2013 Examination for Japanese University Admission for International Students

Science (80 min.)

【Physics, Chemistry, Biology】

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

Ⅰ Rules of Examination

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

Ⅱ Rules and Information Concerning the Question Booklet

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

Subject	Pages
Physics	1－21
Chemistry	23－32
Biology	33－49

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

Ⅲ Rules and Information Concerning the Answer Sheet

1. You must mark your answers on the answer sheet with an HB pencil.
2. Each question is identified by one of the row numbers [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														

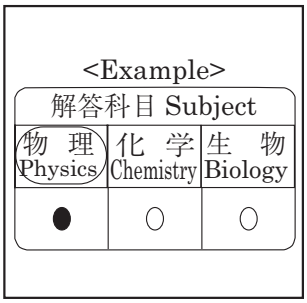
Physics

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.

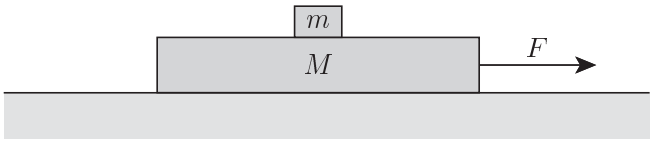
As shown in the example on the right, if you answer the Physics questions, circle "Physics" and completely fill in the oval under the subject name.

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



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.

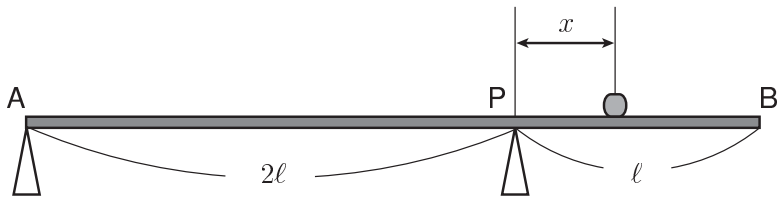
A As shown in the figure below, a board (mass: M) is placed on a smooth, horizontal floor, and a small object (mass: m) is placed on the board. The board is pulled in a horizontal direction by a force of magnitude F, and friction acts between the board and the object. Initially, the board and the object move together at the same speed, but as magnitude F is gradually increased, the object begins to slide on the board when F exceeds F_0.



Q1 What is the coefficient of static friction between the object and the board? From ①-④ below choose the correct answer. **1**

① $\dfrac{F_0}{mg}$　② $\dfrac{F_0}{Mg}$　③ $\dfrac{F_0}{(M+m)g}$　④ $\dfrac{(M+m)F_0}{Mmg}$

B Consider a rigid uniform bar with a length of 3ℓ and a mass of $3m$. Let us denote one end of the bar as A, the other end as B, and the point distance ℓ from B as P. The bar is supported from below at points A and P so that it is horizontal. Next, a small object of mass M ($> 3m$) is gently placed on the bar between P and B at a point distance x from P.



Q2 Given this state, what range should x be so that A does not rise? From ①-④ below choose the best answer. **2**

① $x < \dfrac{m}{M}\ell$ ② $x < \dfrac{3m}{2M}\ell$ ③ $x < \dfrac{2m}{M}\ell$ ④ $x < \dfrac{3m}{M}\ell$

C As shown in Figure 1, a small ball A (mass: m) collides with a small ball B (mass: M), which is initially at rest, on a smooth horizontal surface. As shown in Figure 2, after colliding, A moves in a direction $30°$ from its direction of travel before the collision, and B moves in a direction $45°$ from A's direction of travel before the collision. Let us denote the speed of A after the collision as v_A and the speed of B as v_B.

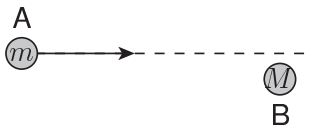


Figure 1

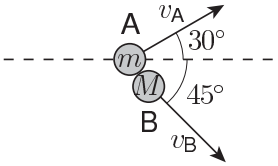
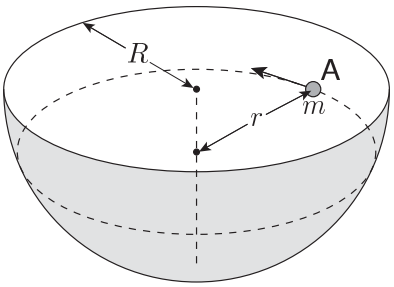


Figure 2

Q3 What is $\frac{v_B}{v_A}$? From ①-④ below choose the correct answer. **3**

① $\frac{\sqrt{2}m}{2M}$ ② $\frac{\sqrt{6}m}{3M}$ ③ $\frac{\sqrt{6}m}{2M}$ ④ $\frac{\sqrt{2}m}{M}$

D As shown in the figure below, a small object A (mass: m) is undergoing uniform circular motion on the smooth inner surface of a fixed hollow hemisphere (radius: R) in a path with radius r ($< R$) within a horizontal plane.



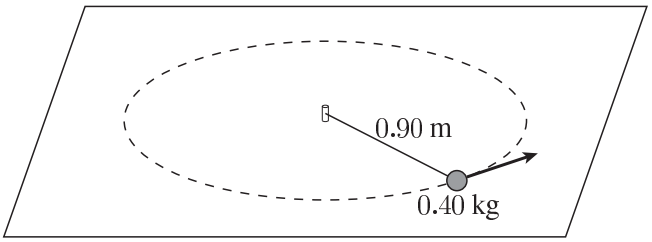
Q4 What is the kinetic energy of A? From ①-⑦ below choose the correct answer. **4**

① $\dfrac{mgr}{2}$ ② $\dfrac{mgR}{2}$ ③ $\dfrac{mgr^2}{2R}$

④ $\dfrac{mg\sqrt{R^2-r^2}}{2}$ ⑤ $\dfrac{mgr\sqrt{R^2-r^2}}{2R}$ ⑥ $\dfrac{mgr^2}{2\sqrt{R^2-r^2}}$

⑦ $\dfrac{mgrR}{2\sqrt{R^2-r^2}}$

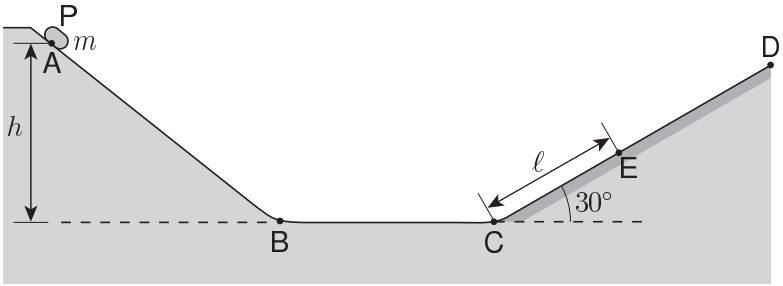
E As shown in the figure below, a small ball (mass: 0.40 kg) is attached to an end of a string with a length of 0.90 m and is undergoing circular motion on a smooth horizontal surface, in a path centered on the other end of the string. The string will break if the magnitude of its tension reaches 16 N. Here, the string is lightweight and inelastic.



Q5 If the speed of the ball is gradually increased, at what speed (in m/s) will the string break? From ①-⑤ below choose the correct answer. **5** m/s

① 3.0　② 6.0　③ 9.0　④ 18　⑤ 36

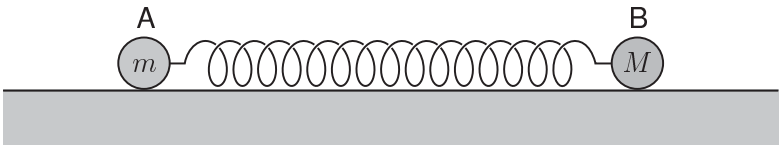
F As shown in the figure below, a small object P (mass: m) is gently released from point A, which is height h from a smooth horizontal surface BC. P slides down a smooth slope AB, moves across BC, and then ascends a rough slope CD before coming to rest at point E, which is distance ℓ from point C. The slope CD forms an angle of 30° with the horizontal, and its coefficient of kinetic friction with P is $\frac{\sqrt{3}}{6}$.



Q6 What is ℓ? From ①-④ below choose the correct answer. **6**

① $\frac{2}{3}h$ ② $\frac{4}{5}h$ ③ h ④ $\frac{4}{3}h$

G As shown in the figure below, a lightweight spring is placed on a smooth horizontal surface, and small objects A (mass: m) and B (mass: M) are attached to opposite ends of the spring. A and B are pulled with both hands and held at rest at positions where the length of the spring exceeds its natural length. Next, A and B are gently released at the same time, and both begin undergoing simple harmonic motion.



Q7 Let us denote the kinetic energy of A and B when the spring returns to its natural length as K_A and K_B, respectively. What is $\frac{K_A}{K_B}$? From ①-⑤ below choose the correct answer.

7

① $\frac{m^2}{M^2}$　② $\frac{m}{M}$　③ 1　④ $\frac{M}{m}$　⑤ $\frac{M^2}{m^2}$

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

A As shown in Figure 1, water of 200 g is placed in a thermally insulated container. The total heat capacity of both the stirring rod and the container is 40 J/K, and the specific heat of water is 4.2 J/(g·K). The initial temperature of the stirring rod, the container, and the water is 20°C. The stirring rod is used to gently stir the water while a direct-current voltage of 20 V is applied to the heater, causing the temperature of the stirring rod, the container, and the water to increase over time as shown in Figure 2. The electrical resistance of the heater does not change while the electrical current passes through it. The heat capacity of the heater and the thermometer is negligible.

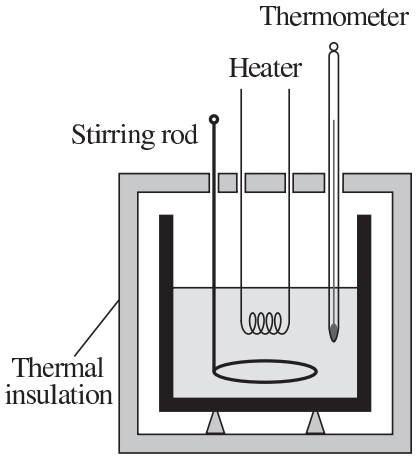


Figure 1

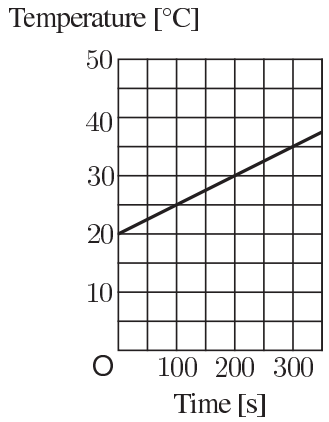
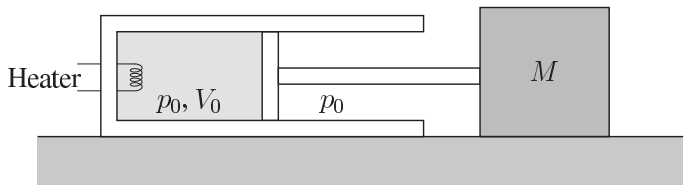


Figure 2

Q1 How many amperes (A) was the current passing through the heater? From ①-⑥ below choose the best answer. **8** A

① 0.22 ② 0.44 ③ 2.2 ④ 4.4 ⑤ 22 ⑥ 44

B As shown in the figure below, a cylinder fixed to a horizontal floor contains a monatomic ideal gas enclosed by a lightweight piston (cross-sectional area: S) that can move smoothly. Initially, the pressure of the gas is equivalent to atmospheric pressure p_0, and its volume is V_0. An object of mass M is placed on the floor in contact with the right end of the piston. The ideal gas is gradually heated using a heater inside the cylinder. After some time passes, the object begins to move to the right. Let us denote the coefficient of static friction between the object and the floor as μ, and the magnitude of acceleration due to gravity as g. Both the cylinder and the piston are made of thermally insulating material, and no exchange of heat occurs with the environment.

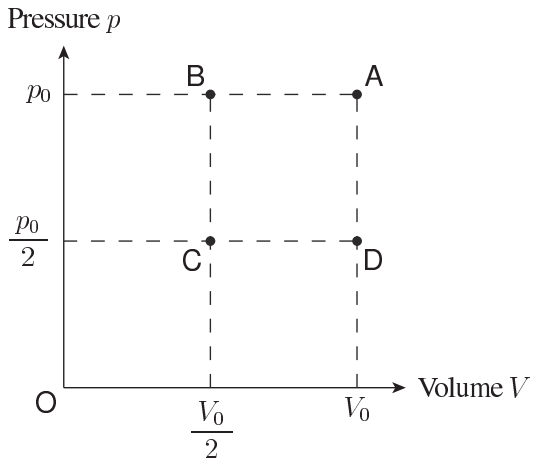


Q2 What is the quantity of heat applied to the ideal gas until immediately before the object began to move? From ①-⑥ below choose the best answer. **9**

① $\dfrac{\mu M g V_0}{S}$ ② $\dfrac{3\mu M g V_0}{2S}$ ③ $\dfrac{5\mu M g V_0}{2S}$

④ $\dfrac{(\mu M g - p_0 S)V_0}{S}$ ⑤ $\dfrac{3(\mu M g - p_0 S)V_0}{2S}$ ⑥ $\dfrac{5(\mu M g - p_0 S)V_0}{2S}$

C The figure below shows four states (A, B, C, D) of a fixed quantity of a monatomic ideal gas in a p-V diagram. Let us denote the internal energy of the gas in the states A, B, C, and D as U_A, U_B, U_C, and U_D, respectively.



Q3 What is the magnitude relationship among U_A, U_B, U_C, and U_D? From ①-④ below choose the correct answer. **10**

① $U_A > U_B = U_D > U_C$

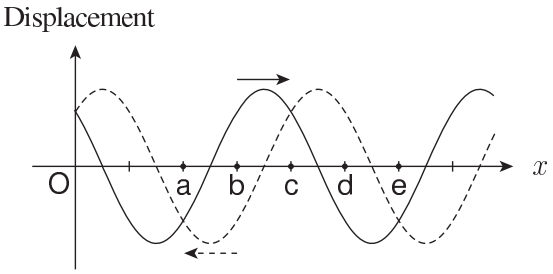
② $U_B > U_A = U_C > U_D$

③ $U_C > U_B = U_D > U_A$

④ $U_D > U_A = U_C > U_B$

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

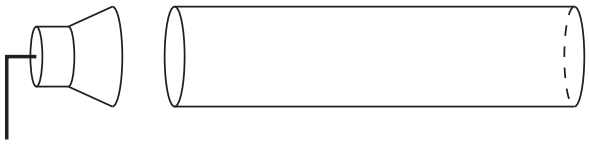
A A stationary wave is formed by the superposition of two sinusoidal waves that are propagating along an x-axis in opposite directions and that have the same wavelength, amplitude, and speed. The figure below shows the waveform of the two sinusoidal waves at a certain moment. The solid line in the figure represents the sinusoidal wave traveling to the right, and the broken line represents the sinusoidal wave traveling to the left.



Q1 Which of points a-e are antinodes (points where oscillation is maximum), and which are nodes (points where no oscillation occurs)? From ①-④ below choose the best combination. **11**

	①	②	③	④
Antinodes	b, d	a, c, e	c	a, e
Nodes	a, c, e	b, d	a, e	c

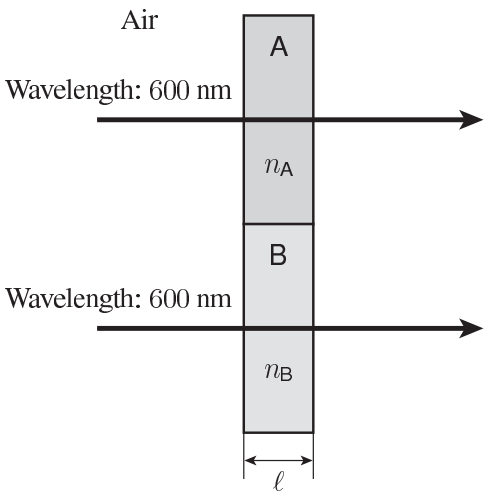
B A pipe is open at both ends. As shown in the figure below, a speaker is placed at one end of the pipe, and the frequency of the sound it emits is gradually increased from zero in order to determine the frequency at which the first resonance occurs. When this experiment is performed in air, the frequency of first resonance is found to be f_1. Next, the pipe is closed at the end opposite to the speaker, and the experiment is repeated in another gas, which is denoted as A. In this case, the frequency of first resonance is found to be f_2. Let us denote the speed of sound in air as V. Assume that open-end correction is negligible.



Q2 What is the speed of sound in gas A? From ①-④ below choose the correct answer. **12**

① $\dfrac{2f_1V}{f_2}$ ② $\dfrac{2f_2V}{f_1}$ ③ $\dfrac{f_1V}{2f_2}$ ④ $\dfrac{f_2V}{2f_1}$

C As shown in the figure below, beams of light whose wavelength in air is 600 nm are perpendicularly incident upon two transparent thin films (A and B) in the same phase. The thickness of A and B is ℓ. The refractive indices of A and B are, respectively, n_A and n_B. The difference of these two indices ($n_A - n_B$) is 6.0×10^{-3}, and the refractive index of air is 1.00. Note that $1\ \text{nm} = 10^{-9}\ \text{m}$.



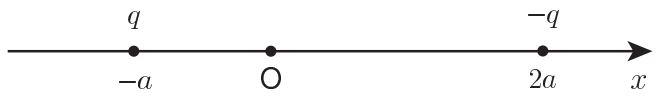
Q3 What value should be assigned to film thickness ℓ in order that the two beams of light directly passing through A and B, respectively, without reflection at the film-air boundaries are of opposite phase (i.e., phase difference corresponding to half a wavelength)? From ①-⑥ below choose the best answer. **13** m

① 1.0×10^{-3}　② 5.0×10^{-4}　③ 2.0×10^{-4}

④ 1.0×10^{-4}　⑤ 5.0×10^{-5}　⑥ 2.0×10^{-5}

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

A As shown in the figure below, a point charge with quantity of electricity q $(q > 0)$ is fixed to a point on the x-axis where $x = -a$ $(a > 0)$, and a point charge with quantity of electricity $-q$ is fixed to a point on the x-axis where $x = 2a$. Let us choose the reference position of electric potential to be at infinity, and denote the proportionality constant of Coulomb's law as k.



Q1 What are the x-component of the electric field (E_x) and the electric potential (V) at origin O? From ①-⑥ below choose the correct combination. **14**

	①	②	③	④	⑤	⑥
E_x	$\frac{3kq}{4a^2}$	$\frac{3kq}{4a^2}$	$\frac{3kq}{4a^2}$	$\frac{5kq}{4a^2}$	$\frac{5kq}{4a^2}$	$\frac{5kq}{4a^2}$
V	$-\frac{kq}{2a}$	$+\frac{kq}{2a}$	$+\frac{3kq}{2a}$	$-\frac{kq}{2a}$	$+\frac{kq}{2a}$	$+\frac{3kq}{2a}$

B When an infinitely wide plate in a vacuum carries a uniform charge of quantity of electricity q per unit area, the electric field is perpendicular to the plate and its magnitude is proportional to $|q|$, regardless of the distance from the plate. When $q > 0$, the electric field is in a direction moving away from the plate, as shown in Figure 1. When $q < 0$, the electric field is in a direction moving toward the plate, as shown in Figure 2. Figure 3 represents three infinitely wide plates (I, II, and III) that are parallel to one another and carry uniform charges of, respectively, quantities of electricity $-2Q$, Q, and $3Q$ per unit area. Let us denote the magnitude of the electric field in regions A, B, and C in Figure 3 as E_A, E_B, and E_C, respectively.

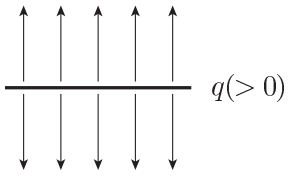


Figure 1

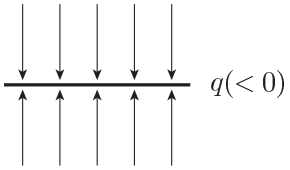


Figure 2

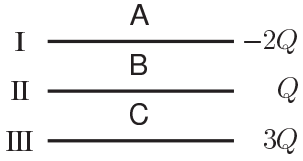


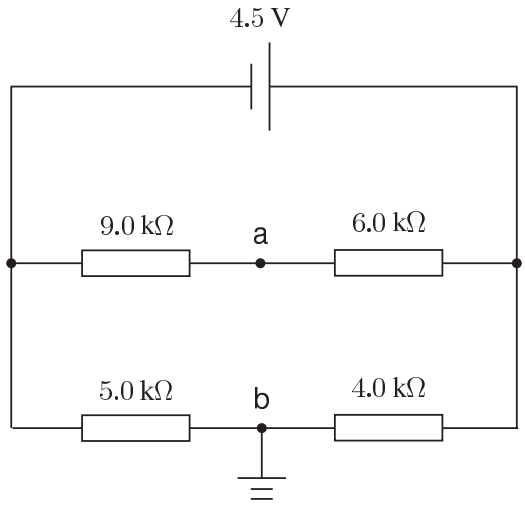
Figure 3

Q2 What is the magnitude relationship among E_A, E_B, and E_C? From ①-⑥ below choose the correct answer. **15**

① $E_A > E_B > E_C$　② $E_A > E_C > E_B$　③ $E_B > E_A > E_C$

④ $E_B > E_C > E_A$　⑤ $E_C > E_A > E_B$　⑥ $E_C > E_B > E_A$

C A battery with an electromotive force of 4.5 V and four resistors (resistance: 4.0 kΩ, 5.0 kΩ, 6.0 kΩ, and 9.0 kΩ) are connected as shown in the figure below. The internal resistance of the battery is negligible.



Q3 If we define point b as the reference point, what is the electric potential at point a? From ①-⑦ below choose the best answer. **16** V

① −0.3 ② −0.2 ③ −0.1 ④ 0

⑤ 0.1 ⑥ 0.2 ⑦ 0.3

D The graph in Figure 1 shows the current-voltage characteristics of a certain light bulb. Two light bulbs of this type are connected to a battery with an electromotive force of 10 V as shown in Figure 2. The internal resistance of the battery is negligible.

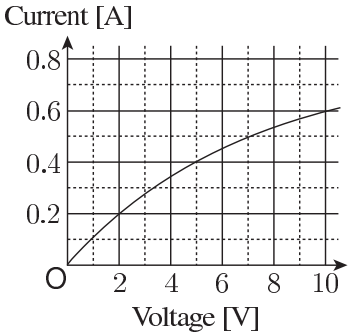


Figure 1

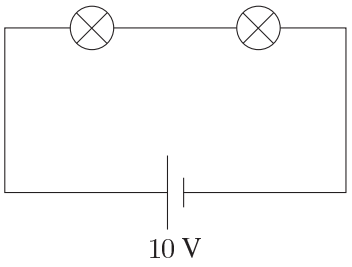


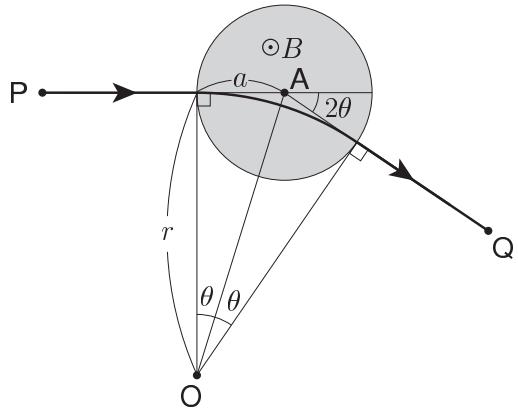
Figure 2

Q4 What is the total electrical power consumed by the two light bulbs in this circuit? From ①-⑥ below choose the best answer. **17** W

① 2.0　② 4.0　③ 6.0

④ 8.0　⑤ 10　⑥ 12

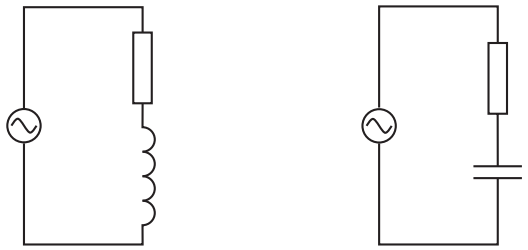
E As shown in the figure below, a uniform magnetic field with magnitude of magnetic flux density B is applied to a circular region that is centered on point A and has a radius of a. The direction of the magnetic field is perpendicular to this page, going from the back to the front. A charged particle with mass m and charge $q(>0)$ is traveling in a straight line from point P outside the magnetic field toward A with a speed of v as it enters the region of the magnetic field. After entering the magnetic field, the particle moves in a circular path that is centered on point O and has a radius of r. The particle then exits the magnetic field and travels straight toward point Q. While the particle curved through the magnetic field, its direction of motion changed by 2θ (the angular difference between direction P→A and A→Q).



Q5 What is tan θ? From ①-④ below choose the correct answer. **18**

① $\dfrac{aqB}{mv}$ ② $\dfrac{amv}{qB}$ ③ $\dfrac{mv}{aqB}$ ④ $\dfrac{qB}{amv}$

F As shown in the figure below, two circuits, a and b, are formed using resistors, a coil, a capacitor, and alternating current power sources. The frequency of the power sources in each circuit is f.



a　　b

Q6 The frequency of the power sources is increased from f while keeping the effective value of their voltage at the same level. How will the time-averaged power consumption of the resistors in circuits a and b change as a result? From ①-④ below choose the correct combination. **19**

	a	b
①	increase	increase
②	increase	decrease
③	decrease	increase
④	decrease	decrease

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.

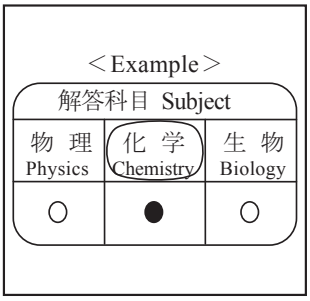
Chemistry

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.



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

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 Cl : 35 Cu : 64

Q1 From the following molecules or ions ①-⑥ choose the one whose total number of electrons is the largest. **1**

① CO ② F^- ③ HCl ④ H_3O^+ ⑤ NO ⑥ O_2

Q2 From the following statements ①-⑤ on the structure and property of atoms choose the correct one. **2**

① Protons have positive charge.

② Protons circle around the atomic nucleus.

③ Neutrons have negative charge.

④ The mass number of an atom is equal to the number of protons of the atom.

⑤ All atoms have neutrons.

Q3 Which atoms, among ${}^{13}_{6}\mathrm{C}$, ${}^{16}_{8}\mathrm{O}$, ${}^{14}_{7}\mathrm{N}$, ${}^{19}_{9}\mathrm{F}$, ${}^{23}_{11}\mathrm{Na}$ and ${}^{24}_{12}\mathrm{Mg}$, are compatible with the following statements (**a**) and (**b**), respectively? From the following ①-⑥ in the table below choose the correct combination. **3**

(**a**) Atoms whose number of neutrons and of electrons are equal.

(**b**) Atoms whose number of outermost shell electrons are the largest.

	a	**b**
①	${}^{13}_{6}\mathrm{C}$	${}^{19}_{9}\mathrm{F}$
②	${}^{13}_{6}\mathrm{C}$	${}^{23}_{11}\mathrm{Na}$
③	${}^{16}_{8}\mathrm{O}$	${}^{24}_{12}\mathrm{Mg}$
④	${}^{16}_{8}\mathrm{O}$	${}^{23}_{11}\mathrm{Na}$
⑤	${}^{14}_{7}\mathrm{N}$	${}^{19}_{9}\mathrm{F}$
⑥	${}^{14}_{7}\mathrm{N}$	${}^{24}_{12}\mathrm{Mg}$

Q4 From the following statements ①-⑤ choose the one which is **not** correct. **4**

① The ionization energies (first ionization energies) of metallic elements are smaller than those of nonmetallic elements.

② A carbon dioxide (CO_2) molecule is polar.

③ Molecules with high polarity readily dissolve in water.

④ The electronegativity of a fluorine atom (F) is larger than that of an oxygen atom (O).

⑤ An atom with high electron affinity readily becomes an anion.

Q5 From the following ①-⑥ choose the closest value for the molar concentration (mol/L) of 20% mass percent concentration of hydrochloric acid (HCl (aq)). Assume that the density of hydrochloric acid used is 1.1 g/cm^3. **5** mol/L

① 0.51 ② 0.61 ③ 1.2 ④ 5.1 ⑤ 6.1 ⑥ 12

Q6 When 1.5 mol of hydrogen (H_2) and 1.5 mol of iodine (I_2) are placed in an airtight container with a constant volume, and are kept at a constant temperature, 2.4 mol of hydrogen iodide (HI) is formed and the following equilibrium state is established.

$$H_2 + I_2 \rightleftarrows 2HI$$

From ①-⑥ below choose the closest value for the equilibrium constant of this reaction. Assume that all components are in the gas state. **6**

① 10 ② 16 ③ 20 ④ 32 ⑤ 40 ⑥ 64

Q7 The heats of combustion of acetylene (ethyne) (C_2H_2), ethane (C_2H_6), and hydrogen (H_2) are given by the following thermochemical equations, respectively.

$$C_2H_2\,(g) + \frac{5}{2}O_2\,(g) = 2CO_2\,(g) + H_2O\,(l) + 1300\ kJ$$

$$C_2H_6\,(g) + \frac{7}{2}O_2\,(g) = 2CO_2\,(g) + 3H_2O\,(l) + 1560\ kJ$$

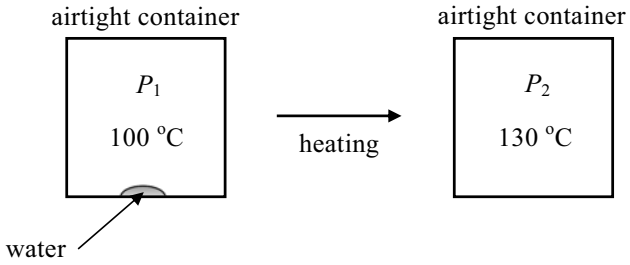
$$H_2\,(g) + \frac{1}{2}O_2\,(g) = H_2O\,(l) + 286\ kJ$$

Ethane is formed when 2.60 g of acetylene (ethyne) is completely hydrogenated. From the following ①-⑥ choose the closest value for the heat released by this reaction.

7 kJ

① －312　② －31.2　③ －26.0　④ 26.0　⑤ 31.2　⑥ 312

Q8 When argon and water were placed in an airtight container with a constant volume and the gas mixture was kept at 100 °C, the pressure of the gas mixture became P_1 with a portion of water remained as liquid. When the whole was heated to 130 °C, all the water was vaporized and the pressure became P_2. From ①-⑥ below choose the correct formula representing the ratio, water/argon, of the quantities (in mol) of water and of argon in the container. Assume that the vapor pressure of water at 100 °C is P_v, that argon is an ideal gas not dissolving in water, and that the volume of water before heating to 130 °C can be neglected. **8**



① $\dfrac{373 \times P_2}{403 \times (P_1 - P_v)} - 1$ ② $\dfrac{403 \times P_2}{373 \times (P_1 - P_v)} - 1$

③ $\dfrac{373 \times P_1}{403 \times (P_2 - P_v)} - 1$ ④ $\dfrac{403 \times P_1}{373 \times (P_2 - P_v)} - 1$

⑤ $\dfrac{373 \times (P_2 - P_v)}{403 \times P_1} - 1$ ⑥ $\dfrac{403 \times (P_2 - P_v)}{373 \times P_1} - 1$

Q9 From the following acidic aqueous solutions ①-⑤ choose the one whose pH is the lowest. **9**

① 0.10 mol/L acetic acid

② 0.010 mol/L nitric acid

③ 0.020 mol/L phosphoric acid

④ 0.030 mol/L hydrochloric acid

⑤ 0.030 mol/L sulfuric acid

Q10 When each of electrolytic solutions is electrolyzed with the aid of electrodes given in the following table, which combination causes an increase of pH? From ①-④ below choose the most appropriate one. **10**

	Electrodes		Electrolytic solution
	Cathode	Anode	
①	Cu	Pt	aqueous copper(II) sulfate ($CuSO_4$ (aq))
②	Pt	C	aqueous sodium chloride (NaCl (aq))
③	Pt	C	aqueous copper(II) chloride ($CuCl_2$ (aq))
④	Pt	Pt	dilute sulfuric acid (dil. H_2SO_4)

Q11 From the following statements ①-⑤ on the properties of oxides choose the correct one. **11**

① When nitrogen dioxide (NO_2) is dissolved in water, the solution is acidic.

② When magnesium oxide (MgO) is dissolved in water, the solution is acidic.

③ When tetraphophorus decaoxide (P_4O_{10}) is dissolved in water, the solution is basic.

④ When sulfur dioxide (SO_2) is dissolved in water, the solution is basic.

⑤ Aluminum oxide (Al_2O_3) does not dissolve in an aqueous solution of a strong base.

Q12 From the following statements ①-⑥ on sulfur dioxide (SO_2) choose the one that is **not** correct. **12**

① Sulfur dioxide is formed by adding concentrated sulfuric acid (conc. H_2SO_4) to copper (Cu) and then heating the mixture.

② Sulfur dioxide is formed by adding dilute sulfuric acid (dil. H_2SO_4) to iron sulfide (FeS).

③ Sulfur dioxide is formed by combusting sulfur (S).

④ Sulfur dioxide is formed by adding dilute sulfuric acid to sodium sulfite (Na_2SO_3).

⑤ Sulfur dioxide reacts with hydrogen sulfide (H_2S) to form sulfur.

⑥ Sulfur dioxide dissolved in water exhibits a reducing action and is used as a bleaching agent.

Q13 When 0.16 g of copper (Cu) powder was heated in air, a part of it was oxidized to give 0.19 g of a mixture of copper and copper(II) oxide (CuO). How many grams of unreacted copper are there in the mixture? From the following ①-⑥ choose the closest value.

13 g

① 0.0080　② 0.010　③ 0.030　④ 0.032　⑤ 0.040　⑥ 0.050

Q14 From the following ①-⑤ choose the one in which the substance in column **A** acts as an oxidizing agent when substances in column **A** and those in column **B** are mixed.

14

	A	**B**
①	zinc (Zn)	dilute hydrochloric acid (dil. HCl)
②	aqueous hydrogen peroxide (H_2O_2 (aq))	potassium permanganate ($KMnO_4$)
③	manganese(IV) oxide (MnO_2)	aqueous hydrogen peroxide (H_2O_2 (aq))
④	manganese(IV) oxide (MnO_2)	concentrated hydrochloric acid (conc. HCl)
⑤	calcium carbonate ($CaCO_3$)	dilute hydrochloric acid (dil. HCl)

Q15 Suppose experiments given in column **B** were carried out to separate two metallic ions contained in aqueous solutions given in column **A**. From the following ①-⑥ choose the one in which the experimental procedure in column **B** is **not** appropriate. **15**

	A	B
①	Ag^+, Fe^{3+}	to add dilute hydrochloric acid (dil. HCl)
②	Al^{3+}, Cu^{2+}	to add aqueous ammonia (NH_3 (aq)) in excess
③	Ba^{2+}, Pb^{2+}	to add aqueous ammonium sulfate ($(NH_4)_2SO_4$ (aq))
④	Ca^{2+}, Na^+	to add aqueous ammonium carbonate ($(NH_4)_2CO_3$ (aq))
⑤	Cu^{2+}, Fe^{3+}	to make the aqueous solution acidic, and then to pass hydrogen sulfide (H_2S) through it
⑥	Cu^{2+}, Zn^{2+}	to add aqueous sodium hydroxide (NaOH (aq)) in excess

Q16 From the following statements ①-⑤ on the isomers of organic compounds choose the correct one. **16**

① Xylene has no isomers.

② Lactic acid has optical isomers.

③ Ethanol and diethyl ether are isomers of each other.

④ Ethylene (ethene) and acetylene (ethyne) are isomers of each other.

⑤ Hexane and cyclohexane are isomers of each other.

Q17 Hydrogen (H_2) was added completely by addition reaction to all the unsaturated bonds contained in 1.0 g of the following acyclic hydrocarbons ①-⑤. Choose the one that requires the largest amount of hydrogen. **17**

① C_2H_4　② C_3H_6　③ C_4H_6　④ C_5H_8　⑤ C_6H_{12}

Q18 Bromine (Br_2) is added to the following alkenes ①-⑤ by addition reaction. Choose the one whose brominated product **does not** have any asymmetric carbon atom.

18

① $CH_2=CH-CH_2-CH_3$

② $CH_2=C(CH_3)-CH_3$

③ $CH_2=C(CH_3)-CH_2-CH_3$

④ $CH_3-CH=C(CH_3)-CH_3$

⑤ $CH_3-CH=C(CH_3)-CH_2-CH_3$

Q19 From the following statements ①-⑥ on carboxylic acids choose the one that is **not** correct.

19

① Acetic anhydride is formed by the condensation reaction of acetic acid.

② Acetic acid is obtained by oxidation of ethanol.

③ Benzoic acid is obtained by oxidation of toluene.

④ Lactic acid is positive in the silver mirror test.

⑤ Maleic acid and fumaric acid are *cis*-*trans* isomers of each other.

⑥ Oxalic acid is a dicarboxylic acid.

Q20 From the following polymers ①-⑤ choose the one that contains ester bonds.

20

① polyacrylonitrile

② polyethylene

③ poly(ethylene terephthalate)

④ poly(vinyl chloride)

⑤ nylon 6,6

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

Marking Your Choice of Subject on the Answer Sheet

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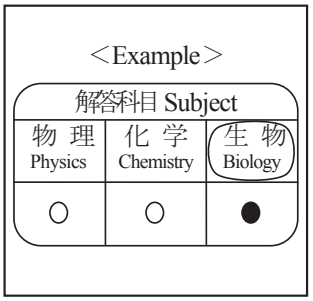


Q1 From ①－⑥ below choose the combination that correctly indicates the bonds or structures involved in the formation of the primary, secondary, and tertiary structures of proteins. **1**

	Primary structure	Secondary structure	Tertiary structure
①	zigzag structure	peptide bond	S-S bond
②	zigzag structure	S-S bond	peptide bond
③	peptide bond	zigzag structure	S-S bond
④	peptide bond	S-S bond	zigzag structure
⑤	S-S bond	zigzag structure	peptide bond
⑥	S-S bond	peptide bond	zigzag structure

Q2 When the cells of three different types of samples (X, Y, Z) were examined using an electron microscope, structures a－e were identified. The following table indicates the presence/absence of the structures in the cells examined (+ : present; － : absent), and describes their characteristics.

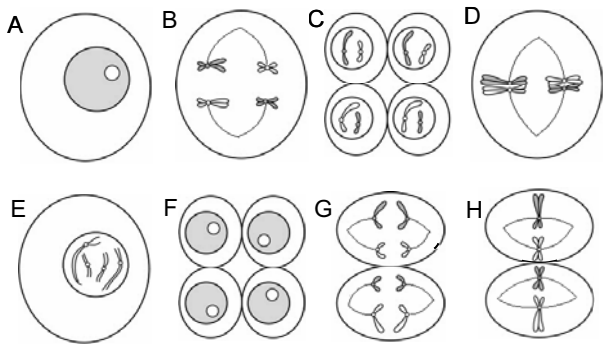
Structure	Sample			Characteristics
	X	Y	Z	
a	－	+	+	It has a double-membrane structure. The inner membrane has folds.
b	－	+	－	It has a double-membrane structure and pigments.
c	－	－	+	Spindle fibers form from it during cell division.
d	－	+	+	It is a stack of flat sacs.
e	+	+	－	It exists in the outermost layer of the cell.

From ①－⑥ below choose the combination of terms that correctly identifies samples X, Y, and Z.

2

	X	Y	Z
①	spinach leaf	mouse liver	*Escherichia coli*
②	spinach leaf	*Escherichia coli*	mouse liver
③	mouse liver	spinach leaf	*Escherichia coli*
④	mouse liver	*Escherichia coli*	spinach leaf
⑤	*Escherichia coli*	spinach leaf	mouse liver
⑥	*Escherichia coli*	mouse liver	spinach leaf

Q3 Figures A－H below schematically represent various stages of meiosis in a cell of an animal with a chromosomal constitution of 2n = 4. From ①－⑥ below choose the answer that correctly arranges A－H in the order of progression of meiosis, where A is defined as the start, and F as the end. **3**



① A → E → H → G → D → B → C → F

② A → E → G → H → B → D → C → F

③ A → E → B → D → G → H → C → F

④ A → E → D → B → H → G → C → F

⑤ A → E → B → G → D → H → C → F

⑥ A → E → D → H → B → G → C → F

Q4 Experiments Ⅰ and Ⅱ below were performed using African clawed frog (*Xenopus laevis*) blastulas. From ①－⑤ on the following page choose the statement that best indicates what can be inferred from these experiments. **4**

Experiment Ⅰ : Figure 1 shows a cross section passing through a blastula's animal and vegetal poles (the animal pole is at the top). As shown in Figure 1, regions A and B were cut away with incisions made at the dashed lines. The two regions were then cultured individually, with A differentiating into ectoderm, and B differentiating into endoderm.

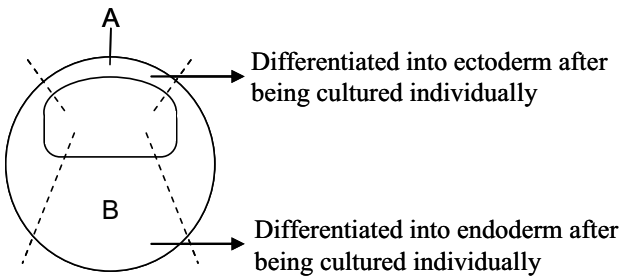


Figure 1

Experiment Ⅱ : Another blastula was cut into separate regions as in Figure 1. Next, as shown in Figure 2, A and B were placed in contact with each other and cultured together. The part of A in contact with B differentiated into mesoderm, the part of A not in contact with B differentiated into ectoderm, and B differentiated into endoderm.

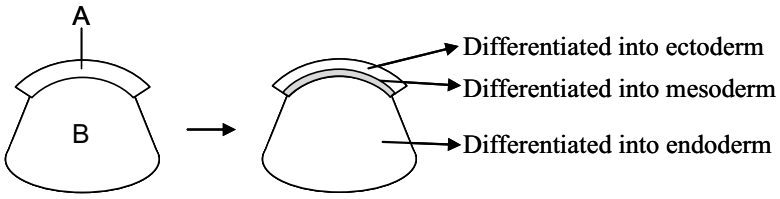


Figure 2

① A functions as an organizer.

② The mesoderm is induced by the action of A on B.

③ The cell fate of A is already determined in the blastula stage.

④ The cell fate of B is altered as a result of being in contact with A.

⑤ B has the ability to induce the development of A into the mesoderm.

Q5 A certain line of silkworm moths produces white cocoons, while another produces yellow cocoons. The heredity of this attribute involves two pairs of alleles. Gene Y codes for yellow cocoons, and gene I inhibits the effect of Y. Consequently, when I is present, the color of cocoons is white, even if Y is also present. The recessive alleles of Y and I are, respectively, y and i. Answer questions (1) and (2) concerning this.

(1) An *iiYY* individual (yellow cocoon) is crossed with an *IIyy* individual (white cocoon), resulting in many F_1 offspring. What would be the phenotypic segregation ratio of F_2 offspring produced from crossing of F_1 males and females? From ①－⑥ below choose the best answer.

5

	Yellow cocoon	:	White cocoon
①	1	:	0
②	0	:	1
③	3	:	1
④	1	:	3
⑤	13	:	3
⑥	3	:	13

(2) An F_1 individual from (1) above was crossed with an individual of unknown genotype that produces a white cocoon. The ratio of cocoon color among the resulting offspring was yellow : white = 1 : 7. From ①－⑥ below choose the answer that correctly indicates the genotype of the white cocoon-producing individual that was crossed with the F_1 individual. **6**

① *IiYy*　② *IIYY*　③ *Iiyy*　④ *iiYy*　⑤ *IiYY*　⑥ *iiyy*

Q6 Statements (a)－(d) below describe human body fluids. From ①－⑦ below choose the combination indicating all statements that are correct. **7**

(a) Human body fluids contain macrophages, which are leukocytes that ingest and break down bacteria and viruses that have invaded the body.

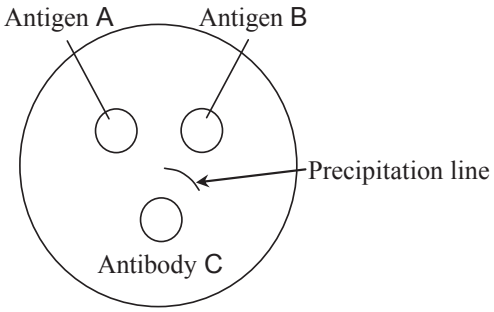
(b) Lymph fluid eventually flows into the bloodstream.

(c) The basic blood cells are, in order of most common to less common: erythrocytes, platelets, and leukocytes.

(d) Lymphocytes, which are a type of platelet, are suspended in lymph fluid.

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

Q7 As shown in the figure below, two types of antigens (A and B) extracted from a virus and an antibody (C) were placed in three holes made in agar contained in a dish. The antigens and antibody are able to disperse throughout the agar, and when antigens and antibodies meet and bind together, they form a precipitation line, which is a pattern of precipitate that is visible to the naked eye. After sufficient time was allowed to pass, the reactions between antigens A/B and antibody C were as shown in the figure. Note that the antibody was produced by inoculating a certain animal with one or both of the antigens.



From ①－⑥ below choose the combination indicating the two statements in (a)－(e) below that correctly describe the relationships between the antigens and the antibody. **8**

(a) Antibody C is able to bind with antigen A only.

(b) Antibody C is able to bind with antigen B only.

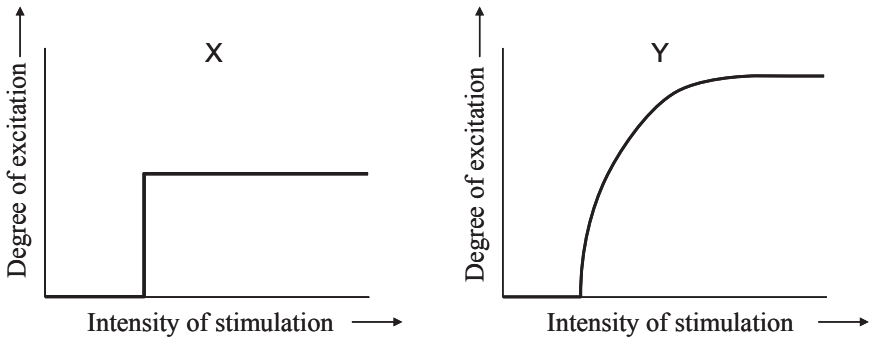
(c) Antibody C is able to bind with antigen A and with antigen B.

(d) Antibody C was produced by inoculation with antigen A.

(e) Antibody C was produced by inoculation with antigen B.

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

Q8 Figures X and Y below show the intensity of stimulation and the degree of excitation in an axon or a nerve (a bundle of axons) when stimulated. From ①－⑤ below choose the statement that does **not** correctly describe this. **9**



① X shows the change in a single axon, while Y shows the change in a bundle of axons.

② The all-or-none law applies to X.

③ In both X and Y, each axon was excited by stimulation whose intensity was greater than the threshold value.

④ In X, excitation occurred when the intensity of stimulation exceeded a certain level, and the degree of excitation was constant.

⑤ In Y, there is no sign of a level of stimulation intensity where the degree of excitation is constant.

Q9 From ①－⑤ below choose the statement that correctly describes a reaction or regulation in plants.

10

① Photonasty is a reaction in which the plant bends toward light.

② Auxin is produced in the plant's apex, and it moves to the base of the plant as a result of gravity.

③ Flower bud formation in long-day plants is stimulated when the plants are subjected to a dark period shorter than the critical dark period.

④ The inhibition of lateral bud growth is the result of the effect of ethylene.

⑤ In seed germination, gibberellin secreted by the embryo acts on the seed coat to stimulate the synthesis of amylase.

Q10 From ①－⑥ below choose the statement that does **not** correctly describe photosynthesis in plants.

11

① The light saturation point is the minimum intensity of light where the photosynthetic rate is at its maximum level under certain constant conditions and thus does not increase any further.

② The compensation point is the intensity of light where the amount of carbon dioxide absorbed through photosynthesis is equal to the amount of carbon dioxide released through respiration.

③ The apparent photosynthetic rate is the result when the respiration rate is subtracted from the actual photosynthetic rate.

④ Generally, the light saturation point of shade plants is lower than that of sun plants.

⑤ Generally, the compensation point of sun plants is lower than that of shade plants.

⑥ Generally, the respiration rate of shade plants is lower than that of sun plants.

Q11 Figure 1 below shows the relationship between reaction time and amount of product in an enzyme reaction involving a specific amount (E) of a certain enzyme. From ①－④ below choose the figure that best represents how this relationship would change if the amount of enzyme were doubled (2E) or halved (0.5E) while the substrate concentration, temperature, and pH were kept constant. **12**

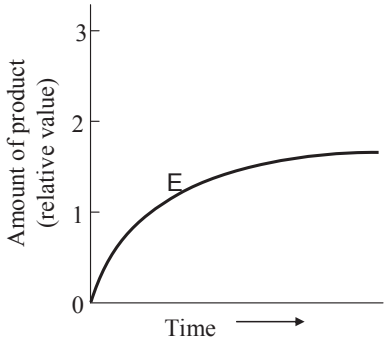
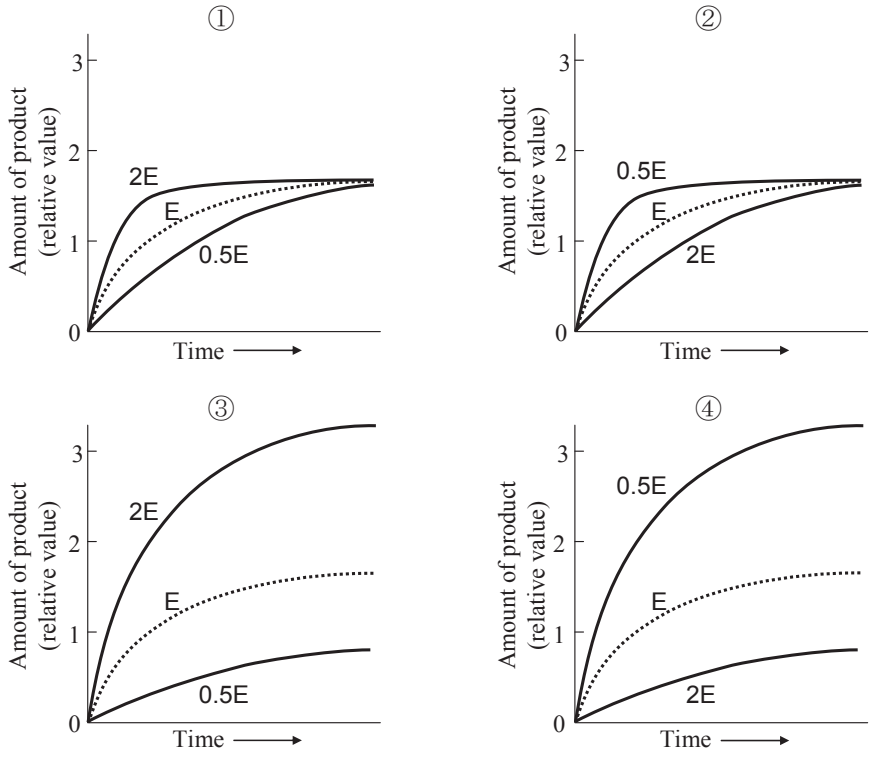


Figure 1



Q12 From ①－⑤ below choose the statement that correctly describes ATP. **13**

① ATP has three phosphates and three high-energy phosphate bonds.

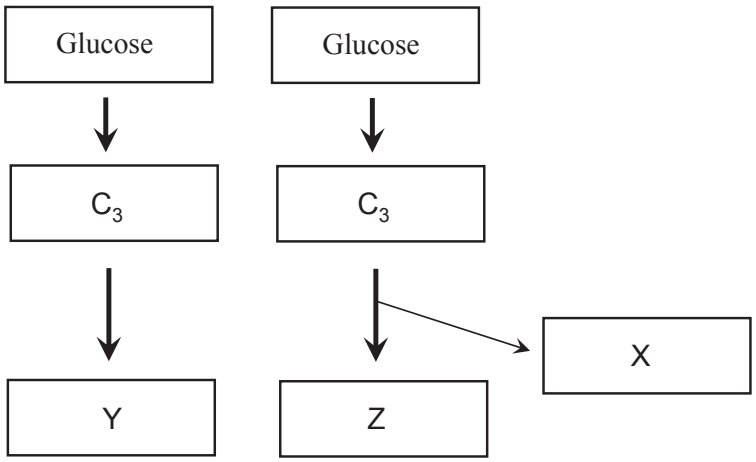
② ATP is produced from ADP and phosphate, and energy is released during production of ATP.

③ The structure of ATP consists of a nucleotide found in RNA whose base is adenine, plus two phosphates.

④ The direct source of energy for muscle contraction is phosphocreatine that has received a phosphate from ATP.

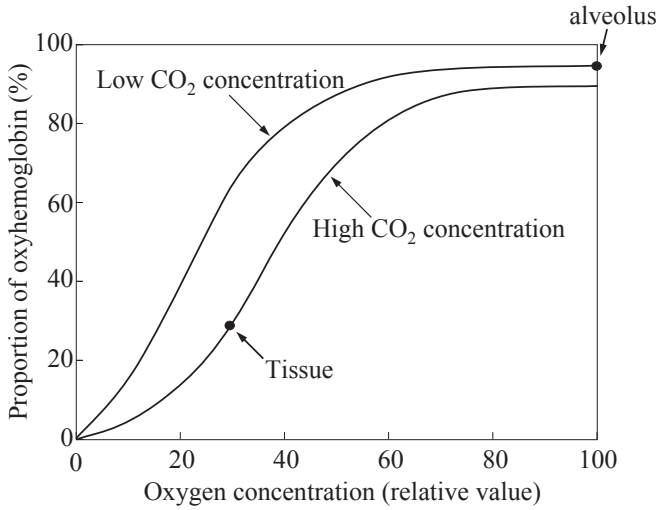
⑤ In animal cells, ATP is produced in the mitochondria, but not in any other parts of the cell.

Q13 The figure below shows two processes of anaerobic respiration in microorganisms. C_3 in the figure represents a substance that has three carbon atoms in its molecular structure. Substance Y is sometimes produced in human muscle. From ①—⑧ below choose the combination that best identifies the substances represented by X–Z in the figure. **14**



	X	Y	Z
①	carbon dioxide	lactic acid	ethanol
②	carbon dioxide	ethanol	lactic acid
③	carbon dioxide	pyruvic acid	ethanol
④	carbon dioxide	lactic acid	pyruvic acid
⑤	water	lactic acid	ethanol
⑥	water	ethanol	lactic acid
⑦	water	ethanol	pyruvic acid
⑧	water	pyruvic acid	lactic acid

Q14 The graph below is an oxygen dissociation curve, which shows the relationship between the proportion of oxyhemoglobin and the oxygen concentration. From ①－⑧ below choose the combination indicating the three statements in (a)－(f) below that correctly describe this graph. **15**



(a) The proportion of hemoglobin bonded with oxygen is small when the oxygen concentration is low, and increases when the oxygen concentration rises.

(b) The proportion of hemoglobin bonded with oxygen is small when the oxygen concentration is high, and increases when the oxygen concentration decreases.

(c) Hemoglobin binds with oxygen more readily when the carbon dioxide concentration is low, than when it is high.

(d) Hemoglobin binds with oxygen less readily when the carbon dioxide concentration is low, than when it is high.

(e) In an alveolus, the oxygen concentration is high but the carbon dioxide concentration is low, so almost all hemoglobin becomes oxyhemoglobin.

(f) In tissue, the oxygen concentration is low but the carbon dioxide concentration is high, so some hemoglobin dissociates and becomes oxyhemoglobin.

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

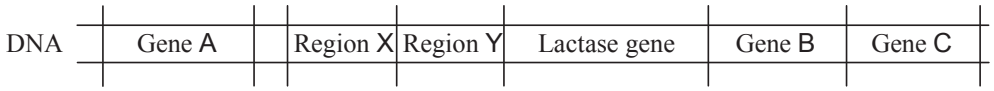
⑤ b, c, e　⑥ b, c, f　⑦ b, d, e　⑧ b, d, f

Q15 Let us denote one of the two nucleotide chains of DNA as the X strand, and the other as the Y strand. When the number of bases in DNA composed of 100 base pairs was examined, it was learned that the number of each of the four base types was the same for both strands. 18 of the bases in the X strand were guanine, and 26 of the bases in the Y strand were adenine. From ①－⑤ below choose the answer that correctly indicates the number of bases in the Y strand that were thymine. **16**

① 18 bases ② 24 bases ③ 26 bases ④ 32 bases
⑤ 50 bases

Q16 The figure below shows a lactose operon in *Escherichia coli* DNA. When *E. coli* is cultured in a medium that contains lactose but not glucose, the gene responsible for production of lactase (enzyme that breaks down lactose) and the two surrounding genes are transcribed. However, if lactose is not present in the culture medium, the transcription process is regulated so that those genes are not transcribed.

The enzyme that carries out transcription first binds with region X in the figure, initiating the transcription process. Protein A, which is synthesized according to gene A in the figure, controls transcription in region Y. Answer questions (1) and (2) concerning the lactose operon.



(1) From ①－⑥ below choose the combination that correctly indicates the enzyme that carries out transcription, and the terms used to describe regions X and Y. **17**

	Transcribing enzyme	Region X	Region Y
①	DNA polymerase	promoter	repressor
②	DNA polymerase	operator	repressor
③	DNA polymerase	repressor	promoter
④	RNA polymerase	promoter	operator
⑤	RNA polymerase	operator	promoter
⑥	RNA polymerase	repressor	operator

(2) From ①－⑤ below choose the statement that correctly describes what happens to the inducer derived from lactose and protein A when transcription takes place. **18**

① The inducer derived from lactose binds with region Y, and protein A binds to the inducer.

② The inducer derived from lactose binds with region Y, and thus blocks the binding of protein A with region Y.

③ The inducer derived from lactose binds with region X, and protein A binds with region Y.

④ The inducer derived from lactose binds with protein A, and together they bind with region Y.

⑤ The inducer derived from lactose binds with protein A, and thus blocks the binding of protein A with region Y.

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.