

2025 年度日本政府(文部科学省)奨学金留学生選考試験

QUALIFYING EXAMINATION FOR APPLICANTS FOR THE JAPANESE
GOVERNMENT (MEXT) SCHOLARSHIP 2025

学科試験 問題

EXAMINATION QUESTIONS

(学部留学生)

UNDERGRADUATE STUDENTS

化 学

CHEMISTRY

注意 ☆試験時間は 60 分。

NOTE: THE TEST PERIOD IS 60 MINUTES.

CHEMISTRY	Nationality		No.		Marks	
	Name	(Please print full name, underlining family name)				

I Select one correct answer and write the corresponding option number.

(1) Which of the following ions 1) to 4) has the same electron configuration as Ar atom?

- 1) F^- 2) Na^+ 3) Al^{3+} 4) S^{2-}

(2) Which of the underlined atoms in the following molecules 1) to 4) has no lone pairs of electrons?

- 1) $\underline{C}O_2$ 2) $\underline{N}H_3$ 3) $H_2\underline{O}$ 4) $H\underline{C}l$

(3) Which of the following substances 1) to 4) has the lowest pH when dissolved in water?

- 1) Na_2CO_3 2) NH_4Cl 3) CH_3COONa 4) $CaCl_2$

(4) Which of the following substances 1) to 4) has the lowest melting point?

- 1) Mg 2) Si 3) Zn 4) Hg

(5) Which of the following descriptions 1) to 4) is false for tin?

- 1) Sn can exhibit two oxidation numbers, +2 and +4.
- 2) Sn is converted to SnO_2 when heated in air.
- 3) Sn is dissolved in acid to generate H_2 .
- 4) Sn is not dissolved in a strong base.

(6) Which of the following operations 1) to 4) produces hydrogen halide?

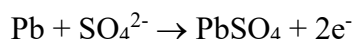
- 1) Addition of concentrated sulfuric acid to calcium fluoride and subsequent heating.
- 2) Blowing chlorine into aqueous solution of sodium hydroxide.
- 3) Blowing chlorine into aqueous solution of potassium bromide.
- 4) Blowing ozone into aqueous solution of potassium iodide.

(7) Which of the following descriptions 1) to 4) is correct for complex ions?

- 1) $[\text{Ag}(\text{NH}_3)_2]^+$ has an angular shape.
- 2) $[\text{Cu}(\text{NH}_3)_4]^{2+}$ has a tetrahedral shape.
- 3) Aqueous solution of $[\text{Zn}(\text{NH}_3)_4]^{2+}$ is colorless.
- 4) The oxidation number of Fe in $[\text{Fe}(\text{CN})_6]^{3-}$ is +2.

II Fill (a) to (e) in the following statements with the appropriate values. Answer the values to two significant figures for the calculation results of (a) and (e). Show the chemical equation appropriate to (A). Use the following values if necessary; $\sqrt{3} = 1.73$ and the atomic weights of O and S are 16 and 32, respectively.

(1) In the discharge process of lead-acid battery, the electrochemical reaction which occurs at the anode is as follows:



On the other hand, the following electrochemical reaction occurs at the cathode:

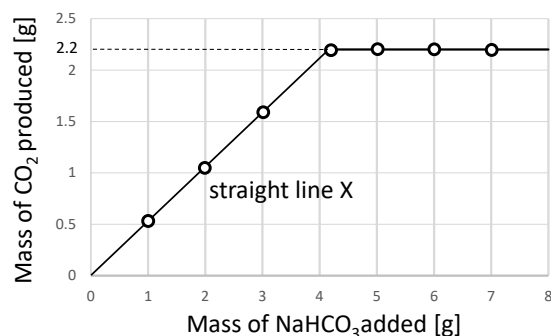


Suppose 1.0 mol of electron flows in the discharge process, the anode gains a mass of (a) g.

(2) Consider the unit cell of a crystal composed of one type of atom. The number of atoms included in the unit cell of simple, body-centered, and face-centered cubic lattice is (b), (c), and (d), respectively. Potassium crystallizes in the body-centered cubic structure under ambient temperature and pressure. The edge length of the unit cell of potassium is 0.523 nm. Suppose the nearest-neighboring potassium atoms are in contact with each other in the crystal structure, the atomic radius of potassium is (e) nm.

III Answer the following questions about a chemical reaction. Use the following values if necessary: the atomic weights of H, C, O, Na and Cl are 1.0, 12, 16, 23, and 35.5, respectively.

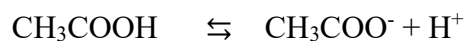
CO₂ was produced when NaHCO₃ was gradually added to 100 mL hydrochloric acid. The following graph shows the relationship between the mass of CO₂ produced and the mass of NaHCO₃ added.



- (1) Give the chemical reaction equation for the above reaction.
- (2) When the concentration of hydrochloric acid is doubled, the maximum mass of CO₂ produced [A: halves, B: doubles, C: remains unchanged]. Choose the appropriate words in brackets and answer with A, B, or C.
- (3) When the concentration of hydrochloric acid is doubled, the slope of the straight line X in the figure [A: halves; B: doubles; C: remains unchanged]. Choose the appropriate words in brackets and answer with A, B, or C.
- (4) The slope of the straight line X in the figure is equal to the ratio of the [A: formula weight, B: molecular weight, C: volume, D: amount (mol)] of CO₂ to [E: formula weight, F: molecular weight, G: volume, H: amount (mol)] of NaHCO₃. Choose the appropriate words in brackets and answer with A, B, C, or D and E, F, G, or H.
- (5) Find the concentration (mol/L) of hydrochloric acid used in this experiment to one significant figure.

IV Answer the following questions regarding neutralization and the electrolytic dissociation of electrolytes in water.

- (1) There are hydrochloric acid (solution A) and sodium hydroxide aqueous solution (solution B) of unknown concentration. When 10 mL of 0.1 mol/L oxalic acid (COOH)₂ solution was neutralized and titrated with solution B, 10 mL of solution B was needed. Also, 20 mL of solution B was needed to neutralize 10 mL of solution A. Find the concentrations (mol/L) of the solutions A and B to one significant figure.
- (2) When acetic acid is dissolved in water, it electrolytically dissociates partially as in the following chemical equation, resulting in an equilibrium state of electrolytic dissociation.



- (2-1) In an aqueous acetic acid solution of concentration C (mol/L), let α be the degree of electrolytic dissociation of acetic acid. Find the concentration (mol/L) of acetic acid (CH₃COOH), and its ions (CH₃COO⁻ and H⁺) using the concentration of aqueous acetic acid solution C and the degree of electrolytic dissociation α in an equilibrium state of electrolytic dissociation, respectively.
- (2-2) Find an expression of the dissociation constant K of acetic acid using C and α .
Also, find an approximate expression of K of acetic acid when the degree of electrolytic dissociation α is well below 1.
- (2-3) When the dissociation constant of acetic acid is 2.5×10^{-5} mol/L, find the proton concentration and pH of a 0.01 mol/L acetic acid solution to one significant figure and two significant figures, respectively. You may also assume that the degree of the electrolytic dissociation α is well below 1. Given: $\log_{10} 2 = 0.3$.

V Answer the following questions about organic compounds. Use the following values if necessary: the atomic weights of C, O, H, and N are 12, 16, 1.0, and 14, respectively.

(1) For the following descriptions 1) to 5) regarding alkanes and alkenes, select one correct combination among options ① to ⑥.

- 1) An alkane with one carbon atom is gaseous at normal temperature and normal pressure.
- 2) An alkene with two carbon atoms does not have cis-trans isomers.
- 3) An alkane with four carbon atoms has three structural isomers.
- 4) Alkane has a larger proportion of hydrogen atoms in the molecule than alkene which has the same number of carbon atoms as the alkane.
- 5) Complete combustion of 1 mol of alkane produces 2 mol more water than carbon dioxide.

① 1), 3) ② 2), 3), 5) ③ 1), 2), 4) ④ 3), 4) ⑤ 2), 4), 5) ⑥ 3), 5)

(2) For the following descriptions 1) to 5) regarding structure of organic compounds, select one correct combination among options ① to ⑥.

- 1) The distance between carbon atoms increases in the order of ethane, ethylene, acetylene.
- 2) The bond between the carbon atoms of ethane can rotate around the bond.
- 3) The bond between the carbon atoms of ethylene cannot rotate around the bond.
- 4) In ethylene, all atoms are collinear.
- 5) In cyclohexane, all carbon atoms are coplanar.

① 1), 2) ② 1), 3) ③ 1), 5) ④ 2), 3) ⑤ 2), 4) ⑥ 3), 5)

(3) Acid-catalyzed hydrolysis of 1 mol of an ester with the molecular formula $C_{10}H_{16}O_4$ yielded 1 mol of compound **X** and 2 mol of compound **Y**. Cis-trans isomers exist for **X**. Also, when **X** was heated, a dehydration reaction occurred, and a compound **Z** with a molecular formula $C_4H_2O_3$ was obtained. **Y** is an alcohol which is oxidized to acetone.

(3-1) Write the molecular formula of **X**.

(3-2) Select one correct description about **X** among options 1) to 5) below.

- 1) **X** is a dicarboxylic acid.
- 2) **X** is a trans isomer.
- 3) When hydrogen is added to the double bond between carbon atoms of **X** (1 mol), a maximum

of 2 mol of hydrogen is added.

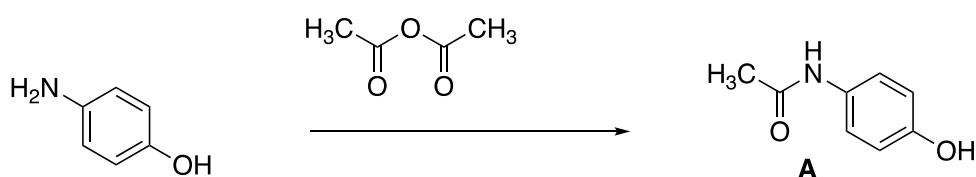
4) **X** does not react with sodium (Na).

5) **X** is an ester.

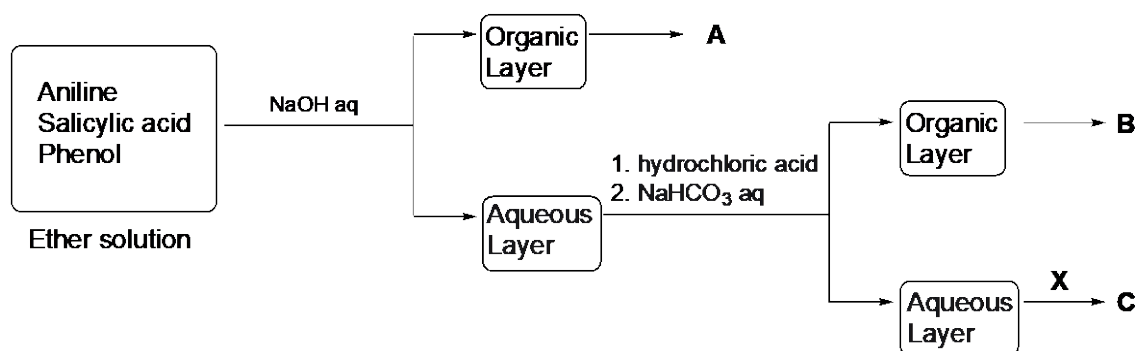
(3-3) How many structural isomers of **Y** exist, including **Y** itself?

(3-4) **Z** is a cyclic compound. How many atoms are there in the ring?

(4) Synthesis of compound **A** is planned by the following scheme. Find the minimum mass (g) of hydroxyaniline required to obtain 300 g of compound **A** to three significant figures.



(5) There is an ether solution of a mixture of aniline, salicylic acid and phenol. The components were separated by the operations shown in the following scheme.



(5-1) Select the most suitable reagent for **X** among options 1) to 4).

- 1) Hot water
- 2) Sodium hydroxide aqueous solution
- 3) Sodium chloride
- 4) Hydrochloric acid

(5-2) Select the correct combination of **A**, **B**, and **C** among options 1) to 6).

	A	B	C
1)	Salicylic acid	Aniline	Phenol
2)	Salicylic acid	Phenol	Aniline
3)	Aniline	Salicylic acid	Phenol
4)	Aniline	Phenol	Salicylic acid
5)	Phenol	Salicylic acid	Aniline
6)	Phenol	Aniline	Salicylic acid

(6) Select one incorrect description of polymers among options 1) to 5).

- 1) Polyvinyl chloride is produced by addition polymerization of vinyl chloride.
- 2) Polyvinyl chloride has C-Cl bonds.
- 3) Polyethylene has carbon-carbon double bonds.
- 4) Nylon 66 (6,6-nylon) is produced by condensation polymerization of adipic acid and hexamethylenediamine.
- 5) Nylon 66 has C-N bonds.

(7) Glycine is an amino acid with the molecular formula $C_2H_5NO_2$.

(7-1) Write the molecular formula of a chain peptide **A** obtained by dehydration condensation of 4 molecules of glycine.

(7-2) What is the mass percentage of nitrogen contained in this peptide **A**? Answer in three significant digits.