

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 - 20
Chemistry	21 - 33
Biology	35 - 51

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													

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also organizes various activities and
events for international students, such
as language classes, cultural exchange
programs, and sports events. The
organization is committed to providing
high-quality services to international
students in Japan.



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.

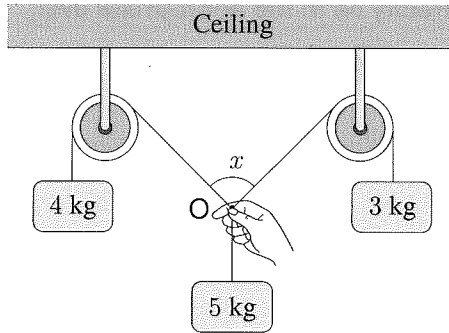
If you do not correctly fill in the appropriate oval, your answers will not be graded.

<Example>

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

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 As shown in the figure below, three weights (mass: 3.0 kg, 4.0 kg, 5.0 kg) are attached to a rope and suspended from two fixed pulleys that rotate smoothly. The rope is held by hand at point O and is positioned so that it forms angle x as shown. The rope is released when $x = \theta$, where all three weights are in equilibrium and remain at rest. The mass of the rope is negligible.

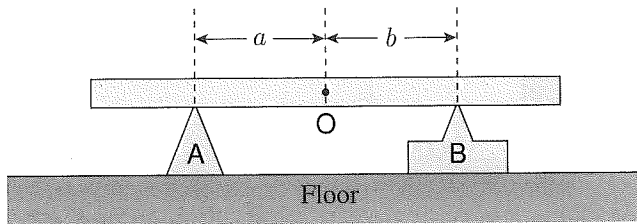


Q1 What is the value of θ ? From ①-⑤ below choose the best answer.

1

- ① 30° ② 45° ③ 60° ④ 90° ⑤ 120°

B As shown in the figure below, a uniform square bar lies horizontally across two supports, A and B. B is fixed to the floor, and A is moved toward center O of the bar with uniform speed. Initially, A slides along the underside of the bar, while the bar remains at rest with respect to B. When A reaches a certain point, however, the bar begins to slide across the top of B. The coefficient of static friction between the bar and each of A and B is 0.50, and the coefficient of kinetic friction is 0.20.

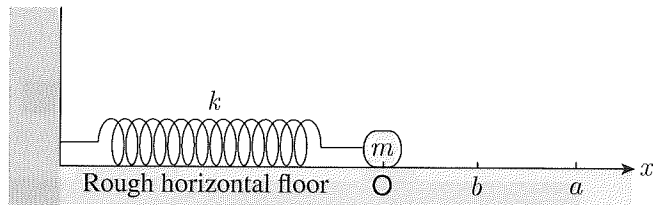


Q2 Consider distances a and b shown in the figure above. What is the value of $\frac{b}{a}$ at the moment when the bar begins to slide across the top of B? From ①-⑤ below choose the best answer.

2

- ① 0.40 ② 0.50 ③ 1.0 ④ 2.0 ⑤ 2.5

- C** As shown in the figure below, one end of a spring (spring coefficient: k) is attached to a wall, and the other end is attached to an object (mass: m) placed on a rough horizontal floor. Here, an x -axis is plotted along the floor, with the origin defined as the position of the object when the spring is at its natural length. The object is pulled to a position where $x = a$ ($a > 0$) and is gently released. The object then comes to rest at $x = b$. The coefficient of kinetic friction between the object and the floor is μ' .



- Q3** What is the value of b ? From ①-④ below choose the correct answer.

3

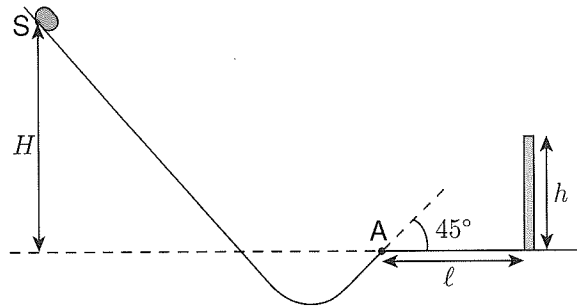
① $a - \frac{\mu' mg}{k}$

② $-a + \frac{\mu' mg}{k}$

③ $a - \frac{2\mu' mg}{k}$

④ $-a + \frac{2\mu' mg}{k}$

D A small object, having an initial speed of zero, slides down a slope shaped like the one shown in the figure below, where the object's starting point is S. From point A, the object leaves the slope, moving upward at an angle of 45° with the horizontal. The position of S is H higher than that of A. Also, a wall of height h stands at horizontal distance ℓ from A. Here, $\ell > h$, and friction between the slope and the object is negligible.



Q4 In terms of ℓ , h , and H , on what condition can the object travel over the wall? From ①-⑥ below choose the best answer. 4

① $H > \frac{\ell^2}{2h}$

② $H > \frac{\ell^2}{4h}$

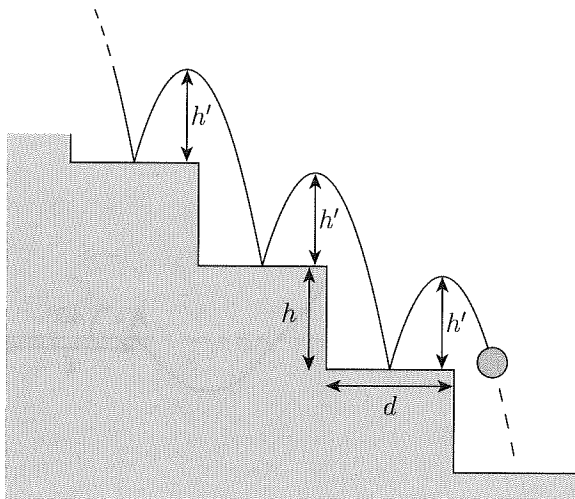
③ $H > \frac{\ell^2}{8h}$

④ $H > \frac{\ell^2}{2(\ell - h)}$

⑤ $H > \frac{\ell^2}{4(\ell - h)}$

⑥ $H > \frac{\ell^2}{8(\ell - h)}$

E As shown in the figure below, a ball (mass: m) travels down stairs whose steps are smooth and horizontal. The ball bounces off every step in exactly the exact same manner. The height of each step is h , and the step width is d . The height attained by the ball after each bounce is h' . The coefficient of restitution between the ball and the steps is e .



Q5 What is $\frac{h'}{h}$? From ①-⑥ below choose the correct answer.

5

① $\frac{e}{1-e}$

② $\frac{e}{1-e^2}$

③ $\frac{e}{(1-e)^2}$

④ $\frac{e^2}{1-e}$

⑤ $\frac{e^2}{1-e^2}$

⑥ $\frac{e^2}{(1-e)^2}$

F Consider a simple pendulum like the one shown in Figure 1 below, and a spring pendulum like the one shown in Figure 2. At the earth’s surface, the period of the simple pendulum’s oscillation in a vertical plane is T_1 , while the period of the spring pendulum’s oscillation along a vertical line is T_2 .

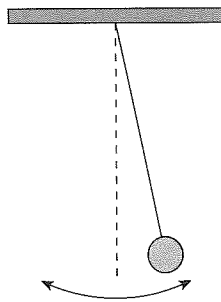


Figure 1

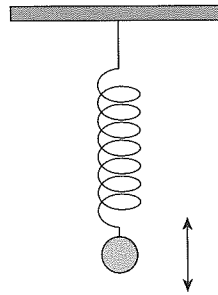
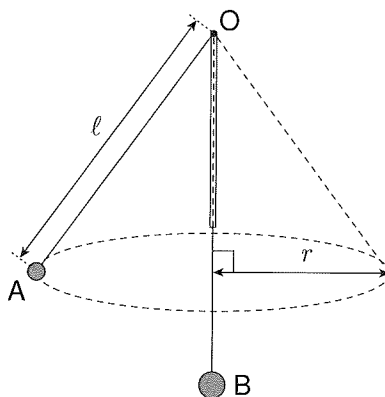


Figure 2

Q6 If the two pendulums were taken to the moon’s surface, where the magnitude of acceleration due to gravity is $\frac{1}{6}$ of that at the earth’s surface, what would be their respective period of oscillation? From ①-⑥ below choose the best combination. 6

	Simple pendulum period	Spring pendulum period
①	$\sqrt{6}T_1$	$\sqrt{6}T_2$
②	$\frac{T_1}{\sqrt{6}}$	T_2
③	T_1	$\frac{T_2}{\sqrt{6}}$
④	$\sqrt{6}T_1$	T_2
⑤	$\frac{T_1}{\sqrt{6}}$	$\frac{T_2}{\sqrt{6}}$
⑥	T_1	$\sqrt{6}T_2$

- G** As shown in the figure below, a lightweight string is passed through a narrow pipe suspended vertically, and ball A (mass: m) is attached to one end of the string, while weight B (mass: M , where $M > m$) is attached to the other end. A is put into uniform circular motion with radius r in a horizontal plane. At this time, B is at rest and the length from point O to the center of A is ℓ . Friction at O is negligible.



- Q7 What is the period of A's circular motion? From ①-⑤ below choose the correct answer.

7

- ① $2\pi\sqrt{\frac{\ell}{g}}$ ② $2\pi\sqrt{\frac{r}{g}}$ ③ $2\pi\sqrt{\frac{\sqrt{\ell^2 - r^2}}{g}}$
- ④ $2\pi\sqrt{\frac{r\sqrt{\ell^2 - r^2}}{g\ell}}$ ⑤ $2\pi\sqrt{\frac{r\ell}{g\sqrt{\ell^2 - r^2}}}$

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

A A 10 g block of ice at 0°C is enclosed in a tightly sealed container, and water vapor at 100°C is injected into the container. After sufficient time elapses, the ice and water vapor turn into water with a temperature of 40°C . Assume that the heat capacity of the container is negligible and heat does not escape from the container. Here, the heat of fusion of ice is $3.3 \times 10^2 \text{ J/g}$, the specific heat of water is $4.2 \text{ J/(g}\cdot\text{K)}$, and the heat of vaporization of water is $2.3 \times 10^3 \text{ J/g}$.

Q1 How many grams of water vapor were injected into the container? From ①-⑥ below choose the best answer. 8 g

① 0.66

② 1.3

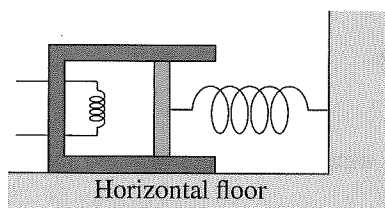
③ 2.0

④ 6.6

⑤ 13

⑥ 20

B As shown in the figure below, 1 mol of monatomic ideal gas is enclosed in a container composed of a cylinder and a piston that are made of heat insulators. The container is equipped with a heater. The piston moves smoothly and is attached to one end of a spring (spring coefficient: k). The other end of the spring is fixed to a wall. The piston has a cross-sectional area of S and its mass is negligible. The cylinder is fixed to a horizontal floor. At this time, the spring is at its natural length. The external air pressure is p_0 .

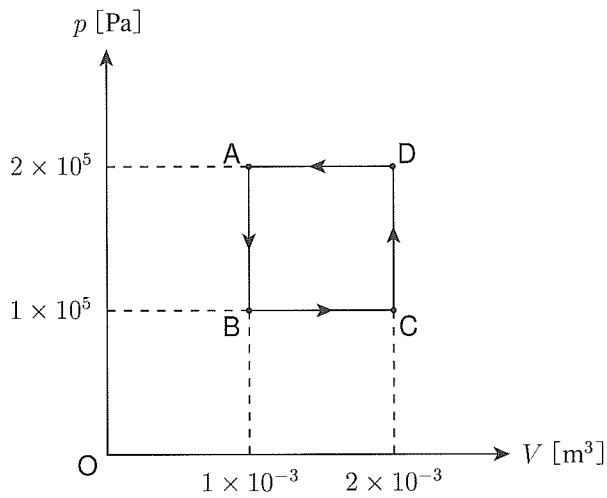


Q2 Next, the heater is used to warm the gas, causing the temperature of the gas to rise by ΔT , and causing the spring's length to contract by Δx . What is ΔU , the change in the internal energy of the gas? Also, what is W , the work done by the gas? From ①-④ below choose the correct combination.

9

	Change in internal energy ΔU	Work done by gas W
①	$\frac{3}{2}R\Delta T$	$p_0S\Delta x + \frac{k}{2}(\Delta x)^2$
②	$\frac{3}{2}R\Delta T$	$p_0S\Delta x + k(\Delta x)^2$
③	$\frac{5}{2}R\Delta T$	$p_0S\Delta x + \frac{k}{2}(\Delta x)^2$
④	$\frac{5}{2}R\Delta T$	$p_0S\Delta x + k(\Delta x)^2$

C As shown in the figure below, the state of a gas is changed as $A \rightarrow B \rightarrow C \rightarrow D \rightarrow A$.



Q3 From ①-⑥ below choose the answer that best indicates the amount of work done on the external environment by the gas. Here, the minus sign expresses that the external environment did work on the gas. 10 J

① -4×10^2

② -2×10^2

③ -1×10^2

④ 1×10^2

⑤ 2×10^2

⑥ 4×10^2

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

A An oscillator P (period of oscillation: 0.20 s) is placed on the surface of water in a tank of uniform depth and propagates circular waves as shown in Figure 1. When P is moved with uniform speed v in the direction indicated by the arrow in Figure 2, the wavelength in the direction of movement is 0.70 m, and the wavelength in the opposite direction is 0.90 m.

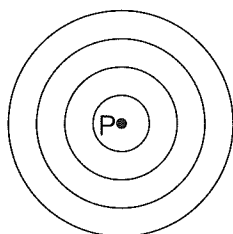


Figure 1

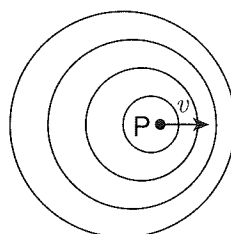


Figure 2

Q1 From ①-⑥ below choose the answer that best indicates the value of v in m/s. **11** m/s

① 0.020

② 0.040

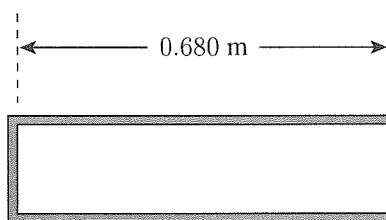
③ 0.10

④ 0.20

⑤ 0.50

⑥ 1.0

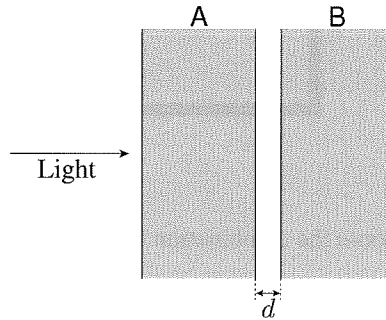
B Consider a tube with one end closed having a length of 0.680 m, like the one shown in the figure below. Assume that the speed of sound is 340 m/s.



Q2 From ①-⑥ below choose the combination that best indicates the frequencies at which this tube resonates. Here, open end correction is negligible. 12

- | | | |
|------------------|------------------|------------------|
| ① 125 Hz, 250 Hz | ② 150 Hz, 450 Hz | ③ 250 Hz, 500 Hz |
| ④ 250 Hz, 625 Hz | ⑤ 375 Hz, 625 Hz | ⑥ 375 Hz, 750 Hz |

- C** As shown in the figure below, two flat glass plates, A and B, are placed parallel to each other and are separated by distance d . A beam of monochromatic light of wavelength λ is perpendicularly incident on plate A and passes through both plates. Interference occurs between the light that directly exits B and the light that exits after reflecting from B and A.

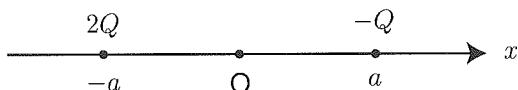


- Q3** For what values of d do the light rays intensify each other? From ①-④ below choose the best answer, where $m = 1, 2, \dots$ **13**

- ① $\left(m - \frac{1}{2}\right) \frac{\lambda}{2}$ ② $m \frac{\lambda}{2}$ ③ $\left(m - \frac{1}{2}\right) \lambda$ ④ $m\lambda$

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

A As shown in the figure below, a point charge of $-Q$ ($Q > 0$) is placed on the x -axis where $x = a$ ($a > 0$) and a point charge of $2Q$ is placed on the x -axis where $x = -a$. Assume that the electric potential at an infinite distance is zero.



Q1 From ①-⑤ below choose the answer that best indicates the x -axis coordinates of the points where the electric potential becomes zero. **14**

① $-\frac{1}{2}a, -2a$

② $-\frac{1}{3}a, -3a$

③ 0

④ $\frac{1}{3}a, 3a$

⑤ $\frac{1}{2}a, 2a$

B Consider a parallel-plate capacitor whose plates (A and B) are separated by a distance $3d$. Another thin plate (P) with the same area is placed between A and B at distance $2d$ from A. As shown in Figure 1 below, the terminals of A and B are connected to switch S_1 and two batteries that each have electromotive force V , while P is connected to a point between the batteries via switch S_2 . Initially, S_1 and S_2 are open, and A, B, and P are uncharged. Next, S_1 and S_2 are closed as shown in Figure 2, and the difference in electric potential between A/P and between P/B becomes V . Afterwards, S_1 and S_2 are opened and, as shown in Figure 3, P moves a distance of d toward A.

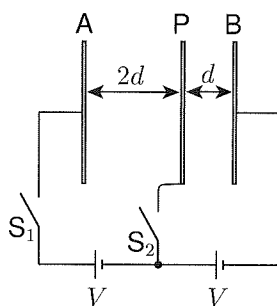


Figure 1

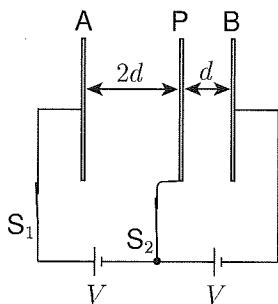


Figure 2

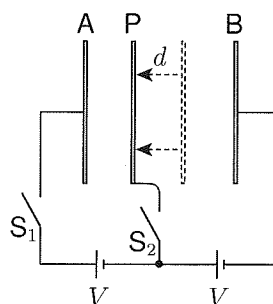


Figure 3

Q2 By what factor does the electrostatic energy stored in the capacitor change when the state changes from that in Figure 2 to that in Figure 3? From ①-⑦ below choose the best answer.

15

- ① $\frac{1}{2}$ ② $\frac{2}{3}$ ③ $\frac{3}{4}$ ④ 1
 ⑤ $\frac{4}{3}$ ⑥ $\frac{3}{2}$ ⑦ 2

C A direct-current power source with variable voltage is connected with three resistors (R_1 , R_2 , R_3) in the configuration shown in Figure 1 below. The resistance of R_1 is 3.0Ω . When the power source's voltage is changed, the current I_1 flowing through R_1 and the current I_2 flowing through R_2 change as shown in Figure 2 and Figure 3.

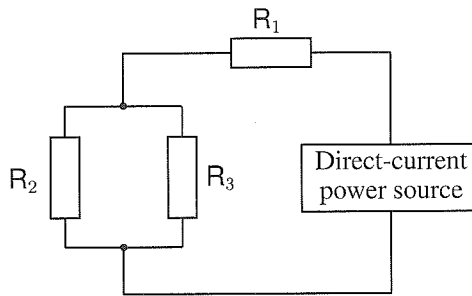


Figure 1

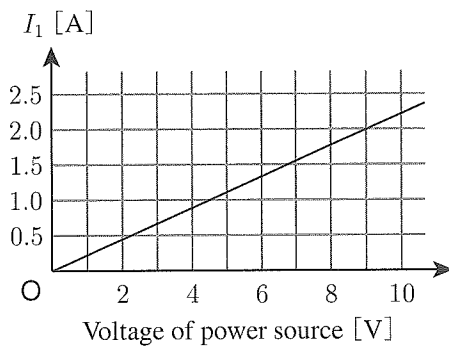


Figure 2

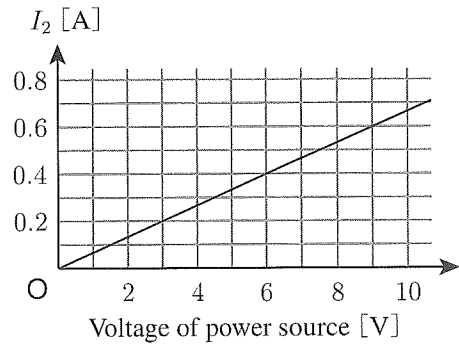


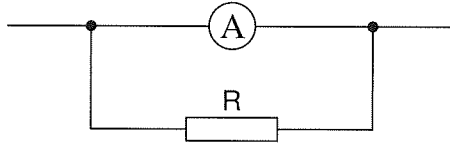
Figure 3

Q3 From ①-⑥ below choose the answer that best indicates the resistance of R_3 .

16 Ω

- ① 1.2 ② 1.6 ③ 2.1 ④ 2.7 ⑤ 3.1 ⑥ 3.8

- D** Consider an ammeter that measures currents up to a maximum of 10 mA and has an internal resistance of $0.90\ \Omega$. As shown in the figure below, resistor R is connected to the ammeter so as to raise its maximum measurable current level to 100 mA.



Q4 From ①-④ below choose the answer that best indicates the resistance of R .

17 Ω

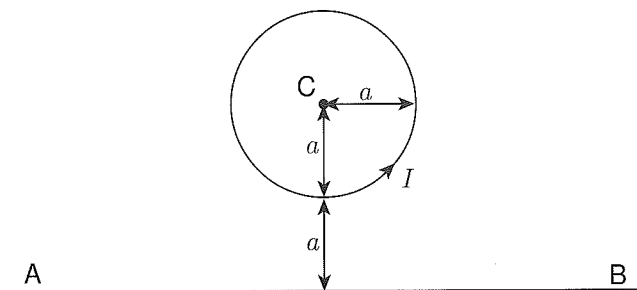
① 0.010

② 0.10

③ 1.0

④ 10

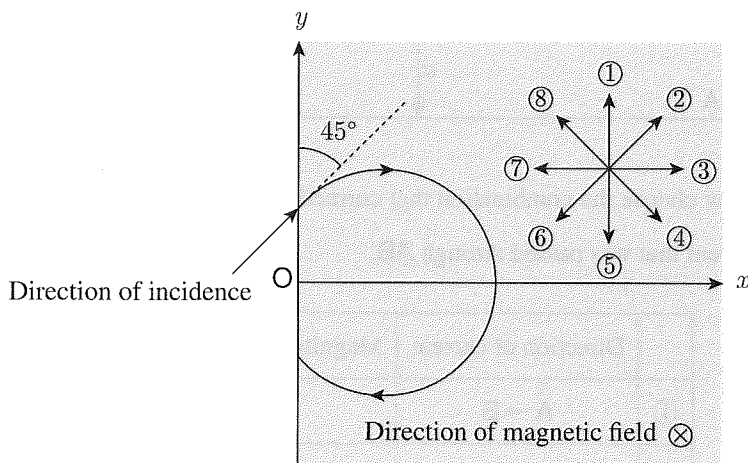
E As shown in the figure below, center C of a circular conducting wire (radius: a) is located distance $2a$ from AB , which is a long, straight conducting wire. While current I was passing through the circle, a current was passed through AB so as to change the magnetic field at C to zero.



Q5 From ①-⑥ below choose the combination that correctly indicates the direction and magnitude of the current that was passed through AB . 18

	Direction of current	Magnitude of current
①	$A \rightarrow B$	πI
②	$A \rightarrow B$	$2\pi I$
③	$A \rightarrow B$	$4\pi I$
④	$B \rightarrow A$	πI
⑤	$B \rightarrow A$	$2\pi I$
⑥	$B \rightarrow A$	$4\pi I$

F As shown in the figure below, a uniform magnetic field oriented in a direction perpendicular to this page (from the front toward the back) exists in the region where $x > 0$. A charged particle is projected into the magnetic field in a direction forming a 45° angle with the y -axis, and travels in the circular path shown. Next, the same experiment is repeated with an electric field of some magnitude applied to the region in a certain direction. This time, the particle travels in a linear path in the direction of incidence with constant speed.



Q6 From ①-⑧ in the figure above choose the arrow that best indicates the direction of the electric field. 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
○	●	○

Use the following values for calculation. "L" indicates liters.

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

The volume of 1 mol of a gas at standard state : 22.4 L

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

Avogadro constant : $N_{\text{A}} = 6.02 \times 10^{23} / \text{mol}$

Faraday constant : $F = 9.65 \times 10^4 \text{ C/mol}$

Atomic weight : H : 1.0 C : 12 N : 14 O : 16 Na : 23

Q1 From the following atom and ions ①-⑥ choose the one whose total number of electrons is **different from that of the others.** ?

- ① Al^{3+} ② Ca^{2+} ③ F^{-} ④ Na^{+} ⑤ Ne ⑥ O^{2-}

Q2 From the following statements ①-⑤ concerning the periodic table, choose the correct one. **2**

- ① The number of elements in the periodic table is less than 100.
- ② Metallic elements are included in each group.
- ③ The elements belonging to the period that begins with Li have the M shell as the outermost shell of their electron configurations.
- ④ Main group elements belonging to the same group have the same number of valence electrons.
- ⑤ All main group elements are nonmetallic elements.

Q3 From ①-⑥ in the table below choose the combination of substances compatible with the following statements (a)-(c), respectively. **3**

- (a) It is a linear molecule.
- (b) It forms a crystal constituted by covalent bonds.
- (c) It has no polarity.

	a	b	c
①	CO ₂	CaO	CCl ₄
②	CO ₂	diamond	NH ₃
③	H ₂ O	SiO ₂	CCl ₄
④	H ₂ O	diamond	CH ₄
⑤	HC≡CH	MgO	CH ₄
⑥	HC≡CH	SiO ₂	CCl ₄

Q4 The density of 15 mol/L aqueous ammonia ($\text{NH}_3 (aq)$) is 0.90 g/cm^3 . From the following ①-⑤ choose the value closest to the mass percent concentration (%) of ammonia in this aqueous ammonia. 4%

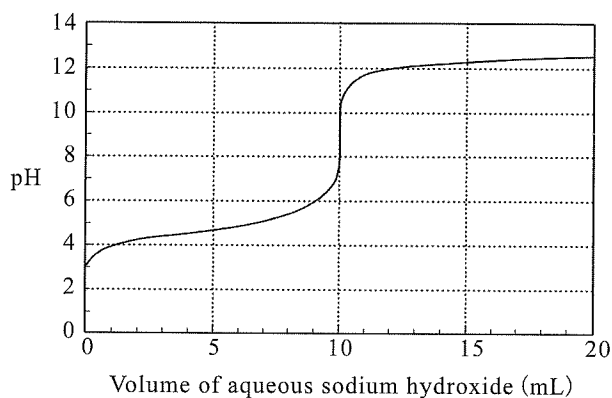
- ① 14 ② 18 ③ 24 ④ 28 ⑤ 34

Q5 The mass composition of a given nitrogen oxide is N: 63.6% and O: 36.4%. From the following ①-⑤ choose the most appropriate formula for this nitrogen oxide. 5

- ① NO ② NO_2 ③ N_2O ④ N_2O_3 ⑤ N_2O_4

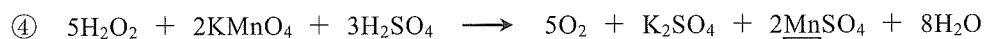
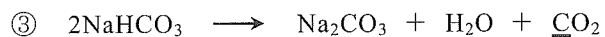
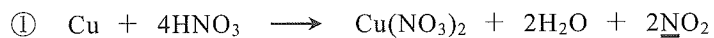
- Q6** The titration curve shown in the following figure was obtained during the neutralization titration of 10 mL of 0.10 mol/L aqueous acid **A** by 0.10 mol/L aqueous sodium hydroxide ($\text{NaOH} (aq)$). From ①-⑥ in the table below choose the correct combination of the acid **A** used and the indicator to determine the end point. The transition interval of Methyl Orange is pH 3.1-4.4 and that of phenolphthalein is pH 8.0-9.8.

6

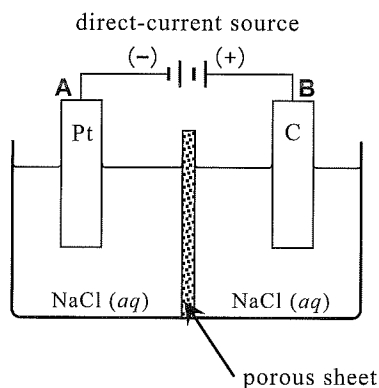


	Acid A	Indicator
①	hydrochloric acid (HCl)	phenolphthalein
②	hydrochloric acid	Methyl Orange
③	acetic acid (CH_3COOH)	phenolphthalein
④	acetic acid	Methyl Orange
⑤	nitric acid (HNO_3)	phenolphthalein
⑥	nitric acid	Methyl Orange

Q7 From the following reaction formulas ①-④ choose the one in which the oxidation number of the underlined atom **decreases the most** as compared with that before the reaction. 7



- Q8** A platinum electrode **A** and a graphite electrode **B** were connected to a direct-current source as shown in the figure. Electrolysis of an aqueous solution of sodium chloride (NaCl (aq)) was carried out for 32 min and 10 s with an electric current of 1.0 A.



From ①-⑨ in the following table choose the most appropriate combination of the gases and their volumes (mL) that were generated at electrodes **A** and **B**. Assume the volumes of the gases are determined at the standard state.

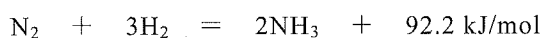
8

	Electrode A		Electrode B	
	gas	volume (mL)	gas	volume (mL)
①	Cl_2	224	H_2	224
②	Cl_2	448	H_2	448
③	Cl_2	448	O_2	112
④	H_2	224	Cl_2	224
⑤	H_2	224	Cl_2	448
⑥	H_2	448	O_2	112
⑦	O_2	112	Cl_2	224
⑧	O_2	112	H_2	224
⑨	O_2	224	H_2	448

Q9 From the compounds ①-⑤ below choose the one whose 0.10 mol/L aqueous solution has the lowest freezing point. 9

- ① ammonia (NH₃) ② sodium chloride (NaCl) ③ glucose
 ④ urea ⑤ sodium sulfate (Na₂SO₄)

Q10 Ammonia (NH₃) is formed as shown below when hydrogen (H₂) and nitrogen (N₂) are reacted using a catalyst composed mainly of iron (Fe).



Choose from ①-⑤ below the most appropriate procedure to increase the amount of ammonia formed when the reaction is in equilibrium. 10

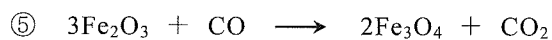
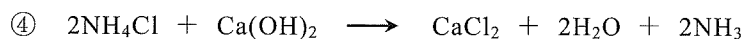
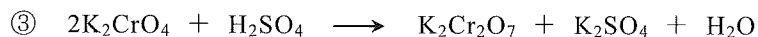
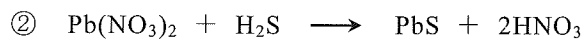
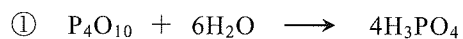
- ① Increase the amount of catalyst.
 ② Prolong the reaction time.
 ③ Raise the pressure without changing the temperature.
 ④ Raise the temperature without changing the pressure.
 ⑤ Lower the pressure and raise the temperature.

Q11 Of the following metals (a)-(e), which two will cause the deposition of copper (Cu) when immersed in aqueous copper sulfate (CuSO₄ (aq))? From ①-⑥ below choose the correct combination. 11

- (a) Ag (b) Fe (c) Hg (d) Pt (e) Zn

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

Q12 From the following reaction formulas ①-⑤ choose the one that is an oxidation-reduction reaction. **12**



Q13 From ①-⑧ in the following table choose the correct combination of properties of aqueous Na_2CO_3 , NaHSO_4 , and NH_4Cl . **13**

	Na_2CO_3	NaHSO_4	NH_4Cl
①	neutral	acidic	neutral
②	neutral	acidic	acidic
③	neutral	basic	neutral
④	neutral	basic	acidic
⑤	basic	acidic	neutral
⑥	basic	acidic	acidic
⑦	basic	basic	neutral
⑧	basic	basic	acidic

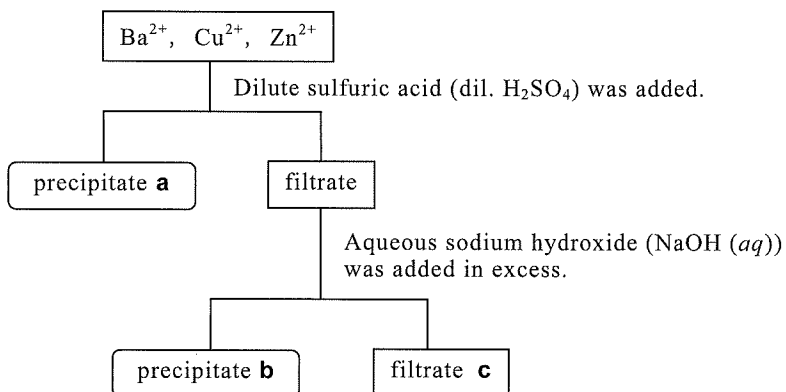
Q14 From ①-⑥ in the table below choose the correct combination of metals that are compatible with the following statements (a)-(c). 14

- (a) It is not soluble in concentrated nitric acid (conc. HNO_3) but is soluble in dilute sulfuric acid (dil. H_2SO_4).
- (b) It is soluble both in hydrochloric acid (HCl (aq)) and aqueous sodium hydroxide (NaOH (aq)).
- (c) It most readily conducts electricity and heat.

	a	b	c
①	Ag	Al	Fe
②	Ag	Fe	Al
③	Al	Fe	Ag
④	Al	Ag	Fe
⑤	Fe	Ag	Al
⑥	Fe	Al	Ag

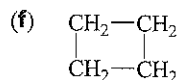
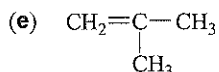
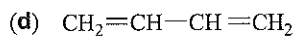
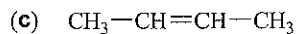
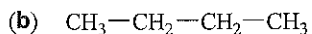
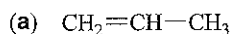
Q15 Each metallic ion was separated from an aqueous solution containing Ba^{2+} , Cu^{2+} , and Zn^{2+} by the procedure shown in the following figure. From ①-⑥ in the table below choose the correct combination of ions that predominates in the precipitates **a**, **b** and the filtrate **c**.

15



	a	b	c
①	Ba^{2+}	Cu^{2+}	Zn^{2+}
②	Ba^{2+}	Zn^{2+}	Cu^{2+}
③	Cu^{2+}	Ba^{2+}	Zn^{2+}
④	Cu^{2+}	Zn^{2+}	Ba^{2+}
⑤	Zn^{2+}	Ba^{2+}	Cu^{2+}
⑥	Zn^{2+}	Cu^{2+}	Ba^{2+}

Q16 Of the following compounds (a)-(f), which are structural isomers of 1-butene? From ①-⑧ below choose the correct combination. **16**



① a, b, d

② a, c, e

③ a, d, f

④ b, c, e

⑤ b, d, f

⑥ c, d, e

⑦ c, e, f

⑧ d, e, f

Q17 Choose from ①-⑥ below the correct combination of compounds from the following compounds (a)-(f) that react with potassium permanganate (KMnO_4) in an acidic aqueous solution. **17**

(a) ethyl alcohol (ethanol)

(b) acetic acid

(c) cyclohexane

(d) 1-butene

(e) propane

(f) benzene

① a, c

② a, d

③ b, d

④ b, f

⑤ d, e

⑥ e, f

Q18 A mixture of benzene and cyclohexene was completely hydrogenated with the aid of a catalyst. In this reaction, 10 mol of hydrogen (H_2) was consumed and 6 mol of cyclohexane was formed. From the following ①-⑤ choose the correct figure for the amount (mol) of benzene that was contained in the mixture. **18** mol

① 1

② 2

③ 3

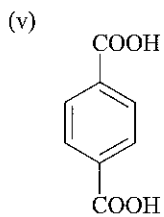
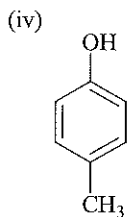
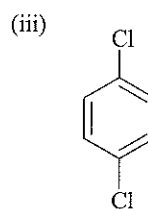
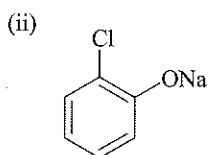
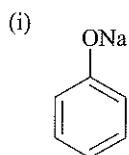
④ 4

⑤ 5

Q19 Which compounds (i)-(v) are obtained by the following reaction (a) and (b), respectively? Choose the correct combination from ①-⑥ in the table below. 19

(a) Chlorobenzene is reacted with sodium hydroxide (NaOH) at high temperature and high pressure.

(b) *p*-Xylene is reacted with potassium permanganate (KMnO₄) in an acidic condition.



	a	b
①	i	iv
②	i	v
③	iii	ii
④	iii	v
⑤	v	ii
⑥	v	iv

Q20 Which of the following compounds (a)-(e) are synthesized by a condensation polymerization? From ①-⑥ below choose the correct combination. **20**

- (a) nylon 6,6 (b) polyethylene (c) poly(ethylene terephthalate)
(d) poly(vinyl acetate) (e) polystyrene

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

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 Statements (a)–(e) below describe cellular structures and functions. From ①–⑧ below choose the combination indicating the statements that are correct. 1

- (a) In bacteria that carry out aerobic respiration, this process takes place in the mitochondria.
- (b) Prokaryotes that carry out photosynthesis, such as nostoc, have chloroplasts.
- (c) Since bacteria do not have a nucleus, they do not possess DNA.
- (d) Cells that secrete vigorously, such as the pancreatic cells of mammals, possess well-developed Golgi bodies.
- (e) Cell walls in angiosperms are primarily made up of cellulose.

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

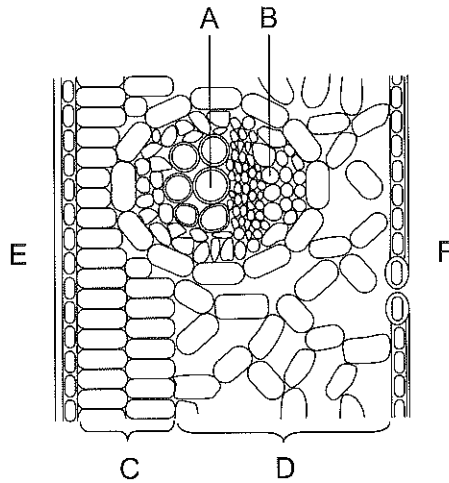
Q2 Statements (a)–(f) below describe the action of channels and pumps in neurons. From ①–⑧ below choose the combination indicating the two statements that are correct. 2

- (a) When the cell membrane is stimulated, sodium channels open and sodium ions (Na^+) flow into the cell, reversing the membrane potential.
- (b) When the cell membrane is stimulated, potassium channels open and potassium ions (K^+) flow into the cell, reversing the membrane potential.
- (c) ATP is synthesized when potassium ions are actively transported out of the cell and sodium ions are actively transported into the cell.
- (d) ATP is consumed when potassium ions are actively transported out of the cell and sodium ions are actively transported into the cell.
- (e) Sodium pumps actively transport sodium ions into the cell using ATP energy.
- (f) Sodium pumps actively transport potassium ions into the cell using ATP energy.

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

Q3 The figure below schematically represents a cross section of a dicotyledon leaf. From ①–⑧ below choose the combination that correctly indicates the locations of vessels, palisade tissue, and the upper leaf surface.

3



	Vessels	Palisade tissue	Upper surface
①	A	C	E
②	A	C	F
③	A	D	E
④	A	D	F
⑤	B	C	E
⑥	B	C	F
⑦	B	D	E
⑧	B	D	F

Q4 From ①–⑤ below choose the statement that does **not** correctly describe a characteristic of human tissues. 4

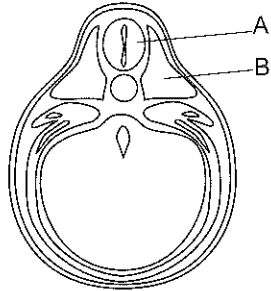
- ① Human tissues are largely divided into four categories: epithelial, connective, muscle, and nerve.
- ② Examples of epithelial tissue include the cells that line the inner surface of the digestive tract and blood vessels.
- ③ Examples of connective tissue include osteocytes and the skin's dermis.
- ④ Examples of muscle tissue include skeletal muscles and tendons, which connect skeletal muscles to bones.
- ⑤ Examples of nerve tissue include neurons and the cell clusters that support and supply nutrients to neurons.

Q5 Statements (a)–(e) below describe germ cell formation and double fertilization in angiosperms. From ①–⑨ below choose the combination indicating the two statements that are correct. 5

- (a) A pollen tube cell in a certain stage contains a smaller generative cell. The nuclear phase of both cells is n .
- (b) Nuclear division occurs two times during the formation of an embryo sac from an embryo sac mother cell.
- (c) An embryo sac is made up of seven cells, and fertilization (union) takes place at two of those cells.
- (d) A sperm cell fertilizes the egg cell to form a fertilized egg, and the central cell fuses with the pollen tube cell to form an endosperm cell.
- (e) The simultaneous fertilization of two egg cells is called “double fertilization.”

- ① a, b ② a, c ③ a, d ④ a, e ⑤ b, c ⑥ b, d
- ⑦ b, e ⑧ c, d ⑨ c, e

Q6 The figure below shows a cross section of a frog tailbud. From what germ layers are A and B in the figure derived? Also, which of statements (a)–(d) below apply to A and B? From ①–⑧ below choose the correct combination. 6

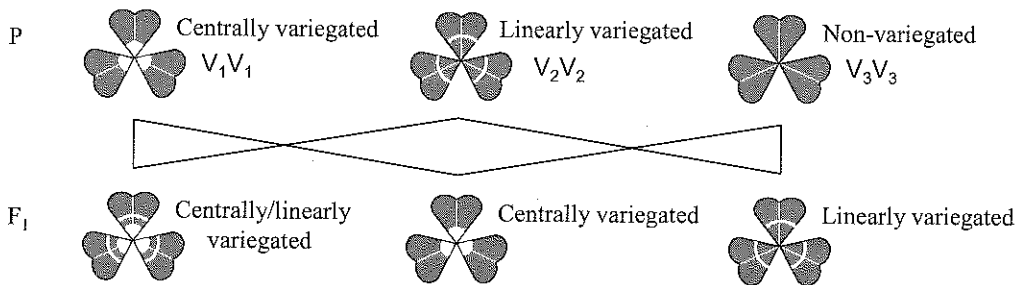


- (a) It differentiates into the digestive tract, and also gives rise to the liver and pancreas.
- (b) It differentiates into skeletal muscle, and also gives rise to the backbone.
- (c) It differentiates into the brain and spinal cord.
- (d) It differentiates into the heart and kidneys.

	A		B	
	Derived from	Statement	Derived from	Statement
①	mesoderm	a	mesoderm	d
②	mesoderm	a	endoderm	d
③	mesoderm	b	endoderm	c
④	mesoderm	b	ectoderm	c
⑤	ectoderm	c	ectoderm	b
⑥	ectoderm	c	mesoderm	b
⑦	ectoderm	d	mesoderm	a
⑧	ectoderm	d	endoderm	a

Q7 Clover leaves often exhibit white leaf mark. Based on the shape of these white patterns, clovers can be divided into: centrally variegated, linearly variegated, centrally and linearly variegated, and non-variegated. These different patterns are determined by three alleles: V_1 , V_2 , and V_3 . The figure below shows the result of crossing between pure-line centrally variegated, linearly variegated, and non-variegated clovers. What would be the result (the segregation ratio of variegation types) if a centrally/linearly variegated individual and a centrally variegated individual selected from the F_1 offspring were crossed? From ①–⑧ below choose the best answer.

7



	Centrally variegated	:	Linearly variegated	:	Centrally/linearly variegated	:	Non-variegated
①	1	:	1	:	1	:	1
②	2	:	1	:	1	:	0
③	1	:	2	:	1	:	0
④	1	:	1	:	2	:	0
⑤	3	:	1	:	0	:	0
⑥	1	:	3	:	0	:	0
⑦	0	:	3	:	1	:	0
⑧	0	:	1	:	3	:	0

Q8 From ①–④ below choose the statement that does **not** correctly describe testcrossing. 8

- ① One of the individuals used in a testcross is a recessive homozygote.
- ② The genotypic segregation ratio of gametes produced by the individual being tested is manifested in the phenotypic segregation ratio of offspring that result from mating of that individual.
- ③ Testcrossing is an effective method for investigating the genotype of an individual that expresses a recessive trait.
- ④ There is a method for determining recombination values by using testcrossing to find out the segregation ratio of offspring.

Q9 The human ear acts as a receptor for senses of hearing and balance. From ①–⑤ below choose the statement that correctly describes ear structure or functioning. 9

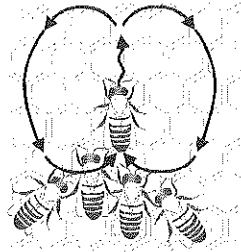
- ① The ear's structure is divided into the external ear, middle ear, and inner ear; auditory stimuli are received by sensory cells in the middle ear, and balance-related stimuli are received by sensory cells in the inner ear.
- ② The sensation of body tilting arises from excitation of sensory cells in response to the flow of lymph in the semicircular canal.
- ③ The sensation of body rotation arises from excitation of sensory cells in response to the flow of lymph in the vestibule.
- ④ The sense of balance arises from excitation of sensory cells in the semicircular canal and vestibule in response to vibration of statoliths.
- ⑤ The sense of hearing arises from excitation of sensory cells in response to vibration of cochlear duct lymph from air vibrations transmitted through the external and middle ears.

Q10 Statements (a)–(e) below describe the nervous system of vertebrates. From ①–⑨ below choose the combination indicating the two statements that are **not** correct. 10

- (a) The vertebrate nervous system is made up of the central nervous system and the peripheral nervous system.
- (b) The peripheral nervous system of vertebrates is made up of sensory nerves, motor nerves, sympathetic nerves, and parasympathetic nerves.
- (c) Vertebrate brains are divided into five regions: cerebrum, diencephalon, midbrain, cerebellum, and spinal cord.
- (d) The degree of development of various brain regions varies between animal species; the brains of all mammals have a developed cerebrum.
- (e) Mammalian cerebral cortex, which has many axons and a wrinkled surface, is composed of neocortex and evolutionarily older cortex.

- ① a, b ② a, c ③ a, d ④ b, c ⑤ b, d ⑥ b, e
⑦ c, d ⑧ c, e ⑨ d, e

Q11 When a honeybee returns to its hive after finding a distant food source, it performs a waggle dance on a vertical surface of the hive. As shown in the figure below, this dance follows a figure-eight pattern: the bee walks in a straight line and circles back from the right; it then goes through the straight run again and circles back from the left. During the straight run, the bee waggles its abdomen.



This dance communicates to other bees the actual angle between the sun's direction and the food source's direction. The angle is expressed by how much the straight run is inclined from the vertical (which symbolizes the sun's direction). For example, the dance shown in Figure 1 below indicates the direction of food source A in Figure 2. Which of directions B–E in Figure 2 is indicated by the dance shown in Figure 3? From ①–④ below choose the correct answer.

11

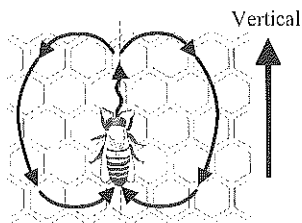


Figure 1

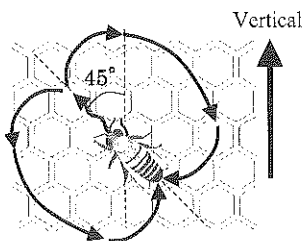


Figure 3

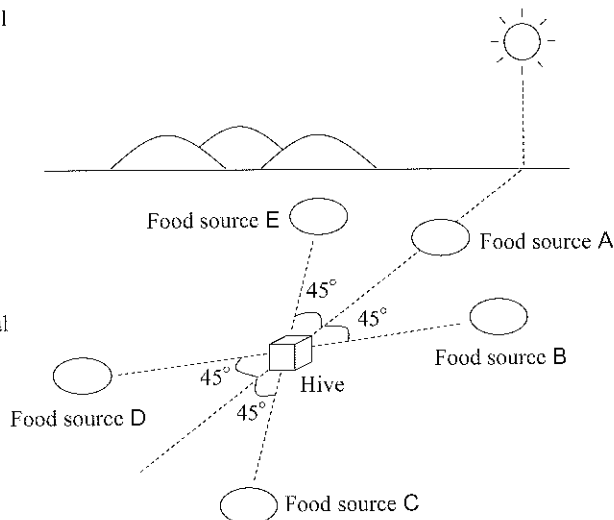
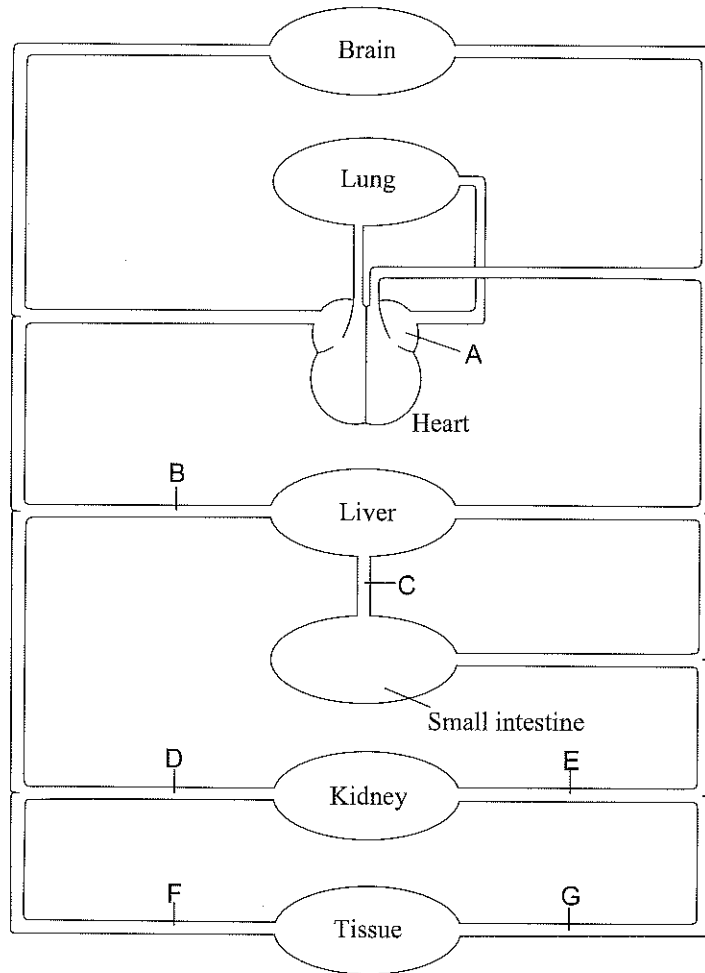


Figure 2

- ① B ② C ③ D ④ E

Q12 The figure below schematically represents the human blood vascular system. Answer questions (1) and (2) on the following page concerning this system.



- (1) From ①–⑥ below choose the combination that correctly indicates the names of A and C in the figure. 12

	A	C
①	left atrium	hepatic vein
②	left atrium	hepatic artery
③	left atrium	hepatic portal vein
④	right atrium	hepatic vein
⑤	right atrium	hepatic artery
⑥	right atrium	hepatic portal vein

- (2) Statements (a)–(e) below describe blood flowing through A–G in the figure. From ①–⑧ below choose the combination indicating the two statements that are correct. 13

- (a) In a healthy human, the blood glucose level is higher in E than in D.
 (b) Blood glucose level is higher in B than in C 30 minutes after eating.
 (c) The urea concentration of blood is lower in D than in B.
 (d) The carbon dioxide concentration of blood is higher in F than in G immediately after running a long distance.
 (e) The percentage of oxyhemoglobin in blood is higher in B than in A.

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

Q13 Read the following paragraph concerning photosynthesis in green plants and answer questions (1) and (2) below.

In photosynthesis, x chlorophyll in the reaction centers of photosystem I and photosystem II is activated by the absorption of light energy, resulting in the release of electrons. The electrons released by are transferred to coenzymes, resulting in the y synthesis of reduced coenzymes. The electrons released by are ultimately transferred to . At this time, , having lost electrons, breaks down , thereby resupplying electrons to the reaction-center chlorophyll. The reduced coenzymes synthesized by these processes are used, along with ATP, in the Calvin-Benson cycle to fix , enabling the z synthesis of carbohydrates.

(1) From ①–④ below choose the combination of terms that correctly fills blanks .

14

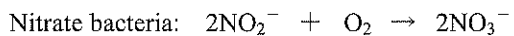
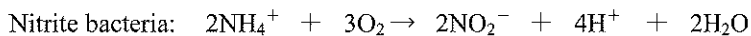
	a	b	c	d
①	photosystem I	photosystem II	CO ₂	H ₂ O
②	photosystem I	photosystem II	H ₂ O	CO ₂
③	photosystem II	photosystem I	CO ₂	H ₂ O
④	photosystem II	photosystem I	H ₂ O	CO ₂

- (2) From ①-⑧ below choose the combination that correctly indicates the sites where underlined reactions X, Y, and Z occur.

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	X	Y	Z
①	thylakoid	thylakoid	thylakoid
②	thylakoid	thylakoid	stroma
③	thylakoid	stroma	thylakoid
④	thylakoid	stroma	stroma
⑤	stroma	thylakoid	thylakoid
⑥	stroma	thylakoid	stroma
⑦	stroma	stroma	thylakoid
⑧	stroma	stroma	stroma

Q14 The following two chemical reactions represent the action of nitrifying bacteria, which convert ammonium ions (NH_4^+) in soil to nitrate ions (NO_3^-).

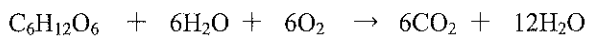


From ①–⑤ below choose the statement that correctly describes these reactions.

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- ① Energy produced by these reactions is used to synthesize an organic compound from an inorganic compound.
- ② Photosynthesis is performed using the nitrite ions (NO_2^-) and nitrate ions produced by these reactions.
- ③ ATP is synthesized in the electron transport system using the nitrite ions and nitrate ions produced by these reactions.
- ④ These reactions represent aerobic respiration by nitrifying bacteria.
- ⑤ Atmospheric nitrogen (N_2) is fixed by these reactions.

Q15 The following chemical equation summarizes the overall reaction process of aerobic respiration in eukaryotes, where glucose is used as the respiration substrate.



The O_2 on the left side of this equation represents oxygen molecules taken into the body by gas exchange. In aerobic respiration, into what molecule on the equation's right side are these O_2 molecules incorporated? Also, what region of the cell uses the oxygen molecules taken in by gas exchange? From ①–⑥ below choose the correct combination.

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	Molecule on right side	Cell region
①	H_2O	cytoplasmic matrix
②	H_2O	mitochondrial matrix
③	H_2O	inner mitochondrial membrane
④	CO_2	cytoplasmic matrix
⑤	CO_2	mitochondrial matrix
⑥	CO_2	inner mitochondrial membrane

Q16 Figure 1 shows the relationship between reaction time and product concentration in a reaction involving an enzyme (biocatalyst), while Figure 2 shows the relationship between substrate concentration and reaction rate for the same reaction. From ①–⑧ below choose the combination indicating the statements in (a)–(d) below that best explain why the curve in each graph levels out. For both graphs, assume that enzyme concentration and temperature remain constant.

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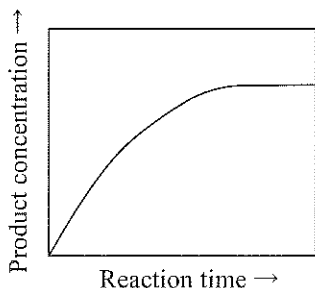


Figure 1

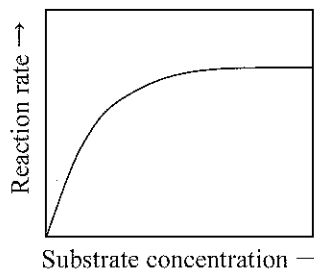


Figure 2

- (a) The reaction is accelerated by the increase in product.
- (b) The reaction speeds up due to the decrease in substrate.
- (c) As the reaction progresses, the substrate concentration decreases.
- (d) When the substrate concentration reaches a high level, almost all the enzymes are used in the reaction with the substrate.

	Figure 1	Figure 2
①	a	b
②	a	c
③	b	c
④	b	d
⑤	c	a
⑥	c	d
⑦	d	a
⑧	d	b

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.

