

2013 Examination for Japanese University Admission
for International Students

Science (80min.)

【Physics, Chemistry, Biology】

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

I Rules of Examination

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

II Rules and Information Concerning the Question Booklet

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

Subject	Pages
Physics	1 – 21
Chemistry	23 – 32
Biology	33 – 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 informed 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.

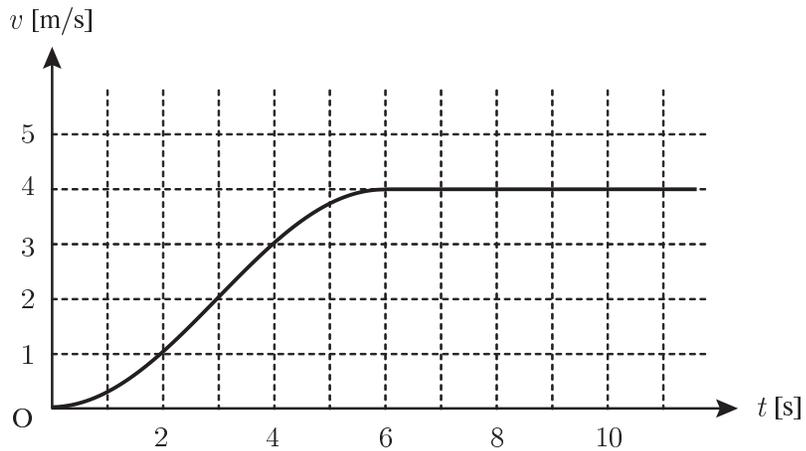
If you do not correctly fill in the appropriate oval, your answers will not be graded.

<Example>

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

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 A bicycle is traveling in a straight line. The figure below shows the relationship between time t [s] and the bicycle's velocity v [m/s].



Q1 What is the distance traveled by the bicycle from time $t = 0$ s to time $t = 10$ s? From

①-⑤ below choose the best value.

1 m

① 12

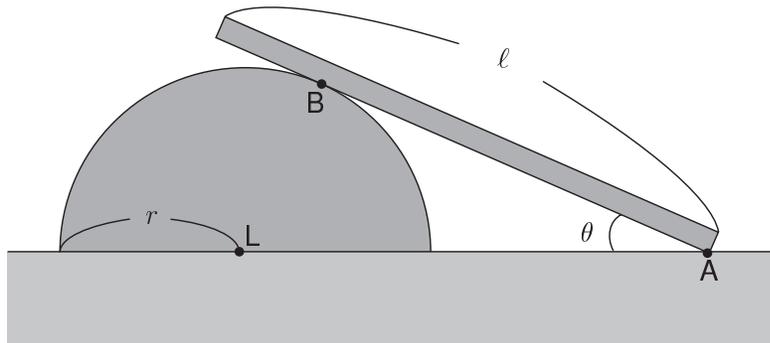
② 16

③ 20

④ 28

⑤ 40

B A half cylinder (half of a cylinder bisected along a plane that includes the central axis L ; the cylinder's radius is r) is fixed on a horizontal floor. As shown in the figure below, a thin uniform rod (length: ℓ ; mass: m) is placed so that it is in contact with the floor at point A , and with the half cylinder at point B . The rod is at rest. The rod exists within a plane that is perpendicular to the central axis L , and the angle formed by the rod and the floor is θ .



Q2 What is the magnitude of the normal force exerted on the rod by the half cylinder at B ?

From ①-⑥ below choose the correct answer.

2

① $\frac{mgl \sin \theta}{2r}$

② $\frac{mgl \cos \theta}{2r}$

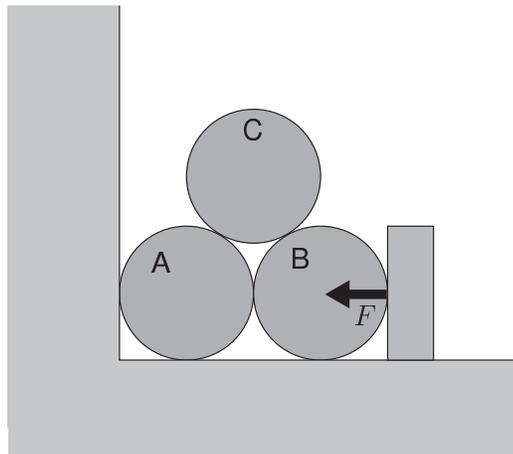
③ $\frac{mgl}{2r \sin \theta}$

④ $\frac{mgl}{2r \cos \theta}$

⑤ $\frac{mgl \sin^2 \theta}{2r \cos \theta}$

⑥ $\frac{mgl \cos^2 \theta}{2r \sin \theta}$

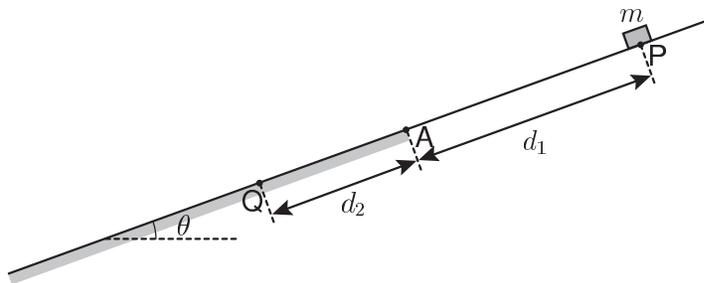
C As shown in the figure below, cylinders A, B, and C are piled on a horizontal floor so that each is in contact with the other two. All three cylinders have the same radius, length, and mass m . A is in contact with a vertical wall, and B is restrained from the right by a force of magnitude F exerted horizontally by a vertical board. The cylinders are uniform, and friction between the cylinders, and between the cylinders and the floor is negligible.



Q3 What is the minimum of F necessary to maintain the condition described above? From ①-⑥ below choose the best answer. **3**

- | | | |
|--------------------------|--------------------------|---------------------------|
| ① $\sqrt{3}mg$ | ② $\frac{\sqrt{3}}{2}mg$ | ③ $\frac{\sqrt{3}}{3}mg$ |
| ④ $\frac{\sqrt{3}}{4}mg$ | ⑤ $\frac{\sqrt{3}}{6}mg$ | ⑥ $\frac{\sqrt{3}}{12}mg$ |

D Consider a slope that forms angle θ with the horizontal. The slope is frictionless above point A on its surface, and has friction below point A. As shown in the figure below, a small object (mass: m) is gently placed above A at point P on the slope. The object begins to slide along the slope, and comes to rest below A at point Q on the slope. The distance between P and A is d_1 , and the distance between A and Q is d_2 . The coefficient of kinetic friction between the object and the slope below A is μ' .



Q4 What is μ' ? From ①-⑥ below choose the correct answer.

4

① $\frac{d_1}{d_2} \sin \theta$

② $\frac{d_1}{d_2} \cos \theta$

③ $\frac{d_1}{d_2} \tan \theta$

④ $\frac{d_1 + d_2}{d_2} \sin \theta$

⑤ $\frac{d_1 + d_2}{d_2} \cos \theta$

⑥ $\frac{d_1 + d_2}{d_2} \tan \theta$

E A small object A (mass: m), traveling in a straight line with a speed of v , collides with a small object B (mass: M), which is at rest. After the collision, B begins traveling in the same straight line with a speed of $\frac{1}{2}v$.

Q5 What is the coefficient of restitution between A and B? From ①-⑥ below choose the correct answer. **5**

① $\frac{1}{2} \left(\frac{M}{m} + 1 \right)$

② $\frac{1}{2} \frac{M}{m}$

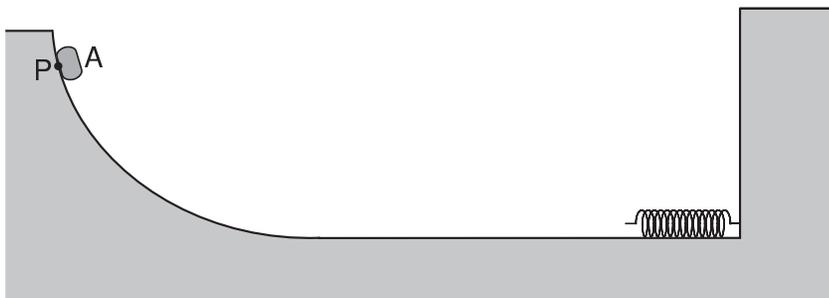
③ $\frac{1}{2} \left(\frac{M}{m} - 1 \right)$

④ $\frac{1}{2} \left(1 + \frac{m}{M} \right)$

⑤ $\frac{1}{2} \frac{m}{M}$

⑥ $\frac{1}{2} \left(1 - \frac{m}{M} \right)$

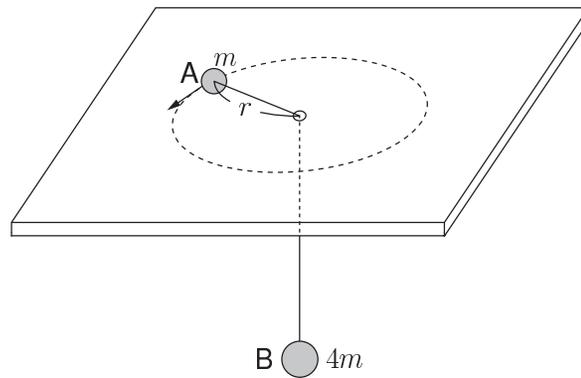
F As shown in the figure below, a frictionless slope is seamlessly joined with a frictionless horizontal floor. A spring is placed on the floor and is fixed to a wall at one end. A small object A (mass: 20 g) is placed at point P on the slope and is gently released. The object A slides down the slope and travels with uniform motion across the floor. The object A then collides with the unfixed end of the spring, causing the spring to compress. The speed of A on the floor before colliding with the spring was 2.0 m/s, and the maximum compression of the spring was 2.0 cm.



Q6 The same experiment is repeated using a small object B (mass: 80 g) instead of A. From ①-⑥ below choose the combination that best indicates the speed of B on the floor before colliding with the spring, and the maximum compression of the spring. **6**

	①	②	③	④	⑤	⑥
Speed on floor [m/s]	2.0	2.0	2.0	4.0	4.0	4.0
Maximum compression of spring [cm]	2.0	4.0	8.0	2.0	4.0	8.0

G A small hole is drilled in a fixed horizontal board, and a lightweight inelastic string is passed through the hole. A small object **A** (mass: m) is attached to the end of the string above the board, and a weight **B** (mass: $4m$) is attached to the other end. As shown in the figure below, **B** is at rest as **A** travels in uniform circular motion with radius r . Friction between **A** and the board, and between the string and the hole is negligible.



Q7 What is the speed of **A**? From ①-⑤ below choose the correct answer.

7

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

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

A Consider three objects designated **A**, **B**, and **C**. First, **A** is placed in contact with **B**. As a result, the temperature of **A** decreases by 4.0 K, and the temperature of **B** increases by 16.0 K, with both objects reaching a temperature of 75.0°C. Next, **B** is placed in contact with **C**. As a result, the temperature of **B** decreases by 15.0 K, and the temperature of **C** increases by 2.5 K, with both objects reaching a temperature of 60.0°C. Assume that there is no exchange of heat with the environment.

Q1 The objects **A** and **C** are placed in contact with each other when the temperature of **A** is 75.0°C and the temperature of **C** is 60.0°C. What is the temperature (in °C) of both objects after sufficient time elapses? From ①-④ below choose the best answer. **8** °C

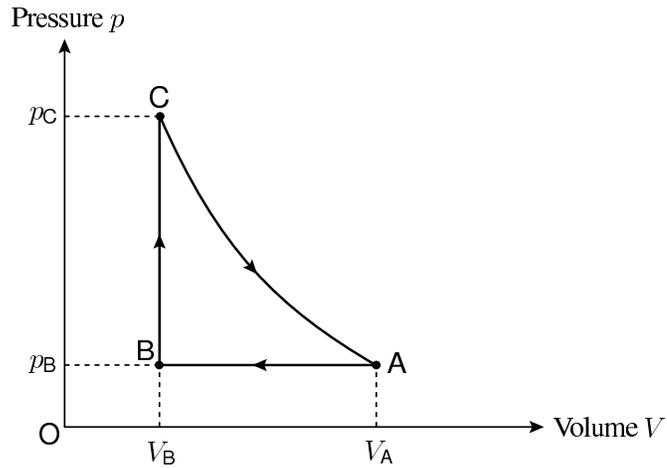
① 63.0

② 66.0

③ 69.0

④ 72.0

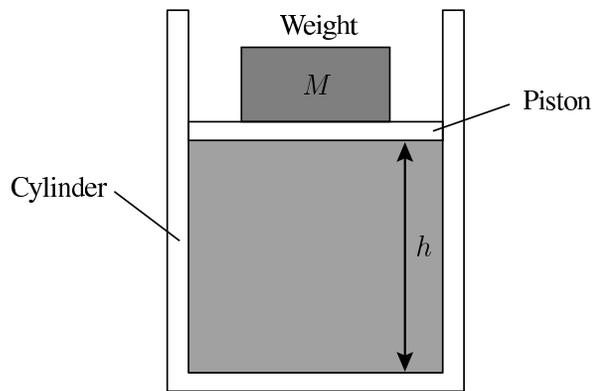
B The state of a fixed amount of ideal gas is changed in the path $A \rightarrow B \rightarrow C \rightarrow A$ as shown in the p - V diagram below. Here, $C \rightarrow A$ is an isothermal change.



Q2 From ①-⑥ below choose the combination that correctly indicates whether the gas absorbs or emits heat during changes $A \rightarrow B$, $B \rightarrow C$, $C \rightarrow A$. 9

	$A \rightarrow B$	$B \rightarrow C$	$C \rightarrow A$
①	absorbs	absorbs	emits
②	absorbs	emits	absorbs
③	emits	absorbs	absorbs
④	emits	emits	absorbs
⑤	emits	absorbs	emits
⑥	absorbs	emits	emits

- C** As shown in the figure below, a monatomic ideal gas (amount of substance: n mol) is enclosed in a cylinder using a piston of negligible mass (cross-sectional area: S). A weight of mass M is placed on the piston, causing the piston to be at rest at height h above the bottom of the cylinder. Let us denote the external pressure as p_0 , the magnitude of acceleration due to gravity as g , the Avogadro constant as N_A , and the mass of one molecule of the gas as m . Friction between the cylinder and the piston is negligible.

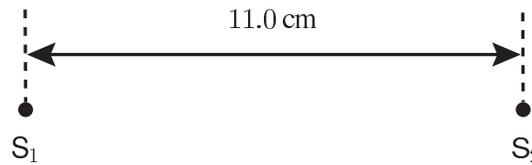


- Q3 What is the mean-square speed $\overline{v^2}$ of the molecules of this gas? From ①-⑥ below choose the correct answer. **10**

- | | | |
|----------------------------------|-----------------------------------|-----------------------------------|
| ① $\frac{(p_0S + Mg)h}{2nN_A m}$ | ② $\frac{(p_0S + Mg)h}{nN_A m}$ | ③ $\frac{3(p_0S + Mg)h}{2nN_A m}$ |
| ④ $\frac{2(p_0S + Mg)h}{nN_A m}$ | ⑤ $\frac{5(p_0S + Mg)h}{2nN_A m}$ | ⑥ $\frac{3(p_0S + Mg)h}{nN_A m}$ |

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

A Point sources S_1 and S_2 on the surface of water are separated by a distance of 11.0 cm and are both generating circular waves that have the same wavelength (3.0 cm) and amplitude, and are in the same phase.



Q1 At how many points on a straight line connecting S_1 and S_2 does the water surface show almost no oscillation? From ①-⑦ below choose the correct value. **11**

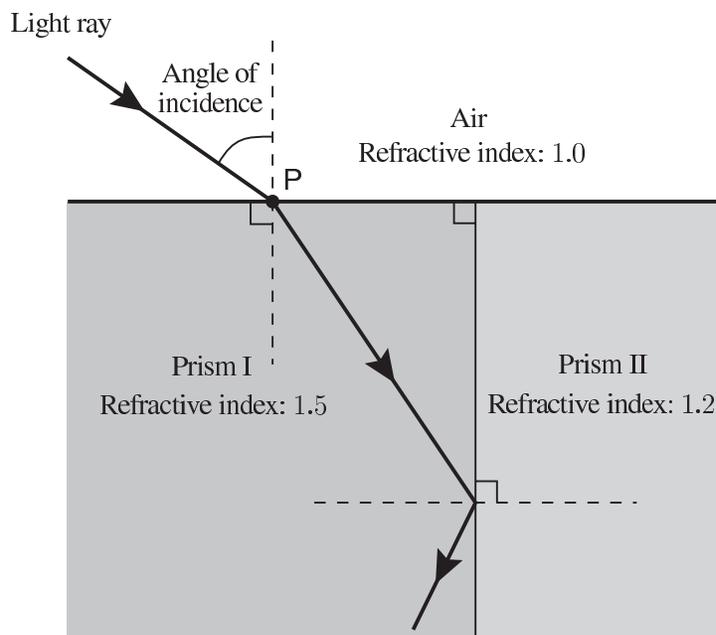
- ① 3 ② 4 ③ 5 ④ 6 ⑤ 7 ⑥ 8 ⑦ 9

B A sound source S is emitting sound with a frequency of 500 Hz as it travels with a speed of 20 m/s directly toward a stationary observer O . Here, the speed of sound is 340 m/s.

Q2 What are the wavelength and frequency of the sound wave as observed by O ? From ①-⑨ below choose the best combination. 12

	Wavelength [m]	Frequency [Hz]
①	0.64	4.7×10^2
②	0.64	5.0×10^2
③	0.64	5.3×10^2
④	0.68	4.7×10^2
⑤	0.68	5.0×10^2
⑥	0.68	5.3×10^2
⑦	0.72	4.7×10^2
⑧	0.72	5.0×10^2
⑨	0.72	5.3×10^2

C Two rectangular prisms, I and II, are joined together. Prism I is made of a transparent material whose refractive index is 1.5, and prism II is made of a transparent material whose refractive index is 1.2. A light ray traveling through air is incident upon point P, which is on the surface of prism I and is slightly apart from the boundary between the prisms. As shown in the figure below, the light passes through prism I and is totally reflected at the boundary. As the angle of incidence of the light ray at P is further increased, part of the light enters prism II. The refractive index of air is 1.0.

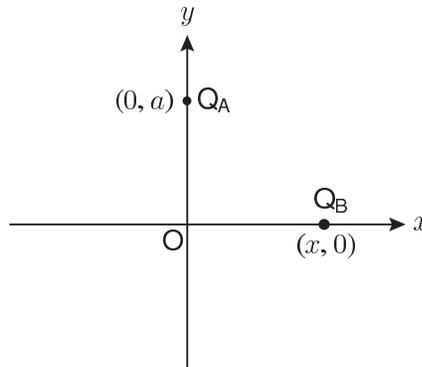


Q3 Let us define θ as the maximum angle of incidence at P for which total reflection occurs at the boundary. What is the value of $\sin \theta$? From ①-⑤ below choose the best answer. **13**

- ① 0.50 ② 0.56 ③ 0.71 ④ 0.86 ⑤ 0.90

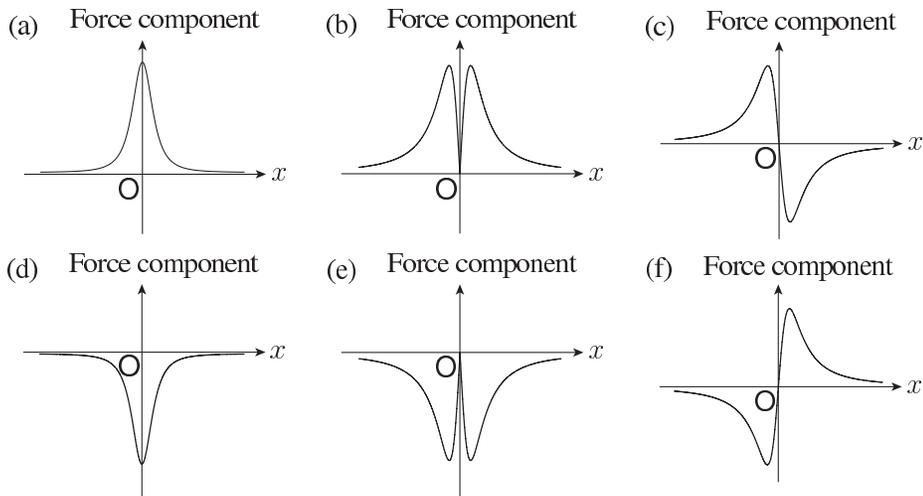
IV Answer questions **A** (Q1), **B** (Q2), **C** (Q3), **D** (Q4), **E** (Q5), and **F** (Q6) below.

A Small sphere Q_A is positively charged and, as shown in the figure below, is fixed in place at point $(0, a)$ in an x - y plane, where $a > 0$. Another positively charged small sphere, Q_B , is placed at point $(x, 0)$.



Q1 Consider the force exerted on Q_B by Q_A . When x is changed, how do this force's x -component and y -component (F_x and F_y , respectively) change? Which of graphs (a)-(f) below represent the change in these force components? From ①-⑧ below choose the best combination.

14



	①	②	③	④	⑤	⑥	⑦	⑧
F_x	(b)	(c)	(e)	(f)	(b)	(c)	(e)	(f)
F_y	(a)	(a)	(a)	(a)	(d)	(d)	(d)	(d)

B A parallel-plate capacitor, whose inter-plate region is filled with a dielectric having a relative permittivity of 3, is charged by connecting it to a battery. Here, the magnitude of the electric field between the plates is denoted as E . Next, the capacitor is disconnected from the battery, and then the dielectric is removed and the distance between the plates is doubled. The magnitude of the electric field between the plates under this condition is denoted as E' .

Q2 What is the value of $\frac{E'}{E}$? From ①-⑧ below choose the best answer.

15

① $\frac{1}{6}$

② $\frac{1}{3}$

③ $\frac{1}{2}$

④ $\frac{2}{3}$

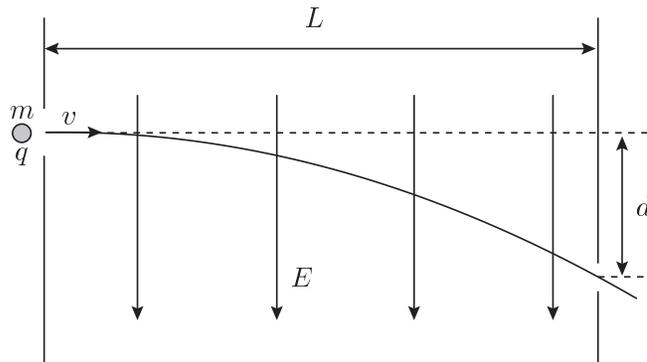
⑤ $\frac{3}{2}$

⑥ 2

⑦ 3

⑧ 6

- C** A uniform electric field with a magnitude of E is applied to a region with length L . As shown in the figure below, a particle (mass: m) carrying charge q is projected into the region, perpendicular to the electric field, with a speed of v . Due to the influence of the electric field, the particle exits the region through a hole that is vertical distance d from the direction of projection. Here, the effect of gravity is negligible.

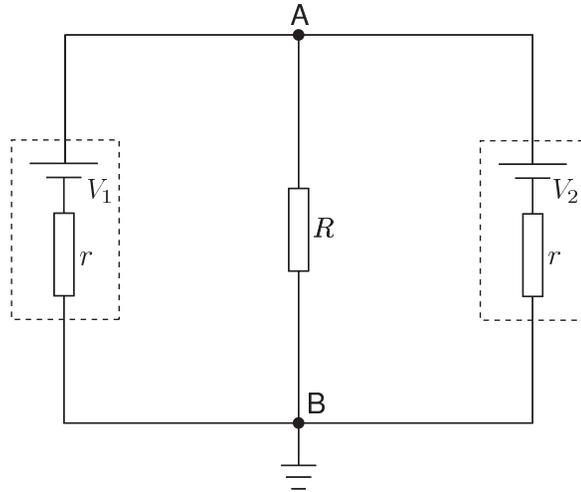


Q3 What is v ? From ①-⑥ below choose the correct answer.

16

- ① $L\sqrt{\frac{qE}{2md}}$ ② $L\sqrt{\frac{qE}{md}}$ ③ $L\sqrt{\frac{2qE}{md}}$
- ④ $\frac{1}{L}\sqrt{\frac{md}{2qE}}$ ⑤ $\frac{1}{L}\sqrt{\frac{md}{qE}}$ ⑥ $\frac{1}{L}\sqrt{\frac{2md}{qE}}$

D Two batteries with the same internal resistance (r) and different electromotive forces (V_1 , V_2) are connected to a resistor with resistance R as shown in the figure below. Let us define point B in the figure as the reference point of electric potential.



Q4 What is the electric potential at point A in the figure? From ①-⑧ below choose the correct answer. **17**

- ① $\frac{R(V_1 + V_2)}{R + 2r}$ ② $-\frac{R(V_1 + V_2)}{R + 2r}$ ③ $\frac{R(V_1 - V_2)}{R + 2r}$ ④ $\frac{R(V_2 - V_1)}{R + 2r}$
- ⑤ $\frac{R(V_1 + V_2)}{2R + r}$ ⑥ $-\frac{R(V_1 + V_2)}{2R + r}$ ⑦ $\frac{R(V_1 - V_2)}{2R + r}$ ⑧ $\frac{R(V_2 - V_1)}{2R + r}$

E An experiment is conducted to examine the direction of the magnetic field generated in two cases: a current I flowing through a straight conducting wire as shown in Figure 1, and a current I flowing through a coil as shown in Figure 2.

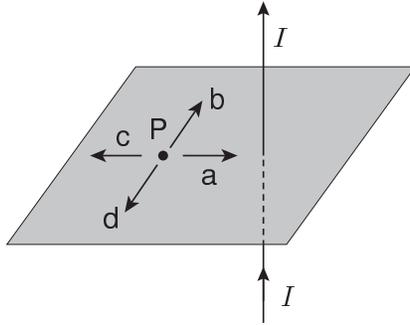


Figure 1

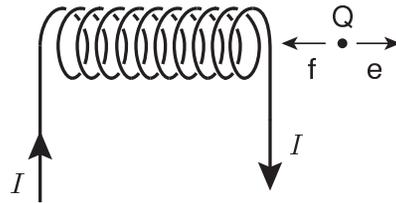
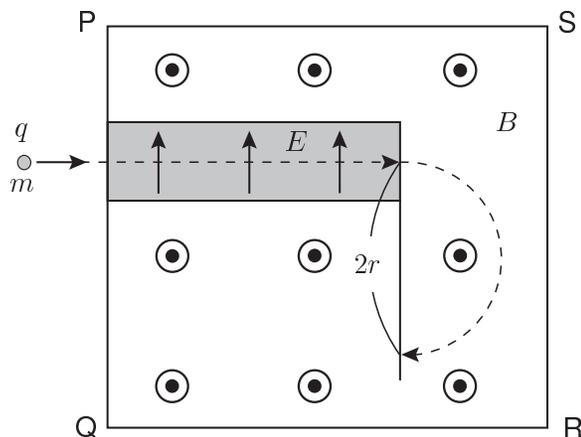


Figure 2

Q5 What is the direction of the magnetic field at point P in Figure 1, and at point Q in Figure 2? Which of arrows a-f in the figures show the magnetic field direction? From ①-⑧ below choose the best combination. 18

	①	②	③	④	⑤	⑥	⑦	⑧
P	a	b	c	d	a	b	c	d
Q	e	e	e	e	f	f	f	f

F A uniform magnetic field (magnitude of magnetic flux density: B) is applied to rectangular region PQRS in the figure below, perpendicular to this page and in the direction from the back of the page to the front. Also, a uniform electric field (magnitude: E) is applied to the shaded area in the figure, parallel to this page and in the upward direction. A particle (mass: m) carrying charge q is projected into the shaded area in a direction perpendicular to both the magnetic field and the electric field. After passing through the shaded area with uniform linear motion, the particle enters the part of region PQRS where only the magnetic field is applied and undergoes uniform circular motion with radius r . Here, the effect of gravity is negligible.



Q6 What is m ? From ①-④ below choose the correct answer.

19

- ① rqE ② $\frac{rqB^2}{E}$ ③ $\frac{qE}{r}$ ④ $\frac{qB^2}{rE}$

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

Do not take this question booklet out of the room.

Chemistry

Marking Your Choice of Subject on the Answer Sheet

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

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

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

< Example >

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

Use the following values for calculation. “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: $F = 9.65 \times 10^4\text{ C}/\text{mol}$

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

Fe : 56 Br : 80

Q1 From the pairs of atoms and/or ions ①-⑥ choose the one that have the same electron configuration. 1

- | | | |
|----------------------------------|--------------------------------|---------------------------------|
| ① Ar, Mg^{2+} | ② F, Mg^{2+} | ③ He, Na^+ |
| ④ K^+ , S^{2-} | ⑤ Li^+ , F^- | ⑥ Na^+ , Cl^- |

Q2 From the following elements ①-⑥ choose the one that has the lowest electronegativity.

2

- ① C ② F ③ H ④ N ⑤ Na ⑥ O

Q3 From the following substances ①-⑤ choose the one that has the largest number of hydrogen atoms in 10 g of it.

3

- ① ammonia (NH₃) ② hydrogen fluoride (HF) ③ methane (CH₄)
④ methanol (CH₃OH) ⑤ water (H₂O)

Q4 Two of the following substances (a)-(e) are nonpolar. From ①-⑦ below choose the combination of them.

4

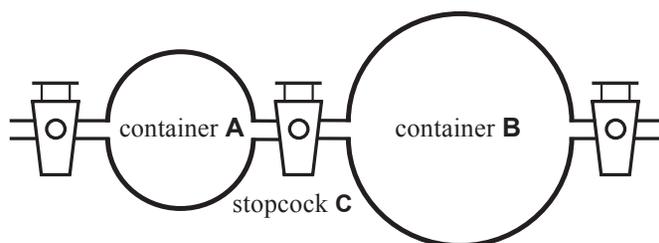
- (a) carbon dioxide (b) carbon monoxide (c) methanol
(d) oxygen (e) water

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

- Q5** From ①-⑥ below choose the closest figure for the number of iron (Fe) atoms which are contained in an iron cube with each side having a length of 1.0 cm. Assume that the density of iron is 7.9 g/cm^3 . **5**

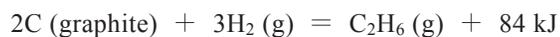
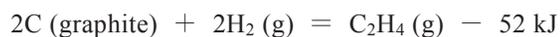
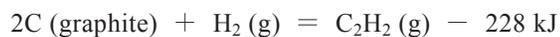
- ① 4.2×10^{22} ② 4.2×10^{23} ③ 4.2×10^{24}
 ④ 8.5×10^{22} ⑤ 8.5×10^{23} ⑥ 8.5×10^{24}

- Q6** In the figure shown below, an apparatus with a stopcock **C** connects a glass container **A** with a volume of 0.500 L to another glass container **B** with a volume of 1.50 L. Containers **A** and **B** contain nitrogen (N_2), at 1.00 atm in **A** and 2.00 atm in **B**, when all stopcocks are closed. After the stopcock **C** is opened, what will the pressure in atm be in the container at the same temperature? From ①-⑤ choose the closest value. **6** atm



- ① 1.00 ② 1.25 ③ 1.50 ④ 1.75 ⑤ 2.00

- Q7** The heats of formation of acetylene (ethyne) (C_2H_2), ethylene (ethene) (C_2H_4), and ethane (C_2H_6) are given by the following thermochemical equations, respectively.



Calculate the amount of heat released in kJ when 0.500 mol of ethylene (ethene) and 0.500 mol of ethane are obtained by hydrogenation of 1.00 mol of acetylene (ethyne). From the following ①-⑥ choose the closest value. **7** kJ

- ① 88 ② 156 ③ 176 ④ 244 ⑤ 312 ⑥ 488

- Q8** Reactions in column **A** of the following table are in equilibrium states. When the conditions are changed as indicated in column **B**, will each equilibrium shift to the left or to the right? From the following ①-⑤ choose the **incorrect** one from column **C** that indicates the direction of the shift.

8

	A	B	C
①	$\text{CH}_3\text{COOH} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}^+$	to increase pH	right
②	$\text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$	to add water	left
③	$\text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$	to add NaOH	left
④	$\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$	to raise the pressure	right
⑤	$\text{H}^+ + \text{OH}^- \rightleftharpoons \text{H}_2\text{O}$	to heat	left

- Q9** Dilute sulfuric acid (dil. H_2SO_4) was electrolyzed with the aid of platinum electrodes. Suppose 19300 C of electricity was applied. Calculate the sum of the amount of gases in mol generated from the anode and the cathode. From ①-⑥ below choose the closest value.

9 mol

- ① 0.050 ② 0.10 ③ 0.15 ④ 0.20 ⑤ 0.25 ⑥ 0.30

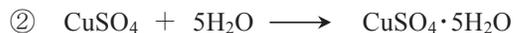
- Q10** Suppose 10.1 mL of 0.200 mol/L aqueous sodium hydroxide ($\text{NaOH} (aq)$) is added to 10.0 mL of 0.200 mol/L hydrochloric acid ($\text{HCl} (aq)$). From the following ①-⑥ choose the closest figure for the pH of the resultant aqueous solution.

10

- ① 8 ② 9 ③ 10 ④ 11 ⑤ 12 ⑥ 13

Q11 From the reactions ①-⑥ below choose the one that is an oxidation-reduction reaction.

11



Q12 From the following statements ①-⑤ with regard to the gases CO_2 , H_2 , HCl , He , and NH_3 , choose the one that is not correct.

12

① All the gases are colorless.

② CO_2 is soluble in water to form a weak acid.

③ HCl is soluble in water to form a strong acid.

④ NH_3 is soluble in water to form a strong base.

⑤ Among these gases, the reactivity of He is the lowest.

Q13 From ①-⑥ in the table below choose the correct combination of “true” or “false” judgments for the following statements (a)-(e) on sodium chloride (NaCl). 13

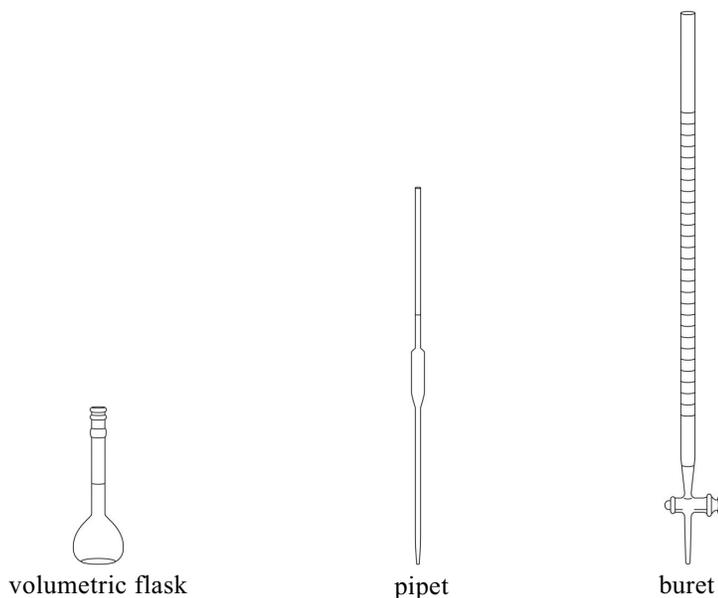
- (a) In its crystal, sodium ion (Na^+) and chloride ion (Cl^-) are alternately and regularly arranged.
- (b) Sodium (Na) and chlorine (Cl) belong to different periods in the periodic table.
- (c) Sodium and chlorine atoms are bonded by covalent bonds.
- (d) When a platinum wire is dipped in its aqueous solution and is then placed in a flame, the flame turns yellow.
- (e) The solid does not exhibit an electric conduction property, but its aqueous solution does.

	a	b	c	d	e
①	true	true	true	true	false
②	true	false	true	true	true
③	true	false	false	true	true
④	false	true	false	true	true
⑤	false	true	true	false	false
⑥	false	false	false	true	true

Q14 There is an aqueous solution that contains one kind of cation. Suppose the aqueous solution is taken in two test tubes. From ①-⑤ below choose the most appropriate one which forms precipitates of its hydroxide in both test tubes when aqueous ammonia ($\text{NH}_3(aq)$) is added to one test tube and aqueous sodium hydroxide ($\text{NaOH}(aq)$) to the other, both in excess. 14

- ① Ag^+ ② Al^{3+} ③ Cu^{2+} ④ Fe^{3+} ⑤ K^+

Q15 Suppose the concentration of vinegar is to be diluted precisely to $\frac{1}{10}$ with the aid of a volumetric flask and an apparatus **A**, pipet or buret, which is wet as it has been washed with distilled water. From the combinations ①-⑥ below choose the most appropriate one that contains the name of apparatus **A** used and the method of using it. **15**



	Apparatus A used	Method of using
①	pipet	to use as it is
②	pipet	to use after heating and drying
③	pipet	to use after rinsing several times with the vinegar to be diluted
④	buret	to use as it is
⑤	buret	to use after heating and drying
⑥	buret	to use after rinsing several times with the vinegar to be diluted

Q16 From the following ①-⑥ choose the one that is correct for the number of structural isomers with the molecular formula C_3H_6BrCl . **16**

- ① 1 ② 2 ③ 3 ④ 4 ⑤ 5 ⑥ 6

Q17 Two of the following statements (a)-(e) with regard to reactions involving alcohols are not correct. From pairs ①-⑥ below choose the combination of them. **17**

- (a) Ethanol reacts with sodium (Na) to form ethylene (ethene).
 (b) If acetaldehyde is reduced, methanol is formed.
 (c) If methyl salicylate is hydrolyzed, salicylic acid and methanol are formed.
 (d) If ethylene (ethene) is reacted with water vapor in the presence of a catalyst, ethanol is formed.
 (e) If carbon monoxide (CO) and hydrogen (H_2) are reacted in the presence of a catalyst, methanol is formed.

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

Q18 When 21 g of an unsaturated hydrocarbon, with a mass ratio of carbon C to hydrogen H = 6 : 1, was reacted with bromine Br_2 , 61 g of the product was obtained. From ①-⑧ below choose the correct molecular formula for the unsaturated hydrocarbon. **18**

- ① C_4H_6 ② C_4H_8 ③ C_5H_8 ④ C_5H_{10}
 ⑤ C_6H_{10} ⑥ C_6H_{12} ⑦ C_7H_{12} ⑧ C_7H_{14}

Q19 In industry, phenol and acetone (2-propanone) are synthesized from benzene and propylene (propene) by the cumene process. How many kg of phenol and acetone (2-propanone) are synthesized, respectively, from 39 kg of benzene? From ①-⑥ below choose the most appropriate combination. **19**

	Phenol (kg)	Acetone (2-propanone) (kg)
①	29	58
②	47	29
③	94	47
④	29	29
⑤	47	58
⑥	94	29

Q20 Among the following compounds (a)-(f), two are classified as phenols. From ①-⑥ below choose the combination of them. **20**

- (a) aniline (b) benzyl alcohol (c) cresol
 (d) phthalic acid (e) salicylic acid (f) toluene

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

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.

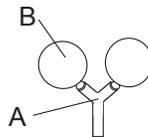
As shown in the example on the right, if you answer the Biology questions, circle “Biology” and completely fill in the oval under the subject name.

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** The figure below schematically represents the antigen-antibody reaction observed between a certain type of antigen and a certain type of antibody. A and B in the figure represent either an antigen or an antibody. From ①–⑥ below choose the combination indicating the two statements in (a)–(e) below that correctly describe this reaction. 1



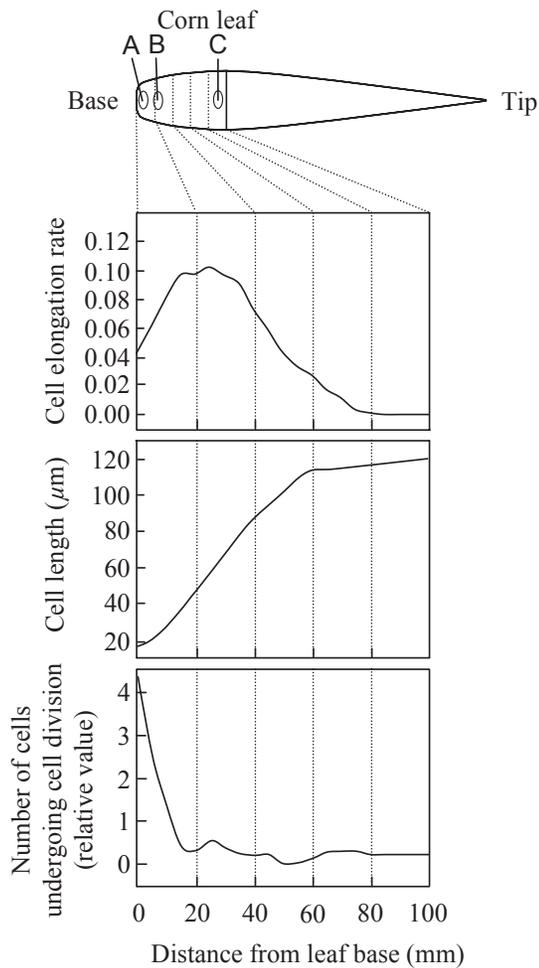
Antigen-antibody complex

- (a) The variable region of A binds specifically with B.
 (b) The constant region of A binds specifically with B.
 (c) A is involved in cell-mediated immunity.
 (d) A has a structure in which one H chain is bound to two L chains.
 (e) One type of A is produced from a single antibody-forming cell.

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

Q2 The figure below shows, for a growing corn leaf, the relationships between the distance from the leaf base and: (1) cell elongation rate, (2) cell length, and (3) the number of cells undergoing cell division. From ①–⑥ on the following page choose the combination that correctly indicates which of A–C in the figure is the region where cell elongation is vigorous, the region where somatic cell division is vigorous, and the region where elongation ends.

2



	Region where cell elongation is vigorous	Region where somatic cell division is vigorous	Region where elongation ends
①	A	B	C
②	A	C	B
③	B	A	C
④	B	C	A
⑤	C	A	B
⑥	C	B	A

Q3 Answer questions (1) and (2) below concerning reproduction.

(1) Reproduction is largely divided into two methods. The following table lists general characteristics of these two methods (A, B).

	A	B
Genetic makeup of offspring	Different from parents	Same as parents
Genetic diversity	Readily occurs	Does not readily occur

Both A and B are subdivided into several reproductive methods. From ①–⑥ below choose the combination correctly indicating all statements in (a)–(f) below that describe reproductive methods classified under A. **3**

- (a) A new individual is formed from the union of two gametes that differ from each other in size and shape.
- (b) A new individual is formed from the development and separation of a bud-like structure on part of the body.
- (c) The original individual divides into two new individuals of nearly the same size.
- (d) Part of a plant root, stem or leaf separates into a new individual after a period of growth.
- (e) A new individual is formed from the union of a motile male gamete and a nonmotile female gamete.
- (f) A new individual is formed from the union of two gametes that have the same size and shape.

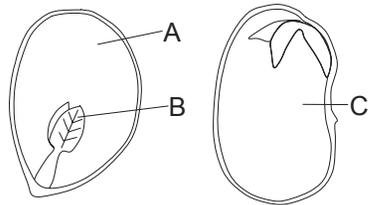
- ① a, d ② a, e ③ b, c, d ④ b, e, f ⑤ a, e, f
 ⑥ c, e, f

(2) From ①–⑤ below choose an organism that exhibits the reproduction method described by statement (f) in question (1) above.

4

- ① sea urchin
- ② sea lettuce (*Ulva*)
- ③ *Chlamydomonas*
- ④ potato
- ⑤ amoeba

Q4 The figure below schematically represents cross sections of an albuminous seed and an exalbuminous seed.



Albuminous seed Exalbuminous seed

Alleles X (x) code for a certain character in a plant that produces albuminous seeds, and alleles Y (y) code for a certain character in a plant that produces exalbuminous seeds. From ①–⑥ below choose the combination that best indicates a possible genotype of cells in regions A, B, and C in the figure.

5

	A	B	C
①	XX	XX	YY
②	XX	xxx	Yyy
③	Xx	XX	Yy
④	XXX	XX	YYy
⑤	XXx	Xx	YY
⑥	Xxx	Xxx	yy

Q5 Experiments I–III below involve dividing an animal embryo into two halves (bisection). From ①–⑥ below choose the combination indicating the statements in (a)–(c) below that correctly describe how the bisected embryo in each experiment would develop. There is no need to consider the size of the complete larvae mentioned in (a)–(c). 6

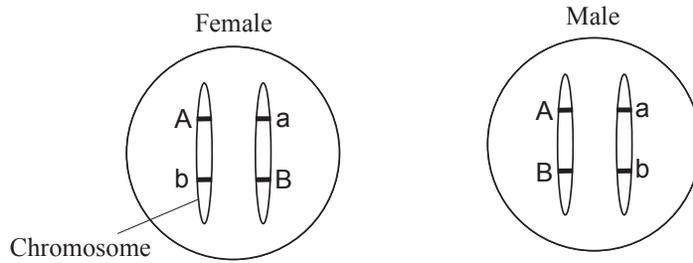
- I A two-celled comb jelly embryo is bisected along the first cleavage plane.
- II A two-celled sea urchin embryo is bisected along the first cleavage plane.
- III A two-celled newt embryo is bisected by tightly constricting it with a loop of hair so that the gray crescent is contained in only one half.

- (a) No complete larvae would develop.
- (b) Only one complete larva would develop.
- (c) Two complete larvae would develop.

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

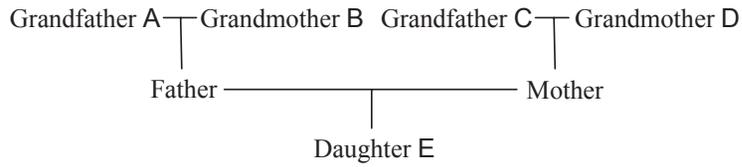
Q6 In a certain animal, chromosomal crossing-over occurs in the female, but not in the male. If A (a) and B (b), two pairs of alleles on the same chromosome in this animal, have a recombination value of 20%, what would be a probable segregation ratio of the phenotypes of offspring produced from the crossing of two individuals with the genes shown in the figure below? From ①–⑤ below choose the best answer, where phenotypes are enclosed in brackets [].

7



	[AB]	:	[Ab]	:	[aB]	:	[ab]
①	2	:	1	:	1	:	0
②	3	:	1	:	3	:	1
③	9	:	3	:	3	:	1
④	11	:	4	:	4	:	1
⑤	54	:	21	:	21	:	4

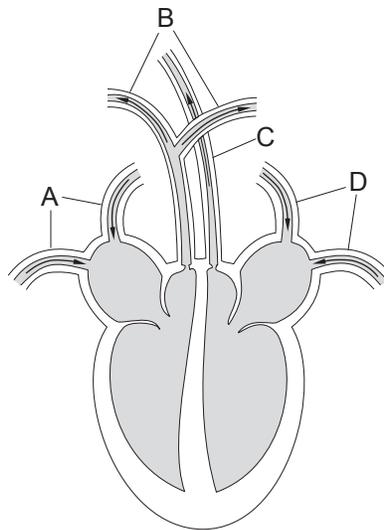
Q7 In the following family tree, from which grandparents (A–D) do the X chromosomes of Daughter E derive? Assuming that no chromosomal crossing-over occurs, from ①–⑧ below choose the answer indicating all grandparents that may have been the sources. 8



- | | | | |
|-----------|-----------|-----------|-----------|
| ① A, C | ② A, D | ③ B, C | ④ B, D |
| ⑤ A, B, C | ⑥ A, B, D | ⑦ A, C, D | ⑧ B, C, D |

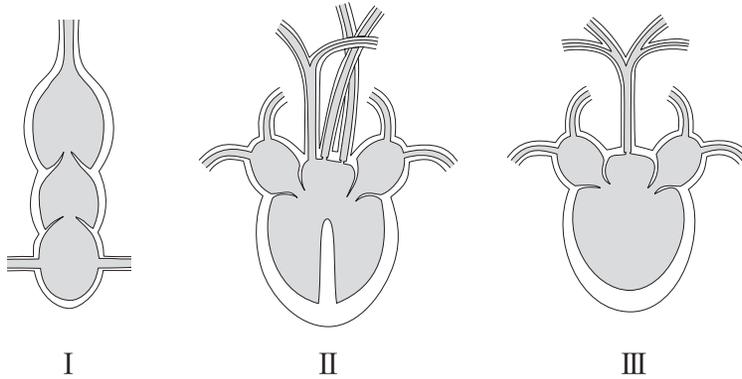
Q8 Answer questions (1) and (2) below concerning vertebrate hearts.

- (1) The figure below schematically represents the human heart. The arrows in the figure represent the direction of blood flow. Compared with blood flowing in vessels A, blood flowing in vessels D is a brighter hue of red. In what paths does blood flow in systemic circulation and pulmonary circulation? Also, does cardiac muscle consist of striated muscle, or smooth muscle? From ①–④ below choose the correct combination. 9



	Systemic circulation	Pulmonary circulation	Cardiac muscle
①	B → bodily tissues → D	C → lungs → A	striated muscle
②	B → bodily tissues → D	C → lungs → A	smooth muscle
③	C → bodily tissues → A	B → lungs → D	striated muscle
④	C → bodily tissues → A	B → lungs → D	smooth muscle

(2) Figures I–III below schematically represent vertebrate hearts. From ①–⑧ below choose the combination correctly indicating vertebrates that typically exhibit these hearts. 10



	I	II	III
①	fishes	birds	amphibians
②	fishes	birds	reptiles
③	fishes	reptiles	amphibians
④	fishes	reptiles	birds
⑤	amphibians	birds	fishes
⑥	amphibians	birds	reptiles
⑦	amphibians	reptiles	birds
⑧	amphibians	reptiles	fishes

Q9 Of the hormones involved in regulation of blood glucose level in humans, let us denote the hormone secreted from the adrenal cortex as A, and the hormone secreted from the adrenal medulla as B. From ①–⑦ below choose the combination correctly indicating which of A and B exhibits the following effects: raising of blood glucose level, lowering of blood glucose level, and stimulation of glycogen breakdown.

11

	Raising of blood glucose level	Lowering of blood glucose level	Stimulation of glycogen breakdown
①	A	B	A
②	A	B	neither
③	B	A	B
④	B	A	neither
⑤	A and B	neither	A and B
⑥	A and B	neither	A
⑦	A and B	neither	B

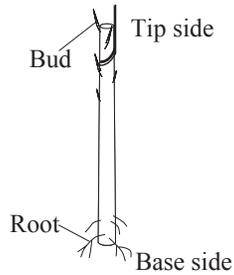
Q10 Growth movement and turgor movement are types of plant movement. Tropism and nasty represent plant responses to stimuli. From ①–⑧ below choose the combination correctly indicating all plant movements described in (a)–(c) below that can be characterized as growth movement, and as nasty.

12

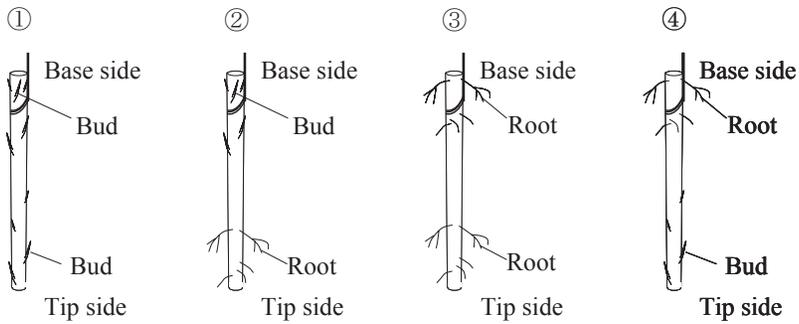
- (a) Tulip petals open when the air temperature rises.
- (b) Sensitive plant (*Mimosa pudica*) leaves close when touched or shaken.
- (c) Onion roots elongate in the direction of gravity.

	Growth movement	Nasty
①	a, b	c
②	a, b	b, c
③	a, c	b
④	a, c	a, b
⑤	b, c	a
⑥	b, c	a, b
⑦	a, b, c	b
⑧	a, b, c	a, c

Q11 A stem was cut from a willow tree and suspended in moist air, with the tip (apex) side at the top. After some time elapsed, buds emerged from the tip side and roots emerged from the base side, as shown in the following figure. 13



Another stem cut from a willow tree was suspended in moist air with the base side at the top. Buds and/or roots formed on this stem after some time elapsed. From ①–④ below choose the figure that correctly represents how the result would appear.



Q12 Alcohol is produced when glucose solution is added to liquid extracted from crushed yeast (yeast liquid). In order for this alcoholic fermentation to take place, a certain enzyme and a certain coenzyme must be present. Experiments 1–4 below were performed to examine this relationship. From ①–⑨ below choose the combination indicating the two statements in (a)–(f) below that can be correctly inferred from the results of these experiments. 14

Experiment 1: Yeast liquid was placed in a semipermeable-membrane pouch, which was then immersed in water for some time to allow dialysis to occur. Next, glucose solution was added to the liquid in the pouch (Liquid A). Very little alcohol was produced.

Experiment 2: Yeast liquid was placed in a semipermeable-membrane pouch, which was then immersed in water for some time to allow dialysis to occur. Next, glucose solution was added to a concentrated sample of the liquid outside the pouch (Liquid B). No alcohol was produced.

Experiment 3: Yeast liquid was boiled (Liquid C) and then glucose solution was added to it. No alcohol was produced.

Experiment 4: Glucose solution was added to a mixture of Liquids A and C. Alcohol was produced.

- (a) The enzyme is present in Liquid B.
- (b) The coenzyme is present in Liquid C.
- (c) The coenzyme molecules are larger than the enzyme molecules.
- (d) The coenzyme is composed of protein.
- (e) Alcohol would be produced if glucose solution is added to a mixture of Liquids A and B.
- (f) Alcohol would be produced if glucose solution is added to a mixture of Liquids B and C.

- ① a, c ② a, d ③ a, f ④ b, c ⑤ b, d ⑥ b, e
- ⑦ b, f ⑧ c, e ⑨ c, f

Q13 Aerobic respiration consists of three processes: glycolysis, the citric acid cycle, and the electron transport system. Statements (a)–(c) below describe these processes. From ①–⑧ below choose the combination that best indicates whether each statement is true (○) or false (×). **15**

- (a) Each of the three processes produces ATP, though in different quantities.
- (b) The reaction of the citric acid cycle takes place on the inner membrane of mitochondria.
- (c) Carbon dioxide is formed only in the citric acid cycle.

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

Q14 Some prokaryotes are not heterotrophic, and instead carry out photosynthesis or chemosynthesis. The following table lists, for three prokaryotes (a–c), the sources of energy they use for assimilation, and the materials that supply the hydrogen used to reduce carbon dioxide.

Prokaryote	Energy source	Material supplying hydrogen
a	light	hydrogen sulfide, etc.
b	light	water
c	oxidation of inorganic substances	water

From ①–⑥ below choose the combination that correctly identifies prokaryotes a–c as cyanobacteria, photosynthetic bacteria, or chemosynthetic bacteria.

16

	a	b	c
①	cyanobacteria	photosynthetic bacteria	chemosynthetic bacteria
②	cyanobacteria	chemosynthetic bacteria	photosynthetic bacteria
③	photosynthetic bacteria	cyanobacteria	chemosynthetic bacteria
④	photosynthetic bacteria	chemosynthetic bacteria	cyanobacteria
⑤	chemosynthetic bacteria	cyanobacteria	photosynthetic bacteria
⑥	chemosynthetic bacteria	photosynthetic bacteria	cyanobacteria

Q15 The following table is a genetic code table that lists, for a certain organism, the mRNA codons and their corresponding amino acids. There are 61 different codons coding for 20 different amino acids. Dashes (—) in the table indicate that a particular codon does not code for an amino acid. Answer questions (1) and (2) on the following page concerning this table.

First base of codon	Second base of codon				Third base of codon
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	U
	UUC	UCC	UAC	UGC	C
	UUA Leucine	UCA	UAA —	UGA —	A
	UUG	UCG	UAG —	UGG Tryptophan	G
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC	CCC	CAC	CGC	C
	CUA	CCA	CAA Glutamine	CGA	A
	CUG	CCG	CAG	CGG	G
A	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	U
	AUC	ACC	AAC	AGC	C
	AUA	ACA	AAA Lysine	AGA Arginine	A
	AUG Methionine	ACG	AAG	AGG	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC	GCC	GAC	GGC	C
	GUA	GCA	GAA Glutamic acid	GGA	A
	GUG	GCG	GAG	GGG	G

- (1) Statements (a)–(e) below concern the genetic code table. From ①–⑥ below choose the combination indicating the two statements that are correct.

17

- (a) One codon codes for two or more different amino acids.
 (b) Many types of amino acids are coded for by more than one codon.
 (c) If the DNA base sequence that codes for proline changes so that its base corresponding to the codon's third base is replaced by a different base, then the amino acid coded for by that base sequence will also change.
 (d) If the DNA base sequence that codes for proline changes so that its base corresponding to the codon's first base is replaced by a different base, then the amino acid coded for by that base sequence will change to serine, threonine, or alanine.
 (e) Even if the DNA base sequence that codes for arginine changes so that its base corresponding to the codon's second base is replaced by a different base, no change will occur in the amino acid coded for by that base sequence.

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

- (2) In this organism, when a change occurred in just one base in the DNA region of a certain gene, that gene consequently synthesized a protein that has one different amino acid. Specifically, the amino acid changed from glutamic acid to valine. What base changed in the gene's DNA that serves as the mRNA template? From ①–⑧ below choose the correct answer.

18

- ① A changed to G ② A changed to T
 ③ T changed to A ④ T changed to C
 ⑤ G changed to A ⑥ G changed to C
 ⑦ C changed to G ⑧ C changed to A

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.