questions (1) to (4).

**Pollutant A** (nitrogen oxides): One chemical form ( a ), a colorless gas, generates under high-combustion temperatures in automobile engines and coal-burning power and industrial plants. Another form ( b ), a reddish-brown gas, was formed by the reaction of ( a ) and oxygen in the air. Some of the ( b ) reacts with water vapor in the air to form acid, a component of harmful acid deposition.

**Pollutant B**: Compounds that exist as gases in the atmosphere, such as hydrocarbons emitted by the leaves of many plants. Other forms are liquids that can evaporate into the atmosphere. The examples are ( c ) and other liquids used industrial solvents, dry-cleaning fluids, and various compounds of gasoline. This material reacts some of the nitrogen oxides in the air on a clear day and the mixture of the pollutants form ( d ), which is sometimes called brown-air smog. The resulting pollutants, are called collectively as ( e ), can damage lung tissue.

**Pollutant C**: A colorless and highly reactive gas. It can cause coughing and breathing problems, aggravate lung and heart diseases, and irritate the eyes, nose, and throat. It also damages plants, rubber in tires, fabrics and paints. This material is main ingredient of ( e ) in the troposphere near ground level. While this substance in the stratosphere protects us from harmful UV radiation.

**Pollutant D**: A colorless gas with an irritating odor. The two-thirds come from human sources, mostly combustion of sulfur-containing coal in power and industrial plants, oil refining, and smelting of ores. In the atmosphere, it can be converted to aerosols, which consist of microscopic suspended droplet of acid. It causes (i)acid deposition, sometimes called acid rain.

(1)  Write appropriate names of pollutants B, C and D.

(2)  Write appropriate words for (a) to (e) in the above sentences.

(3)  Underlined phrase, (i)acid deposition, has a number of harmful effects. Describe them in about 3 lines.

(4) Describe how to reduce (i)acid deposition in about 3 lines.

## Environmental Science (Compulsory)

**Question 3**    Answer the questions from (1) to (5) after reading the following sentences.

In urban areas, most waterborne wastes from homes and businesses flow through a network of sewer pipes to wastewater or sewage treatment plants. Raw sewage reaching a treatment plant typically undergoes usually three levels of wastewater treatment. The first is (i)primary sewage treatment (a physical process), and the second level is (ii)secondary sewage treatment under the aerobic condition (a biological process). Last step is that water from second sewage treatment undergoes (iii)a chemical process before discharge.

(1)    Write the reason in around three lines why the sewage (wastewater) should be treated. The answer must include following words: "human health" and "infection".

(2)    Explain in around three lines how the sewage should be treated in the area without the sewage treatment plant.

(3)    As for underline (i), explain in around two lines what kind of processing is performed to be concrete.

(4)    As for underline (ii), explain in around two lines what kind of processing is performed to be concrete.

(5)    As for underline (iii), write what chemical substance is used in this step. In addition, explain a fault and an advantage of this method in around one line, respectively.

**Mathematics and Physics**

**Question 4**   Answer the following questions (1) to (5).

(1) Differentiate the following functions.

(a) $(x+1)e^{-x^2}$          (b) $a^x$

(2) Calculate the following limits.

(a) $\lim\limits_{x\to\infty}\left(x-\sqrt{x^2+a}\right)$      (b) $\lim\limits_{x\to\infty}x\left(x-\sqrt{x^2-a}\right)$

(3) Taylor series around $x = 0$ is called as Maclaurin series. Answer the following questions on Maclaurin series.

(a) Obtain the Maclaurin series of $e^{ix}$.

(b) Obtain the Maclaurin series of $\sin x$.

(c) Prove $e^{ix}=\cos x+i\sin x$.

(d) Prove $e^{i\pi}+1=0$  (Euler's formula)  .

(4) Answer the following questions on Gamma function $\Gamma(x)=\int_0^\infty z^{x-1}e^{-z}\,dz$.

(a)   Calculate $\Gamma(1)$.

(b)   Prove $\Gamma(x)=(x-1)\Gamma(x-1)$.

(c)   Calculate $\int_0^\infty z^{-7/2}e^{-z}\,dz$, using $\Gamma\left(\dfrac{1}{2}\right)=\sqrt{\pi}$.

(5) Answer the following questions on an Hermite matrix, $\mathbf{A} = \begin{pmatrix} 3 & 2+i \\ 2-i & -1 \end{pmatrix}$. Note the inner

product of complex vector, $< \mathbf{x}, \mathbf{y} >$, is defined by $\sum_k x_k^* y_k$, where symbol * means "complex

conjugate", and $x_k$, $y_k$ are the k-th element of vector $\mathbf{x}, \mathbf{y}$, respectively.

(a) Obtain two eigenvalues of matrix $\mathbf{A}$.

(b) Obtain the eigenvectors $\mathbf{u}_1, \mathbf{u}_2$ belonging to the first and second eigenvalues

in (a). Note that $\mathbf{u}_1, \mathbf{u}_2$ are the normalized vectors that satisfy

$< \mathbf{u}_j, \mathbf{u}_j > = 1 \; (j = 1, 2)$.

(c) Prove that $\mathbf{u}_1, \mathbf{u}_2$ are orthogonal.

(d) Set a matrix $\mathbf{U}$ whose first and second columns are $\mathbf{u}_1, \mathbf{u}_2$. Prove that the

inverse matrix of $\mathbf{U}$ is $(\mathbf{U}^T)^*$, where symbol $T$ represents "transpose the

matrix".

(e) Set $\mathbf{P} = \mathbf{u}_1 (\mathbf{u}_1^T)^*$. Prove that square of $\mathbf{P}$ is exactly the same as $\mathbf{P}$ itself,

where symbol $T$ represents "transpose the vector".

**Mathematics and Physics**

**Question 5**    Read following sentences and answer questions (1)-(8).

Fig. 1 illustrates a sphere centered on the Sun with a radius of $d$. Denote the amount of solar radiation received per unit area on the sphere as $I$. The amount of solar radiation received at whole surface area of the sphere is written as 【　A　】. When $d$ is equal to the mean distance between the Sun and the Earth ($d_1$), $I$ is equal to 1.37 $\times 10^3$ W m$^{-2}$ or 【　B　】 J m$^{-2}$ sec$^{-1}$ which is so-called 【　C　】. If the surface area of the sphere becomes 【　D　】 as increasing $d$, $I$ becomes 【　E　】. Spacecraft for planet exploration consider (i)this relationship between the distance from the Sun and available radiation when designing solar panels.
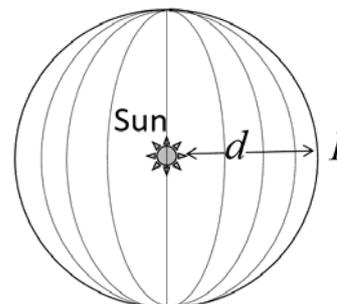


Fig. 1: Illustration of the Sun and sphere.

Fig. 2 displays global annual mean of shortwave radiation energy budget of the Earth. Approximately 【　F　】 of (ii)incoming radiation of 342 W m$^{-2}$ is absorbed at the Earth's surface, and 67 W m$^{-2}$ is absorbed by the atmosphere. At the Earth's surface, 30 W m$^{-2}$ is (iii)reflected back to the space. As a summary, (iv)net shortwave radiation absorbed by the Earth system is 235 W m$^{-2}$.
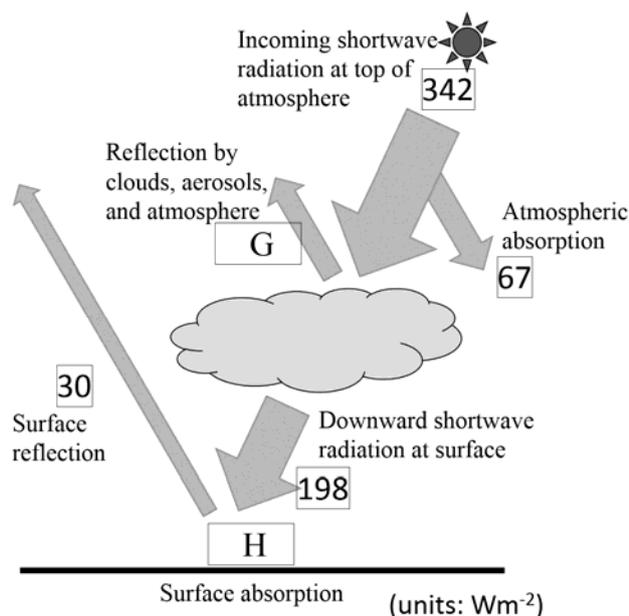


Fig. 2: Shortwave radiation budget of the Earth.

(1) Choose appropriate terms from the choices below to fill parentheses 【　A　】 to 【　F　】.

Choices:  $I\pi d^2$ ,  $2I\pi d$ ,  $2I\pi d^2$ ,  $\frac{4}{3}I\pi d^3$ ,  $4I\pi d^2$ ,  $1.37\times 10^3$,  $1.37\times 10^5$,  13.7,  327.4,

solar constant, UV intensity, effective radiation, larger, smaller, one-third, half, three-fourths

(2) For underlined phrase (i), derive an equation describing *I* for a planet rotating around the Sun with a mean distance of $d_2$.

(3) When the mean distance between the Sun and Mars is $1.52d_1$, compute *I* for Mars in W m$^{-2}$ unit. You must write down all calculation steps as well as the final answer.

(4) Answer appropriate values to fill the boxes    G    and    H    in Fig. 2.

(5) Aerosols shown in Fig. 2 are known to modulate surface downward solar radiation by affecting cloud properties. Explain the detailed process on how aerosols affect cloud properties in about 4 lines. Answer must include phrases of "wettable aerosol" and "saturation vapor pressure".

(6) For underlined phrase (ii), explain the reason why the value of incoming radiation in Fig. 2 is different from $1.37 \times 10^3$ W m$^{-2}$. You may draw figures in the answer sheet to explain the reason, if necessary.

(7) For underlined phrase (iii), select all description(s) from the following sentences which meet suitable explanation for the reflection.

   (a) Ocean surface reflectivity varies depending on the solar angle.
   (b) Snow reflectivity increases with time if no snowfall occurs.
   (c) The mean Earth's reflectivity is approximately 0.7.
   (d) Reflectivity of the desert is lower than that of the grassland.

(8) For underlined sentence (iv), Fig. 2 indicates that incoming radiation of the Earth is larger than outgoing radiation. Explain the reason why the Earth's temperature is relatively stable regardless of the excess incoming radiation in about 5 lines.

## Ecology and Geography

**Question 6**    Answer the questions (1) and (2).

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

    (A) Describe each of the five ecological terms (i) to (v).
        (i) ecological niche, (ii) intra-specific competition, (iii) acclimation, (iv) boreal forest,
        (v) Raunkier's life form

    (B) Answer the questions (i) to (iv), based on the figures (a) to (e) and text.

(a)               (b)              (c)
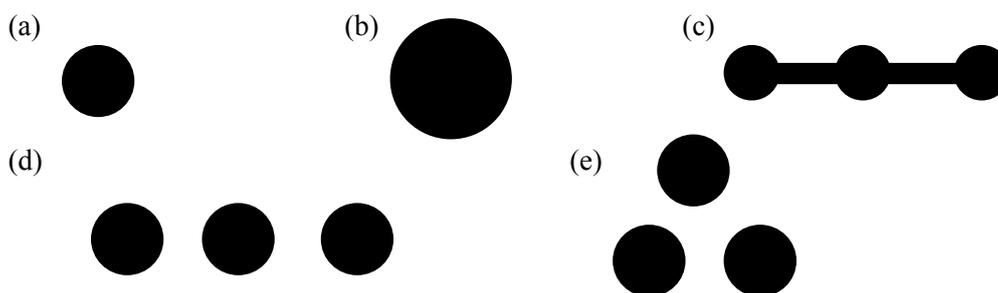
(d)                          (e)

Fig. Layout methods in setting up a nature reserve. Black areas indicate the nature reserves.

   (i) Number of species (species richness) increases generally with increasing the area of habitats, although the species richness is influenced not only by the area of habitats but also by the shape.   Therefore, it is common that the nature reserve (b) supports more species than the nature reserve (a).   However, area is not the only important item for the design of nature reserves.   For instance, (ii) the nature reserve (c) has the same sum total area of nature reserves with that of nature reserve (d) but shows different species richness in the reserves.   As well, (iii) the species richness is different between the nature reserves (d) and (e).   In particular, the selection of single large nature reserve, as shown in the reserve (b), or several small nature reserves, as shown in the reserve (e), had been controversial.   This issue is called as (iv)SLOSS (a single large or several small).   Nowadays, it is concluded that the suitable design of nature reserves is dependent on the objectives of nature reserves.

(Source: Key Notes in Ecology 2001, slightly modified).

    (i)   Write the relational equation between *S* (number of species) and *A* (area).

    (ii)   Which does higher species richness show, the reserve (c) or (d)?   Explain the reasons of selection.

    (iii) Which nature reserve shows higher species richness, the reserve (d) or (e)?   Explain the reasons of selection.

    (iv) Explain what cases we should apply the design (b) and what cases we should apply the design (e).

(2)  Answer the following questions (A) to (F) after carefully examining the paragraph below.

If (i) <u>a predator has a choice of a number of prey types</u>, then if it is optimizing its effort, it should choose the most [ (a) ] prey. The most [ (a) ] prey is not necessarily the [ (b) ] individuals but rather those individuals which offer the highest [ (c) ] per unit time. Predators, which can feed on a variety of prey types, occasionally exhibit selective feeding preference to the most numerically abundant prey. (ii) <u>This preference can flexibly change when the prey compositional shift leads the dominance of other species</u>. Furthermore, as prey density increases, (iii) <u>a predator's consumption rate will increase until it is consuming at its maximum possible rate</u>. In some cases, prey density is regulated by the density of predator (bottom-up control), or in contrast, (iv) <u>predators exert a strong influence on the population level of prey</u>. Such trophic interactions are important when understating community structure and its associated ecological functions. Many large animal species have a high risk of extinction due to anthropogenic activities in various ecosystems. The extinction of [ (d) ] species, which has a significant and disproportionate effects on the community, can lead to drastic changes in entire ecosystems. However, [ (d) ] species are not necessarily positioned at the top of food chains.

(Source: Instant Notes in Ecology 2001, slightly modified).

(A) In predator-prey interactions such as the underlined (i), predator productivity rarely exceeds prey productivity. Describe the reason.

(B) Choose 4 different words suitable to fill each of the blanks (a) to (d) from the following list.

List: stable, fluctuating, larger, adaptive, profitable, small, general, rare, high, low, predation risk, radiation exchange, energy reward, density-dependence, pyramid, keystone, umbrella

(C) Explain what the phenomenon in the underlined (ii) implies from the viewpoint of fitness.

(D) Provide a term explaining the response in the underlined (iii).

(E) Provide a term explaining the phenomenon in the underlined (iv).

(F) "Complexity" and "stability" are the two characteristics of biological communities. Explain those two terms, respectively. Also, logically provide your opinions about the hypothesis "complex communities are also more stable".

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## Ecology and Geography

**Question 7** Provide answers to both questions (1) and (2).

(1) Read the following text, and answer questions (A) to (E) below the text.

Land surface can be classified, on the basis of its height and relief, into: (i)<u>mountains</u>, which have a certain height and relief; 【a】, which are characterized as flat land; and 【b】, intermediate landform between mountains and 【a】. However, mountains and 【b】 are colloquial expression and there are no clear definitions of mountains and 【b】.

Landforms of mountains and 【b】 are decided by a combination of 【c】 and 【d】. Development of landform means moving crustal materials, and the movement of the crustal materials happens by 【e】. 【e】 are divided into the following two: (ii)<u>endogenic processes</u> and (iii)<u>exogenic processes</u>.

【f】 energy and kinetic energy are consumed by friction on the riverbed when water flows downstream. During this movement, land-surface materials are also moved by the flowing water. This is called an 【g】 process of rivers. (iv) <u>Rivers' 【g】 process becomes zero at the level where the 【f】 energy becomes zero (which is normally the surface of the sea or lakes).</u>

(A) Select appropriate terms in 【a】 to 【g】 from the followings.

**plains, kinetic, lakes, coasts, denudation, erosion, isostasy, uplift, geomorphic processes, geological structure, potential, dynamic, orogenic movement, hills**

(B) On the part of underline (i), it is said that there is no clear agreement on the definition. Some mountain residents in Nepal even claim that they do not call land surface below 4,000 m in altitude a mountain. If a mountain is defined by an altitude alone, what kind of problem(s) would occur?   Provide such problem(s).

(C) On the part of underline (ii), provide two examples of the processes.

(D) On the part of underline (iii), provide one example of the processes.

(E) On the part of underline (iv), provide one example that causes erosion on the land surface, which is located lower than the surface of the sea or lakes.

（Continued to the following page）

(2) The topographic map shown in the next page is downloaded from the website of the Geographical Survey Institute of Japan. The left side corresponds to the north. Assuming that the scale of the printed map is 1:15,000, answer the following questions, (A) to (E).

(A) Provide the geomorphological term showing the area surrounded by a thick solid line (labeled with 'K'). Also, provide the definition of the term.

(B) Calculate an approximate horizontal distance between 'L' and 'M'. Use the scale below for the calculation.

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 L__L__L__L__L__L__L__L__L__L__L
 0    1    2    3    4    5 cm
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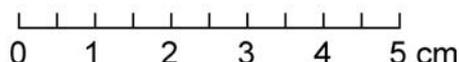
(C)  Calculate the relative height (difference of the altitudes) between 'L' and 'M'.

(D) The land surface showing the label of 'N' is greatly modified by human activities. Explain about the original morphology of the land surface before the human modification.

(E) When you walk from site 'O' via 'P' and 'Q' to site 'R', which of the following four items, (a) to (d), is appropriate?

(a) Soon after walking, the road becomes steep ascending way. At site 'P', you traverse the slope, seeing the large river to the north, which flows from the west to the east. Then, you reach site 'Q', which is located in the valley. From there, you walk in the valley down to site 'R'.

(b) Soon after walking, the road becomes steep ascending way. At site 'P', you traverse the slope, seeing the large river to the west, which flows from the south to the north. Then, you reach site 'Q', which is located on the ridge. From there, you walk on the ridge up to site 'R'.

(c) Soon after walking, the road becomes steep ascending way. At site 'P', you traverse the slope, seeing the large river to the north, which flows from the east to the west. Then, you reach site 'Q', which is located in the valley. From there, you walk in the valley down to site 'R'.

(d) Soon after walking, the road becomes steep ascending way. At site 'P', you traverse the slope, seeing the large river to the west, which flows from the north to the south. Then, you reach site 'Q', which is located on the ridge. From there, you walk on the ridge up to site 'R'.
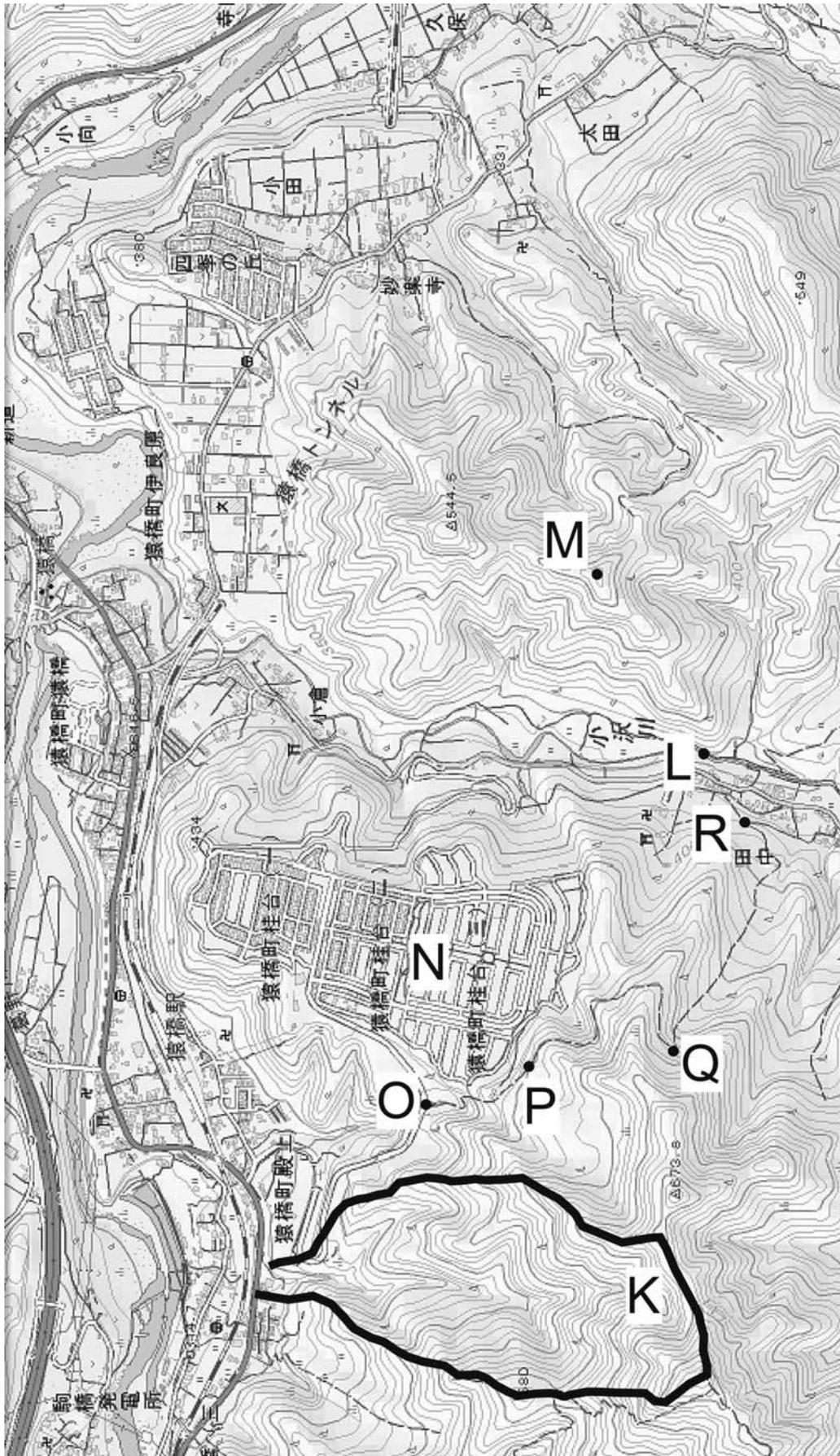
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## Environment and Society

**Question 8**    Read sentences below and answer questions.

(1)    (a)    is the main convention for promoting international responses to climate change.    (a)    entered into force in March 1994 and has achieved near universal ratification by 189 of the 194 United Nation member states (December 2006).    (b)    is the first addition to    (a)   , was adopted in 1997, and entered into force in February 2005. Under Article 3.1 of    (b)   , Annex I Parties in aggregate agreed to reduce their overall greenhouse gas (GHG) emissions to at least    (c)    % below 1990 levels. Its full implementation by all    (b)    signatories, however, would still be far from reversing overall global GHG-emission trends. The significance of    (b)    is (i)its provision for market mechanisms and its institutional architecture.

   (A) Fill appropriate terms or number into blank columns (a), (b) and (c).

   (B) According to the underlined phrase (i), list three market mechanisms and explain in around 4 lines for each.

(2) How did Intergovernmental Panel on Climate Change (IPCC) Assessment Report deal with uncertainties existing in observational and modeling results? Answer in several lines by referring to terms such as "agreement" and "evidence".

(3) Describe in around 4 lines about points that environmental issues such as global warming and ocean acidification are different from typical environmental pollution (*kogai*) such as Minamata disease.

## Environment and Society

**Question 9**   Answer questions below.

(1) Read the following paragraph and fill appropriate terms into blank columns (a) and (b), and appropriate case examples into blank columns (c) through (f).

There are two kinds of strategies against global warming: ⬚ (a) ⬚ and ⬚ (b) ⬚. ⬚ (a) ⬚ is a strategy to try to suppress causes of global warming. This strategy includes such as ⬚ (c) ⬚ and ⬚ (d) ⬚. ⬚ (b) ⬚ is a strategy to try avoiding the influences of global warming, including such as ⬚ (e) ⬚ and ⬚ (f) ⬚.

(2) Consider a situation that a cattle farmer is thinking of installing a biogas plant and generating biogas by putting in cow excrement excreted through dairy farming processes. Answer the following questions by assuming conditions below: the electric power is 15kW; the number of annual operation days is 300; 30% of the electric energy is for captive consumption and the rest is sold for 40 yen per 1kWh.

(A) Calculate how much annual income the cattle farmer is expected to get by selling the electric energy. Write the answer with the calculation process.

(B) Assume that initial invest cost of the biogas plant is 30 million yen and half of the cost is covered by subsidies. If annual running cost is 1 million yen, how long does it take for the cattle farmer to recoup the initial investment cost? Write the answer with the calculation process.

(C) Product generated by using biogas plants to treat livestock excrement is not only biogas. What is considered to be an effective way to utilize the product rather than biogas to increase the cattle farmer's income or shorten the period for recouping the initial investment cost? Describe about the way concretely.

(D) Describe in total around 7 lines about both benefits of disposing livestock excrement in biogas plants and problems in installing biogas plants.

## Chemistry and Biology

**Question 10**   Answer the following questions (1) to (4). In the case of a numerical calculation, do not omit calculation process and the reasons in the description in your answer sheet.

(1)   Answer the following questions.

(A) Calculate moles of 40 g of ethane ($C_2H_6$). Answer with two significant figures.

(B) Write the reaction formula when ethane is combusted completely with oxygen.

(C) When the heat of combustion of ethane is 1561 kJ mol$^{-1}$, calculate the increase in temperature of 100 g water by the combustion of 40 g ethane. The specific heat capacity of water is 4.2 J g$^{-1}$ K$^{-1}$ and all of heat are used only for the increase in temperature of water.

(2)   The initial rates of the reaction between X and Y were measured while changing the concentration of X and Y and we got the following results.

| Experiment | [X] (mol L$^{-1}$) | [Y] (mol L$^{-1}$) | Initial rate (mol L$^{-1}$s$^{-1}$) |
|---|---|---|---|
| 1 | 0.10 | 0.010 | $1.2 \times 10^{-3}$ |
| 2 | 0.10 | 0.020 | $4.8 \times 10^{-3}$ |
| 3 | 0.20 | 0.010 | $2.4 \times 10^{-3}$ |

(A) Select the most appropriate equation to represent the rate of this reaction from below and answer with a symbol. k is the rate constant of this reaction.

(a)   k[X][Y],   (b)   k[X]$^2$[Y]$^2$,   (c) k([X] – [Y]),   (d)   k[X][Y]$^2$,   (e)   k[Y]$^2$

(B) Calculate the rate constant (k) of this reaction.

(C) Calculate the reaction rate when [X] is 0.40 mol L$^{-1}$ and [Y] is 0.040 mol L$^{-1}$.

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(3) Answer the following (A) to (E). In the calculation of pH, answer with two significant figures using the acid dissociation constant of acetic acid ($K_a$), $-\log K_a = 4.6$.

(A) Calculate pH of 0.010 mol $L^{-1}$ HCl solution.

(B) Calculate pH of 0.010 mol $L^{-1}$ $CH_3COOH$ solution.

(C) Calculate pH of a mixed solution of 100 mL of 0.2 mol $L^{-1}$ $CH_3COOH$ and 100 mL of 0.2 mol $L^{-1}$ $CH_3COONa$.

(D) Select the nearest pH to that when 10 mL of (A) solution is added into 100 mL of (C) solution from below and answer with a symbol.
  (a) pH=2.0,  (b) pH= 3.2,  (c) pH= 4.4,  (d) pH= 5.6,  (e) pH= 6.8

(E) What is the solution like (C) called?


(4) Answer the following (A) to (C) when the solubility products of $Mg(OH)_2$ (molar mass: 58.3) and $Ca(OH)_2$ are $1.08 \times 10^{-11}$ and $8.0 \times 10^{-6}$, respectively.

(A) Calculate the solubility of $Mg(OH)_2$ with two significant figures.
(B) Calculate the concentration of Mg(II) which can be solved in the solution with pH=12.
(C) There is a mixed solution containing Ca(II) and Mg(II), whose concentrations are 0.010 mol $L^{-1}$. Select the appropriate pH of the solution when more than 90% of Mg(II) are precipitated and more than 90% of Ca(II) are solved from below and answer with a symbol.
  (a) pH=8.0,  (b) pH= 9.0,  (c) pH=12,  (d) pH=14

## Chemistry and Biology

**Question 11**  Answer the following questions (1) to (4). In the case of a numerical calculation, do not omit calculation process and the reasons in the description in your answer sheet.

(1) Which of the following statements are correct? Answer true or false in (A) to (D). If answer is false, write corrected statement.

   (A) Allosteric enzymes have two or more binding sites for substrate.

   (B) Noncovalent bonds are too weak to influence the three-dimensional structures of macromolecule.

   (C) Gel-filtration chromatography separates molecules according to size. Smaller molecules are eluted early through a gel-filtration as compared with larger ones.

   (D) Disulfide bonds help stabilize a favored protein conformation. Usually in the proteins, methionine residues contribute disulfide bonds.

(2) Answer the following questions (A) and (B).

   (A) A cup of water, containing exactly 1.0 mole of water, was emptied into the Aegean Sea 3000 years ago. What are the chances that the same quantity of water, scooped today from the Pacific Ocean, would include at least one of these "Greek" water molecules? Calculate molecular number of "Greek" water in 180 mL of sea water in the Pacific Ocean. Assume perfect mixing, an approximate volume for the ocean in the world of 1.5 billion cubic kilometers ($1.5 \times 10^9$ km$^3$), and Avogadro's number of $6 \times 10^{23}$.

   (B) You were given a mixture consisting of one molecule each of all possible sequences of a smallish peptide of molecular weight 1200 daltons. If average molecular of an amino acid is 120 daltons, calculate how much the sample weighs. Assume amino acid numbers of 20.

(3) Answer the questions from (A) to (C) .

   (A) Industrial workers exposed for a limited time to chemical carcinogens that induce mutations in DNA do not usually begin to develop cancers characteristic of their habit occupation until 10, 20 or even more years after the exposure. Suggest an explanation for this long delay in arround five lines.

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(B) Why does ionizing radiation stop cell division? Explain the reason in around 6 lines.

(C) Leukemia－that is, cancers arising through mutations that cause excessive production of white blood cells－have an earlier average age of onset than other cancers. Propose an explanation for why this might be the case within 6 lines.

(4) A gene encoding one of the proteins involved in DNA replication has been inactivated by mutation in a cell. In the absence of this protein the cell attempts to replicate its DNA for the very last time. What DNA products would be generated if each of the following proteins were missing? Answer in around two lines with the reason.

(A) DNA polymerase

(B) DNA ligase

(C) DNA helicase