

2023 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 2023

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**。

PLEASE NOTE: THE TEST PERIOD IS **60 MINUTES**.

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

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

(1) Which of the following elements 1) to 4) has no allotropes?

- 1) C 2) O 3) Ne 4) P

(2) Which of the following atoms 1) to 4) has the highest electron affinity?

- 1) Na 2) Al 3) Si 4) Cl

(3) Which of the following molecules 1) to 4) is nonpolar?

- 1) HF 2) H₂S 3) CCl₄ 4) NH₃

(4) Which of the following substances 1) to 4) is a solid under atmospheric pressure at 25 °C?

- 1) S₈ 2) Ar 3) Br₂ 4) Hg

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

- 1) NO is generated when silver is dissolved into concentrated nitric acid solution.
- 2) SO₂ is generated when silver is dissolved into hot concentrated sulfuric acid solution.
- 3) Addition of sodium chloride aqueous solution into an aqueous solution of Ag⁺ leads to the precipitation of AgCl.
- 4) Addition of sodium hydroxide aqueous solution into an aqueous solution of Ag⁺ leads to the precipitation of Ag₂O.

(6) Which of the following reactions described in 1) to 4) is not accompanied by the generation of gas?

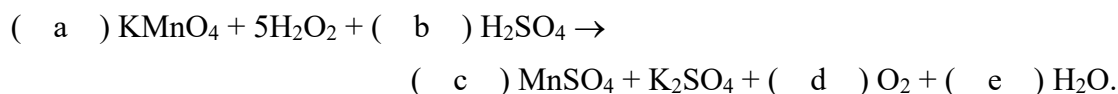
- 1) Adding concentrated nitric acid solution to iron.
- 2) Adding concentrated sulfuric acid solution to sodium chloride.
- 3) Adding sodium hydroxide aqueous solution to zinc.
- 3) Heating copper (II) oxide above 1000°C.

(7) Which of the following descriptions 1) to 4) is true for metallic crystals?

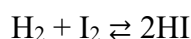
- 1) Most metallic crystals have low thermal conductivity.
- 2) Most metallic crystals are volatile.
- 3) The van der Waals interaction is predominant in a metallic bond.
- 4) Metallic crystals are ductile and malleable.

II Fill (a) to (g) in the following statements with the appropriate values. Answer the values to two significant figures for the calculation results of (f) and (g).

(1) The reaction of potassium permanganate with hydrogen peroxide in a sulfuric acid aqueous solution is written as follows:



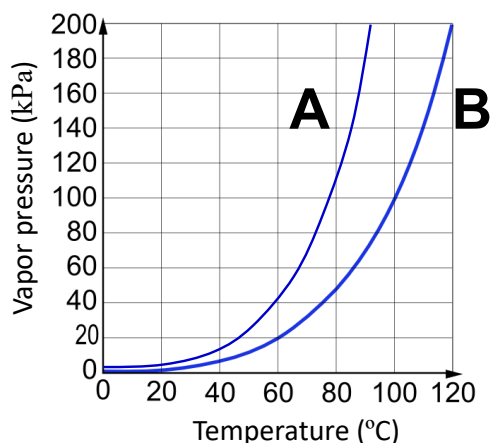
(2) In a sealed vessel, 4.0 mol of hydrogen and 4.0 mol of iodine, both in a gaseous state, were kept at a constant temperature for long enough to reach an equilibrium according to the following reaction:



The hydrogen iodide formed by the reaction was also in a gaseous state. The equilibrium constant was 25 at the reaction temperature. In equilibrium, the amounts of hydrogen and hydrogen iodide were (f) mol and (g) mol, respectively.

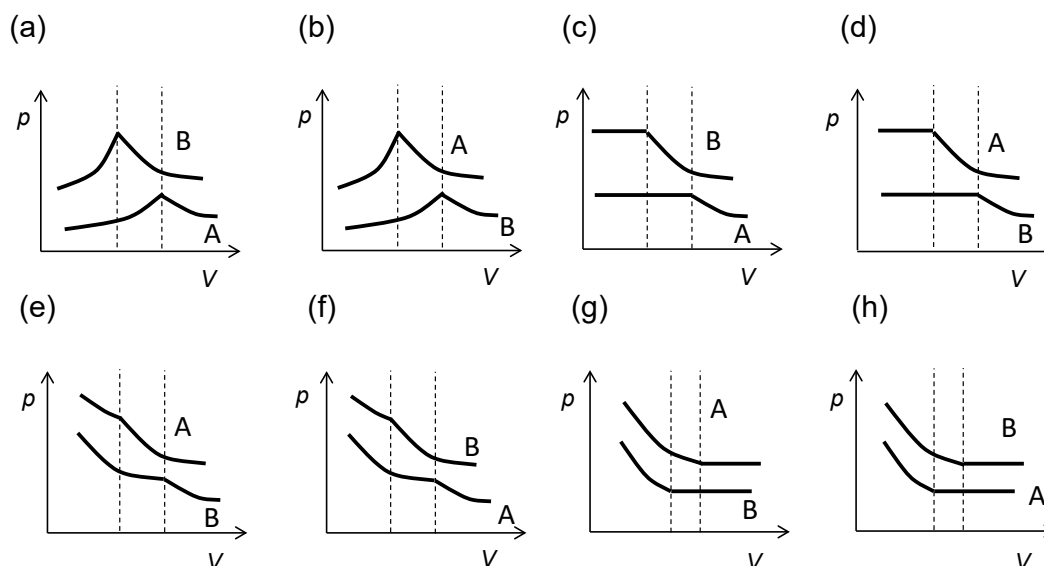
III Answer the following questions about saturation pressure.

The figure below shows the vapor pressure curves of molecules A and B. The saturation pressures of molecule B at 60°C and 100°C are 20 kPa and 101 kPa, respectively. Even if liquefied components appear due to the operations in each question, their volumes can be ignored.

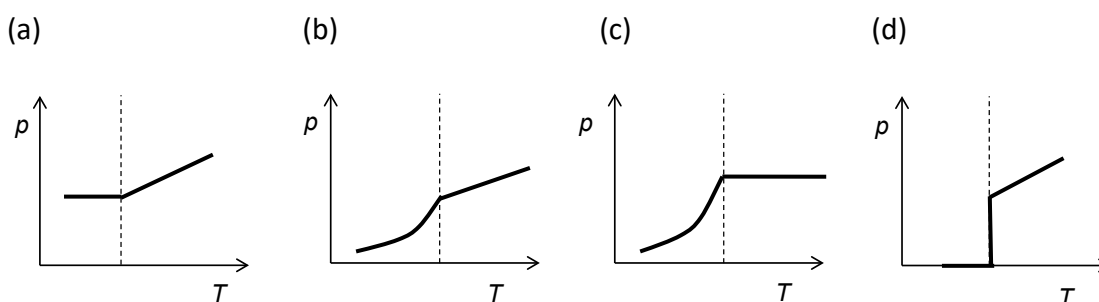


- (1) When molecule B was added at 60°C into a volume-variable vacuum vessel X with a frictionless piston, molecule B was vaporized entirely. Afterwards, the volume of the vessel was reduced while maintaining the temperature at 60°C. Molecule B started to condense when the volume of the vessel reached 80 ml. The amount of molecule B is $\frac{x}{333R}$ mol. Find the value of x to two significant figures. R [kPa L/ K mol] is the gas constant.

- (2) When molecules A and B were added separately into two variable-volume vacuum vessels X at a certain temperature, molecules A and B were vaporized entirely. Afterwards, the volumes of the vessels were reduced while maintaining the initial temperature. Which of graphs (a) to (h) below shows the relation between the volume (V) of the vessel and pressure (p) of each molecule in this process?



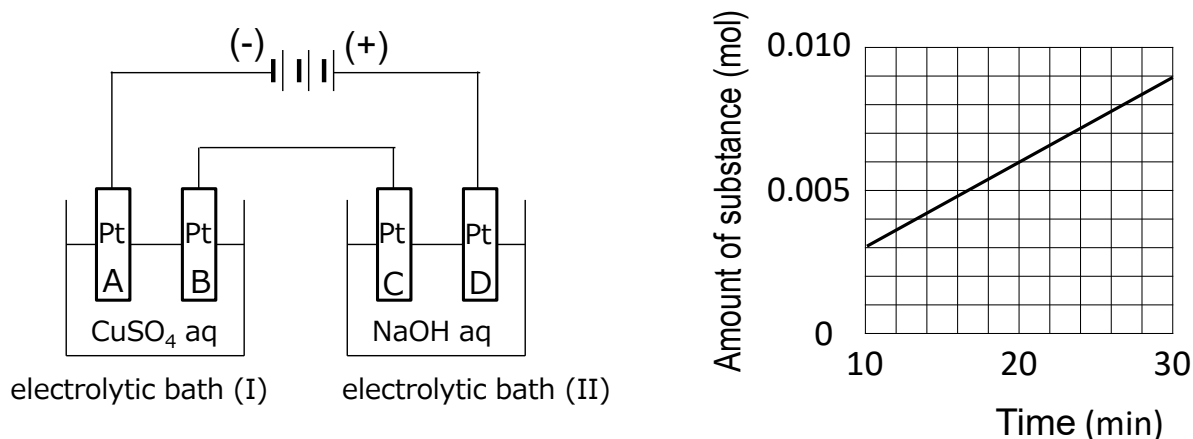
- (3) When molecule A was added at a certain temperature into a vacuum vessel X, molecule A was vaporized entirely. Afterwards, the temperature of the vessel was lowered while maintaining the initial volume. Which of graphs (a) to (d) in the figure below shows the relation between temperature (T) of the vessel and pressure (p) of molecule A in this process?



- (4) When molecule B and He gas were added at 60°C into a volume-variable vacuum vessel X, the total pressure was 120 kPa in the presence of liquid B. Afterwards, when the temperature of the vessel was raised to 100°C while maintaining the initial volume, liquid was still remained. Find the total pressure in the vessel at 100°C to three significant figures.

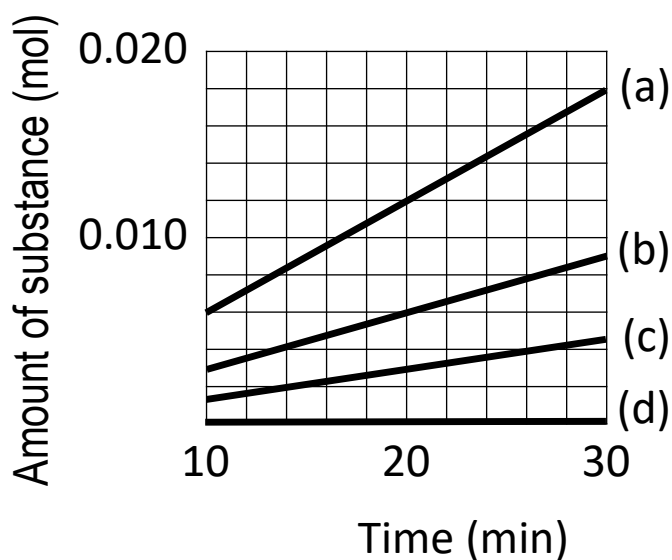
IV Answer the following questions on electrolysis.

The apparatus for electrolysis is shown on the left below. Copper (II) sulfate aqueous solution is in electrolytic bath I and sodium hydroxide aqueous solution is in electrolytic bath II. All electrodes are platinum. The current was applied at 0.965 A for 30 min under constant current conditions. The amount of substance deposited on electrode A with time is shown in the right-hand-side figure below.



- (1) Show the chemical equation of the reaction that occurred at electrode A.
- (2) Find the electric charge [C] required for the deposition of 5.00×10^{-3} mol of the substance on electrode A to three significant figures. The Faraday constant is 96500 C/mol.
- (3) Choose the appropriate graph from (a) to (d) in the figure below that shows the relation of the amount of gas or solid produced on electrodes B and C with time. If no gas or solid is produced, choose graph (d).

- (3-1) Gas produced on electrode B
- (3-2) Gas produced on electrode C
- (3-2) Solid produced on electrode C



V Answer the following questions about organic compounds. Use the following values if necessary: the atomic weights of C, O, H, and Br are 12, 16, 1.0, and 80, respectively.

(1) There is a compound with chemical formula $C_8H_nO_2$. When 51 mg of the compound was combusted completely with dry oxygen, 27 mg of H_2O was generated. What is the number n of hydrogen in the chemical formula?

(2) Hydrolysis of an ester having a molecular formula of $C_5H_{10}O_2$ gave a carboxylic acid with a reducing ability and an alcohol. Select the molecular formula of the alcohol obtained here from 1) - 5). Next, how many structural isomers does the alcohol have?

1) CH_3OH 2) C_2H_5OH 3) C_3H_7OH 4) C_4H_9OH 5) $C_5H_{11}OH$

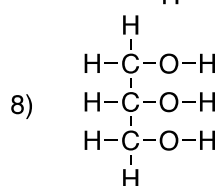
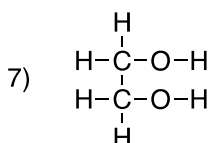
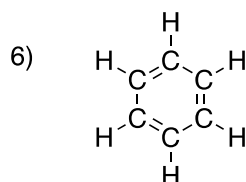
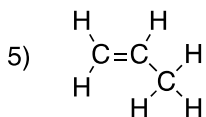
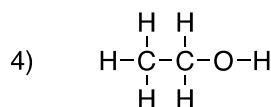
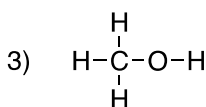
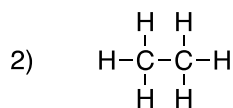
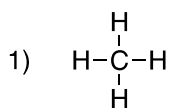
(3) Select the most appropriate chemical structure of the organic compound applicable to the following compounds **A**, **B**, **C**, and **D** among the options 1) to 8). The same one may be selected repeatedly.

A is a substance produced by the fermentation of starch and is contained in alcoholic beverages.

The polymer produced by the addition polymerization of **B** is used for tableware and plastic films.

C gives ethylene when heated at 160-170 °C in concentrated sulfuric acid solution.

D is an alcohol produced from carbon monoxide and hydrogen as raw materials in the presence of a catalyst.



(4) Ethyl acetate can be synthesized from acetic acid and ethanol using a concentrated sulfuric acid solution as catalyst. When 150 g of acetic acid and 460 g of ethanol were reacted, 132 g of ethyl acetate was obtained. What percentage of acetic acid was converted to ethyl acetate? Calculate the percentage to two significant figures.

(5) The addition of aqueous iron (III) chloride solution to an aromatic compound with a molecular weight of 94 resulted in a purple color reaction. Substitution reaction occurred when a sufficient amount of bromine water was added to this compound. Select the suitable value of the molecular weight of the obtained compound among options 1) to 5).

1) 173 2) 252 3) 331 4) 411 5) 490

(6) Select one incorrect description about fats and oils and soap among options 1) to 5).

- 1) When cooking oil was added to soapy water and stirred vigorously, it was emulsified.
- 2) When soap was dissolved in water, the resulting aqueous solution showed weak acidity.
- 3) When an aqueous solution of calcium chloride was added to soapy water, precipitation occurred.
- 4) When hydrogen was added in the presence of catalysts to fats and oils that were liquid at room

temperature and contained a large amount of components consisted of unsaturated fatty acids, the melting point increased and they became solid at room temperature.

5) When a sufficient amount of aqueous sodium hydroxide solution was added to fats and oils and the mixture was heated, glycerol and sodium salts of fatty acids were produced.

(7) Select all incorrect descriptions about organic compounds among options 1) to 5).

- 1) Maleic acid and fumaric acid have the relationship as cis-trans isomers.
- 2) Phthalic acid and fumaric acid have the relationship as structural isomers.
- 3) 2-Butene has cis-trans isomers (geometric isomers).
- 4) Lactic acid has enantiomers.
- 5) 2-Propanol has enantiomers.

(8) Select one correct structural formula of nylon 66 (nylon 6,6) among options 1) to 6).

