2023 年 8 月 28 日 14 時~16 時 30 分 14:00-16:30, August 28, 2023

# B 都市工学専門 B Urban Engineering Subjects

## 受験番号

(Examination I.D.)

(1) すべての答案用紙の所定の欄に、問題番号、受験番号を記入し なさい。<u>氏名を記入してはならない。</u> Write the question number and your examination I.D. on all the answer sheets. Do not write your name. (2) 問題冊子に受験番号を記入しなさい。 Write your examination I. D. on this sheet. (3) B-1~B-15の15問の中から5問を選択し、解答しなさ い。ただし、5問の解答の中で以下の条件を満たすこと。 ・専攻分野として「都市環境工学」を希望するものは、B-1~ B-7のうちから3問以上選択しなければならない。 ・専攻分野として「都市計画」を希望するものは、B-8~B-15のうちから3問以上選択しなければならない。 Answer five questions out of the 15 questions (B-1 to B-15) following the instruction below: • If your major field of study is "Urban Environmental Engineering," then select at least three questions from B-1 to B-7. • If your major field of study is "Urban Planning," then select at least three questions from B-8 to B-15. (4) 答案用紙は1問につき1枚(裏を含む)とし、問題毎に用紙を変 えなさい。

Use one answer sheet for each question. You may write your answers overleaf.

#### B-1 Water and Wastewater Engineering

- Q.1 Explain the following terms on water supply systems.
- (1) Block formation of water supply areas
- (2) Minimum night flow method
- (3) Small-scale hydro-power generation
- (4) Water purification by membrane filtration processes
- Q.2 Answer the following questions on generation sources and reduction methods of greenhouse gases in sewerage works.
- (1) List three major sources of greenhouse gas emission in sewerage works, and propose reduction methods of greenhouse gas emission for each source.
- (2) It is estimated that the population, as well as the amount of wastewater, in Japan will decrease. Taking such a trend into consideration, compare the centralized public sewerage works and the decentralized wastewater treatment systems, including *Jokaso*, with respect to effluent water quality, easiness of maintenance, and greenhouse gas emissions. Then, discuss desirable wastewater treatment systems in the future in Japan.

#### B-2 Hydraulics

- Q.1 Explain the following terms.
- (1) Equivalent roughness
- (2) Manning's equation
- (3) Hagen-Poiseuille flow
- (4) Hydraulic grade line
- Q.2 Assume that the unit flow  $q (m^2/s)$  is constant in an open channel flow. Answer the following questions.
- (1) Show how the water depth  $h_c$  that minimizes the specific energy is given by  $\sqrt[3]{\frac{q^2}{a}}$ .
- (2) When the unit flow q is 3.0 m<sup>2</sup>/s and the water depth  $h_1$  is 0.40 m, find the Froude number *Fr*. In addition, find the conjugate depth  $h_2$ .
- (3) Consider a case where the channel bed has one unevenness, the channel bed height is equal before and after the unevenness, and the transition from supercritical flow to subcritical flow occurs without any hydraulic jumps.
  - a) Answer whether the elevation of the unevenness is higher or lower than the channel bed and explain the reason.
  - b) Answer whether the water depth after the transition is higher or lower compared to the case where the hydraulic jump occurs, and explain the reason.
- Q.3 Answer the following questions.
- (1) Give an expression for the *x*-directional component of the Navier-Stokes equations for an incompressible fluid. In addition, indicate the term representing inertial force and the term representing viscous force in the expression.
- (2) Show that the Reynolds number is dimensionless.

#### B-3 Water Environment

- Q.1 Answer the questions below.
- (1) Environmental Quality Standards for Water in Japan may be revised on occasion. List up and concisely explain the potential reasons to order the revisions. Also, answer two items in the standards that were revised in 2021.
- (2) Environmental Quality Standards for Water in Japan include the standards regarding the adaptability to aquatic life habitat conditions. In the standard, to classify the required level of water environment, what kind of factor(s) are considered in addition to the species of aquatic life? Explain the factor(s) concisely.
- (3) What kind of impacts may be raised on water environment by the change of rainfall patterns due to climate change? Explain concisely the impacts on both water quality and water quantity, respectively, including the effects on water use.
- Q.2 Explain concisely the terms below on water environment, respectively.
- (1) Blue carbon
- (2) Nitrogenous BOD
- (3) Internal production

#### B-4 Environmental Microbiology

- Q.1 For each of the following statements, mark with " $\bigcirc$ " (a circle) if the statement is correct, or provide the correct statement if the statement is not correct.
- (1) All virus particles consist of genomic DNA or RNA encapsulated within a membrane called envelope.
- (2) The anammox reaction is a catabolic reaction where ammonium ion (NH4<sup>+</sup>) as the electron accepter and nitrate (NO3<sup>-</sup>) as the electron donor are converted into the products mainly consisting of nitrogen gas (N2) and water (H2O).
- (3) The amount of generated sludge decreases when solids retention time is prolonged in activated sludge processes because bacteria with lower cell yields become more advantageous in survival than those with higher cell yields under longer solids retention times.
- Q.2 Answer the questions regarding anaerobic reactions expressed by following Eqs. (1), (2) and (3), where  $\Delta G^{o'}$  represents the Gibbs free energy change under the biochemical standard state.

Ethanol fermentation		-
$CH_3CH_2OH + H_2O \rightarrow (i) + H^+ + 2H_2$	$\Delta G^{o'} = +9.7 \text{ kJ/reaction}$	Eq.(1)
Methane generation reactions		
$4H_2 + HCO_3^- + H^+ \rightarrow CH_4 + 3H_2O$	$\Delta G^{o'} = -136 \text{ kJ/reaction}$	Eq.2
$(i) + H_2 O \rightarrow CH_4 + HCO_3^-$	$\Delta G^{o'} = -31 \text{ kJ/reaction}$	Eq.③

- (1) Give the chemical formula that fits (i) in the above Eqs.(1) and (3).
- (2) Answer the Gibbs free energy change under the biochemical standard state when one mole of ethanol is anaerobically converted to methane and hydrogen carbonate.
- (3) There is an approach to increase methane production by injecting hydrogen gas into anaerobic digesters. Give the possible reason(s) why the injection of hydrogen gas can increase methane production. In addition, give an example of negative effects on the anaerobic digestion process by hydrogen gas injection. In each case, explain the rationale of your answers by referring to the relationship to the above equations.

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Q.3 Explain the reasons why 16S rRNA genes are widely used in phylogenetic analyses of microorganisms. In addition, provide issue(s) in the microbial community analyses targeting the 16S rRNA genes.

#### B-5 Environmental Chemistry and Reaction

- Q.1 Answer the following questions on chemical equilibrium.
- (1) Assuming dilute water solutions, explain the relationship between the Gibbs free energy change and equilibrium constant K.
- (2) At 25°C, ammonia dissociation has equilibrium constant K as below.

$$NH_3(aq) + H_2O \rightleftharpoons NH_4^+ + OH^ K = 1.8 \times 10^{-5}$$

Answer the pH value of the dilute ammonia solution at which the molar concentrations of dissolved free ammonia (NH<sub>3</sub>(*aq*)) and ammonium ions NH<sub>4</sub><sup>+</sup> become equal. Use the ion product of water =  $10^{-14}$  and  $\log_{10} 1.8 = 0.255$ .

(3) Ammonia stripping is a method to remove ammonia in wastewater as gas. In this method, effective ammonia removal is achieved by controlling pH and temperature. Explain the mechanism of the effective removal.

#### Q.2 Answer the following questions.

- (1) Explain about Freundlich adsorption isotherm, by referring to its formula, characteristics, and differences from other types of adsorption isotherms.
- (2) Regarding the emerging water pollution by PFAS, explain their molecular structures and physicochemical properties, and describe their applications and environmental problems.
- (3) Explain about DLVO theory, by referring to the concept and an example of applications in water treatment technology.

#### B-6 Global Environment Engineering

- Q.1 Some private companies, local governments, and universities estimate greenhouse gas emissions related to their own activities. When estimating the emissions, emission sources are divided into Scope 1, Scope 2, and Scope 3. Answer the following questions.
- (1) Describe the contents of Scope 1, Scope 2, and Scope 3 within 4 lines, respectively.
- (2) With regard to Scope 3 for a university like the University of Tokyo, give three examples of emission sources, and explain their contents briefly.
- Q.2 Explain the following terms within 4 lines each, and show one specific example of related countermeasures, respectively.
- (1) Climate change adaptation
- (2) Depletion of the ozone layer
- Q.3 The following sentences (S1 and S2) are extracted from the IPCC AR6 Synthesis Report. Answer the following questions.

(S1) Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming, with global surface temperature reaching 1.1°C above 1850-1900 in 2011-2020. Global greenhouse gas emissions have continued to increase, with unequal historical and ongoing contributions arising from unsustainable energy use, land use and land-use change, (A) <u>lifestyles and patterns of consumption and production</u> across regions, between and within countries, and among individuals (*high confidence*).

(S2) Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred. Human-caused climate change is already affecting many <sub>(B)</sub> weather and climate <u>extremes</u> in every region across the globe. This has led to widespread adverse impacts and related losses and damages to nature and people (*high confidence*). <sub>(C)</sub> <u>Vulnerable communities who have historically contributed the least to current climate change are disproportionately affected</u> (*high confidence*).

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- (1) Regarding the underlined part (A) in S1, explain how this affects greenhouse gas emissions within 10 lines.
- (2) Explain underlined parts (B) and (C) within 8 lines, respectively.

#### B - 7 Waste Management and Material Cycles

- Q.1 Recycling methods of food waste include a) conversion to animal feed, b) conversion to compost, and c) conversion to biogas. Answer the following questions about them.
- (1) Explain the advantages and problems of each of the methods a) to c).
- (2) Complete the reaction formula below that shows the biogas generation when the chemical formula of the organic matter in food waste is assumed to be  $C_{17}H_{29}O_{11}N$ .

)

 $C_{17}H_{29}O_{11}N + 5 H_2O \rightarrow ($ 

- (3) Answer one type of organic waste other than food waste, and explain a method <u>other than a</u>) to c) to effectively use the waste you answered.
- Q.2 Answer the following questions related to home appliance recycling.
- (1) Categorize the following home appliances from ① to ⑩ into groups based on Japanese laws that promote the recycling of the products, and explain the laws and collection methods related to each group.

①TV ②Camera ③Air conditioner ④PC ⑤Mobile phone
⑥Refrigerator ⑦Vacuum cleaner ⑧Laundry machine ⑨Rice cooker ⑩Fan

- (2) Some home appliances are not sufficiently collected. Answer an example of such home appliances and explain the reason.
- Q.3 Explain the following terms related to waste management.
- (1) Sanitary landfill
- (2) Extended producer responsibility

### B-8 Urban Planning

- Q. The District Plan under the City Planning Act of Japan is a district-level city planning that designates necessary matters to shape a good urban environment based on the characteristics of each district within a city.
- (1) Explain the contents that can be designated in District Plans.
- (2) Explain the process of adopting District Plans, clearly describing who can propose them and who approves them.
- (3) Explain the major purposes and contents of the Streetscape Promoting District Plan.You may explain making reference to a case study.

#### B-9 Urban Design

- Q.1 Explain the following technical terms in about 7 lines each, including examples and their relation to urban design:
- (1) *Machiya* (Japanese)
- (2) Diagram
- (3) Passage (French)
- Q.2 In recent years, there has been a search for ways to design cities given the introduction of new mobility services. In particular, the introduction of Green Slow Mobility (GSM), defined as "a small mobility service utilizing electric vehicles that can travel on public roads at speeds of less than 20 km/h," is being considered in many areas. Answer the following questions about the relationship between GSM and urban design.
- (1) Describe the characteristics of GSM as mobility, both in terms of strengths and weaknesses, in about 7 lines.
- (2) GSM is expected to be used for solving various issues in addition to securing transportation modes. Discuss in about 15 lines, what kind of utilization is possible in what kind of areas, and what is the contribution of urban design in such utilization, referring to actual examples as necessary.

#### B - 1 0 Urban Housing

Q.1 The Basic Plan for Living (National Plan) approved by the Cabinet in 2021 sets eight goals from the following three perspectives and comprehensively promotes these measures. Select two of the eight goals and describe what specific measures will be required for each.

Perspectives on "Changes in Social Environment"

Goal 1: Promote new routines, DX (digital transformation,) etc.

Goal 2: Creation of safe housing and residential areas, etc.

Perspective of "Residents and Communities"

Goal 3: Homes where it is easy to have and raise children

Goal 4: Communities where the elderly can live safely, etc.

Goal 5: Establishment of safety net functions

Perspective of "Housing Stock and Industry"

Goal 6: Establishment of a housing circulation system, etc.

- Goal 7: Management, demolition and utilization of vacant houses
- Goal 8: Growth of housing and living industry
- Q.2 In the Tokyo region, housing prices are soaring, especially in the Tokyo 23 wards, where the average price for a newly built condominium unit has exceeded 100 million yen, breaking the previous record of 97.38 million yen in 1991.
- (1) Explain three reasons for this phenomenon.
- (2) Point out the problems of this phenomenon from the viewpoint of housing affordability and describe possible measures to address these problems.

#### B – 1 1 Urban Disaster Management and Planning

- Q.1 Explain each of the following pairs of terms related to urban disaster management by focusing on their mutual differences.
- (1) "Basic Disaster Management Plan" and "Disaster Management Operation Plan" (Answer in about 3 lines in total)
- (2) "Evacuation of the elderly, etc." and "Emergency safety measures" (Answer in about 3 lines in total)
- Q.2 Answer the following questions regarding earthquake damage estimates by local governments.
- (1) Explain the method used to calculate "building damage due to shaking," specifying the data to be used. (Answer in about 4 lines)
- (2) Explain the method used to calculate the "number of stranded commuters," specifying the data to be used. (Answer in about 4 lines)
- (3) Explain the difference between "District-based earthquake vulnerability assessments by the Tokyo Metropolitan Government" and "Earthquake damage estimates".
   (Answer in about 4 lines)
- (4) Explain the points to consider when assessing earthquake risk using earthquake damage estimates. (Answer in about 7 lines)
- Q.3 Explain the similarities and differences between "The Great Fire of *Meireki* (in Japan)" and "The Great Fire of London". (Answer in about 10 lines)

#### B-1 2 Urban Analysis

- Q. 1 Consider a square OABC with a side of 1 km.
  Point P is randomly placed on the side AB and point Q is randomly placed on the side BC. Random here means that points are plotted following the same probability density at any point on the line segment. Please answer the following questions.
- (1) Find the expected value of the area of the triangle OAP.



- (2) Find the expected value of the area of the triangle OPQ.
- (3) Find the probability that the area of triangle OAP is larger than that of triangle OPQ.
- Q. 2 In the case of redevelopment projects preserving historically important remains, the preservation can be regarded as a social contribution, therefore public subsidies are appropriate.
- What points must be considered in order to determine the fair amount of such subsidies?
   List the important items that should be considered, and state what kind of consideration should be given to each item.
- (2) Explain the appropriate method for determining the social value of historical remains.

#### B – 1 3 Urban Transportation Planning

Q.1 The table below shows estimated parameters of a disaggregate travel mode choice logit model. Using these results, answer the questions below.

	Variable	Coefficient	Standard error
asc <sub>train</sub>	Train constant	0	_
asc <sub>car</sub>	Car constant	-0.3	0.12
$x_{i,n,1}$	Travel cost (JPY)	-0.006	0.003
<i>x</i> <sub><i>i</i>,<i>n</i>,2</sub>	Travel time (min)	-0.02	0.002

*i* indicates the travel mode.

- (1) The car constant is negative. Explain the meaning of this result in 2 to 3 lines.
- (2) Write the equation for the choice expected maximum utility,  $V'_n$ , for individual n.
- (3) Assuming that car travel time is 40 min, and car choice probability,  $P_n(car)$ , is 0.17, calculate the direct elasticity of car travel time,  $E_{car,n,2}^{P_n(car)}$ , for individual *n*. Round your results to two decimal places.
- (4) Interpret the direct elasticity calculated in (3).
- Q.2 Considering the degree to which it is shared with cars, the right-of-way for public transport is classified into three types. Explain the three right-of-way types and name one representative transport mode for each type, within 1 to 2 lines each.
- Q.3 Explain within 1 to 2 lines each, the environmental space functions of station-front plazas.

#### B-1 4 Regional Planning

Answer each of the following questions regarding Japan's National Spatial Plan.

- Q.1 Answer "o" (circle) if each of the following statements is correct, and answer "×" (cross) if it is incorrect.
  - a) The National Spatial Planning Act is sometimes referred to by another name, the National Land Use Planning Act, when discussing the contents of national land use.
  - b) The National Spatial Strategies consists of the National Plan, Prefectural Plans, and Municipal Plans.
  - c) The basic measures specified in the National Plan include the development of infrastructures and the proper industrial locations, but not those related to the preservation of the environment.
  - d) The spatial range covered by the National Plan also includes marine areas such as Exclusive Economic Zones.
- Q.2 Select four of the directions, a) through f), in the new National Plan that have been discussed in Japan by July 2023, and describe in 4 to 7 lines the effects that these plans would have on the revitalization of regional areas where population decline is progressing.
  - a) Promotion of telework
  - b) Expansion of so-called "related population" (Kankei-jinko)
  - c) Realization of carbon neutrality
  - d) Realization of an inclusive society
  - e) Promotion of sustainable land management
  - f) Digitization of urban services
- Q.3 For any given plan, evaluating whether or not its goals have been achieved is desirable. Select one of the directions you chose in Q.2 and provide a specific example and explanation of one input indicator, one output indicator, and one outcome indicator that are related to each other, and can be used to adequately assess the extent to which the plan's goals have been achieved. Answer in a total of 4 to 7 lines.

#### B-1 5 Landscape Planning and Environmental Design

- Q.1 "Green Infrastructure" aims to solve various social issues in urban and regional planning by utilizing the multifunctionality of nature, but the definition of this concept varies from country to country and from region to region. For example, in the U.S., the focus is mainly on (A), while in Europe, it is not limited to (A), but takes a more diverse view of nature's functions.
- (1) Briefly explain the function of nature that applies to (A).
- (2) Green infrastructure has been attracting attention in recent years in various policies related to urban and regional planning in Japan. Give two reasons for this and explain in about 3 lines each.
- (3) For the two reasons stated in (2), explain in 3 to 4 lines each, the issues of using green infrastructure and how it can be improved.
- Q.2 Briefly explain the following four terms and places related to landscape planning within 3 to 4 lines each.
- (1) OECM
- (2) Hibiya Park
- (3) The Emerald Necklace
- (4) Eco-DRR