2019 Enrolment The 1$_{st}$

Japan University Examination

Chemistry

Examination Date: November 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 booklet contains 13 pages.

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 4 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'sNo.	Name

Atomic mass: H＝1.0，C＝12，N＝14，O＝16，Al＝27，S＝32，Cu＝63.5，Zn＝65

Unit volume: $1 \text{ L} = 1 \text{ dm}^3 = 1000 \text{ mL} = 1000 \text{ cm}^3$

Density: $1 \text{ g/cm}^3 = 1 \text{ g cm}^{-3}$

Molarity: $1 \text{ mol／L} = 1 \text{ mol L}^{-1} = 1 \text{ M} = 1 \text{ mol dm}^{-3}$

Heat per one mol: $1 \text{ kJ／mol} = 1 \text{ kJ mol}^{-1}$

Under standard condition (0℃, 1.013×10^5 Pa), molar volume of the gas is 22.4 L／mol ($= 22.4 \text{ L mol}^{-1}$)

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

Question 1

Please choose one from ① to ④ for the following questions of (1) to (8) and write your answers with number in the answer columns provided.

(1) The symbol for element Silver.

    ① Si   ② S   ③ Au   ④ Ag

(2) The atoms with **different** numbers of neutrons and protons

    ① ^{12}C ② ^{16}O ③ ^{23}Na ④ ^{28}Si

(3) The elementary substance which is liquid at normal temperature (25℃) and normal pressure (1.013×10^5 Pa).

    ① Hg   ② Cu   ③ Na   ④ Ar

(4) The molecule with a triple bond.

    ① Ammonia   ② Chlorine   ③ Nitrogen   ④ Carbon dioxide

(5) The description of elements which is **incorrect**

① The elements of group 1 except H are called alkali metal elements, and all are strong positive.

② The elements of group 13 are nonmetallic elements.

③ The elements of group 17 are called halogen elements, and all are strong negative.

④ The elements of Group 18 are called noble gas elements, all are present as monatomic molecules.

(6) There is concentrated sulfuric acid with a percent concentration of mass of 98 % and a density of 1.8 g/cm³. How much volume (mL) of concentrated sulfuric acid is needed when diluting this concentrated sulfuric acid with water to make 500 mL of 0.20 mol / L dilute sulfuric acid?

① 1.1   ② 2.8   ③ 5.6   ④ 11

(7) The description of acids and bases which is **incorrect**.

① Sodium hydroxide is a stronger base than magnesium hydroxide.

② The aqueous solution of carbon dioxide shows acidity.

③ 2 mol of the amount of substance of sodium hydroxide is needed to completely neutralize 1 mol of sulfuric acid.

④ When adding ammonia water to the blue litmus paper, it changes to red.

(8) The description of reduction–oxidation reaction which is **incorrect**

① In the oxidation-reduction reaction, there are atoms whose oxidation number increases and atoms whose oxidation number decreases.

② A substance that oxidizes other substances is called an oxidizing agent.

③ When calcium carbonate reacts with hydrochloric acid, calcium carbonate is reduced.

④ When hydrogen chloride is formed from chlorine and hydrogen, hydrogen acts as a reducing agent.

Question 2

(1) When 2.7 g of aluminum was completely burned, aluminum oxide Al_2O_3 was produced. Answer the following questions (a・b) about this.

  a How much mol is the amount of substance of 2.7 g aluminum? Please answer it with two significant figures.

  b How much is the volume of air required for completely burning aluminum, in the standard state (0℃, 1.013×10^5 Pa)? Please answer it with two significant figures. Here, it is assumed that the air is a mixed gas whose volume ratio of nitrogen and oxygen is 4:1.

(2) Please answer the following questions (a・b) about sulfur dioxide.

  a Among the operations ① to ⑤ below, Please choose one that does not generate sulfur dioxide.

  ① Add concentrated sulfuric acid to copper and heat it.
  ② Add dilute sulfuric acid to iron sulfide (Ⅱ).
  ③ Add dilute sulfuric acid to sodium bisulfite.
  ④ Burn sulfur.
  ⑤ Burn pyrite (main component FeS2).

  b About the descriptions about sulfur dioxide, Please choose one of ① to ⑤ that is **incorrect**.

  ① It is a colorless gas and has a pungent smell.
  ② It changes the color of potassium iodide starch paper moistened with water to bluish purple.
  ③ When passing through hydrogen peroxide water, sulfur dioxide acts as a reducing agent to produce sulfuric acid.
  ④ When passing through to hydrogen sulfide water, sulfur dioxide acts as an oxidizing agent to produce sulfur.
  ⑤ It is used as a bleaching agent for fibers by utilizing its reducing action.

(3) When the mixed gas of carbon monoxide and hydrogen was burned completely, 22.0g of carbon dioxide was formed. And the amount of heat generated at this time was 571 kJ. Pleas answer the following questions (a・b) about this. Here, assume that all the water generated by combustion is liquid and use the value of the enthalpy change below.

Standard enthalpy change of combustion of hydrogen :　　　$\Delta H° = -286 \, \text{kJ/mol}$
Standard enthalpy change of combustion of carbon monoxide :　$\Delta H° = -283 \, \text{kJ/mol}$
Standard enthalpy change of combustion of graphite :　　　　$\Delta H° = -394 \, \text{kJ/mol}$

a　Find the value of standard enthalpy change of formation (kJ/mol) of carbon monoxide and answer it as an integer.

b　The composition of the mixed gas before combustion was expressed as the ratio (CO:H$_2$) of s the amount of substance, and choose the most appropriate numeric form from the following ① to ⑤.

①　1 : 1　　②　1 : 2　　③　1 : 3　　④　2 : 1　　⑤　3 : 1

Question 3

(1)　Neutralization titration experiment were conducted to find the concentration of aqueous sodium hydroxide solution. Answer the following questions (a ～ c) about this experiment.

　　10.0 mL of an aqueous solution of oxalic acid ($H_2C_2O_4$) of 0.100 mol/L was put in a $_x$ whole pipette which was placed in a $_y$ conical beaker. After adding ┃　A　┃ as an indicator, a sodium hydroxide aqueous solution was dropped from the $_z$ burette and the color of the aqueous solution changed ┃　B　┃ when 12.5 mL of the sodium hydroxide aqueous solution was added so this point was taken as the neutralization point.

　　a　About the underlined part x ～ z of the laboratory glassware, which can be used while being wet with distilled water? Please choose one of the following ① to ⑥ that is the most appropriate.

　　① 　x　　　　　　　② 　y　　　　　　　③ 　z
　　④ 　x and y　　　　⑤ 　x and z　　　　⑥ 　y and z

　　b　About the name of the indicator ┃　A　┃ and ┃　B　┃ in the article above, choose one of the following ① to ⑥ hat is the most appropriate.

	A	B
①	Phenolphthalein	From colorless to light red
②	Phenolphthalein	From light red to colorless
③	Phenolphthalein	From light red to yellow
④	Methyl orange	From colorless to red
⑤	Methyl orange	From red to yellow
⑥	Methyl orange	From yellow to red

　　c　What is the concentration of sodium hydroxide aqueous solution in mol/L? Answer it with two significant figures.

(2)   Arrange the following aqueous solutions a ～ c in descending order of pH. Please choose one of ① to ⑥ that is correct.

   a   0.10 mol/L hydrochloric acid
   b   0.10 mol/L sodium hydroxide aqueous solution
   c   0.10 mol/L ammonia water

   ① a＞b＞c   ② a＞c＞b   ③ b＞a＞c
   ④ b＞c＞a   ⑤ c＞a＞b   ⑥ c＞b＞a

(3)   Please choose one of the following ① to ⑤ for the chemical equation in which the underlined substance acts as a reducing agent.

   ① $Cu + 4\underline{HNO_3} \longrightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2$
   ② $2Ag + 2\underline{H_2SO_4} \longrightarrow Ag_2SO_4 + 2H_2O + SO_2$
   ③ $FeS + 2\underline{HCl} \longrightarrow FeCl_2 + H_2S$
   ④ $H_2S + 2\underline{NaOH} \longrightarrow Na_2S + 2H_2O$
   ⑤ $K_2Cr_2O_7 + 3\underline{H_2O_2} + 4H_2SO_4 \longrightarrow Cr_2(SO_4)_3 + K_2SO_4 + 3O_2 + 7H_2O$

(4)   The following description (a・b) is about an experiment using three kinds of metals (A～C) of Al, Cu and Na. Please choose one of the following ① to ⑥ that is most appropriate as a combination of the metals A ～ C.

   a   A reacted with water at room temperature to generate hydrogen.
   b   When C is added to the aqueous sulfate solution of B, an elementary substance of B is separated.

	A	B	C
①	Al	Cu	Na
②	Al	Na	Cu
③	Cu	Al	Na
④	Cu	Na	Al
⑤	Na	Al	Cu
⑥	Na	Cu	Al

⑸　As shown in Figure 1 is a schematic diagram of a Daniel cell. Please choose one of ① to ⑤ that is correct about it.
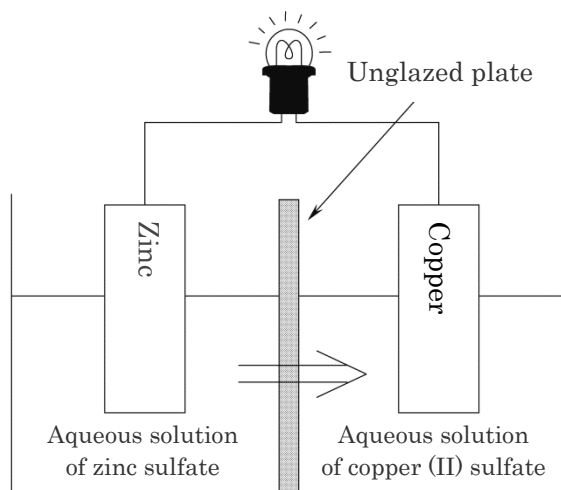
Fig. 1

① The negative electrode active material is zinc.
② In the positive electrode, copper (Ⅱ) ion is oxidized.
③ The current flows from the zinc plate through the miniature light bulb to the copper plate.
④ The sulfate ion moves through the unglazed plate in the direction of the arrow (⇒).
⑤ The masses of the positive electrode and the negative electrode does not change.

(6) Experiment of electrolysis was conducted through the device shown in Figure 2. The volume of the aqueous solution in each electrolytic cell before electrolysis was 1 L, and the concentration was 1 mol/L each. Please answer the following question (a・b) about this.
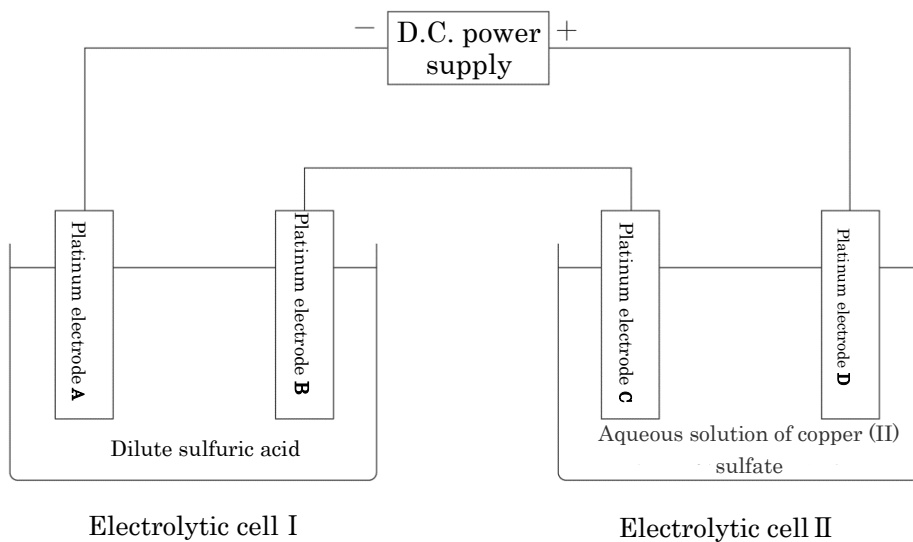

Fig.2

a   About the electrolysis in electrolytic cell Ⅰ, please choose one of ① to ⑤ that is correct.

① Oxidation reaction occurs at electrode A
② Hydrogen is generated at electrode A
③ The electrode B is the cathode.
④ In electrode B, platinum dissolves out as cation.
⑤ The amount of sulfuric acid in the aqueous solution decreases.

b Copper is separated at one of the electrode C and D in electrolytic cell Ⅱ, and gas is generated at the other electrode. As a graph shows the relation between the amount of substance of separated copper, the generated gas, and the electrical quantity, choose one of ① to ⑥ that is the most appropriate. Here, it is assumed that the Faraday constant is 9.65×10^4 C/mol.
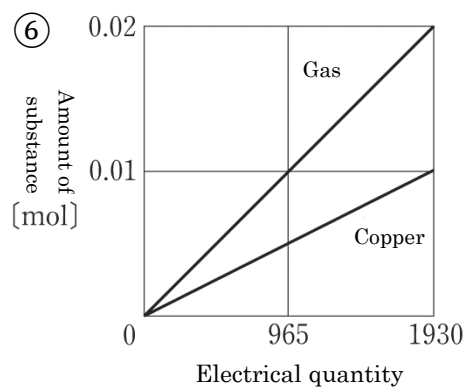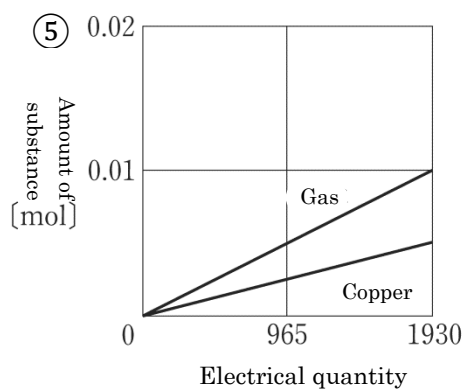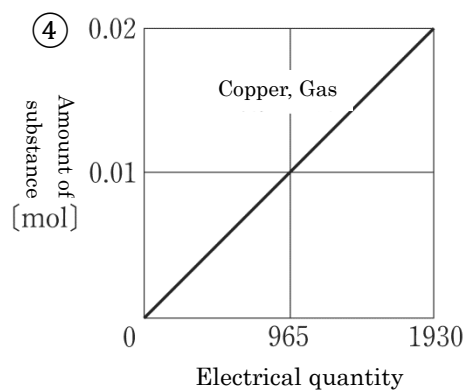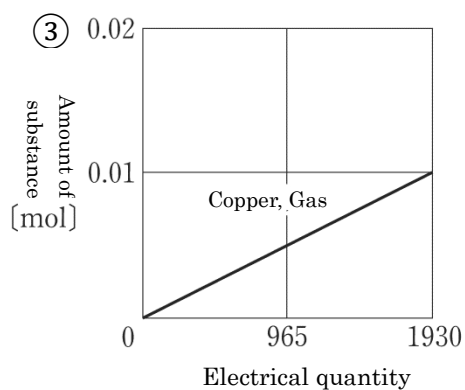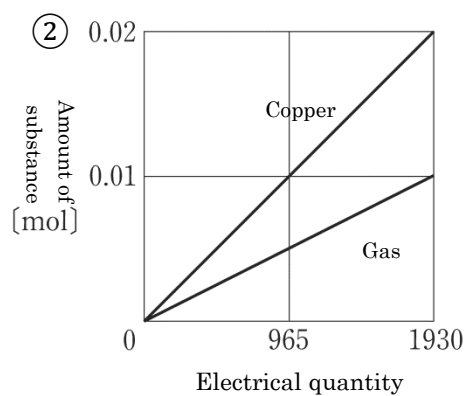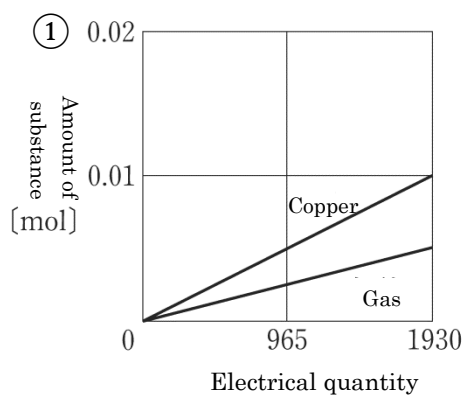
Question 4
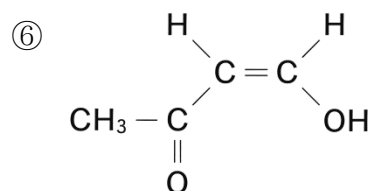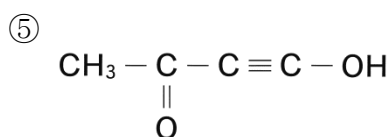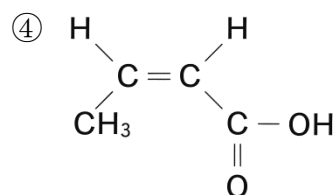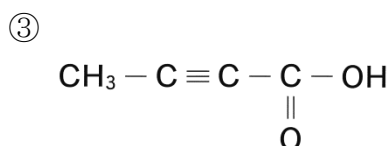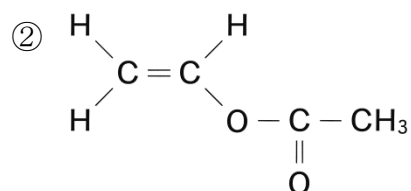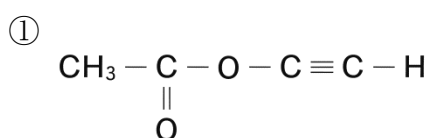
(1) Choose one of the following ① to ⑤ that is correct as a description about saturated hydrocarbons.

  ① A chain form is called an alkane, and a cyclic one is called a cycloalkane. When the number of carbon atoms is n, molecular formula for each is represented by the general formula C_nH_{2n+2}

  ② Methane dissolves very well in water.

  ③ Ethane reacts additionally with bromine to decolorize the reddish brown color of bromine.

  ④ Propane has all the carbon atoms in the molecule on the same straight line.

  ⑤ Butane is a gas at normal temperature (25℃) and normal pressure $(1.013 \times 10^5$ Pa), and it is used as fuel.

(2) Choose one of the following ① to ⑥ as the correct structural formula of the substance generated by the reaction of acetylene (ethyne) and acetic acid.
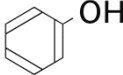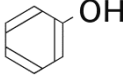
①
$$CH_3 - \underset{\underset{O}{\|}}{C} - O - C \equiv C - H$$

②
$$\underset{H}{\overset{H}{\diagdown}} C = C \overset{H}{\underset{O - \underset{\underset{O}{\|}}{C} - CH_3}{\diagup}}$$

③
$$CH_3 - C \equiv C - \underset{\underset{O}{\|}}{C} - OH$$

④
$$\underset{CH_3}{\overset{H}{\diagdown}} C = C \overset{H}{\underset{\underset{\underset{O}{\|}}{C} - OH}{\diagup}}$$

⑤
$$CH_3 - \underset{\underset{O}{\|}}{C} - C \equiv C - OH$$

⑥
$$\underset{CH_3 - \underset{\underset{O}{\|}}{C}}{\overset{H}{\diagdown}} C = C \overset{H}{\underset{OH}{\diagup}}$$

– 10 –
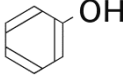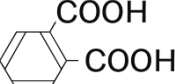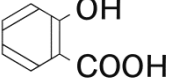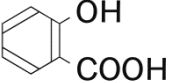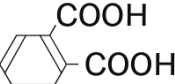
(3) Please choose one of the following ① to ⑥ as the correct combination of the numbers in the blank A and B in the following sentences.

There is (are) A kind(s) of structural isomers in the compound whose molecular formula is C₃H₈O. Among them, there is(are) B kind(s) of gas which react(s) with metal sodium to generate gas.

	A	B
①	1	1
②	2	1
③	2	2
④	3	1
⑤	3	2
⑥	3	3

(4)　Please choose one of the following ① to ⑥ as the correct combination of compounds about the sentences (a・b).

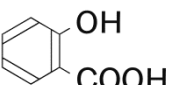　　a　The product generated when carbon dioxide is passed through an aqueous solution of sodium phenoxide

　　b　The materials for polyethylene terephthalate

	a	b
①	OH (phenol)	COOH (benzoic acid)
②	OH (phenol)	HOOC–⬡–COOH (terephthalic acid)
③	OH (phenol)	COOH, COOH (ortho, phthalic acid)
④	OH, COOH (salicylic acid)	COOH (benzoic acid)
⑤	OH, COOH (salicylic acid)	HOOC–⬡–COOH (terephthalic acid)
⑥	OH, COOH (salicylic acid)	COOH, COOH (ortho)

(5)　0.31 g of aniline was reacted with acetic anhydride to completely acetylate. How much g is the acetanilide generated at this time? Please answer it with two significant figures.

(6) Separation Operations are conducted with the diethyl ether solution containing aniline, benzoic acid, toluene. Choose one of the following ① to ⑥ that is most appropriate as a combination of aromatic compounds contained in ether layer Ⅱ and Ⅲ.

```
        ┌─────────────────────────────────────────┐
        │  Diethyl ether solution containing aniline, │
        │         benzoic acid, toluene            │
        └─────────────────────────────────────────┘
                        │ Add aqueous sodium hydroxide solution
         ┌──────────────┴───────────────┐
   ┌───────────┐                  ┌───────────┐
   │Water layer│                  │Ether layer│
   │     Ⅰ     │                  │     Ⅰ     │
   └───────────┘                  └───────────┘
  Add dilute hydrochloric          Add dilute hydrochloric acid
   acid and ether
   ┌─────┴─────┐                   ┌─────┴─────┐
┌────────┐ ┌────────┐          ┌────────┐ ┌────────┐
│Water   │ │Ether   │          │Water   │ │Ether   │
│layer Ⅱ │ │layer Ⅱ │          │layer Ⅲ │ │layer Ⅲ │
└────────┘ └────────┘          └────────┘ └────────┘
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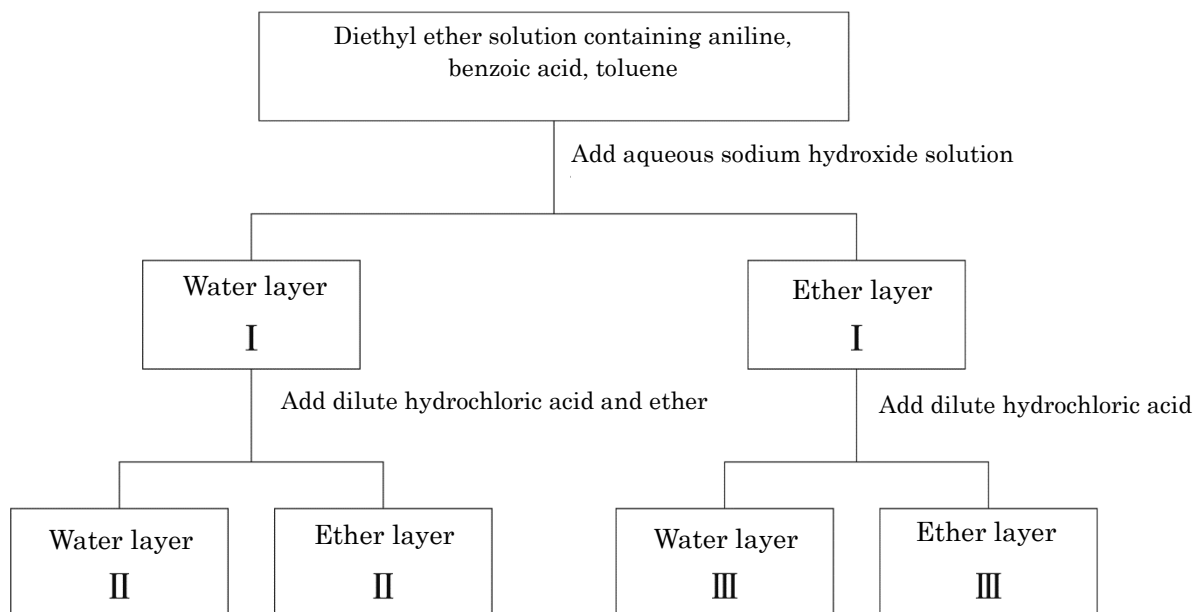
	Ether layer Ⅱ	Ether layer Ⅲ
①	Aniline	Benzoic acid
②	Aniline	Toluene
③	Benzoic acid	Aniline
④	Benzoic acid	Toluene
⑤	Toluene	Aniline
⑥	Toluene	Benzoic acid