2018 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 JAPANESE GOVERNMENT（MEXT）SCHOLARSHIPS 2018

学科試験　問題

EXAMINATION QUESTIONS

（学部留学生）

UNDERGRADUATE STUDENTS

化　　学

CHEMISTRY

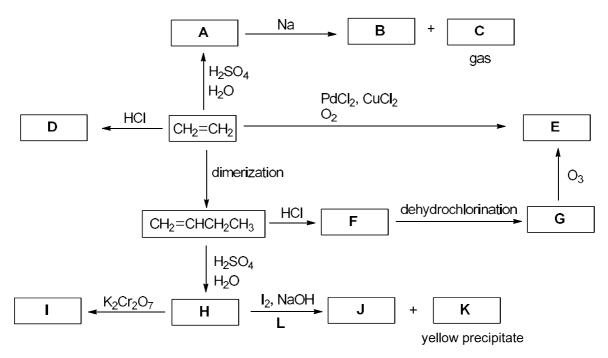**注意**　☆試験時間は６０分。

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

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

CHEMISTRY

Marks	

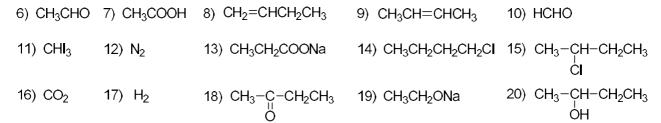I   Write the reference number of the correct answer.

(1)   Which of the atoms 1) to 4) has the largest electron affinity?

   1)   N   2)   O   3)   F   4)   Ne

(2)   Which of the ions 1) to 4) has the largest ionic radius?

   1) Li^+ 2) Na^+ 3) K^+ 4) Rb^+

(3)   Which of the molecules 1) to 4) has a linear shape?

   1) H_2O 2) H_2O_2 3) CO_2 4) NO_2

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

   1)   HF   2)   HCl   3)   HBr   4)   HI

(5)   Which of the descriptions 1) to 4) is not correct for the properties of silver and gold?

   1)   Both have high electrical conductivity.
   2)   Both have high thermal conductivity.
   3)   Both dissolve in nitric acid.
   4)   Silver is more easily oxidized than gold.

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

    1) Boiling water is added to magnesium.

    2) Hydrofluoric acid is added to silicon dioxide.

    3) Hydrochloric acid is added to calcium carbonate.

    4) Aqueous solution of sodium hydroxide is added to aluminum

(7) Which of the descriptions 1) to 4) is not correct for ideal gas?

    1) The pressure is inversely proportional to the temperature at a constant volume.

    2) The volume is proportional to the temperature at a constant pressure.

    3) The pressure is inversely proportional to the volume at a constant temperature.

    4) The pressure is proportional to the number of gas molecules or atoms at a constant volume and temperature.

II   Give the appropriate numbers for (a) to (c) and the chemical equation for (d) in the sentences below.

Sulfur dioxide reacts with oxygen to form sulfur trioxide. Further reaction of sulfur trioxide with water leads to the formation of sulfuric acid. The oxidation number of the sulfur atom is (a) for sulfur dioxide, (b) for sulfur trioxide, and (c) for sulfuric acid. Sulfur dioxide also reacts with hydrogen sulfide to form sulfur, the chemical equation of which is expressed as (d).

III   Calculate the values appropriate to (a) and (b) in the sentences below to two significant figures.

There is 10.0 mL of 0.30 mol L^{-1} $AgNO_3$ aqueous solution, which is added to 20.0 mL of 0.30 mol L^{-1} NaCl aqueous solution. This procedure leads to the precipitation of AgCl and equilibrium between solutes and the precipitate is achieved. The concentrations of Ag^+ and Cl^- in the aqueous solution are estimated to be (a) and (b) mol L^{-1}, respectively. Here, the solubility product of AgCl is 1.8×10^{-10} mol^2 L^{-2}.

IV   Fill in (a) ~ (d) in the sentences below with the most appropriate values. Use the following values if necessary; the atomic weights of K, O, and H are 39, 16, and 1.0, respectively, and log 3 = 0.48. Calculate the values to two significant figures for (a) and (b), and one to three significant figures for (d).

(1)   Heat of 11.6 kJ was released when 11.2 g of KOH was completely dissolved in water. The heat of solution is (a) kJ mol^{-1}. Water was more added to adjust 2.0 L of KOH solution. Next, 5.0 mL of this KOH solution was added to 10.0 mL of 0.10 mol L^{-1} hydrochloric acid. The pH of the resultant solution is (b).

(2)   The unit cell of NaCl crystal contains four Na$^+$ ions and four Cl$^-$ ions. One Na$^+$ ion is surrounded by (c) Cl$^-$ ions in the crystal. The ionic radii of Na$^+$ and Cl$^-$ ions are 0.116 and 0.167 nm, respectively. Therefore, the edge length of the unit cell is (d) nm.

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

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

1) CH_3CH_2Cl 2) CH_3CH_3 3) CH_3CH_2OH 4) $ClCH_2CH_2Cl$ 5) $ClCH_2CH_2OH$

6) CH_3CHO 7) CH_3COOH 8) $CH_2=CHCH_2CH_3$ 9) $CH_3CH=CHCH_3$ 10) $HCHO$

11) CHI_3 12) N_2 13) CH_3CH_2COONa 14) $CH_3CH_2CH_2CH_2Cl$ 15) $CH_3-\underset{\underset{Cl}{|}}{CH}-CH_2CH_3$

16) CO_2 17) H_2 18) $CH_3-\underset{\underset{O}{\|}}{C}-CH_2CH_3$ 19) CH_3CH_2ONa 20) $CH_3-\underset{\underset{OH}{|}}{CH}-CH_2CH_3$

(2) Select the appropriate name for the reaction **L** from 1) to 5).

1) Iodoform reaction   2) Wacker reaction   3) ozonolysis   4) Fehling test   5) Biuret test

VI Answer the following questions.

(1) There is a hydrocarbon that satisfies the following three conditions. What is the molecular formula of the hydrocarbon.

　　1) The compound is an alicyclic hydrocarbon consisting of one ring.
　　2) The compound contains two double bonds in the ring and all the remaining bonds are single bonds.
　　3) The compound contains four more hydrogen atoms than the number of carbon atoms.

(2) Which of the descriptions 1) to 6) are correct as characteristics of phenol? Select two.

1) insoluble in water   2) soluble in water and neutral   3) soluble in water and acidic
4) soluble in water and basic   5) undergo silver mirror reaction   6) show blue-violet when treated with iron(III) chloride solution

(3) Molecules 1) to 4) dissolve in ether. Which would move from the ether layer to the aqueous layer when a dilute hydrochloric acid solution is added to the ether solution, and the mixed solution is then shaken, and then left for a while until separation into two layers occurs?

　　1) benzene   2) phenol   3) benzoic acid   4) aniline

(4) Molecules 1) to 4) dissolve in ether. Which would move from the ether layer to the aqueous layer when an aqueous solution of sodium hydrogen carbonate is added to the ether solution, and the mixed solution is shaken, and then left for a while until separation into two layers occurs?

  1) benzene   2) phenol   3) salicylic acid   4) nitrobenzene

(5) Which of the amino acids 1) to 5) is a neutral amino acid?

  1) HOOCH$_2$C–CH–COOH   2) H$_2$N(CH$_2$)$_4$–CH–COOH   3) H$_2$N$>$–NH(H$_2$C)$_3$–CH–COOH
                | | HN |
               NH$_2$ NH$_2$ NH$_2$

  4) HN$<$$^{=N}$–CH$_2$–CH–COOH   5) HOCH$_2$–CH–COOH
                         | |
                        NH$_2$ NH$_2$

(6) Which of the descriptions 1) to 6) are not correct. Select two.

  1) The boiling points of carboxylic acids are higher than those of alcohols which have a similar molecular weight.
  2) The melting points of carboxylic acids are lower than those of alcohols which have a similar molecular weight.
  3) Carboxylic acids are stronger acids than carbonates.
  4) Carboxylic acids easily form the dimers through hydrogen bonding.
  5) Formic acid can function as a reducing reagent.
  6) Acetic anhydride indicates acidity.

(7) How many structural isomers are possible for the compound with a molecular formula of C$_4$H$_{10}$O?

VII   Answer the following questions concerning the determination of nitrogen (Kjeldahl method).

(1)   When 0.056g of protein was heated with concentrated sulfuric acid, the protein was completely decomposed. Which of 1) to 5) is the nitrogen compound that is formed?

   1) ammonium sulfate 2) aniline 3) pyridine 4)   ammonium chloride
   5) carbon dioxide

(2)   Ammonia, which is generated by alkalizing the nitrogen compound produced in the above question (1), is completely collected with 10.0 mL of a 0.050 mol L^{-1} H$_2$SO$_4$ solution. When an acid-base titration of the solution with 0.10 mol L^{-1} NaOH aqueous solution is performed, 3.6 mL of the NaOH aqueous solution is required. What weight percentage of nitrogen did the protein used in (1) contain? Answer the value to two significant figures. Use the following value necessary; the atomic weight of N is 14.