2019 Enrolment The 1st

Japan University Examination

Advanced 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 16 pages.
2. The answer sheet is printed both-sided.
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'sNo.	Name

Atomic mass: H＝1.0, C＝12, N＝14, O＝16, Mg＝24, S＝32, Cu＝64

Avogadro's constant: N_A＝6.0×10^{23} /mol, Faraday constant: F＝9.65×10^4 C/mol

Unit volume: 1 L＝1 dm^3＝1000 mL＝1000 cm^3

     Density : 1 g/cm^3＝1 g cm^{-3}

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

     Heat per 1 mol :1 kJ/mol＝1 kJ mol^{-1}

Under standard condition (0℃, 1.013×10^5 Pa) molar volume of the gas is 22.4 L/mol

(＝22.4 L mol^{-1})

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

Question 1

    Please answer questions I and II.

I   The elements in the third period of the periodic table and the oxides with the maximum oxidation numbers are shown in the following table. Please answer the following questions about the elementary substance and oxides.

Group number	1	2	13	14	15	16	17
Element	Na	Mg	Al	Si	P	S	Cl
Maximum oxidation number	＋1	＋2	＋3	＋4	＋5	＋6	＋7
Oxides	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_3	Cl_2O_7

Q1 Please choose an elementary substance that does not react with cold water, but reacts with hot water to generate gas from the following ① to ⑦, and answer with the number.

     ① Na   ② Mg   ③ Al   ④ Si   ⑤ P   ⑥ S   ⑦ Cl

Q2   Please choose one **incorrect** description about the elementary substance and oxides
    from the following ① to ⑤, and answer with the number.

    ①   Aluminum dissolves in concentrated nitric acid and generates gas.
    ②   Chlorine water indicates acidity.
    ③   The elementary substance of Silicon is not produced naturally.
    ④   P4O10 is a white crystal and deliquescent.
    ⑤   When SiO2 is heated with sodium hydroxide, it becomes a glassy solid.

Q3 Al_2O_3 reacts with either acid or strong base. Answer the following (1) and (2).

(1)   What is such oxide called in general? Please choose one of the following ① to ④
    and answer with the number.

    ①   Basic oxide   ②   Acidic oxide   ③   Amphoteric oxide   ④   Oxyacid

(2)   About the change that occurs when Al_2O_3 is dissolved in concentrated sodium
    hydroxide aqueous solution, which chemical equation is correct? Choose one of the
    following ① to ④ and answer with the number.

    ① $Al_2O_3 + 3 H_2O + 2 NaOH \longrightarrow 2 Na[Al(OH)_4]$
    ② $Al_2O_3 + 7 H_2O + 2 NaOH \longrightarrow 2 Na[Al(OH)_6] + 2 H_2$
    ③ $Al_2O_3 + 6 NaOH \longrightarrow 2Al(OH)_3 + 3 Na_2O$
    ④ $Al_2O_3 + 3 H_2O + 6 NaOH \longrightarrow 2 Na_3[Al(OH)_6]$

II   It is known that solutions A $\sim$ C are aqueous solutions containing one kind of salt of the following ① to ⑤.

  ① $CuSO_4$ ② $ZnCl_2$ ③ $AlCl_3$ ④ $Fe(NO_3)_3$ ⑤ $FeSO_4$

  For the aqueous solutions A $\sim$ C, the following operations were conducted. Please answer the following questions with reference to these operations.

  As ammonia water was added to the aqueous solution A, a bluish white color precipitated at the beginning, but as the ammonia water was added more, the precipitate dissolved and became a (a) deep blue aqueous solution. In addition, when a barium chloride aqueous solution was added to the aqueous solution A, precipitation occurred.

  When ammonia water was added to the aqueous solution B, a white precipitate occurred. As ammonia water was added more, the precipitate dissolved to a colorless aqueous solution. Also, (b) when a silver nitrate aqueous solution was added to the aqueous solution B, a white precipitate occurred.

  When ammonia water was added to the aqueous solution C, a reddish-brown precipitate occurred. This precipitate did not dissolve even when ammonia water was added more.

Q4   What is the salt contained in aqueous solution A, B and C? Please choose one from the above ① to ⑤ and answer with the number.

Q5   What are the compounds or ions that are deep blue in the underlined part (a) ? Please choose one of the following ① to ⑥ and answer with the number.

  ① $[Cu(OH)_4]^{2-}$ ② $[Fe(OH)_6]^{3-}$ ③ $[Fe(OH)_6]^{4-}$
  ④ $[Cu(NH_3)_4]^{2+}$ ⑤ $[Fe(NH_3)_6]^{3+}$ ⑥ $[Fe(NH_3)_6]^{2+}$

Q6   About the change in the underlined part (b), which is correctly expressed as an ionic equation? Please choose one of the following ① to ④ and answer with the number.

  ① $2\,Ag^+ + SO_4{}^{2-} \longrightarrow Ag_2SO_4$
  ② $Ag^+ + Cl^- \longrightarrow AgCl$
  ③ $Zn^{2+} + 2\,OH^- \longrightarrow Zn(OH)_2$
  ④ $Al^{3+} + 3\,OH^- \longrightarrow Al(OH)_3$

Question 2

Please answer questions I and II.

I　Read the article below and please answer the following questions.

　200 g of water was placed in a container made of expanded polystyrene, then 8.0 g of ammonium nitrate was added and stirred. The temperature of the aqueous solution changed as shown in the following graph.
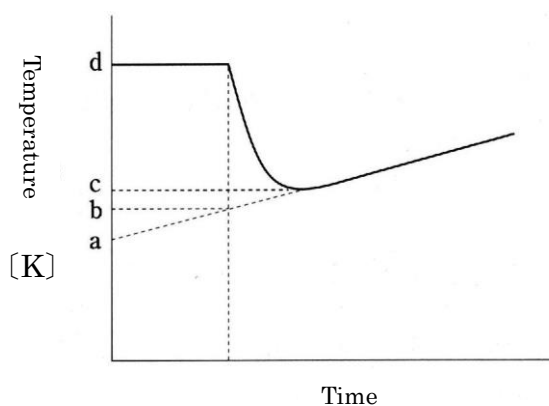
Q1　In this experiment, choose the most appropriate formula as the temperature change $\triangle t$ 〔K〕 when calculating the heat of dissolution of ammonium nitrate. Please choose one of the following ① to ⑥ and answer with the number.

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

Q2　The value of $\triangle t$ obtained from this experiment is 3.0 K. How much kJ is the enthalpy change when 8.0 g of ammonium nitrate is dissolved? Please choose the most appropriate value from the following ① to ⑥ and answer with the number. Here, the heat capacity of the ammonium nitrate aqueous solution is set to $C_p = 4.2$ J/(g·K).

　　①　−262 kJ　　　②　−26.2 kJ　　　③　−2.62 kJ
　　④　2.62 kJ　　　⑤　26.2 kJ　　　⑥　262 kJ

Q3   How much kJ/mol is the dissolution enthalpy of ammonium nitrate? Please choose
the most appropriate value from the following ① to ⑥ and answer with the number.

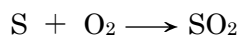① −262 kJ/mol   ② −131 kJ/mol   ③ −26.2 kJ/mol
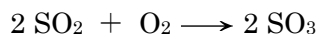
④ 26.2 kJ/mol   ⑤ 131 kJ/mol   ⑥ 262 kJ/mol

Ⅱ Read the article below and please answer the following questions.

 In order to produce sulfuric acid industrially, first, burn the sulfur obtained from petroleum refining in air.

$$S + O_2 \longrightarrow SO_2$$

 Next, oxidize the sulfur dioxide moreover in the presence of vanadium oxide (V).

$$2\,SO_2 + O_2 \longrightarrow 2\,SO_3$$

 Further, the produced sulfur trioxide is absorbed into concentrated sulfuric acid and becomes fuming sulfuric acid, and dilute sulfuric acid is added to obtain concentrated sulfuric acid which is commercially available.

Q4 Please choose one of the following ① to ④ that is the most appropriate as the function of the underlined material and answer with a number.

  ① Oxidant agent   ② Reducing agent   ③ Catalyst   ④ Desiccant

Q5 Please choose one of the following descriptions ① to ⑤ that is **incorrect** about the properties of sulfuric acid and answer with a number.

  ① Dilute sulfuric acid reacts with metals such as iron and generates hydrogen.
  ②   The heated concentrated sulfuric acid reacts with copper and generates hydrogen.
  ③ When concentrated sulfuric acid is added to the powder of glucose, it turns black.
  ④ To make dilute sulfuric acid, add concentrated sulfuric acid little by little to water.
  ⑤ Hydrogen chloride is generated when concentrated sulfuric acid is added to salt and heated.

Q6 How many kg of 98 % concentrated sulfuric acid can be obtained from 64 kg of raw material sulfur ? Choose the most appropriate answer from the following ① to ⑥ and answer with the number. Here, it is assumed that all of the raw material sulfur has changed to sulfuric acid.

  ① 98 kg   ② 100 kg   ③ 196 kg
  ④ 200 kg   ⑤ 392 kg   ⑥ 400 kg

Question 3

Please answer questions I and II.

Ⅰ Read the article below and please answer the following questions.

When passing gaseous chlorine through the potassium iodide aqueous solution, the next reaction ① occurs and the aqueous solution turns brown.

$$2 \text{ KI } + \text{ Cl}_2 \longrightarrow 2 \text{ KCl } + \text{ I}_2 \qquad \qquad ……①$$

In this reaction, iodide ions in solution $\boxed{\text{ A }}$ electrons and the oxidation number $\boxed{\text{ B }}$. On the other hand, chlorine $\boxed{\text{ C }}$ electrons and oxidation number $\boxed{\text{ D }}$. At this time, potassium iodide works as a(an) $\boxed{\text{ a }}$ and chlorine works as a(an) $\boxed{\text{ b }}$. In addition, although the produced iodine is insoluble in water, it reacts with unreacted iodide ion and dissolves in water, and the solution turns brown.

On the other hand, <u>sulfuric acid is added to the potassium iodide aqueous solution to make it acidic, and when hydrogen peroxide water is added, iodine is produced</u>. At this time, hydrogen peroxide changes as in the following reaction ②

$$\text{H}_2\text{O}_2 + 2 \text{ H}^+ + 2\text{e}^- \longrightarrow 2 \text{ H}_2\text{O} ……②$$
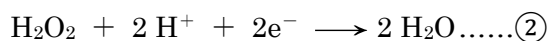
Q1 Please choose one of the following ① to ④ as the combination of words appropriate for the blanks $\boxed{\text{ A }}$ to $\boxed{\text{ D }}$ in the article above and answer with a number.

	A	B	C	D
①	Accept(s)	Increase(s)	Release(s)	Decrease(s)
②	Accept(s)	Decrease(s)	Release(s)	Increase(s)
③	Release(s)	Increase(s)	Accept(s)	Decrease(s)
④	Release(s)	Decrease(s)	Accept(s)	Increase(s)

Q2 Please choose one of the following ① to ④ as the most appropriate words for the blanks $\boxed{\text{ a }}$ and $\boxed{\text{ b }}$ in the article above and answer with a number for each.

① Coagulant   ② Deicing agent   ③ Oxidant   ④ Reducing agent

Q3　Please choose one of the following substances ① to ④ that has the biggest oxidation number of the element underlined and answer with the number.

　　① H$_2$$\underline{O}$$_2$　　② K$_2$$\underline{Cr}$$_2O_7$　　③ H$\underline{N}$O$_3$　　④ $\underline{Mn}$O$_2$

Q4　Please choose one of the following reactions ① to ④ that is not a redox reaction and answer with a number.

　　①　MnO$_2$ ＋ 4 HCl ⟶ MnCl$_2$ ＋ 2 H$_2$O ＋ Cl$_2$
　　②　Cu ＋ 2 H$_2$SO$_4$ ⟶ CuSO$_4$ ＋ 2 H$_2$O ＋ SO$_2$
　　③　2 K$_2$CrO$_4$ ＋ H$_2$SO$_4$ ⟶ K$_2$Cr$_2$O$_7$ ＋ K$_2$SO$_4$ ＋ H$_2$O
　　④　2 FeSO$_4$ ＋ H$_2$O$_2$ ＋ H$_2$SO$_4$ ⟶ Fe$_2$(SO$_4$)$_3$ ＋ 2 H$_2$O

Q5　About the underlined part in the article, which chemical equation is correct?
　　Please choose one of the following ① to ④ and answer with the number.

　　①　2 KI ＋ H$_2$SO$_4$ ＋ H$_2$O$_2$ ⟶ I$_2$ ＋ K$_2$SO$_4$ ＋ 2 H$_2$O
　　②　2 KI ＋ H$_2$O$_2$ ⟶ I$_2$ ＋ 2 KOH
　　③　2 KI ＋ 2 H$_2$SO$_4$ ＋ H$_2$O$_2$ ⟶ I$_2$ ＋ O$_2$ ＋ 2 KOH ＋ 2 H$_2$O ＋ 2 SO$_2$
　　④　2 KI ＋ 2 H$_2$SO$_4$ ＋ H$_2$O$_2$ ⟶ I$_2$ ＋ O$_2$ ＋ K$_2$SO$_3$ ＋ 3 H$_2$O ＋ SO$_2$

Q6   A certain amount of gaseous chlorine was passed through 20 mL of a 0.10 mol/L potassium iodide aqueous solution to react all the chlorine. As taking 10 mL of this reaction solution and dropping 0.10 mol/L sodium thiosulfate aqueous solution from Burette, 3.8 mL was needed up to the end point. The ionic equation of the change at this time is as follows.

$$I_2 \ + \ 2\,S_2O_3{}^{2-} \ \longrightarrow \ 2\,I^- \ + \ S_4O_6{}^{2-}$$

In the above description, please answer questions (1) and (2).

(1)   How much mol of iodine is contained in 10 mL of the reaction solution? Please choose the most appropriate one from the following ① to ⑥ and answer with the number.

  ① 4.75×10^{-5} mol   ② 9.50×10^{-5} mol   ③ 1.90×10^{-4} mol
  ④ 2.85×10^{-4} mol   ⑤ 3.80×10^{-4} mol   ⑥ 7.60×10^{-4} mol

(2)   How many mL is the volume of chlorine passed through in the standard state (0℃, 1.013×10^5 Pa)? Please choose the most appropriate one from the following ① to ⑥ and answer with the number.

  ① 2.1 mL   ② 2.8 mL   ③ 4.3 mL
 ④ 5.7 mL   ⑤ 8.5 mL   ⑥ 17 mL

Ⅱ Please answer the questions below.

Q7 Please choose one of the following descriptions ① to ⑤ that is **incorrect** and answer with a number.

① Diffusion is not only seen in gas molecules, but also in molecules in solution or in ions.

② As gaseous carbon dioxide is pressurized at 0℃ it becomes liquid.

③ When lowering the external pressure, the boiling point falls.

④ A real gas approaches an ideal gas at high temperature and low pressure.

⑤ Ideal gas is a gas without molecular mass and intermolecular force.

Q8 1 mol of nitrogen was enclosed in a container which the volume V can be changed freely. Heat it from 0℃ to 100℃ at 1.0×10^5 Pa and lower the pressure P when keeping the temperature at 100℃. Please choose one of the following graphs ① to ⑥ as the most appropriate one showing the change state of the pressure P and the volume V at this time and answer with a number.
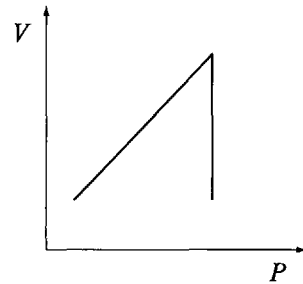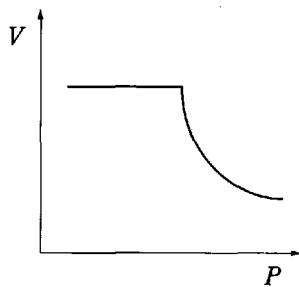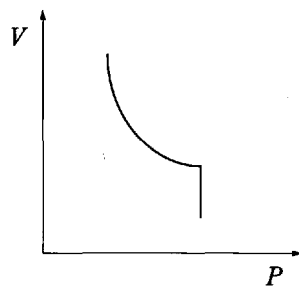
①

V

P

②

V
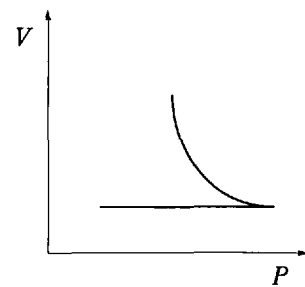
P

③

V

P

④

V

P

⑤

V

P

⑥

V

P
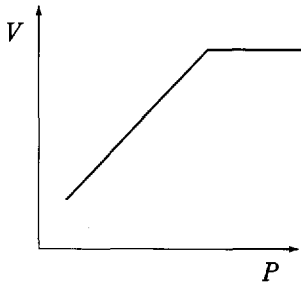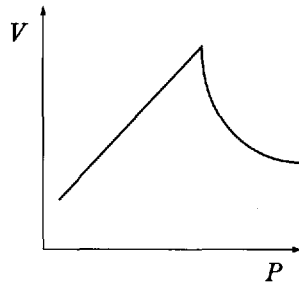
Question 4

Please answer questions I and II.

Ⅰ   Read the article below and answer the following questions.

Completely burning 26.4 mg of Compound A, consisting of carbon, hydrogen, and oxygen with a molecular weight of 100 or less, 52.8 mg of carbon dioxide and 21.6 mg of water were obtained. When A was hydrolyzed, carboxylic acid B and alcohol C were obtained. When B was added an ammoniacal silver nitrate aqueous solution, silver was separated. Also, when iodine and sodium hydroxide aqueous solution were added to C and heated up, a yellow precipitate D was formed.

Q1   As the composition formula of compound A, choose the most appropriate one of the following ① to ④ and answer with a number.

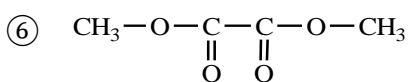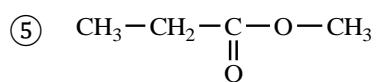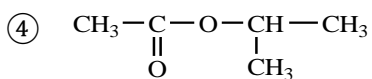① CHO   ② CH_2O ③ C_2H_2O ④ C_2H_4O

Q2   As the structural formula of carboxylic acid B, choose the most appropriate one of the following ① to ④ and answer with a number.

①   H—C—OH   ② CH_3—C—OH
          ‖   ‖
          O   O

③ CH_3—CH_2—C—OH   ④   HO—C—C—OH
                        ‖   ‖   ‖
                        O   O   O

Q3   As the molecular formula of yellow precipitate D, Please choose the most appropriate one of the following ① to ④ and answer with a number.

① CH_3I ② CH_2I_2 ③ CHI_3 ④ CI_4

Q4 As the structural formula of compound A, please choose the most appropriate one of the following ① to ⑥ and answer with a number.

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

② $H-\underset{\underset{O}{\|}}{C}-O-\underset{\underset{CH_3}{|}}{CH}-CH_3$

③ $CH_3-\underset{\underset{O}{\|}}{C}-O-CH_2-CH_3$

④ $CH_3-\underset{\underset{O}{\|}}{C}-O-\underset{\underset{CH_3}{|}}{CH}-CH_3$

⑤ $CH_3-CH_2-\underset{\underset{O}{\|}}{C}-O-CH_3$

⑥ $CH_3-O-\underset{\underset{O}{\|}}{C}-\underset{\underset{O}{\|}}{C}-O-CH_3$
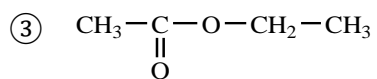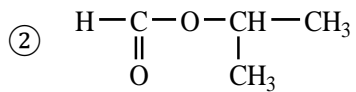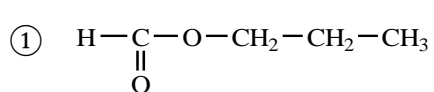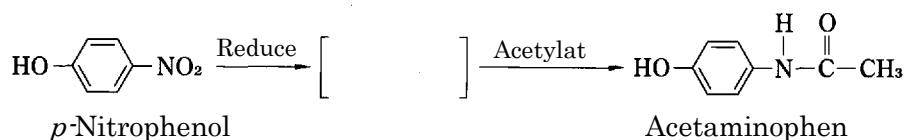
II Read the article below and answer the following questions.

    There are various kinds of medicines; ethanol, hydrogen peroxide solution, etc. are
used as ⌞ 1 ⌟, and aspirin, acetaminophen, etc. are used as ⌞ 2 ⌟. Also, some inorganic
compounds are used as medicines, and some digestive medicines containing
    ⌞ 3 ⌟ are used to neutralize stomach acid. Also, since ⌞ 4 ⌟ is stable and insoluble
even in an acidic solution, it is sometimes used as a contrast agent in X-ray examination
of digestive organs.

Q5 Please choose one of the following ① to ⑧ as the words appropriate for the blanks
    ⌞ 1 ⌟ to ⌞ 4 ⌟ in the article above and answer with a number.

    ① Antibiotic(S)   ② Antipyretic analgesic(S)   ③ Poultice(S)
    ④ Antiseptic(S)   ⑤ Sodium chloride   ⑥ Barium sulfate
    ⑦ Barium carbonate   ⑧ Sodium hydrogen carbonate

Q6 Acetaminophen is made from *p*-nitrophenol as shown below. As the structural
    formula of the compound in 〔   〕 , choose the most appropriate one of the
    following ① to ⑥ and answer with a number.

$$HO-\!\!\bigcirc\!\!-NO_2 \xrightarrow{\text{Reduce}} \left[\qquad \right] \xrightarrow{\text{Acetylat}} HO-\!\!\bigcirc\!\!-\overset{\overset{H}{|}}{N}-\overset{\overset{O}{||}}{C}-CH_3$$

        p-Nitrophenol   Acetaminophen

① $HO-\!\!\bigcirc\!\!-NH_2$ ② $\bigcirc\!\!-NH_2$

③ $HO-\!\!\bigcirc\!\!-NH-OH$ ④ $\bigcirc\!\!-NH-OH$

⑤ $HO-\!\!\bigcirc\!\!-NH-\overset{\overset{O}{||}}{C}-H$ ⑥ $\bigcirc\!\!-NH-\overset{\overset{O}{||}}{C}-H$

Question 5

Read the article below and answer the following questions.

When an aqueous ninhydrin solution is added to glycine which is an α-amino acid and heated, it becomes ⬚1⬚. In the crystal of glycine, the carboxy group of glycine exists as an ion by providing hydrogen ions to an amino group in the molecule. Such ions are called ⬚2⬚. Therefore, the melting point of glycine is higher than that of benzene with the same molecular weight.

There is a peptide X. (a) It did not change even when an aqueous copper sulfate (II) solution was added after adding aqueous sodium hydroxide solution to the aqueous solution of peptide X to make it basic. Also, (b)when concentrated nitric acid was added to the aqueous solution of peptide X and heated, it became ⬚3⬚, and when ammonia water was added moreover, it became orange-yellow.

Q1   Please choose one of the following ① to ⑨ as the words appropriate for the blanks ⬚1⬚ to ⬚3⬚ in the article above and answer with a number.

   ① Positive ion(S)   ② Negative ion(S)   ③ Zwitterion(S)
   ④ Complex ion(S)   ⑤ Yellow   ⑥ Reddish-purple
   ⑦ Reddish-brown   ⑧ Black   ⑨ Blue

Q2   Peptide X has been found to be composed of several of the following amino acids (A) to (D). Please answer the following (1)~(3).

   (A) Alanine   (B) Serine   (C) Cysteine   (D) Tyrosine

(1)   From the underlined part (a), how many amino acids are constituting peptide X? Please choose the most appropriate one of the following ① to ⑥ and answer with a number.

   ① 1   ② 2   ③ 3   ④ 4   ⑤ 5   ⑥ 6

(2) From underlined part (b), which amino acid contained in peptide X is presumed to be (A) to (D)? Please choose the most appropriate one of the following ① to ④ and answer with a number.

① (A)   ② (B)   ③ (C)   ④ (D)

(3) How many kinds of peptides are considered as peptide X? Please choose the most appropriate one of the following ① to ⑥ and answer with a number. In addition, it is assumed that all the amino acids constituting X are different, and the stereoisomers is negligible.

① 1   ② 2   ③ 3   ④ 4   ⑤ 5   ⑥ 6