

2011 Examination for Japanese University Admission  
for International Students

# Science (80min.)

## 【Physics, Chemistry, Biology】

- ※ Choose and answer two subjects.
- ※ Answer the questions using the front side of the answer sheet for one subject, and the reverse side for the other subject.

### I Rules of Examination

1. Do not leave the room without the proctor's permission.
2. Do not take this question booklet out of the room.

### II Rules and Information Concerning the Question Booklet

1. Do not open this question booklet until instructed.
2. After instruction, write your name and examination registration number in the space provided below, as printed on your examination voucher.
3. The pages of each subject are as in the following table.

Subject	Pages
Physics	1 – 21
Chemistry	23 – 32
Biology	33 – 45

4. If your question booklet is missing any pages, raise your hand.
5. You may write notes and calculations in the question booklet.

### III Rules and Information Concerning the Answer Sheet

1. You must mark your answers on the answer sheet with an HB pencil.
2. Each question is identified by one of the row numbers **1**, **2**, **3**, ...  
Follow the instruction in the question and completely black out your answer in the corresponding row of the answer sheet (mark-sheet).
3. Make sure also to read the instructions on the answer sheet.

- ※ Once you are informed to start the examination, fill in your examination registration number and name.

Examination registration number			*				*					
Name												



# Physics

## Marking your Choice of Subject on the Answer Sheet

Choose and answer two subjects from Physics, Chemistry, and Biology. Use the front side of the answer sheet for one subject, and the reverse side for the other subject.

As shown in the example on the right, if you answer the Physics questions, circle “Physics” and completely fill in the oval under the subject name.

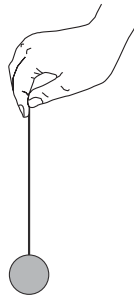
<Example>

解答科目 Subject		
物理 Physics	化学 Chemistry	生物 Biology
●	○	○

**If you do not correctly fill in the appropriate oval, your answers will not be graded.**

**I** Answer questions **A ( Q 1 )**, **B ( Q 2 )**, **C ( Q 3 )**, **D ( Q 4 )**, **E ( Q 5 )**, **F ( Q 6 )**, and **G ( Q 7 )** below, where  $g$  denotes the magnitude of acceleration due to gravity, and air resistance is negligible.

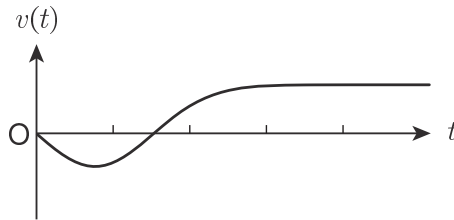
**A** An object whose mass is 0.50 kg is suspended from a string, and is made to move by moving the upper end of the string. Consider the magnitude of the pulling force exerted on the object by the string.



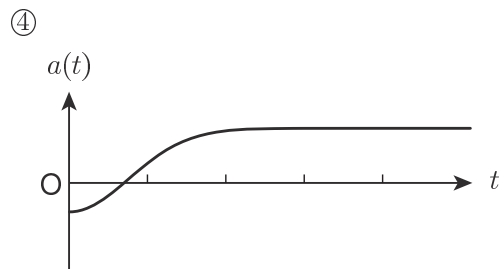
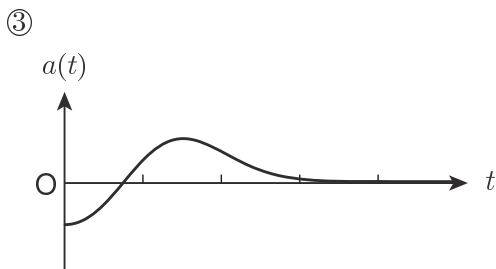
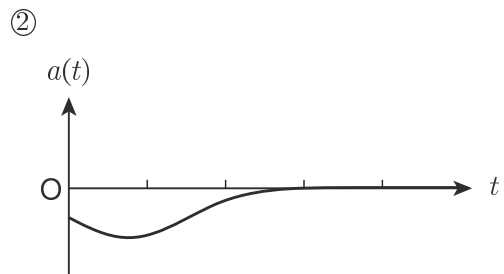
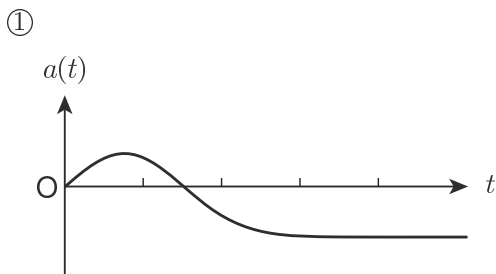
**Q1** When the object moves vertically upward with uniform acceleration (linear motion) of  $2.8 \text{ m/s}^2$ , the magnitude of tension is , and when the object moves vertically downward with uniform velocity (linear motion) of  $1.4 \text{ m/s}$ , the magnitude of tension is . From ①-⑥ below choose the combination of values that best fills blanks  and  above, where  $g = 9.8 \text{ m/s}^2$ . **1**

	a	b
①	3.5 N	4.2 N
②	3.5 N	4.9 N
③	3.5 N	5.6 N
④	6.3 N	4.2 N
⑤	6.3 N	4.9 N
⑥	6.3 N	5.6 N

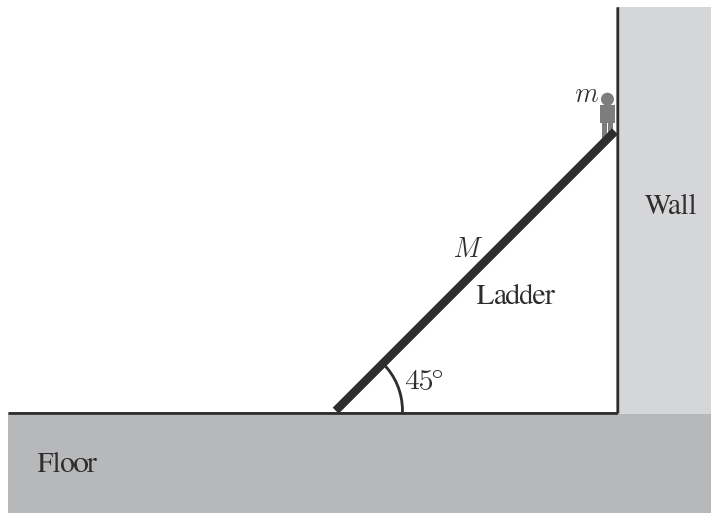
**B** Consider a small ball that moves on an  $x$ -axis. The ball's velocity at time  $t$ , denoted as  $v(t)$ , changes with  $t$  as shown in the graph below.



**Q2** From ①-④ below choose the graph that best represents the change in the ball's acceleration at time  $t$ , denoted as  $a(t)$ . 2



**C** As shown in the figure below, a uniform ladder of mass  $M$  is leaned against a vertical wall so as to form an angle of  $45^\circ$  with the horizontal floor. The wall is smooth, and the coefficient of static friction between the floor and the ladder is  $\frac{2}{3}$ . The center of mass of the ladder is at its geometric center.

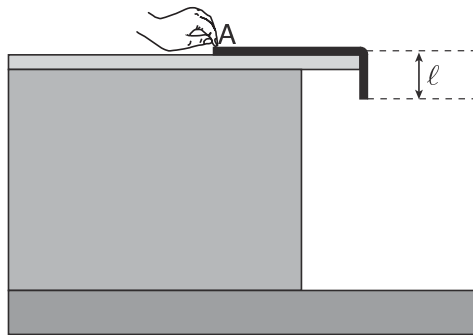


**Q3** When a person of mass  $m$  stands at the top of the ladder, the ladder does not slide if  $m < x$ , but slides if  $m > x$ . From ①-④ below choose the answer that best indicates mass  $x$ .

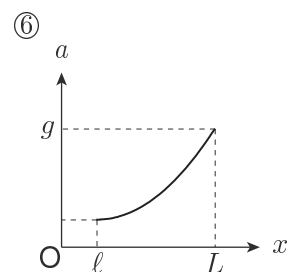
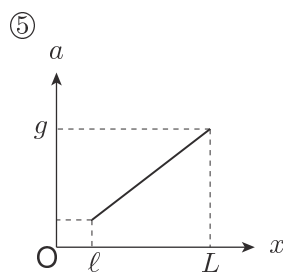
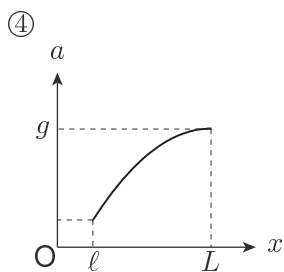
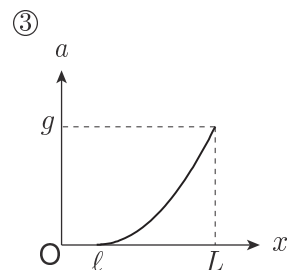
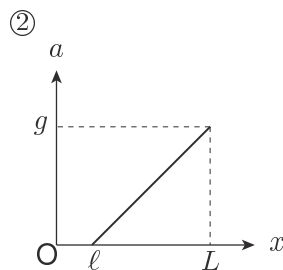
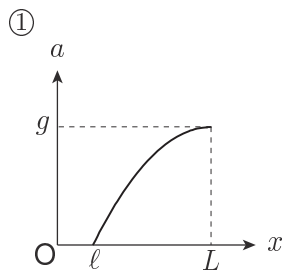
$x =$  **3**

- ①  $2M$                       ②  $\frac{3}{2}M$                       ③  $\frac{2}{3}M$                       ④  $\frac{1}{2}M$

**D** As shown in the figure below, a uniform string of length  $L$  is partially placed on top of a table, and the rest of the string is suspended vertically from the edge of the table. The string's end on the table, **A**, is fixed in place so that the portion of the string suspended from the table has length  $\ell$ . Next, **A** is released and the string begins sliding on top of the table. The table's surface is horizontal, and friction between it and the string is negligible.



**Q4** From ①-⑥ below choose the graph that best represents the relationship between the magnitude of acceleration of **A** (denoted as  $a$ ) and the length of the suspended portion of the string (denoted as  $x$ ). 4



**E** A weight of mass  $m$  is attached to the bottom end of a suspended spring. As shown in Figure 1 below, initially the weight is supported with a board so that the spring is at its natural length. Next, the board is gently lowered. When the spring has extended distance  $d$  as shown in Figure 2, the weight separates from the board and comes to rest.

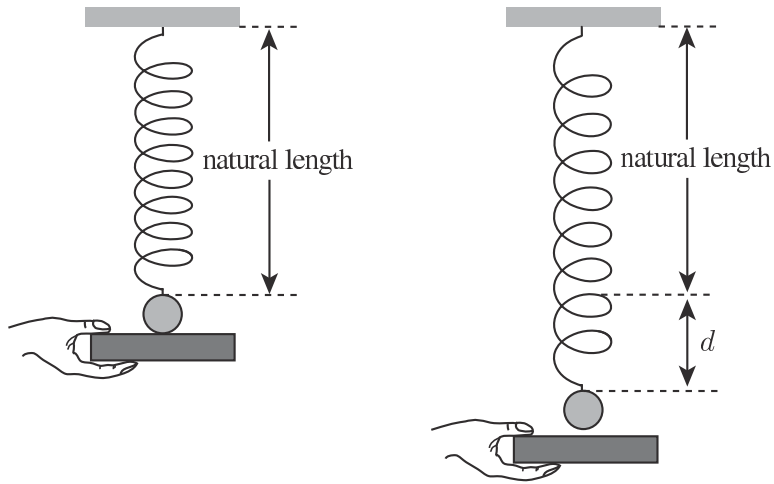


Figure 1

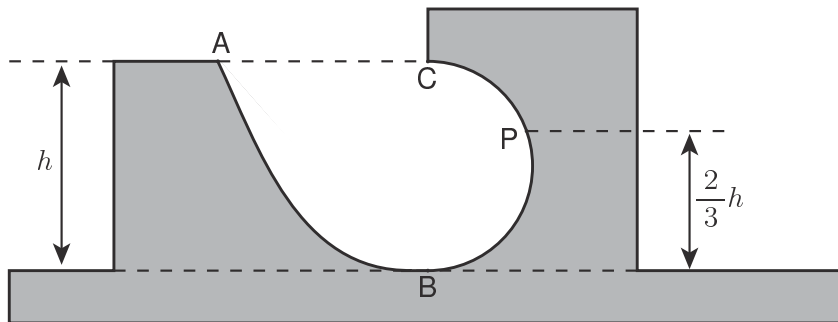
Figure 2

**Q5** Let the total mechanical energy of the spring and the weight be defined as  $U_1$  for the state in Figure 1, and as  $U_2$  for the state in Figure 2. What is  $(U_2 - U_1)$ ? From ①-⑤ below choose the correct answer. **5**

- ①  $-mgd$                       ②  $-\frac{1}{2}mgd$                       ③  $0$
- ④  $\frac{1}{2}mgd$                       ⑤  $mgd$



**F** The figure below shows a vertical cross section of a smooth curved surface. Points A, B, and C on the curved surface are located on the same vertical plane. Both A and C are positioned at height  $h$  from B, and the curve BC is a semicircle with a diameter of  $h$ . A small object of mass  $m$  is released from A with an initial speed of zero and travels along the curved surface.



**Q6** Let us define a point P on curve BC whose height is  $\frac{2}{3}h$  from B. What is the magnitude of the centripetal force acting on the object when it passes P? From ①-⑥ below choose the best answer. **6**

①  $\frac{2}{3}mg$

②  $mg$

③  $\frac{4}{3}mg$

④  $\frac{5}{3}mg$

⑤  $2mg$

⑥  $4mg$

**G** The International Space Station (ISS), acted upon by universal gravitation, travels with constant speed in a circular orbit at height  $h$  above the earth's surface.

**Q7** What is the magnitude of the centripetal acceleration of the ISS? From ①-⑤ below choose the correct answer, where the earth's radius is  $R$  and the magnitude of acceleration due to gravity at the earth's surface is  $g$ . **7**

①  $\frac{R^2}{(R+h)^2}g$

②  $\frac{R}{R+h}g$

③  $g$

④  $\frac{R+h}{R}g$

⑤  $\frac{(R+h)^2}{R^2}g$

**II** Answer questions **A** ( Q1 ), **B** ( Q2 ), and **C** ( Q3 ) below.

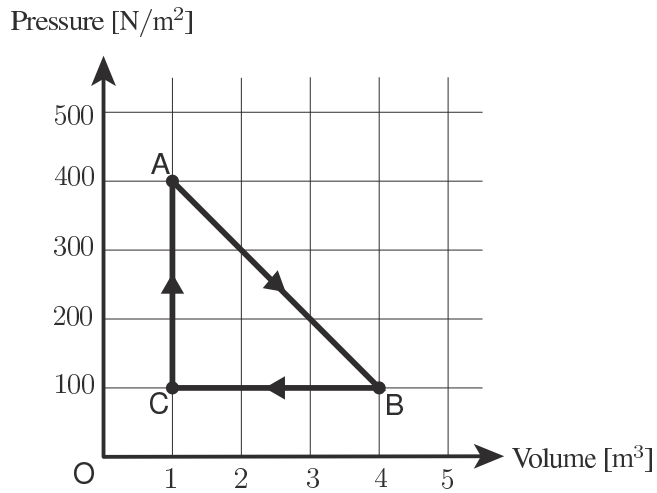
**A** A container equipped with a heater holds 2.0 kg of water at 20°C. Upon being heated by the heater for 42 minutes, the water's temperature reaches 80°C. At that point, 1.0 kg of water at 20°C is added to the water in the container, and the water continues to be heated with the same heater. Here, evaporation is negligible, the quantity of heat emitted by the heater per unit time remains constant, and all of the heat is transferred to the water in the container, without escaping to the container or the environment. Use the value 4.2 J/(g·K) for the specific heat of water.

**Q1** After the 1.0 kg of water is added, how many minutes elapse until the temperature of the water in the container reaches 100°C? From ①-⑥ below choose the best answer.

**8** min

- ① 10      ② 26      ③ 33      ④ 42      ⑤ 56      ⑥ 64

**B** As shown in the figure below, the state of a fixed amount of an ideal gas is changed in the path  $A \rightarrow B \rightarrow C \rightarrow A$ .



Q2 How much work does the gas do on its environment during the process  $A \rightarrow B \rightarrow C \rightarrow A$  (one cycle)? From ①-④ below choose the best answer. 9 J

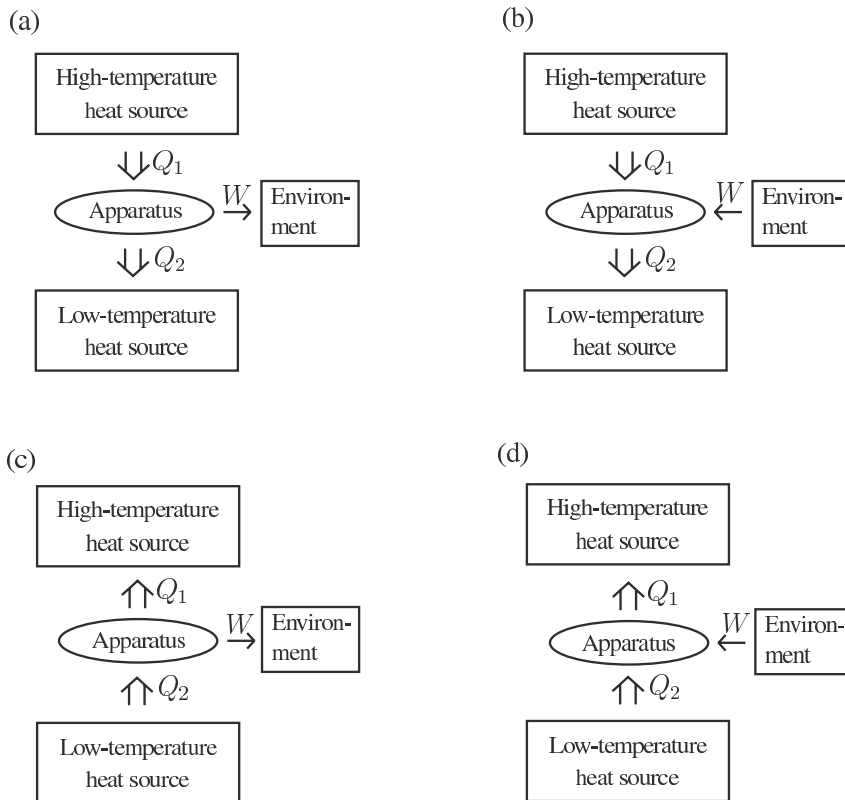
① 300

② 450

③ 750

④ 900

**C** Figures (a)-(d) below show, for a particular apparatus, candidates representing the flow of energy when the state of the apparatus is restored to its original state after being changed through a certain process. In the figures,  $Q_1$  and  $Q_2$  represent quantities of heat, and  $W$  represents work. The up and down arrows ( $\uparrow$ ,  $\downarrow$ ) indicate the direction of heat transfer. The left and right arrows ( $\leftarrow$ ,  $\rightarrow$ ) point to the side on which work is done.

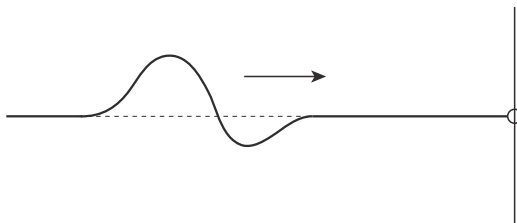


**Q3** Which of figures (a)-(d) above corresponds to a heat engine? Which corresponds to a refrigerator? From ①-④ below choose the best combination. **10**

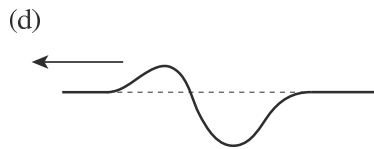
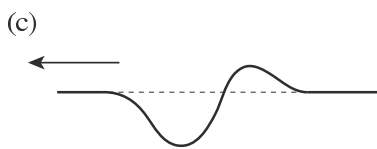
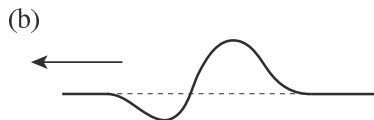
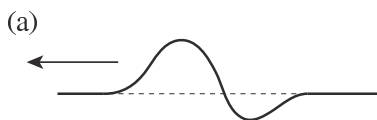
	①	②	③	④
Heat engine	(a)	(a)	(b)	(b)
Refrigerator	(c)	(d)	(c)	(d)

**III** Answer questions **A** ( Q1 ), **B** ( Q2 ), and **C** ( Q3 ) below.

**A** The figure below partially represents the wave form of a wave traveling toward the right-side end of a medium. The wave is reflected by the right-side end.



**Q1** What form is taken by the reflected wave when the right-side end is a fixed end, and when the right-side end is a free end? From ①-⑧ below choose the best combination. **11**



	①	②	③	④	⑤	⑥	⑦	⑧
Fixed end	(a)	(a)	(b)	(b)	(c)	(c)	(d)	(d)
Free end	(b)	(c)	(a)	(d)	(a)	(d)	(a)	(b)

**B** Two sound sources that emit sound waves at the same frequency,  $f$ , and in phase with each other are located at points **A** and **B**. Measurement of sound along line segment **AB** reveals the presence of 20 points where the sound waves weaken each other (excluding **A** and **B**). Here, distance between **A** and **B** is 2.50 m and the speed of sound is 350 m/s.

Q2 From ①-④ below choose the answer that best indicates the possible range of  $f$ .

**12**

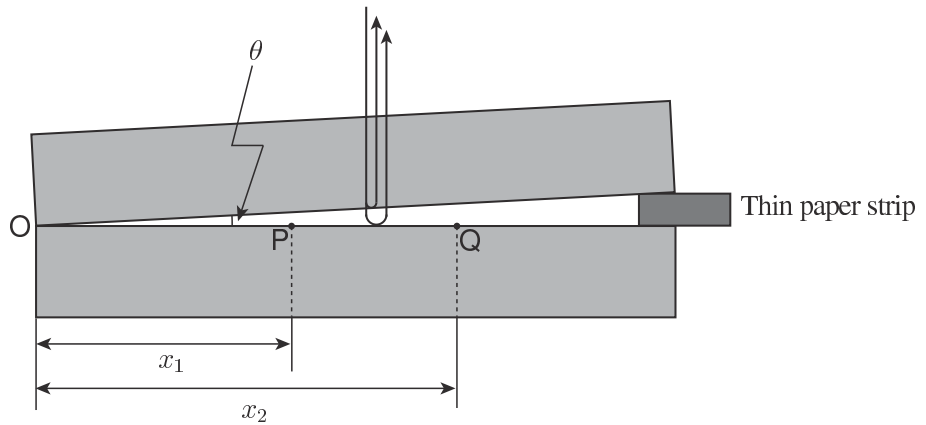
①  $1330 \text{ Hz} < f \leq 1470 \text{ Hz}$

②  $1470 \text{ Hz} < f \leq 1610 \text{ Hz}$

③  $2660 \text{ Hz} < f \leq 2940 \text{ Hz}$

④  $2940 \text{ Hz} < f \leq 3220 \text{ Hz}$

**C** Two flat glass plates are stacked, and a thin paper strip is inserted between them at one side, creating a narrow wedge-shaped space between the plates. As shown in the figure below, monochromatic light that has wavelength  $\lambda$  in air is directed at the plates from above. When viewed from above, parallel bright and dark fringes appear. This is the result of interference between light reflected from the bottom surface of the upper plate and light reflected from the top surface of the lower plate.



**Q3** When the angle between the glass plates is  $\theta$ ,  $N$  number of bright fringes are observed between points P and Q, whose distances from O, the point of contact between the plates, are  $x_1$  and  $x_2$ , respectively. What is the value of  $\lambda$ ? From ①-④ below choose the best answer, where  $N$  is sufficiently large and  $\theta$  is sufficiently small so that  $\tan \theta \approx \theta$ . **13**

- ①  $\frac{(x_2 - x_1)\theta}{N}$       ②  $\frac{2(x_2 - x_1)\theta}{N}$       ③  $\frac{x_2 - x_1}{N\theta}$       ④  $\frac{2(x_2 - x_1)}{N\theta}$



**IV** Answer questions **A** ( Q1 ), **B** ( Q2 ), **C** ( Q3 ), **D** ( Q4 ), **E** ( Q5 ), and **F** ( Q6 ) below.

**A** Two small balls of the same mass are attached to each end of two electrically insulated strings of length  $\ell$ . An electrical charge of  $q_1 (> 0)$  is imparted to each ball. When the balls are suspended from the same point, they assume the positions shown in Figure 1 below, at rest within the vertical plane. When an electrical charge of  $q_2 (> 0)$  is imparted to each ball, they assume the positions shown in Figure 2, at rest within the vertical plane.

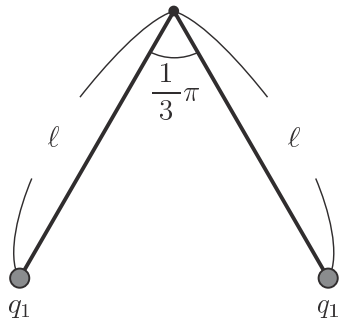


Figure 1

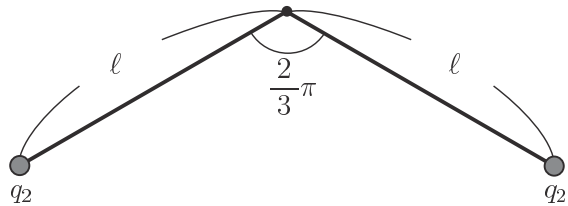


Figure 2

**Q1** What is  $\frac{q_2}{q_1}$ ? From ①-⑤ below choose the correct answer.

**14**

①  $\sqrt{2}$

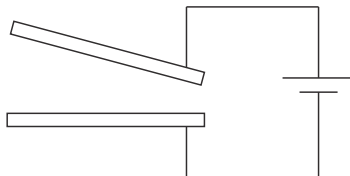
②  $\sqrt{3}$

③ 2

④ 3

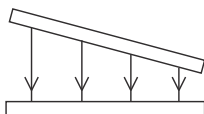
⑤ 9

**B** As shown in the figure below, two metal plates are placed at a certain angle with each other. When voltage is applied to the plates, an electric field is created between them.

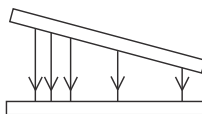


Q2 From ①-⑥ below choose the figure that best represents the electric lines of force between the metal plates (excluding the end regions of the plates). 15

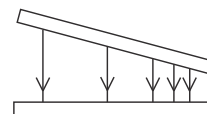
①



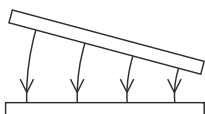
②



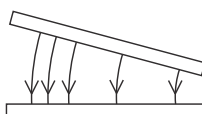
③



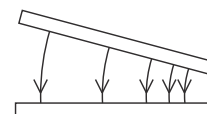
④



⑤



⑥



**C** The graph in Figure 1 below represents the relationship between voltage and current for a certain miniature bulb, L. As shown in Figure 2 below, a circuit is formed using L, two resistors (resistance:  $30\ \Omega$  and  $15\ \Omega$ ), and a battery whose electromotive force is  $6.0\ \text{V}$  and whose internal resistance is negligible.

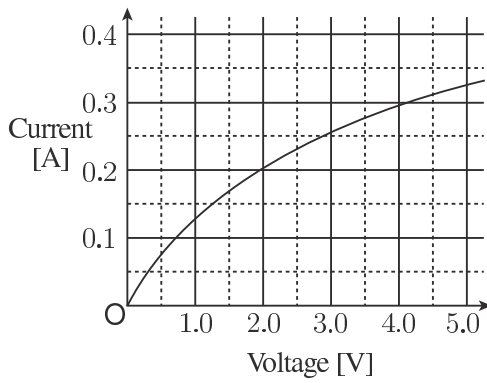


Figure 1

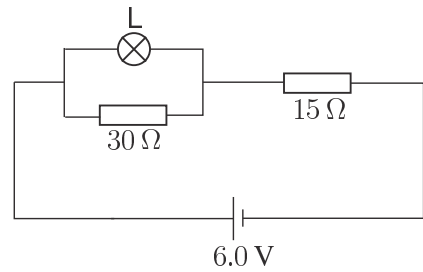


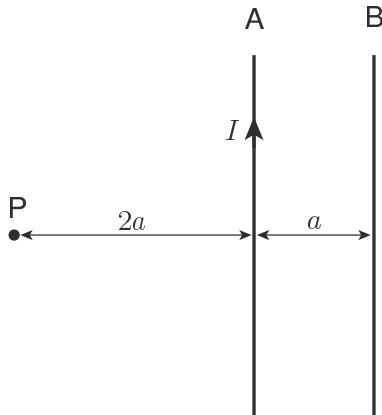
Figure 2

**Q3** What is the current (in A) flowing through L? From ①-④ below choose the best answer.

**16** A

- ① 0.13      ② 0.20      ③ 0.26      ④ 0.30

**D** As shown in the figure below, two straight conducting wires, A and B (both having sufficient length), are placed parallel to each other, separated by distance  $a$ . Point P exists in the same plane as A and B, separated from A by distance  $2a$  and from B by distance  $3a$ . An electrical current of magnitude  $I$  flows upward through A. Under this condition, when a current of magnitude  $I_B$  flows through B, the magnitude of the magnetic flux density at P becomes  $\frac{1}{4}$  of the amount it would be when no current flows through B; however, the direction of the magnetic flux density is the same in both cases.



**Q4** From ①-⑧ below choose the combination that correctly indicates the direction (upward,  $\uparrow$ , or downward,  $\downarrow$ ) and magnitude ( $I_B$ ) of the current flowing through B. **17**

	①	②	③	④	⑤	⑥	⑦	⑧
Direction	$\uparrow$	$\downarrow$	$\uparrow$	$\downarrow$	$\uparrow$	$\downarrow$	$\uparrow$	$\downarrow$
$I_B$	$\frac{9}{8}I$	$\frac{9}{8}I$	$\frac{15}{8}I$	$\frac{15}{8}I$	$\frac{27}{16}I$	$\frac{27}{16}I$	$\frac{45}{16}I$	$\frac{45}{16}I$

**E** A wire is shaped in a plane as shown in Figure 1 below, where  $AB = BC = CD = a$ . The wire is suspended so that  $PA$  and  $DQ$  are in the same horizontal line. Next, an electrical current  $I$  is passed through the wire in the direction  $A \rightarrow B \rightarrow C \rightarrow D$ , and a vertically upward uniform magnetic field (magnitude of magnetic flux density:  $B$ ) is applied in the entire region. As a result, the wire rotates to the position shown in Figure 2, where  $AB$  and  $CD$  form a  $30^\circ$  angle with the vertical line. The mass of the  $ABCD$  portion of the wire is  $m$ , and the magnitude of acceleration due to gravity is  $g$ .

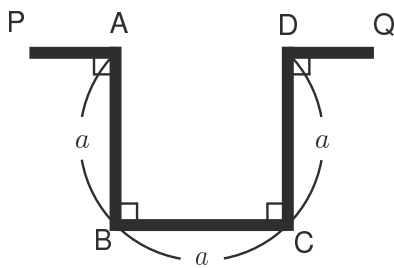


Figure 1

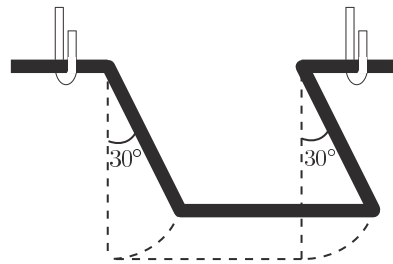


Figure 2

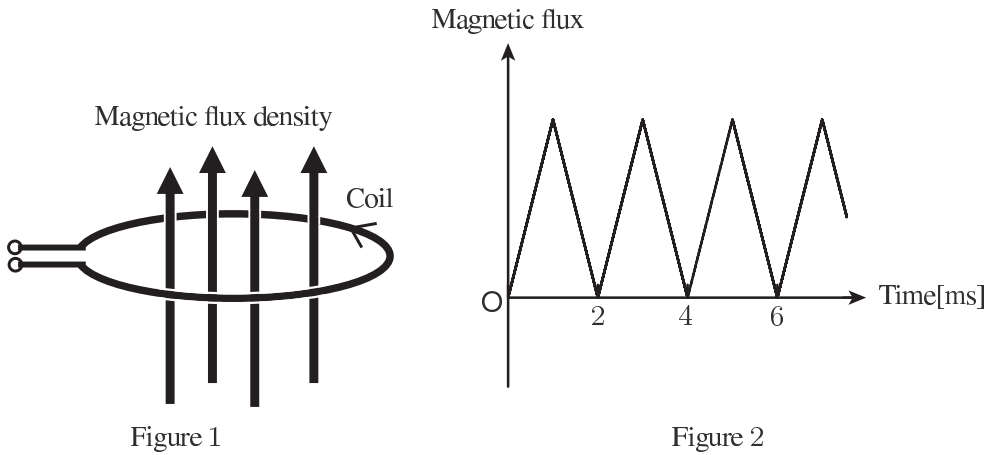
**Q5** How is  $I$ , the current flowing through the wire, expressed in terms of  $m$ ,  $g$ ,  $B$  and  $a$ ? From

①-④ below choose the correct answer.

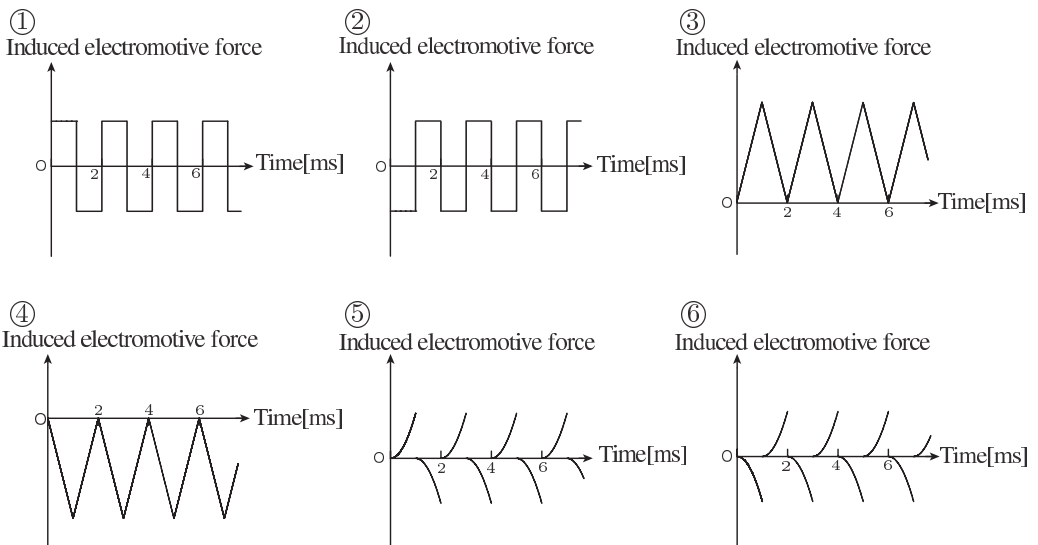
**18**

- ①  $\frac{2\sqrt{3}}{3} \frac{mg}{Ba}$       ②  $\frac{mg}{Ba}$       ③  $\frac{\sqrt{3}}{3} \frac{mg}{Ba}$       ④  $\frac{2\sqrt{3}}{9} \frac{mg}{Ba}$

**F** As shown in Figure 1 below, a magnetic flux passes through a single-loop coil. Figure 2 is a graph that shows the change in the magnetic flux over time. The direction of arrows representing the magnetic flux density in Figure 1 is the positive direction of the magnetic flux.



**Q6** From ①-⑥ below choose the graph that correctly indicates the change over time of the induced electromotive force arising in the coil. The direction of the arrows shown in the coil in Figure 1 is the positive direction of the induced electromotive force. **19**



End of Physics questions. Leave the answer spaces **20** ~ **75** blank. Please check once more that you have properly marked the name of your subject as “Physics” on your answer sheet.

**Do not take this question booklet out of the room.**





# Chemistry

## Marking Your Choice of Subject on the Answer Sheet

Choose and answer two subjects from Physics, Chemistry, and Biology. Use the front side of the answer sheet for one subject, and the reverse side for the other subject.

As shown in the example on the right, if you answer the Chemistry questions, circle “Chemistry” and completely fill in the oval under the subject name.

**If you do not correctly fill in the appropriate oval, your answers will not be graded.**

< Example >

解答科目 Subject		
物理 Physics	化学 Chemistry	生物 Biology
<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

Use the following values. “L” indicates liters.

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

The molar volume of an ideal gas at the standard state : 22.4 L/mol

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

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

**Atomic weight :** H : 1.0 C : 12 N : 14 O : 16 S : 32 Zn : 65

**Q1** From ①-⑥ below choose the one that contains the correct pair of the following statements (a)-(d) on atoms and electrons. **1**

- (a) An atomic nucleus is composed of electrons, protons and neutrons.
- (b) The number of protons contained in a nucleus is called the atomic number of the atom.
- (c) An electron has a negative charge, and its mass is much smaller than that of a neutron.
- (d) Atoms with the same atomic number but a different mass number are called allotropes each other.

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

**Q2** Among the following molecules (a)-(e), two are polar molecules. From ①-⑥ below choose the correct pair of polar molecules. **2**

- (a) acetylene (ethyne)
- (b) hydrogen chloride
- (c) carbon dioxide
- (d) methanol (methyl alcohol)
- (e) methane

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

**Q3** The following compounds (a)-(c) have nearly the same molecular weight. From ①-⑥ below choose the one that correctly orders their boiling points in increasing order. **3**

- (a) ethane  
 (b) formaldehyde  
 (c) methanol (methyl alcohol)

- ①  $a < b < c$       ②  $a < c < b$       ③  $b < a < c$   
 ④  $b < c < a$       ⑤  $c < a < b$       ⑥  $c < b < a$

**Q4** Two substances out of the following (a)-(e) are molecular crystals in their solid states. From ①-⑥ below choose the correct pair. **4**

- (a) potassium chloride (KCl)      (b) silicon (Si)  
 (c) magnesium oxide (MgO)      (d) carbon dioxide (CO<sub>2</sub>)  
 (e) iodine (I<sub>2</sub>)

- ① **a, c**      ② **a, d**      ③ **b, c**      ④ **b, e**      ⑤ **c, d**      ⑥ **d, e**

**Q5** From the following substances ①-④ choose the one that contains the largest total number of atoms in a 10 g sample. **5**

- ① CO<sub>2</sub>      ② H<sub>2</sub>S      ③ N<sub>2</sub>      ④ NH<sub>3</sub>

**Q6** At the standard state, a 224 mL sample of a gas mixture of hydrogen (H<sub>2</sub>) and nitrogen (N<sub>2</sub>) weighs 107 mg. From the following ①-⑤ choose the most appropriate molar ratio of hydrogen to nitrogen (H<sub>2</sub> : N<sub>2</sub>) in that gas mixture. **6**

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

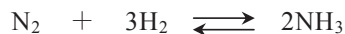
- Q7** Suppose 10 mL of 0.10 mol/L of an aqueous base **B** was added to 10 mL of 0.10 mol/L of an aqueous acid **A**. From the following ①-④ choose the combination of acid **A** and base **B** that makes the pH of the resultant aqueous solution smallest. **7**

	Acid <b>A</b>	Base <b>B</b>
①	hydrogen chloride (HCl)	sodium hydroxide (NaOH)
②	acetic acid (CH <sub>3</sub> COOH)	sodium hydroxide (NaOH)
③	sulfuric acid (H <sub>2</sub> SO <sub>4</sub> )	sodium hydroxide (NaOH)
④	hydrogen chloride (HCl)	sodium carbonate (Na <sub>2</sub> CO <sub>3</sub> )

- Q8** Suppose an aqueous solution of sodium chloride (NaCl (aq)) is electrolyzed. From the following ①-⑤ choose the most appropriate statement on the concentration of ions in the solution, or the gases generated from the electrodes. **8**

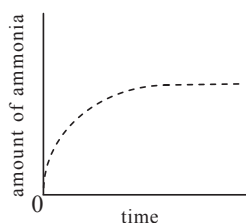
- ① The concentration of sodium ion (Na<sup>+</sup>) decreases.
- ② The concentration of chloride ion (Cl<sup>-</sup>) decreases.
- ③ Oxygen (O<sub>2</sub>) is generated at the anode.
- ④ Hydrogen (H<sub>2</sub>) is generated at the anode.
- ⑤ Chlorine (Cl<sub>2</sub>) is generated at the cathode.

**Q9** The formation of ammonia ( $\text{NH}_3$ ) from nitrogen ( $\text{N}_2$ ) and hydrogen ( $\text{H}_2$ ), as indicated in the following equation,



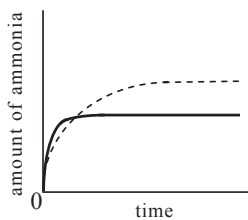
is a reversible and exothermic reaction.

The relation between the amount of ammonia formed and the time of reaction is shown by the dashed line ( - - - - - ) in the following figure.

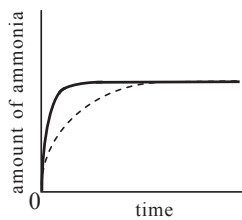


When the same reaction was carried out at the same pressure and a higher temperature, from the following figures ①-⑥ choose the most appropriate one whose solid line ( ——— ) represents the relation between the amount of ammonia expected to be formed and the time of reaction. 9

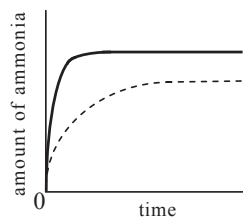
①



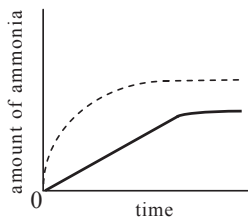
②



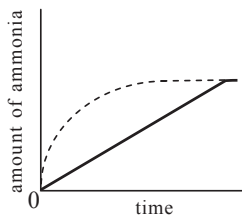
③



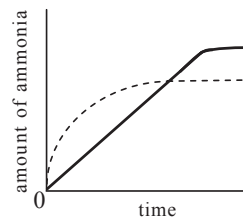
④



⑤



⑥



**Q10** The heat of combustion of methane (CH<sub>4</sub>) and of ethane (C<sub>2</sub>H<sub>6</sub>) is 890 kJ/mol and 1560 kJ/mol, respectively. A 2.24 L of sample of a gas mixture of methane and ethane at the standard state is completely combusted to generate 142 kJ of heat. What is the amount of methane (mol) before combustion? From the following ①-⑥ choose the most appropriate value. Assume that both methane and ethane are ideal gases.

**10** mol

- ① 0.011      ② 0.016      ③ 0.021  
 ④ 0.026      ⑤ 0.031      ⑥ 0.036

**Q11** Select the chemical equation in which the underlined substance acts as an oxidizing agent. From ①-⑤ below choose the correct one.

**11**

- ① CuSO<sub>4</sub> + 2NaOH → Cu(OH)<sub>2</sub> + Na<sub>2</sub>SO<sub>4</sub>  
 ② 2Al + 6HCl → 2AlCl<sub>3</sub> + 3H<sub>2</sub>  
 ③ 2H<sub>2</sub>S + SO<sub>2</sub> → 3S + 2H<sub>2</sub>O  
 ④ H<sub>2</sub>SO<sub>4</sub> + 2NaOH → Na<sub>2</sub>SO<sub>4</sub> + 2H<sub>2</sub>O  
 ⑤ 2Na + 2H<sub>2</sub>O → 2NaOH + H<sub>2</sub>

**Q12** From ①-⑥ in the table below choose the most appropriate combination of metals Cu, Fe, and Zn that is compatible with the following statements (a)-(c). **12**

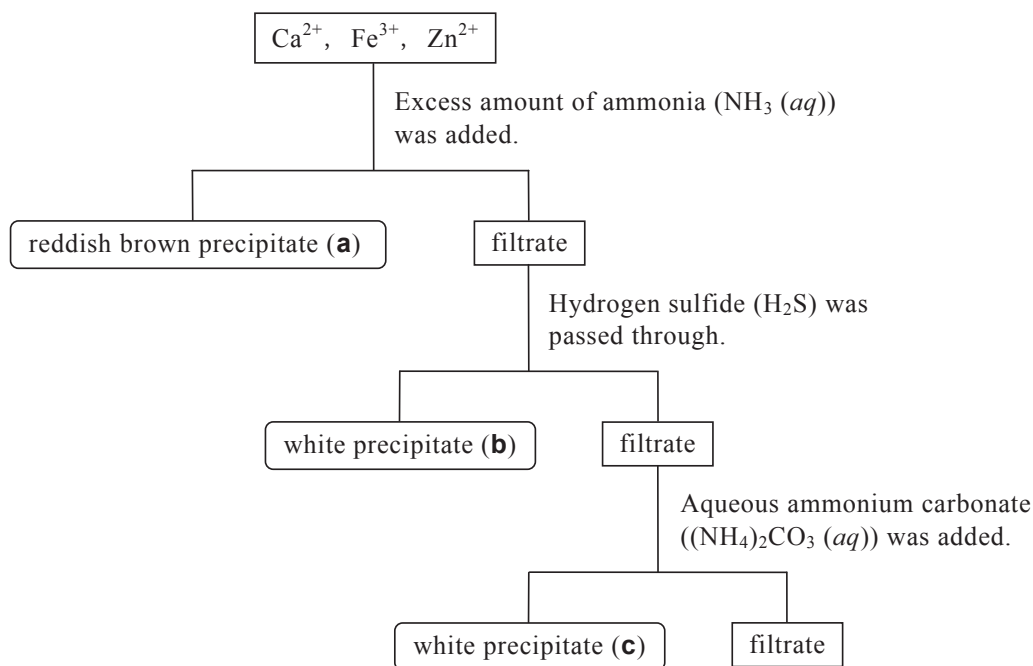
- (a) It dissolves in aqueous sodium hydroxide ( $\text{NaOH}$  (aq)) accompanied by the generation of hydrogen ( $\text{H}_2$ ).
- (b) It does not dissolve in concentrated nitric acid (conc.  $\text{HNO}_3$ ) but dissolves in dilute sulfuric acid (dil.  $\text{H}_2\text{SO}_4$ ) accompanied by the generation of hydrogen.
- (c) It does not dissolve in dilute sulfuric acid but dissolves in hot concentrated sulfuric acid (hot conc.  $\text{H}_2\text{SO}_4$ ) accompanied by the generation of sulfur dioxide ( $\text{SO}_2$ ).

	<b>a</b>	<b>b</b>	<b>c</b>
①	Cu	Fe	Zn
②	Cu	Zn	Fe
③	Fe	Cu	Zn
④	Fe	Zn	Cu
⑤	Zn	Cu	Fe
⑥	Zn	Fe	Cu

**Q13** From the following statements ①-⑤ on halogens and their compounds, choose the one that contains an error. **13**

- ① All halogen atoms easily become monovalent anions.
- ② An aqueous solution of chlorine ( $\text{Cl}_2$ ) exhibits acidity.
- ③ If a wet potassium iodide-starch paper is inserted in chlorine, the paper turns blue-purple.
- ④ If chlorine water is added to aqueous potassium bromide ( $\text{KBr}$  (aq)), bromine ( $\text{Br}_2$ ) is generated.
- ⑤ An aqueous solution of hydrogen iodide ( $\text{HI}$ ) is a weak acid.

**Q14** By the procedures shown in the following figure, each ion was separated from an aqueous solution containing metallic ions  $\text{Ca}^{2+}$ ,  $\text{Fe}^{3+}$ , and  $\text{Zn}^{2+}$ . From ①-⑥ in the table below choose the most appropriate combination of metallic ions contained in the precipitates (a)-(c). **14**



	Ion contained in <b>a</b>	Ion contained in <b>b</b>	Ion contained in <b>c</b>
①	$\text{Ca}^{2+}$	$\text{Fe}^{3+}$	$\text{Zn}^{2+}$
②	$\text{Ca}^{2+}$	$\text{Zn}^{2+}$	$\text{Fe}^{3+}$
③	$\text{Fe}^{3+}$	$\text{Ca}^{2+}$	$\text{Zn}^{2+}$
④	$\text{Fe}^{3+}$	$\text{Zn}^{2+}$	$\text{Ca}^{2+}$
⑤	$\text{Zn}^{2+}$	$\text{Ca}^{2+}$	$\text{Fe}^{3+}$
⑥	$\text{Zn}^{2+}$	$\text{Fe}^{3+}$	$\text{Ca}^{2+}$



**Q15** How many mg of hydrogen ( $H_2$ ) are generated when 1.3 g of zinc (Zn) is completely dissolved in dilute sulfuric acid (dil.  $H_2SO_4$ )? From ①-⑤ below choose the most appropriate value. **15** mg

- ① 10      ② 20      ③ 40      ④ 60      ⑤ 80

**Q16** From the following statements ①-④ on hydrocarbons choose the most appropriate one. **16**

- ① The molecular formulas of all saturated hydrocarbons are represented by  $C_nH_{2n+2}$ .  
 ② All alkanes are either gases or liquids at room temperature.  
 ③ Acetylene (ethyne) undergoes an addition reaction with bromine ( $Br_2$ ).  
 ④ There is no isomer for xylene.

**Q17** When 7.4 g of a compound with a molecular formula  $C_nH_{2n+2}O$  ( $n$  is an integer) was reacted with a sufficient amount of sodium (Na), 1.12 L of hydrogen ( $H_2$ ) was generated at the standard state. Determine the value of  $n$ . Among the structural isomers of this compound, how many of them exhibit the reaction mentioned above? From ①-⑥ in the following table choose the correct combination. **17**

	$n$	Number of compounds
①	3	3
②	3	4
③	3	5
④	4	3
⑤	4	4
⑥	4	5

**Q18** From the following statements ①-⑤ choose the one that is compatible with neither ethanol (ethyl alcohol) nor acetone. **18**

- ① It is a liquid at room temperature.
- ② It is readily soluble in water.
- ③ It is oxidized by potassium dichromate ( $K_2Cr_2O_7$ ).
- ④ It gives an iodoform reaction.
- ⑤ It turns purple when aqueous iron(III) chloride ( $FeCl_3(aq)$ ) is added.

**Q19** From the following statements ①-④ on aniline choose the most appropriate one. **19**

- ① It is a solid at room temperature.
- ② Acetanilide is formed when it is reacted with acetic anhydride.
- ③ It dissolves easily in aqueous sodium hydroxide ( $NaOH(aq)$ ).
- ④ Nitrobenzene is formed when it is dissolved in dilute hydrochloric acid (dil. HCl) and then aqueous sodium nitrite ( $NaNO_2(aq)$ ) is added to that solution under cooling.

**Q20** When 0.5 mol of a hydrocarbon was completely combusted, 1.5 mol of carbon dioxide ( $CO_2$ ) and 1.0 mol of water were generated. From ①-⑥ below choose the correct molecular formula for this hydrocarbon. **20**

- ①  $C_2H_2$       ②  $C_2H_4$       ③  $C_2H_6$       ④  $C_3H_4$       ⑤  $C_3H_6$       ⑥  $C_3H_8$

End of Chemistry questions. Leave the answer spaces **21** ~ **75** blank.

Please check once more that you have properly marked the name of your subject as "Chemistry" on your answer sheet.

**Do not take this question booklet out of the room.**

# Biology

## Marking Your Choice of Subject on the Answer Sheet

Choose and answer two subjects from Physics, Chemistry, and Biology. Use the front side of the answer sheet for one subject, and the reverse side for the other subject.

As shown in the example on the right, if you answer the Biology questions, circle “Biology” and completely fill in the oval under the subject name.

**If you do not correctly fill in the appropriate oval, your answers will not be graded.**

< Example >

解答科目 Subject		
物理 Physics	化学 Chemistry	生物 Biology
<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>

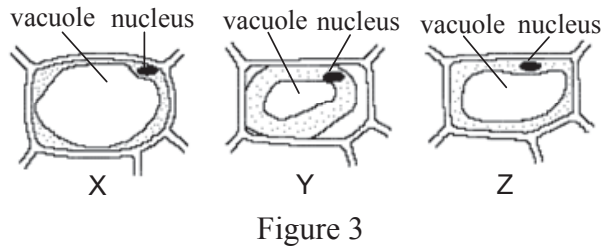
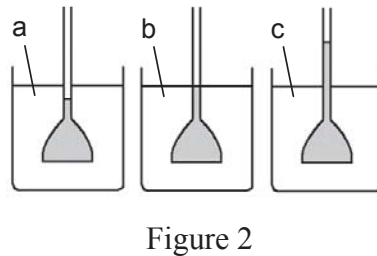
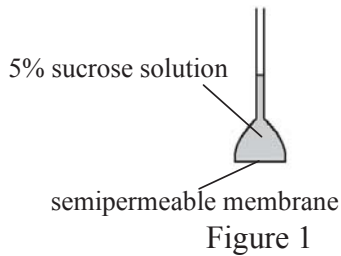
**Q1** From ①–⑤ below choose the statement that does **not** correctly describe human leukocytes.

1

- ① Some leukocytes have the ability to produce antibodies.
- ② Lymph contains lymphocytes, which are a type of leukocyte.
- ③ There are various types of leukocytes; some have a nucleus, while others do not.
- ④ Some leukocytes directly attack foreign substances, such as bacteria and viruses.
- ⑤ Some leukocytes store information on antigens for a certain period of time.

**Q2** Figure 1 below shows a funnel-shaped glass tube that is covered on the bottom with a semipermeable membrane and contains a 5% sucrose solution. Figure 2 shows the state of three glass tubes (identical to the one in Figure 1) that have been immersed for some time in three beakers containing sucrose solutions of different concentrations (a, b, c). Figure 3 schematically represents a microscopic view of the state of three plant cells that have been immersed for some time in sucrose solutions a, b, and c. In which sucrose solution (a, b, c) were X, Y, and Z respectively immersed? From ①–⑥ below choose the correct combination.

2



	X	Y	Z
①	a	b	c
②	a	c	b
③	b	a	c
④	b	c	a
⑤	c	a	b
⑥	c	b	a

**Q3** From ①–⑤ below choose the statement that does **not** correctly describe asexual reproduction. **3**

- ① Amoeba and bacteria divide into two new individuals of roughly the same size. This form of asexual reproduction is called “fission.”
- ② The fission form of asexual reproduction occurs only in unicellular organisms, never in multicellular organisms.
- ③ In yeast, new individuals grow from bud-like protrusions on the parent’s body. This form of asexual reproduction is called “budding.”
- ④ Certain multicellular organisms, such as hydras, reproduce through budding.
- ⑤ Asexual reproduction in which a new individual forms from part of a plant’s vegetative organ (root, stem, leaf, etc.) is called “vegetative reproduction.”

**Q4** Statements (a)–(e) below describe the development of sea urchins and frogs. From ①–⑥ below choose the combination indicating the two statements that do **not** apply to both sea urchins and frogs. **4**

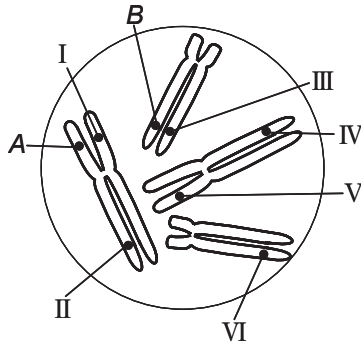
- (a) The third cleavage is an equal cleavage.
- (b) As the series of cleavages proceeds, a cavity called a “blastocoel” forms inside the embryo.
- (c) The cells fold inward from the blastopore, forming the archenteron.
- (d) Part of the ectoderm forms a trough-like depression that becomes the neural tube.
- (e) The blastopore ultimately develops into the anus.

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

**Q5** Answer questions (1) and (2) below concerning an angiosperm whose chromosome number is  $2n = 4$ .

(1) The figure below shows the state of chromosomes in the metaphase of somatic cell division.

*A* and *B* in the figure indicate the sites of genes *A* and *B*, respectively.



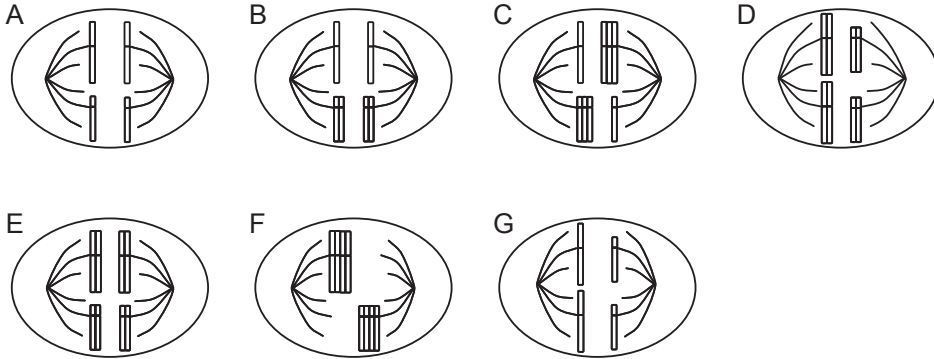
If the genotype of the cell in the figure is *AaBb*, which of I–VI in the figure represent the locations of *a* and *b*, the alleles of *A* and *B*? From ①–⑥ below choose the correct combination.

**5**

	a	b
①	I	IV
②	I	III
③	III	II
④	III	VI
⑤	V	IV
⑥	V	VI

- (2) Figures A–G below represent chromosomal movement during a certain stage of meiosis in this plant. From ①–⑧ below choose the combination indicating the two figures that are correct.

6



- ① A, B      ② A, E      ③ A, G      ④ B, F  
 ⑤ C, D      ⑥ D, E      ⑦ D, G      ⑧ F, G

- Q6** The sex chromosomes of quails are represented as ZZ for males, and ZW for females. The genes that determine feather color are located on the Z-chromosome. If we define the gene for wild-type color as B and the gene for brown feathers as b, we can represent a Z-chromosome with B as  $Z^B$ , and a Z-chromosome with b as  $Z^b$ . Let us assume that B is dominant over b. If we wish to be able to identify the sex of chicks by their feather color, what chromosomal composition should their parents have? From ①–⑥ below choose the correct combination.

7

	Female	Male
①	$Z^B W$	$Z^B Z^B$
②	$Z^B W$	$Z^B Z^b$
③	$Z^B W$	$Z^b Z^b$
④	$Z^b W$	$Z^B Z^B$
⑤	$Z^b W$	$Z^B Z^b$
⑥	$Z^b W$	$Z^b Z^b$

**Q7** From ①–⑤ below choose the statement that does **not** correctly describe the structure and functions of the human liver. 8

- ① There are two types of blood vessels that conduct blood to the liver: the hepatic artery and the hepatic portal vein.
- ② Ammonia, a toxic byproduct of the breakdown of proteins, is converted by the liver to the less toxic substance urea.
- ③ Excitation of the parasympathetic nerves to the liver stimulates the liver's breakdown of glycogen.
- ④ Thyroxine, which is secreted by the thyroid gland, raises the liver's metabolic rate, increasing the amount of heat generated by the liver.
- ⑤ The liver produces bile, which aids the digestion of fat.

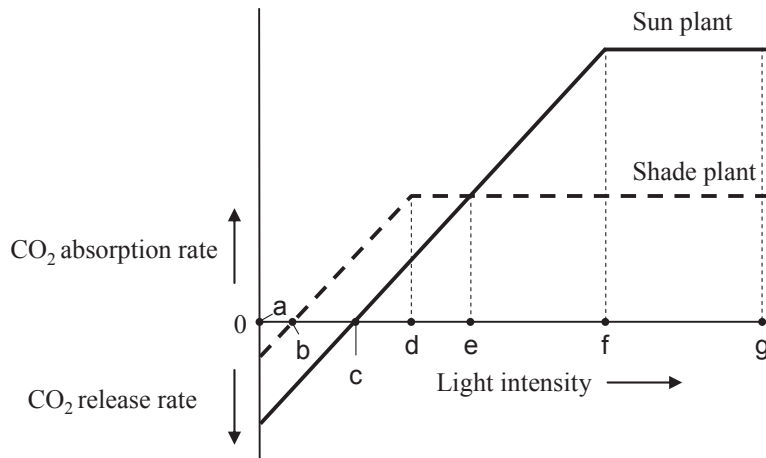
**Q8** Statements (a)–(d) below concern stimulus reception and transmission of stimulus information in humans. From ①–⑥ below choose the combination indicating the two statements that are correct. 9

- (a) The sense of taste arises when chemicals dissolved in water are received by taste cells of the tongue's taste buds, and the resulting excitation is transmitted to the brain's taste center.
- (b) The skin has receptors that receive temperature and pressure stimuli; both high and low temperatures are received by the warm spots.
- (c) Even in the absence of light, stimulation of the optic nerve results in sensation of light.
- (d) A cone cell contains three pigments that readily absorb blue, red, and green light.

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



**Q9** The following figure schematically represents the photosynthetic light response curves for a certain sun plant and a certain shade plant. From ①–⑤ below choose the statement that correctly describes this figure. Assume that the temperature remained constant and the environmental CO<sub>2</sub> concentration was the same as that of the atmosphere. **10**



- ① The photosynthetic rate of the sun plant is equal to that of the shade plant when the light intensity is a–d.
- ② The photosynthetic rate of the sun plant is faster than that of the shade plant only when the light intensity is e–g.
- ③ For the sun plant, increases in the CO<sub>2</sub> concentration will raise the photosynthetic rate when the light intensity is a–f.
- ④ Respiration does not occur in the sun plant when the light intensity is c–g.
- ⑤ Respiration does not occur in the shade plant when the light intensity is d–g.

**Q10** Statements (a)–(e) below concern auxin in plants. From ①–⑧ below choose the combination indicating the two statements that are correct. 11

- (a) Apical dominance occurs because auxin stimulates the growth of both apical buds and lateral buds.
- (b) Of all parts of the plant, the optimal concentration of auxin for stimulating growth is highest for the root.
- (c) Auxin travels from the base of a stem to the tip by polar transport.
- (d) Phototropism in stems occurs because auxin stimulates growth on the dark side of the plant.
- (e) When a seedling is placed horizontally on the ground, auxin inhibits growth on the ground side of the root, resulting in root gravitropism.

- ① a, b      ② a, c      ③ a, e      ④ b, c
- ⑤ b, d      ⑥ b, e      ⑦ c, d      ⑧ d, e

**Q11** Statements (a)–(d) below describe the action of various proteins. From ①–⑥ below choose the combination indicating the two proteins that also act as ATPases. **12**

- (a) Hemoglobin, which is present in erythrocytes, contains iron and carries oxygen from the lungs to all parts of the body.
- (b) Myosin is present in large quantities in skeletal and smooth muscle cells, and is involved in muscle contraction.
- (c) Antibodies, which are produced by the immune system, bind very specifically with various antigens.
- (d) Sodium-potassium pumps are present in cell membranes and use active transport to move sodium ions and potassium ions across the membranes.

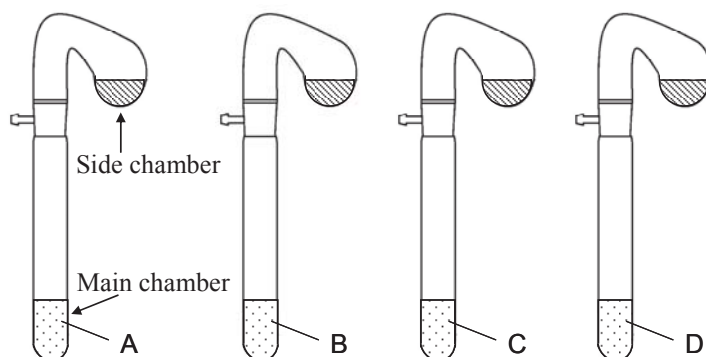
① a, b    ② a, c    ③ a, d    ④ b, c    ⑤ b, d    ⑥ c, d

**Q12** Consider the characteristics of mitochondria and chloroplasts in sunflower. From ①–⑤ below choose the characteristic that applies to mitochondria only. **13**

- ① They synthesize ATP.
- ② They have electron transport systems.
- ③ They break glucose down into pyruvic acid.
- ④ They have decarboxylation pathways.
- ⑤ They have a double-membrane structure.

**Q13** The following experiment was performed concerning succinate dehydrogenase. Answer questions (1) and (2) on the following page.

As shown in the figure below, four Thunberg tubes were prepared for an experiment. The side chamber of every tube was partially filled with sodium succinate solution and methylene blue solution, and four different solutions, A–D (described below the figure), were separately placed in the main chambers. After  $\times$  the air was removed from the tubes, the solutions in the side chambers were poured into the main chambers. Solutions A, B, and D were reacted at 40°C and solution C was reacted at 20°C, and these  $\gamma$  solutions were observed for changes in color. Note that methylene blue changes from blue to colorless when it is reduced.



- A: Physiological salt solution
- B: Solution extracted from ground chicken liver using physiological salt solution
- C: Solution extracted from ground chicken liver using physiological salt solution
- D: Solution extracted from ground chicken liver using physiological salt solution, and heat-treated at 100°C for 3 minutes

- (1) From ①–⑤ below choose the answer that correctly indicates the purpose of underlined section X. **14**

- ① To keep the solutions at a constant pH.
- ② To keep the solutions at a constant temperature.
- ③ To remove nitrogen from the tubes.
- ④ To remove oxygen from the tubes.
- ⑤ To remove carbon dioxide from the tubes.

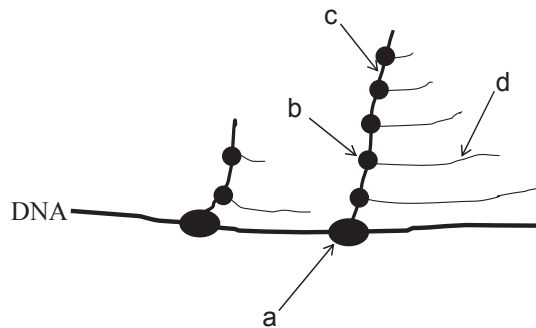
- (2) From ①–⑥ below choose the answer that correctly indicates the results of underlined section Y. **15**

- ① The methylene blue turned colorless in A, B, and C; this change was quickest in A.
- ② The methylene blue turned colorless in A, B, and C; this change was quickest in B.
- ③ The methylene blue turned colorless in B and C; this change was quicker in B.
- ④ The methylene blue turned colorless in B and C; this change was quicker in C.
- ⑤ The methylene blue turned colorless in B, C, and D; this change was quickest in C.
- ⑥ The methylene blue turned colorless in B, C, and D; this change was quickest in D.

**Q14** Gene X in a certain eukaryotic cell is made up of 3,000 base pairs. 75% of those pairs are introns, and the rest are exons. From ①–⑦ below choose the answer that most closely indicates the number of amino acids in a protein synthesized by gene X. **16**

- ① 250
- ② 750
- ③ 1,000
- ④ 2,250
- ⑤ 3,000
- ⑥ 6,750
- ⑦ 9,000

**Q15** In prokaryotic cells in which splicing does not occur, translation starts while the transcription process is still underway. This phenomenon is schematically represented in the figure below. Answer questions (1) and (2) on the following page concerning this figure.



- (1) What do **a** and **d** in the figure represent? From ①–⑥ below choose the correct combination. **17**

	<b>a</b>	<b>d</b>
①	DNA polymerase	mRNA being synthesized
②	DNA polymerase	protein being synthesized
③	RNA polymerase	mRNA being synthesized
④	RNA polymerase	protein being synthesized
⑤	ribosome	mRNA being synthesized
⑥	ribosome	protein being synthesized

- (2) In which direction does **a** travel on the DNA in the figure? Also, in which direction does **b** travel on **c** in the figure? From ①–④ below choose the correct combination. **18**

	Direction of <b>a</b>	Direction of <b>b</b>
①	left	up
②	left	down
③	right	up
④	right	down

End of Biology questions. Leave the answer spaces **19** ~ **75** blank.

Please check once more that you have properly marked the name of your subject as “Biology” on your answer sheet.

**Do not take this question booklet out of the room.**