2007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 (MONBUKAGAKUSHO) SCHOLARSHIPS 2007

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.
I Write the reference number of the correct answer in the answer box.

(Atomic weights: H=1.0, C=12.0, N=14.0, O=16.0, and Cl=35.5. Gas constant: \( R = 0.082 \text{ l} \cdot \text{atm}/(\text{K} \cdot \text{mol}) \))

(1) Which of the following compounds 1) to 4) is insoluble in aqueous ammonia?
   1) AgCl  
   2) Al(OH)₃  
   3) Cu(OH)₂  
   4) Zn(OH)₂

(2) Which of the following gases 1) to 5) has a density of 1.96g/l at 0°C and 1-atm pressure?
   1) oxygen  
   2) nitrogen  
   3) hydrogen chloride  
   4) propane  
   5) butane

(3) Which of the following metals 1) to 6) reacts with water to evolve hydrogen gas at room temperature?
   1) Ag  
   2) Ca  
   3) Cu  
   4) Fe  
   5) Pb  
   6) Zn

(4) Heating a mixture of sodium chloride and concentrated sulfuric acid evolves
   1) HCl  
   2) Cl₂  
   3) H₂  
   4) H₂S  
   5) SO₂
(5) Which of the following gaseous atoms 1) to 5) has the smallest first ioniza-
tion potential?

1) helium  2) neon  3) argon
4) krypton  5) xenon

(6) Bubbling hydrogen sulfide through an acidic solution produces black precipi-
tates. Which of the following cations 1) to 5) is contained in the solution?

1) Al^{3+}  2) Ba^{2+}  3) Cd^{2+}
4) Pb^{2+}  5) Zn^{2+}

(7) It is found that 0.42g of a gaseous compound containing only hydrogen and
carbon occupies 410ml at a temperature of 300K and a pressure of 0.90atm.
Assuming the gaseous compound is an ideal gas, what is the molecular formula
of the compound?

1) CH_{4}  2) C_{2}H_{6}  3) C_{3}H_{4}
4) C_{2}H_{2}  5) C_{3}H_{6}  6) C_{3}H_{5}

(8) Which of the following descriptions 1) to 4) is correct?

1) The pH of the solution that results when 10ml of 1.0 \times 10^{-5}mol/l HCl is
diluted to 10l with distilled water is 8.

2) The pH of the solution that results when 10ml of 1.0 \times 10^{-3}mol/l NaOH is
diluted to 1.0l with distilled water is 9.

3) The pH of the solution that results when 10ml of 1.0 \times 10^{-3}mol/l
CH_{3}COOH is diluted to 1.0l with distilled water is 4.

4) The pH of the solution that results when 10ml of 1.0 \times 10^{-3}mol/l H_{2}SO_{4} is
diluted to 1.0l with distilled water is 5.
(9) In the electrolysis of an aqueous solution of sodium hydroxide using platinum electrodes, the reactions that occur at the anode and the cathode are respectively

1) \( \text{Na}^+ + \text{e}^- \rightarrow \text{Na} \)  \hspace{2cm} 2) \( 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^- \)

3) \( \text{Na} \rightarrow \text{Na}^+ + \text{e}^- \)  \hspace{2cm} 4) \( 2\text{OH}^- \rightarrow \text{H}_2 + \text{O}_2 + 2\text{e}^- \)

5) \( 4\text{OH}^- \rightarrow 2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^- \)

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<th>(1)</th>
<th>(2)</th>
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<td>(6)</td>
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(II) A 40.0\( \mu \)l sample of \( \text{N}_2 \) gas containing \( \text{SO}_2 \) gas as an impurity was bubbled through a 3% solution of \( \text{H}_2\text{O}_2 \). The \( \text{SO}_2 \) was converted to \( \text{H}_2\text{SO}_4 \):

\( \text{SO}_2 + \text{H}_2\text{O}_2 \rightarrow \text{H}_2\text{SO}_4 \)

A 25.0ml portion of 0.0100mol/l NaOH was added to the solution, and the excess base was back-titrated with 13.6ml of 0.0100mol/l HCl. Calculate the parts per million of \( \text{SO}_2 \) (that is, ml \( \text{SO}_2 \)/10\(^6\)ml sample) if the density of \( \text{SO}_2 \) is 2.85g/l. (Atomic weights: \( \text{H}=1.0, \text{N}=14.0, \text{O}=16.0, \text{Na}=23.0, \text{S}=32.0, \) and \( \text{Cl}=35.5 \))

\[ \text{ppm} \]
Exactly 4.32g of oxygen gas was required to completely burn a 2.16g sample of a mixture of methanol and ethanol. Answer the following questions (1) and (2). (Atomic weights: H=1.0, C=12.0, and O=16.0)

(1) How many moles of ethanol are contained in the sample?

(2) What is the percentage by weight of methanol in the sample? Write the percentage to two significant figures.

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<tr>
<td>mol</td>
<td>%</td>
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Answer the following questions (1) to (3).

(1) Select the functional group from [B] of each of the compounds ①—⑧ in [A], and select the name of the compound from [C].

<table>
<thead>
<tr>
<th>[A]</th>
<th>[B]</th>
<th>[C]</th>
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<tbody>
<tr>
<td>① CH₃OH</td>
<td>(a) ketone</td>
<td>(a) acetaldehyde</td>
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<tr>
<td>② CH₃CHO</td>
<td>(b) carboxyl</td>
<td>(b) methyl acetate</td>
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<td>③ CH₃OCH₃</td>
<td>(c) nitro</td>
<td>(c) nitromethane</td>
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<td>④ CH₃NO₂</td>
<td>(d) amino</td>
<td>(d) toluene</td>
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<td>⑤ CH₃Br</td>
<td>(e) ester</td>
<td>(e) methylamine</td>
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<td>⑥ CH₂COOH</td>
<td>(f) ether</td>
<td>(f) methanol</td>
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<tr>
<td>⑦ CH₃NH₂</td>
<td>(g) aldehyde</td>
<td>(g) dimethyl ether</td>
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<td>⑧ CH₃COCH₃</td>
<td>(h) propyl</td>
<td>(h) acetic acid</td>
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<td></td>
<td>(i) sulfonyl</td>
<td>(i) ethanol</td>
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<td></td>
<td>(i) phenyl</td>
<td>(i) bromomethane</td>
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<td></td>
<td>(k) hydroxyl</td>
<td>(k) acetone</td>
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<td></td>
<td>(l) halogen</td>
<td>(l) xylene</td>
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<td>(A)</td>
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(2) What is the product when ① and ⑥ in (A) are heated with a small amount of sulfuric acid? Select the product from (C).

(3) What is the product when ② in (A) is heated with ammoniacal silver nitrate solution? Select the product from (C).

V Answer the following questions concerning oils and fats.

Question 1. Oils and fats are esters from higher fatty acids and [A]. The specific gravities of oils and fats are [B] than water, and oils and fats are insoluble in water but soluble in organic solvents. Oils and fats that are solid at ambient temperatures are called [C] and oils and fats that are liquid at ambient temperatures are called [D].
(1) Write the reference of the correct answer to [A].

(a) carboxylic acid  (b) amine  (c) glycerol (glycerin)
(d) glycol  (e) halogen

(2) Select an appropriate word for [B].

(a) heavier  (b) bigger  (c) smaller
(d) higher  (e) harder

(3) Select an appropriate word for [C].

(a) fatty oil  (b) ether  (c) margarine
(d) soap  (e) fat

(4) Select an appropriate word for [D].

(a) fatty oil  (b) ether  (c) margarine
(d) soap  (e) fat

Question 2. A kind of fatty acid was obtained by hydrolysis of some oil and fat. For hydrolysis of 0.884g of the oil and fat, 15mL of 0.2mol/l aqueous solution of potassium hydroxide was required.

(5) What is the molecular weight of the oil and fat?
(6) What is the molecular weight of the fatty acid?