

2019 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 2019

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

(2019)

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

I Write the reference number of the correct answer.

(1) Which nucleus of the atoms 1) to 4) has just one neutron?

- 1) ^1H 2) ^4He 3) ^6Li 4) ^5Be

(2) Which of the atoms 1) to 4) has the smallest atomic radius?

- 1) Si 2) Ge 3) Sn 4) Pb

(3) Which of the underlined atoms in the molecules 1) to 4) has just one lone pair of electrons?

- 1) $\underline{\text{B}}\text{F}_3$ 2) $\underline{\text{C}}\text{O}_2$ 3) $\underline{\text{N}}\text{H}_3$ 4) $\text{H}\underline{\text{F}}$

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

- 1) He 2) N_2 3) O_2 4) Kr

(5) Which of the descriptions 1) to 4) is correct for copper and zinc?

- 1) Both form divalent cation.
- 2) Both dissolve in hydrochloric acid.
- 3) Both sulfides dissolve in concentrated hydrochloric acid.
- 4) Copper is more easily oxidized than zinc.

(6) Which of reactions described in 1) to 4) is an oxidation-reduction reaction?

- 1) $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$
- 2) $\text{P}_4\text{O}_{10} + 6\text{H}_2\text{O} \rightarrow 4\text{H}_3\text{PO}_4$
- 3) $\text{Al}(\text{OH})_3 + \text{NaOH} \rightarrow \text{Na}[\text{Al}(\text{OH})_4]$
- 4) $\text{I}_2 + 2\text{Na}_2\text{S}_2\text{O}_3 \rightarrow 2\text{NaI} + \text{Na}_2\text{S}_4\text{O}_6$

(7) Which of the descriptions 1) to 4) is not correct to describe a phenomenon that can be observed when a catalyst is introduced in a chemical reaction?

- 1) The activation energy of a chemical reaction with a catalyst is lower than that of a chemical reaction without a catalyst.
- 2) The heat of reaction of a chemical reaction with a catalyst is lower than that of a reaction without a catalyst.
- 3) The rate of forward reaction of a chemical reaction with a catalyst is higher than that of a reaction without a catalyst.
- 4) The rate of reverse reaction of a chemical reaction with a catalyst is higher than that of a reaction without a catalyst.

II Give the appropriate chemical formulas for (a) to (d) in the sentences below.

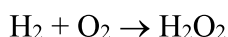
Dissolution of metallic silver $\text{Ag}(0)$ into dilute and concentrated nitric acid solutions generates (a) and (b) gases, respectively. Addition of aqueous ammonia into an aqueous solution of silver nitrate generates (c) as a black precipitate, and further addition of excess aqueous ammonia causes (c) to disappear. In the resultant aqueous solution, (d) is present as a cation.

- III Calculate the values appropriate to (a) and (b) in the paragraph below to two significant figures. Use the following values if necessary; the atomic weights of Ne and Ar are 20 and 40, respectively, and the gas constant is $8.3 \times 10^3 \text{ Pa L mol}^{-1} \text{ K}^{-1}$.

There is a mixture of gaseous neon and argon in a sealed vessel, the volume of which is 2.0 L at 300 K. The masses of neon and argon in the vessel are 1.0 g and 4.0 g, respectively. The molar fraction of neon is (a), and the partial pressure of argon is (b) MPa. Here, it is assumed that both neon and argon are ideal gases and that they do not react with each other.

- IV Fill (a) to (d) in the sentences below with appropriate values. Calculate the values to three significant figures for (a), (b), and (d). Use the following value if necessary; $\sqrt{3} = 1.73$.

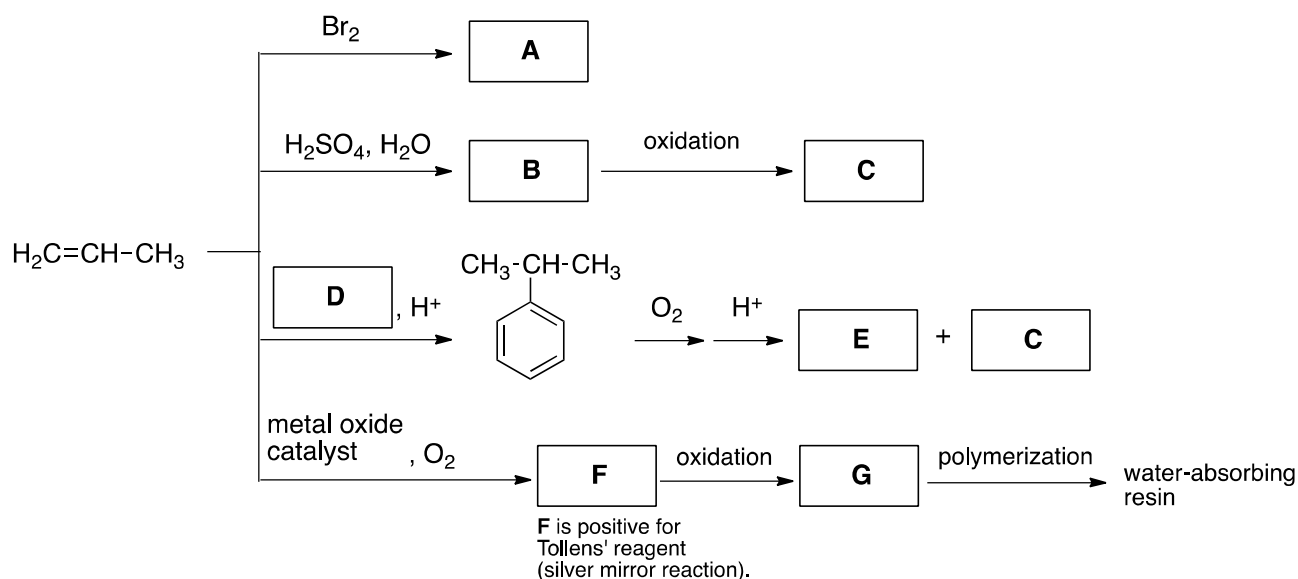
(1) The dissociation energies of H_2 and O_2 are 436 kJ mol^{-1} and 498 kJ mol^{-1} , respectively, and the bond energy of O–H bond is 463 kJ mol^{-1} . The heat of vaporization for water (liquid) is 44.0 kJ mol^{-1} . Therefore, the heat of formation for water (liquid) is (a) kJ mol^{-1} . Furthermore, hydrogen reacts with oxygen to form gaseous hydrogen peroxide as follows:



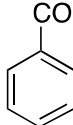
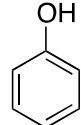
In the above reaction, 142 kJ mol^{-1} is released as heat. Hence, the bond energy of O–O bond in the hydrogen peroxide molecule is (b) kJ mol^{-1} .

(2) In ionic crystals with 1:1 ratio of cations and anions, there are two representative types of crystal structure, NaCl and CsCl types. In NaCl crystals, the number of nearest-neighboring Cl^- ions surrounding one Na^+ ion is 6. On the other hand, in CsCl crystals, the number of nearest-neighboring Cl^- ions surrounding one Cs^+ ion is (c). The ionic radius of Cl^- ion is 0.167 nm, and the edge length of a cubic unit cell of CsCl is 0.412 nm. Therefore, the ionic radius of Cs^+ ion is (d) nm.

V Outlined here are the synthetic processes of organic compounds using propylene as a starting material.



(1) Select the appropriate structural formulas for the compounds **A** to **G** from options 1) to 20).

- 1) $\text{CH}_3\text{CH}_2\text{Cl}$ 2) HCHO 3) $\text{CH}_3\text{CH}_2\text{OH}$ 4) $\text{H}_2\text{C}(\text{Br})-\text{CH}(\text{Br})-\text{CH}_3$ 5) $\text{H}_2\text{C}(\text{Br})-\text{CH}(\text{OH})-\text{CH}_3$
- 6) CH_3CHO 7) CH_3COOH 8) $\text{CH}_2=\text{CHCH}_2\text{CH}_3$ 9) $\text{H}_2\text{C}=\text{CH}-\text{C}(=\text{O})-\text{H}$ 10) $\text{H}_3\text{C}-\text{CH}(\text{OH})-\text{CH}_3$
- 11) $\text{H}_2\text{C}=\text{CH}-\text{C}(=\text{O})-\text{OH}$ 12) $\text{H}_3\text{C}-\text{C}(=\text{O})-\text{CH}_3$ 13) $\text{CH}_3-\text{C}(=\text{O})-\text{CH}_2\text{CH}_3$ 14) $\text{CH}_3-\text{CH}(\text{OH})-\text{CH}_2\text{CH}_3$
- 15) CO_2 16) H_2 17) N_2 18)  19)  20) 

(2) Select the appropriate compound that is obtained as an equimolar mixture of enantiomers from **A** to **G**.

(3) Which of pure compounds from **A** to **G** dissolved in diethyl ether give rise to H_2 when mixed with Na? Select all appropriate ones.

(4) Compound **E** produces an industrially important thermosetting resin by condensation polymerization with a compound. Select the appropriate compound from options 1) to 20).

VI Answer the following questions about separation of the four compounds described below.

- 1) benzoic acid 2) phenol 3) aniline 4) nitrobenzene

(1) Compounds 1) to 4) are dissolved in ether. After addition of dilute hydrochloric acid to the ether solution, the mixture is shaken and left for a while to give two layers, ether layer A and aqueous layer B. The separated aqueous layer B is mixed with ether and NaOH. After shaking the mixture, two layers (ether and aqueous layers) are observed. Which of the compounds 1) to 4) is included in the final ether layer?

(2) An aqueous solution of NaHCO_3 is added to ether layer A. The mixture is shaken and left for a while to give two layers, ether layer C and aqueous layer D. The separated aqueous layer D is mixed with ether and dilute hydrochloric acid. After shaking the mixture, two layers (ether and aqueous layers) are observed. Which of the compounds 1) to 4) is included in the final ether layer?

(3) An aqueous solution of NaOH is added to ether layer C. The mixture is shaken and left for a while to give two layers, ether layer E and aqueous layer F. The separated aqueous layer F is mixed with ether and dilute hydrochloric acid. After shaking the mixture, two layers (ether and aqueous layers) are observed. Which of the compounds 1) to 4) is included in the final ether layer?

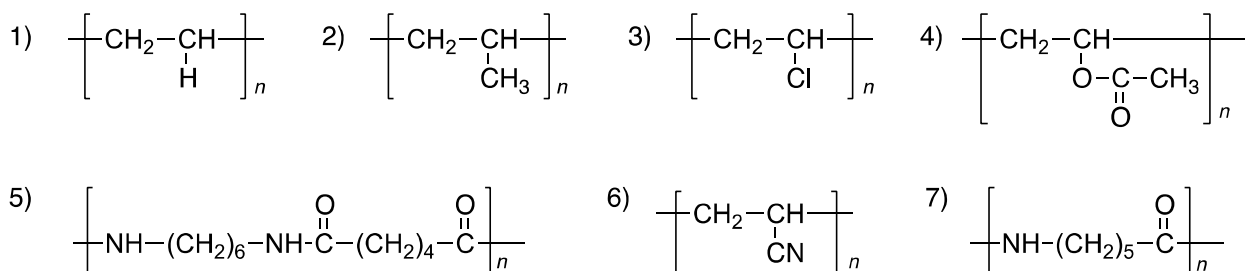
(4) Which of the compounds 1) to 4) is included in the ether layer E?

(5) Which of the compounds 1) to 4) shows the strongest acidity?

(6) Compounds **X** and **Y** are among compounds 1) to 4). Compound **X** gives **Y** by reduction using Sn. What are compounds **X** and **Y**?

VII Answer the following questions about polymers, proteins, and amino acids. Use the following values if necessary; the atomic weights of C, N, O, and H are 12.0, 14.0, 16.0, and 1.00, respectively.

(1) The polymerization reaction of 219 g hexamethylene diamine with 219 g adipic acid gives a polymer. Select the structure of the polymer from 1) to 7).



(2) If the reaction described in (1) proceeds completely, how many grams of the polymer is formed? Calculate the mass to three significant figures.

(3) When a protein dissolved in water is treated with concentrated nitric acid at an elevated temperature, the color turns to yellow. Select the name of this reaction from 1) to 3).

1) Ninhydrin reaction 2) Xanthoproteic reaction 3) Biuret reaction

(4) Which of the amino acids 1) to 5) has the smallest molecular weight?

1) glycine 2) alanine 3) methionine 4) valine 5) phenylalanine

(5) Which of the amino acids 1) to 5) contains a sulfur in the molecule?

1) glycine 2) alanine 3) methionine 4) valine 5) phenylalanine

(6) Which of the amino acids 1) to 5) contains a benzene ring in the molecule?

1) glycine 2) alanine 3) methionine 4) valine 5) phenylalanine