

2014 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 – 33
Biology	35 – 52

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

III Rules and Information Concerning the Answer Sheet

1. You must mark your answers on the answer sheet with an HB pencil.
2. Each question is identified by one of the row numbers **1**, **2**, **3**, ...
Follow the instruction in the question and completely black out your answer in the corresponding row of the answer sheet (mark-sheet).
3. Make sure also to read the instructions on the answer sheet.

- ※ Once you are instructed to start the examination, fill in your examination registration number and name.

Examination registration number			*				*					
Name												

Physics

Marking your Choice of Subject on the Answer Sheet

Choose and answer two subjects from Physics, Chemistry, and Biology. Use the front side of the answer sheet for one subject, and the reverse side for the other subject.

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

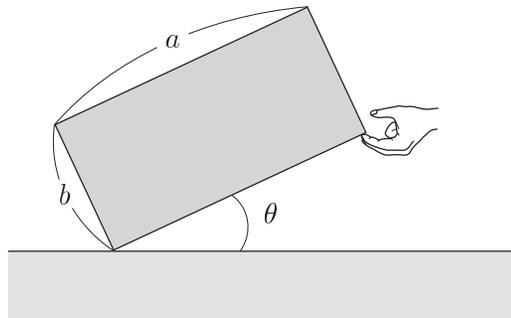
If you do not correctly fill in the appropriate oval, your answers will not be graded.

<Example>

解答科目 Subject		
物 理 Physics	化 学 Chemistry	生 物 Biology
●	○	○

I Answer questions **A** (Q1), **B** (Q2), **C** (Q3), **D** (Q4), **E** (Q5), **F** (Q6), and **G** (Q7) below, where g denotes the magnitude of acceleration due to gravity, and air resistance is negligible.

A As shown in the figure below, a cuboid with uniform density is tilted by hand so that one edge remains in contact with a roughly surfaced floor. The angle of tilt, θ , is gradually increased, and when θ becomes larger than θ_0 , the cuboid leaves the fingers and rotates. As indicated in the figure, the lengths of the two edges are a and b . The edge in contact with the floor does not slide.



Q1 What is $\tan \theta_0$? From ①-⑥ below choose the correct answer.

1

① $\frac{b}{a}$

② $\frac{a}{\sqrt{a^2 + b^2}}$

③ $\frac{b}{\sqrt{a^2 + b^2}}$

④ $\frac{a}{b}$

⑤ $\frac{\sqrt{a^2 + b^2}}{a}$

⑥ $\frac{\sqrt{a^2 + b^2}}{b}$

B A small ball is thrown vertically upward from the ground with an initial speed of v_0 and reaches a maximum height of h above the ground. Next, the ball is thrown horizontally from the position of maximum height (h above the ground) with the same initial speed of v_0 . The ball lands on the ground at a point whose horizontal distance from the point where the ball was thrown is d .

Q2 What is the value of $\frac{d}{h}$? From ①-⑤ below choose the best answer.

2

① $\frac{1}{4}$

② $\frac{1}{2}$

③ 1

④ 2

⑤ 4

C A small metal ball falls vertically downward in oil, where it is acted upon by resistance kv , which is directly proportional to the ball's speed, v . Here, k is a proportionality constant. After sufficient time elapses, the ball maintains a constant speed of 1.0 m/s. The density of the oil is $1.0 \times 10^3 \text{ kg/m}^3$, the mass of the ball is $1.4 \times 10^{-2} \text{ kg}$, and the ball's volume is $4.0 \times 10^{-6} \text{ m}^3$. Assume that g is $1.0 \times 10^1 \text{ m/s}^2$.

Q3 What is the value of k ? From ①-④ below choose the best answer.

3 kg/s

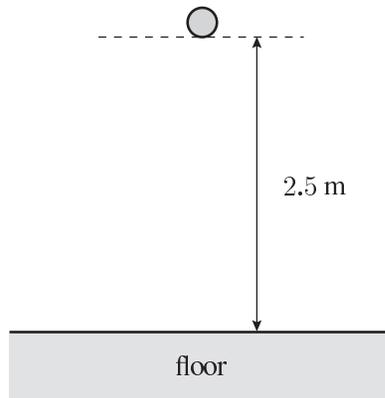
① 0.10

② 0.20

③ 0.30

④ 0.40

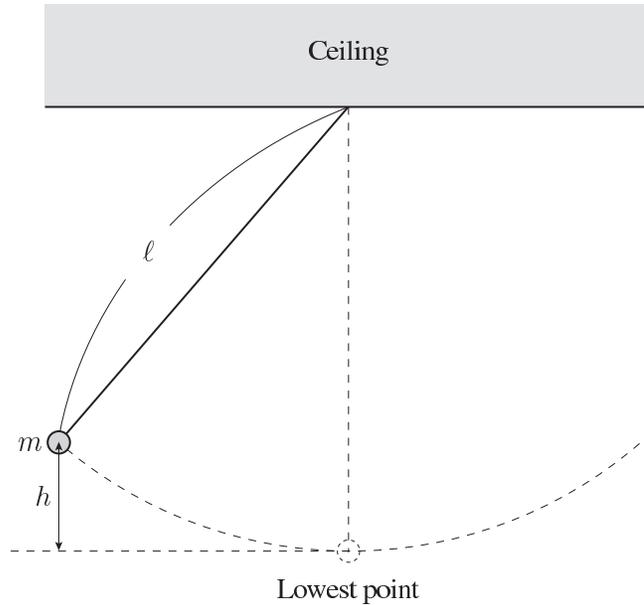
- D** As shown in the figure below, a small ball (mass: 0.20 kg) is dropped from a height of 2.5 m above a floor, with an initial velocity of zero. Upon colliding with the floor, the ball bounces vertically upward. The coefficient of restitution between the ball and the floor is 0.50. Assume that $g = 9.8 \text{ m/s}^2$.



- Q4 What is the magnitude of the impulse applied to the ball by the floor in the time from immediately before collision to immediately after collision? From ①-④ below choose the best answer. 4 kg·m/s

- ① 0.70 ② 1.4 ③ 2.1 ④ 2.8

E As shown in the figure below, a small ball of mass m is suspended from a ceiling by a light, inelastic string of length ℓ . As the string is kept taut, the ball is raised to a height h from its lowest point and is gently released.



Q5 At what value of h will the tension in the string be $2mg$ when the ball is at its lowest point?

From ①-④ below choose the correct answer.

5

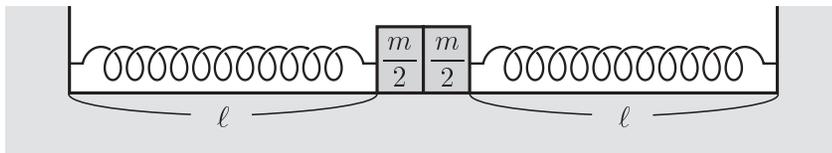
① $\frac{1}{4}\ell$

② $\frac{1}{2}\ell$

③ $\frac{3}{4}\ell$

④ ℓ

- F** Two identical light springs (spring constant: k) each have an object of mass $\frac{m}{2}$ attached to one end. As shown in the figure below, the objects are bonded together into a single unit, and are placed with their springs on a smooth horizontal surface, with the other ends of the springs fixed in place so that both springs are at their natural length, ℓ . The two objects are slid together to the right and are gently released. They begin undergoing simple harmonic motion, moving as a single unit.

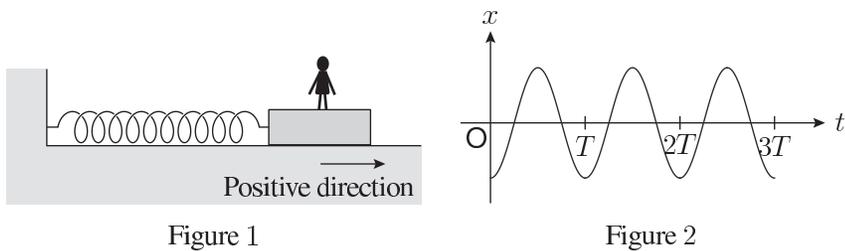


- Q6** What is the period of this simple harmonic motion? From ①-⑤ below choose the correct answer.

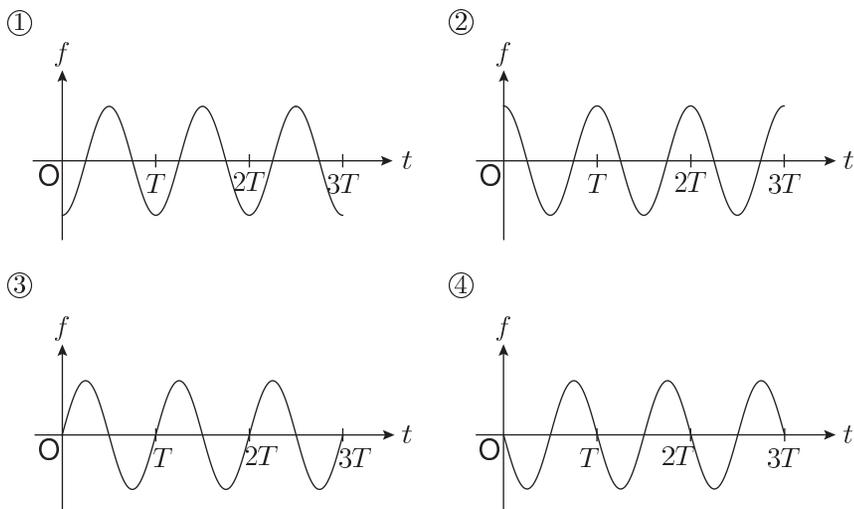
6

- ① $2\pi\sqrt{\frac{m}{4k}}$ ② $2\pi\sqrt{\frac{m}{2k}}$ ③ $2\pi\sqrt{\frac{m}{k}}$
- ④ $2\pi\sqrt{\frac{2m}{k}}$ ⑤ $2\pi\sqrt{\frac{4m}{k}}$

G As shown in Figure 1 below, one end of a spring is attached to a platform on a smooth horizontal surface, and the other end is fixed in place. A person is standing on the platform. The platform is pushed to the left, compressing the spring to less than its natural length, and is gently released. The platform begins undergoing simple harmonic motion with a period of T . Let us denote the displacement of the platform from its position when the spring is at its natural length as x , where its positive direction is indicated by the arrow in Figure 1 (pointing to the right). The displacement x changes with time t as shown in Figure 2.



Q7 How does the inertial force f experienced by the person standing firmly in place on the platform change with time t ? From ①-④ below choose the graph that best represents this change, where the positive direction of f is the same direction as the arrow in Figure 1 (to the right). **7**



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

A A certain quantity of heat is applied to 2.4×10^2 g of water at 10°C , raising its temperature to 15°C . When the same quantity of heat is applied to a certain volume of air at 10°C , the air's temperature rises to 15°C without any change in volume. The specific heat of water is $4.2 \text{ J}/(\text{g}\cdot\text{K})$, the specific heat of air at constant volume is $0.72 \text{ J}/(\text{g}\cdot\text{K})$, and the density of the air is $1.2 \times 10^{-3} \text{ g}/\text{cm}^3$.

Q1 What is the volume of the air? From ①-④ below choose the best answer. **8** cm^3

- ① 1.7 ② 1.4×10^3 ③ 1.2×10^6 ④ 1.0×10^9

B As shown in Figure 1 below, an ideal gas is enclosed in a horizontal cylinder by a smoothly moving piston with cross-sectional area S . Initially, the piston is distance ℓ from the base of the cylinder, and the pressure of the ideal gas is equal to atmospheric pressure, p_0 . An external force is applied to the piston so that it is pushed inward very slowly. As the piston moves, the temperature of the gas is kept constant. As shown in Figure 2, the magnitude of the force applied to the piston is F when the piston is distance d from its initial position.

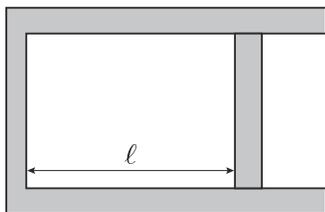


Figure 1

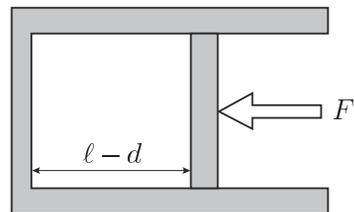


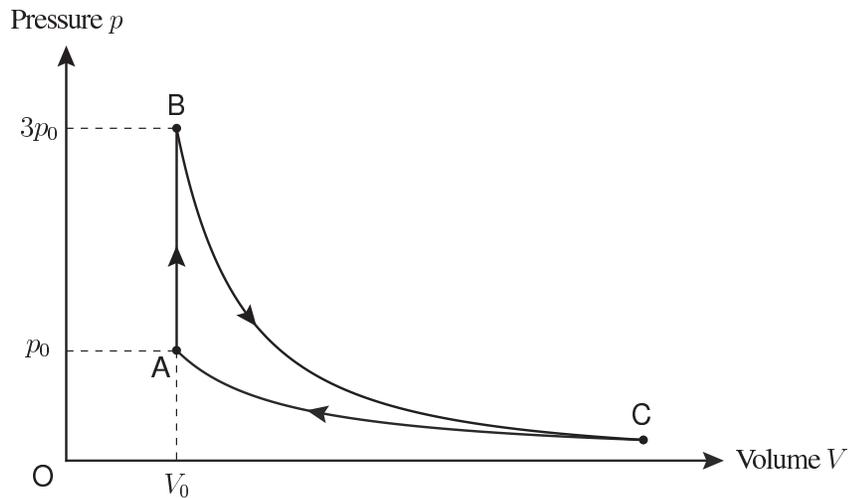
Figure 2

Q2 What is F ? From ①-④ below choose the correct answer.

9

- ① $\frac{p_0 S d}{\ell}$ ② $\frac{p_0 S d}{\ell - d}$ ③ $\frac{p_0 S (\ell - d)}{\ell}$ ④ $\frac{p_0 S \ell}{\ell - d}$

- C** The state of a fixed amount of a monatomic ideal gas is changed in the path $A \rightarrow B \rightarrow C \rightarrow A$ as shown in the p - V diagram below, where $A \rightarrow B$ is an isochoric change, $B \rightarrow C$ is an adiabatic change, and $C \rightarrow A$ is an isothermal change. In state A, the pressure is p_0 , and the volume is V_0 . In state B, the pressure is $3p_0$, and the volume is V_0 .

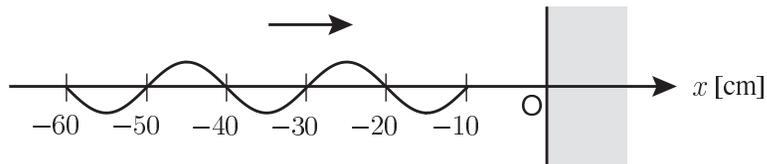


- Q3** What is the work done on the gas in process $B \rightarrow C$? From ①-⑧ below choose the correct answer. **10**

- ① $\frac{3}{2}p_0V_0$ ② $\frac{5}{2}p_0V_0$ ③ $3p_0V_0$ ④ $5p_0V_0$
- ⑤ $-\frac{3}{2}p_0V_0$ ⑥ $-\frac{5}{2}p_0V_0$ ⑦ $-3p_0V_0$ ⑧ $-5p_0V_0$

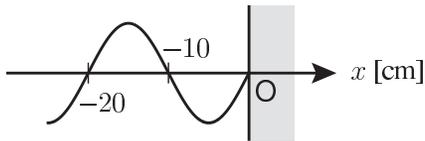
III Answer questions A (Q1), B (Q2), and C (Q3) below.

A The figure below represents, for a particular instant, the waveform of a sinusoidal wave that has a wavelength of 20 cm and is propagating in the positive direction of the x -axis with a speed of 10 cm/s. The wave undergoes free-end reflection at a barrier located at $x = 0$ cm.

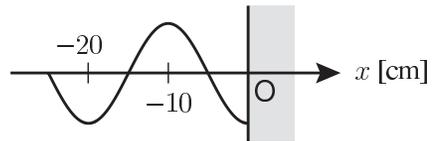


Q1 What is the waveform of the resultant wave formed by the incident wave and the reflected wave at 3.5 seconds after this instant? From ①-⑤ below choose the best answer. 11

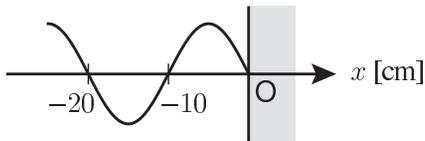
①



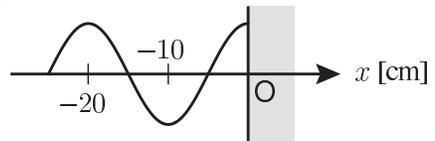
②



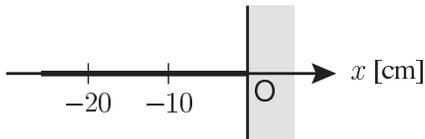
③



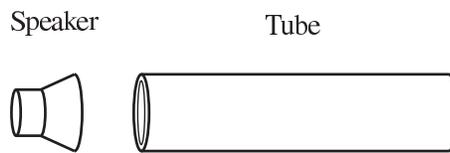
④



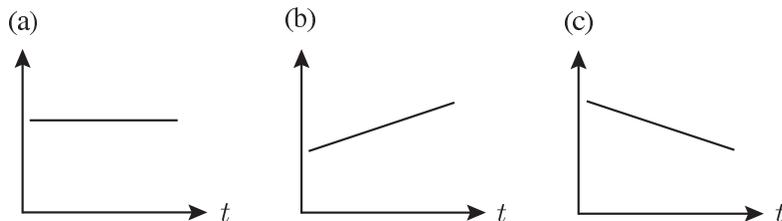
⑤



B The speed of sound traveling through air increases with temperature. The speed of sound V (in m/s) at 1 atm and temperature $t^\circ\text{C}$ is expressed as $V = 331.5 + 0.6t$. As shown in the figure below, a speaker is placed facing the open end of a tube closed at the other end. The frequency of the sound emitted by the speaker is gradually increased from zero. When the frequency reaches a certain value f , the first resonance occurs. Let us denote the wavelength of the sound at this instant as λ . Here, thermal expansion of the tube and open-end correction are negligible.

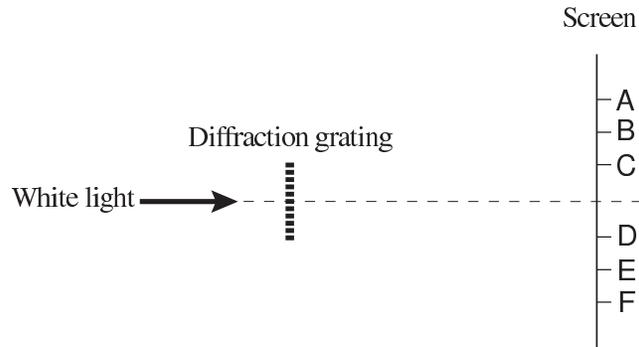


Q2 How does f change with temperature t ? Also, how does λ change with temperature t ? Which graphs in (a)-(c) below represent these changes? From ①-⑥ below choose the best combination. 12



	Relationship of f and t	Relationship of λ and t
①	(a)	(b)
②	(a)	(c)
③	(b)	(a)
④	(b)	(c)
⑤	(c)	(a)
⑥	(c)	(b)

C As shown in the figure below, white light is perpendicularly incident upon a diffraction grating, creating two bands of continuously changing colors at positions A-C and D-F near the center of a screen placed apart from the grating.



Q3 From ①-⑧ below choose the combination that best indicates the colors observed at positions A-F. **13**

	①	②	③	④	⑤	⑥	⑦	⑧
A	Red	Red	Green	Blue	Red	Red	Green	Blue
B	Blue	Green	Blue	Green	Blue	Green	Blue	Green
C	Green	Blue	Red	Red	Green	Blue	Red	Red
D	Red	Red	Green	Blue	Green	Blue	Red	Red
E	Blue	Green	Blue	Green	Blue	Green	Blue	Green
F	Green	Blue	Red	Red	Red	Red	Green	Blue

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 placed at the origin of an x -axis ($x = 0$), and a point charge with quantity of electricity $4q$ is placed at $x = a$. Let us choose the electric potential at infinity as zero.



Q1 What is the x -coordinate of the point on the x -axis in the range $0 < x < a$ where the electric potential is zero? From ①-④ below choose the correct answer. **14**

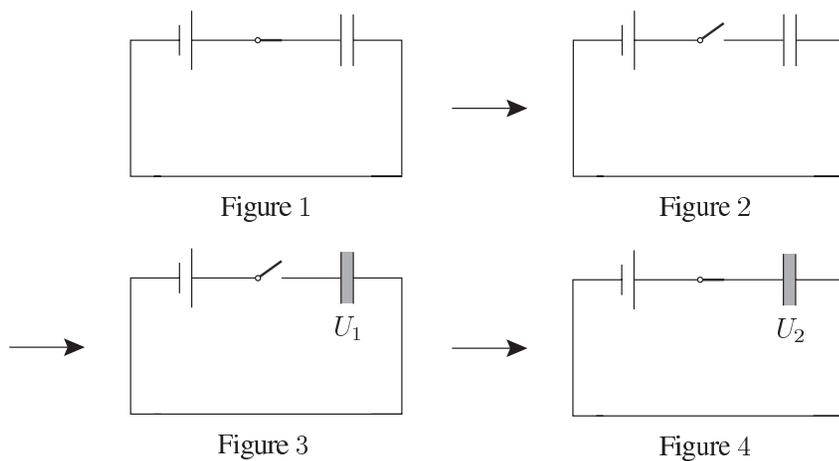
① $\frac{1}{5}a$

② $\frac{1}{3}a$

③ $\frac{2}{3}a$

④ $\frac{4}{5}a$

B As shown in Figure 1, a circuit is formed from a battery, a switch, and a parallel-plate capacitor placed in vacuum. Initially, the switch is closed (Figure 1), and after sufficient time elapses, the switch is opened (Figure 2). As this condition is maintained, the area between the capacitor's plates is filled with a dielectric of permittivity ϵ , and subsequently the static electric energy stored in the capacitor becomes U_1 (Figure 3). Next, as the dielectric is kept in place, the switch is closed again and after sufficient time elapses, the static electric energy stored in the capacitor changes to U_2 (Figure 4). Let us denote the permittivity of vacuum as ϵ_0 .



Q2 What is $\frac{U_1}{U_2}$? From ①-⑤ below choose the best answer.

15

① 1

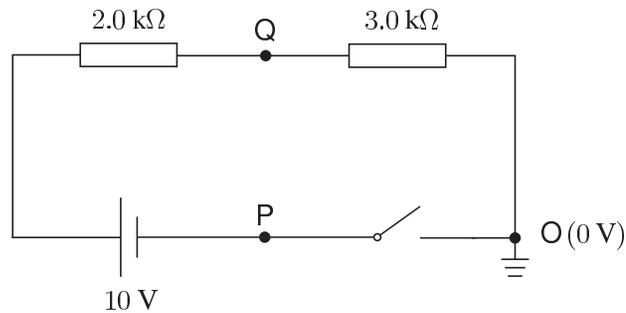
② $\frac{\epsilon_0}{\epsilon}$

③ $\frac{\epsilon}{\epsilon_0}$

④ $\left(\frac{\epsilon_0}{\epsilon}\right)^2$

⑤ $\left(\frac{\epsilon}{\epsilon_0}\right)^2$

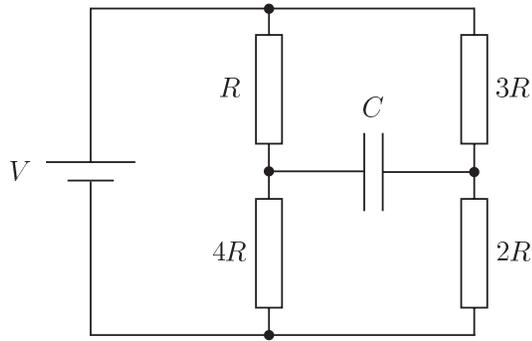
C As shown in the figure below, a circuit is formed from a switch, a battery (electromotive force: 10 V), and two resistors (resistance: 2.0 kΩ and 3.0 kΩ). Point O in the figure represents the reference point for electric potential. The internal resistance of the battery is negligible.



Q3 What is the electric potential V_P at point P when the switch is open? Also, what is the electric potential V_Q at point Q when the switch is closed? From ①-⑥ below choose the best combination of values. **16**

	V_P	V_Q
①	0 V	4.0 V
②	0 V	5.0 V
③	0 V	6.0 V
④	-10 V	4.0 V
⑤	-10 V	5.0 V
⑥	-10 V	6.0 V

D As shown in the figure below, a circuit is formed from a battery (electromotive force: V), four resistors (resistance: R , $2R$, $3R$, and $4R$), and a capacitor (capacitance: C). The internal resistance of the battery is negligible.



Q4 What is the electrical charge stored in the capacitor after sufficient time elapses? From ①-⑥ below choose the best answer. **17**

- | | | |
|-------------------|-------------------|-------------------|
| ① 0 | ② $\frac{1}{5}CV$ | ③ $\frac{2}{5}CV$ |
| ④ $\frac{3}{5}CV$ | ⑤ $\frac{4}{5}CV$ | ⑥ CV |

E As shown in Figure 1 below, a long, straight conducting wire is stretched horizontally directly above a magnetic compass, both of which are separated by distance d . When electrical current is not flowing through the wire, the compass needle points in a direction parallel with the wire's direction. When a current flows through the wire, the north pole of the needle rotates 60° to the east and comes to rest. Next, as shown in Figure 2, while the current continues to flow, the wire is moved vertically upward to a position distance D from the compass. As a result, the north pole of the needle rotates and comes to rest in a position pointing 45° east of north.

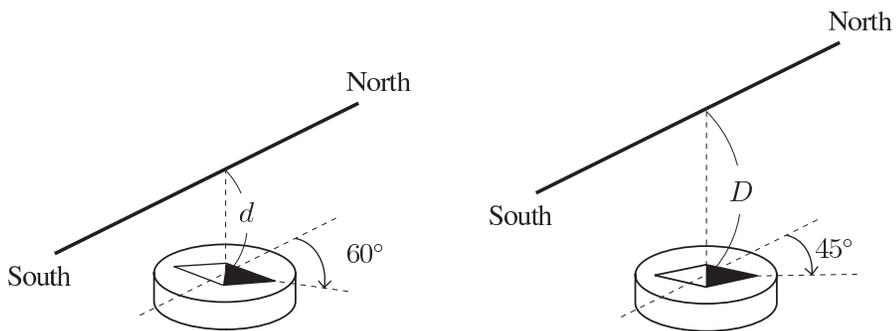


Figure 1

Figure 2

Q5 What is the value of $\frac{D}{d}$? From ①-⑤ below choose the best answer.

18

① $\frac{2\sqrt{3}}{3}$

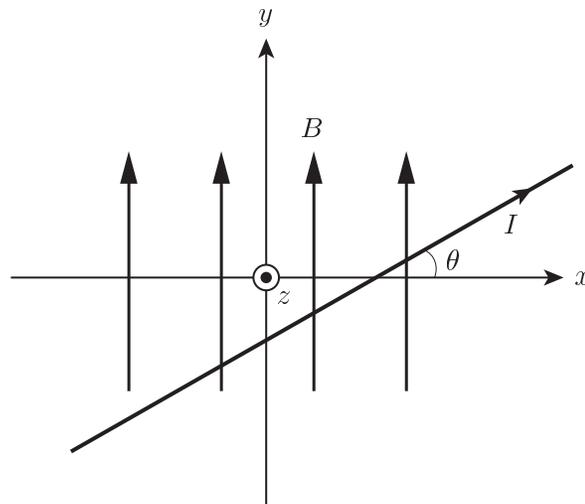
② $\frac{\sqrt{6}}{2}$

③ $\sqrt{2}$

④ $\sqrt{3}$

⑤ $\sqrt{6}$

F An electrical current with magnitude I flows through a long, straight conducting wire located in a uniform magnetic field (magnitude of magnetic flux density: B). As shown in the figure below, x - y axes are chosen in the plane which contains the wire and is parallel to the magnetic field so that the positive direction of y -axis becomes the same as the direction of the magnetic field. The positive direction of the z -axis is perpendicular to this page, going from the back of the page to the front. The direction of the current forms angle θ ($0 < \theta < \frac{\pi}{2}$) with the positive direction of the x -axis.



Q6 What is the magnitude and direction of the force that the magnetic field exerts on the current flowing through a segment of the wire with length ℓ ? From ①-⑥ below choose the correct combination. **19**

	Magnitude	Direction
①	$IB\ell$	positive direction of z -axis
②	$IB\ell$	negative direction of z -axis
③	$IB\ell \sin \theta$	positive direction of z -axis
④	$IB\ell \sin \theta$	negative direction of z -axis
⑤	$IB\ell \cos \theta$	positive direction of z -axis
⑥	$IB\ell \cos \theta$	negative direction of z -axis

End of Physics questions. Leave the answer spaces **20** ~ **75** blank. Please check once more that you have properly marked the name of your subject as “Physics” on your answer sheet.

Do not take this question booklet out of the room.

Chemistry

Marking Your Choice of Subject on the Answer Sheet

Choose and answer two subjects from Physics, Chemistry, and Biology. Use the front side of the answer sheet for one subject, and the reverse side for the other subject.

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

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

< Example >

解答科目 Subject		
物 理 Physics	(化 学) Chemistry	生 物 Biology
<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

Use the following values for calculation. “L” indicates liters.

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

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

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

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

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

Atomic weight: H : 1.0 C : 12 N : 14 O : 16 F : 19 S : 32

Cl : 35 Br : 80

Q1 From the following statements ①-⑥ on the electron configuration and structure of atoms and ions choose the one in which the underlined part is **not correct**.

1

- ① The electron configuration of Al^{3+} and that of Cl^- are identical.
- ② The electron configuration of ^{12}C and that of ^{13}C are identical.
- ③ The number of valence electrons of F is 7.
- ④ The outermost shell of K is the N shell.
- ⑤ The number of neutrons of ^{23}Na is equal to that of ^{24}Mg .
- ⑥ The number of protons of S is 16.

Q2 Among the following compounds (a)-(e), two are constituted by connecting atoms exclusively by single bonds. From ①-⑧ below choose the correct combination.

2

- (a) acetic acid
- (b) ammonia
- (c) carbon dioxide
- (d) ethylene (ethene)
- (e) methanol

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

Q3 In two molecules out of the following (a)-(d), all atoms constituting each molecule exist in one plane. From ①-⑥ below choose the correct combination containing those two molecules. **3**

(a) CH₄ (b) C₂H₄ (c) C₂H₆ (d) C₆H₆

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

Q4 From ①-⑥ below choose the correct value for the coefficient x in the following reaction formula. **4**



① 1 ② 2 ③ 3 ④ 4 ⑤ 5 ⑥ 6

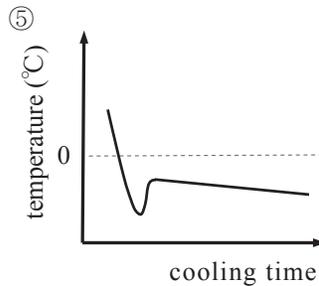
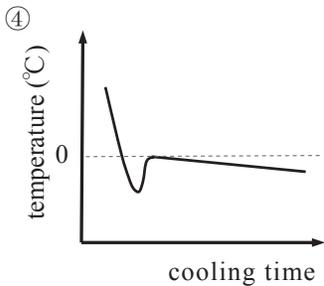
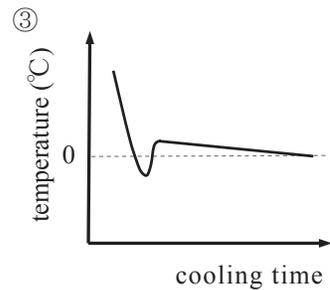
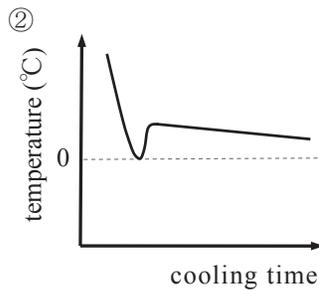
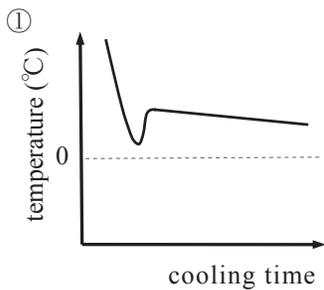
Q5 From the following ①-⑤ choose the correct one for the ratio of density of gases H₂, CH₄, and O₂ at 0 °C and 1 atm. **5**

① 1 : 1 : 1 ② 1 : 2 : 4 ③ 1 : 4 : 8
④ 1 : 8 : 16 ⑤ 1 : 16 : 16

Q6 Suppose the temperature of 3.0 L of argon at 300 K and 1.0 atm is raised to 360 K and its volume is increased to 7.2 L. Calculate the pressure (atm) of argon. From the following ①-⑥ choose the closest value. **6** atm

- ① 0.30 ② 0.50 ③ 1.0 ④ 2.0 ⑤ 2.4 ⑥ 3.0

Q7 An aqueous solution of 0.1 mol/kg glucose was cooled. From the following ①-⑤ choose the most appropriate graph that represents the relation between the cooling time and the temperature of the aqueous solution. **7**



Q8 From the following statements ①-⑤ on chemical reactions choose the one that is not correct. 8

- ① The rate of reaction changes if the temperature is changed.
- ② For reactions between gases, the rate of reaction changes if the partial pressure of each gas is changed.
- ③ The rate of reaction does not change if the amount of the catalyst is changed.
- ④ The equilibrium constant of a reaction does not change if the amount of the catalyst is changed.
- ⑤ The heat of reaction does not change if the amount of the catalyst is changed.

Q9 A 40 mL sample of 0.20 mol/L aqueous sodium hydroxide (NaOH) was required to neutralize 10 mL of sulfuric acid of unknown concentration. From the following ①-⑤ choose the closest value for the concentration (mol/L) of the sulfuric acid.

9 mol/L

- ① 0.10 ② 0.20 ③ 0.40 ④ 0.80 ⑤ 1.0

Q10 Aqueous sodium chloride (NaCl) was electrolyzed with the aid of platinum electrodes. When an electric current of 2.00 A was applied for a certain period, 224 mL of hydrogen (H_2) at the standard state was generated from the cathode. Calculate the time (s) required for the electrolysis. From the following ①-⑥ choose the closest value. 10 s

- ① 4.83×10 ② 9.65×10 ③ 4.83×10^2
④ 9.65×10^2 ⑤ 4.83×10^3 ⑥ 9.65×10^3

Q11 Some experiments were carried out to identify the solute in a colorless aqueous solution and the following results (a)-(c) were obtained. From ①-⑤ below choose the most appropriate solute for this aqueous solution. 11

- (a) When a platinum wire was dipped in the solution and then placed in a flame, the flame turned yellow.
- (b) When aqueous calcium chloride (CaCl_2) was added, white precipitates were formed.
- (c) When the solution was electrolyzed with the aid of platinum electrodes, hydrogen (H_2) from the cathode and oxygen (O_2) from the anode, respectively, were generated.

- ① AgNO_3 ② HCl ③ H_2SO_4 ④ NaCl ⑤ Na_2SO_4

Q12 From the following statements ①-⑤ on the reactions of aqueous silver nitrate (AgNO_3) choose the one that is not correct. 12

- ① White precipitates are formed when aqueous potassium chloride (KCl) is added.
- ② When a copper plate is dipped into the solution, silver (Ag) is deposited on the surface.
- ③ Black precipitates are formed when hydrogen sulfide (H_2S) is passed through.
- ④ White precipitates are formed when aqueous sodium hydroxide (NaOH) is added.
- ⑤ The precipitates once formed dissolve when aqueous ammonia (NH_3) is added in excess.

Q13 When aqueous ammonia (NH_3) is added to the aqueous solutions ①-⑤, precipitates may or may not be formed, depending on the compounds. In the cases where precipitates are formed, on addition of excess NH_3 the precipitate from one of the solutions remains undissolved. Choose the one from the following aqueous solutions ①-⑤. **13**

- ① aqueous alum ($\text{AlK}(\text{SO}_4)_2$)
- ② aqueous calcium chloride (CaCl_2)
- ③ aqueous copper sulfate (CuSO_4)
- ④ aqueous sodium chloride (NaCl)
- ⑤ aqueous zinc chloride (ZnCl_2)

Q14 When 10 mL of 0.10 mol/L aqueous silver nitrate (AgNO_3) and 10 mL of 0.20 mol/L aqueous zinc chloride (ZnCl_2) were mixed, white precipitates were formed in the aqueous solution. From the following ①-⑤ choose the closest value for the concentration (mol/L) of chloride ion Cl^- in this aqueous solution.

14 mol/L

- ① 0.10 ② 0.15 ③ 0.20 ④ 0.25 ⑤ 0.30

Q15 Two out of statements (a)-(f) on methods for generating various gases involve oxidation-reduction reactions. From ①-⑧ below choose the correct combination.

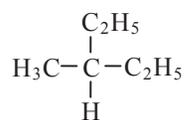
15

- (a) Ammonium chloride (NH_4Cl) and calcium hydroxide ($\text{Ca}(\text{OH})_2$) are mixed, and then the mixture is heated.
- (b) Dilute sulfuric acid (dil. H_2SO_4) is added to iron(II) sulfide (FeS).
- (c) Concentrated hydrochloric acid (conc. HCl) is added to manganese(IV) oxide MnO_2 , and then the mixture is heated.
- (d) Concentrated sulfuric acid (conc. H_2SO_4) is added to sodium chloride (NaCl).
- (e) Copper (Cu) is added to dilute nitric acid (dil. HNO_3).
- (f) Acetic acid (CH_3COOH) is added to sodium hydrogencarbonate (NaHCO_3).

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

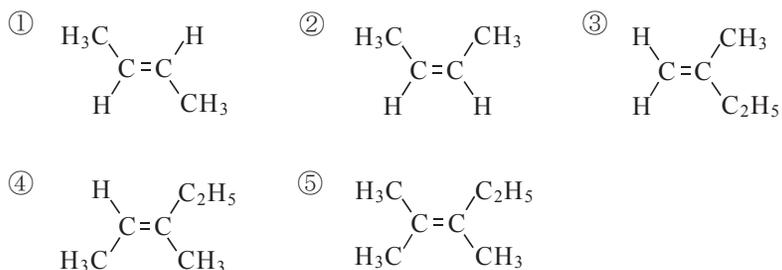
Q16 From ①-⑤ below choose the correct name for the hydrocarbon represented by the following structural formula.

16



- ① 1,1-diethylethane
- ② diethylmethylethane
- ③ 2-ethylbutane
- ④ 3-methylpentane
- ⑤ 1-ethyl-1-methylpropane

Q17 From ①-⑤ below choose the one which yields a compound with an asymmetric carbon atom when hydrogen (H_2) is added by the addition reaction in the presence of a catalyst. **17**

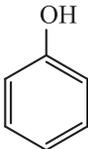
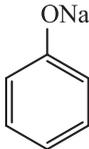
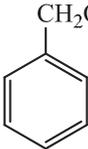
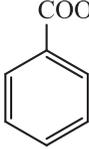
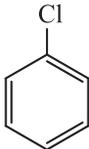
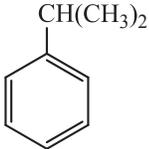
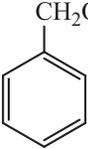
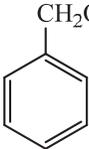


Q18 The product obtained by the addition reaction of bromine (Br_2) to a certain amount of ethylene (ethene) was 45 g heavier than that obtained by the addition reaction of chlorine (Cl_2) to the same amount of ethylene. Calculate the amount of ethylene in mol used in these reactions. From the following ①-⑥ choose the closest value. **18** mol

- ① 0.10 ② 0.30 ③ 0.50 ④ 0.60 ⑤ 0.80 ⑥ 1.0

Q19 When each of the organic compounds listed in column **A** of the following table is reacted by the procedure indicated in column **B**, the organic compound listed in column **C** is mainly obtained. From ①-⑤ in the following table choose the one in which the product is correctly given.

19

	A	B	C
①		Aqueous sodium hydrogencarbonate (NaHCO_3) is added.	
②		Aqueous potassium permanganate (KMnO_4) is added.	
③		Chlorine (Cl_2) is added and irradiated with ultraviolet light.	
④		Acetone (CH_3COCH_3) is added.	
⑤		Aqueous sodium hydroxide (NaOH) is added.	

Q20 When 1.0 mol of an unsaturated carboxylic acid with one carboxy group was completely combusted, 18 mol of carbon dioxide (CO_2) and 16 mol of water (H_2O) were generated. Calculate the amount of hydrogen (H_2) in mol required to convert 1.0 mol of this unsaturated carboxylic acid into saturated carboxylic acid. From the following ①-⑤ choose the closest value. **20** mol

- ① 1.0 ② 2.0 ③ 3.0 ④ 4.0 ⑤ 5.0

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

Please check once more that you have properly marked the name of your subject as “Chemistry” on your answer sheet.

Do not take this question booklet out of the room.

Biology

Marking Your Choice of Subject on the Answer Sheet

Choose and answer two subjects from Physics, Chemistry, and Biology. Use the front side of the answer sheet for one subject, and the reverse side for the other subject.

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

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

<Example>

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

Q1 Statements a – d below describe human hormones. From ① – ⑥ below choose the combination indicating the two statements that are correct. 1

- a Hormones produced by the endocrine glands travel to their target organs via ducts.
- b Target cells have receptors that bind with specific hormones.
- c The hypothalamus, located in the interbrain, has hormone-secreting cells that are a type of neuron.
- d There is no type of hormone that acts on different target organs.

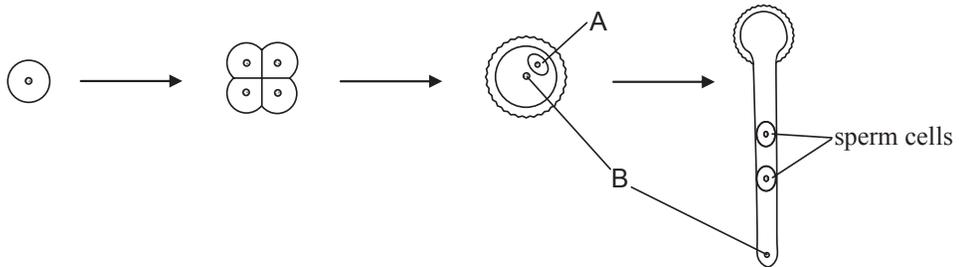
- ① a, b ② a, c ③ a, d ④ b, c ⑤ b, d ⑥ c, d

Q2 Statements a–e below describe various phases of somatic cell division in animals. From ①–⑧ below choose the answer that correctly arranges these phases in the order that somatic cell division progresses. 2

- a The chromosomes assume a string-like form, and the nuclear membrane and nucleoli appear.
- b Each chromosome divides into two as if splitting longitudinally, and the members of each pair are pulled to opposite poles by the spindle fibers.
- c The chromosomes line up along the equatorial plane.
- d The chromosomes condense and the nuclear membrane and nucleoli disappear. The spindle fibers extending from the centrosomes attach to the kinetochores.
- e Constriction occurs at the equatorial plane and cytokinesis ends.

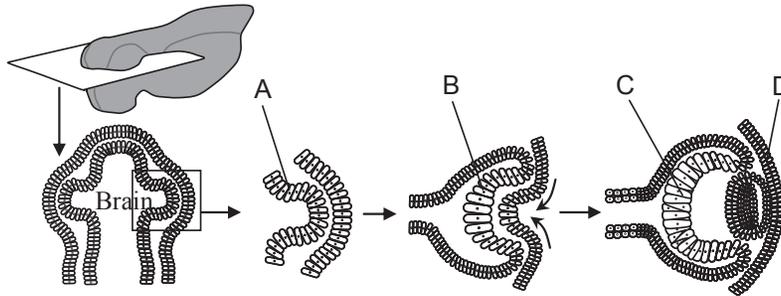
- ① a → b → c → d → e
- ② a → b → c → e → d
- ③ a → c → b → d → e
- ④ a → c → b → e → d
- ⑤ d → b → c → a → e
- ⑥ d → c → a → b → e
- ⑦ d → c → b → a → e
- ⑧ d → c → b → e → a

Q3 The figure below shows the formation of pollen in angiosperms and the changes that occur. From ①–⑥ below choose the combination that correctly identifies parts A and B in the figure. **3**



	A	B
①	spermatogonium	pollen tube nucleus
②	spermatogonium	spermatocyte
③	spermatogonium	pollen mother cell
④	generative cell	pollen tube nucleus
⑤	generative cell	spermatocyte
⑥	generative cell	pollen mother cell

Q4 The figure below shows a cross section of the head of a newt in the tail-bud stage, and the process of eye development. Answer questions (1) and (2) below concerning this.



(1) What would be the effect on eye formation if region A in the figure is removed early in the development process? From ①–⑥ below choose the best answer. 4

- ① A normal eye would form.
- ② An eye without a cornea would form.
- ③ An eye without a crystalline lens would form.
- ④ An eye without a cornea and a crystalline lens would form.
- ⑤ An eye without a retina would form.
- ⑥ Eye formation would not be observed.

(2) From ①–⑥ below choose the combination that best identifies parts B, C, and D in the figure.

5

	B	C	D
①	retina	optic vesicle	crystalline lens
②	optic vesicle	optic cup	cornea
③	optic cup	retina	cornea
④	retina	crystalline lens	cornea
⑤	optic vesicle	retina	crystalline lens
⑥	optic cup	optic vesicle	crystalline lens

Q5 From ①–⑧ below choose the combination of terms that correctly fills blanks – in the paragraph below.

A certain mammal has a type that forms a tail and another that does not form a tail. These characteristics are determined by a pair of alleles. If a tailed male and a tailed female are crossed, all the resulting offspring will be tailed. It is known that the tailless type is not a pure line, and if a tailless male is crossed with a tailless female, the ratio of tailed offspring to tailless offspring will be 1:2. From this we can determine that the tailless characteristic is , and the gene responsible for the tailless type functions as a when it is present in a .

	A	B	C
①	dominant	suppressor gene	homozygote
②	dominant	suppressor gene	heterozygote
③	recessive	suppressor gene	homozygote
④	recessive	suppressor gene	heterozygote
⑤	dominant	lethal gene	homozygote
⑥	dominant	lethal gene	heterozygote
⑦	recessive	lethal gene	homozygote
⑧	recessive	lethal gene	heterozygote

Q6 Consider four neurons that are connected in the circuit shown in Figure 1 below. A stimulus is applied at the location indicated by the arrow, and the electric potential is measured with respect to time using electrodes inserted at regions A–E. Figure 2 shows the expected results of these measurements. Judging from the properties of excitation transmission and conduction, from ①–⑦ below choose the combination that best indicates the regions (A–E in Figure 1) where measurements I–IV were taken. Note that an action potential was not observed in the case of III. 7

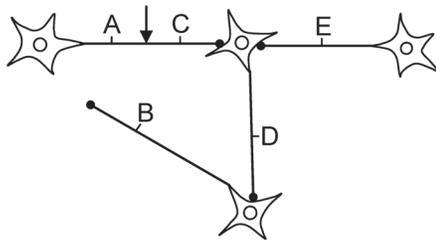


Figure 1

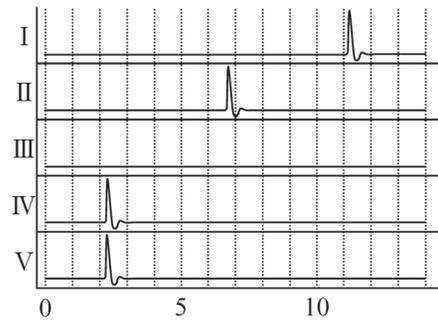
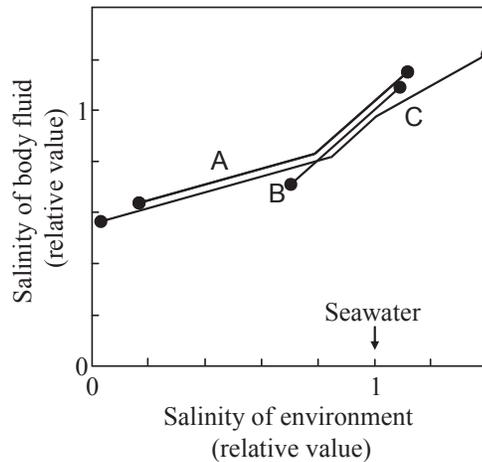


Figure 2

	I	II	III	IV
①	B	A	D	C
②	B	D	E	A
③	B	E	D	A
④	C	A	B	E
⑤	D	B	E	A
⑥	D	E	B	C
⑦	D	E	A	C

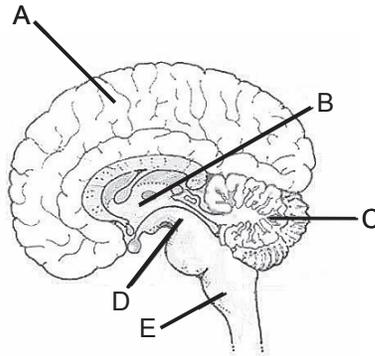
- Q7 The figure below shows changes in the salinity of body fluid in three types of aquatic organisms (A–C) when they are transferred to an environment with a level of salinity different from that of the original environment. The black circles (●) indicate that the organism cannot survive at higher or lower salinity for a long time. From ①–④ below choose the statement that does **not** correctly describe this figure.

8



- ① Organism A lives in an environment near a river mouth where freshwater and seawater mix.
- ② Of the three organisms, B has the weakest ability to regulate osmotic pressure.
- ③ Organism B is a freshwater species.
- ④ Organism C is an organism that migrates back and forth between freshwater and seawater.

Q8 The figure below shows a cross section of the human brain. From ①–⑧ below choose the combination that correctly indicates which of regions A–E in the figure are the locations of the centers described in X and Y below. 9



X: Center that regulates the autonomic nervous system

Y: Center that regulates eye movement and pupil size

	X	Y
①	A	D
②	B	D
③	B	E
④	C	B
⑤	C	E
⑥	D	B
⑦	D	C
⑧	E	C

Q9 Statements a – e below concern immunity. From ①–⑦ below choose the answer indicating all statements that apply to T cells. 10

- a They are large cells that exhibit phagocytosis.
- b They are cells that produce antibodies.
- c They are a type of lymphocyte.
- d They secrete stimulants to activate cells that produce antibodies.
- e They are produced in bone marrow and mature in the thymus.

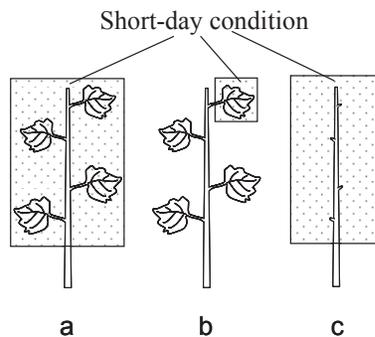
- ① a, b, c ② a, e ③ b, c ④ b, c, e ⑤ c, d
⑥ c, d, e ⑦ d, e

Q10 Experiments 1 and 2 below were performed using the common cocklebur (a short-day plant) to examine photoperiodism in flower bud formation. The figures below show the content of each experiment. In Experiment 1, after which treatments (a–c) would flower bud formation be observed? In Experiment 2, after which treatments (d–f) would flower bud formation on stem Y be observed? From ①–⑧ on the following page choose the correct combination of answers. Note that all plant parts were exposed to the same long-day condition, except for the parts indicated as exposed to the same short-day condition in the figures.

11

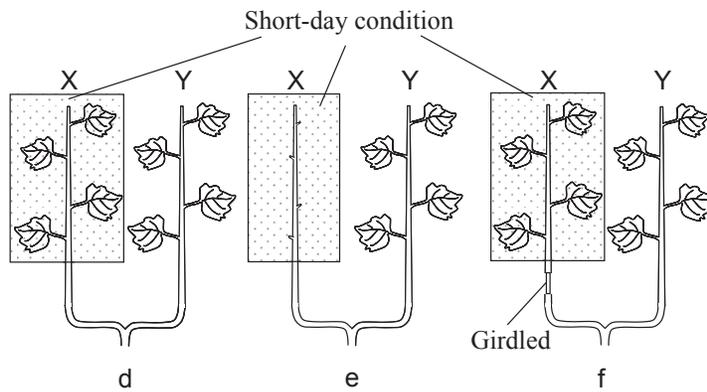
Experiment 1: Treatments a–c below were applied to unbranched plants.

- a The entire plant was exposed to the short-day condition.
- b Only one leaf was exposed to the short-day condition.
- c The plant was exposed to the short-day condition after all leaves were removed.



Experiment 2: Treatments d–f below were applied to plants branched into two large stems.

- d Stem X was completely exposed to the short-day condition.
- e Stem X was exposed to the short-day condition after all its leaves were removed.
- f Stem X was exposed to the short-day condition after its base was girdled.



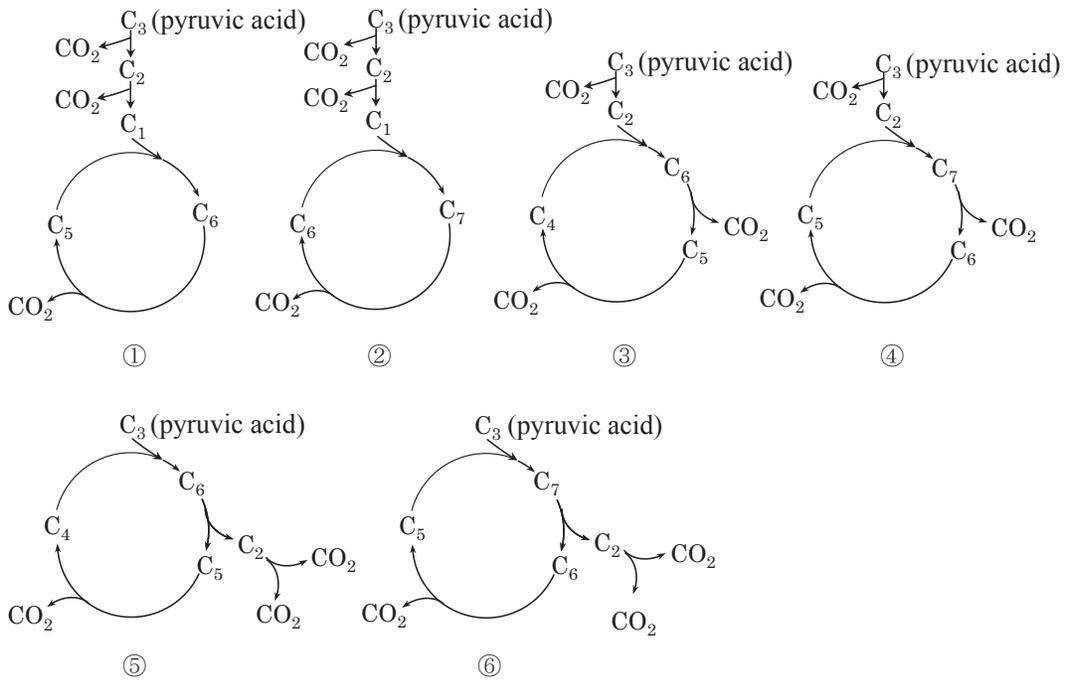
	Experiment 1	Experiment 2
①	a, b	d
②	a, b	d, f
③	a	e
④	a	d, f
⑤	b	e
⑥	b	d, f
⑦	c	e
⑧	c	d

Q11 The following paragraph describes enzyme-catalyzed reactions. From ① – ⑨ below choose combination of terms that correctly indicates the name of the reaction underlined and marked with “a,” and the name of the substance underlined and marked with “b.” **12**

There are various reactions catalyzed by enzymes. For example, enzymes are involved in the reaction by which energy is acquired from the breakdown of organic compounds, the a reaction that synthesizes sugar from the assimilation of carbon dioxide, and the reaction in which b gas is released when a piece of pig liver is placed in a hydrogen peroxide solution.

	a	b
①	photosystem I	oxygen
②	photosystem I	hydrogen
③	photosystem I	carbon dioxide
④	photosystem II	oxygen
⑤	photosystem II	hydrogen
⑥	photosystem II	carbon dioxide
⑦	Calvin-Benson cycle	oxygen
⑧	Calvin-Benson cycle	hydrogen
⑨	Calvin-Benson cycle	carbon dioxide

Q12 The process of aerobic respiration can be thought of being divided into glycolysis, the citric acid cycle, and the electron transport system. From ①–⑥ below choose the schematic diagram that best represents the citric acid cycle. Note that “C” in the diagrams represents carbon, and the accompanying numeral indicates the number of carbon atoms. Also, several reaction processes have been omitted for simplicity. **13**



Q13 A certain type of bacteria can take in atmospheric nitrogen (N_2) and convert it into NH_4^+ . From ①–⑥ below choose the combination that correctly identifies this function and the bacteria that perform it.

14

	Function	Bacteria
①	nitrogen fixation	nitrite bacteria
②	nitrogen fixation	nitrate bacteria
③	nitrogen fixation	root nodule bacteria
④	nitrogen assimilation	nitrite bacteria
⑤	nitrogen assimilation	nitrate bacteria
⑥	nitrogen assimilation	root nodule bacteria

Q14 Statements a–c below describe the structure and characteristics of DNA and/or RNA. From ①–⑧ below choose the combination that best indicates whether each statement is true (○) or false (×).

15

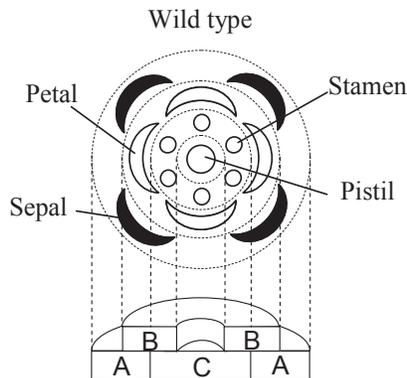
- a The nucleotides that make up DNA and RNA are composed of a sugar, a phosphate, and a base; the phosphates and the bases are the same for both DNA and RNA.
- b Complementary base pairs are formed in DNA replication, but the base sequences transcribed from DNA are not complementary.
- c Some portions of eukaryotic DNA are not translated, even if they are transcribed.

	a	b	c
①	○	○	○
②	○	○	×
③	○	×	○
④	○	×	×
⑤	×	○	○
⑥	×	○	×
⑦	×	×	○
⑧	×	×	×

Q15 The formation of thale cress (*Arabidopsis thaliana*) flowers is controlled by three types of regulatory genes (A, B, C). In the wild type, the parts of flowers are arranged in the following order, proceeding inward from the outside: sepals, petals, stamens, and pistil. Genes A–C act upon specific regions in the flower primordium, and the combination of their effects determines what is formed. As shown in the figure below, when only A acts, the sepals are formed, and when both A and B act, the petals are formed. Also, when both B and C act, the stamens are formed, and when only C acts, the pistil is formed.

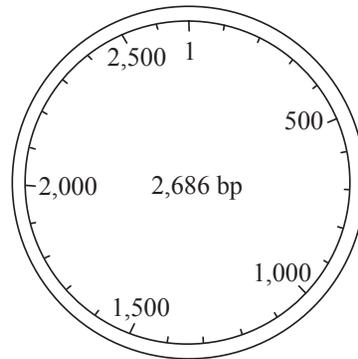
There is a mutant of *Arabidopsis thaliana* whose flowers have only sepals and a pistil. In this mutant, which of genes A–C has/have stopped functioning? From ①–⑦ below choose the best answer.

16



- ① Gene A
- ② Gene B
- ③ Gene C
- ④ Genes A and B
- ⑤ Genes A and C
- ⑥ Genes B and C
- ⑦ Genes A, B, and C

Q16 The following figure shows a plasmid that contains 2,686 base pairs (bp).

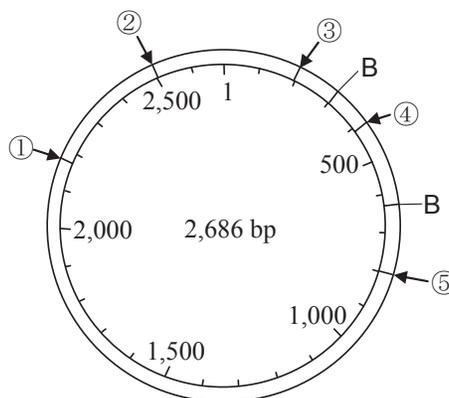


When this plasmid is cut using two types of restriction enzymes, A and B, the linear DNA fragments listed in the table below are obtained.

Restriction enzyme used	Fragment length (bp)
A	2,686
B	322 ; 2,364
A+B	322 ; 815 ; 1,549

The figure below shows the locations where the plasmid is cut by restriction enzyme B. From ①–⑤ in the figure choose the answer that indicates the location where the plasmid is cut by restriction enzyme A.

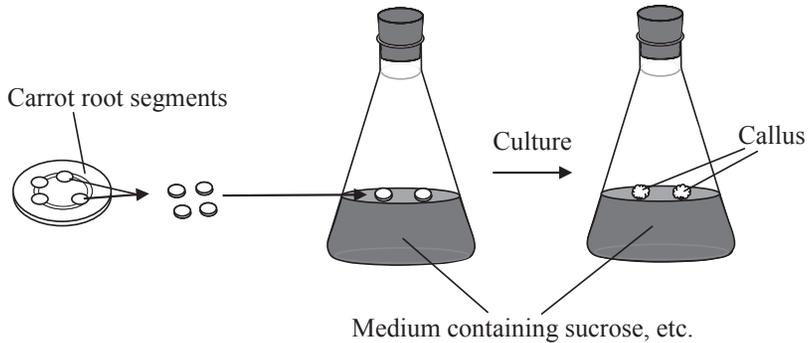
17



Q17 The figure below shows part of an experiment attempting to regenerate carrots from root segments.

Referring to this experiment, from ①–④ below choose the statement that is **not** correct.

18



- ① This type of experiment is referred to as tissue culture technique, which is a basic technique of biotechnology.
- ② A callus is an unorganized mass of differentiated cells.
- ③ The cells in a callus, a cluster of cells, all possess the same genetic information as one another.
- ④ The ability to regenerate a complete plant from a callus by adjusting the media conditions (plant hormone concentration, etc.) demonstrates that plant cells possess totipotency.

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.