Question Booklet

2015 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 – 35
Biology	37 – 50

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

III　Rules and Information Concerning the Answer Sheet

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

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

Examination registration number			*					*						
Name														

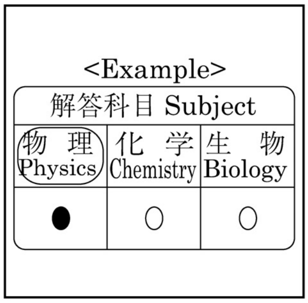
Physics

Marking your Choice of Subject on the Answer Sheet

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

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

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



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

A As shown in Figure 1 below, a thin uniform rod is bent at a right angle. The length from one end A of the rod to the corner B is $2L$, and the length from B to the other end C is L. Next, a string is attached to B and the rod is suspended. As shown in Figure 2, the rod comes to rest in an orientation where the part AB forms angle θ with the horizontal.

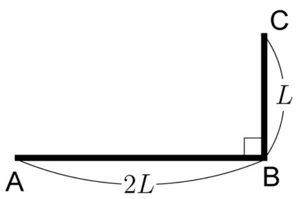


Figure 1

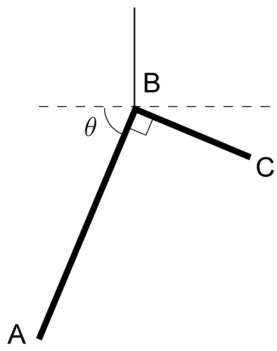


Figure 2

Q1 What is $\tan\theta$? From ①-④ below choose the correct answer. **1**

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

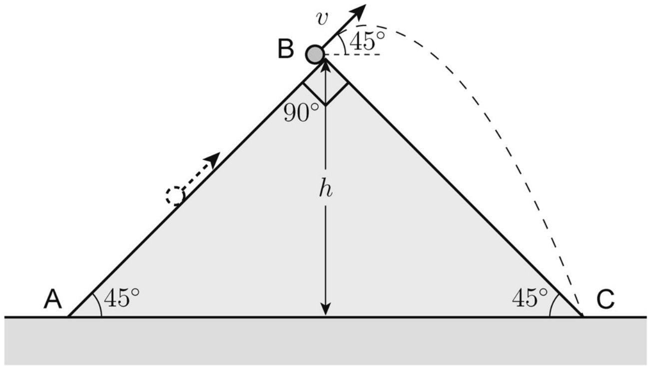
B An object at rest begins moving with constant acceleration. It travels 36 m in 12 s from the time it started moving.

Q2 What is the speed (in m/s) of the object at 12 s after it starts moving? From ①-⑥ below choose the best answer. $\boxed{\mathbf{2}}$ m/s

① 1.0 ② 2.0 ③ 3.0

④ 4.0 ⑤ 5.0 ⑥ 6.0

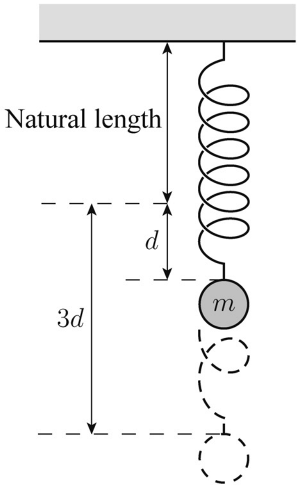
C As shown in the figure below, a triangular prism whose cross section is isosceles right triangle ABC is fixed to a horizontal surface, with side AC at the base. ∠ ABC is a right angle, and the height of vertex B from side AC is h. A small ball is projected upward along side AB which forms an angle of $45°$ with the horizontal. Upon reaching vertex B, the ball flies off the prism with speed v, and lands at vertex C.



Q3 What is v? From ①-⑤ below choose the correct answer. $\boxed{3}$

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

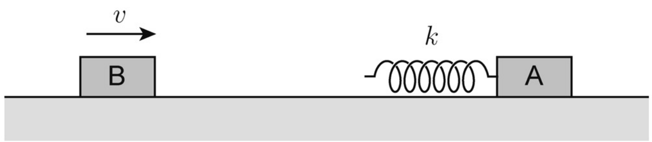
D As shown in the figure below, when a weight of mass m is attached to a lightweight spring and the spring is suspended vertically from a ceiling, the weight comes to rest at a point where the spring is stretched distance d from its natural length. Next, the weight is pulled vertically downward to a point where the spring is stretched distance $3d$ from its natural length, and is gently released. As a result, the weight undergoes simple harmonic motion in the vertical direction.



Q4 What is the speed of the weight at the instant when the spring is compressed to its natural length? From ①-⑤ below choose the correct answer. $\boxed{4}$

① $\sqrt{gd}$ ② $\sqrt{2gd}$ ③ $\sqrt{3gd}$ ④ $2\sqrt{gd}$ ⑤ $\sqrt{5gd}$

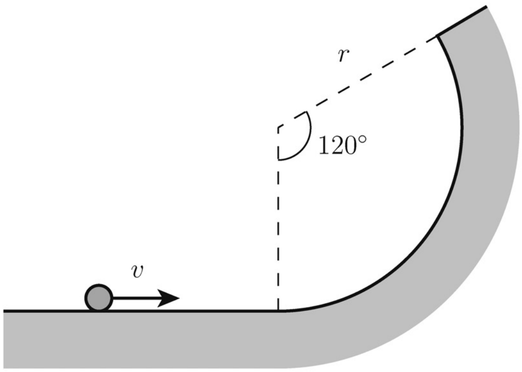
E As shown in the figure below, object A (mass: m) is at rest on a smooth, horizontal surface, and a lightweight spring that compresses/stretches in the horizontal direction is attached to it. Object B, which has the same mass m, approaches A from the left side with speed v and collides with the spring. The spring compresses and A begins to move. A, B, and the spring travel in a straight line.



Q5 What is the speed of A when the spring is at maximum compression? From ①-④ below choose the correct answer. $\boxed{5}$

① $\frac{1}{2}v$　　② $\frac{\sqrt{2}}{2}v$　　③ v　　④ $\sqrt{2}\,v$

F As shown in the figure below, a horizontal surface is seamlessly joined to a section of a cylindrical surface whose radius is r and whose central angle is $120°$. A small ball is projected along the horizontal surface with speed v so that the ball moves along the cylindrical surface. In order for the ball to remain in contact with the cylindrical surface and reach the uppermost edge, v must exceed a certain speed v_0. Friction between the ball and the horizontal/cylindrical surfaces is negligible.



Q6 What is v_0? From ①-⑤ below choose the correct answer. $\boxed{6}$

① $\sqrt{3gr}$ ② $\sqrt{\frac{7gr}{2}}$ ③ $2\sqrt{gr}$ ④ $3\sqrt{\frac{gr}{2}}$ ⑤ $\sqrt{5gr}$

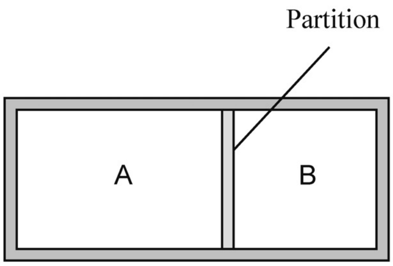
II Answer questions **A** (Q1), **B** (Q2), and **C** (Q3) below.

A When 3.0×10^3 J of heat is applied to 1.0×10^2 g of substance A, the temperature of the substance increases by 1.5×10^1 K. When 4.0×10^3 J of heat is applied to 1.0×10^2 g of substance B, the temperature of the substance increases by 1.0×10^1 K. When 4.0×10^2 g of substance A and 3.0×10^2 g of substance B are placed in contact with each other at the same temperature and then 1.0×10^4 J of heat is applied to them, the temperature of both increases by t [K].

Q1 What is t [K]? From ①-⑥ below choose the best answer. $\boxed{7}$ K

① 1.0 ② 2.0 ③ 3.0 ④ 4.0 ⑤ 5.0 ⑥ 6.0

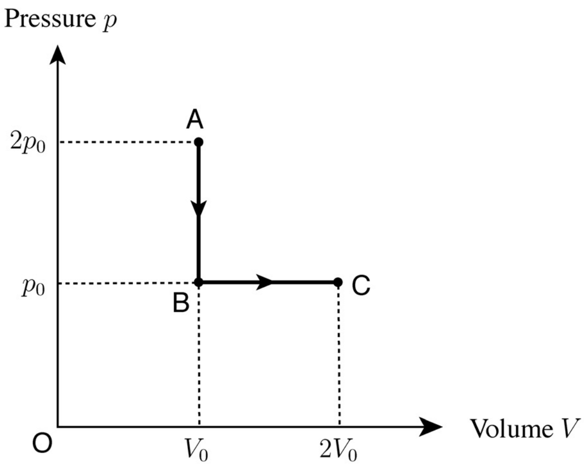
B As shown in the figure below, a thermally insulated container is divided into two chambers (A and B) by a thermally conducting, smoothly moving partition. Chamber A contains N_{A} molecules of an ideal gas (mass of a molecule: m_{A}), and chamber B contains N_{B} molecules of an ideal gas (mass of a molecule: m_{B}). The gases are in thermal equilibrium at the same temperature and the same pressure. Let us denote the volume of the gas in chamber A as V_{A}, and the root-mean-square speed of its molecules as $\sqrt{\overline{v_{\mathrm{A}}^2}}$. Also, let us denote the volume of the gas in chamber B as V_{B}, and the root-mean-square speed of its molecules as $\sqrt{\overline{v_{\mathrm{B}}^2}}$.



Q2 What are $\dfrac{V_{\mathrm{A}}}{V_{\mathrm{B}}}$ and $\dfrac{\sqrt{\overline{v_{\mathrm{A}}^2}}}{\sqrt{\overline{v_{\mathrm{B}}^2}}}$? From ①-④ below choose the correct combination. $\boxed{8}$

	①	②	③	④
$\dfrac{V_{\mathrm{A}}}{V_{\mathrm{B}}}$	$\dfrac{N_{\mathrm{A}}}{N_{\mathrm{B}}}$	$\dfrac{N_{\mathrm{A}}}{N_{\mathrm{B}}}$	$\dfrac{N_{\mathrm{B}}}{N_{\mathrm{A}}}$	$\dfrac{N_{\mathrm{B}}}{N_{\mathrm{A}}}$
$\dfrac{\sqrt{\overline{v_{\mathrm{A}}^2}}}{\sqrt{\overline{v_{\mathrm{B}}^2}}}$	$\sqrt{\dfrac{m_{\mathrm{A}}}{m_{\mathrm{B}}}}$	$\sqrt{\dfrac{m_{\mathrm{B}}}{m_{\mathrm{A}}}}$	$\sqrt{\dfrac{m_{\mathrm{A}}}{m_{\mathrm{B}}}}$	$\sqrt{\dfrac{m_{\mathrm{B}}}{m_{\mathrm{A}}}}$

C Pressure p and volume V of an ideal gas (amount of substance: n mol) are changed in the path A→B→C as shown in the figure below. The volume and pressure in state A are V_0 and $2p_0$, respectively. The volume, pressure, and absolute temperature in state B are V_0, p_0, and T_0, respectively. The volume and pressure in state C are $2V_0$ and p_0, respectively. Let us denote molar specific heat of this gas at constant volume as C_V, its molar specific heat at constant pressure as C_p, and the gas constant as R.



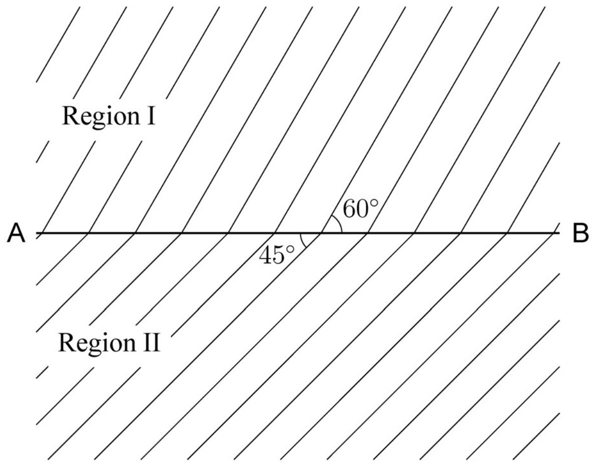
Q3 What is the net quantity of heat absorbed by the gas during the entire process of A→B→C? From ①-⑧ below choose the correct answer. $\boxed{9}$

① $-nRT_0$ ② $-nC_VT_0$ ③ $-nC_pT_0$ ④ $-n(C_V+C_p)T_0$

⑤ nRT_0 ⑥ nC_VT_0 ⑦ nC_pT_0 ⑧ $n(C_V+C_p)T_0$

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

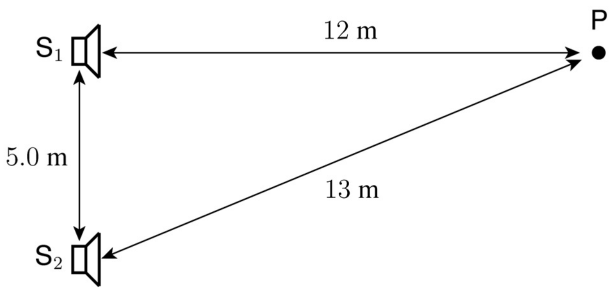
A As shown in the figure below, a tank contains water in two interfacing regions, I and II, of different depths that are divided by a straight-line boundary, AB. The figure represents the tank as seen from above. Surface waves refract when traveling from region I into region II; when the wavefront of a wave in region I is inclined $60°$ from boundary AB, the incline changes to $45°$ as the wave enters region II. Let us denote wave speed in regions I and II as v_{I} and v_{II}, respectively. Assume that the tank is sufficiently wide and shallow.



Q1 What is $\dfrac{v_{\mathrm{I}}}{v_{\mathrm{II}}}$? From ①-④ below choose the correct answer. **10**

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

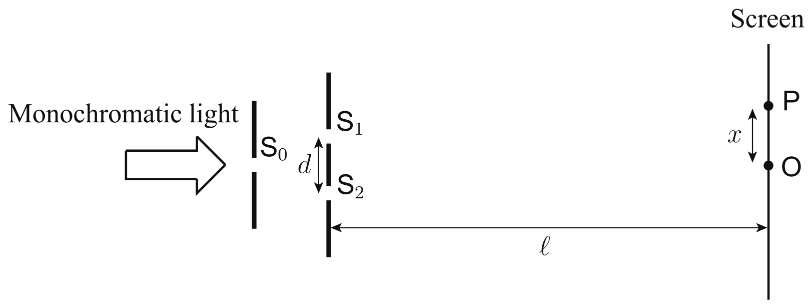
B As shown in the figure below, two speakers, S_1 and S_2, are placed 5.0 m apart from each other, and are emitting sound waves in the same frequency and the same phase. The sound waves from S_1 and S_2 are directly observed at point P, which is 12 m apart from S_1 and 13 m apart from S_2. Assume that the speed of sound is 340 m/s.



Q2 If the frequency of the sound waves from S_1 and S_2 is gradually increased from 500 Hz, what is the first frequency (in Hz) at which destructive interference by the sound waves will be observed at P? From ①-④ below choose the best answer. **11** Hz

① 510　　② 680　　③ 850　　④ 1020

C As shown in the figure below, monochromatic light is passed through a single slit (S_0) and then double slits (S_1 and S_2, separated by distance d), resulting in the formation of bright and dark bands on a screen placed sufficiently large distance ℓ from the double slits. Neighboring bright bands in the vicinity of the center of the screen are spaced by a separation a. When the distance between the double slits is increased from d to $1.5d$, the separation a changes to a'. Let us denote the point on the screen equidistant from S_1 and S_2 as O, and a point on the screen that is distance x from O as P. When S_1 and S_2 are separated by distance d, the difference between the distance from S_1 to P and the distance from S_2 to P can be expressed as $\dfrac{xd}{\ell}$.

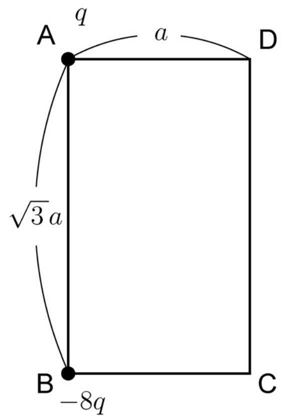


Q3 What is $\dfrac{a'}{a}$? From ①-④ below choose the best answer. $\boxed{12}$

① 0.33 ② 0.67 ③ 1.5 ④ 3.0

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 (>0) is fixed in place at vertex A of the rectangle ABCD, and a point charge with quantity of electricity $-8q$ is fixed in place at vertex B. The length of side AD is a, and the length of side AB is $\sqrt{3}\,a$. Let us denote the electric potential at points C and D as V_{C} and V_{D}, respectively, and denote the proportionality constant of Coulomb's law as k.

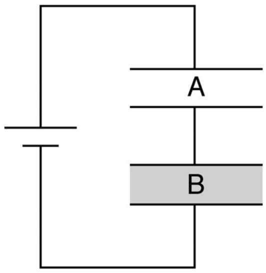


Q1 What is $V_{\mathrm{D}} - V_{\mathrm{C}}$? From ①-⑧ below choose the correct answer. **13**

① $-\dfrac{11kq}{2a}$ ② $-\dfrac{9kq}{2a}$ ③ $-\dfrac{7kq}{2a}$ ④ $-\dfrac{5kq}{2a}$

⑤ $\dfrac{5kq}{2a}$ ⑥ $\dfrac{7kq}{2a}$ ⑦ $\dfrac{9kq}{2a}$ ⑧ $\dfrac{11kq}{2a}$

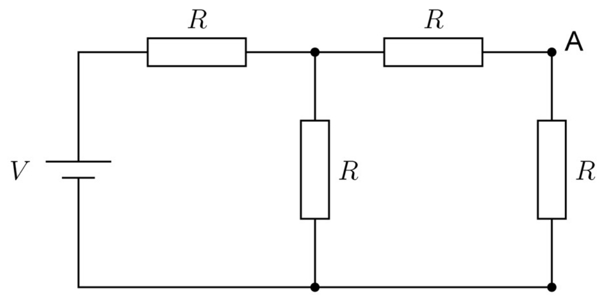
B Consider two parallel plate capacitors, A and B, that have the same shape. The space between the plates of A is vacuum, while that of B is filled with a dielectric with relative permittivity ε_r. Both A and B are connected to a battery as shown in the figure below. Let us denote the charge stored in A as Q_A and the magnitude of the electric field between its plates as E_A. Also, let us denote the charge stored in B as Q_B and the magnitude of the electric field between its plates as E_B.



Q2 What are $\dfrac{Q_\mathrm{B}}{Q_\mathrm{A}}$ and $\dfrac{E_\mathrm{B}}{E_\mathrm{A}}$? From ①-⑥ below choose the correct combination. **14**

	①	②	③	④	⑤	⑥
$\dfrac{Q_\mathrm{B}}{Q_\mathrm{A}}$	1	1	1	ε_r	ε_r	ε_r
$\dfrac{E_\mathrm{B}}{E_\mathrm{A}}$	$\dfrac{1}{\varepsilon_r}$	1	ε_r	$\dfrac{1}{\varepsilon_r}$	1	ε_r

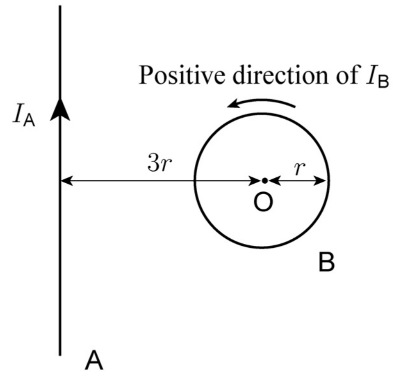
C Four resistors, each with resistance R, and a battery with electromotive force V are connected as shown in the figure below. Let us denote the magnitude of the current flowing through point A in this circuit as I. The internal resistance of the battery is negligible.



Q3 What is I? From ①-⑤ below choose the correct answer. **15**

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

D As shown in the figure below, a sufficiently long straight conducting wire A and a circular coil B exist within the same plane. The radius of B is r, and the distance from A to the center O of B is $3r$. An electrical current of magnitude I_A is flowing through A in the direction indicated by the arrow in the figure. When a current of magnitude I_B is made to flow through B, the magnetic field at O becomes zero. An arrow above B in the figure indicates the positive direction of I_B.

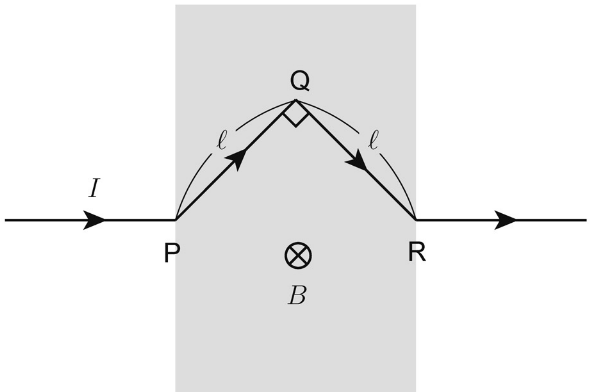


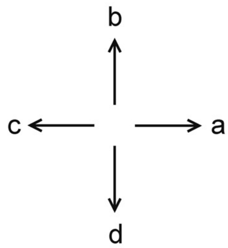
Q4 What is $\frac{I_B}{I_A}$? From ①-⑥ below choose the correct answer. $\boxed{16}$

① $-\frac{2}{3\pi}$ ② $-\frac{1}{3\pi}$ ③ $-\frac{1}{6\pi}$

④ $\frac{1}{6\pi}$ ⑤ $\frac{1}{3\pi}$ ⑥ $\frac{2}{3\pi}$

E As shown in the figure below, a certain conducting wire has a part PQR that forms the two legs of a right isosceles triangle. An electrical current of magnitude I is flowing through the wire in the direction indicated by the arrows in the figure. The wire exists in the plane of this page, and the part PQR is located in a uniform magnetic field. The magnetic field is perpendicular to this page, and is in the direction from the front of this page to the back. The magnitude of magnetic flux density is B. Legs PQ and QR each have a length of ℓ. The effect of the magnetic field produced by the current flowing through the wire is negligible.

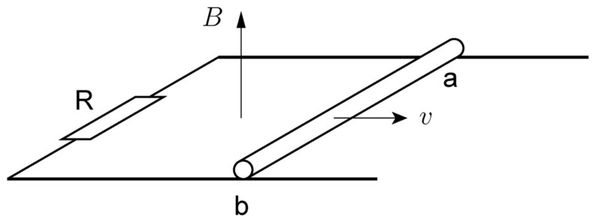




Q5 What is the magnitude of the force acting upon the part PQR? Also, which of arrows a～d in the figure represents the direction of that force? From ①-⑧ below choose the correct combination. **17**

	①	②	③	④	⑤	⑥	⑦	⑧
Magnitude	$\sqrt{2}IB\ell$	$\sqrt{2}IB\ell$	$\sqrt{2}IB\ell$	$\sqrt{2}IB\ell$	$2IB\ell$	$2IB\ell$	$2IB\ell$	$2IB\ell$
Direction	a	b	c	d	a	b	c	d

F As shown in the figure below, two long, parallel metal rails are placed horizontally within a uniform magnetic field whose direction is vertically upward and whose magnetic flux density has a magnitude of B. The left ends of the rails are connected to resistor R. Conducting rod ab is placed on the rails perpendicularly to them and is moved to the right with a constant speed of v. Electric resistance of the rod and the rails is negligible.



Q6 What is the direction of the current flowing through the conducting rod? Also, what is the relationship between the electric potential at a and the electric potential at b? From ①-⑥ below choose the best combination. **18**

	Current direction	Electric potential at a/b
①	a→b	Electric potential is higher at a
②	a→b	Electric potential is higher at b
③	a→b	Electric potential is the same at a and b
④	b→a	Electric potential is higher at a
⑤	b→a	Electric potential is higher at b
⑥	b→a	Electric potential is the same at a and b

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

A The energy level of the nth stationary state of a hydrogen atom is derived with the following formula.

$$E_n = -\frac{2.2 \times 10^{-18}}{n^2}\ \mathrm{J}$$

Q1 What is the wavelength of the light (in m) emitted when a hydrogen atom makes a transition from stationary state $n = 4$ to $n = 2$? From ①-⑥ below choose the best answer. Assume that Planck's constant is 6.6×10^{-34} J·s and the speed of light is 3.0×10^8 m/s. **19** m

① 1.6×10^{-7} ② 2.4×10^{-7} ③ 3.2×10^{-7}

④ 4.8×10^{-7} ⑤ 6.4×10^{-7} ⑥ 7.2×10^{-7}

End of Physics questions. Leave the answer spaces $\boxed{20}$ – $\boxed{75}$ 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.

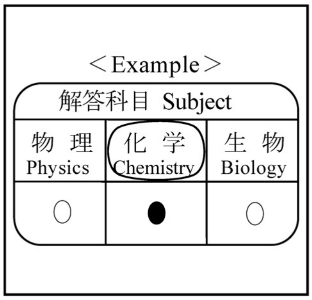
Chemistry

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

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

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

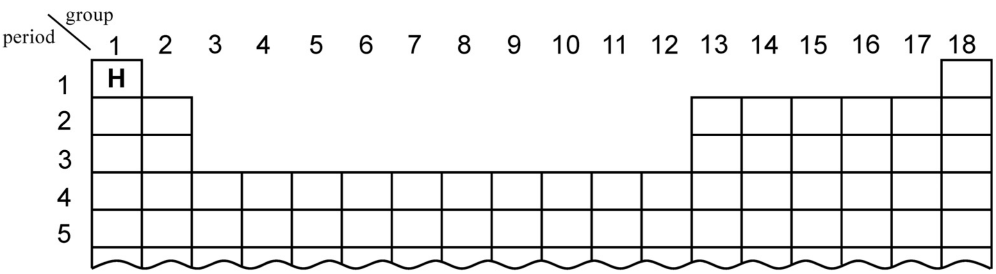
Gas constant: $R = 8.31 \times 10^3$ Pa·L/(K·mol)

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 Na : 23 Al : 27 Fe : 56

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



Q1 There are molecules among the following (**a**)-(**e**) whose total numbers of electrons are the same each other. From ①-⑥ below choose the correct combination of them. **1**

(**a**) CO_2 (**b**) HF (**c**) N_2 (**d**) NH_3 (**e**) O_2

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

Q2 Among the statements (**a**)-(**f**) on the structures and properties of atoms, two are **not** correct. From ①-⑧ below choose the combination of them. **2**

(**a**) Among halogens, the larger the atomic number, the smaller the electronegativity.

(**b**) The smaller the ionization energy (the first ionization energy) of an atom, the easier it becomes a cation.

(**c**) The noble gases have either two or eight valence electrons.

(**d**) Atoms that have the same number of protons but have a different number of neutrons are called isotopes of each other.

(**e**) Among the elements of the second period in the periodic table, the larger the atomic number, the larger the ionization energy.

(**f**) The total number of electrons that can be accommodated in the K and L shells is 10.

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

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

Q3 Naturally occurring boron has the atomic weight 10.8 and is composed of ^{10}B (relative atomic mass: 10.0) and ^{11}B (relative atomic mass: 11.0). From the following ①-⑥ choose the closest value for the abundance (%) of ^{10}B. $\boxed{3}$ %

① 10 ② 20 ③ 30 ④ 40 ⑤ 80 ⑥ 90

Q4 Among the following substances (**a**)-(**f**), two are pure substances. From ①-⑧ below choose the correct combination of them. $\boxed{4}$

(**a**) brass
(**b**) hydrochloric acid
(**c**) gasoline
(**d**) sodium chloride
(**e**) liquid air
(**f**) ice

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

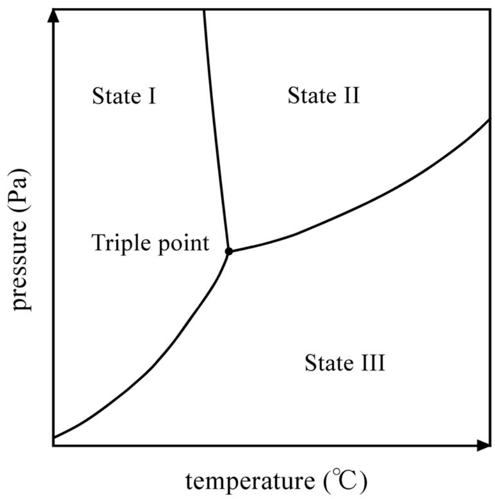
Q5 In the refining of iron (Fe), iron(III) oxide (Fe_2O_3) is reduced by carbon monoxide (CO) generated from coke.

$$Fe_2O_3 \quad + \quad 3CO \longrightarrow 2Fe \quad + \quad 3CO_2$$

How many tons of Fe_2O_3 are necessary to produce 8.4 t of iron? From the following ①-⑤ choose the closest value. $\boxed{5}$ t

① 10 ② 12 ③ 14 ④ 16 ⑤ 18

Q6 The following diagram shows the states of water depending on temperature and pressure. States I-III each corresponds to one of solid, liquid, or gas states. From ①-⑥ in the table below choose the correct combination of them. At the triple point (6.08×10^2 Pa, 0.01 ℃) in the figure, solid, liquid, and gas coexist. **6**



	State I	State II	State III
①	gas	liquid	solid
②	solid	liquid	gas
③	liquid	solid	gas
④	gas	solid	liquid
⑤	solid	gas	liquid
⑥	liquid	gas	solid

Q7 Among the following statements (**a**)-(**d**) on colloids, two are correct. From ①-⑥ below choose the combination of them. $\boxed{7}$

(**a**) Colloidal particles can pass through semipermeable membranes.

(**b**) Hydrophobic colloids coagulate if a small amount of electrolyte is added.

(**c**) When colloidal solution loses fluidity and solidifies, it is called a gel.

(**d**) KCl is more effective than Na_2SO_4 to coagulate the iron(III) hydroxide ($Fe(OH)_3$) colloid.

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

Q8 When 20 g of sodium hydroxide (NaOH) completely dissolved in 980 g of water contained in an insulating container, the temperature of the aqueous solution rose by 5.2 ℃. Calculate the heat of dissolution of sodium hydroxide in kJ/mol. From ①-⑤ below choose the closest value. Assume that the specific heat capacity (specific heat) of this aqueous solution is 4.2 J/(g･K). $\boxed{8}$ kJ/mol

① 11 ② 22 ③ 44 ④ 66 ⑤ 88

Q9 Among the following 0.01 mol/L aqueous solutions (**a**)-(**f**) choose the one whose pH value is the highest and the one whose pH value is the lowest. From ①-⑥ below choose the correct combination of them. **9**

(**a**) aqueous calcium hydroxide ($Ca(OH)_2$)
(**b**) aqueous oxalic acid ($(COOH)_2$)
(**c**) aqueous potassium hydroxide (KOH)
(**d**) hydrochloric acid (HCl aq)
(**e**) sulfuric acid (H_2SO_4 aq)
(**f**) aqueous ammonia (NH_3)

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

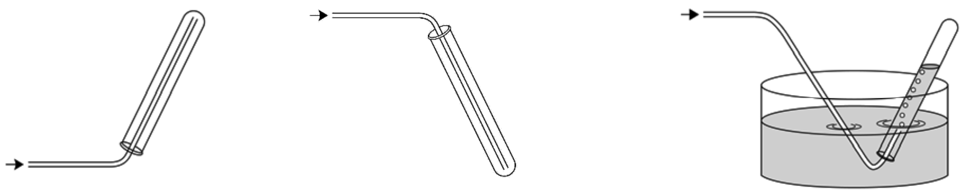
Q10 An aqueous solution of potassium hydroxide (KOH) was electrolyzed with the aid of platinum electrodes by an electric current of 1.00 A for 965 s. Calculate the volumes of gases in mL at the standard state generated at the cathode and at the anode, respectively. From ①-⑥ in the following table choose the most appropriate combination of them. **10**

	Volume of gas generated at cathode (mL)	Volume of gas generated at anode (mL)
①	56.0	56.0
②	112	56.0
③	112	112
④	112	224
⑤	224	112
⑥	224	224

Q11 What is the color of the gas generated by the reaction between copper (Cu) and dilute nitric acid (dil. HNO_3)? Which method, out of the following (i)-(iii), should be used to collect the gas? From ①-⑥ in the table below choose the most appropriate combination of them.

$\boxed{11}$

(i) upward delivery (ii) downward delivery (iii) displacement of water



	Color of gas	Method to collect gas
①	colorless	i
②	colorless	ii
③	colorless	iii
④	reddish brown	i
⑤	reddish brown	ii
⑥	reddish brown	iii

Q12 When the aqueous solutions containing the ions in column **A** of the following table were treated according to the procedures given in column **B**, precipitates formed. From the following ①-⑤ choose the one in which the color of the precipitate given in column **C** is **not** correct. **12**

	A	B	C
①	Ag^{+}	Hydrochloric acid (HCl aq) is added.	white
②	Cu^{2+}	Aqueous sodium hydroxide (NaOH) is added.	bluish white
③	Fe^{3+}	Aqueous sodium hydroxide is added.	greenish white
④	Pb^{2+}	Aqueous potassium chromate (K_2CrO_4) is added.	yellow
⑤	Zn^{2+}	Hydrogen sulfide (H_2S) is passed through under a basic condition.	white

Q13 From the following chemical reactions ①-⑤ choose the one in which the underlined sulfur atom (S) is reduced. **13**

① $Na_2\underline{S}O_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + SO_2$

② $Fe\underline{S} + H_2SO_4 \longrightarrow FeSO_4 + H_2S$

③ $\underline{S}O_3 + H_2O \longrightarrow H_2SO_4$

④ $I_2 + \underline{S}O_2 + 2H_2O \longrightarrow 2HI + H_2SO_4$

⑤ $2H_2S + \underline{S}O_2 \longrightarrow 2H_2O + 3S$

Q14 From the following statements ①-⑤ choose the correct one. **14**

① When chlorine (Cl_2) is passed through aqueous sodium fluoride (NaF), fluorine (F_2) is generated.

② When bromine (Br_2) is added to aqueous sodium chloride (NaCl), chlorine is generated.

③ When chlorine is passed through aqueous sodium iodide (NaI), iodine (I_2) is generated.

④ When water is added to magnesium (Mg) at room temperature, hydrogen (H_2) is generated.

⑤ When dilute sulfuric acid (dil. H_2SO_4) is added to copper (Cu), hydrogen is generated.

Q15 Aluminum is produced by utilizing electrolysis based on the following equation.

$$Al^{3+} + 3e^{-} \longrightarrow Al$$

From the following statements ①-⑤ on this reaction choose the correct one. **15**

① This reaction does not occur in the aqueous solution.

② Aluminum ion is oxidized in this reaction.

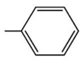
③ This reaction takes place at the anode.

④ During this reaction the oxidation number of aluminum increases by 3.

⑤ To obtain 3.0 mol of aluminum by this reaction, 1.0 mol of electron is required.

Q16 The ‘**X**’ part for the structural formulas CH_3－**X** are given in the following table. Column **A** of this table includes statements on the reactions of these organic compounds. From ①-⑤ in the following table choose the one whose statement in column **A** is correct.

$\boxed{16}$

	－X	A
①	－OH	It is oxidized to yield acetaldehyde.
②	－CHO	It is positive to the iodoform reaction.
③	－COOH	It is positive to the silver mirror test.
④	$-OCH_3$	It is dehydrated to yield an alkene.
⑤		It is oxidized to yield phenol.

Q17 Aniline was synthesized by reducing nitrobenzene with the aid of appropriate reagents. Suppose 82 % of the initial amount of nitrobenzene reacted and 18.6 g of aniline was obtained. How many grams of nitrobenzene were initially used? From the following ①-⑥ choose the closest value.

$\boxed{17}$ g

① 20 ② 25 ③ 30 ④ 35 ⑤ 40 ⑥ 45

Q18 Among the following statements (**a**)-(**e**) two are compatible with both ethanol and phenol. From ①-⑧ below choose the correct combination of them. **18**

(**a**) Both react with sodium (Na) to generate hydrogen (H_2).

(**b**) Both react with acetic anhydride to give esters.

(**c**) Both are oxidized to give aldehydes.

(**d**) If these are dissolved in water, aqueous solutions with a weak acidity are obtained.

(**e**) If aqueous iron(III) chloride ($FeCl_3$) is added, both exhibit a purple color.

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

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

Q19 From ①-⑤ in the following table choose the correct combination of the polymer compounds and the bond contained in them. **19**

	Polymer compound	Bond
①	polyethylene	$>C=C<$
②	nylon	$>C=N^{\diagup}$
③	polystyrene	$>C=O$
④	raw rubber (natural rubber)	$>C=C<$
⑤	cellulose	$>C=O$

Q20 From the following statements ①-④ on DNA (deoxyribonucleic acid) and RNA (ribonucleic acid), choose the correct one. **20**

① Both DNA and RNA contain four kinds of bases, adenine, guanine, cytosine, and thymine.

② There exist two hydrogen bonds both between adenine and thymine, and between guanine and cytosine.

③ Generally DNA is a double strand and RNA is a single strand.

④ DNA is formed by polymerization of nucleosides.

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.

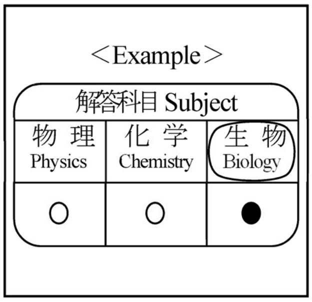
Biology

Marking Your Choice of Subject on the Answer Sheet

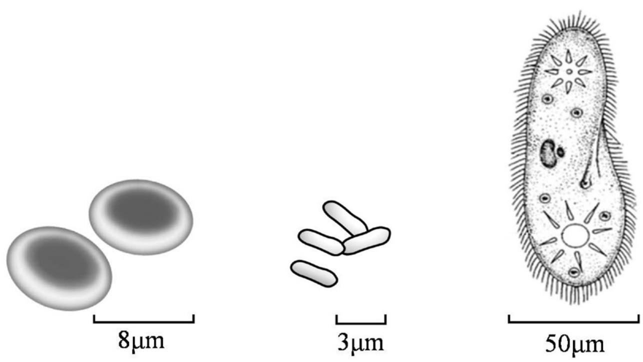
Choose and answer two subjects from Physics, Chemistry, and Biology. Use the front side of the answer sheet for one subject, and the reverse side for the other subject.

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.



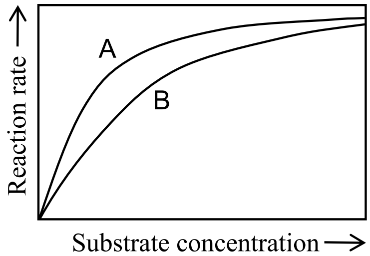
Q1 Each of figures A – C below schematically represents *Escherichia coli*, a paramecium, or human erythrocytes. Which of these are prokaryotic cells? From ① – ⑥ below choose the best answer. **1**



A B C

① A ② B ③ C ④ A, B ⑤ A, C ⑥ B, C

Q2 In the following figure, curve A represents the relationship between reaction rate and substrate concentration for a particular enzyme; $_X$at substrate concentrations above a certain level, the reaction rate remains constant. Curve B shows this relationship for when an inhibitor of the enzyme is added to the same type of reaction system represented by curve A; $_Y$the reaction rate is slower when the substrate concentration is low, but at higher concentrations curve B approaches curve A. Note that the inhibitor is very structurally similar to the substrate. Answer questions (1) and (2) below concerning this.



(1) From ①－④ below choose the statement that correctly describes why the enzyme's reaction rate becomes constant as mentioned in underlined text X. **2**

① At high substrate concentrations, almost all enzyme molecules are bound with substrate molecules.

② At high substrate concentrations, the reaction products break down the enzyme.

③ At high substrate concentrations, substrate molecules begin to bind with one another, which prevents the enzyme from reacting with them.

④ At high substrate concentrations, the enzyme is inactivated by the heat produced from the chemical reaction.

(2) From ①－④ below choose the statement that correctly explains the reason for the phenomenon mentioned in underlined text Y. **3**

① At high substrate concentrations, almost all enzyme molecules are bound with substrate molecules.

② At high substrate concentrations, almost all enzyme molecules are bound with reaction products.

③ At high substrate concentrations, almost all enzyme molecules are bound with inhibitor molecules.

④ At high substrate concentrations, almost all reaction products are bound with substrate molecules.

Q3 From ①– ④ below choose the statement that best describes the use of nitrogen in plants or nitrogen fixation. **4**

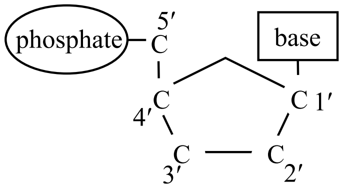
① Plants can directly produce nitrogen compounds from atmospheric nitrogen (N_2).

② Plant roots can absorb ammonium ions, but not nitrate ions.

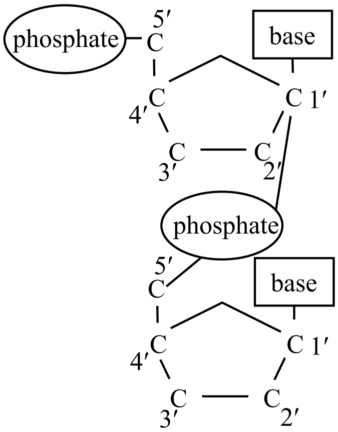
③ Legumes share a symbiotic relationship with root nodule bacteria, which fix nitrogen.

④ Nitrogen-fixing bacteria can directly produce nitrate ions from nitrogen (N_2).

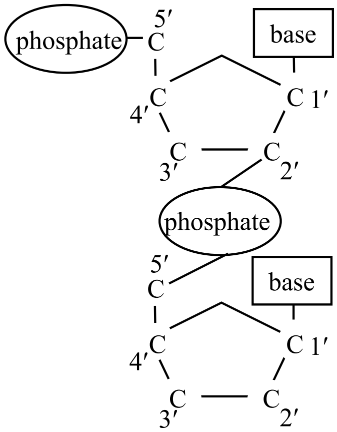
Q4 The following figure represents the structure of a nucleotide. A DNA nucleotide is bonded to its adjoining nucleotide via its phosphate. From ①－⑤ below choose the figure that best represents the carbon atom (C) to which the phosphate binds when two nucleotides join together. **5**



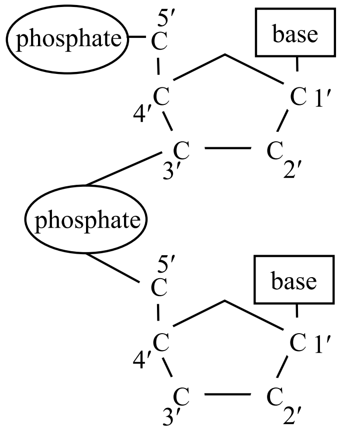
①



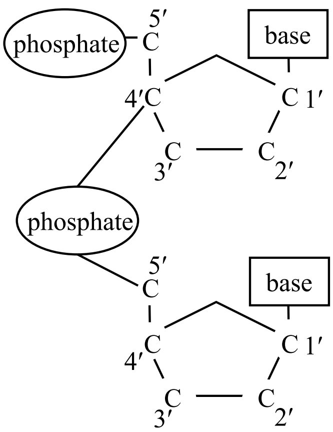
②



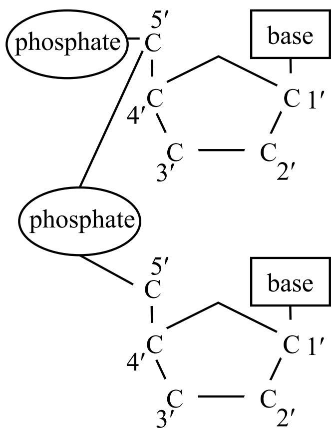
③



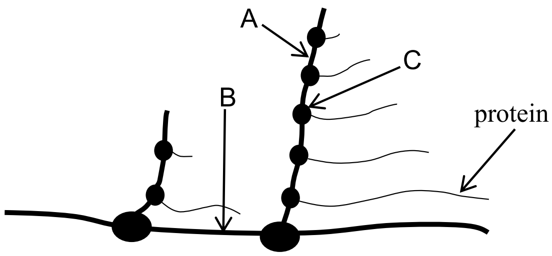
④



⑤



Q5 The following figure schematically represents transcription and translation in a prokaryotic cell. Protein is being synthesized at C in the figure. From ①–⑥ below choose the combination of terms that correctly identifies the items represented by A, B, and C in the figure. **6**

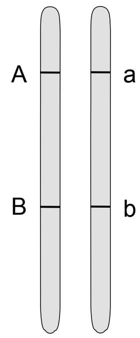


	A	B	C
①	DNA	mRNA	ribosome
②	DNA	ribosome	mRNA
③	mRNA	DNA	ribosome
④	mRNA	ribosome	DNA
⑤	ribosome	DNA	mRNA
⑥	ribosome	mRNA	DNA

Q6 The following figure schematically represents the chromosomal composition and gene arrangement of somatic cells in a certain organism. If the recombination value between genes A and B is 20%, what would be the ratio of genetic combinations

AB: Ab: aB: ab

in gametes produced by this organism? From ①–④ below choose the correct answer. **7**



① 1 : 4 : 4 : 1

② 4 : 1 : 1 : 4

③ 1 : 8 : 8 : 1

④ 8 : 1 : 1 : 8

Q7 Statements a–d below describe reproduction. From ①–⑥ below choose the combination indicating the two statements that are correct. **8**

a The term clone refers to a member of a group of genetically identical organisms that were produced by asexual reproduction.

b Unlike asexual reproduction, sexual reproduction results in genetically diverse offspring.

c Vegetative reproduction, exemplified by the creation of new individuals from a portion of the root or stalk of a sweet potato or potato, is a form of sexual reproduction.

d In asexual reproduction, gametes are formed.

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

Q8 What are the nuclear phases of the fertilized egg and the endosperm nucleus after double fertilization takes place in the embryo sac of an angiosperm? From ①－⑥ below choose the correct combination, where the nuclear phase of a sperm cell is defined as n. **9**

	Fertilized egg	Endosperm nucleus
①	$2n$	n
②	$2n$	$2n$
③	$2n$	$3n$
④	$3n$	n
⑤	$3n$	$2n$
⑥	$3n$	$3n$

Q9 The following table lists the concentration (%) of constituents of blood plasma and urine in the human kidney. From ①－⑤ below choose the answer that best indicates the concentration ratio of urea when urine is formed from blood plasma. **10**

Constituent	Blood plasma (%)	Urine (%)
Water	90 – 93	95
Glucose	0.10	0
Na^+	0.30	0.35
Urea	0.03	1.80

① 0.02　② 0.6　③ 1.2　④ 60　⑤ 99

Q10 Read the following paragraph and answer questions (1) and (2) below.

Human body temperature is regulated by the autonomic nervous system and the endocrine system. In a cold environment, $\boxed{\text{ A }}$ nerves act upon the blood vessels and arrector pili muscles to suppress the loss of heat from the body surface. The body also responds to the lowering of its temperature by secreting hormones such as thyroxine that stimulate heat generation by the skeletal muscles and the $\boxed{\text{ B }}$.

(1) From ①–⑥ below choose the combination of terms that correctly fills blanks $\boxed{\text{ A }}$ and $\boxed{\text{ B }}$ in the paragraph. $\boxed{\textbf{11}}$

	A	B
①	sympathetic	kidney
②	sympathetic	liver
③	sympathetic	heart
④	parasympathetic	kidney
⑤	parasympathetic	liver
⑥	parasympathetic	heart

(2) The following figure schematically represents the pathway of thyroxine secretion in humans. From ①–⑥ below choose the combination of terms that correctly identifies the organs represented by X and Y in the figure. **12**

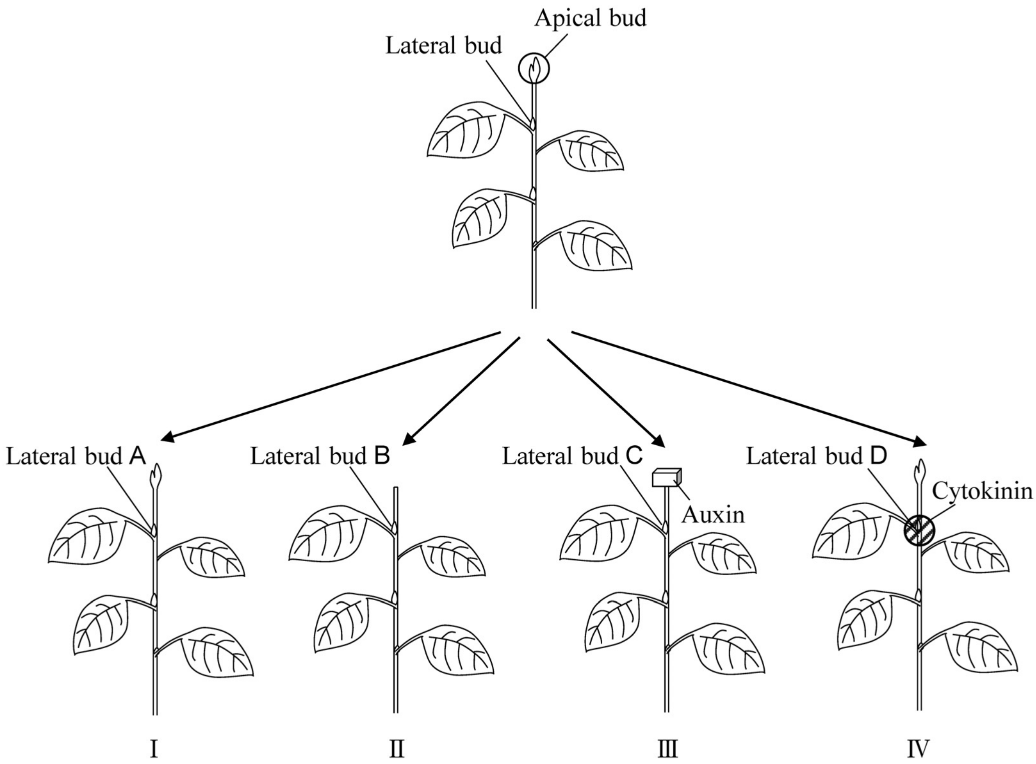
X → Anterior pituitary → Y ⇒ Thyroxine secretion

	X	Y
①	mesencephalon	thyroid
②	mesencephalon	pancreas
③	hypothalamus	thyroid
④	hypothalamus	pancreas
⑤	medulla oblongata	thyroid
⑥	medulla oblongata	pancreas

Q11 From ①–⑥ below choose the combination of terms that correctly identifies the human ear organ where auditory cells are located, a, and the structure involved in excitation of auditory cells, b. **13**

	a	b
①	semicircular canal	tectorial membrane
②	vestibule	tectorial membrane
③	cochlea	tectorial membrane
④	semicircular canal	statolith
⑤	vestibule	statolith
⑥	cochlea	statolith

Q12 The following figure schematically represents four experiments (I – IV) using a plant that exhibits apical dominance. From ①–⑥ below choose the combination that correctly indicates the two lateral buds among A – D that exhibited growth. **14**



I : Untreated.

II : Apical bud removed.

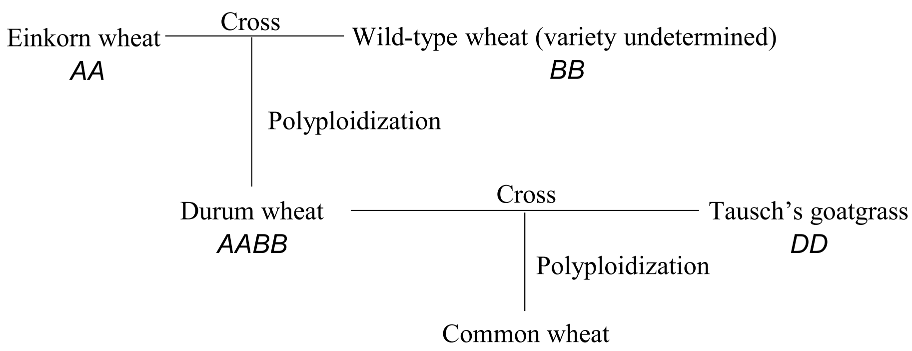
III : Apical bud removed; agar containing auxin placed on the cut surface.

IV : Cytokinin applied to lateral bud D.

① A, B　② A, C　③ A, D　④ B, C　⑤ B, D　⑥ C, D

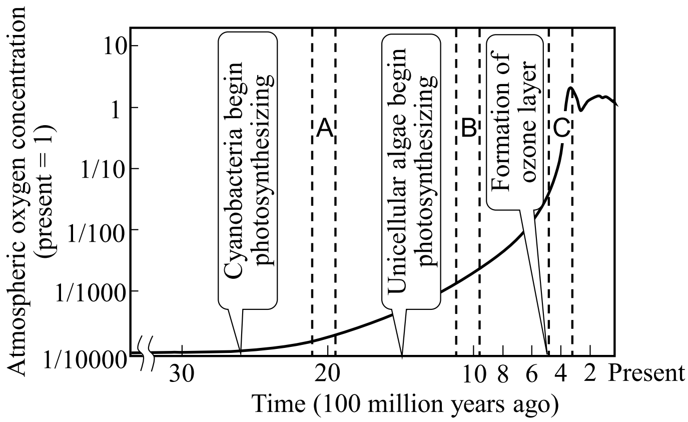
Q13 As shown in the figure below, common wheat (*Triticum aestivum*) is the product of crossings of different types of wheat and polyploidization of the chromosomes. How many times higher is the number of chromosomes in common wheat than in einkorn wheat (*Triticum monococcum*)? From ①–④ below choose the correct answer.

Note that durum wheat (*Triticum durum*) is tetraploid, and that durum wheat's parents and Tausch's goatgrass (*Aegilops tauschii*) are diploid. A/B/D in the figure represent different genomes. $\boxed{15}$



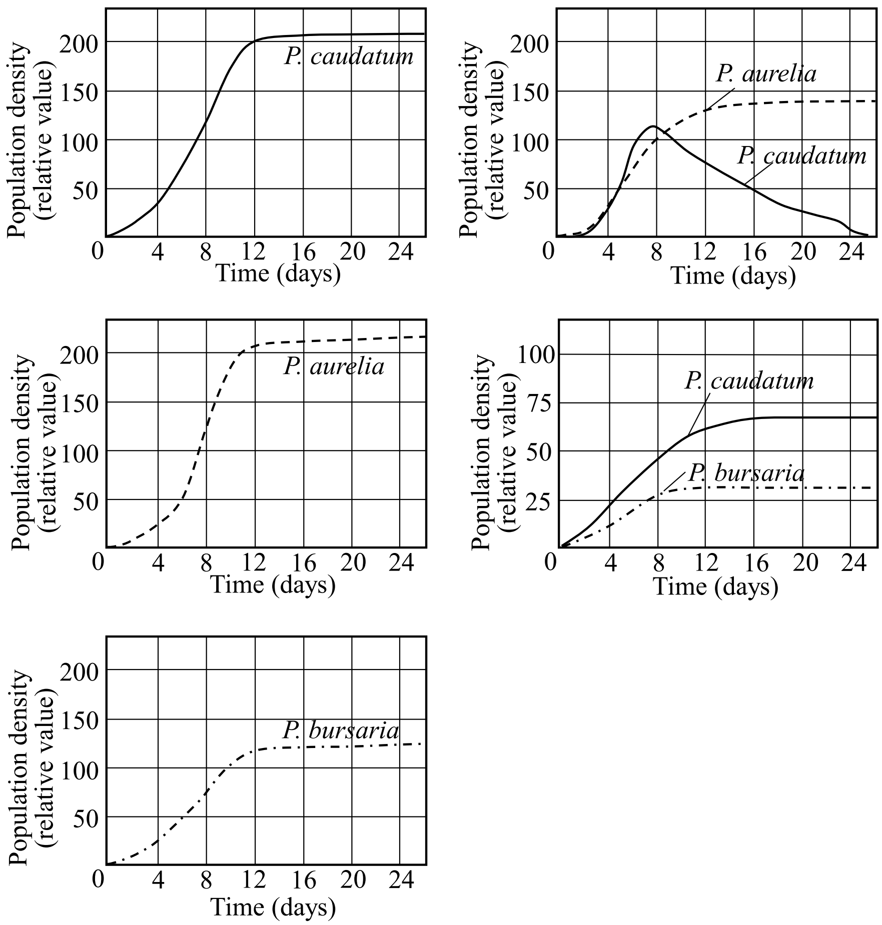
① 2 times ② 3 times ③ 4 times ④ 8 times

Q14 The following figure shows how the oxygen concentration of the earth's atmosphere has changed across time. From ①－⑥ below choose the combination that correctly indicates events that occurred in periods A – C in the figure. **16**



	A	B	C
①	living organisms begin colonizing land	the first multicellular organisms appear	the first eukaryotes appear
②	living organisms begin colonizing land	the first eukaryotes appear	the first multicellular organisms appear
③	the first eukaryotes appear	living organisms begin colonizing land	the first multicellular organisms appear
④	the first eukaryotes appear	the first multicellular organisms appear	living organisms begin colonizing land
⑤	the first multicellular organisms appear	living organisms begin colonizing land	the first eukaryotes appear
⑥	the first multicellular organisms appear	the first eukaryotes appear	living organisms begin colonizing land

Q15 The following figures show the proliferation of *Paramecium caudatum*, *Paramecium aurelia*, and *Paramecium bursaria* when cultured separately, and when two of these three species are cultured together. From ①–④ below choose the combination indicating the two statements in a – d below that best describe these results. **17**



a　*P. caudatum* and *P. aurelia* can coexist for a long period of time.

b　*P. caudatum* and *P. aurelia* cannot coexist for a long period of time.

c　*P. caudatum* and *P. bursaria* can coexist for a long period of time.

d　*P. caudatum* and *P. bursaria* cannot coexist for a long period of time.

① a, c　　② a, d　　③ b, c　　④ b, d

Q16 From ①–④ below choose the statement that does **not** correctly describe bioaccumulation. 18

① Bioaccumulation is a phenomenon in which a particular substance accumulates in an organism's body at a relatively high concentration compared with the surrounding environment.

② Bioaccumulation often involves fat-soluble substances that are not readily broken down in the body, or substances that are not readily eliminated by the body.

③ Bioaccumulated substances accumulate at higher concentrations in low-level consumers than in high-level consumers.

④ DDT (dichlorodiphenyltrichloroethane), formerly used as an insecticide, is known to be a bioaccumulating substance.

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.