2010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 2010

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.
Use the following values. “L” indicates liters.

**Gas constant:** \( R = 8.31 \times 10^3 \text{ Pa} \cdot \text{L/(K} \cdot \text{mol)} = 8.31 \text{ J/(K} \cdot \text{mol)} \\
= 0.082 \text{ atm} \cdot \text{L/(K} \cdot \text{mol)}

**Avogadro constant:** \( N_A = 6.0 \times 10^{23} \text{ /mol)}

**Standard state:** 0°C, 1.0 \times 10^5 \text{ Pa} (= 1.0 \text{ atm})

**Atomic weight:** H : 1.0  C : 12  N : 14  O : 16  F : 19  Na : 23  
S : 32  Cl : 36  Ar : 40

**Q1** From ①–⑤ below choose the atom that has the largest number of outermost shell electrons.

① B  ② Cl  ③ He  ④ Na  ⑤ S

**Q2** An atom has 32 neutrons and its trivalent cation has 24 electrons. From ①–⑤ below choose the atom.

① \(^{53}\text{Cr}\)  ② \(^{55}\text{Mn}\)  ③ \(^{57}\text{Fe}\)  ④ \(^{59}\text{Co}\)  ⑤ \(^{66}\text{Zn}\)

**Q3** Given that the following gases ①–⑤ have the same mass, choose the one that has the smallest number of molecules.

① Ar  ② \(\text{Cl}_2\)  ③ CO  ④ O\(_3\)  ⑤ SO\(_2\)
Q4 From ①～⑤ choose the best pair of methods to purify iodine (I₂) and potassium nitrate (KNO₃).

<table>
<thead>
<tr>
<th></th>
<th>Iodine</th>
<th>Potassium nitrate</th>
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</thead>
<tbody>
<tr>
<td>①</td>
<td>recrystallization</td>
<td>sublimation</td>
</tr>
<tr>
<td>②</td>
<td>recrystallization</td>
<td>distillation</td>
</tr>
<tr>
<td>③</td>
<td>sublimation</td>
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<td>④</td>
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</tr>
<tr>
<td>⑤</td>
<td>distillation</td>
<td>recrystallization</td>
</tr>
</tbody>
</table>

Q5 By heating 0.322 g of sodium sulfate hydrate (Na₂SO₄·nH₂O), 0.142 g of its anhydride is obtained. From ①～⑤ below choose the most appropriate value for n.

① 4  ② 6  ③ 8  ④ 10  ⑤ 12

Q6 The following reaction is in an equilibrium state.

\[ 2\text{NO}_2 \text{ (brown)} = \text{N}_2\text{O}_4 \text{ (colorless)} + 57 \text{kJ} \]

From ①～④ below choose two correct ones out of statements (a)～(d).

(a) As the temperature is increased, the color darkens.
(b) As the temperature is increased, the color lightens.
(c) As the pressure is increased, the brown color first darkens, and then, after a few seconds, lightens.
(d) As the pressure is increased, the brown color first lightens, and then, after a few seconds, darkens.

① a, c  ② a, d  ③ b, c  ④ b, d
Q7 From ①-⑤ below choose the molecule that is linear and has the double bond.

① acetylene ② carbon dioxide ③ hydrogen peroxide ④ methane ⑤ propene (propylene)

Q8 Given that air is a mixture of N$_2$ and O$_2$ with a volume ratio of 4:1, from ①-⑤ below choose the one that identifies a gas that has a larger density than air at the same temperature and pressure.

① CH$_4$ ② C$_3$H$_8$ ③ HF ④ N$_2$ ⑤ NH$_3$

Q9 Sulfur dioxide (SO$_2$) is formed when copper (Cu) is dissolved in a hot, concentrated sulfuric acid (conc. H$_2$SO$_4$). From ①-⑤ below, choose the one that is the correct value for the change in the oxidation number of sulfur in this reaction.

① 2 ② 3 ③ 4 ④ 5 ⑤ 6
Q10 An electric current is made to flow through an aqueous copper sulfate (CuSO₄ \textit{aq}) as shown below. From ①–⑥ below choose the pair that includes correct statements describing the change that takes place at the electrodes A and B, respectively.

\[
\begin{array}{|c|c|c|}
\hline
& \text{A} & \text{B} \\
\hline
\text{①} & \text{The mass increases.} & \text{The mass decreases.} \\
\text{②} & \text{The mass increases.} & \text{A gas is generated.} \\
\text{③} & \text{The mass decreases.} & \text{The mass increases.} \\
\text{④} & \text{The mass decreases.} & \text{A gas is generated.} \\
\text{⑤} & \text{A gas is generated.} & \text{The mass increases.} \\
\text{⑥} & \text{A gas is generated.} & \text{The mass decreases.} \\
\hline
\end{array}
\]

Q11 From ①–⑥ below choose the one that contains two methods to generate hydrogen.

(a) Metallic sodium (Na) is added to water.
(b) Hydrochloric acid (HCl \textit{aq}) is added to copper (Cu).
(c) Water is electrolyzed.
(d) Hydrochloric acid is added to manganese(IV) oxide (MnO₂) and the mixture is heated.

① a, b  ② a, c  ③ a, d  ④ b, c  ⑤ b, d  ⑥ c, d
Q12 The following statements (a)-(c) on sodium chloride (NaCl) are either true or false. From ①-⑥ below choose the correct combination of “true (T)” and “false (F)”.

(a) Its crystal does not conduct electricity.
(b) Molten sodium chloride conducts electricity.
(c) By electrolyzing its aqueous solution with a carbon electrode, chlorine (Cl₂) and hydrogen (H₂) are obtained.

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<thead>
<tr>
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<tbody>
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<tr>
<td>⑥</td>
<td>F</td>
<td>F</td>
<td>F</td>
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</table>
Q13 From ①-⑥ below choose the best combination of elements that are true for the following statements (a)-(c), respectively.

(a) Its oxide is a basic oxide.
(b) Its hydrogen compound is soluble in water and exhibits a strong acidity.
(c) The composition of its hydrogen compound is XH₄ (where X stands for an element).

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<tbody>
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<tr>
<td>⑥</td>
<td>Na</td>
<td>S</td>
<td>P</td>
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Q14 From ①-④ below choose the metal that does not deposit silver (Ag) on the surface when immersed in aqueous silver nitrate (AgNO₃ aq).

① Cu  ② Fe  ③ Pt  ④ Zn
Q15 From ①–④ below choose the statement that is only true for aluminum (Al) or only true for zinc (Zn).

① The metal dissolves in hydrochloric acid (HCl $aq$).
② The metal dissolves in aqueous sodium hydroxide (NaOH $aq$).
③ A precipitate is formed when aqueous ammonia (NH$_3$ $aq$) is added to the aqueous solution of each ion. This precipitate dissolves if excess aqueous ammonia is added.
④ A precipitate is formed when aqueous sodium hydroxide is added to the aqueous solution of each ion. This precipitate dissolves if excess aqueous sodium hydroxide is added.

Q16 From ①–⑤ below choose the most appropriate combination of general names of the following functional groups (a)-(c).

(a) $-\text{SO}_3\text{H}$  (b) $-\text{OH}$  (c) $\text{O}$

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<tr>
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Q17 From ①—⑤ below choose the pair of compounds that are both hardly soluble in water.

① acetic acid and acetone
② aniline and ethanol
③ ethylene glycol and phenol
④ ethyl acetate and hexane
⑤ formaldehyde and naphthalene

Q18 Of the isomers with the molecular formula C₄H₈, from ①—⑥ below choose the correct combination of them that have the following properties (a) and (b).

(a) Optical isomers are formed when the addition reaction of chlorine (Cl₂) takes place.

(b) There exist cis and trans isomers.

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>①</td>
<td>1-butene (but-1-ene)</td>
<td>1-butene (but-1-ene)</td>
</tr>
<tr>
<td>②</td>
<td>1-butene (but-1-ene)</td>
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</tr>
<tr>
<td>③</td>
<td>1-butene (but-1-ene)</td>
<td>methylpropene</td>
</tr>
<tr>
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<td>1-butene (but-1-ene)</td>
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<tr>
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<td>methylpropene</td>
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</tr>
<tr>
<td>⑥</td>
<td>methylpropene</td>
<td>methylpropene</td>
</tr>
</tbody>
</table>
Q19 Hydrogen (H₂) is added to 0.10 mol of fat which contains only oleic acid C₁₇H₃₃COOH as the fatty acid component. How much hydrogen (in L) at the standard state is necessary to saturate the fat completely. From ①-⑤ below choose the closest value.

① 0.67  ② 1.12  ③ 2.24  ④ 4.48  ⑤ 6.72

Q20 From ①-⑥ below choose the correct combination of compounds (a)-(d) which are appropriate as the starting compounds for the following synthesis of nylon-6,6.

\[ nA + nB \rightarrow \begin{bmatrix} \text{C} & \text{(CH}_2\text{)}_4 & \text{C} & \text{N} & \text{N} \\ \text{O} & \text{O} & \text{O} & \text{O} & \text{O} \end{bmatrix}^n \]

(a) HO\text{--(CH}_2\text{)}_4\text{--C--OH}  \quad (b) \text{H}_2\text{N--(CH}_2\text{)}_4\text{--C--NH}_2

(c) HO\text{--(CH}_2\text{)}_6\text{--OH}  \quad (d) \text{H}_2\text{N--(CH}_2\text{)}_6\text{--NH}_2

① a, b  ② a, c  ③ a, d  ④ b, c  ⑤ b, d  ⑥ c, d