2017 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 − 50

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), and **F** (Q6) below,

where g denotes the magnitude of acceleration due to gravity, and air resistance is negligible.

A As shown in the figure below, a small ball (mass: m) is suspended from a ceiling using

three lightweight strings (**a, b, c**) joined together. String **a** forms an angle of $60°$ with the

vertical, and string **b** forms an angle of $30°$ with the vertical. Let us denote as T_a and T_b the

tension in **a** and **b**, respectively.
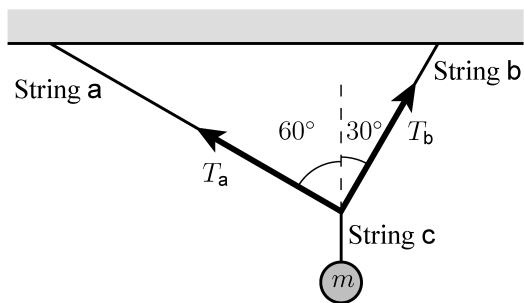
Q1 What is T_a? From ①-⑤ below choose the correct answer.   **1**

① $\dfrac{1}{2}mg$ ② $\dfrac{\sqrt{3}}{3}mg$ ③ $\dfrac{\sqrt{3}}{2}mg$ ④ mg ⑤ $\sqrt{3}\,mg$

B As shown in the figure below, a small object (mass: m) is placed on a rough slope that forms angle θ with horizontal, and a force of magnitude F is applied to the object in the upward direction along the slope, which brings the object to rest. Next, F is gradually decreased. When F becomes less than a certain magnitude F_0, the object begins sliding down the slope. Let us denote as μ the coefficient of static friction between the object and the slope.
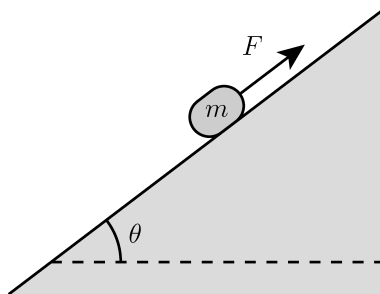
Q2 What is F_0? From ①-④ below choose the correct answer. $\boxed{2}$

① $mg(\cos\theta - \mu\sin\theta)$

② $mg(\sin\theta - \mu\cos\theta)$

③ $mg\left(\dfrac{1}{\mu}\cos\theta - \sin\theta\right)$

④ $mg\left(\dfrac{1}{\mu}\sin\theta - \cos\theta\right)$

C As shown in the figure below, small object A (mass: m) and small object B (mass: $2m$) are attached to opposite ends of an inelastic lightweight string that passes over a fixed pulley. A is placed on the floor and B is held in a position where the string remains taut and vertical. Here, the height of B above the floor is h. Next, B is gently released and it begins moving vertically downward. The speed of B immediately before colliding with the floor is v. Assume that the pulley rotates without friction and its mass is negligible.
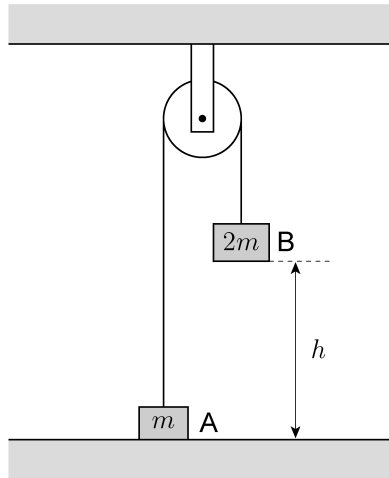
Q3　What is h? From ①-⑦ below choose the correct answer.　　　　**3**

①　$\dfrac{v^2}{3g}$　　　　②　$\dfrac{v^2}{2g}$　　　　③　$\dfrac{2v^2}{3g}$　　　　④　$\dfrac{v^2}{g}$

⑤　$\dfrac{3v^2}{2g}$　　　　⑥　$\dfrac{2v^2}{g}$　　　　⑦　$\dfrac{3v^2}{g}$

D   An object at rest splits into two pieces, A and B, that move in opposite directions. Let us denote as m_A, v_A, and K_A the mass, speed, and kinetic energy of A, respectively, and as m_B, v_B, and K_B the mass, speed, and kinetic energy of B, respectively.

Q4   What are $\dfrac{v_A}{v_B}$ and $\dfrac{K_A}{K_B}$? From ①-④ below choose the correct combination.   **4**

	①	②	③	④
$\dfrac{v_A}{v_B}$	$\dfrac{m_A}{m_B}$	$\dfrac{m_A}{m_B}$	$\dfrac{m_B}{m_A}$	$\dfrac{m_B}{m_A}$
$\dfrac{K_A}{K_B}$	$\dfrac{m_A}{m_B}$	$\dfrac{m_B}{m_A}$	$\dfrac{m_A}{m_B}$	$\dfrac{m_B}{m_A}$

E As shown in the figure below, a small ball is attached to one end of a lightweight spring placed on a smooth horizontal floor, and the other end is fixed in place to a wall. The ball is pulled distance d from its position when the spring is at its natural length and is gently released. The ball begins undergoing simple harmonic motion centered on the position of the natural length, with amplitude d. The speed of the ball when passing through the position of the natural length is v_0. When the speed of the ball is $\dfrac{v_0}{2}$, the ball is distance x from the position of the natural length.

Natural length d
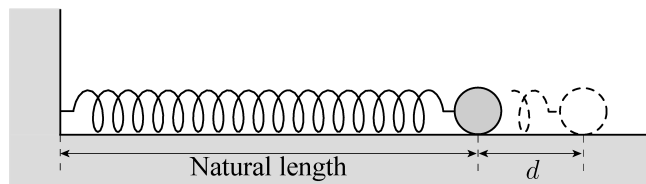
Q5 What is x? From ①-⑥ below choose the correct answer. $\boxed{5}$

① $\dfrac{d}{4}$

② $\dfrac{d}{2}$

③ $\dfrac{\sqrt{6}\,d}{4}$

④ $\dfrac{\sqrt{2}\,d}{2}$

⑤ $\dfrac{3d}{4}$

⑥ $\dfrac{\sqrt{3}\,d}{2}$

F As shown in the figure below, an artificial satellite is travelling in an elliptical orbit where the earth is at one of the foci. If we denote as r the distance between the satellite and the center of the earth when the satellite is at its closest distance to the earth, then the lengths of the major and minor axes of the orbit are $10r$ and $6r$, respectively. Let us denote as v_0 the speed of the satellite when it is nearest to the earth, and as v_1 the speed of the satellite when it crosses the minor axis of the orbit.
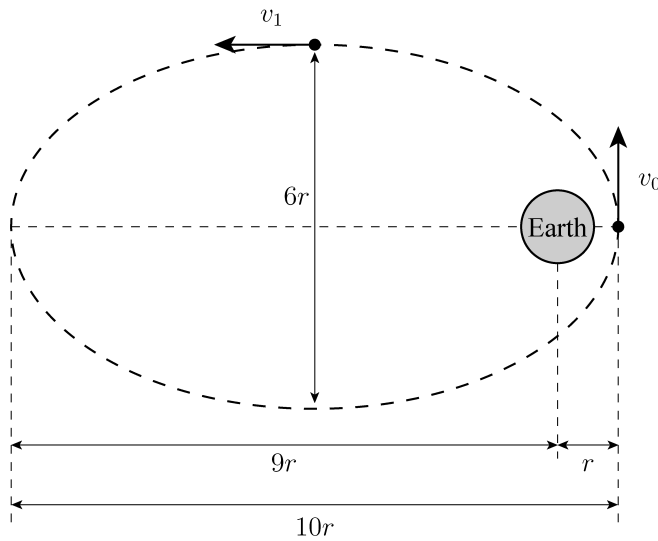
Q6 What is $\dfrac{v_1}{v_0}$? From ①-⑥ below choose the correct answer.

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6
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① 1

② $\dfrac{1}{2}$

③ $\dfrac{1}{3}$

④ $\dfrac{1}{4}$

⑤ $\dfrac{1}{5}$

⑥ $\dfrac{1}{6}$

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

A Ice of mass 200 g at 0 °C is placed in water of mass 1000 g at 30 °C held in a thermally insulated container. The heat of fusion of ice is 330 J/g and the specific heat of water is 4.2 J/(g · K). The heat capacity of the container is negligible.

Q1 What is the temperature inside the container after sufficient time elapses? From ①-⑥ below choose the best answer. $\boxed{7}$ °C

     ① 10   ② 12   ③ 14   ④ 16   ⑤ 18   ⑥ 20

B As shown in the figure below, two identical cylinders, A and B, are fixed in place on a horizontal floor, facing each other. The two pistons move smoothly, have the same cross sectional area, and are joined together by a common rod. The pistons enclose 0.20 mol and 0.60 mol of an ideal gas in A and B, respectively. The gas in A can be heated with a heater. Initially, the gases in A and B are at the same temperature and pressure. The heater is used to heat the gas in A for a certain amount of time. As a result, the volume of the gas in A increases by a factor of 1.5. Let us denote as T_A and T_B the temperature of the gas in A and the gas in B, respectively, for this state. The cylinders and pistons are made of thermally insulating material, and their heat capacity is negligible.

Cylinder A   Common rod   Cylinder B

Heater
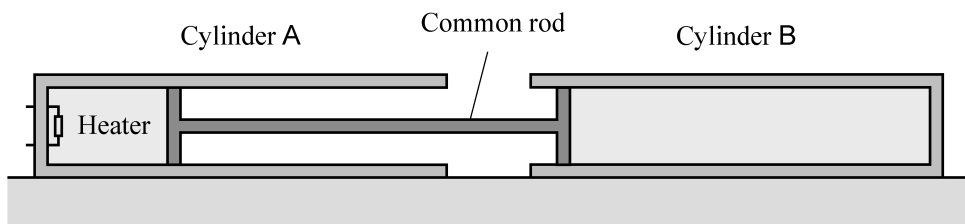
Q2 What is $\dfrac{T_A}{T_B}$? From ①-⑥ below choose the best answer.   **8**

① 0.50   ② 0.80   ③ 1.0   ④ 1.3   ⑤ 1.8   ⑥ 2.0

C Let us denote as p, V, and T the pressure, volume, and absolute temperature of a fixed quantity of an ideal gas, respectively. The state of the gas is changed in the pathway A→B→C→D→A as shown in the V-T diagram in Figure 1 below.
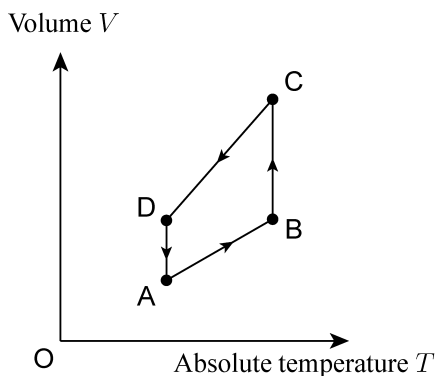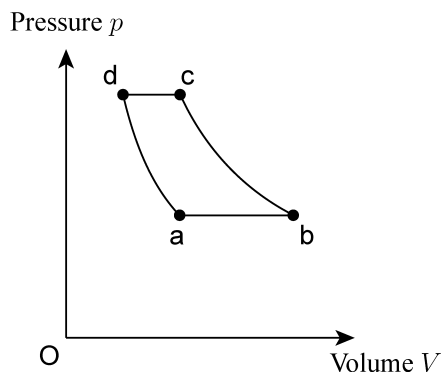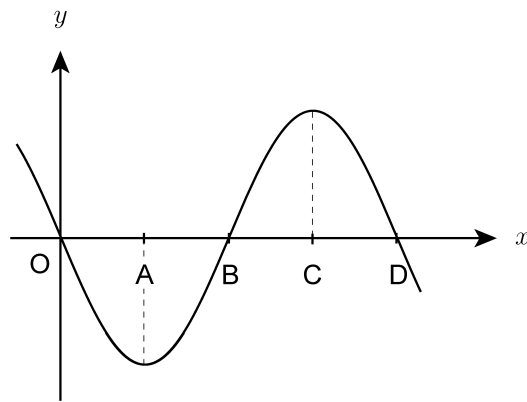
Figure 1

Figure 2

Q3 How is this change of state expressed in the p-V diagram in Figure 2? From ①-⑧ below choose the correct answer. **9**

① a → b → c → d → a ② a → d → c → b → a

③ b → c → d → a → b ④ b → a → d → c → b

⑤ c → d → a → b → c ⑥ c → b → a → d → c

⑦ d → a → b → c → d ⑧ d → c → b → a → d

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

A The figure below is a graph representing, for a transverse wave propagating in the positive direction of the x-axis, the relationship between displacement of the medium, y, and position x at a certain time.

Q1 Of positions O, A, B, C, and D in the figure, where is the velocity of the medium at its maximum in the negative direction of the y-axis? From ①-⑤ below choose the answer correctly indicating all such positions. **10**

    ① A   ② B   ③ C   ④ A，C   ⑤ O，D

B Consider a device that determines the speed of a moving object by emitting an ultrasonic wave toward the object and measuring the frequency of the ultrasonic wave reflected by the object. Now, an object moving with speed v is approaching the device, which is at rest. The device emits an ultrasonic wave of frequency f_0 toward the object, and measures the frequency of the ultrasonic wave reflected by the object, which is found to be f. Let us denote as V the speed of the ultrasonic wave.

Q2 What is v? From ①-⑥ below choose the correct answer. **11**

① $\dfrac{f - f_0}{f} V$ ② $\dfrac{f_0 - f}{f} V$

③ $\dfrac{f - f_0}{f_0} V$ ④ $\dfrac{f_0 - f}{f_0} V$

⑤ $\dfrac{f - f_0}{f + f_0} V$ ⑥ $\dfrac{f_0 - f}{f + f_0} V$

C As shown in the figure below, two flat glass plates measuring 300 mm along one side are stacked in air, and a gap of 0.030 mm is opened between them at one end. Monochromatic light of wavelength 600 nm (6.0×10^{-7} m) is projected at them from directly above, resulting in the formation of a striped pattern of bright and dark bands when viewed from directly above. Assume that the refractive index of air is 1.0.

Monochromatic light

⇩

0.030 mm

300 mm
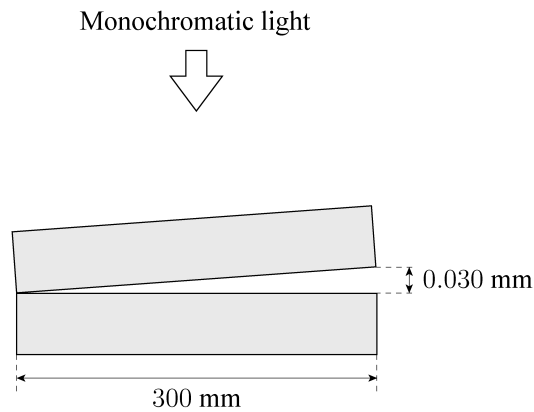
Q3 What is the interval of the dark bands (in mm)? From ①-⑥ below choose the best answer.

12 mm

① 1.0   ② 2.0   ③ 3.0

④ 4.0   ⑤ 5.0   ⑥ 6.0

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

A Two lightweight nonconducting strings of the same length are attached to a ceiling, separated by horizontal distance $3a$. Small balls **A** and **B**, of the same mass, are attached to the other ends of the strings, so that they are suspended. As shown in Figure 1, when a charge with quantity of electricity q (> 0) is given to **A** and a charge with quantity of electricity $-q$ is given to **B**, **A** and **B** come to rest at positions separated by distance a. Next, as shown in Figure 2, when a charge with quantity of electricity Q (> 0) is given to both **A** and **B**, they come to rest at positions separated by distance $5a$.
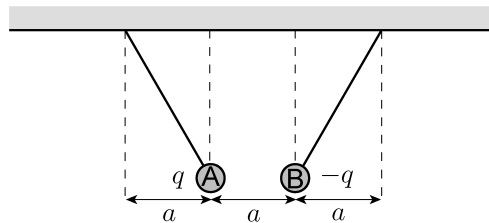

Figure 1
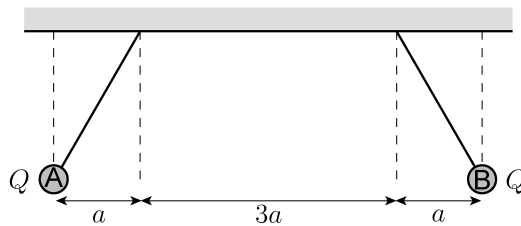
Figure 2

Q1　What is $\dfrac{Q}{q}$? From ①-⑥ below choose the correct answer. | **13**

　① $\sqrt{3}$ 　　② $\sqrt{5}$ 　　③ 3 　　④ 5 　　⑤ 9 　　⑥ 25

B As shown in the figure below, two point charges, each with quantity of electricity $Q\,(>0)$, are fixed in place at points symmetrically centered on origin O in an x-y plane, $(-d, 0)$ and $(d, 0)$. Another point charge P with quantity of electricity $q\,(>0)$ is moved along paths (a), (b), and (c) in the figure, from the start point of each path to its end point in the direction indicated by each arrow.

Q2 From ①-⑦ below choose the answer correctly indicating all movements where the work done by the electrostatic force acting on P from start to end of movement is zero. ☐14

① (a)   ② (b)   ③ (c)

④ (a) , (b)   ⑤ (a) , (c)   ⑥ (b) , (c)

⑦ (a) , (b) , (c)

C A parallel plate capacitor, a battery, a resistor, and switch S are connected as shown in the figure below. Initially, S is closed to charge the capacitor. Next, S is opened and then the distance separating the capacitor plates is doubled. Let us denote as U_1 the electrostatic energy stored in the capacitor in this state. Next, while keeping the plate distance doubled, S is closed to charge the capacitor. Let us denote as U_2 the electrostatic energy stored in the capacitor in this state.
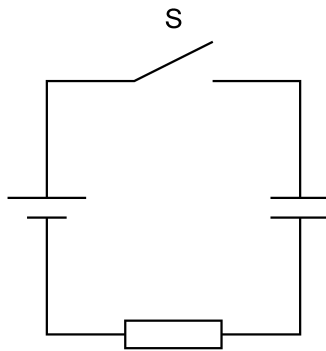
Q3 What is $\dfrac{U_2}{U_1}$? From ①-⑤ below choose the best answer. **15**
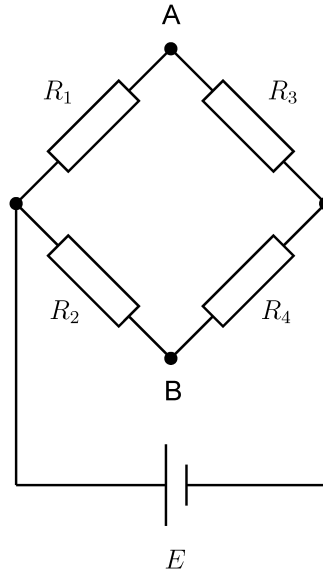
 ① $\dfrac{1}{4}$ ② $\dfrac{1}{2}$ ③ 1   ④ 2   ⑤ 4

D Four resistors (resistance: R_1, R_2, R_3, R_4) and a battery (electromotive force: E) are connected as shown in the figure below. Let us denote as V the electric potential at terminal A with respect to terminal B. The internal resistance of the battery is negligible.

Q4 What is $\dfrac{V}{E}$? From ①-④ below choose the correct answer. $\boxed{16}$

① $\dfrac{R_1 R_3 - R_2 R_4}{(R_1 + R_2)(R_3 + R_4)}$ ② $\dfrac{R_2 R_4 - R_1 R_3}{(R_1 + R_2)(R_3 + R_4)}$

③ $\dfrac{R_1 R_4 - R_2 R_3}{(R_1 + R_3)(R_2 + R_4)}$ ④ $\dfrac{R_2 R_3 - R_1 R_4}{(R_1 + R_3)(R_2 + R_4)}$

E As shown in Figure 1 below, three sufficiently long straight conducting wires pass through points A $(a, 0)$, B $(0, a)$, and C $(-2a, 0)$ in an x-y plane coinciding with the plane of this page, perpendicular to this page ($a > 0$). As shown in Figure 2, initially a current of magnitude I is made to flow through only the wire passing through A, in the direction from the back of this page to the front. The magnitude of the resulting magnetic field at origin O is H_0. Next, as shown in Figure 3, currents of magnitude I are made to flow through all three wires, in the direction from the back of this page to the front. The magnitude of the resulting magnetic field at O is H_1.
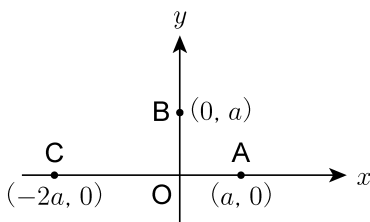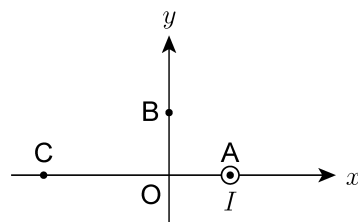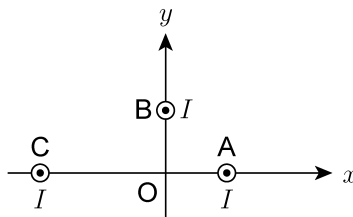
Figure 1

Figure 2

Figure 3

Q5 What is $\dfrac{H_1}{H_0}$? From ①-⑥ below choose the correct answer. $\boxed{17}$

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

F As shown in the figure below, three sufficiently long straight conducting wires (L_1, L_2, L_3) are placed in the same plane, parallel to one another and separated by equal distances of a. Currents of equal magnitude are flowing upward through L_1 and L_2. A current of a certain magnitude is flowing through L_3 in a certain direction. A force of magnitude F per unit length is acting on L_1 rightward, and a force of magnitude $2F$ per unit length is acting on L_2 leftward. Here, upward, downward, rightward and leftward refer to the directions indicated by the four arrows in the figure.
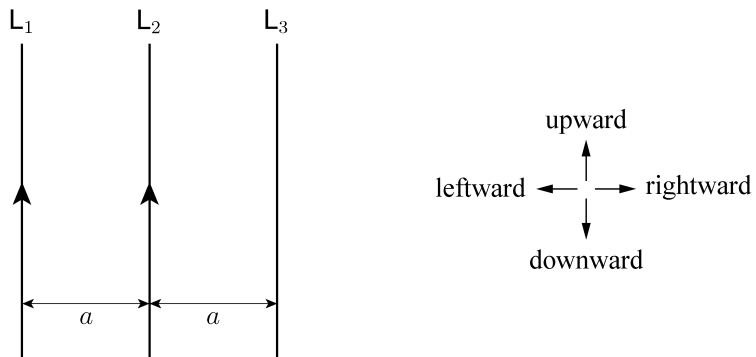
Q6 What are the direction of the current flowing through L_3, the direction of the force acting on L_3, and the magnitude of the force acting on L_3 per unit length? From ①-⑧ below choose the correct combination. $\boxed{18}$

	Direction of current	Direction of force	Magnitude of force per unit length
①	upward	rightward	F
②	upward	rightward	$3F$
③	upward	leftward	F
④	upward	leftward	$3F$
⑤	downward	rightward	F
⑥	downward	rightward	$3F$
⑦	downward	leftward	F
⑧	downward	leftward	$3F$

V Answer question **A** (Q1) below.

A A nucleus **X** with mass number A and atomic number Z is expressed as ^A_Z**X**. Unstable nucleus $^{230}_{90}$Th undergoes α-decay a times and β-decay b times to become stable $^{206}_{82}$Pb.

Q1 What is the set of values for (a, b)? From ①-⑥ below choose the correct answer. **19**

①　$(5, 3)$　　　　　　②　$(5, 4)$　　　　　　③　$(5, 5)$

④　$(6, 3)$　　　　　　⑤　$(6, 4)$　　　　　　⑥　$(6, 5)$

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

Use the following values for calculation. The unit of volume "liter" is represented by "L".

Standard state: $0\,℃$, 1.01×10^5 Pa   (= 1.00 atm)

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

Gas constant: $R = 8.31\times10^3$ Pa·L/(K·mol)

Avogadro constant: $N_A = 6.02\times10^{23}$ /mol

Faraday constant: $F = 9.65\times10^4$ C/mol

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

Mg : 24   S : 32   Pb : 207

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 The following figures indicate the electron configurations of atom X and atom Y.

X   Y

○ atomic nucleus

● electron
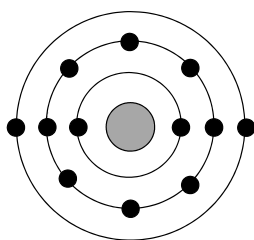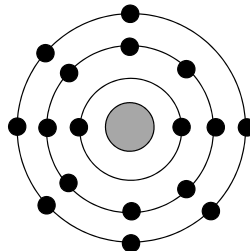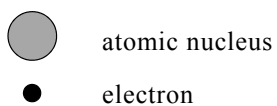
From ①-⑥ in the following table choose the correct combination of the ion formula of X when it forms a stable ion, and the compositional formula of a compound formed between X and Y by ionic bonds. | 1 |

	Ion formula	Compositional formula
①	X^{2+}	XY
②	X^{2+}	XY_2
③	X^{2+}	X_2Y
④	X^{2-}	YX
⑤	X^{2-}	Y_2X
⑥	X^{2-}	YX_2

Q2　From the following statements ①-⑤ on the chemical bond choose the one in which the underlined part is **not** correct.　　　　　　　　　　　　　　　　　　　　　│**2**│

　① In metallic iron (Fe), iron atoms are connected to each other by <u>metallic bonds</u>.

　② In ice, water molecules (H_2O) are connected to each other by <u>hydrogen bonds</u>.

　③ In dry ice, carbon dioxide molecules (CO_2) are connected to each other by <u>covalent bonds</u>.

　④ In an ammonium ion (NH_4^+), an ammonia molecule (NH_3) is bonded to a hydrogen ion (H^+) by <u>a coordinate bond</u>.

　⑤ In sodium chloride (NaCl), sodium ions (Na^+) and chloride ions (Cl^-) are connected to each other by <u>ionic bonds</u>.

Q3　From the following combinations of molecules ①-⑤ choose the one in which both are polar molecules.　　　　　　　　　　　　　　　　　　　　　　　　　│**3**│

　① CH_4, CCl_4　　② H_2O, CO_2　　③ N_2, NH_3　　④ HCl, CH_3Cl　　⑤ F_2, Cl_2

Q4　There is a gas mixture of nitrogen (N_2) and hydrogen (H_2), and its average molecular weight is 8.5. From the following ①-⑤ choose the closest value for the molar ratio of nitrogen to hydrogen (N_2 : H_2) of the gas mixture.　　　　　　　　　　　　　　　　| **4** |

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

Q5　At the standard state, 1.0 L of propane (C_3H_8) and 10.0 L of oxygen (O_2) were placed in an airtight container, and the propane was completely combusted. After the water formed during the reaction was removed, the temperature and the pressure were returned to the standard state. Calculate the volume of the gas in L. From ①-⑥ below choose the closest value.　　　　　　　　　　　　　　　　　　　　　　　　| **5** | L

　　① 3.0　　　② 4.0　　　③ 5.0　　　④ 6.0　　　⑤ 7.0　　　⑥ 8.0

Q6   The following figure indicates the crystal structure of copper (Cu).
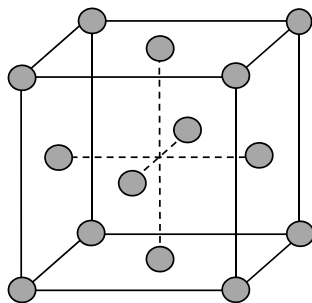
Among the following statements (**a**)-(**d**) on this crystal, two are correct. From ①-⑥ below choose the correct combination.   **6**

(**a**) This crystal structure is one of the close-packed structures.

(**b**) The number of atoms contained in one unit cell is 14.

(**c**) When the radius of a copper atom is r, the length of a side of the unit cell is given by $2\sqrt{2}\,r$.

(**d**) Each atom has 8 nearest neighbor atoms.

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

Q7   From 0.01 mol/L aqueous solutions of the following compounds ①-⑥, choose the one that has the lowest pH.   **7**

① H_2S ② HNO_3 ③ $(COOH)_2$ ④ CH_3COOH ⑤ H_3PO_4 ⑥ H_2SO_4

Q8   A lead storage battery was discharged to flow 0.4 mol of electrons. From the following ①-⑥ choose the statement that correctly describes the change of the mass of the cathode.

8

① It increased by 12.8 g.

② It increased by 19.2 g.

③ It increased by 25.6 g.

④ It decreased by 12.8 g.

⑤ It decreased by 19.2 g.

⑥ It decreased by 25.6 g.

Q9   The heat of formation of gaseous dinitrogen tetraoxide (N_2O_4) is Q_1 kJ/mol and that of gaseous nitrogen dioxide (NO_2) is Q_2 kJ/mol. From ①-⑥ below choose the correct equation representing the value of Q in the following thermochemical equation.   **9**

$$N_2O_4(gas) = 2NO_2(gas) + Q \text{ kJ}$$

① $Q = Q_1 + Q_2$ ② $Q = Q_1 - Q_2$ ③ $Q = -Q_1 + Q_2$

④ $Q = Q_1 + 2Q_2$ ⑤ $Q = Q_1 - 2Q_2$ ⑥ $Q = -Q_1 + 2Q_2$

Q10 When 1.0 mol of dinitrogen tetraoxide (N_2O_4) was placed in a 10 L container at a constant temperature, the pressure of the gas was 1.0×10^5 Pa. Keeping the temperature constant, nitrogen dioxide (NO_2) was formed and the following equilibrium was established. The total pressure was changed to 1.1×10^5 Pa.

$$N_2O_4 \rightleftharpoons 2NO_2$$
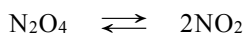
From the following ①-⑥ choose the closest value for the concentration equilibrium constant at this temperature. Assume that all substances in the container are ideal gases.

$\boxed{10}$ mol/L

① 0.0011   ② 0.0022   ③ 0.0044   ④ 0.011   ⑤ 0.022   ⑥ 0.044

Q11 From the following metals ①-⑤ choose the one that dissolves in aqueous sodium hydroxide (NaOH) but does not dissolve in concentrated nitric acid (conc. HNO₃).

$\boxed{11}$

① Ag   ② Al   ③ Fe   ④ Zn   ⑤ Pb

Q12   Among the acidic oxides listed in column **A** of the following table, two of them yield
the acids listed in column **B** when reacted with a sufficient amount of water. From ①-⑥
below choose the correct combination.   **12**

	A	B
a	nitrogen dioxide (NO_2)	nitric acid (HNO_3)
b	tetraphosphorus decaoxide (P_4O_{10})	phosphoric acid (H_3PO_4)
c	sulfur dioxide (SO_2)	sulfuric acid (H_2SO_4)
d	dichlorine heptaoxide (Cl_2O_7)	hydrochloric acid (HCl)

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

Q13 Among the following reactions (**a**)-(**e**), there are two in which the underlined substances are oxidized. From ①-⑦ below choose the correct combination. $\boxed{\textbf{13}}$

(**a**) $2\underline{Cu}$ $+$ O_2 $\longrightarrow$ $2CuO$

(**b**) $2\underline{CuO}$ $+$ C $\longrightarrow$ $2Cu$ $+$ CO_2

(**c**) $2H_2$ $+$ $\underline{O_2}$ $\longrightarrow$ $2H_2O$

(**d**) $2\underline{Al}$ $+$ $6HCl$ $\longrightarrow$ $2AlCl_3$ $+$ $3H_2$

(**e**) $3Cu$ $+$ $8\underline{HNO_3}$ $\longrightarrow$ $3Cu(NO_3)_2$ $+$ $4H_2O$ $+$ $2NO$
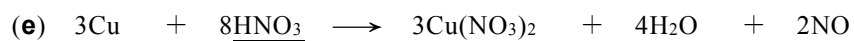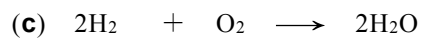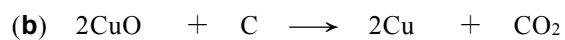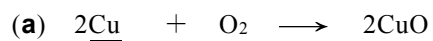
① **a**, **b**   ② **a**, **d**   ③ **a**, **e**   ④ **b**, **d**   ⑤ **b**, **e**   ⑥ **c**, **d**   ⑦ **d**, **e**

Q14   0.10 mol of hydrogen (H_2) was generated when dilute hydrochloric acid (dil. HCl) was added to 3.0 g of magnesium (Mg) powder containing some impurities. Calculate the purity of this magnesium in mass percent (%). From the following ①-⑤ choose the closest value. Assume that the impurities do not react with dilute hydrochloric acid.

$\boxed{14}$ %

   ①   20   ②   40   ③   50   ④   80   ⑤   96

Q15   Column **A** of the following table lists anions and column **B** lists reagents used to detect the anions as their precipitates. From ①-⑤ below choose the one in which the reagent in column **B** is **not** correct. $\boxed{15}$

	A	**B**
①	Cl^-	$AgNO_3$
②	SO_4^{2-}	$Mg(NO_3)_2$
③	CO_3^{2-}	$Ba(NO_3)_2$
④	CrO_4^{2-}	$Pb(NO_3)_2$
⑤	$[Fe(CN)_6]^{4-}$	$FeCl_3$

Q16 When 29 mg of a hydrocarbon was completely combusted, 88 mg of carbon dioxide (CO_2) was obtained. From the following ①-⑥ choose the correct one for the molecular formula of this hydrocarbon.   **16**

① C_2H_5 ② C_2H_6 ③ C_3H_6 ④ C_3H_7 ⑤ C_4H_{10} ⑥ C_4H_{12}

Q17 From the following ①-⑦ choose the number of aliphatic compounds with the molecular formula $C_4H_{10}O$ which react with metallic sodium (Na) to generate hydrogen (H_2). When stereoisomers are involved, they are to be counted separately.   **17**

① 1   ② 2   ③ 3   ④ 4   ⑤ 5   ⑥ 6   ⑦ 7

Q18 Two compounds listed in column **A** of the following table are to be distinguished with the aid of the reagents listed in column **B**. From ①-④ below choose the one in which the reagent in column **B** is **not** correct. ⌷18⌷

	A	B
①	nitrobenzene, aniline	solution of bleaching powder (CaCl(ClO) aq)
②	phenol, toluene	aqueous sodium hydroxide (NaOH)
③	salicylic acid, acetylsalicylic acid	aqueous sodium hydrogen carbonate (NaHCO$_3$)
④	benzoic acid, methyl salicylate	aqueous iron(III) chloride (FeCl$_3$)

Q19 Among the following polymer compounds (**a**)-(**d**) two are synthesized by condensation polymerization. From ①-⑥ below choose the correct combination. ⌷19⌷

(**a**) poly(ethylene terephthalate)

(**b**) poly(vinyl acetate)

(**c**) poly(methyl methacrylate)

(**d**) nylon 6,6

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

Q20   From the following statements ①-⑤ on the protein of egg whites choose the one in

which underlined part is **not** correct.   20

① It dissolves in a dilute solution of table salt.

② It solidifies when heated.

③ It is denatured when it is added to hydrochloric acid (HCl aq).

④ It turns reddish purple when aqueous sodium hydroxide (NaOH) and aqueous

copper(II) sulfate ($CuSO_4$) are added.

⑤ It turns yellow when ninhydrin solution is added and the mixture is heated.

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 ①－⑤ below choose the statement that correctly describes nucleic acids. **1**

① Both DNA and RNA have the same four types of bases: adenine, guanine, cytosine, and thymine.

② DNA has the following four types of bases: adenine, guanine, cytosine, and uracil.

③ Both DNA and RNA have ribose as their sugar.

④ The base sequence of an mRNA is the same as that of its DNA template.

⑤ In protein synthesis, tRNAs transport amino acids to the ribosome.

Q2 Catalase is an enzyme found in the cytoplasm of plants and animals.

In order to examine the catalytic activity of catalase and manganese (IV) oxide, eight test tubes A –
H were prepared with the combinations of substances as shown in the following table, kept at 37℃ and
observed for the formation of bubbles. In which of test tubes A – H were bubbles observed, and what
kind of gas was formed? From ①– ⑧ below choose the correct combination.   **2**

Test tube	A	B	C	D	E	F	G	H
3% hydrogen peroxide solution	3 mL	—	3 mL	—	3 mL	—	3 mL	—
Distilled water	—	3 mL	—	3 mL	—	3 mL	—	3 mL
Pieces of raw liver	0.1 g	0.1 g	—	—	—	—	—	—
Pieces of boiled liver	—	—	0.1 g	0.1 g	—	—	—	—
Manganese (IV) oxide	—	—	—	—	0.1 g	0.1 g	—	—
Boiled manganese (IV) oxide	—	—	—	—	—	—	0.1 g	0.1 g

	Test tubes in which bubbles were observed	Gas formed
①	A, B, E, F	oxygen (O_2)
②	A, B, E, F	hydrogen (H_2)
③	B, D, F, H	oxygen (O_2)
④	B, D, F, H	hydrogen (H_2)
⑤	A, E, G	oxygen (O_2)
⑥	A, E, G	hydrogen (H_2)
⑦	C, E, G	oxygen (O_2)
⑧	C, E, G	hydrogen (H_2)

Q3 Cells in the mitotic phase of the cell cycle can be classified into the four phases: prophase, metaphase, anaphase, and telophase.

The following photo shows somatic cell division taking place in an onion root tip, with regions A – D each depicting a cell in a different phase of mitosis. Among the cells A – D, which cells are in prophase, metaphase, or anaphase? From ① – ⑧ below choose the correct combination.
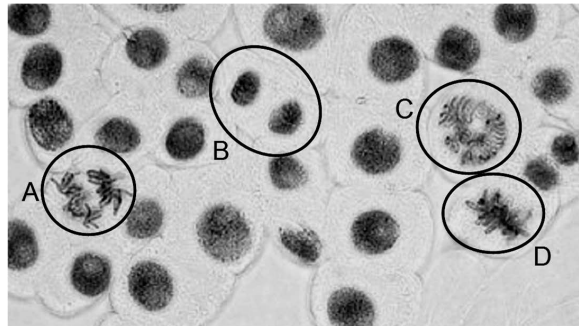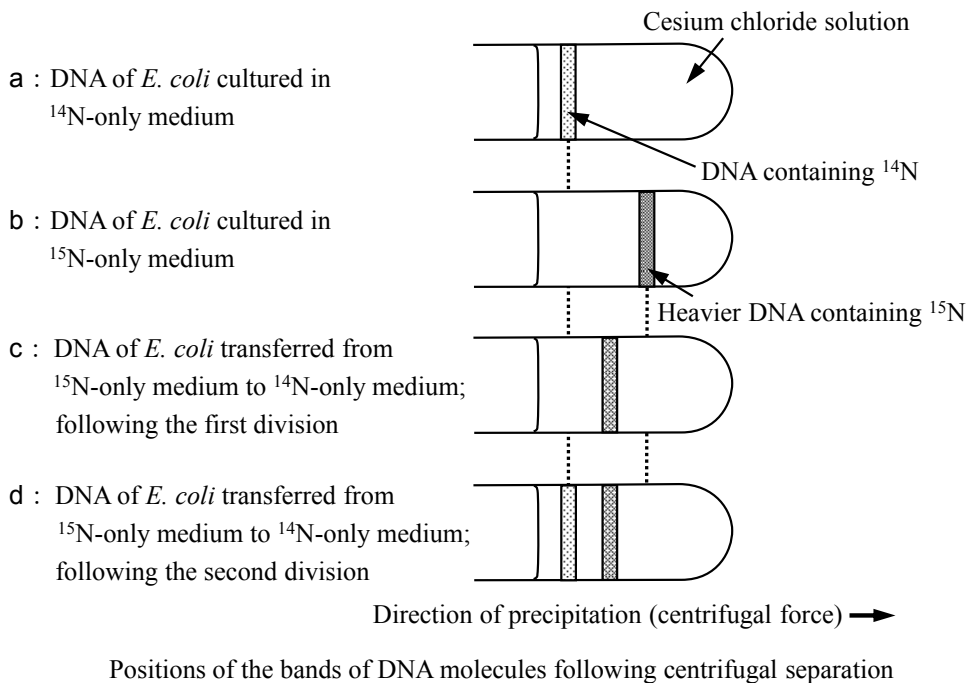
| 3 |

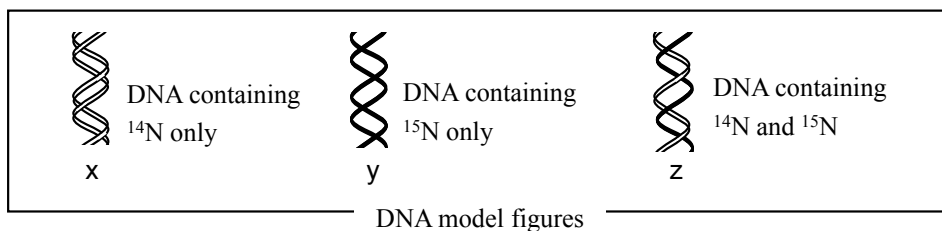|	Prophase	Metaphase	Anaphase
①	A	C	D
②	A	D	B
③	B	A	C
④	B	D	C
⑤	C	A	D
⑥	C	D	A
⑦	D	A	B
⑧	D	C	A

Q4 Nitrogen (N) mainly exists as ^{14}N, but a heavier isotope ^{15}N also exists. It is possible to determine which isotope is present in DNA by centrifuging DNA extracted from cells and examining the position of the band.

Escherichia coli were cultured in a medium containing ^{14}N only or in a medium containing ^{15}N only. Figures a and b below show the DNA bands that formed for the samples extracted from cells grown in the media described above.

Next, E. coli cultured in a ^{15}N-only medium were transferred to a ^{14}N-only medium. Figures c and d below show the DNA bands of the samples taken from the cells immediately after the first and second divisions following the transfer, respectively. When E. coli DNA is represented with model figures x – z on the following page, which model figure represents the DNA of the E. coli after the first division, and which represents the DNA of the E. coli after the second division? From ①–⑥ on the following page choose the correct answer. **4**

a : DNA of E. coli cultured in
   ^{14}N-only medium

Cesium chloride solution

DNA containing ^{14}N

b : DNA of E. coli cultured in
   ^{15}N-only medium

Heavier DNA containing ^{15}N

c : DNA of E. coli transferred from
   ^{15}N-only medium to ^{14}N-only medium;
   following the first division

d : DNA of E. coli transferred from
   ^{15}N-only medium to ^{14}N-only medium;
   following the second division

Direction of precipitation (centrifugal force) ⟶

Positions of the bands of DNA molecules following centrifugal separation

	DNA containing ^{14}N only	DNA containing ^{15}N only	DNA containing ^{14}N and ^{15}N
	x	y	z

DNA model figures

	E. coli DNA following the first division	*E. coli* DNA following the second division
①	x	x, y
②	x	y, z
③	y	x, y
④	y	x, z
⑤	z	x, z
⑥	z	y, z

Q5 From ①–④ below choose the combination indicating the two statements in the following a – d that correctly describe splicing in eukaryotic cells. | 5 |

a   Splicing takes place in the nucleus.

b   Splicing takes place in the cytoplasmic matrix.

c   mRNA is formed through removal of the regions corresponding to exons from precursor mRNA (the RNA immediately after transcription).

d   mRNA is formed through removal of the regions corresponding to introns from precursor mRNA.

① a, c   ② a, d   ③ b, c   ④ b, d

Q6 Read the following paragraphs, and from ①-⑧ below, choose the combination of terms that best fills blanks │ a │ - │ c │ in the last paragraph.

6

Escherichia coli produce lactase and related enzymes in a medium that contains lactose but lacks glucose; however, those enzymes are not produced in the absence of lactose.

The following figure schematically represents a cluster of the *E. coli* genes for lactase and the other enzymes, and the regions of DNA that are involved in the regulation of the expression of these genes.

DNA ▬▬▬ regulator gene ▬▬ promoter ▬ operator ▬ cluster of enzyme genes ▬▬
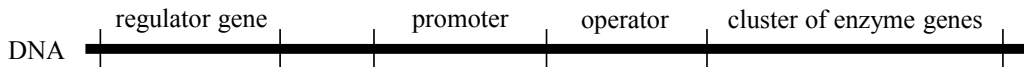
In *E. coli* grown in a medium that contains lactose but lacks glucose, a lactose metabolite binds to a regulatory protein (a), altering its conformation. As a result, the regulatory protein can no longer bind to the │ b │ region, and thus the inhibition of transcription by │ c │ is removed.

	a	b	c
①	histone	operator	DNA polymerase
②	histone	operator	RNA polymerase
③	histone	promoter	DNA polymerase
④	histone	promoter	RNA polymerase
⑤	repressor	operator	DNA polymerase
⑥	repressor	operator	RNA polymerase
⑦	repressor	promoter	DNA polymerase
⑧	repressor	promoter	RNA polymerase

Q7 Meiosis consists of two divisions, meiosis I and meiosis II. From ① – ⑥ below choose the combination that correctly indicates the nuclear phases (*n* or 2*n*) of the mother cell, prophase I, prophase II, and the daughter cell in the process of meiosis. 〔7〕

	Mother cell	Prophase I	Prophase II	Daughter cell
①	2*n*	2*n*	2*n*	*n*
②	2*n*	2*n*	*n*	*n*
③	2*n*	*n*	*n*	*n*
④	*n*	2*n*	2*n*	2*n*
⑤	*n*	*n*	2*n*	2*n*
⑥	*n*	*n*	*n*	2*n*

Q8 From ① – ⑤ below choose the statement that does **not** correctly describe gametogenesis and genes. 〔8〕

① Genes that are located on the same chromosome are said to be linked.

② Genes that are not linked segregate independently of each other.

③ Chromosomal crossing-over takes place during metaphase II.

④ Genetic recombination contributes to diverse combinations of genes in gametes.

⑤ Meiosis results in a production of gametes inheriting various combinations of parental chromosomes. This is one of the mechanisms that confer genetic diversity.

Q9 From ① – ④ below choose the statement that does **not** correctly describe gametogenesis in angiosperms.　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　 <u>9</u>

①　Through meiosis, a pollen mother cell gives rise to a pollen tetrad consisting of four cells.

②　Through meiosis, a megaspore mother cell gives rise to four cells; three of those cells degenerate while the remaining cell is called the egg cell.

③　The nuclei of the pollen tube cell and the generative cell that are found in a pollen grain have identical genomes.

④　In an embryo sac, the nuclei of the antipodal cells, the synergids, and the egg cell, and the polar nuclei of the central cell all have identical genomes.

Q10 The following paragraph describes blood coagulation. From ① – ⑧ below choose the combination of terms that correctly fills blanks ☐ a ☐ – ☐ c ☐ in the paragraph.　　　　　　 <u>10</u>

A sample of blood left standing in a test tube will eventually coagulate, resulting in the formation of a ☐ a ☐. A ☐ a ☐ is a deposit of cellular elements of blood, such as blood cells, that are trapped with thread-like proteins called ☐ b ☐. The yellowish fluid above the deposit in the test tube is called ☐ c ☐.

	a	b	c
①	platelet	globulin	blood plasma
②	platelet	globulin	serum
③	platelet	fibrin	blood plasma
④	platelet	fibrin	serum
⑤	blood clot	globulin	blood plasma
⑥	blood clot	globulin	serum
⑦	blood clot	fibrin	blood plasma
⑧	blood clot	fibrin	serum

Q11 The following figure schematically represents the mechanism by which the blood glucose level is increased, that involves the adrenal gland. From ① – ⑥ below choose the combination that correctly indicates the hormones A and B in the figure. 　　**11**
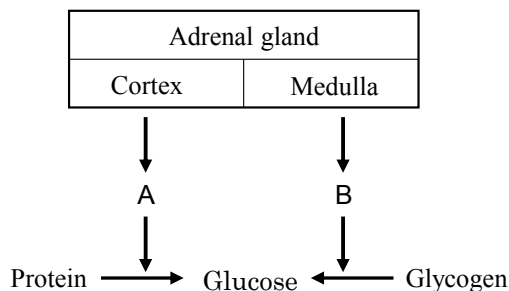

	A	B
①	glucagon	adrenaline
②	glucagon	glucocorticoid
③	adrenaline	glucagon
④	adrenaline	glucocorticoid
⑤	glucocorticoid	adrenaline
⑥	glucocorticoid	glucagon

Q12 Statements ① – ⑤ below describe B cells and T cells, which are involved in immunity. Choose the statement that applies to both B cells and T cells. 　　**12**

① Some of the activated cells remain as memory cells.

② The activated cells differentiate into antibody-forming cells (plasma cells).

③ These cells originate in the bone marrow and mature in the thymus.

④ These cells become activated directly through antigen presentation by a dendritic cell.

⑤ These cells can become infected by the human immunodeficiency virus (HIV).

Q13 An experiment for examining dark adaptation of the human eye was performed by acclimatizing the eyes of the subject to a brightly lit room and then suddenly turning off all lights in the room. The following graph shows the relationship between the time spent in darkness and the minimum intensity of perceptible light.

From ① – ⑥ below choose the combination that best indicates the cells which act as main functioning cells at the conditions represented by the curves A and B in the graph, respectively. $\boxed{\textbf{13}}$
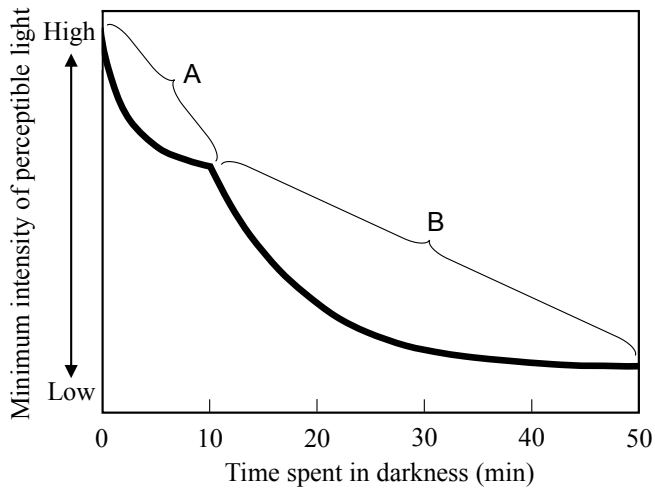
|	Curve A	Curve B
①	rod cells	cone cells
②	rod cells	glia cells
③	cone cells	rod cells
④	cone cells	glia cells
⑤	glia cells	rod cells
⑥	glia cells	cone cells

Q14 The following figure schematically represents a cross section of a barley seed. The arrows in the figure indicate the movement of substances after the seed absorbs water and begins germinating. From ① – ⑥ below choose the combination that best indicates substances A – C in the figure. 14
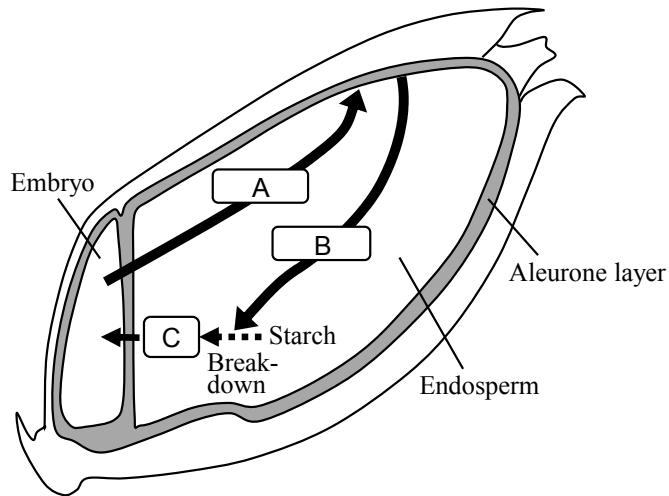
	A	B	C
①	gibberellin	amylase	sugar
②	gibberellin	sugar	amylase
③	amylase	sugar	gibberellin
④	amylase	gibberellin	sugar
⑤	sugar	amylase	gibberellin
⑥	sugar	gibberellin	amylase

Q15 The following paragraph describes the relationship between light and the mechanism by which stomata open and close. The figure below schematically represents the structure of the region surrounding a stoma. Referring to the figure, from ① – ⑧ below choose the combination of terms that best fills blanks ☐ a ☐ – ☐ c ☐ in the paragraph. **15**

When the photoreceptors in the guard cells absorb ☐ a ☐ light, the osmotic pressure in the guard cells ☐ b ☐. As a result, water moves into the guard cells and the turgor pressure in the guard cells ☐ c ☐, which causes the cells to change the shape, thus opening the stoma.
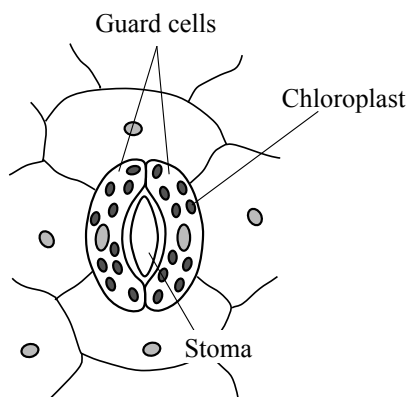

	a	b	c
①	blue	increases	increases
②	blue	increases	decreases
③	blue	decreases	increases
④	blue	decreases	decreases
⑤	red	increases	increases
⑥	red	increases	decreases
⑦	red	decreases	increases
⑧	red	decreases	decreases

Q16 The following figure schematically shows inputs and outputs of the organic matter at the various trophic

levels of an ecosystem.

From ① – ⑥ below choose the combination of terms that correctly indicates what A – C represent

in the figure. 16
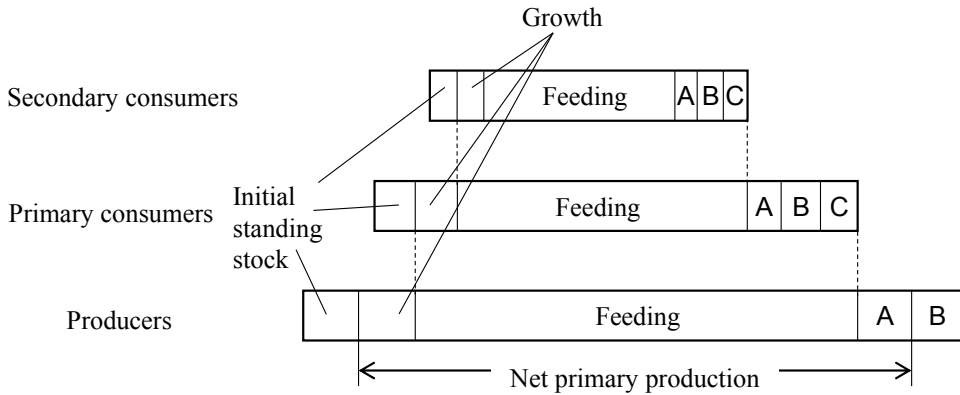
	A	B	C
①	respiration	death, dead plant tissue	excretion
②	respiration	excretion	death, dead plant tissue
③	death, dead plant tissue	respiration	excretion
④	death, dead plant tissue	excretion	respiration
⑤	excretion	respiration	death, dead plant tissue
⑥	excretion	death, dead plant tissue	respiration

Q17 The following statements a – e below describe organelles of eukaryotic cells. From ① – ⑥ below choose the combination indicating the two statements that best represent the evidence supporting the endosymbiotic theory. ⃞17

a Chloroplasts have a double membrane: an inner membrane and an outer membrane.

b There are two types of endoplasmic reticulum: rough endoplasmic reticulum, to which ribosomes are attached, and smooth endoplasmic reticulum, which is not associated with ribosomes.

c The Golgi body is composed of a single membrane and it consists of a stack of flattened sac-like structures.

d Vacuoles develop in plant cells, some of which may contain pigments.

e Mitochondria have their own DNA, which is different from that of the nucleus.

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

Q18 From ① – ⑤ below choose the statement that does **not** correctly describe the evolution of living organisms. ⃞18

① Cyanobacteria emerged during the Precambrian.

② Reptiles flourished during the Mesozoic era.

③ Colonization of land by plants began in the Paleozoic era.

④ Gymnosperms flourished during the Mesozoic era.

⑤ Birds emerged during the Cenozoic era.

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.