2018 Enrolment The 2nd

Japan University Examination

Advanced Chemistry

Examination Date: May 2017

(60 min)

Do not open the examination booklet until the starting signal for the exam is given.
Please read the following instructions carefully.
Please fill in the examinee no. and name below.

Instructions

1. The bookletcontains 14pages.

2. The answer sheet is one piece of one sided paper.

3. In the case that you notice there are parts in the booklet where the print is not clear or there are missing pages or misplaced pages, or the answer sheet is soiled, raise your hand to report to the invigilator.

4. There are 5 questions to be answered.

5. Fill the examinee no. and name in the answer sheet.

6. Use black pencil to write answers in the designated section in the answer sheet.

7. Memos and calculations can be written on the examination booklet.

8. When the signal to end the exam is given, check again to see that the examinee no. and name is filled in and submit the answer sheet and the examination booklet according to the invigilator's instructions.

Examinee's No.	Name

Advanced Chemistry

Atomic mass: H＝1.0, C＝12, O＝16, Na＝23, S＝32, Cl＝35.5, Zn＝65, Br＝80, Ba ＝137

Unit volume: 1 L＝1 dm³＝1000 mL＝1000 cm³

Molarity: 1 mol/L＝1 mol L⁻¹＝1 M＝1 mol dm⁻³

Under standard condition (0℃, 1.013×10⁵ Pa), molar volume of the gas is 22.4 L／mol (＝ 22.4 L mol⁻¹)

(Remarks): The molar volume of the gas is volume of 1 mol gas.
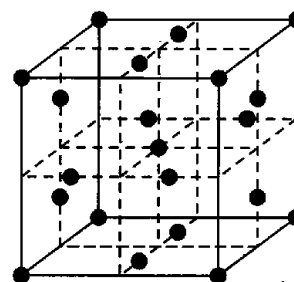
Question 1

Please answer the following questions.

Q1　Which of the following substances is the mixture? Please choose the most appropriate one from the following ①to ⑤and write it with a mark.

① Mercury　② Water vapor　③ Sea water　④ Salt　⑤ Hydrogen

Q2　Which one of the following underlined atoms has the smallest oxidation number? Please choose the most appropriate one from the following ①to ⑤and write it with a mark.

① $K_2\underline{Cr}_2O_7$　② $\underline{C}H_4$　③ $\underline{N}H_4^+$　④ $H_2\underline{S}$　⑤ $H\underline{N}O_3$

Q3　In recent years, methane hydrate is one of the substances that are drawing attention as natural resources. As shown in the right figure, the methane molecules in the unit lattice of the methane hydrate crystal are located at each vertex of the unit lattice, the center of the unit lattice, and two places on each surface. What is the number of methane molecules contained in this unit lattice? Please choose the most appropriate one from the following ①to ⑤and write it with a mark.

●Methane molecule

① 2　　② 4　　③ 8　　④ 14　　⑤ 21

Q4　A nickel-cadmium battery is a secondary battery that can be charged. The following change will occur when discharged.

$$Cd + 2NiO(OH) + 2H_2O \longrightarrow Cd(OH)_2 + 2Ni(OH)_2$$
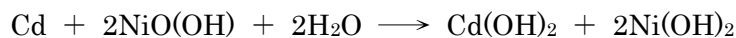
Which of the following statements regarding this battery is correct? Please choose the most appropriate one from the following ① to ⑤ and write it with a mark.

①　The substance reacting at the positive electrode is Cd when it is discharging,

②　The mass of the negative electrode decreases when it is discharging.

③　The positive electrode is connected to the positive electrode of the external DC power supply when it is charging.

④　The mass of the positive electrode increases when it is charging.

⑤　Dilute sulfuric acid is used as an electrolytic solution.

Q5　After a certain hydrocarbon X was burned completely, 17.6mg of carbon dioxide and 9.0 mg of water were obtained. Please answer the following (1) and (2) basing on this.

(1)　Which one of the following is the composition formula of X. Please choose the most appropriate one from the following ① to ⑤ and write it with a mark.

①　CH_2　　　②　C_2H_5　　　③　CH_3　　　④　CH_4　　　⑤　C_4H_5

(2)　Which one of the following is the molecular formula of X. Please choose the most appropriate one from the following ① to ⑤ and write it with a mark.

①　C_2H_4　　　②　C_2H_5　　　③　C_2H_6　　　④　C_3H_6　　　⑤　C_4H_{10}

Q6   In order to find out the mass composition of sodium hydroxide (referred to as solid
A) as impurities which contains sodium carbonate and water, the following
experiments 1 to 3 were conducted.

Experiment 1: We weighed 12.00g of solid A and dissolved it in water to make 500mL of
an aqueous solution (this was designated as aqueous solution B).
Experiment 2: When barium chloride was sufficiently added to the aqueous solution B,
1.97g of barium carbonate white precipitate of was formed.
Experiment 3: In order to <u>weigh 10.0 mL of the supernatant</u> of the solution obtained in
experiment 2, it was titrated with 0.200 mol/L hydrochloric acid, and 21.0 mL of
hydrochloric acid was required up to the neutralization point.
    Please answer (1) and (2) basing on this. However, it is assumed that the volume
change of the aqueous solution by adding barium chloride can be negligible in
experiment 2.

(1)   What (mol) is the amount of sodium hydroxide contained in the underlined
supernatant? Please choose the most appropriate one from the following ① to
⑥ and write it with a mark.

① 4.20×10^{-3} mol   ② 5.10×10^{-3} mol   ③ 6.00×10^{-3} mol

④ 2.10×10^{-1} mol   ⑤ 2.55×10^{-3} mol   ⑥ 3.00×10^{-1} mol

(2)   What (g) is the mass of water contained in Solid A? Please choose the most
appropriate one from the following ① to ⑥ and write it with a mark.

①   0.508 g   ②   1.27 g   ③   2.54 g
④   3.60 g   ⑤   10.0 g   ⑥   10.7 g

Question 2

Please answer the following questions.

Q1 Please choose the names of bonds included in the following substances (1) to (3) one by one from the following ① to ⑤ and write it with a mark.

(1) Zinc
(2) Hydrogen chloride
(3) Zinc chloride

　　① Coordinate bond　　② Covalent bond　　③ Ionic bond
　　④ Hydrogen bond　　⑤ Metal bond

Q2 Please choose the two correct ones of the following descriptions ① to ⑤ on free electrons and write it with a mark.

① Zinc has large electric conductivity due to it has free electrons.
② Zinc is easy to dissolve in water due to it has free electrons.
③ Zinc has high thermal conductivity due to it has free electrons.
④ Two electrons of the zinc atom K shell in zinc are free electrons.
⑤ There are 30 free electrons in every zinc atom due to it has an atomic number of 30.

Q3 Please choose one of the following substances ① to ⑤ that has the highest boiling point and write it with a mark.

① Water　② Hydrogen chloride　③ Hydrogen bromide
④ Sulfur dioxide　⑤ Hydrogen sulfide

Q4   When dilute hydrochloric acid was added to 2.76 g of zinc powder whose surface was oxidized (this was designated as A), the reaction represented by the following reaction formula was completely progressed and all of A was dissolved.

$$Zn \ + \ 2HCl \ \longrightarrow \ ZnCl_2 \ + \ H_2$$
$$ZnO \ + \ 2HCl \ \longrightarrow \ ZnCl_2 \ + \ H_2O$$
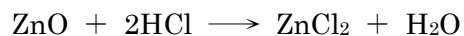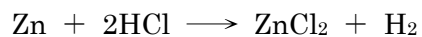
At this time, 672 mL of hydrogen was generated at 0℃ and 1.013×10^5 Pa. Please answer the following (1) and (2) basing on this.

(1)   What (mol) is the amount of hydrogen generated? Please choose the most appropriate value from the following ① to ⑥ and write it with a mark.

① 3.0×10^{-1} ② 1.5×10^{-1} ③ 1.2×10^{-1}

④ 4.2×10^{-2} ⑤ 3.0×10^{-2} ⑥ 1.5×10^{-2}

(2)   What (g) is the mass of zinc oxide in A? Please choose the most appropriate value from the following ① to ⑥ and write it with a mark.

①   0.46   ②   0.69   ③   0.76

④   0.81   ⑤   1.38   ⑥   1.84

Q5　When acetic acid and ethanol are mixed, with a small amount of concentrated sulfuric acid added as a catalyst and then left for a while, ethyl acetate and water are formed by esterification and an equilibrium state expressed by the following formula is obtained.

$$CH_3COOH \ + \ C_2H_5OH \ \rightleftarrows \ CH_3COOC_2H_5 \ + \ H_2O$$
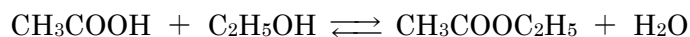
The equilibrium constant K of this reaction is expressed by the following equation.

$$K = \frac{[CH_3COOC_2H_5][H_2O]}{[CH_3COOH][C_2H_5OH]}$$

Please answer the following (1) and (2) basing on this.

(1)　Please choose the most suitable condition for increasing the amount of ethyl acetate formed in the equilibrium state from the following ①〜④ and write it with a mark.

① Increase the amount of ethanol to be added at the beginning.
② Reduce the amount of acetic acid to be added at the beginning.
③ Add a small amount of concentrated sulfuric acid after equilibrium is reached.
④ Add water after equilibrium is reached.

(2)　Mix 1.5 mol of acetic acid and 1.5 mol of ethanol, add a small amount of concentrated sulfuric acid and leave for a while, equilibrium state is reached when 1.0 mol of ethyl acetate is formed. Please answer the following a and b regarding this equilibrium state. However, the amount of water contained in concentrated sulfuric acid can be ignored.

a　What (mol) is the amount of acetic acid present in the equilibrium state? Please choose the most appropriate value from the following ① to ⑥ and write it with a mark.

① 0.25 mol　　② 0.50 mol　　③ 0.75 mol
④ 1.0 mol　　⑤ 1.3 mol　　⑥ 1.5 mol

b What is the value of the equilibrium constant K? Please choose the most appropriate value from the following ① to ⑥ and write it with a mark.

① 0.25   ② 0.45   ③ 1.5

④ 2.3   ⑤ 3.5   ⑥ 4.0

Question 3

Please answer the following questions.

Q1   Please choose the two of the following substances ① to ⑦ that are well soluble in water and write them with a mark.

① Graphite   ② Iron   ③ Crystal   ④ Hydrogen chloride

⑤ Acetone   ⑥ Diethyl ether   ⑦ Silver chloride

Q2   Please answer the following (1) to (3) regarding 100 g of potassium nitrate saturated aqueous solution at 25℃. However, the solubility of potassium nitrate is 40 g per 100g of water at 25℃and 110 g per 100g of water at 60℃.

(1)   What is the mass percent concentration of this saturated aqueous solution? Please choose the most appropriate value from the following ① to ⑤ and write it with a mark.

① 29%   ② 40%   ③ 52%   ④ 67%   ⑤ 80%

(2)   If we add water and potassium nitrate to the saturated aqueous solution to make 300 g of saturated aqueous solution at 60℃. What (g) is the required amount of potassium nitrate? Please choose the most appropriate value from the following ① to ⑤ and write it with a mark.

① 4.0×10 g   ② 7.0×10 g   ③ 8.0×10 g

④ 1.3×10^2 g   ⑤ 1.6×10^2 g

(3)   The saturated aqueous solution of (2) was cooled again to 25℃.What (g) is the amount of potassium nitrate precipitated? Please choose the most appropriate value from the following ① to ⑤ and write it with a mark.

① 1.1×10 g   ② 4.0×10 g   ③ 7.0×10 g

④ 8.0×10 g   ⑤ 1.0×10^2 g

Q3 The freezing point of benzene is 5.53℃. The freezing point of the solution with 0.010mol of benzyl alcohol (molecular weight 108) dissolved in 100 g of benzene was measured and the freezing point changed by 0.51℃ from the freezing point of benzene. What is the freezing point of the completely dissolved solution added with 2.16 g of benzyl alcohol to this solution? Please choose the most appropriate value from the following ① to ⑤ and write it with a mark. However, benzyl alcohol shall not ionize nor associate in benzene.

① 3.0   ② 4.0   ③ 5.0   ④ 6.0   ⑤ 7.0

Q4 As shown in the figure below, pure water was filled in the left side of a glass container with a plug, and glucose aqueous solution of 0.10 mol / kg was filled in the right side, the plug was left open. Please choose the most suitable description from the following ① to ⑤ as a change that occurs at this time and write it with a mark.
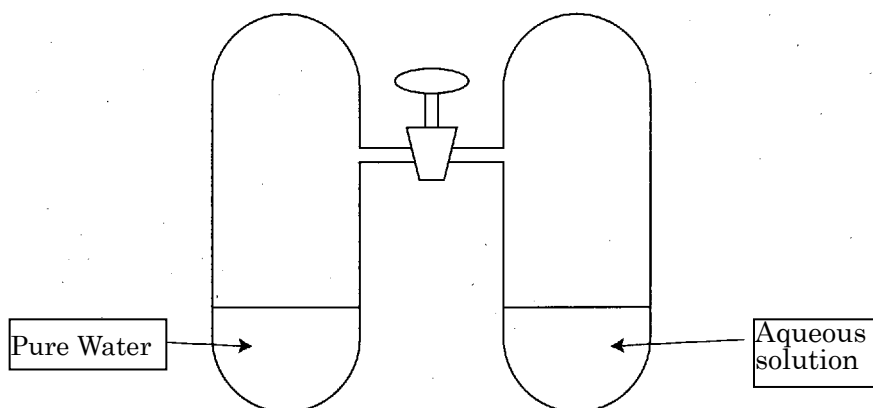
① Water moves from the pure water side to the solution side, and there is no liquid water left in the pure water side.
② Water moves from the pure water side to the solution side and when the concentration on the solution side reaches a certain value, water will stop moving.
③ Water moves from the solution side to the pure water side, and the concentration on the solution side will become higher. The water will stop moving when crystal precipitation starts.
④ Glucose moves from solution side to pure water side, and glucose concentrations on both sides will become equal.
⑤ No changes can be seen.

Question 4

Please read the following text and answer the following questions.

An alkene is a hydrocarbon having one carbon-carbon double bond（C＝C）in the molecule and an alkyne is a hydrocarbon having one carbon-carbon tripl*e* bond (C≡C) in the molecule. If one water molecule is added to ethylene, alcohol is formed, but if one water molecule to acetylene, ₆ <u>aldehyde</u> is formed via ₐ <u>alcohol</u>.In addition, if one molecule of acetic acid is added to acetylene, ₍ <u>vinyl acetate</u> is formed.

There are alkene **A** and alkene **B** in the molecular formula expressed as C_4H_8. When one water molecule was added to each of these compounds, alcohol **C** was obtained from **A** and alcohol **D** with an asymmetric carbon atom was obtained from **B**. When each of the alcohol **C** and alcohol **D** was oxidized by a sulfuric acid acidic potassium dichromate aqueous solution, **C** did not change, but **D** changed to the compound. When iodine and aqueous sodium hydroxide solution were added to compound **E** and heated, d <u>yellow precipitate</u> was formed.

Q1　Please choose the compound names of the alcohol of the underlined part a　and
　　the aldehyde of the underlined part b in the article one by one from the following ①
　　to ⑨ and write them with a mark.

　　① Methanol　　　　② Acetaldehyde ③ Ethylene glycol
　　④ Vinyl alcohol　　⑤ 1-propanol　　　　⑥ Acetone
　　⑦ Ethanol　　　　 ⑧ Formaldehyde ⑨ Propionaldehyde

Q2　Please choose one of the following functional groups and bonds from ① to ⑥
　　that is not contained in underlined part c vinyl acetate in the text and write it with
　　a mark.

　　① Methyl group　　　　　　　　　　② 　Hydroxyl group
　　③ Carbon-carbon double bond（C＝C）　④ 　Vinyl group
　　⑤ Ester bond　　　　　　　　　　　⑥ Carbon-oxygen double bond（C＝O）

Q3   Please choose one of the following ① to ⑤ as the chemical formula for the yellow precipitate underlined part d in the text and write it with a mark.

① CH_3I ② CH_2I_2 ③ CHI_3 ④ CI_4
⑤ CH_3CH_2COONa

Q4   Please choose one of the following ① to ④ as the structural formula of alcohol **C** and write it with a mark.

① $CH_3-CH_2-CH_2-CH_2$
                          OH

② $CH_3-CH_2-CH-CH_3$
                          OH

③ $CH_3-CH-CH_2$
            CH_3 OH

④ CH_3-C-CH_3
            CH_3 OH

Q5   Please choose one of the following ① to ④ as the structural formula of Alkene **A** and write it with a mark.

① $CH_3-CH_2-CH=CH_2$

②
$$\underset{H\qquad\quad H}{\overset{CH_3\qquad\ CH_3}{C=C}}$$

③
$$\underset{H\qquad\quad CH_3}{\overset{CH_3\qquad\quad H}{C=C}}$$

④ $CH_3-C=CH_2$
            CH_3

Q6   Please choose one of the following ① to ④ as the structural formula of compound **E** and write it with a mark.

① $CH_3-CH_2-CH_2-\underset{O}{\overset{\|}{C}}-H$

② $CH_3-CH_2-\underset{O}{\overset{\|}{C}}-CH_3$

③ $CH_3-\underset{}{\overset{CH_3}{CH}}-\underset{O}{\overset{\|}{C}}-H$

④ $CH_3-CH_2-CH_2-\underset{O}{\overset{\|}{C}}-OH$

Question 5

lease read the following text and answer the following questions.

If compound **A** expressed by the molecular formula $C_{13}H_{11}NO_2$ is heated with hydrochloric acid, compound **B** and compound **C** are obtained by hydrolysis. The figure below shows the results of several reactions after separating compound **B** and compound **C** from the reaction solution after hydrolysis.
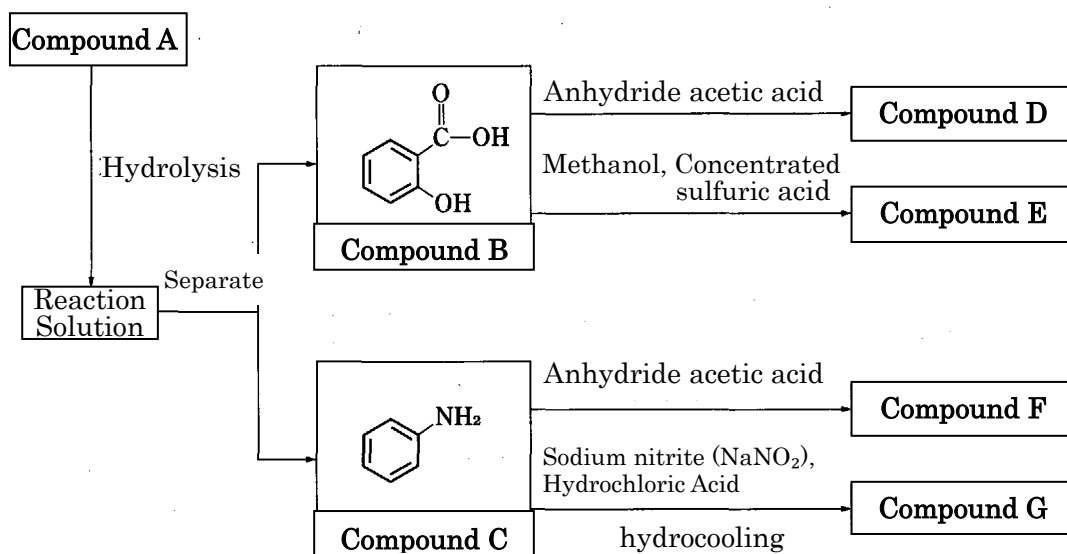
Q1   Please choose one of the following ① to ⑥ as the structural formula of compound **A** and write it with a mark.
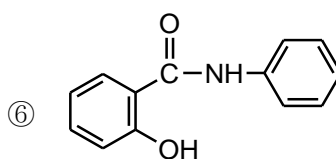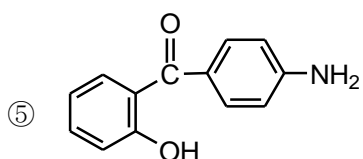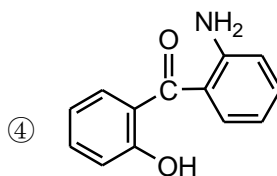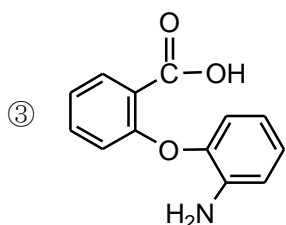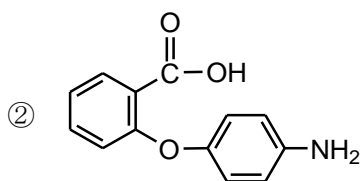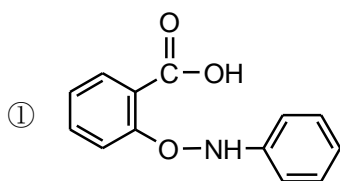
Q2   Please choose the names of compound **B** and compound **C** one by one from the following ① to ⑩ and write them with a mark.

 ① Nitrobenzene   ② Aniline   ③ Phenol
 ④ Acetylsalicylic acid ⑤ Methyl salicylate ⑥ Salicylic acid
 ⑦ Benzoic acid   ⑧ Phthalic acid   ⑨ Tere-phthalic acid
 ⑩ Iso-phthalic acid

Q3   Please choose one of the following ① to ④ as a right description of change that occurs when diethyl ether is added to the reaction solution in the figure, and write it with a symbol.
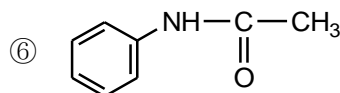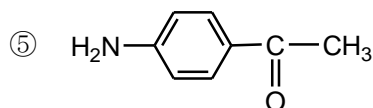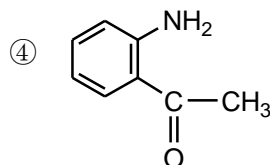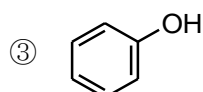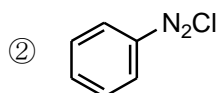
 ① Compound **B** dissolves as salt in the ether layer, and compound **C** remains in the aqueous layer.

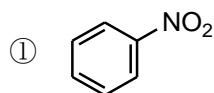 ② Compound **B** dissolves in the ether layer, and compound **C** remains in the aqueous layer as salt.

 ③ Compound **C** dissolves as salt in the ether layer, and compound **B** remains in the aqueous layer.

 ④ Compound **C** dissolves in the ether layer, and compound **B** remains in the aqueous layer as salt.

Q4   Please choose the aromatic compounds from ① to ③ below one by one that is corresponding to the following descriptions (1) and (2) and write them with a mark.

 (1) It does not change even if sodium bicarbonate aqueous solution is added.

 (2) The color of the solution does not change even if an aqueous solution of iron chloride (III) is added.

  ① Compound **B**   ② Compound **D**   ③ Compound **E**

Q5   Please choose the structural formulas of compound **F** and compound **G** one by one from the following ① to ⑥ and write them with a mark.

① ⟨benzene⟩–NO₂ $\quad$ ② ⟨benzene⟩–N₂Cl

③ ⟨benzene⟩–OH $\quad$ ④ ⟨benzene⟩ with NH₂ and C(=O)–CH₃

⑤ H₂N–⟨benzene⟩–C(=O)–CH₃ $\quad$ ⑥ ⟨benzene⟩–NH–C(=O)–CH₃

Q6   Please choose the aromatic compounds from ① to ⑦ below one by one that is corresponding to the following descriptions (1) and (2) and write them with a mark.

(1)   If sodium phenoxide is added to the aqueous solution, an orange-red pigment is formed.

(2)   After reacting benzene with a mixture of concentrated nitric acid and concentrated sulfuric acid, the formed yellow liquid is reduced with tin and concentrated hydrochloric acid to obtain an aqueous solution that is basic.

①   Compound **A**   ②   Compound **B**   ③   Compound **C**   ④   Compound **D**
⑤   Compound **E**   ⑥   Compound **F**   ⑦   Compound **G**