2006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 2006

学科試験　　問題

EXAMINATION QUESTIONS

（高等専門学校留学生）

COLLEGE OF TECHNOLOGY STUDENTS

化　　学

CHEMISTRY

注意　☆試験時間は60分。

PLEASE NOTE : THE TEST PERIOD IS 60 MINUTES.

CHEMISTRY

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

Marks	

If necessary, use the following equation, constants, and atomic weights to answer the questions below.

Equation of state of gas : PV=nRT

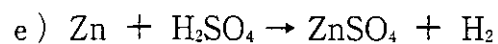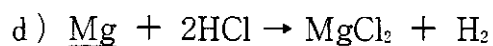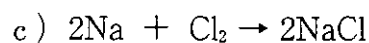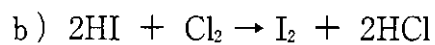Gas constant R : 0.082 $\ell \cdot$ atm/K$\cdot$mol

Faraday constant : 96500 C/mol

Atomic weights : H=1.0, C=12.0, N=14.0, O=16.0

1 Answer the following questions. Write the number of the correct answer in each answer box.

(A) Which of the following atoms has the smallest number of valence electrons?

(1) $_6C$ (2) $_8O$ (3) $_{11}Na$ (4) $_{16}S$ (5) $_{20}Ca$

(B) Are the underlined atoms oxidated or reduced in the following reactions?

a)´ CO_2 + $\underline{H_2}$ → CO + H_2O

b) 2HI + $\underline{Cl_2}$ → I_2 + 2HCl

c) $2\underline{Na}$ + Cl_2 → 2NaCl

d) $\underline{Mg}$ + 2HCl → $MgCl_2$ + H_2

e) $\underline{Zn}$ + H_2SO_4 → $ZnSO_4$ + H_2
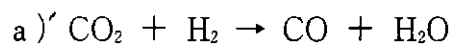
(1)   a：oxidized   b：reduced   c：oxidized   d：oxidized   e：oxidized

(2)   a：oxidized   b：oxidized   c：reduced   d：oxidized   e：oxidized

(3)   a：oxidized   b：reduced   c：reduced   d：reduced   e：oxidized

(4)   a：reduced   b：reduced   c：oxidized   d：oxidized   e：oxidized

(5)   a：oxidized   b：reduced   c：oxidized   d：oxidized   e：reduced

（C）How many isomers are there for one kind of alkene, C_4H_8?

   (1) 2   (2) 3   (3) 4   (4) 5   (5) 6

（D）How many simple substances of the following elements can exist as a gas un-
der 1 atm at room temperature?

   H   Li   O   Ar   He   Mg   Si   B   C

   (1) 2   (2) 3   (3) 4   (4) 5   (5) 6

（E）Select one inaccurate description from among the followings.

   (1)   An atom with a large electronegativity is rather negative and apt to easily
change into an anion.

   (2)   The larger the difference in electronegativity between two kinds of atoms
is, the stronger the polarity of the bond formed by those two atoms is.

   (3)   A water molecule is one of the triatomic molecules.

   (4)   A molecular crystal will have a comparatively low melting point, because
its intermolecular force is stronger.

(5) The isotopes of an element are atoms whose nuclei contain the same number of protons but different numbers of neutrons.

⬜

(F) Which of the following relationships in the first ionization energy between two different atoms is correct?

(1) He > Ne   (2) Li < Na   (3) B > Be   (4) O > Ar   (5) F < Cl

⬜

2 Under the presence of a proper catalyst, 1.00 mole of N_2 and 3.00 mole of H_2 were mixed in a reaction vessel with a volume of V ℓ and maintained at a certain temperature. The following reaction then occurred in this gas mixture:

$$3 H_2 + N_2 \leftrightarrows 2 NH_3$$
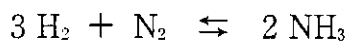
The total pressure of the mixture was 30.0 atm at the beginning and settled down to 25.0 atm after equilibration. Answer the following questions concerning this reversible reaction.

Write the number of the correct answer in each answer box.

(A) What is the mole fraction of NH_3 at equilibrium?

(1) 0.20   (2) 0.46   (3) 0.57   (4) 0.72   (5) 0.83

⬜

(B) Nitrogen has two kinds of natural isotope, hydrogen also has two. How many NH_3 moclecules with a different mass can exist?

(1) 4   (2) 5   (3) 6   (4) 7   (5) 8

3 Answer the following questions concerning thermochemistry. Write the number of the correct answer in each answer box.

(A) The heat of combustion of propane is 2220 kJ/mol when the water formed is liquid. Evaluate the heat of formation of propane by using this fact as well as the following thermochemical equations.

$$C(graphite) + O_2 = CO_2 + 394\,kJ$$
$$2H_2 + O_2 = 2H_2O(\ell) + 572\,kJ$$
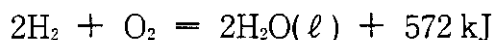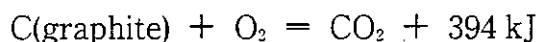
(1) 64 kJ/mol   (2) 85 kJ/mol   (3) 106 kJ/mol

(4) 137 kJ/mol   (5) 182 kJ/mol

(B) What is the volume of propane needed at STP to raise the temperature of 2.00 ℓ water from 15.0 to 95.0 ℃ using the heat evolved through its combustion, given that the density of water is 1.00 g/cm³, and that the specific heat of water is 4.18 J/g·℃. The calculation should be done under the assumption : 1.00 cm³=1.00 mℓ.

(1) 4.85 ℓ   (2) 6.75 ℓ   (3) 8.65 ℓ   (4) 11.7 ℓ   (5) 18.5 ℓ

4 What is the pH of 50 $m\ell$ of the 0.14 mol/ℓ HCl solution mixed with 50 $m\ell$ of 0.10 mol/ℓ NaOH solution? Write the number of the correct answer in the answer box. log 2 = 0.30.

   (1) 1.5   (2) 1.7   (3) 1.9   (4) 2.1   (5) 2.3

5 A 0.100 mol/ℓ aqueous solution of copper sulfate(II) whose volume was 300 $m\ell$ was electrolyzed with a current of 863 mA for an hour, using a pair of platinum electrodes. Answer the following questions concerning this electrolysis. Write the number of the correct answer in each answer box.

(A) What quantity of electrons passed during this electrolysis?

   (1) 2.40×10^{-2} mol   (2) 3.22×10^{-2} mol   (3) 6.65×10^{-2} mol

   (4) 8.73×10^{-2} mol   (5) 9.47×10^{-2} mol

(B) What was the volume of gas generated from the anode, under 25 ℃ and 0.90 atm?

   (1) 125 $m\ell$ (2) 184 $m\ell$ (3) 219 $m\ell$ (4) 276 $m\ell$ (5) 329 $m\ell$

(C) What was the concentration of $CuSO_4$ aqueous solution after the electrolysis, assuming the volume of the solution to be constant?

(1) 3.42×10^{-2}mol/ℓ　　(2) 4.63×10^{-2}mol/ℓ　　(3) 5.84×10^{-2}mol/ℓ

(4) 7.05×10^{-2}mol/ℓ　　(5) 8.13×10^{-2}mol/ℓ

6 Combustion of 12.0 mg of compound A, which contains only carbon, hydrogen, and oxygen, gave 26.5 mg CO_2 and 14.4 mg H_2O. 30 mg of A, vaporized at 27 ℃ and 0.60 atm, occupied 20.5 mℓ. Answer the following questions. Write the number of the correct answer in each answer box.
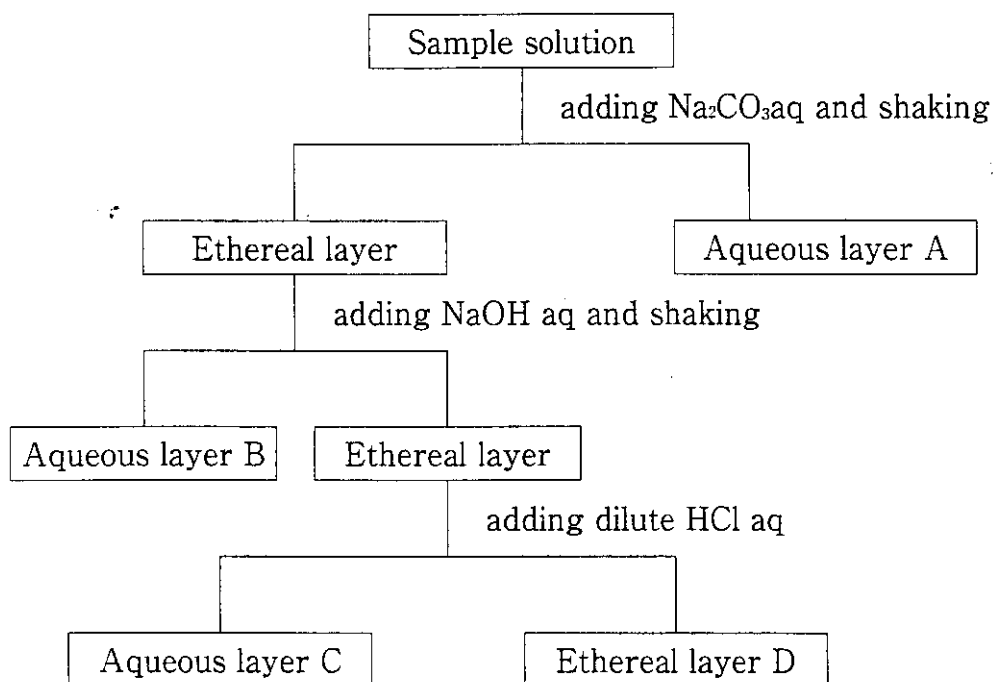
(A) Which is the molecular formula of A?

(1)　CH_2O　　　　(2)　C_2H_6O　　　　(3)　$C_2H_6O_2$

(4)　C_3H_6O　　　　(5)　$C_3H_6O_2$　　　　(6)　C_3H_8O

(B) How many structural isomers of A would be expected?

(1)　1　　　(2)　2　　　(3)　3　　　(4)　4　　　(5)　5　　　(6)　6

7 The following figure shows a flow chart of the analysis of an ethereal sample solution containing phenol, acetic acid, aniline and nitrobenzene.

```
                        ┌─────────────────┐
                        │ Sample solution │
                        └─────────────────┘
                              │ adding Na₂CO₃aq and shaking
              ┌───────────────┴───────────────┐
      ┌─────────────────┐            ┌──────────────────┐
      │ Ethereal layer  │            │ Aqueous layer A  │
      └─────────────────┘            └──────────────────┘
              │ adding NaOH aq and shaking
      ┌───────┴───────┐
┌──────────────────┐ ┌─────────────────┐
│ Aqueous layer B  │ │ Ethereal layer  │
└──────────────────┘ └─────────────────┘
                          │ adding dilute HCl aq
              ┌───────────┴────────────┐
      ┌──────────────────┐    ┌──────────────────┐
      │ Aqueous layer C  │    │ Ethereal layer D │
      └──────────────────┘    └──────────────────┘
```

Write the number of the correct combination of compounds A, B, C and D in the answer box.

(1) A : aniline   B : acetic acid   C : nitrobenzene D : phenol

(2) A : acetic acid   B : phenol   C : aniline   D : nitrobenzene

(3) A : acetic acid   B : aniline   C : phenol   D : nitrobenzene

(4) A : aniline   B : acetic acid   C : phenol   D : nitrobenzene

(5) A : nitrobenzene   B : aniline   C : phenol   D : acetic acid

```
┌──────────┐
│          │
│          │
│          │
└──────────┘
```

8 The molecular weight of amino acid $RCH(NH_2)COOH$ is 75. 18 amino acids condensed to give a substance resembling protein. Answer the following questions. Write the number of the correct answer in each answer box.

(A) Which is the rational formula of the amino acid?

    (1) $CH(NH_2)COOH$ (2) $CH_2(NH_2)COOH$

    (3) $CH_3CH(NH_2)COOH$ (4) $CH_3CH_2(NH_2)COOH$

    (5) $CH_3CH_2CH(NH_2)COOH$

(B) Derive the molecular weight of the substance resembling protein.

    (1) 1026   (2) 1044   (3) 1291   (4) 1305   (5) 1350

9 Choose a suitable chemical formula and generic material from the members of group B and C below to correspond to the following compounds (1)~(5) of group A. Write the number of the correct combination in the answer box.

    A : (1) vinyl acetate   (2) styrene   (3) adipic acid

        (4) ethylene glycol   (5) isoprene

    B : (a) $CH_2 = CH-C_6H_5$ (b) $HO-(CH_2)_2-OH$

       (c) $CH_2 = CH-C(CH_3) = CH_2$ (d) $HOOC-(CH_2)_4-COOH$

       (e) $CH_2 = CH-OCOCH_3$

C : ① ester   ② conjugated diene   ③ aromatic hydrocarbon

      ④ alcohol   ⑤ carboxylic acid

(1)   1 — c —①、   2 — a —③、   3 — d —②、   4 — e —⑤、   5 — b —④

(2)   1 — a —②、   2 — b —④、   3 — e —①、   4 — c —③、   5 — d —⑤

(3)   1 — e —①、   2 — a —③、   3 — d —⑤、   4 — b —④、   5 — c —②

(4)   1 — e —①、   2 — b —④、   3 — d —⑤、   4 — a —③、   5 — c —②

(5)   1 — b —⑤、   2 — c —①、   3 — a —③、   4 — d —②、   5 — e —④