2015 Examination for Japanese University Admission
for International Students

Science (80 min.)

【Physics, Chemistry, Biology】

※ Choose and answer <u>two subjects</u>.

※ Answer the questions using <u>the front side of the answer sheet for one subject</u>, and <u>the reverse side for the other subject</u>.

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	23－35
Biology	37－49

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 $\boxed{1}$, $\boxed{2}$, $\boxed{3}$, …. 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 instructed 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.

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
●	○	○

I Answer questions **A** (Q1), **B** (Q2), **C** (Q3), **D** (Q4), **E** (Q5), and **F** (Q6) below, where g denotes the magnitude of acceleration due to gravity. Air resistance is negligible, except in question **D** (Q4).

A Consider a plate of negligible mass that is shaped as an isosceles triangle (vertices: O, A, and B), as shown in Figure 1. The plate is able to rotate freely about fixed vertex O. The length of base AB is 2ℓ, and the height of vertex O from AB is d. A weight of mass m_1 is suspended from vertex A and a weight of mass m_2 is suspended from vertex B, using two strings of negligible mass. As a result, the plate rotates and comes to rest so that base AB forms angle θ with the horizontal, as shown in Figure 2.
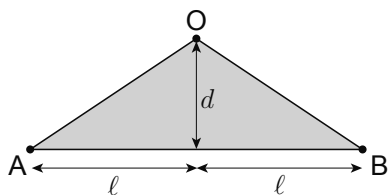

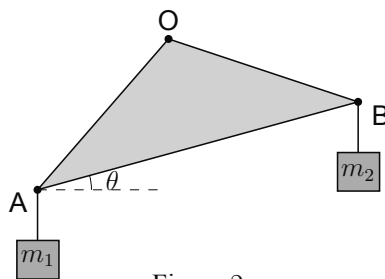Figure 1   Figure 2

Q1 What is $\dfrac{m_1}{m_2}$? From ①-⑥ below choose the correct answer.   **1**

① $\dfrac{\ell\cos\theta + d\sin\theta}{\ell}$

② $\dfrac{\ell}{\ell\cos\theta - d\sin\theta}$

③ $\dfrac{\ell\cos\theta + d\sin\theta}{\ell\cos\theta - d\sin\theta}$

④ $\dfrac{\ell\cos\theta + d\tan\theta}{\ell}$

⑤ $\dfrac{\ell}{\ell\cos\theta - d\tan\theta}$

⑥ $\dfrac{\ell\cos\theta + d\tan\theta}{\ell\cos\theta - d\tan\theta}$

B Consider a building of height h and a vertical wall that are separated by horizontal distance L. As shown in the figure below, a small ball is thrown horizontally with a speed of v from point A on the edge of the building's rooftop; the ball then collides with the wall, bounces, and lands at point B, directly below point A. There is no friction between the ball and the wall, and their collision is elastic.
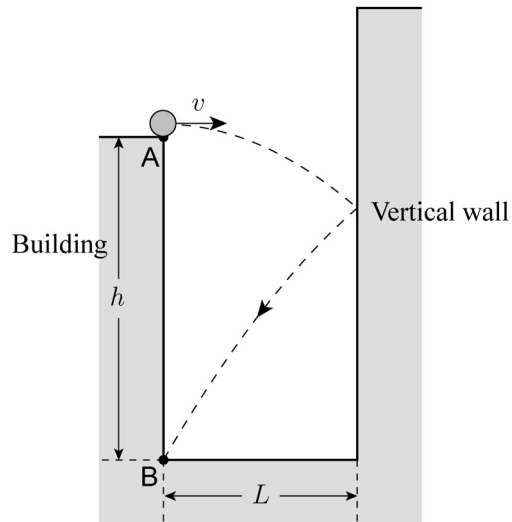
Q2 What is v? From ①-④ below choose the correct answer. **2**

① $L\sqrt{\dfrac{g}{h}}$　　　　　　　　② $L\sqrt{\dfrac{2g}{h}}$

③ $2L\sqrt{\dfrac{g}{h}}$　　　　　　　④ $2L\sqrt{\dfrac{2g}{h}}$

C As shown in the figure below, small object A (mass: m_A) is traveling in a linear path on a horizontal surface and collides elastically with small object B (mass: m_B), at rest on the same line, with a speed of v. Friction between the objects and the horizontal surface is negligible.

A v B

m_A $\longrightarrow$ m_B

Q3 What is the impulse imparted to A by B during the collision? Here, the positive direction of impulse is defined as the direction of A's velocity before collision. From ①-④ below choose the correct answer.   **3**

① $-\dfrac{2m_A m_B}{m_A + m_B}v$

② $-\dfrac{m_A(m_A - m_B)}{m_A + m_B}v$

③ $\dfrac{2m_A m_B}{m_A + m_B}v$

④ $\dfrac{m_A(m_A - m_B)}{m_A + m_B}v$

D A small ball of mass m is falling vertically while being acted upon by resistance directly proportional to its speed v. The magnitude of the resistance is kv, where k is a proportionality constant. After sufficient time elapses, the ball's speed becomes constant.

Q4　What is the magnitude of the work done by the resistance per unit time after the ball's speed becomes constant? From ①-④ below choose the correct answer. $\boxed{4}$

①　$\dfrac{mg}{k}$　　　　②　$\dfrac{mg}{k^2}$　　　　③　$\dfrac{(mg)^2}{k}$　　　　④　$\dfrac{(mg)^2}{k^2}$

E As shown in the figure below, objects A and B (mass: m and M, respectively) are initially at rest at the start line on a smooth horizontal surface (the figure shows the view from directly above). Next, A and B are pulled to the finish line with the same force F applied over the same distance. Let us denote the magnitude of the momentum of A and B at the instant they reach the finish line as p_A and p_B, respectively.


Q5 What is $\dfrac{p_A}{p_B}$? From ①-⑤ below choose the correct answer. 【5】

① $\dfrac{m}{M}$ ② $\sqrt{\dfrac{m}{M}}$ ③ 1   ④ $\sqrt{\dfrac{M}{m}}$ ⑤ $\dfrac{M}{m}$

F As shown in the figure below, one end of a lightweight, inelastic string (length: 1.0 m) is fixed in place, and the other end is connected to a weight with a mass of 1.0 kg. The weight is made to undergo circular motion in a vertical plane. The weight's speed at the highest point P is 4.0 m/s. Assume that the magnitude of acceleration due to gravity is 9.8 m/s^2.
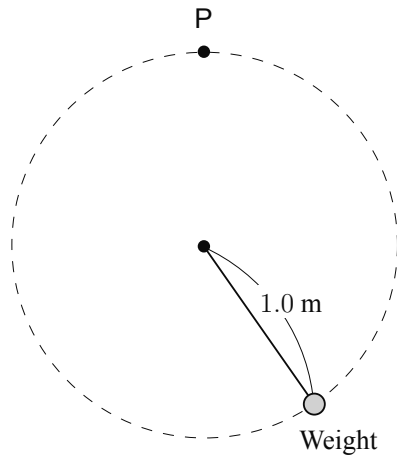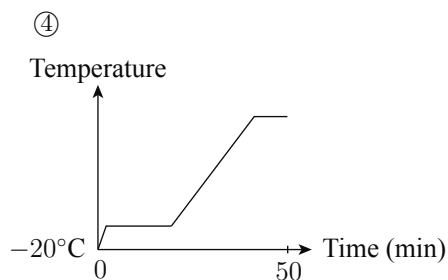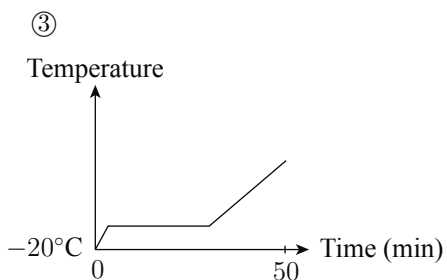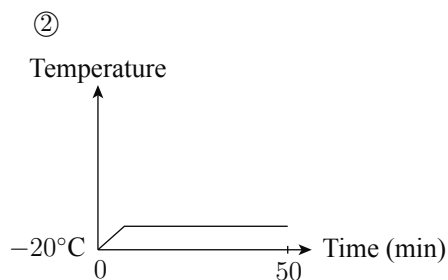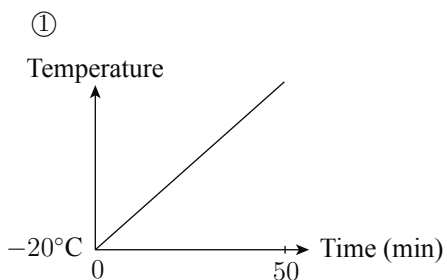

Q6 What is the magnitude (in N) of the tension in the string at the instant when the weight passes through P? From ①-④ below choose the best answer. **6** N

① 6.2   ② 9.8   ③ 16   ④ 26

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

A Ice of 100 g at $-20°C$ is placed in thermally insulated container at constant pressure and is heated for 50 minutes at a rate of 10 J/s using a heater inside the container. The specific heat of ice is 2.1 J/(g·K), the heat of fusion of ice is 3.3×10^2 J/g, the specific heat of water is 4.2 J/(g·K), and the heat of vaporization of water is 2.3×10^3 J/g.

Q1 From ①-④ below choose the graph that best represents how the container's internal temperature changes with time during the 50 minutes of heating. 　　7

①
Temperature

$-20°C$　　　　　→ Time (min)
　　　0　　　　50

②
Temperature

$-20°C$　　　　　→ Time (min)
　　　0　　　　50

③
Temperature

$-20°C$　　　　　→ Time (min)
　　　0　　　　50

④
Temperature

$-20°C$　　　　　→ Time (min)
　　　0　　　　50

B As shown in the figure below, an ideal gas (amount of substance: n mol) is enclosed inside a cylinder (fixed to a horizontal floor) by a smoothly moving piston with cross-sectional area S. The piston is attached to a horizontal spring (spring constant: k), and the spring's other end is fixed in place. Initially, the gas has an absolute temperature of T_0 and its pressure is equal to atmospheric pressure p_0, and the spring is at its natural length. Next, a heater inside the cylinder is used to heat the gas, changing the absolute temperature of the gas to $T_0 + \Delta T$. As a result, the gas expands and the piston moves distance Δx to the right. Denote the molar specific heat of the gas at constant volume as C_V. The cylinder and the piston are made of thermally insulated material. There is no exchange of heat between the gas and the environment.
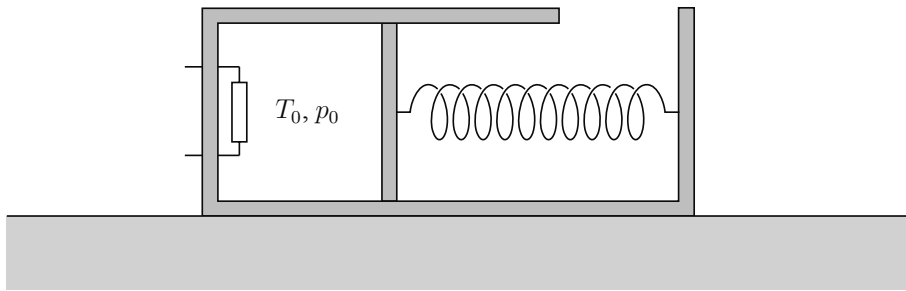
Q2 What is the quantity of heat applied to the gas? From ①-⑥ below choose the correct answer. [8]

① $nC_V\Delta T$ ② $nC_V\Delta T + p_0 S\Delta x$
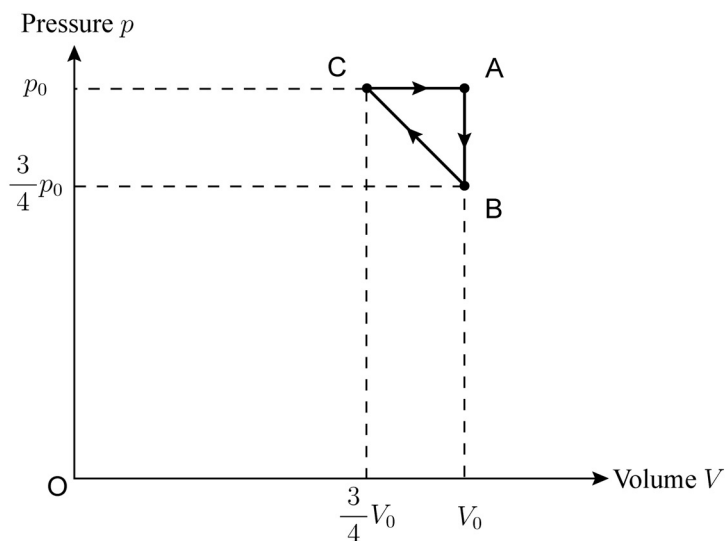
③ $nC_V\Delta T + \dfrac{1}{2}k(\Delta x)^2$ ④ $nC_V\Delta T - \dfrac{1}{2}k(\Delta x)^2$

⑤ $nC_V\Delta T + p_0 S\Delta x + \dfrac{1}{2}k(\Delta x)^2$ ⑥ $nC_V\Delta T + p_0 S\Delta x - \dfrac{1}{2}k(\Delta x)^2$

C A certain quantity of a monatomic ideal gas is enclosed in a cylinder with a smoothly moving piston, and the state of the gas is changed in the path A→B→C→A as shown in the p-V diagram below. The gas absorbs heat only during process C→A.

Q3 What is the thermal efficiency of this cycle (A→B→C→A)? From ①-④ below choose the best answer. 　　9

① $\dfrac{1}{20}$ 　　　　② $\dfrac{1}{12}$ 　　　　③ $\dfrac{1}{10}$ 　　　　④ $\dfrac{1}{6}$

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

A Consider a sinusoidal wave propagating along an x-axis with a speed of 2 m/s. The solid line in the figure below shows the relationship between the wave's displacement y [m] in the medium and its position coordinate x [m] at time $t = 0$ s. The broken line represents the waveform at time $t = 0.1T$, where T [s] is the period of this wave.
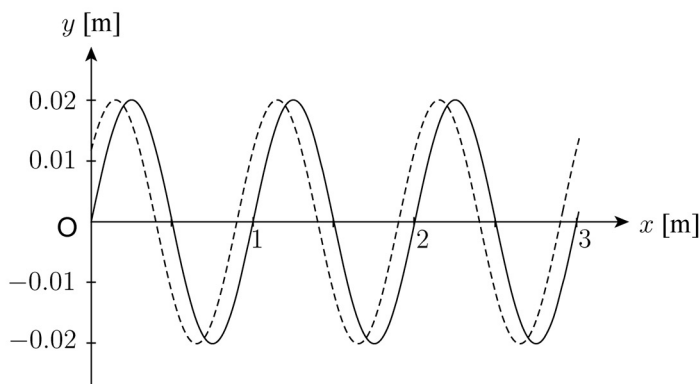
Q1 From ①-④ below choose the answer that best indicates the formula for expressing this wave's displacement y as a function of time t and coordinate x. **10**

① $\quad y = -0.02 \sin 2\pi(0.5t - x)$ 　　　　② $\quad y = 0.02 \sin 2\pi(0.5t + x)$

③ $\quad y = -0.02 \sin 2\pi(2t - x)$ 　　　　　④ $\quad y = 0.02 \sin 2\pi(2t + x)$

B As shown in the figure below, two speakers, S_1 and S_2, are placed 5.0 m apart. Both speakers are emitting sound waves at the same frequency and in phase. When the sound of these speakers is heard at various positions by moving along line **B**, which is parallel to line **A** connecting the speakers and is 12 m away, it is discovered that positions where the sound is loud alternate with positions where the sound is soft. The sound is loud at point P_0, which is the same distance from S_1 and S_2. P_1 and P_2 indicate the next two positions where the sound is loud as the observer moves away from P_0. P_2 is 2.5 m from P_0. Assume that the speed of sound is 340 m/s.
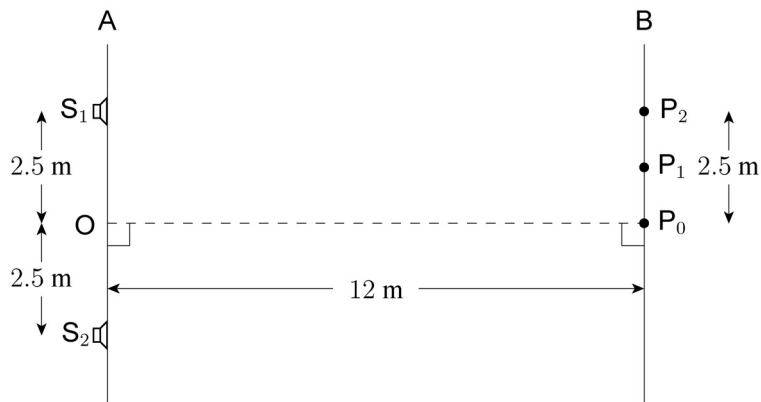
Q2 What is the frequency (in Hz) of the sound emitted by the speakers? From ①-④ below choose the best answer. 　　　　　　　　　　　　　　　 **11** Hz
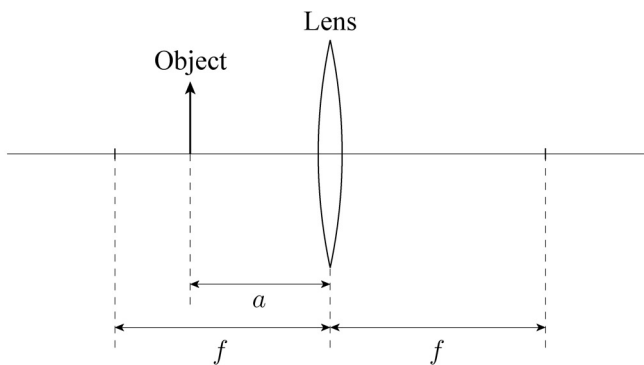
　① 170　　　　　　② 340　　　　　　③ 680　　　　　　④ 1360

C Consider a convex lens whose focal length is f. When an object is placed distance a ($a < f$) from the lens as shown in the figure below, a virtual image appears at a position distance b from the lens.

Lens

Object

a

f f

Q3 If the object is moved closer to the lens (i.e., distance a is reduced), how would b (distance between the lens and the virtual image) and the size of the virtual image change? From ①-④ below choose the correct combination.   **12**

	①	②	③	④
b	decrease	decrease	increase	increase
Virtual image size	decrease	increase	decrease	increase

IV Answer questions **A** (Q1), **B** (Q2), **C** (Q3), **D** (Q4), **E** (Q5), and **F** (Q6) below.
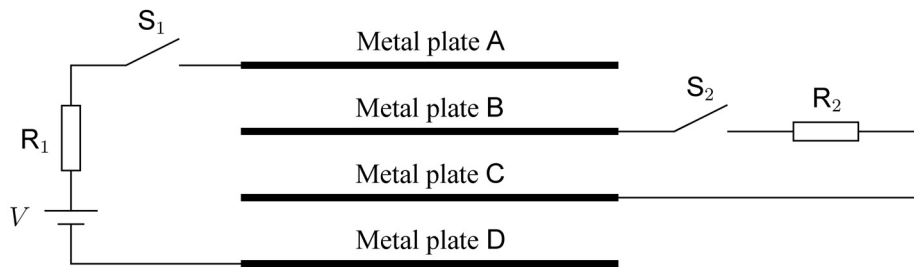
A As shown in the figure below, two point charges with the same quantity of electricity and the same sign are placed at points **A** and **B** in a plane.

A   B

Q1 From ①-④ below choose the figure that best represents the electric field lines (the electric lines of force) in this plane. Note that arrows have not been added to the field lines. **13**

①

②

③

④
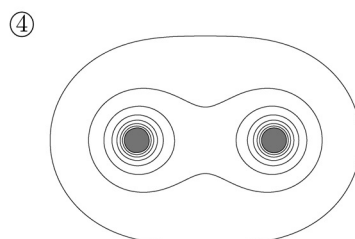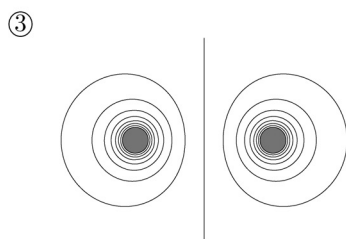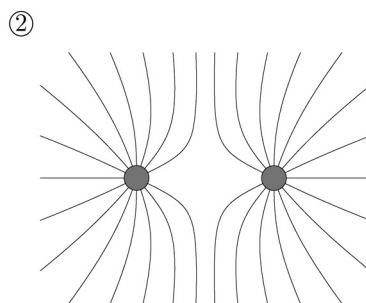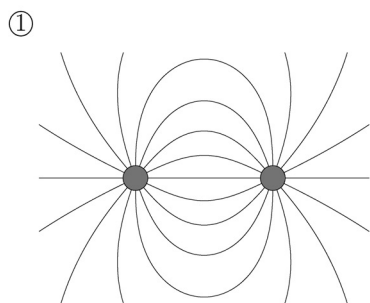
B As shown in the figure below, four uncharged metal plates (A, B, C, D) of the same area are placed in a vacuum, parallel to one another and separated by equal distances. They are connected by conducting wires to two resistors (R_1 and R_2), two open switches (S_1 and S_2), and a battery (electromotive force: V). The thickness of the plates is negligible, and their area is sufficiently large. S_1 is now closed, and after sufficient time elapses, a charge with quantity of electricity Q is stored in A. Next, as S_1 is kept closed, S_2 is also closed. After sufficient time elapses, a charge with quantity of electricity Q' is stored in A.
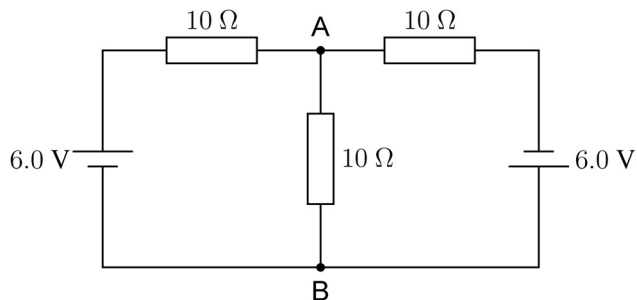

Q2 What is the value of $\dfrac{Q'}{Q}$? From ①-⑤ below choose the correct answer.   **14**

① $\dfrac{1}{2}$ ② $\dfrac{2}{3}$ ③ 1   ④ $\dfrac{3}{2}$ ⑤ 2

C As shown in the figure below, two batteries, each with an electromotive force of 6.0 V, are connected with three $10\ \Omega$ resistors. The internal resistance of the batteries is negligible.

Q3 What is current I (in amperes, A) flowing between points **A** and **B** in the figure above? The positive direction of the current is the direction from **A** to **B**. From ①-⑦ below choose the best answer. **15** A

① -1.2 ② -0.80 ③ -0.40 ④ 0.0

⑤ 0.40 ⑥ 0.80 ⑦ 1.2

D As shown in Figure 1 below, a circular coil with radius a is placed in an x-y plane of xyz coordinate system, and is centered upon the origin O. Also, a sufficiently long straight conducting wire is placed parallel to the x-axis in the same plane so that it passes through point A $(0, 2a, 0)$. When electric current I_1 is passed through the coil in the direction shown while no current is passed through the straight wire, the magnitude of the magnetic field at the origin O is H. Next, as shown in Figure 2, a current I_2 is passed through the straight wire in the direction shown while I_1 continues to flow in the coil. As a result, the magnitude of the magnetic field at the origin O becomes zero. Next, as shown in Figure 3, the straight wire is rotated about point A until the direction of its current is in the positive direction of the z-axis, while the magnitudes of both I_1 and I_2 are maintained.
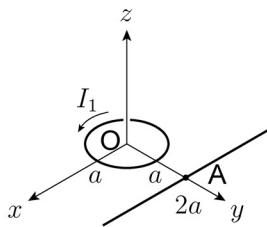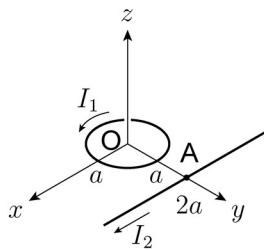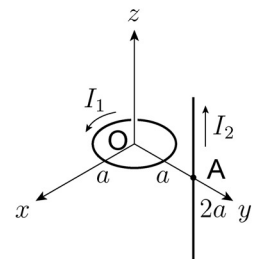

Figure 1   Figure 2   Figure 3

Q4 From ①-⑥ below choose the answer that correctly indicates the magnetic field vector at the origin O under the conditions of Figure 3, in terms of the x, y, and z components.

16

① $(0, H, H)$ ② $(H, 0, H)$ ③ $(H, H, 0)$

④ $(2H, 0, 0)$ ⑤ $(0, 2H, 0)$ ⑥ $(0, 0, 2H)$

E As shown in the figure below, two sufficiently long straight conducting wires, P and Q, and square coil ABCD are placed in the same plane. P, Q, and coil sides AB and CD are parallel to one another. An electric current of magnitude I_1 flows in P and Q, and a current of magnitude I_2 flows in the coil, in the directions indicated by the arrows.
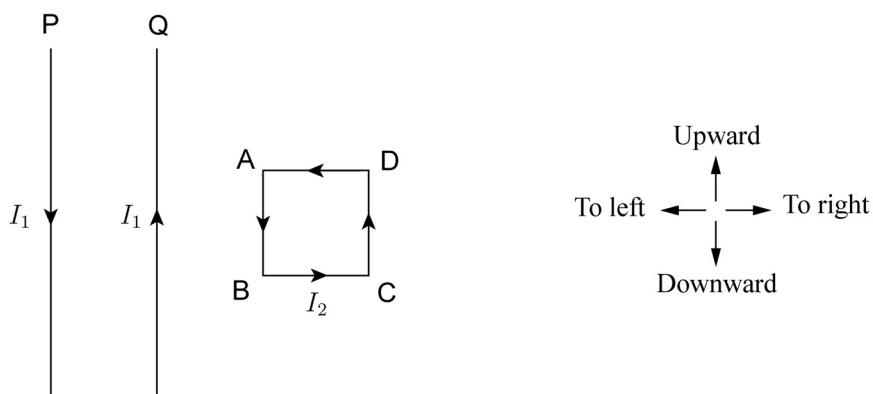
Q5 What is the direction of the resultant force of the forces acting upon the sides of the coil? From ①-④ below choose the correct answer, where the directions stated (upward, downward, to left, to right) correspond to the directions indicated by the arrows on the right side of the figure. **17**

① Upward, parallel to P and Q   ② Downward, parallel to P and Q

③ To left, perpendicular to P and Q   ④ To right, perpendicular to P and Q

F As shown in Figure 1 below, a sufficiently long straight conducting wire A and circular coil B are placed in the same plane. Electric current I_A is passed through A and changes with time t as indicated in Figure 2. As a result, current I_B flows through B (the positive direction is as indicated in Figure 1), changing with time t. Assume that the magnetic field produced by the current flowing in B is negligible.
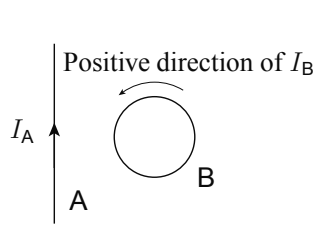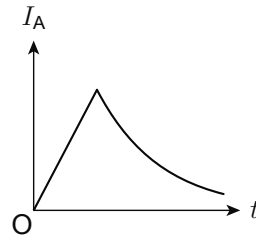

Figure 1   Figure 2

Q6   From ①-⑥ below choose the graph that best represents how I_B changes with t.   **18**
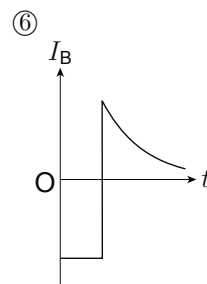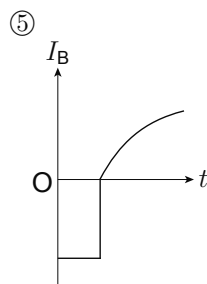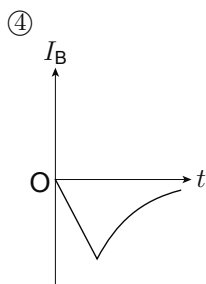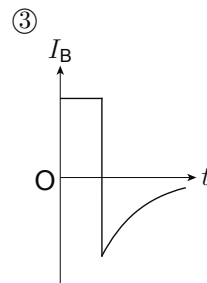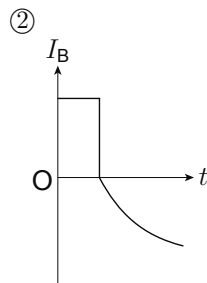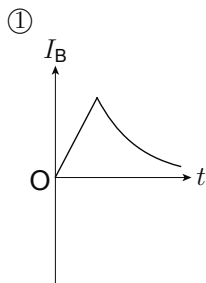
$\boxed{\text{V}}$ Answer question **A** (Q1) below.

A The Bohr model of the hydrogen atom assumes that an electron (quantity of electricity: $-e$) orbits a nucleus (quantity of electricity: e) in uniform circular motion with radius r and speed v, with electrostatic force acting as a centripetal force. From this, the model arrives at the following equation of motion:

$$m\frac{v^2}{r} = k_0\frac{e^2}{r^2}$$

where m is the mass of the electron and k_0 is the proportionality constant of Coulomb's law. Bohr proposed the quantization condition $mvr = \dfrac{nh}{2\pi}$ for the relation between v and r, where n is a positive integer and h is the Planck constant. Let us denote the speed of an electron as v_1 when $n = 1$, and as v_2 when $n = 2$.

Q1 What is the value of $\dfrac{v_1}{v_2}$? From ①-⑦ below choose the correct answer. $\boxed{\textbf{19}}$

① $\dfrac{1}{4}$ ② $\dfrac{1}{2}$ ③ $\dfrac{1}{\sqrt{2}}$ ④ 1

⑤ $\sqrt{2}$ ⑥ 2 ⑦ 4

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. <u>Use the front side of the answer sheet for one subject, and the reverse side for the other subject</u>.

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. The unit of volume "liter" is represented by "L".

Standard state:　0 ℃，1.0×10^5 Pa (= 1.0 atm)

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

Gas constant:　$R = 8.31 \times 10^3$ Pa·L/(K·mol)

Avogadro constant:　$N_A = 6.02 \times 10^{23}$ /mol

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

Atomic weight:　　H : 1.0　　C : 12　　N : 14　　O : 16　　Cu : 64　　Ag : 108

The relation between the group and the period used in this examination is indicated in the following periodic table. Atomic symbols other than **H** are omitted.

Q1　Among the statements (**a**)-(**d**) on elements, two are correct. From ①-⑥ below choose the combination of them.　　　　　　　　　　　　　　　　　**1**

(**a**)　The atoms $_{12}^{26}$Mg and $_{13}^{27}$Al have the same number of neutrons.

(**b**)　The ionization energy (the first ionization energy) of Na is larger than that of Ne.

(**c**)　The atom S has more valence electrons than Cl.

(**d**)　The electron affinity of O is smaller than that of F.

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

Q2　From the following combinations of substances ①-⑥ choose the one in which the two substances are allotropes of each other.　　　　　　　　　　　　　　**2**

①	diamond	silicon
②	ozone	carbon dioxide
③	rubbery sulfur	rubber
④	fullerene	graphite
⑤	phosphorus	nitrogen
⑥	ice	water

Q3   From the following statements ①-⑤ choose the one in which the underlined part is **not** correct.　　　　　　　　　　　　　　　　　　　　　　　　　　　　 **3**

① In an ammonium ion, an NH_3 molecule combines with H^+ by an ionic bond.

② In a hydrogen chloride molecule, an H atom and a Cl atom combine with each other by a covalent bond.

③ In diamond, C atoms combine with each other by covalent bonds.

④ In metallic iron, atoms combine with each other by metallic bonds.

⑤ In dry ice, CO_2 molecules interact with each other through intermolecular forces.

Q4   The synthesis of urea is represented by the following chemical equation.

$$2NH_3 \ + \ CO_2 \ \longrightarrow \ (NH_2)_2CO \ + \ H_2O$$
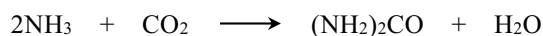
How many grams of urea in maximum will be obtained from 17 g of ammonia and 44 g of carbon dioxide? From the following ①-⑤ choose the closest value.　　 **4** g

① 30　　　 ② 42　　　 ③ 48　　　 ④ 56　　　 ⑤ 61

Q5　The following figure represents the crystal structure of cesium chloride (CsCl).

$\bigcirc$: Cl⁻

 : Cs⁺
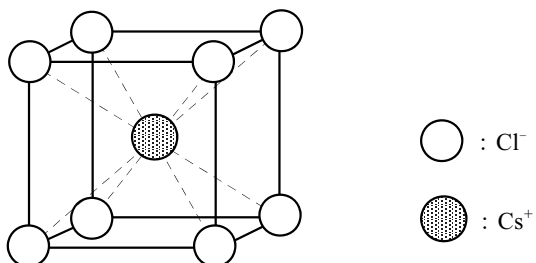
From ①-⑧ in the table below choose the combination that includes the correct values for the following statements (**a**) and (**b**) on this crystal.　　　 **5**

(**a**)　the number of Cs⁺ which contacts one Cl⁻

(**b**)　the number of Cl⁻ contained in the unit cell

	a	b
①	4	$\dfrac{1}{8}$
②	8	$\dfrac{1}{8}$
③	4	$\dfrac{1}{4}$
④	8	$\dfrac{1}{4}$
⑤	4	1
⑥	8	1
⑦	4	8
⑧	8	8

Q6　　Among the graphs (i)-(iii) there are two, each of which represents the statements (**a**) or (**b**) on ideal gases. Choose from ①-⑥ in the table below the correct combination.

(**a**)　The relation between the pressure P and the volume V when the temperature is kept constant.

(**b**)　The relation between the volume V and the absolute temperature T when the pressure is kept constant.

$\boxed{\textbf{6}}$

(i)

(ii)
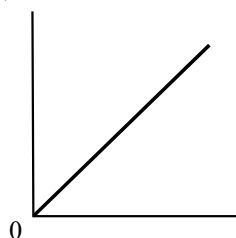
(iii)
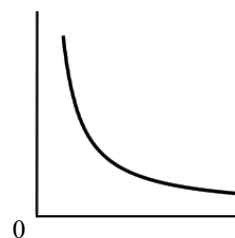
	a	**b**
①	i	ii
②	i	iii
③	ii	i
④	ii	iii
⑤	iii	i
⑥	iii	ii

Q7 Suppose 0.1 mol/L aqueous solutions of each of the following substances ①-⑥ are prepared. From the following ①-⑥ choose the one that has the highest osmotic pressure.

| **7** |

① HCl ② NH_3 ③ KCl ④ Na_2SO_4 ⑤ CH_3COOH ⑥ $C_6H_{12}O_6$

Q8 Compounds **A** and **B** yield compound **C** according to the following chemical equation.

$$a\mathbf{A} \ + \ b\mathbf{B} \ \overset{K}{\rightleftharpoons} \ c\mathbf{C}$$

When the reaction is carried out at constant temperature and pressure, the amounts (mol) of each compound before the reaction and at the equilibrium state are given in the following table. From ①-⑥ below choose the closest value for the equilibrium constant K of this reaction.

| **8** |

	amount of **A** (mol)	amount of **B** (mol)	amount of **C** (mol)
before the reaction	2.0	2.0	0
at equilibrium	1.0	1.0	2.0

① 1.0 ② 2.0 ③ 3.0 ④ 4.0 ⑤ 5.0 ⑥ 6.0

Q9 From ①-⑤ below choose the one in which the pH of the following aqueous solutions **A**-**D** are arranged in decreasing order. ⧠**9**

Aqueous solution **A**   0.10 mol/L hydrochloric acid (HCl aq)

Aqueous solution **B**   0.10 mol/L aqueous acetic acid (CH₃COOH)

Aqueous solution **C**   A mixed aqueous solution of equal volume of 0.10 mol/L acetic acid and 0.10 mol/L sodium acetate (CH₃COONa)

Aqueous solution **D**   0.10 mol/L aqueous sulfuric acid (H₂SO₄)

① **D** > **B** > **A** > **C**

② **B** > **C** > **A** > **D**

③ **B** > **C** > **D** > **A**

④ **D** > **A** > **B** = **C**

⑤ **C** > **B** > **A** > **D**

Q10　When the cell shown in the following figure was discharged, the mass of the silver plate changed by 0.54 g. From the following ①-⑥ choose the most appropriate one for the change of the mass of the copper plate.　**10**

porous sheet
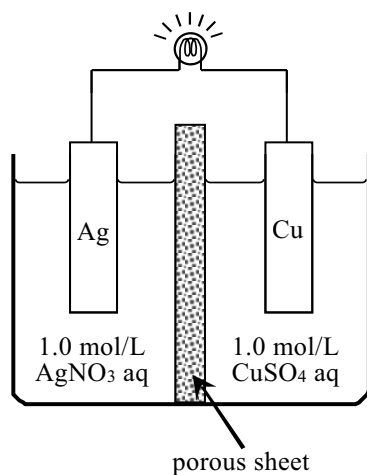
①　decreased by 0.16 g　　②　decreased by 0.32 g　　③　decreased by 0.64 g

④　increased by 0.16 g　　⑤　increased by 0.32 g　　⑥　increased by 0.64 g

Q11 From the following statements ①-⑤ on the elements belonging to the third period of the periodic table choose the one that is **not** correct. 11

① Aluminum (Al) reacts with aqueous sodium hydroxide (NaOH) to generate oxygen (O_2).

② Chlorine (Cl_2) reacts with water to yield hypochlorous acid (HClO).

③ Magnesium (Mg) reacts with dilute hydrochloric acid (dil. HCl) to generate hydrogen (H_2).

④ Sodium (Na) reacts with ethanol (C_2H_5OH) to generate hydrogen.

⑤ Sulfur (S) generates sulfur dioxide (SO_2) by combustion.

Q12 From the following statements ①-⑤ on oxidation-reduction reactions choose the one that is **not** correct. 12

① When zinc (Zn) is added to dilute sulfuric acid (dil. H_2SO_4), hydrogen (H_2) is generated.

② When a mixture of aluminum oxide (Al_2O_3) and iron (Fe) is heated, aluminum (Al) is formed.

③ When sulfur dioxide (SO_2) is passed through aqueous hydrogen sulfide (H_2S), sulfur (S) is formed.

④ When an iron wire is dipped in aqueous copper sulfate ($CuSO_4$), copper (Cu) is deposited on the surface of the iron wire.

⑤ When an aqueous solution of chlorine (Cl_2) is added to an aqueous solution of potassium iodide (KI), iodine (I_2) is formed.

Q13 Two among the following statements (**a**)-(**e**) describe reactions by which chlorine (Cl_2) is generated. From ①-⑥ below choose the correct combination. $\boxed{13}$

(**a**) Manganese(IV) oxide (MnO_2) is added to potassium chlorate ($KClO_3$) and the mixture is heated.

(**b**) Concentrated hydrochloric acid (conc. HCl) is added to manganese(IV) oxide and the mixture is heated.

(**c**) Calcium hydroxide ($Ca(OH)_2$) is added to ammonium chloride (NH_4Cl).

(**d**) Concentrated hydrochloric acid is added to bleaching powder ($CaCl(ClO) \cdot H_2O$).

(**e**) Concentrated sulfuric acid (conc. H_2SO_4) is added to sodium chloride (NaCl).

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

Q14 In two reactions out of the following (**a**)-(**f**), the oxidation numbers of the underlined atoms increase by 2. From ①-⑥ below choose the correct combination. $\boxed{14}$

(**a**) $\underline{N}_2 + 3H_2 \longrightarrow 2NH_3$

(**b**) $\underline{Fe} + H_2SO_4 \longrightarrow FeSO_4 + H_2$

(**c**) $2K\underline{Cl} + F_2 \longrightarrow 2KF + Cl_2$

(**d**) $2\underline{Fe}Cl_2 + Cl_2 \longrightarrow 2FeCl_3$

(**e**) $2\underline{S}O_2 + O_2 \longrightarrow 2SO_3$

(**f**) $2K\underline{Mn}O_4 + 3H_2SO_4 + 5H_2O_2 \longrightarrow K_2SO_4 + 2MnSO_4 + 5O_2 + 8H_2O$

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

Q15 From ①-⑤ below choose the most appropriate metal ion which is compatible with all of the following statements (**a**)-(**c**). ⟨15⟩

(**a**) No precipitate is formed when dilute hydrochloric acid (dil. HCl) is added to the aqueous solution containing this ion.

(**b**) No precipitate is formed when dilute sulfuric acid (dil. H_2SO_4) is added to the aqueous solution containing this ion.

(**c**) When aqueous sodium hydroxide (NaOH) is added to an aqueous solution containing this ion, a precipitate forms, which then dissolves in excess NaOH.

① Ag^+　　② Ba^{2+}　　③ Cu^{2+}　　④ Pb^{2+}　　⑤ Zn^{2+}

Q16 When two hydrogen atoms of ethane, ethene (ethylene) and benzene are replaced by two chlorine atoms, how many isomers will be obtained from each of them? From ①-⑦ in the following table choose the correct combination of values. The *cis*- and *trans*-isomers are to be counted independently. ⟨16⟩

	ethane	ethene (ethylene)	benzene
①	2	2	2
②	3	3	2
③	2	3	2
④	3	2	3
⑤	2	3	3
⑥	3	4	3
⑦	2	4	2

Q17   An organic compound **A** is hydrolyzed to yield a compound **B** which is positive for the silver mirror test and a compound **C** which undergoes the iodoform reaction. From the following ①-⑥ choose the correct formula for **A**. |**17**|

① HCOOCH$_3$ ② HCOOC$_2$H$_5$ ③ CH$_3$COOCH$_3$

④ CH$_3$COOC$_2$H$_5$ ⑤ C$_2$H$_5$COOCH$_3$ ⑥ C$_2$H$_5$COOC$_2$H$_5$

Q18   From the following statements ①-⑤ on the properties and reactions of aniline choose the one that is **not** correct. |**18**|

① Aniline is a weak base.

② Aniline is prepared by reducing nitrobenzene with tin (Sn) and concentrated hydrochloric acid (conc. HCl).

③ Aniline yields a reddish purple substance by oxidizing with bleaching powder (CaCl(ClO)·H$_2$O).

④ Aniline yields acetanilide by reacting with acetic anhydride.

⑤ Aniline yields nitrobenzene by reacting with sodium nitrite (NaNO$_2$) and hydrochloric acid.

Q19 20 mL of 1.0 mol/L aqueous sodium hydroxide (NaOH) was required to saponify 6.0 g of fat. From ①-⑤ below choose the closest value for the average molecular weight of this fat. **19**

① 300 ② 600 ③ 675 ④ 900 ⑤ 1800

Q20 How many kg of water in maximum will be generated when 20 kg of nylon 6,6 with the following structural formula is synthesized from adipic acid ($HOOC(CH_2)_4COOH$) and hexamethylenediamine ($H_2N(CH_2)_6NH_2$) by condensation polymerization? Choose from ①-⑥ below the closest value. **20** kg

$$HO\!-\!\!\left[OC\!-\!(CH_2)_4\!-\!CO\!-\!NH\!-\!(CH_2)_6\!-\!NH\right]_{n}\!\!H$$
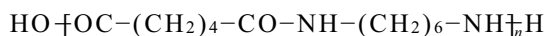
① 0.16 ② 0.24 ③ 1.6 ④ 2.4 ⑤ 3.2 ⑥ 4.0

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

Q1　From ① – ④ below choose the statement that does **not** correctly describe the structure or function of cell membranes.　　　　│**1**│

①　In general, molecules such as hydrophilic amino acids and sugars do not readily cross cell membranes.

②　Ion channels and the sodium pump are proteins that span the width of cell membranes.

③　Exocytosis is a phenomenon in which large molecules and foreign material unable to cross cell membranes are brought inside cells.

④　Cell membranes have proteins that receive external information and enable communication with other cells.

Q2 The figure below shows the structure of three types of amino acids, with $R_1 - R_3$ representing amino acid side chains. From ① – ⑤ below choose the figure that correctly shows the structure formed when these three amino acids are joined by peptide bonds. $\boxed{2}$

$$NH_2-\underset{\underset{H}{|}}{\overset{\overset{R_1}{|}}{C}}-COOH \quad NH_2-\underset{\underset{H}{|}}{\overset{\overset{R_2}{|}}{C}}-COOH \quad NH_2-\underset{\underset{H}{|}}{\overset{\overset{R_3}{|}}{C}}-COOH$$

①
$$NH_2-\underset{\underset{H}{|}}{\overset{\overset{R_1}{|}}{C}}-\underset{\underset{H}{|}}{N}-\underset{\underset{H}{|}}{\overset{\overset{R_2}{|}}{C}}-\underset{\underset{H}{|}}{N}-\underset{\underset{H}{|}}{\overset{\overset{R_3}{|}}{C}}-COOH$$

②
$$NH_2-\underset{\underset{H}{|}}{\overset{\overset{R_1}{|}}{C}}-\overset{\overset{O}{\|}}{C}-\underset{\underset{H}{|}}{\overset{\overset{R_2}{|}}{C}}-\overset{\overset{O}{\|}}{C}-\underset{\underset{H}{|}}{\overset{\overset{R_3}{|}}{C}}-COOH$$

③
$$NH_2-\underset{\underset{H}{|}}{\overset{\overset{R_1}{|}}{C}}-\overset{\overset{O}{\|}}{C}-O-\underset{\underset{H}{|}}{N}-\underset{\underset{H}{|}}{\overset{\overset{R_2}{|}}{C}}-\overset{\overset{O}{\|}}{C}-O-\underset{\underset{H}{|}}{N}-\underset{\underset{H}{|}}{\overset{\overset{R_3}{|}}{C}}-COOH$$

④
$$NH_2-\underset{\underset{H}{|}}{\overset{\overset{R_1}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{R_2}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{R_3}{|}}{C}}-COOH$$

⑤
$$NH_2-\underset{\underset{H}{|}}{\overset{\overset{R_1}{|}}{C}}-\overset{\overset{O}{\|}}{C}-\underset{\underset{H}{|}}{N}-\underset{\underset{H}{|}}{\overset{\overset{R_2}{|}}{C}}-\overset{\overset{O}{\|}}{C}-\underset{\underset{H}{|}}{N}-\underset{\underset{H}{|}}{\overset{\overset{R_3}{|}}{C}}-COOH$$
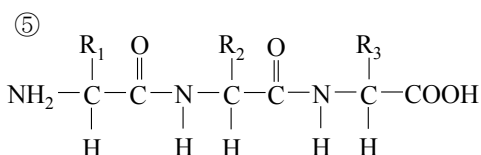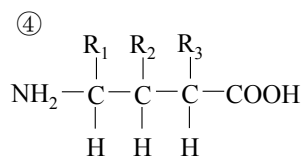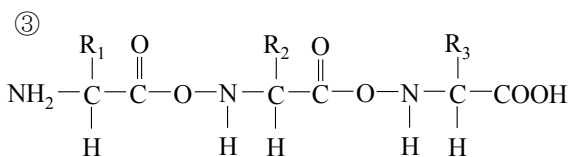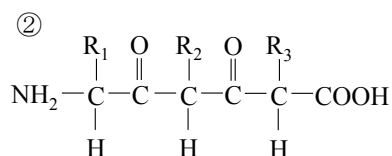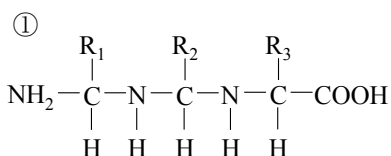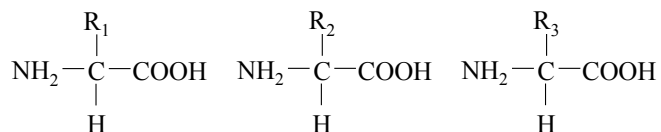
Q3 The following paragraph describes some of the reaction processes of respiration, but one of the underlined terms (A – F) is incorrect. From ① – ⑥ below choose the combination that indicates the underlined term that is wrong and the correct term that needs to replace the wrong term. **3**

The reaction in which one molecule of _A glucose is converted into two molecules of _B pyruvic acid is called glycolysis, and takes place in the _C cytoplasmic matrix. The _D citric acid cycle is a reaction system in which _B pyruvic acid, through the action of decarboxylase and dehydrogenase in the _E outer membrane of mitochondria, produces _F carbon dioxide and the reduced coenzymes NADH and FADH$_2$.

	Incorrect term	→	Correction
①	A	→	ethanol
②	B	→	lactic acid
③	C	→	Golgi bodies
④	D	→	Calvin-Benson cycle
⑤	E	→	matrix
⑥	F	→	oxygen

Q4 A colony of *Escherichia coli* that had only ^{15}N for the nitrogen in their DNA (Generation 0) was placed in a culture medium containing ^{14}N and made to proliferate. From ① – ⑥ below choose the answer that correctly indicates, for Generation 3 produced from division, the respective ratios of individuals whose DNA nitrogen consisted of [only ^{15}N], [^{15}N and ^{14}N], and [only ^{14}N]. $\boxed{\textbf{4}}$

	Only ^{15}N	:	^{15}N and ^{14}N	:	Only ^{14}N
①	0	:	1	:	1
②	0	:	1	:	3
③	0	:	3	:	1
④	1	:	1	:	2
⑤	1	:	1	:	0
⑥	1	:	1	:	1

Q5 From ① – ④ below choose the statement that correctly describes transcription or translation in eukaryotes. $\boxed{\textbf{5}}$

① DNA contains regions of special base sequences called promoters, and transcription is initiated by the binding of DNA polymerase to a promoter.

② Some genes have base sequences that are not translated; these are called exons.

③ The process by which non-translated sequences are removed from the RNA created by transcription is called splicing; RNA that has been spliced is called mRNA.

④ Translation is initiated by the binding of tRNA with a ribosome.

Q6　Answer questions (1) and (2) below concerning meiosis.

(1)　Figure 1 below schematically represents a germ cell of a certain organism during meiosis. From this figure we can determine that the chromosome number of this organism is 2n = ▢a▢. From ①－④ below choose the numeral that correctly fills blank ▢a▢.　▮6▮

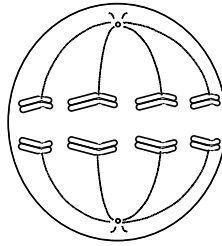Fig. 1

①　2　　　②　4　　　③　8　　　④　16

(2)　Figure 2 below shows changes in the amount of DNA per cell (relative value) that take place with meiosis. Which of A－D in this figure corresponds with the phase of the germ cell shown in Figure 1 in (1) above? From ①－④ below choose the best answer.　▮7▮
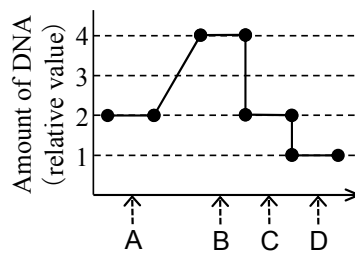

Fig. 2

①　A　　　②　B　　　③　C　　　④　D

Q7 From ① – ⑤ below choose the answer that correctly indicates the name of the cell that is formed at the end of meiosis during pollen formation in angiosperms. 　 **8**

① pollen tetrad 　　② generative cell

③ sperm cell 　　④ pollen mother cell

⑤ pollen tube cell

Q8 From ① – ④ below choose the statement that correctly describes urine formation in humans. 　 **9**

① When the salt concentration of body fluid becomes too low, the secretion of mineralocorticoid is suppressed, resulting in a reduction of the reabsorption of sodium ions, etc.

② Of the various substances in blood, water, mineral salts, glucose, and proteins can pass through the tiny pores of glomeruli, and hence are included in the filtered primitive urine.

③ When the salt concentration of body fluid becomes too high, the secretion of vasopressin is stimulated, resulting in an increase in the reabsorption of water.

④ Of the various constituents of primitive urine, urea is completely reabsorbed.

Q9   The figure below schematically represents the process by which immune cells engulf and digest/decompose foreign material that has invaded the body. From ①－④ below choose the combination that best indicates all types of immune cells in **a** – **f** below that exhibit this function.   **10**
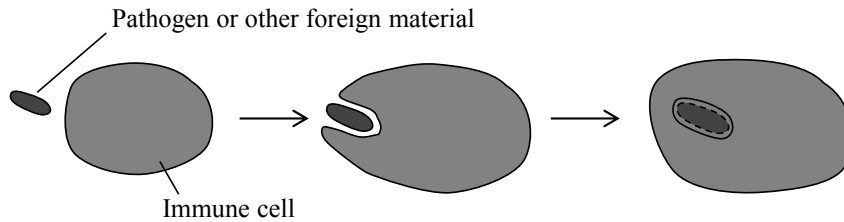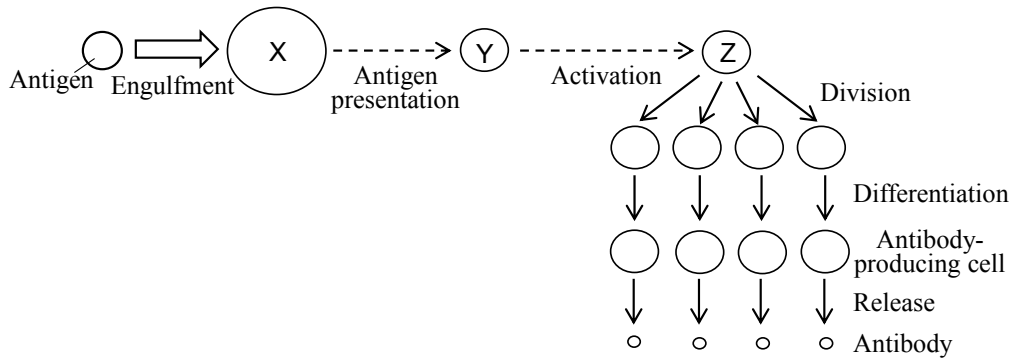

a   Macrophages   b   Dendritic cells

c   Killer T cells   d   Helper T cells

e   Neutrophils   f   B cells

① a, b, e   ② b, c, f   ③ c, d, e   ④ d, e, f

Q10 The following figure shows the functions of cells involved in humoral immunity in humans.

(1) From ① – ⑥ below choose the combination that correctly indicates the names of the cells represented by X, Y, and Z in the figure above.　**11**

	X	Y	Z
①	dendritic cell	killer T cell	helper T cell
②	dendritic cell	helper T cell	B cell
③	B cell	helper T cell	killer T cell
④	B cell	dendritic cell	killer T cell
⑤	helper T cell	killer T cell	B cell
⑥	helper T cell	B cell	killer T cell

(2) From ① – ④ below choose the combination of terms that correctly fills blanks ⬚a⬚ and

⬚b⬚ in the following statement concerning antibodies. **12**

An antibody is a protein called an immuno ⬚a⬚ ; the figure below represents an antibody.

Region A in the figure is called the ⬚b⬚ region.
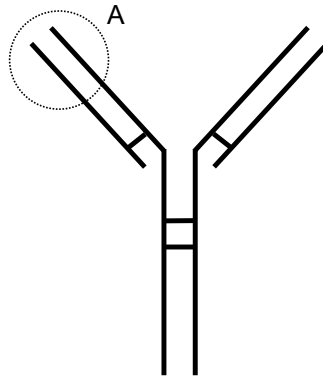
	a	b
①	hemoglobin	constant
②	hemoglobin	variable
③	globulin	constant
④	globulin	variable

Q11 Electrical stimulation was applied to a neuron for a certain amount of time. Statements a and b below describe the intensity of the stimulus and the neuron's excitation. From ① – ④ below choose the combination that best indicates whether each statement is true (○), or false (×). **13**

a The degree of excitation increases with the intensity of the stimulus applied to the neuron.

b Excitation will be observed when the stimulus is applied, but the frequency of excitation will not change even if the intensity of the stimulus is increased.

	a	b
①	○	○
②	○	×
③	×	○
④	×	×

Q12 From ① – ④ below choose the statement that does **not** correctly describe the plant hormone florigen. **14**

① In short-day and long-day plants, synthesis of florigen in the plant depends on photoperiod.

② Florigen is produced in the leaves.

③ Florigen moves to the shoot apex via the vessels.

④ Florigen stimulates flower bud formation.

Q13 The figure below shows the relationship between annual precipitation and annual mean temperature for the world's various terrestrial biomes.
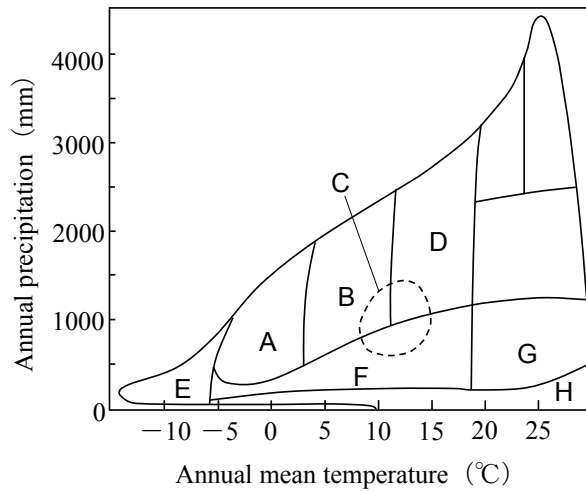
Which of A－H in this figure represents a biome found in inland regions of the temperate zones that does not support tree growth due to the low precipitation, and is populated with herbs such as members of the Poaceae (Gramineae) family? From ①－⑧ below choose the best answer. **15**

① A   ② B   ③ C   ④ D   ⑤ E   ⑥ F

⑦ G   ⑧ H

Q14 The following table lists the mass balance of producers in a certain forest ecosystem. The figures represent the annual amount of organic matter per square meter of forest area $(g/m^2/yr)$.

Gross primary productivity	Respiration	Dead plant tissue	Feeding
2650	1450	670	30

From ① – ⑥ below choose the combination that correctly indicates the producers' net primary productivity (A) and amount of growth (B). **16**

	A	B
①	1980	1280
②	1980	530
③	1950	1280
④	1950	500
⑤	1200	530
⑥	1200	500

Q15 From ① – ④ below choose the statement that best describes the structure of well-developed forests, which can be seen in laurel forests and summer green forests. **17**

① While the height of the trees in a forest varies, most of the trees are the same species at the same age.

② In many cases, sun plants thrive near the forest floor.

③ Since the tree layer absorbs most of the light, plants occupying the shrub layer and herbaceous layer grow by obtaining nutrients from sources other than photosynthesis.

④ The forests exhibit a layered structure, consisting of different layers such as the tree layer, sub-tree layer, shrub layer and herbaceous layer.

Q16 According to endosymbiotic theory, the mitochondria and chloroplasts of eukaryotic cells evolved from different organisms that had an endosymbiotic relationship with their host cell. From ①－④ below choose the statement that does **not** correctly describe this theory. **18**

① One piece of evidence for endosymbiotic theory is the fact that mitochondria and chloroplasts possess DNA that is distinctively different from the DNA in the cell's nucleus.

② Mitochondria are believed to have originated from endosymbiosis with primitive cyanobacteria.

③ It is believed that host cells, by developing endosymbiosis with aerobic bacteria residing within them, acquired a more efficient means of respiration, namely, aerobic respiration.

④ It is believed that plant cells evolved from an organism that engulfed a photosynthesizing prokaryote and a respiring prokaryote, and then developed symbiosis with those prokaryotes.

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.