2014 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	37－51

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 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）, **F**（Q6）, and **G**（Q7）below, where g denotes the magnitude of acceleration due to gravity, and air resistance is negligible.

A As shown in the figure below, a right triangular prism (lengths of legs: a and h) is fixed to a horizontal surface, and object **A** (mass: m) is at rest on the prism's upper surface.
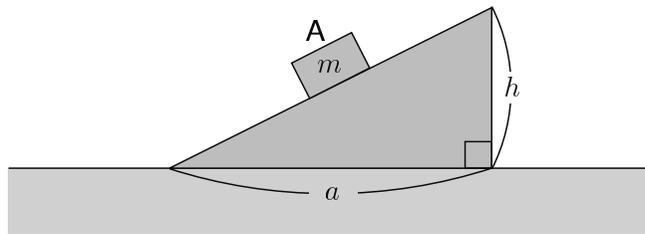
Q1 What is the magnitude of the normal force exerted on **A** by the prism's upper surface? From ①-⑥ below choose the correct answer. $\boxed{1}$

① $\dfrac{h}{a}mg$ ② $\dfrac{a}{h}mg$ ③ $\dfrac{h}{\sqrt{a^2+h^2}}mg$

④ $\dfrac{a}{\sqrt{a^2+h^2}}mg$ ⑤ $\dfrac{\sqrt{a^2+h^2}}{a}mg$ ⑥ $\dfrac{\sqrt{a^2+h^2}}{h}mg$

B Consider a thin uniform rod with a length of 0.50 m. As shown in the figure below, the rod remains at rest when one end of it, A, is placed on a horizontal floor with friction and the other end, B, is leaned against a smooth wall. The distance between A and the wall is 0.40 m, and the magnitude of the gravitational force acting on the rod is 12 N.
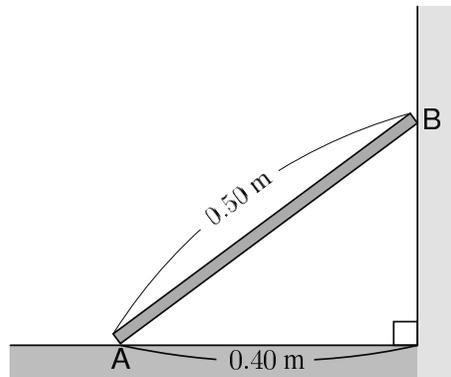
Q2 What is the magnitude (in N) of the static frictional force acting on the rod at A? From ①-④ below choose the best answer. $\boxed{2}$ N

① 6.0   ② 8.0   ③ 10   ④ 12

C The following figure represents how velocity v of an object traveling along an x-axis changes with time t.
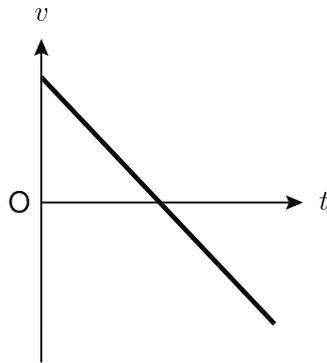
Q3 From ①-⑤ below choose the graph that best expresses the relationship between t and the object's position coordinate x. 　　　　3

①

②

③

④

⑤
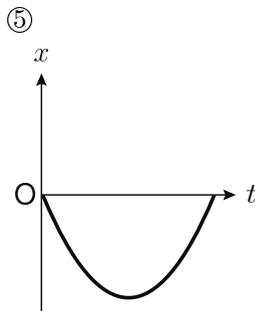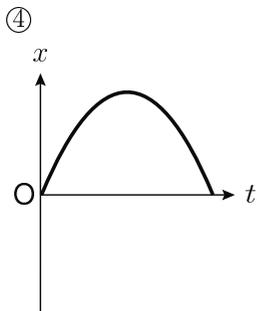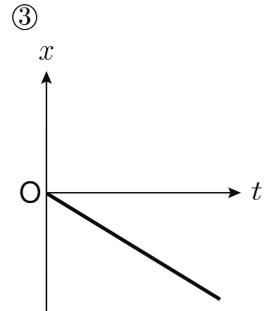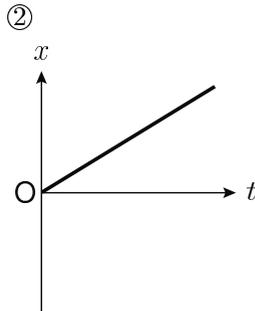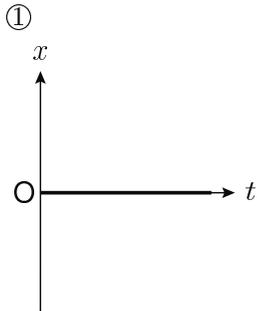
D As shown in the figure below, small object A is projected upward along a smooth slope forming angle α with the horizontal plane, with initial speed v_0 in the direction of angle θ from the horizontal within the slope's plane. The object continues to travel along the surface of the slope. Let us denote as h the maximum height that A attains on the slope, where height is measured vertically from A's starting point.
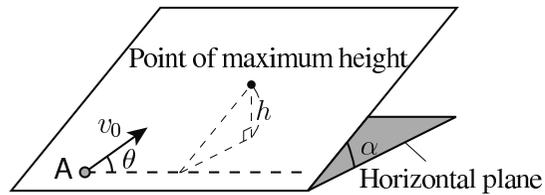
Q4 What is v_0? From ①-⑥ below choose the correct answer. $\boxed{4}$

① $\dfrac{1}{\cos\theta}\sqrt{\dfrac{2gh}{\sin\alpha}}$ ② $\dfrac{\sqrt{2gh}}{\cos\theta}$ ③ $\dfrac{\sqrt{2gh\sin\alpha}}{\cos\theta}$

④ $\dfrac{1}{\sin\theta}\sqrt{\dfrac{2gh}{\sin\alpha}}$ ⑤ $\dfrac{\sqrt{2gh}}{\sin\theta}$ ⑥ $\dfrac{\sqrt{2gh\sin\alpha}}{\sin\theta}$

E As shown in the figure below, a small object of mass m is placed at point A on a slope with friction, and is given initial speed v_0 in a direction upward along the slope. After sliding upward and reaching height h, the object begins sliding downward. During the time that the object slides upward and downward, it is acted upon by a kinetic frictional force of constant magnitude.
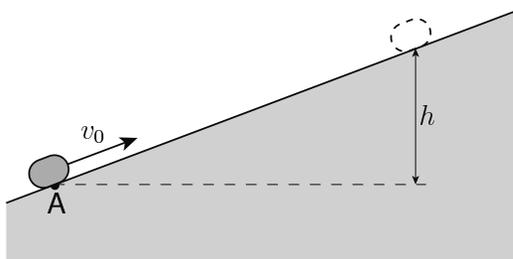
Q5 What is the speed of the object at the instant when it returns to A? From ①-⑤ below choose the correct answer.　　　　　　　　　　　　　　　　　　　　　　　　　　 **5**

① $\sqrt{2gh}$ 　　　　　　② $\sqrt{v_0{}^2 - 2gh}$ 　　　　　　③ $v_0 - \sqrt{2gh}$

④ $\sqrt{4gh - v_0{}^2}$ 　　　　⑤ $2\sqrt{gh} - v_0$

F Consider two small objects, A and B, that have masses of $3m$ and m, respectively, and are traveling on a smooth horizontal surface. As shown in the figure below, A is undergoing uniform motion with speed v, while B is undergoing uniform motion with speed $4v$ in a direction perpendicular to A's direction of travel. Both objects collide and subsequently travel as a unit with uniform motion in a direction forming angle θ with A's direction of travel before the collision.
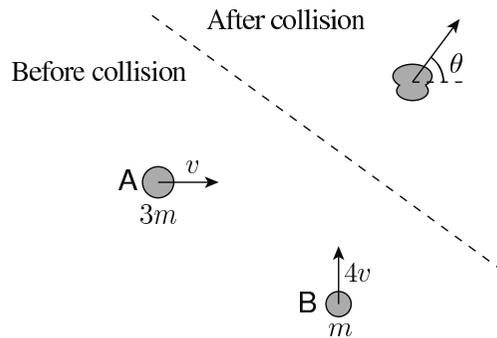
Q6 What is the value of $\tan\theta$? From ①-⑥ below choose the correct answer. ⬚**6**

① $\dfrac{3}{5}$ ② $\dfrac{3}{4}$ ③ $\dfrac{4}{5}$ ④ $\dfrac{4}{3}$ ⑤ $\dfrac{5}{4}$ ⑥ $\dfrac{5}{3}$

G As shown in the figure below, a slope is seamlessly joined with a partial cylindrical surface that has a radius of r. Let us denote the lowest point of the cylindrical surface as O, a point on the slope that is height $2r$ above O as P, and a point on the cylindrical surface that is height r above O as Q. Small object A (mass: m) is placed at point P and is then gently released. Friction between A and the slope/cylindrical surface is negligible.
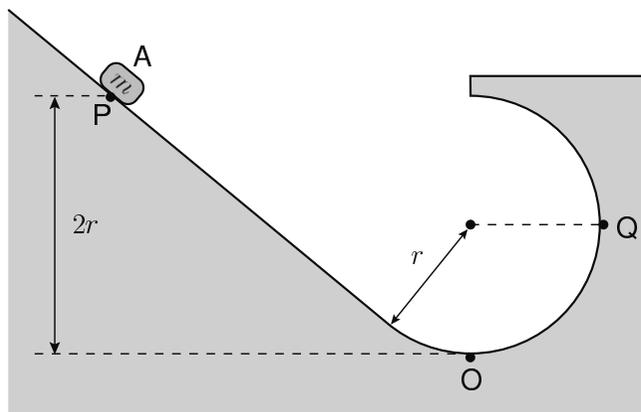
Q7 What is the magnitude of the normal force exerted on A by the cylindrical surface at Q? From ①-⑥ below choose the correct answer. $\boxed{7}$

① mg ② $2mg$ ③ $3mg$

④ $4mg$ ⑤ $5mg$ ⑥ $6mg$

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

A A certain mass of ice at $-20°C$ is placed in a container, and then an equal mass of water at $43°C$ is added. After sufficient time elapses, a mixture of ice and water at $0°C$ remains in the container. 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 specific heat of ice is 2.1 J/(g·K). The heat capacity of the container is negligible, and no heat is transferred to or from the environment.

Q1 After sufficient time elapses, as a percentage, what is the ratio of the mass of the remaining ice to the mass of the ice initially placed in the container? From ①-④ below choose the best answer. <u>**8**</u> %

① 26   ② 42   ③ 58   ④ 74

B As shown in the figure below, a monatomic ideal gas is enclosed in a fixed cylinder by a smoothly moving piston that has a cross-sectional area of S and whose mass is negligible. One end of an inelastic string of negligible mass is attached to the piston, and the other end is attached to a weight of mass m, which is suspended from a fixed pulley. Initially, the weight is at rest. Next, a heater is used to apply quantity of heat Q to the gas. As a result, the weight descends a distance of d before coming to rest again. The pulley rotates smoothly and has negligible mass. Let us denote the magnitude of acceleration due to gravity as g, and atmospheric pressure as p. Assume that the cylinder and the piston do not conduct heat.
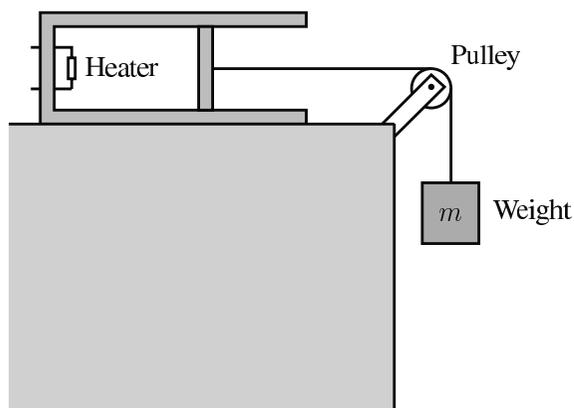
Q2　What is d? From ①-④ below choose the correct answer.　　　　　9

① $\dfrac{2Q}{5(pS+mg)}$　　② $\dfrac{2Q}{3(pS+mg)}$　　③ $\dfrac{2Q}{5(pS-mg)}$　　④ $\dfrac{2Q}{3(pS-mg)}$

C The pressure p and volume V of a fixed amount of an ideal gas are changed in the path A → B → C → A as shown in the p-V diagram below. Process A → B is an isobaric change, B → C is an isochoric change, and C → A is an isothermal change.
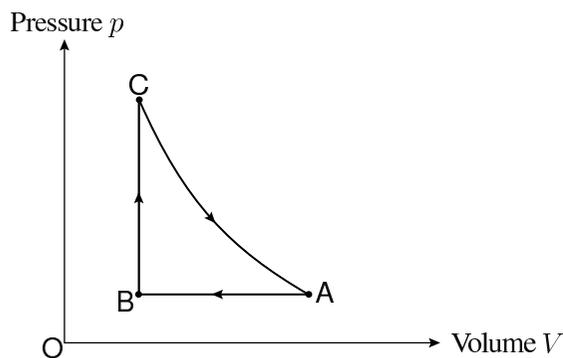
Q3 In processes A → B, B → C, and C → A, is the work done on the environment positive, negative, or zero? From ①-⑥ below choose the correct combination. **10**

	A → B	B → C	C → A
①	positive	negative	0
②	positive	0	negative
③	negative	positive	0
④	negative	0	positive
⑤	0	positive	negative
⑥	0	negative	positive

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

A Consider a sinusoidal wave propagating along an x-axis in the positive direction with a speed 0.50 m/s. The figure below is a graph representing the relationship between medium displacement y and time t for where $x = 0$ m.
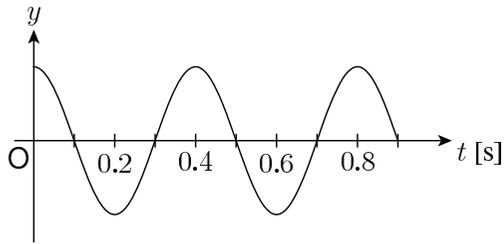
Q1 From ①-④ below choose the graph that best represents the relationship between medium displacement y and time t for where $x = 0.45$ m. **11**

①

②

③

④
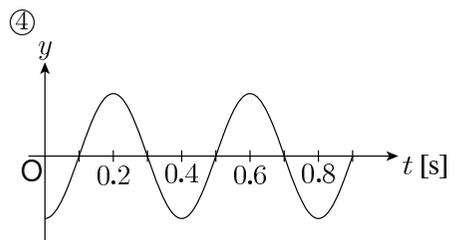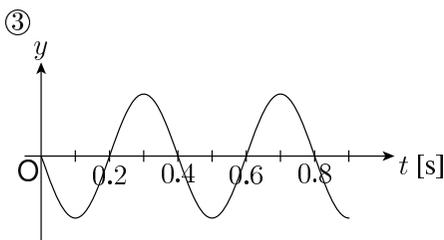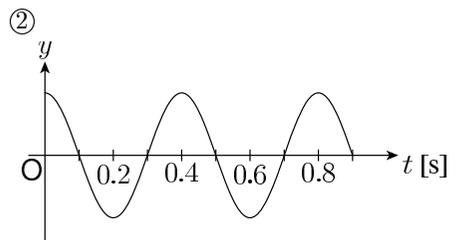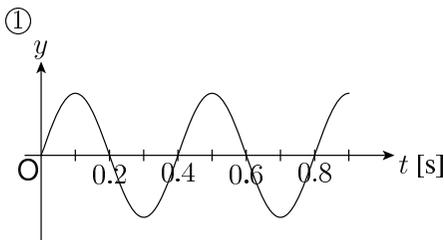
B Two strings are stretched tautly parallel to each other. The length of one is L_1 and the length of the other is L_2 $(> L_1)$. When both are simultaneously made to undergo fundamental vibration, beats can be heard at a frequency n. The waves in both strings travel at the same speed. Let us denote the fundamental frequency of the string with length L_1 as f_1.

Q2 What is $\dfrac{L_2 - L_1}{L_1}$? From ①-⑥ below choose the correct answer. $\boxed{12}$

① $\dfrac{n}{f_1 - n}$ ② $\dfrac{n}{f_1}$ ③ $\dfrac{n}{f_1 + n}$

④ $\dfrac{2n}{f_1 - n}$ ⑤ $\dfrac{2n}{f_1}$ ⑥ $\dfrac{2n}{f_1 + n}$

C As shown in the figure below, an object and a screen are fixed in place at distance of 0.90 m from each other. A convex lens is moved between the object and the screen parallel to the optical axis, as shown. While the lens is moved, a real image appears on the screen twice. The distance between the object and the lens at the appearance of the first real image is equal to the distance between the screen and the lens at the appearance of the second real image. The size of one of the real images is four times larger than that of the other.

Screen

Lens

Direction of movement

Object

0.90 m
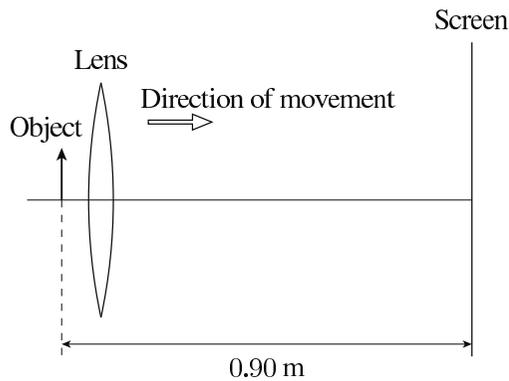
Q3 What is the focal length (in m) of the convex lens? From ①-④ below choose the best answer. **13** m

① 0.10   ② 0.20   ③ 0.30   ④ 0.40

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

A As shown in Figure 1, a point charge with quantity of electricity Q (> 0) is fixed to point A $(a, 0)$ ($a > 0$) in an x-y plane. At this time, the magnitude of the electric field at the origin O is E_0. Next, as shown in Figure 2, two more point charges, each with quantity of electricity Q, are fixed to the plane, one at point B $(0, a)$, and the other at point C $(-2a, 0)$. As a result, the magnitude of the electric field at O becomes E_1.
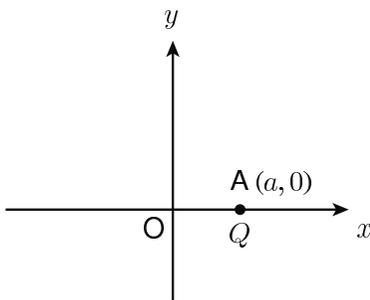
Figure 1
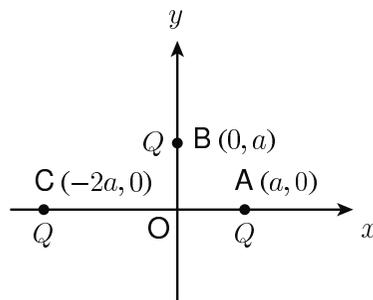
Figure 2

Q1 What is the value of $\dfrac{E_1}{E_0}$? From ①-⑥ below choose the correct answer. **14**

① $\dfrac{\sqrt{5}}{2}$ ② $\dfrac{5}{4}$ ③ $\dfrac{\sqrt{41}}{4}$ ④ $\dfrac{7}{4}$ ⑤ $\dfrac{\sqrt{13}}{2}$ ⑥ $\dfrac{9}{4}$

B As shown in the figure below, dielectric plate A, which has a thickness of $2d$, is placed within a uniform electric field with a magnitude of E_0, perpendicularly to the electric field's direction. The electric field within A is in the same direction as the outside, and has a constant magnitude of E_1 $(< E_0)$. As shown below, an x-axis is chosen parallel to the electric field's direction, where the origin O is located at the center of A. The x-coordinates of the left and right sides of A are $-d$ and d, respectively.
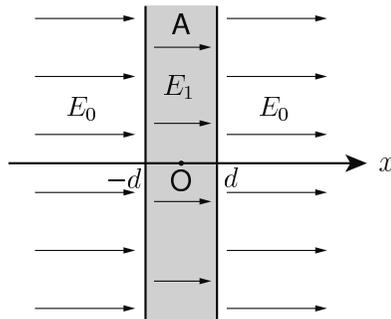
Q2 From ①-⑧ below choose the graph that best expresses the change in electric potential V along the x-axis. | 15 |

①

②

③

④

⑤

⑥

⑦

⑧

C As shown in the figure below, seven resistors, each with resistance R, and a battery with electromotive force V are connected. Internal resistance of the battery is negligible.

Q3 What is the magnitude of the electrical current I passing through point A in the circuit? From ①-④ below choose the correct answer. `16`

① $\dfrac{V}{3R}$ ② $\dfrac{2V}{5R}$ ③ $\dfrac{4V}{7R}$ ④ $\dfrac{8V}{7R}$
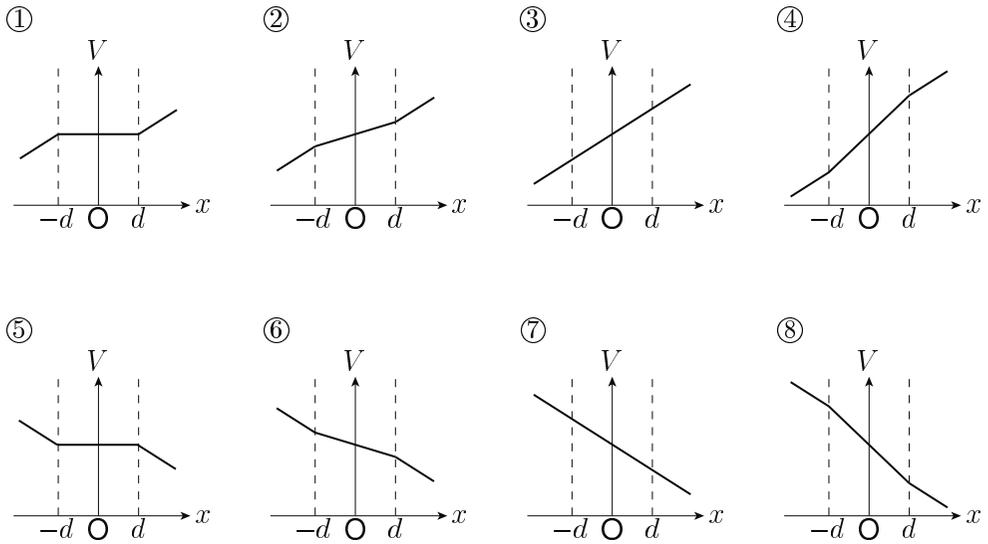
D As shown in Figure 1, two parallel-plate capacitors, whose plates have area S and are separated by distance d, a battery with electromotive force V, and a switch are connected. First, the switch is closed, and after sufficient time elapses, it is opened. Here, let us assume that the permittivity of air is equal to the permittivity of a vacuum, ε_0. Next, as shown in Figure 2, the space between the plates of the capacitor on the right is filled with a dielectric with a permittivity of $2\varepsilon_0$. After sufficient time elapses, a charge of Q is stored in the capacitor on the right.
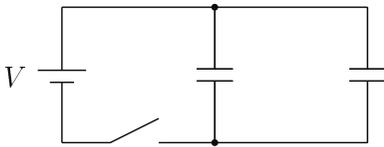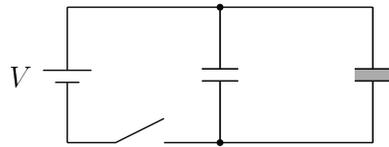
Figure 1   Figure 2

Q4 What is Q? From ①-④ below choose the correct answer.   17

① $\dfrac{2\varepsilon_0 SV}{3d}$ ② $\dfrac{2dV}{3\varepsilon_0 S}$ ③ $\dfrac{4\varepsilon_0 SV}{3d}$ ④ $\dfrac{4dV}{3\varepsilon_0 S}$

E   As shown in the figure below, two straight conducting wires of infinite length are placed so that they cross each other perpendicularly. The wires are insulated from each other at their intersection. Let us choose an x-y coordinate system so that the origin O is located at the intersection of the wires, and the x-axis and y-axis each coincide with one of the wires. A current with a magnitude of I_0 flows through the wire on the x-axis in the positive direction of the axis. Also, a current with a magnitude of $2I_0$ flows through the wire on the y-axis in the positive direction of the axis. Under this condition, the magnitude of the magnetic field at a certain point (x_0, y_0) in the x-y plane other than the origin is zero.
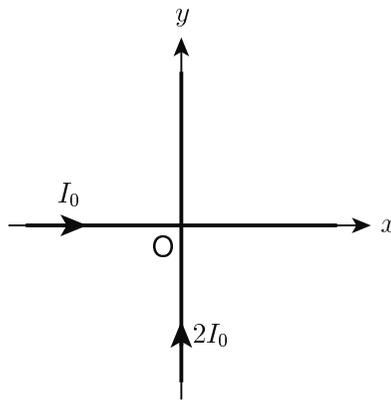
Q5   What is the relationship between x_0 and y_0? From ①-④ below choose the correct answer.

18

① $y_0 = \dfrac{1}{2}x_0$ ② $y_0 = 2x_0$ ③ $y_0 = -\dfrac{1}{2}x_0$ ④ $y_0 = -2x_0$

F As shown in the figure below, an electron is projected into a region filled with a uniform magnetic field by accelerating it from an initial speed of zero between two electrodes that have electric potential difference V. The electron enters the region in a direction perpendicular to the magnetic field's direction, travels with a constant speed in a semicircular path (radius: r), and then exits the region after time T elapses from the moment of entry. The direction of the magnetic field is perpendicular to this page, going from front to back.

$\otimes$ Magnetic field

r

V

Electron
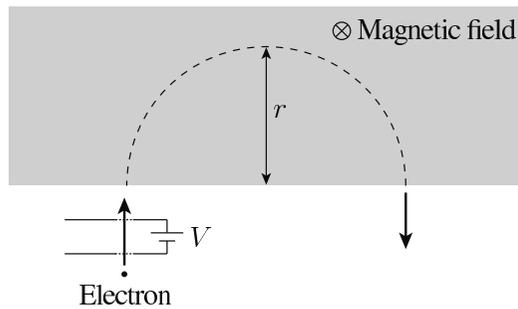
Q6 If V is doubled, how do r and T change? From ①-⑥ below choose the correct combination. `19`

	r	T
①	increase by a factor of $\sqrt{2}$	no change
②	increase by a factor of $\sqrt{2}$	increase by a factor of $\sqrt{2}$
③	increase by a factor of $\sqrt{2}$	increase by a factor of 2
④	increase by a factor of 2	no change
⑤	increase by a factor of 2	increase by a factor of $\sqrt{2}$
⑥	increase by a factor of 2	increase by a factor of 2

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. 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　Mg : 24　Cl : 35

Cu : 64　Br : 80

Q1   From the following statements ①-⑤ on the elements belonging to the first four periods of the periodic table choose the one that is **not** correct. The fourth period is the one starting from potassium (K).   ⎡**1**⎤

①   Aluminum (Al) is a main group element.

②   Potassium (K) is an alkaline earth metal.

③   Iron (Fe) is a transition element.

④   The first ionization energy of helium (He) is the largest.

⑤   The electronegativity of fluorine (F) is the largest.

Q2   From the following compounds ①-④ choose a covalent crystal.   ⎡**2**⎤

① $BaSO_4$ ②   CaO   ③ CO_2 ④ SiO_2

Q3   The reaction between pyrite (FeS_2) and oxygen (O_2) is represented by the following reaction formula. From ①-⑤ below choose the correct value for the coefficient x. ☐**3**

$$4FeS_2 \quad + \quad x\,O_2 \quad \longrightarrow \quad y\,Fe_2O_3 \quad + \quad z\,SO_2$$
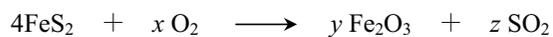
① 5   ② 7   ③ 11   ④ 12   ⑤ 14

Q4   From the following ①-⑤ choose the gas whose density is 1.25 g/L at the standard state. ☐**4**

① CH_4 ② CO_2 ③ H_2 ④ N_2 ⑤ O_2

Q5 Suppose 100 mL of 0.10 mol/L aqueous oxalic acid ($C_2H_2O_4$) is prepared with the aid of a volumetric flask whose volume is 100 mL. How many grams of oxalic acid are required? Which one, (**a**) or (**b**), in the following figure is correct to measure up to the marked line on the volumetric flask? From ①-⑥ in the table below choose the correct combination.

5

volumetric flask

(**a**)
marked line ——→

(**b**)
marked line ——→
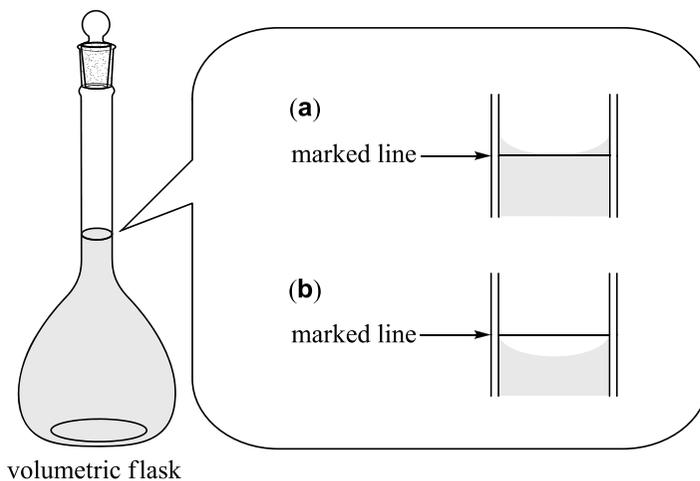
	Mass of oxalic acid required (g)	How to measure up to the marked line on the volumetric flask
①	0.90	a
②	0.90	b
③	9.0	a
④	9.0	b
⑤	90	a
⑥	90	b

Q6   Methanol (CH_3OH) is synthesized by a reaction between carbon monoxide (CO) and hydrogen (H_2) with the aid of a catalyst. The thermochemical equation of this reaction is as follows.

$$CO(g) \ + \ 2H_2(g) \ = \ CH_3OH(g) \ + \ 92 \text{ kJ}$$
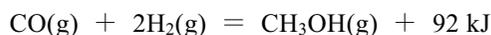
From the following ①-⑤ choose the correct one for the statement of the reaction in an equilibrium state.   **6**

①   Equilibrium is a state where neither forward nor reverse reactions take place, and hence the reaction ceases.

②   In this equilibrium state, the ratio of the amount (mol) of carbon monoxide and methanol is always 1:1.

③   If the amount of the catalyst is increased, the equilibrium shifts to the right.

④   If the temperature is raised without changing the pressure, the equilibrium shifts to the right.

⑤   If the pressure is raised without changing the temperature, the equilibrium shifts to the right.

Q7　From ①-⑤ below choose the correct statement on the following aqueous solutions **A** and **B**. 　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　 $\boxed{7}$

　　　Aqueous solution **A**　0.050 mol/L aqueous acetic acid (CH_3COOH)

　　　　　　　　　　　　　　(degree of electrolytic dissociation：0.020)

　　　Aqueous solution **B**　0.10 mol/L aqueous sodium hydroxide (NaOH)

　　①　The pH of **A** is 4.

　　②　The pH of **B** is 12.

　　③　The pH of the solution prepared by mixing 20 mL of **A** and 10 mL of **B** is 7.

　　④　If **A** is 100 times diluted, the pH increases by 2.

　　⑤　If **B** is 100 times diluted, the pH decreases by 2.

Q8　From statements ①-⑤ below on the following oxidation-reduction reaction choose the one that is **<u>not</u>** correct. 　　　　　　　　　　　　　　　　　　　　 $\boxed{8}$

　　　$2KMnO_4 + 5H_2O_2 + 3H_2SO_4 \longrightarrow 2MnSO_4 + 5O_2 + 8H_2O + K_2SO_4$

　　①　The oxidation number of the oxygen atoms in H_2O_2 changed from -1 to 0.

　　②　H_2O_2 acted as an oxidizing agent.

　　③　When 2 moles of $KMnO_4$ and 5 moles of H_2O_2 reacted, 10 moles of electrons were transferred.

　　④　The Mn atom of $KMnO_4$ received electrons.

　　⑤　H_2SO_4 was employed so that the reaction condition was made acidic.

Q9   Aqueous copper(II) sulfate ($CuSO_4$) was electrolyzed with the aid of platinum electrodes for 3860 seconds with 0.25 A electric current. From the following ①-⑥ choose the correct combination of the substance generated at the cathode, and its mass.   **9**

	Substance generated at cathode	Mass (g)
①	H_2	0.0020
②	H_2	0.010
③	Cu	0.064
④	Cu	0.32
⑤	O_2	0.016
⑥	O_2	0.080

Q10　The following graph represents the relation between the solubility of potassium nitrate (KNO_3) in water and the temperature. The solubility is the value of the mass (g) of the solute soluble in 100 g of water.

　Suppose 50 g of potassium nitrate is dissolved in 50 g of water at 60 ℃ and the solution is cooled to 10 ℃. How many grams of potassium nitrate are deposited? From ①-⑤ below choose the closest value.　　　　　　　　　　　　　　　　　　**10** g
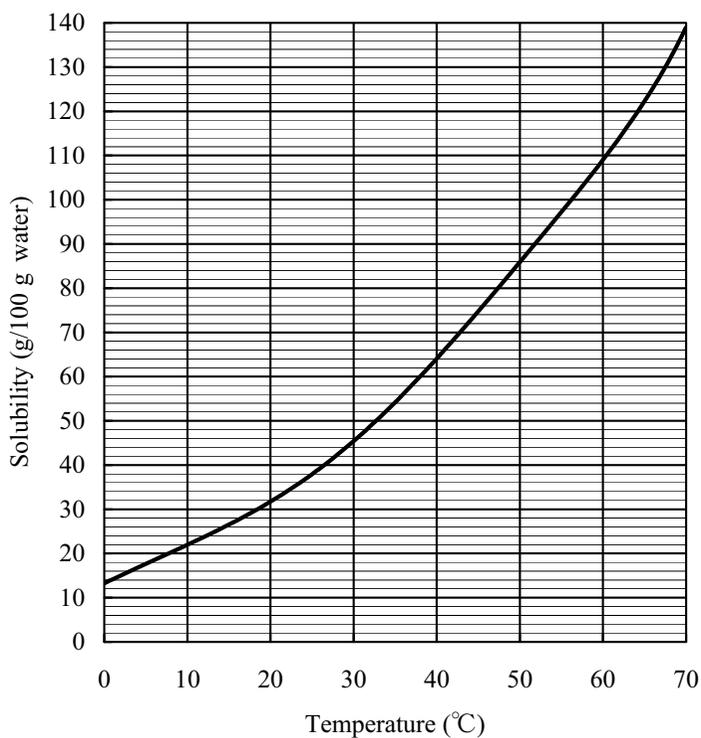
① 4.4　　② 16　　③ 39　　④ 46　　⑤ 78

Q11 From the following statements ①-⑤ on halogens choose the one that is **not** correct.

11

① The oxidation numbers of halogen atoms are not always −1 (minus one).

② Halogen atoms have 7 valence electrons.

③ A mixture of chlorine (Cl_2) and hydrogen (H_2) reacts explosively when irradiated with light at normal temperature.

④ The oxidizing power is $F_2 < Cl_2 < Br_2 < I_2$ (the weakest is first).

⑤ Two among F_2, Cl_2, Br_2, and I_2, are gases at normal temperature and pressure.

Q12 Among the following procedures (**a**)-(**e**), from ①-⑥ below choose the combination of correct methods to prepare chlorine (Cl_2) and sulfur dioxide (SO_2) gases, respectively.

12

(**a**) Concentrated hydrochloric acid (conc. HCl) is added to manganese(IV) oxide (MnO_2) and the mixture is heated.

(**b**) Diluted sulfuric acid (dil. H_2SO_4) is added to iron (Fe).

(**c**) Diluted sulfuric acid is added to iron(II) sulfide (FeS).

(**d**) Concentrated sulfuric acid (conc. H_2SO_4) is added to sodium chloride (NaCl) and the mixture is heated.

(**e**) Diluted sulfuric acid is added to sodium hydrogen sulfite ($NaHSO_3$).

	Cl_2	SO_2
①	**a**	**b**
②	**a**	**c**
③	**a**	**e**
④	**d**	**b**
⑤	**d**	**c**
⑥	**d**	**e**

Q13 From the following compounds ①-⑤ choose the one whose underlined atom has the largest oxidation number. $\boxed{13}$

① $\underline{N}H_3$ ② $H_2\underline{S}O_4$ ③ $\underline{Fe}Cl_3$ ④ $K_2\underline{Cr}_2O_7$ ⑤ $KMnO_4$

Q14 Two compounds out of the following (**a**)-(**d**) form precipitates when 0.01 mol/L aqueous copper(II) sulfate ($CuSO_4$) is added to 0.01 mol/L of them. From ①-⑥ below choose the correct combination of them. $\boxed{14}$

(**a**) $BaCl_2$ (**b**) H_2S (**c**) NaCl   (**d**) $ZnCl_2$

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

Q15 Hydrogen (H_2) was generated by adding 500 mL of 0.50 mol/L hydrochloric acid (HCl) to 8.0 g of magnesium (Mg). How much hydrogen in liter (L) at the standard state was generated? From the following ①-⑤ choose the closest value. Assume that either hydrochloric acid or magnesium was completely reacted. $\boxed{15}$ L

① 2.8   ② 3.7   ③ 5.6   ④ 7.4   ⑤ 15

Q16   From the following ①-⑤ choose the correct number of isomers of a chain hydrocarbon represented by the molecular formula C_5H_{10}. Assume that each of *cis-trans* isomers is to be counted when such is the case.   **16**

① 5   ② 6   ③ 7   ④ 8   ⑤ 9

Q17   A sufficient amount of chlorine (Cl_2) underwent an addition reaction with a certain amount of alkene **A**. The mass of the product was 140 g heavier than that of **A**. Then a sufficient amount of bromine (Br_2) underwent addition to the same amount of **A**. The mass of the product was 460 g. From the following ①-⑥ choose the correct one as the number of carbon atoms of **A**.   **17**

① 4   ② 5   ③ 6   ④ 7   ⑤ 8   ⑥ 9

Q18　From the following statements ①-⑤ choose the correct one concerning the reactions of the organic compound represented by the following structural formula.　|**18**|

$$CH_3CH_2 - \underset{\underset{OH}{|}}{\overset{\overset{H}{|}}{C}} - CH_3$$
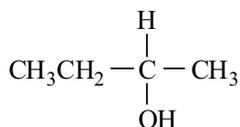
①　Carbon dioxide (CO_2) is generated if sodium (Na) is added to it.

②　It is not oxidized by aqueous potassium dichromate ($K_2Cr_2O_7$) acidified with sulfuric acid.

③　It is positive in the silver mirror test.

④　It is positive in the iodoform reaction.

⑤　Only one kind of alkene is formed by dehydration of it.

Q19　In the following table two of the compounds given in column **B** are obtained by reduction reactions of the compounds given in column **A**. From ①-⑧ below choose the correct pair.　|**19**|

	A	**B**
a	nitrobenzene	aniline
b	benzene	chlorobenzene
c	acetylene (ethyne)	acetaldehyde
d	acetone	2-propanol
e	salicylic acid	acetylsalicylic acid

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

⑤　**b**, **d**　　⑥　**b**, **e**　　⑦　**c**, **d**　　⑧　**d**, **e**

Q20   Among the following polymers (**a**)-(**d**), two are formed by addition polymerization. From ①-⑥ below choose the correct combination.   **20**

(**a**)   nylon 6,6

(**b**)   polyacrylonitrile

(**c**)   poly(ethylene terephthalate)

(**d**)   poly(vinyl chloride)

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

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 Which of the following structures (a – i) are found in prokaryotic cells? From ① – ⑦ below choose the combination that best indicates all applicable structures.   1

a   nucleus

b   Golgi body

c   mitochondria

d   cell membrane

e   ribosome

f   chloroplast

g   endoplasmic reticulum

h   cell wall

i   vacuole

① a, d, e, h   ② a, b, d, e, i   ③ b, c, f, g   ④ b, d, e, i

⑤ c, d, g, i   ⑥ d, e, h   ⑦ d, e, f, h, i

Q2   The figure below schematically represents a cross-section of a particular organelle in a certain organism. From ① – ⑤ below choose the statement that correctly describes this organelle. **2**
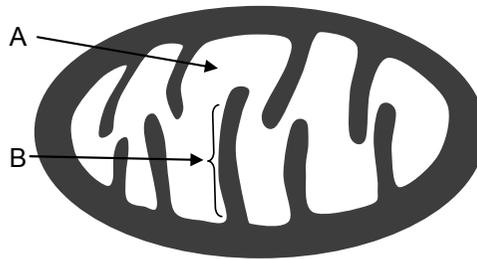
①   This organelle has the function of transporting synthesized proteins toward the cell membrane.

②   In region A, two molecules of pyruvic acid are produced from one molecule of glucose.

③   Region A is the site of the citric acid cycle of respiration.

④   Numerous photosynthetic pigments are found on the surface of B.

⑤   The surface of B is the site of glycolysis.

Q3   From ① – ④ below choose the statement that correctly describes sexual reproduction. **3**

①   In angiosperms, the nucleus of an embryo sac cell divides three times in a row to form an embryo sac with eight nuclei.

②   The seeds from which common bean and other leguminous plants form are albuminous seeds.

③   In oogenesis in animals, second polar bodies are the cells that result from the division of a first polar body.

④   As a result of the second division of meiosis, the chromosome number and amount of DNA per cell are reduced by half.

Q4 Which of statements a–d below correctly describe the results of the following two experiments (I and II) concerning development? From ① – ⑥ below choose the correct combination. $\boxed{4}$

Experiments

I   Part of the presumptive epidermis and part of the presumptive neural region of an early newt gastrula were transplanted to each other's original site.

II Part of the presumptive epidermis and part of the presumptive neural region of an early newt neurula were transplanted to each other's original site.

Results

a   After transplantation, the presumptive epidermis differentiated into epidermis, and the presumptive neural region differentiated into nerves.

b   After transplantation, the presumptive epidermis differentiated into nerves, and the presumptive neural region differentiated into the epidermis.

c   After transplantation, both the presumptive epidermis and the presumptive neural region differentiated into epidermis.

d   After transplantation, both the presumptive epidermis and the presumptive neural region differentiated into nerves.

	Exp. I	Exp. II
①	a	b
②	a	d
③	b	a
④	b	c
⑤	c	d
⑥	d	a

Q5   From ① – ⑨ below choose the combination correctly indicating all vertebrate tissues and organs in
a–f below that derive from the mesoderm. | 5 |

a   dermis

b   digestive tract epithelium

c   lens

d   spinal cord

e   skeletal muscle

f   heart

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

⑤   a, e, f   ⑥   b, c, e   ⑦   b, c, f   ⑧   b, d, e

⑨   b, d, f

Q6 The following table was created to show the ABO blood types of children born to mothers and fathers with certain blood types. Of pairings Ⅰ－Ⅵ in the table, which pairings could result in the birth of both children with blood type O and children with blood type A? From ①－⑥ below choose the correct combination. $\boxed{6}$

		Maternal blood type			
		A	B	AB	O
Paternal blood type	A	Ⅰ	Ⅱ		
	B		Ⅲ	Ⅳ	
	AB			Ⅴ	Ⅵ
	O				

① Ⅰ, Ⅱ

② Ⅰ, Ⅱ, Ⅲ

③ Ⅰ, Ⅱ, Ⅲ, Ⅵ

④ Ⅱ, Ⅳ

⑤ Ⅱ, Ⅲ, Ⅴ

⑥ Ⅱ, Ⅲ, Ⅴ, Ⅵ

Q7 Paramecia possess contractile vacuoles, which are organelles that periodically contract to expel water that has entered the paramecium cell, so as to prevent the cell from swelling.

An experiment was performed to examine osmotic pressure inside paramecia by immersing five paramecia in saline solutions of various concentrations and measuring the number of their contractile vacuole contractions per minute. The results are listed in the table below.

Saline solution concentration (%)	Number of contractions per minute				
	Paramecium 1	Paramecium 2	Paramecium 3	Paramecium 4	Paramecium 5
0 (distilled water)	12	11	12	13	13
0.2	8	9	7	8	7
0.4	4	4	6	5	5
0.6	2	3	2	2	3
0.8	0	0	0	0	1
1.2	0	0	0	0	0

From ① – ⑤ below choose the statement that best describes the experiment results. ⑦

① Since osmotic pressure in the cell rises when the saline solution concentration increases, the contractile vacuoles contract more vigorously, causing the contraction cycle to shorten.

② Since salt enters the cell when the saline solution concentration increases, the contractile vacuoles contract more vigorously, causing the contraction cycle to shorten.

③ Since the contractile vacuole's contraction cycle becomes much longer when the saline solution concentration exceeds 0.8%, the paramecium's intracellular fluid is isotonic with the saline solution whose concentration is around 0.8%.

④ Since the amount of water that enters the cell increases when the saline solution concentration increases, the contractile vacuole's contraction cycle becomes longer.

⑤ No relationship is observed between the saline solution and the contractile vacuole's contraction cycle.

Q8 The human body keeps its internal conditions stable through the action of the autonomic nervous system and the endocrine system. This is called homeostasis. From ① – ⑤ below choose the statement that correctly describes an example of this. $\boxed{8}$

① Excitation of sympathetic nerves results in effects such as stimulation of stomach movement and contraction of blood vessels in the skin.

② Excitation of parasympathetic nerves results in effects such as contraction of the pupils and contraction of the arrector pili muscles.

③ The pancreas' islets of Langerhans contain sympathetic nerves but not parasympathetic nerves.

④ Increases in the blood glucose level lead to stimulation of the adrenal medulla's secretion of adrenaline.

⑤ Decreases in the body temperature lead to stimulation of the anterior pituitary's secretion of thyroid-stimulating hormone.

Q9 The following figure schematically represents a cross-section of the human eye. The paragraph below describes the visual cells located at regions I – III in the figure. From ① – ⑥ below choose the combination that correctly fills blanks ⎡ a ⎤ – ⎡ c ⎤ in the paragraph. 〔 **9** 〕
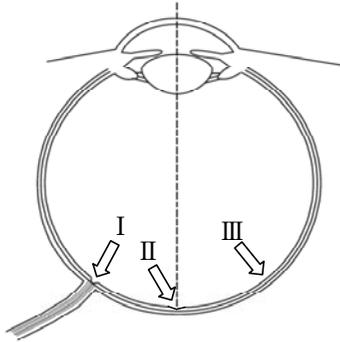
Region ⎡ a ⎤ in the figure has a large number of cone cells, while region ⎡ b ⎤ has many rod cells but few cone cells. No cone cells or rod cells exist in region ⎡ c ⎤.

	a	b	c
①	I	II	III
②	I	III	II
③	II	I	III
④	II	III	I
⑤	III	I	II
⑥	III	II	I

Q10 From ① – ⑧ below choose the combination of terms that correctly fills blanks [a] – [c] in the following paragraph describing the opening and closing of stomata. **10**

The opening and closing of stomata is brought about by changes in the shape of the guard cells. Since a guard cell's wall next to the stoma stretches [a] readily than the wall on the opposite side of the cell, when the cell [b] water, the increase in [c] pressure causes the cell to bend, thereby opening the stoma.

	a	b	c
①	more	absorbs	osmotic
②	more	absorbs	turgor
③	more	releases	osmotic
④	more	releases	turgor
⑤	less	absorbs	osmotic
⑥	less	absorbs	turgor
⑦	less	releases	osmotic
⑧	less	releases	turgor

Q11 Corn coleoptiles were used to perform the experiment shown in the figure below in a dark room. Two coleoptiles were severed at lines A and B, and the resulting segments were placed on pieces of agar, with one segment placed upright and the other inverted. Also, a piece of agar containing auxin was placed on top of each segment. After sufficient time passed, the pieces of agar at the bottom of the segments were removed and placed on the tops of two other coleoptiles whose tips had been freshly removed, with the agar shifted to the left. Afterwards, what will happen to these coleoptiles? From ①－⑨ below choose the correct combination. **11**

Agar containing auxin

Coleoptile

A
B

Upright

A
B

B
A

Inverted

Agar

Corn seedling
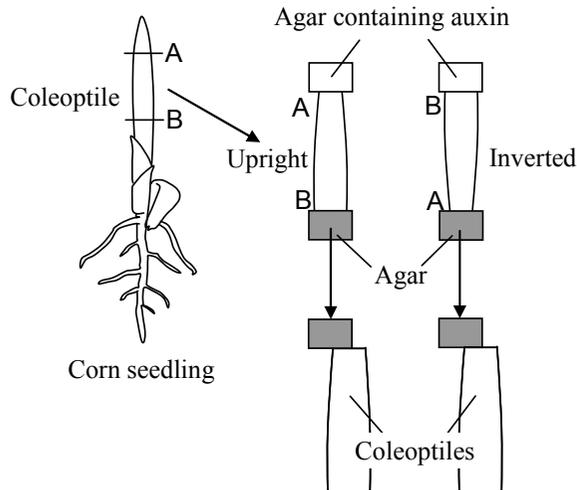
Coleoptiles

	Using the agar from the bottom of the upright segment	Using the agar from the bottom of the inverted segment
①	The coleoptile will bend to the right.	The coleoptile will bend to the right.
②	The coleoptile will bend to the right.	The coleoptile will bend to the left.
③	The coleoptile will bend to the right.	The coleoptile will not bend.
④	The coleoptile will bend to the left.	The coleoptile will bend to the right.
⑤	The coleoptile will bend to the left.	The coleoptile will bend to the left.
⑥	The coleoptile will bend to the left.	The coleoptile will not bend.
⑦	The coleoptile will not bend.	The coleoptile will bend to the right.
⑧	The coleoptile will not bend.	The coleoptile will bend to the left.
⑨	The coleoptile will not bend.	The coleoptile will not bend.

Q12 Three milliliters of 3% hydrogen peroxide solution was added to each of the six test tubes described below (A–F), and, as a result, gas evolved in one or more of the test tubes. The enzyme solution used was prepared by grating pig liver. All six experiments were performed at a temperature of 30°C.

Test tube A : 2 ml of distilled water

Test tube B : 2 ml of enzyme solution

Test tube C : 2 ml of distilled water with 0.1 g of manganese dioxide

Test tube D : 2 ml of enzyme solution that was boiled before the experiment

Test tube E : 2 ml of distilled water with 0.1 g of manganese dioxide that was boiled before the experiment

Test tube F : 1 ml of enzyme solution with 1 ml of 5% hydrochloric acid

(1) From ① – ⑦ below choose the combination that correctly indicates all test tubes in which gas vigorously evolved. | 12 |

　① A 　　 ② A, B 　　 ③ B, C 　　 ④ B, C, D 　　 ⑤ B, C, E

　⑥ B, C, D, E 　　 ⑦ B, C, F

(2) From ① – ⑤ below choose the answer that correctly indicates the name of the enzyme involved in the evolution of gas in these experiments. | 13 |

　① amylase 　　 ② catalase 　　 ③ pepsin 　　 ④ lipase 　　 ⑤ trypsin

Q13 Items a－e below simply express certain various metabolic processes that take place in the bodies of living organisms. From ①－⑤ below choose the combination correctly indicating the processes that are part of aerobic respiration. 　14

a　carbon dioxide　→ glucose

b　glucose　→ pyruvic acid

c　pyruvic acid　→ ethanol ＋ carbon dioxide

d　pyruvic acid　→ lactic acid

e　pyruvic acid　→ citric acid　→ carbon dioxide

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

Q14 The reactions that take place in the chloroplasts of green plants can be divided into the following three stages, a－c.

a   Breakdown of water and synthesis of ATP

b   Absorption of light by photosynthetic pigments

c   Fixation of carbon dioxide

From ① － ⑥ below choose the combination that correctly indicates the order of these three stages, and the site of the reactions of the first two stages. **15**

	Order of stages	Site of the reactions of the first two stages
①	a → b → c	thylakoids
②	a → b → c	stroma
③	b → a → c	thylakoids
④	b → a → c	stroma
⑤	c → b → a	thylakoids
⑥	c → b → a	stroma

Q15 From ① － ⑤ below choose the statement that does **not** correctly describe immunity. **16**

①   The cells that develop into T-cell lymphocytes are formed in the bone marrow.

②   Allergies to pollen and other substances are a type of antibody reaction to an antigen.

③   The rejection of a skin graft from another individual is a type of humoral immunity.

④   Macrophages engulf foreign matter that has invaded the body.

⑤   The antibodies produced by antibody-forming cells identify and bind to specific antigens.

Q16 The following figure represents the relationship among a portion of two complementary DNA strands (strand a, strand b), the mRNA transcribed from one of them, and the tRNA anticodons that bind to the mRNA codons. The underlined blanks in the figure each represent a certain base. Answer questions (1) and (2) below concerning this figure.

$$
\begin{array}{ll}
\text{DNA} \left\{ \begin{array}{l}
\text{A \_ \_ C \_ G \_ T \_} \quad (\text{strand a}) \\
\text{\_ G \_ \_ T \_ \_ \_ A} \quad (\text{strand b})
\end{array} \right. \\
\text{mRNA} \quad \text{\_ \_ \_ \_ \_ \_ \_ \_ \_} \\
\begin{array}{l}
\text{tRNA} \\
\text{anticodons}
\end{array} \quad \underline{\text{\_ \_ G}} \; \underline{\text{C \_ \_}} \; \underline{\text{U \_ \_}}
\end{array}
$$
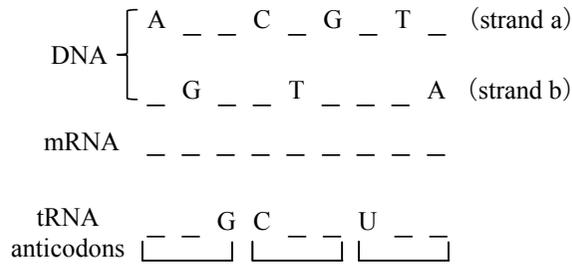
(1) From ① – ④ below choose the answer that correctly indicates the base sequence of the mRNA.

17

 ① TGCGTCAAA

 ② ACGCAGTTT

 ③ UGCGUCAAA

 ④ ACGCAGUUU

(2) How many amino acids are coded for by this DNA? From ① – ⑥ below choose the correct answer. Assume that all base sequences of the transcribed mRNA are translated into amino acids.

18

 ① 3 ② 4 ③ 5 ④ 6 ⑤ 8 ⑥ 9

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.