

2021年8月28日 13:00~15:00

## B 都市工学専門

### Urban Engineering Subjects

- (1) すべての解答用紙と下書用紙の所定の欄に、問題番号、受験番号を記入しなさい。氏名を記入してはならない。  
Write the question number and your examinee number in the specified place of all answer sheets and the draft paper.  
Do not write your name.
- (2) 問題ファイル（このファイル）は、答案アップロード終了後、指示に従い削除すること。削除していないことが判明した場合には不正行為となることがある。  
After uploading your answer sheets, delete this file containing question sheets following the instruction. In case you do not follow this instruction, it will be regarded as misconduct behavior.
- (3) 都市環境工学専攻分野志望の受験者は、B-1～B-7の7問の中から5問を選択し、解答しなさい。  
Those who apply to the Urban Environmental Engineering should choose and answer 5 questions from B-1 to B-7.
- (4) 都市計画専攻分野志望の受験者は、B-8～B-15の8問の中から5問を選択し、解答しなさい。  
Those who apply to the Urban Planning should choose and answer 5 questions from B-8 to B-15.
- (5) 答案は1問につき1枚を利用すること。  
Answer each question on a separate answer sheet.
- (6) 解答終了後は監督者の指示に従い、5枚の答案すべてをアップロードすること。  
Upload all 5 answer sheets following the instruction.
- (7) 問題のスクロールと拡大縮小のため、パソコンのマウスやトラックパッドの使用は認めるが、キーボードには触れてはならない。  
Note that using a mouse or trackpad for scrolling and zooming in/out is allowed but touching a keyboard is prohibited.

English translation of question sheets follows Japanese version.

## B—1 Water and Wastewater Engineering

Q 1 Answer the following questions regarding UV disinfection and chlorine disinfection.

- (1) Explain disinfection principles of each disinfection method in about 5 lines.
- (2) Explain the advantages and disadvantages of applying each disinfection method to 1) water purification and 2) municipal wastewater treatment, respectively.

Q 2 When treating municipal wastewater biologically by the process shown in Fig. 1, answer the following questions.

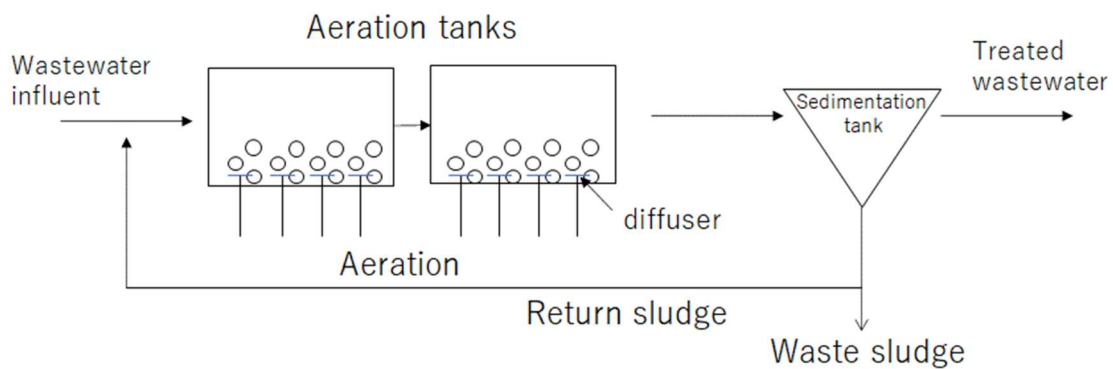


Figure 1. A schematic diagram of the municipal wastewater treatment process.

- (1) A modification was requested to improve the process shown in Fig. 1 without changing the number of aeration tanks and sedimentation tanks for the improved removal of nitrogen. Propose modification of the process by drawing a schematic diagram for the improvement and explain the reasons of modification.
- (2) When nitrogen in the municipal wastewater is removed by the modified process proposed in the question (1), show chemical reaction formulas of the conversion.

## B – 2 Hydraulics

Q.1 Explain the following terms concisely.

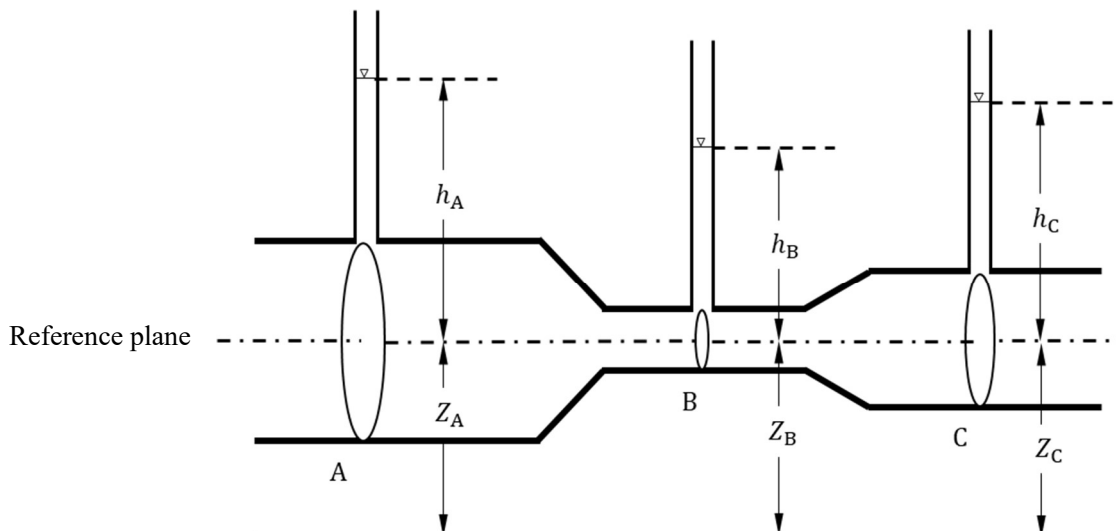
- 1) logarithmic distribution law
- 2) siphon
- 3) Darcy's law
- 4) Froude number

Q.2 Answer the following questions on flow in a rectangular open channel with a channel width  $B$ .

- 1) Express the specific force  $F$  in terms of flow rate  $Q$  and water depth  $h$ .
- 2) Assuming that the water depths of upstream and downstream of a hydraulic jump are  $h_1$  and  $h_2$ , respectively, express  $h_2$  using  $h_1$ .
- 3) Express the energy loss  $\Delta E$  in terms of  $h_1$  and  $h_2$ .

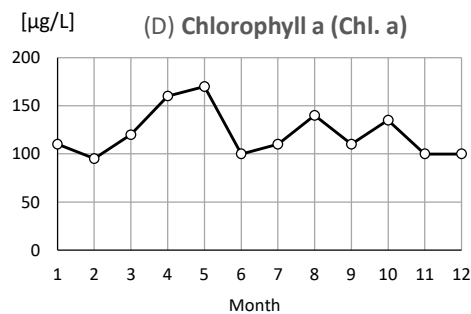
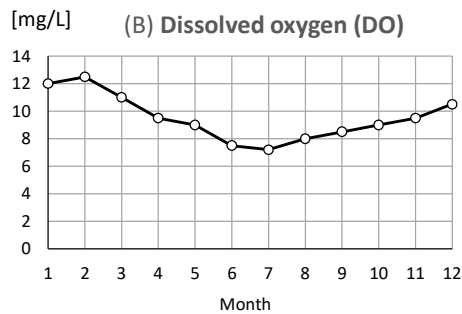
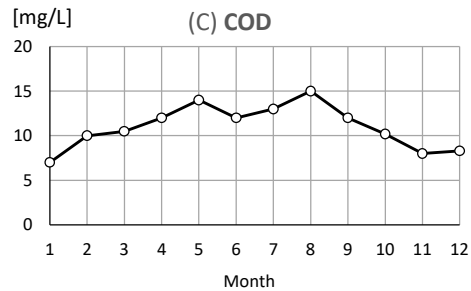
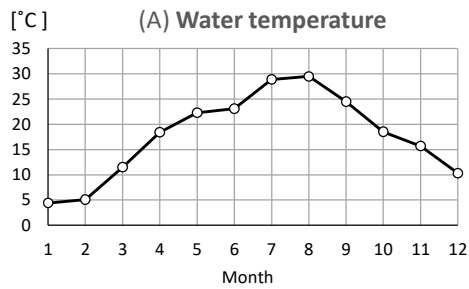
Q.3 Answer the following questions on flow in a circular pipe with constriction shown in the figure below. Pressure head in the pipe is measured by the height of the water column  $h$  from the reference plane in the narrow pipe built on top of the pipe. Here, water heads at cross-sections A, B, and C are  $Z_A, Z_B, Z_C$ , the flow rates are  $V_A, V_B, V_C$ , and the cross-sectional areas are  $A_A, A_B, A_C$  ( $A_A > A_C > A_B$ ). The loss factor of gradual expansion of the pipe is  $K_{ge}$ . The loss due to gradual contraction and frictional loss in the pipe are assumed to be negligible.

- 1) Express the total hydraulic head at the cross-section A.
- 2) Express the differences in the heights of the water columns between cross-sections A-B, cross-sections B-C, and cross-sections A-C without using  $h_A, h_B$  or  $h_C$ , respectively.
- 3) Express the flow rate in the pipe  $Q$  by a formula including  $K_{ge}$ .



## B—3 Water Environment

Q.1 Lake X is used as a water source for drinking water and agriculture use. The annual changes in items (A) to (D) in X are shown below. Answer the following questions (1) to (3).



- (1) Among the items (A), (C), and (D), select the most influential factor on the annual change in the item (B), and explain the reason.
- (2) Explain the meaning of measuring COD in lakes as a water quality index as shown in (C), referring to the difference in measurement principle from BOD.
- (3) Explain the following three points regarding the index shown in (D).
  - What does this index represent?
  - What kind of problems may occur when the value of this index is high?
  - What measures can be taken against the problems above?

Q.2 Assume that the following water quality items are measured in a shallow well used as a drinking water source. Explain the meanings for measuring each item and give possible causes when the values of each item are high.

- (1) Nitrate nitrogen
- (2) *Escherichia coli*
- (3) Electrical conductivity

## B – 4 Environmental Microbiology

Q.1 Concisely explain the following two terms, referring to the relation between the two terms.

- (1) Antibiotic agent, Horizontal gene transfer
- (2) Solids retention time in wastewater treatment, F/M ratio

Q.2 An experiment below, related to dissolved organic compounds and microbes in water, was conducted. Answer the following questions. Assume that the experiment was performed correctly, and random error can be excluded from the factors affecting the experimental results.

Experiment:

A water sample was taken from a river and filtrated to remove all the microbes present in the sample. Then, the sample was inoculated with strain A, a chemoorganoheterotroph and (a) a facultative anaerobe, and incubated under aerobic condition at an ambient temperature. During the incubation, (b) bacterial cell concentration was measured at a regular interval, which showed an increase over time and then stayed at (c) a constant concentration.

- (1) On underline (a), “facultative anaerobe” is a bacterium that acquires energy by aerobic  if oxygen is present, but does so by anaerobic  or  if oxygen is absent. Answer the terms for  and .
- (2) On underline (b), when measuring bacterial cell concentration in environmental waters, in general, direct total microbial counting methods using a microscope provide higher cell concentration values than plate counting methods using agar plates. Provide two reasons for this.
- (3) Bacterial cell concentration at underline (c) was  $1 \times 10^6$  cells/ml. From this result, estimate the amount of dissolved organic carbon (per 1 L) consumed by strain A during the incubation. Assume that the initial bacterial cell concentration is negligible compared to the one at the end of the incubation. Give appropriate values for parameters which are necessary in the calculation. Include the calculation process in the answer.
- (4) An identical experiment was conducted except that strain B was used for inoculation instead of strain A, which is similarly a chemoorganoheterotroph and a facultative anaerobe. The amount of dissolved organic carbon consumed by strain B was estimated from the bacterial cell concentration at the end of incubation. As a result, the estimated value was higher than that obtained with strain A. Provide one possible reason for this observation.

## B – 5 Environmental Chemistry and Reaction Kinetics

Q.1 Assume a degradation reaction of chemical A in wastewater in a complete mix reactor with volume  $V$  [L].

(1) The wastewater containing chemical A with the concentration of  $C_{in}$  [mg/L] continuously flows into the reactor at a flow rate of  $Q$  [L/s]. The steady state effluent concentration is  $C_{out}$  [mg/L] and the degradation rate is  $r$  [mg/(L·s)]. Express  $C_{out}$  using  $Q$ ,  $V$ ,  $C_{in}$  and  $r$ .

(2) Assume that the degradation follows a first-order reaction with its rate constant  $k$  [1/s]. Express  $r$  by an equation containing  $k$  and the symbols given in (1).

(3) Assume that the reactor is divided into 2 tanks with an equal volume of  $V/2$  [L] in series and the degradation follows the first-order reaction given in (2). Express the effluent concentration from the second tank  $C'_{out}$  [mg/L] in a mathematical formula.

Q.2 Answer the following questions with the derivation process.

(1) Calculate pH of 1.0 [mmol/L] sodium hydroxide aqueous solution, assuming that the water temperature is 25 °C.

(2) Assume that a poorly soluble chemical  $M_2A$  dissociates into  $M^+$  and  $A^{2-}$  when  $M_2A$  is dissolved. Express the solubility product of  $M_2A$  using its solubility  $s$  [mol/L].

Q.3 Explain the mechanism of ozone formation in the tropospheric air, referring to nitrogen oxides, volatile organic compounds and ultraviolet radiation.

## B— 6 Global Environment Engineering

The following statement is extracted from the Environmental White Paper (Environmental/ Recycle Oriented Society and Bio Diversity White Paper) by the Ministry of Environment Japan published in 2021. Answer the questions (1)-(2).

“Present world is endangered by the global scale environmental crisis such as climate change, ocean plastic waste, and bio-diversity deterioration as well as the growing crisis of pandemic by COVID-19. Those problems are inter-linked among each other and need to be considered as the pressing problems for all the living entity on the globe. “

--omission-- “Paris Agreement was enacted officially from 2020, pandemic expansion of COVID-19 provided enormous damage on Japan and all the countries in the world, which stopped and stagnated world socio-economic systems. Climate change and environmental deterioration are progressing even through the period that the world needs to take serious care of the pandemic, and to manage ①climate change problems, which is currently referred to as climate crisis, ②new actions toward the carbon neutral future in 2050 are now under movement.”

- (1) Related with the underlined ①, identify three climate change issues to become more explicit and serious in the society, economy and environment of Japan. Evaluate three issues by high/medium/low for the following points: the emergency, seriousness of impacts and certainty of expression, and explain the reasons for the evaluations.
- (2) Related with the underlined ②, cities are planning to integrate wide range of challenges. Describe 3 examples of specific technologies and policy options to realize a decarbonized city. Describe mechanisms for each technology and policy option to make contribution to realizing the decarbonized city.

## B – 7 Waste Management and Material Cycles

Japan aims at reducing the net greenhouse gas (GHG) emission to zero by 2050. For realizing the decarbonized society, GHG emissions from the waste category need to be reduced to zero. Based on the calculation method of the amounts of GHG emissions from the waste category in the National GHG Inventory of Japan (hereinafter, referred to as the calculation method), carbon dioxide (CO<sub>2</sub>) emissions from incineration and feedstock/energy utilization of municipal solid waste (MSW) are determined by the following formula. Answer the questions (1) and (2) in 10 to 15 lines, respectively, regarding reduction measures for the GHG emissions.

$$\sum_i (EF_i \times A_i) \times (1 - R) + \sum_i (EF_i \times A_i) \times R + EF_P \times \tilde{A}_P$$

$EF_i$  : CO<sub>2</sub> emission intensity of the composition  $i$  in MSW [kg-CO<sub>2</sub>/t (dry base)]

$A_i$  : Amount of incineration of the composition  $i$  in MSW [t (dry base)]

$R$  : Rate of MSW that is incinerated in MSW incinerators equipped with energy recovery

$EF_P$  : CO<sub>2</sub> emission intensity of plastic [kg-CO<sub>2</sub>/t (dry base)]

$\tilde{A}_P$  : Amount of feedstock/energy utilization (excluding material recycling) of plastic in MSW [t (dry base)]

- ✓ The formula presented in the calculation method is simplified and partly revised.
  - ✓ Plastic is one of the compositions  $i$  ( $P \in i$ ).
  - ✓ GHGs other than CO<sub>2</sub> due to waste incineration and landfilling, incineration of industrial waste, feedstock/energy utilization of waste tires, refuse-derived fuels, biological treatment, open burning, wastewater treatment, and others (surfactant) are omitted in this formula.
- (1) When we follow the above formula, what measures are there to approach the zero emission of CO<sub>2</sub> due to incineration and feedstock/energy utilization of MSW? a) Give an example of the measures, b) explain its outline, c) specify a coefficient or a variable to which it is relevant, and d) describe constraint(s) which can be obstacle(s) to its implementation.
- (2) For some measures of waste treatment and resource circulation that contribute to reduction in the national total GHG emissions, the effects are not reflected to the emission amount in the waste category when we follow the calculation method of Japan, while the reduction effects are reflected to the emission amounts in other categories. a) Give an example of the corresponding measures, b) explain its outline, and c) describe how it can reduce the GHG emissions in categories other than the waste category.



## B – 8 Urban Planning

Briefly answer to the following questions related to urban development projects.

- ( 1 ) Explain the difference between land readjustment project and urban redevelopment project.
- ( 2 ) Land readjustment projects and urban redevelopment projects will become difficult to be implemented in the era of shrinking population and economy. Explain the reason why.
- ( 3 ) What kind of urban development projects will be necessary in the era of shrinking population and economy? List up the issues on urban development projects and present requirements that the institutional framework of urban development projects should be equipped with to respond to those issues.
- ( 4 ) Pick up the case of urban redevelopment project and explain the characteristics of urban spaces shaped through the project.

## B – 9 Urban Design

Q.1 Explain the following terms in about 7 lines each, with regard to their practical example and their contribution to urban design.

- (1) Conservation of street façade
- (2) Color temperature of illumination
- (3) Atrium

Q.2 Answer the following questions regarding green infrastructure from urban design perspective.

- (1) Discuss in about 7 lines what kind of land use categories should be targeted to introduce green infrastructure effectively with its reason.
- (2) Describe in bullet points the elements that should be considered from design perspective in terms of the environment and landscape of the area where green infrastructure would be introduced.

## B — 1 0 Urban Housing

- Q.1 Explain the relationship between urban problems in the 19th century and the development of suburban residential areas in the early 20th century in Britain within 24 lines using the following terms: Public Health Act 1875, Model company towns, Garden Cities.
- Q.2 "3Ds" (Density, Diversity, Design) are known as environmental elements that encourage walking. Answer the following questions from the perspective of older adults living in suburban residential areas in Japan.
- (1) List two improvement measures for each of the "3Ds". (within 15 lines in total)
  - (2) What if you add one new element to the "3Ds"? Answer in one word, explain why you added it, and list two of its specific measures. The word does not have to start with "D". (within 9 lines in total)

## B — 1 1 Urban Disaster Management and Planning

Q.1 Explain the following terms from the viewpoint of urban disaster management and planning in about 2 lines each.

- (1) Landslide
- (2) Long Period Earthquake Ground Motions
- (3) Local Disaster Management Plan
- (4) Ignition by Firebrands

Q.2 Answer the following questions.

- (1) Explain respectively the meaning of “hazard”, “exposure” and “vulnerability” from the viewpoint of urban disaster management and planning, in about 2 lines each.
- (2) Provide three theoretically possible countermeasures against tsunami disaster and explain the details of these countermeasures and their issues, considering the interrelationship of the three terms (“hazard”, “exposure” and “vulnerability”).

## B – 1 2 Urban Analysis

Q. 1 Due to the epidemic of infectious diseases, it is important to maintain social distancing. Assuming that people can be represented by points and that we must secure a distance of 2m or more from others, we will consider the problem of how many people can be placed in a certain area at the maximum. In the following, it is assumed that the boundary of the area is included in the area. Answer the questions with reasons.

- (1) Find the maximum number of people that can be placed within the area of a circle with a radius of 2m.
- (2) Find the maximum number of people that can be placed in a square area with a side of 4m.
- (3) Find the maximum value of population density when the area is convex and large enough.

Q. 2 In recent years, attention has been focused on the fact that a large amount of digital data can be used as urban activity data. Among them, it is expected that information on when and where an individual is (hereafter referred to as personal spatiotemporal information), which is provided by GPS-equipped mobile phones, can be used in various ways.

Answer the following questions about this.

- (1) Describe what kind of new merits can be obtained by utilizing personal spatiotemporal information assuming specific usage scenes.
- (2) Describe ethical precautions when handling personal spatiotemporal information.
- (3) There are errors in personal spatiotemporal information. Discuss statistical methods to deal with that error.

## B – 1 3 Urban Transportation Planning

Q.1 The estimated parameters of a disaggregate binary logit model of travel mode choice between train and car are presented in the table below. Using these results, answer the following questions.

Variable	Coefficient	Standard error
Train constant	0	-
Car constant	-0.25	0.12
Travel cost (JPY)	-0.0006	0.00003
Travel time (min)	-0.013	0.004

- (1) What is the name of the method generally used to estimate disaggregate logit models? Explain this method briefly.
- (2) The coefficient of the train constant is 0. Explain why this is so.
- (3) Calculate the value of travel time. Report your results up to the second decimal.
- (4) Given the following values, calculate the car choice probability. Report your results up to the second decimal.

Train travel cost: JPY 180

Train travel time: 25 min

Car travel cost: JPY 120

Car travel time: 30 min

Hint : For this question, you can approximate  $\exp x$  using the following equation:

$$\exp x = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!}$$

Q.2 In recent years, Mobility as a Service (MaaS) has been gathering attention. Answer the following questions regarding MaaS.

- (1) Briefly explain the concept of MaaS. (Answer within 9 lines in total)
- (2) Name 3 important MaaS stakeholders and briefly explain some of the merits of MaaS for each stakeholder (Answer within 15 lines in total)
- (3) Name 3 barriers to implementation of MaaS, and briefly explain each one. (Answer within 15 lines in total)

## B – 1 4 Regional Planning

In Japan, an excessive concentration to Tokyo is advancing and thus economic vitalization in non-metropolitan areas is an important issue. There are following three policy measures for economic vitalization in non-metropolitan areas.

- (1) Attracting investment (e.g., factories) from the outside
- (2) Strengthening of local industrial clusters and promoting the collaborations of various local actors (e.g., collaboration between private companies and universities)
- (3) Attracting human resources through the efforts to improve urban amenity and spread information on the unique attractiveness of the area, etc.

Explain (a) advantages and (b) disadvantages of the above three policy measures for economic vitalization in non-metropolitan areas from multiple viewpoints.

## B — 1 5 Landscape Planning and Environmental Design

Roles, as well as conservation and development concepts, of urban parks, open spaces, and farmlands in and around large cities are in the process of a major change due to (1) DX (Digital Transformation), (2) climate change and natural disasters, and (3) spread of infectious diseases. Take (a) urban parks and open spaces and (b) farmlands in the suburb of large cities, and discuss your thoughts on their future roles, as well as conservation and development concepts from three perspectives as mentioned above; (1), (2), and (3) (within 45 lines in total).