

2010 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 admission card.
3. The pages of each subject are as in the following table.

Subject	Pages
Physics	1 – 21
Chemistry	23 – 35
Biology	37 – 53

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.

<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"/>

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

I Answer questions **A** (Q1), **B** (Q2), **C** (Q3), **D** (Q4), **E** (Q5), **F** (Q6) and **G** (Q7) on pages 2-8, where g denotes the magnitude of acceleration due to gravity, and air resistance is negligible.

A In the International System of Units (SI), length [m], mass [kg], time [s] and electric current [A] are used as a part of base units.

Q1 How would units of pressure and electric resistance be expressed with combinations of the aforementioned base units? From ①-⑥ below choose the correct answer. 1

	Pressure	Electric resistance
①	$[m^{-1} \cdot kg \cdot s^{-2}]$	$[m^2 \cdot kg \cdot s^{-2} \cdot A^{-2}]$
②	$[m^{-2} \cdot kg \cdot s^{-2}]$	$[m^2 \cdot kg \cdot s^{-2} \cdot A^{-2}]$
③	$[m^{-1} \cdot kg \cdot s^{-2}]$	$[m^2 \cdot kg \cdot s^{-3} \cdot A^{-2}]$
④	$[m^{-2} \cdot kg \cdot s^{-2}]$	$[m^2 \cdot kg \cdot s^{-3} \cdot A^{-2}]$
⑤	$[m^{-1} \cdot kg \cdot s^{-2}]$	$[m^2 \cdot kg \cdot s^{-4} \cdot A^{-2}]$
⑥	$[m^{-2} \cdot kg \cdot s^{-2}]$	$[m^2 \cdot kg \cdot s^{-4} \cdot A^{-2}]$

B As shown in Figure 1 below, a weight is attached to one end of a lightweight spring held at the other end. When the weight comes to rest, the spring is stretched 20 cm beyond its natural length. Next, as shown in Figure 2, the weight is completely immersed in water. When the weight comes to rest, the spring is stretched 15 cm beyond its natural length.

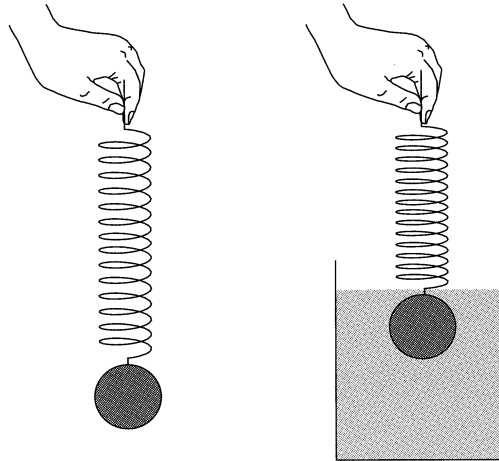


Figure 1

Figure 2

Q2 How many times greater is the density of the weight, compared with the density of water?

From ①-⑥ below choose the best answer.

2 times

① 1.5

② 2.0

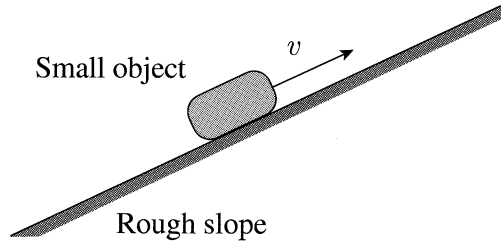
③ 2.5

④ 3.0

⑤ 3.5

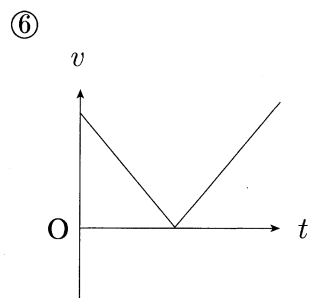
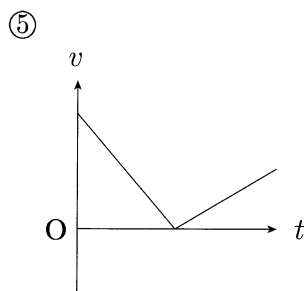
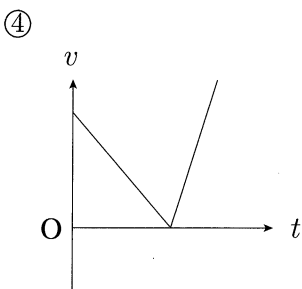
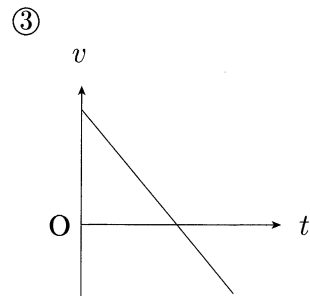
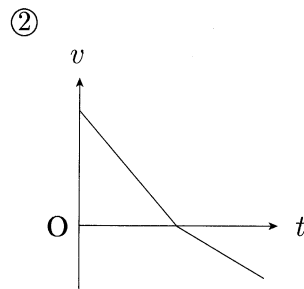
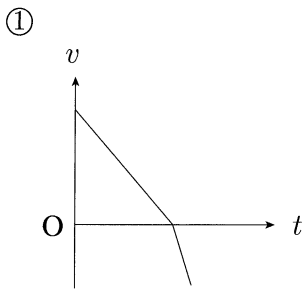
⑥ 4.0

C As shown in the figure below, an initial velocity is applied to a small object on a rough slope, in the upward direction of the slope. The object slides up the slope until it reaches a certain maximum height, and then slides back down. Here, the velocity of the object is denoted as v and the direction of movement up the slope is defined as the positive direction of v . The time elapsed from the start of motion is denoted as t .

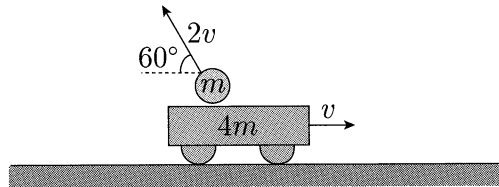


Q3 From ①-⑥ below choose the graph that best represents the relationship between v and t .

3



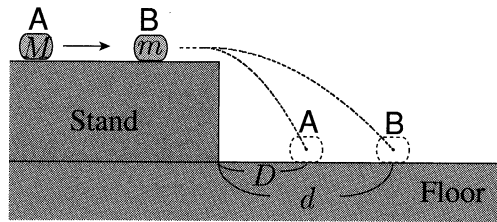
- D** A wagon of mass $4m$ is carrying a ball of mass m as it moves to the right along a smooth horizontal floor. The ball is launched upward to the left. Immediately afterwards, a person at rest on the floor observes that, as shown in the figure below, the wagon is moving horizontally to the right with speed v and the ball is moving at an angle of 60° with the horizontal with speed $2v$.



- Q4** What is the speed of the wagon before the launch? From ①-⑤ below choose the correct answer. 4

- ① $\frac{2}{5}v$ ② $\frac{4 - \sqrt{3}}{5}v$ ③ $\frac{3}{5}v$ ④ $\frac{4}{5}v$ ⑤ $\frac{6}{5}v$

E As shown in the figure below, small object A (mass: M) collides with small object B (mass: m), which is initially at rest, on top of a horizontal stand fixed to a horizontal floor. Both A and B proceed to shoot horizontally off the stand and then fall to the floor. Horizontal distance D from the edge of the stand to the point where A lands is $\frac{1}{2}$ of the horizontal distance d to the point where B lands. Friction between the objects and the stand is negligible.



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

① $\frac{M}{m + 2M}$

② $\frac{M}{2m + M}$

③ $\frac{2M}{m + 2M}$

④ $\frac{m}{m + 2M}$

⑤ $\frac{m}{2m + M}$

⑥ $\frac{2m}{m + 2M}$

F Two certain small objects, **A** and **B**, each have mass m . As shown in Figure 1 below, **A** is suspended using a lightweight, inelastic string, and **B** is placed on a rough horizontal floor in a position where it is in contact with the vertically suspended **A**. Next, as shown in Figure 2, **A** is raised to height h above its original position while the string is kept taut, and then is gently released. **A** collides elastically with **B**, which then slides along the floor distance d before coming to rest.

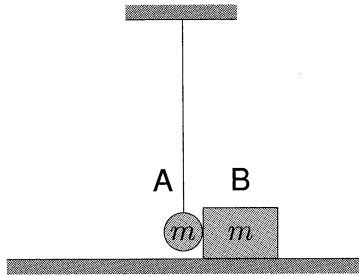


Figure 1

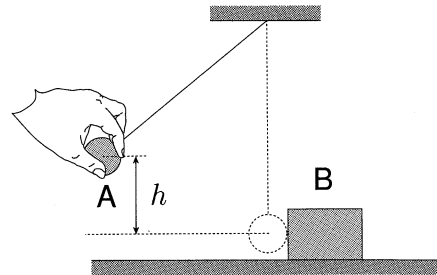


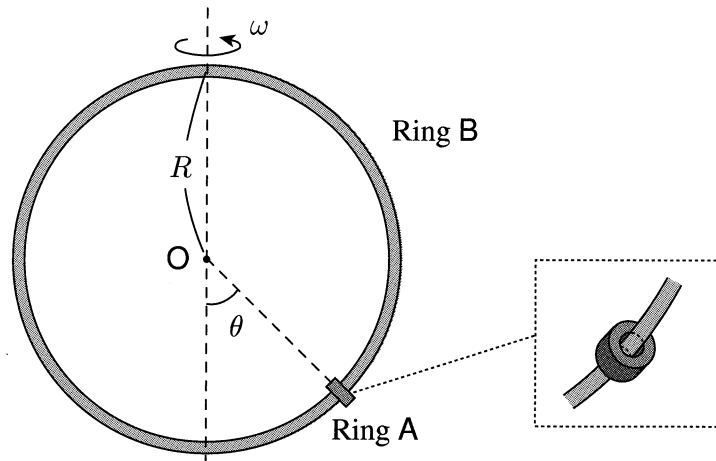
Figure 2

Q6 What is the coefficient of kinetic friction between **B** and the floor? From ①-⑥ below choose the correct answer.

6

- ① $\frac{h}{2d}$ ② $\frac{h}{d}$ ③ $\frac{2h}{d}$ ④ $\frac{d}{2h}$ ⑤ $\frac{d}{h}$ ⑥ $\frac{2d}{h}$

G Ring A, which has mass m , encircles the band of a larger ring, B, which has a radius of R . A can move freely along B. As shown in the figure below, B is oriented vertically and is made to revolve with angular velocity ω around the vertical axis passing through center point O. At this time, A is stopped at a certain point on B. A line OA forms angle θ with the aforementioned vertical axis. Friction between A and B is negligible.



Q7 What is the value of angular velocity ω ? From ①-⑥ below choose the correct answer.

7

① $\cos \theta \sqrt{\frac{g}{R}}$

② $\sqrt{\frac{g \cos \theta}{R}}$

③ $\sqrt{\frac{g}{R \cos \theta}}$

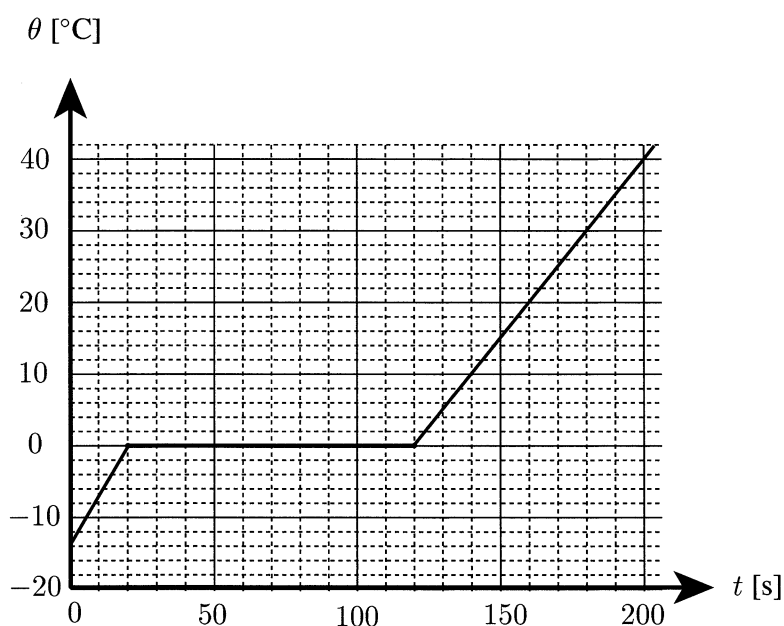
④ $\sqrt{\frac{g \sin \theta}{R}}$

⑤ $\sqrt{\frac{g \tan \theta}{R}}$

⑥ $\frac{1}{\cos \theta} \sqrt{\frac{g \sin \theta}{R}}$

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

A Ice is placed in a copper container surrounded with thermal insulation, and the container is heated with a heater at a rate of 1.0×10^3 J/s. The graph below shows the relationship between time elapsed t and temperature θ during the heating process. All the heat from the heater is conducted through the container, ice, and water, with no heat exchange occurring with the external environment. The specific heat of water is 4.2 J/g·K, the specific heat of copper is 0.39 J/g·K, and the heat of fusion of ice is 3.3×10^2 J/g.



Q1 What is the mass of the container? From ①-④ below choose the best answer.

8 g

- ① 3.0×10^2 ② 1.2×10^3 ③ 1.9×10^3 ④ 2.6×10^3

B As shown in Figure 1 below, an ideal gas is contained in a vertical cylinder sealed with a smoothly moving piston that has cross-sectional area S , and mass M . The height of the gas is L_0 , and the absolute temperature of the system including the gas is T_0 . Next, as shown in Figure 2, a weight with mass m is placed on top of the piston, and the entire system is heated so as to restore the height of the gas to L_0 . At this time, the absolute temperature of the entire system changes to T . Here, atmospheric pressure is denoted as p_0 , and the magnitude of acceleration due to gravity is denoted as g .

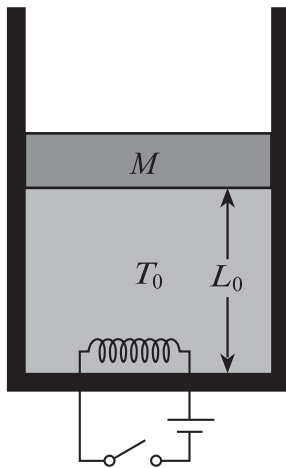


Figure 1

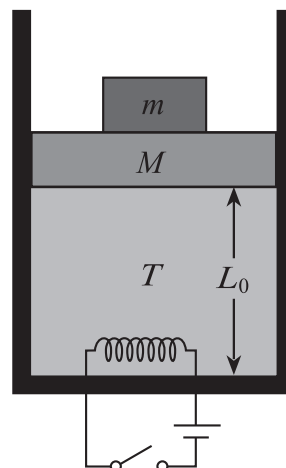


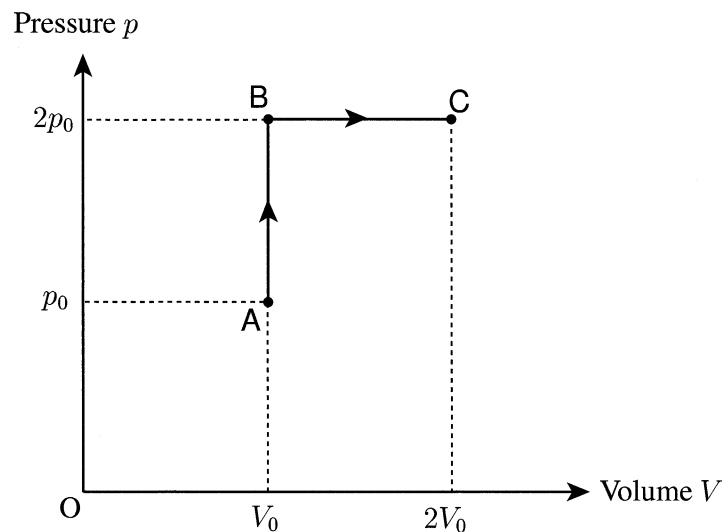
Figure 2

Q2 What is the value of T ? From ①-⑥ below choose the correct answer.

9

- ① $\left(1 + \frac{M}{m}\right) T_0$ ② $\left(1 + \frac{Mg}{p_0 S}\right) T_0$ ③ $\left(1 + \frac{Mg}{p_0 S + mg}\right) T_0$
- ④ $\left(1 + \frac{m}{M}\right) T_0$ ⑤ $\left(1 + \frac{mg}{p_0 S}\right) T_0$ ⑥ $\left(1 + \frac{mg}{p_0 S + Mg}\right) T_0$

- C** The state of n [mol] of a monatomic ideal gas is changed according to $A \rightarrow B \rightarrow C$ as shown in the p - V diagram below. The absolute temperature of the initial state, A , is denoted as T , and the gas constant is denoted as R .

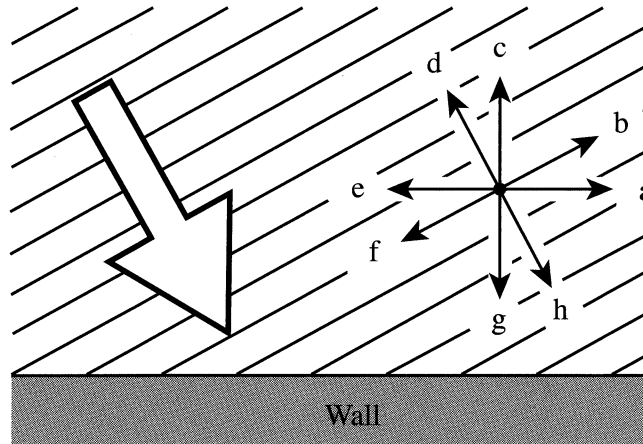


- Q3** What is the quantity of heat added to the gas in the process of $A \rightarrow B \rightarrow C$? From ①-⑥ below choose the correct answer. 10

- ① $\frac{9}{2}nRT$ ② $\frac{11}{2}nRT$ ③ $\frac{13}{2}nRT$
- ④ $\frac{15}{2}nRT$ ⑤ $\frac{17}{2}nRT$ ⑥ $\frac{19}{2}nRT$

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

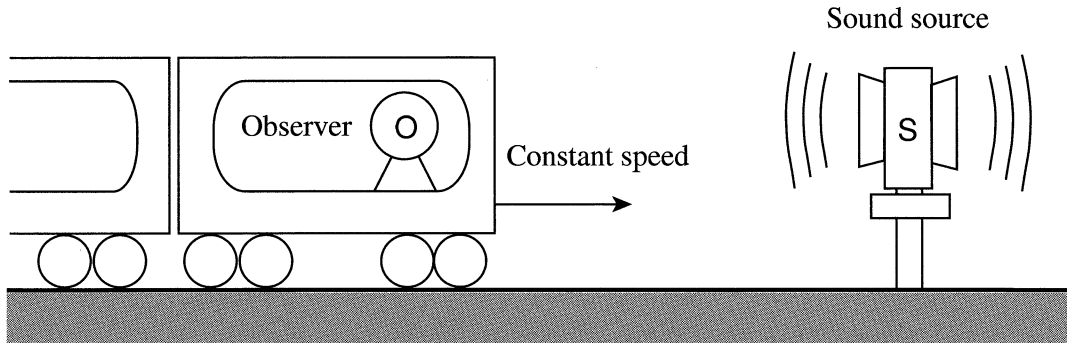
A The figure below shows the top view of a plane wave propagating on the surface of water, which is slantly incident on a vertical wall. The lines in the figure represent incident wave crests at a certain time. Free-end reflection of this wave occurs at the wall, resulting in a reflected wave.



Q1 Which of arrows a-h in the figure indicates the direction of travel over time of crests formed by constructive interference between the incident wave and the reflected wave? From ①-⑧ below choose the best answer. **11**

- | | | | |
|-----|-----|-----|-----|
| ① a | ② b | ③ c | ④ d |
| ⑤ e | ⑥ f | ⑦ g | ⑧ h |

B As shown in the figure below, an observer **O** moving with constant speed passes by sound source **S**, which emits sound with a frequency of f , and a wavelength of λ .



Q2 What is the relation to f and λ of the sound's frequency f' and wavelength λ' as measured by **O** when approaching **S**, and when moving away from **S**? From ①-⑥ below choose the best answer. **12**

	When O approaches S	When O moves away from S
①	$f' < f, \lambda' < \lambda$	$f' > f, \lambda' < \lambda$
②	$f' < f, \lambda' = \lambda$	$f' > f, \lambda' = \lambda$
③	$f' < f, \lambda' > \lambda$	$f' > f, \lambda' > \lambda$
④	$f' > f, \lambda' < \lambda$	$f' < f, \lambda' < \lambda$
⑤	$f' > f, \lambda' = \lambda$	$f' < f, \lambda' = \lambda$
⑥	$f' > f, \lambda' > \lambda$	$f' < f, \lambda' > \lambda$

C Rainbows result from the refraction, reflection, and dispersion of sunlight passing through water droplets in the air. As shown in Figure 1 below, the angle subtended by the radius of a rainbow of a given color is equal to the angle θ between the incident sunlight and the light refracted and reflected by the water droplets. Figure 2 represents a large rainbow and a small rainbow appearing simultaneously. In one of the rainbows (denoted as A), the light inside the water droplets is, as shown in Figure 3, reflected one time only, with the rainbow's color changing from violet in the inner side to red in the outer side. As shown in Figure 4, light is reflected twice inside the water droplets of the other rainbow (denoted as B).

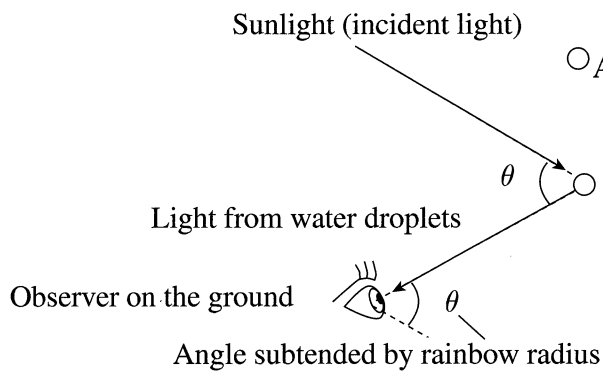


Figure 1

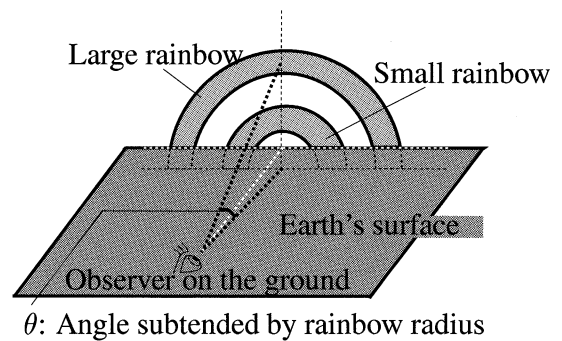


Figure 2

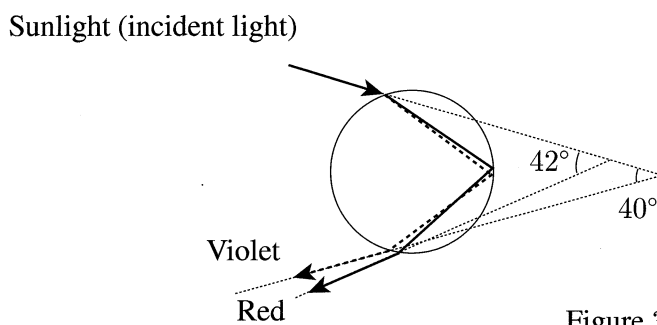
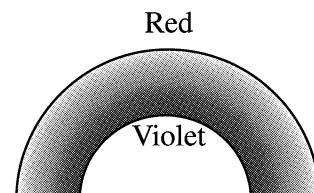


Figure 3: Rainbow A



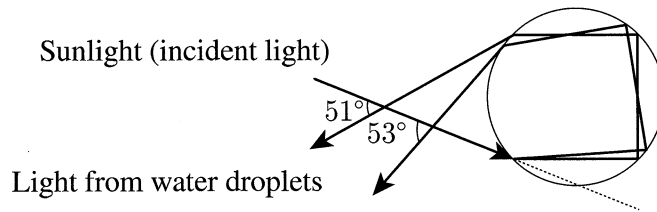


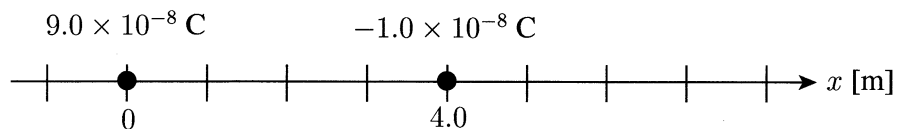
Figure 4: Rainbow B

Q3 Is rainbow B the large-radius rainbow, or the small-radius rainbow? Also, how does the color change from the rainbow's inner boundary to the outer boundary? From ①-④ below choose the correct combination. 13

	Radius of rainbow B	Change from inner to outer
①	small	from red to violet
②	small	from violet to red
③	large	from red to violet
④	large	from violet to red

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

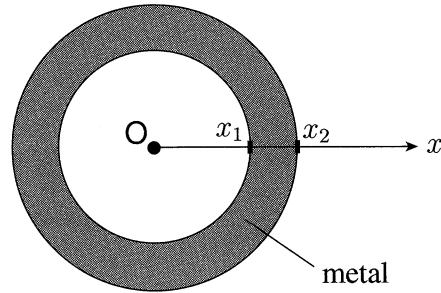
A As shown in the figure below, a point charge of $9.0 \times 10^{-8} \text{ C}$ is fixed at the origin on the x -axis , and a point charge of $-1.0 \times 10^{-8} \text{ C}$ is fixed to the x -axis at $x = 4.0 \text{ m}$.



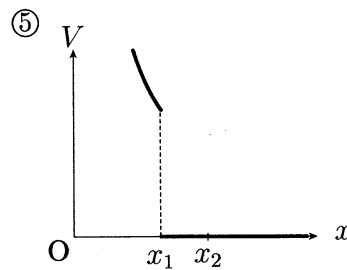
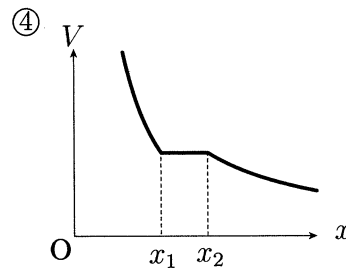
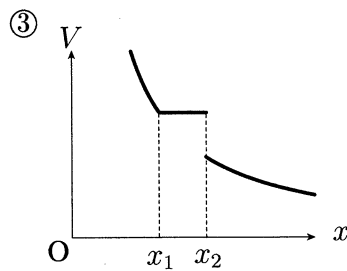
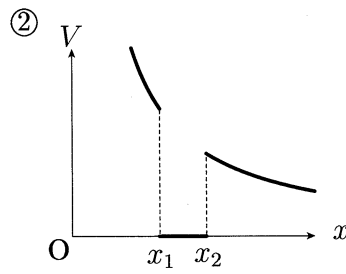
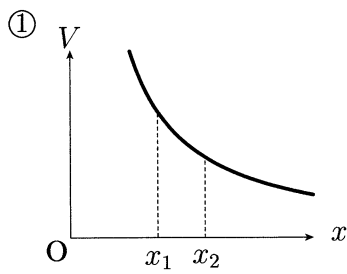
Q1 When placing a positive point charge on the x -axis, at what position would the resultant force acting on this charge be zero? From ①-④ below choose the best answer. **14** m

- ① $x = 3.0$ ② $x = 3.5$ ③ $x = 4.5$ ④ $x = 6.0$

B A positive point charge is placed at center point O of an uncharged hollow metal sphere. The figure below presents a cross-sectional view of the sphere, and plots an x -axis using O as the origin.



Q2 From ①-⑤ below choose the graph that best represents the change in electric potential V along the x -axis. 15

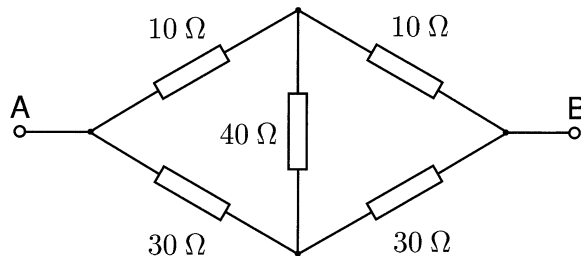


C Consider a parallel plate capacitor in which a dielectric can be inserted in the entire space between the plates. First, the capacitor is charged by connecting it to a battery, without a dielectric inserted. Next, the capacitor is disconnected from the battery, and a dielectric with relative permittivity ϵ_r is inserted in the entire space between the plates.

Q3 What is the ratio of the energy stored in the capacitor now to the energy stored before the dielectric was inserted? From ①-⑤ below choose the correct answer. **16**

- ① 1 ② $\frac{1}{\epsilon_r}$ ③ $\frac{1}{\epsilon_r^2}$ ④ ϵ_r ⑤ ϵ_r^2

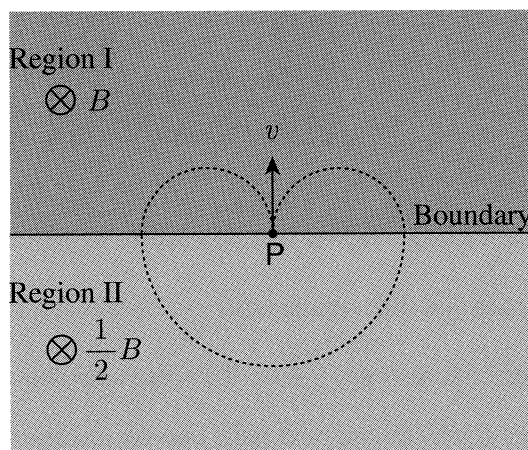
D As shown in the figure below, five resistors are connected together. Each has a value of resistance of $10\ \Omega$, $30\ \Omega$, or $40\ \Omega$.



Q4 What is the resultant resistance (in Ω) between terminals A and B? From ①-⑥ below choose the best answer. **17** Ω

- ① 10 ② 15 ③ 20 ④ 30 ⑤ 45 ⑥ 60

E As shown in the figure below, a uniform magnetic field (magnitude of magnetic flux density: B) oriented in a direction perpendicular with respect to this page (from the front toward the back) exists within a certain region (Region I), while another uniform magnetic field (magnitude of magnetic flux density: $\frac{1}{2}B$) oriented in the same direction exists in an adjacent region (Region II). The plane boundary between the regions is perpendicular to this page. A particle of mass m carrying a positive charge q , is launched from point P on the boundary with a speed of v , in a direction toward Region I and perpendicular to the boundary. The particle follows the orbit indicated with the dotted line and returns to point P. Here, the effect of gravitational force is negligible.



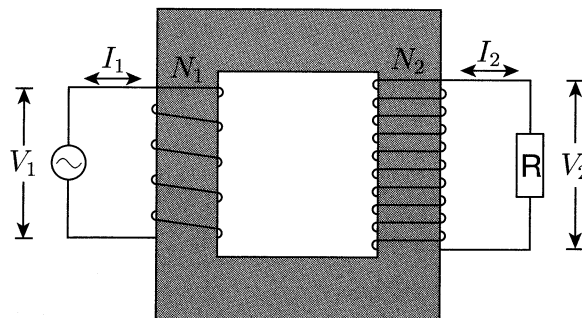
Q5 How much time elapses between the particle's departure from point P and its return to P?

From ①-⑤ below choose the correct answer.

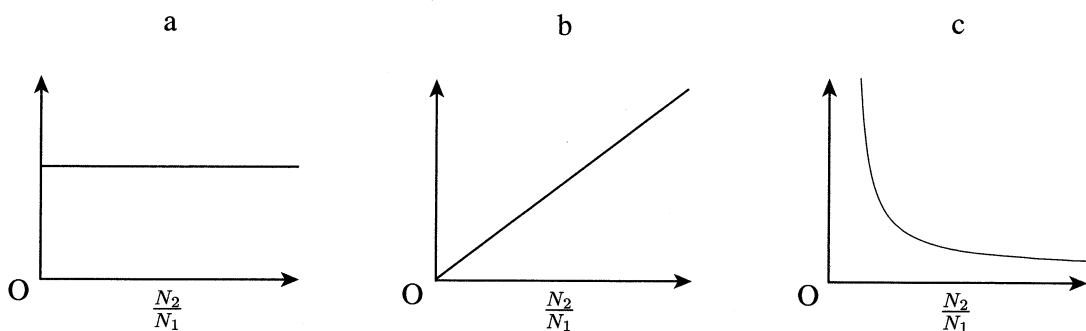
18

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

F Consider an electrical transformer that, as shown in the figure below, is formed of an iron core whose primary side is wound by a coil with N_1 turns, and whose secondary side is wound by a coil with N_2 turns. An alternating current power source with voltage V_1 is connected to the primary side, where it generates current I_1 . As a result, voltage V_2 is applied to register **R** on the secondary side, causing current I_2 to flow through **R**. Here, V_1 , I_1 , V_2 and I_2 are effective values of alternating current.



Q6 Which of graphs a, b, and c below can be used to express the number-of-turns ratio $\frac{N_2}{N_1}$ on the horizontal axis and the voltage ratio $\frac{V_2}{V_1}$, on the vertical axis? Which can be used to express the number-of-turns ratio $\frac{N_2}{N_1}$ on the horizontal axis and the current ratio $\frac{I_2}{I_1}$ on the vertical axis? From ①-⑨ on the next page choose the best combination. Here, no energy loss is assumed to exist inside the transformer. 19



	Graph when vertical axis is $\frac{V_2}{V_1}$	Graph when vertical axis is $\frac{I_2}{I_1}$
①	a	a
②	a	b
③	a	c
④	b	a
⑤	b	b
⑥	b	c
⑦	c	a
⑧	c	b
⑨	c	c

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 the left-hand side of your answer sheet.

Do not take this question booklet out of the room.

Chemistry

Marking Your Choice of Subject on the Answer Sheet

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

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

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

< Example >

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

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

Gas constant: $R = 8.31 \times 10^3 \text{ Pa} \cdot \text{L}/(\text{K} \cdot \text{mol}) = 8.31 \text{ J}/(\text{K} \cdot \text{mol})$
 $= 0.082 \text{ atm} \cdot \text{L}/(\text{K} \cdot \text{mol})$

Avogadro constant: $N_A = 6.0 \times 10^{23} / \text{mol}$

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

Atomic weight: H : 1.0 He : 4.0 C : 12 N : 14 O : 16 Na : 23 Cl : 36

Q1 From the gases ①—⑤ below choose the one that **does not contain** an unsaturated bond in the molecule. **1**

- ① methane (CH_4) ② acetylene (C_2H_2) ③ carbon dioxide (CO_2)
 ④ nitrogen (N_2) ⑤ oxygen (O_2)

Q2 Of the following five molecules, how many of them have all component atoms on the same plane? From ①—⑥ below choose the correct number. **2**

methane ethylene (ethene) propylene (propene)
benzene ammonia

- ① 1 ② 2 ③ 3 ④ 4 ⑤ 5 ⑥ 0

Q3 From ①—⑧ below choose the correct combination of “true” and “false” judgments on the following statements (a)—(c). **3**

- (a) The mass number of an atom is equal to the sum of the number of protons and that of neutrons in the atomic nucleus.
- (b) The atomic weight of an element is the average value determined from the relative masses and their abundance ratio of the component isotopes.
- (c) The mass of 1 mol of carbon atom ^{12}C whose mass number is 12 is 12.00 g.

	a	b	c
①	true	true	true
②	true	true	false
③	true	false	true
④	false	true	true
⑤	true	false	false
⑥	false	true	false
⑦	false	false	true
⑧	false	false	false

Q4 To each of the following aqueous solutions **A** and **B**, 10.6 g of sodium carbonate (Na_2CO_3) is added and the reaction is completed at normal temperature to generate a gas. From ①—⑥ below choose the most appropriate one for the relation between V_A and V_B , if the volumes of the generated gases are V_A and V_B , respectively. **4**

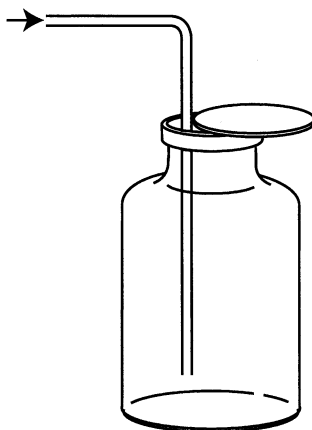
A : 100 mL of 1.0 mol/L hydrochloric acid (HCl aq)

B : 100 mL of 3.0 mol/L hydrochloric acid

① $V_B = 0.5 V_A$ ② $V_B = V_A$ ③ $V_B = 1.5 V_A$

④ $V_B = 2 V_A$ ⑤ $V_B = 2.5 V_A$ ⑥ $V_B = 3 V_A$

Q5 Suppose the following gases ①—⑤ are generated in a laboratory. From ①—⑤ below choose the gas that is most appropriately collected by the downward delivery as shown in the figure. **5**



- ① acetylene (C_2H_2) ② hydrogen (H_2) ③ hydrogen chloride (HCl)
 ④ ammonia (NH_3) ⑤ nitrogen monoxide (NO)

Q6 The mass of 22.4 L of a gaseous mixture of helium (He) and nitrogen (N₂) at the standard state was 8.8 g. Calculate the partial pressure (in Pa) of helium in the gaseous mixture. From ①—④ below choose the closest value. 6 Pa

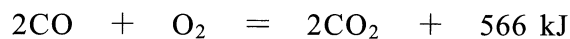
- ① 2.0×10^4 ② 4.0×10^4 ③ 5.0×10^4 ④ 8.0×10^4

Q7 The heats of formation of C₂H₄ and C₂H₆ are -53 kJ/mol and 84 kJ/mol, respectively. From ①—⑥ below choose the most appropriate one for the heat of reaction Q of the following thermochemical equation. 7 kJ



- ① -137 ② -69 ③ -31 ④ 31 ⑤ 69 ⑥ 137

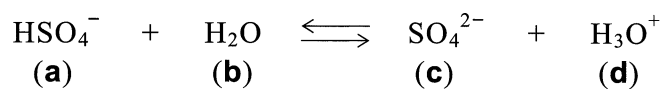
Q8 Suppose the following reaction is at equilibrium state. What effect will be induced on the equilibrium by the procedures (a)–(c), respectively? From ①–⑥ below choose the most appropriate combination. **8**



- (a) Carbon monoxide (CO) is added while the temperature is kept constant.
 (b) The pressure is raised while the temperature is kept constant.
 (c) The temperature is raised while the pressure is kept constant.

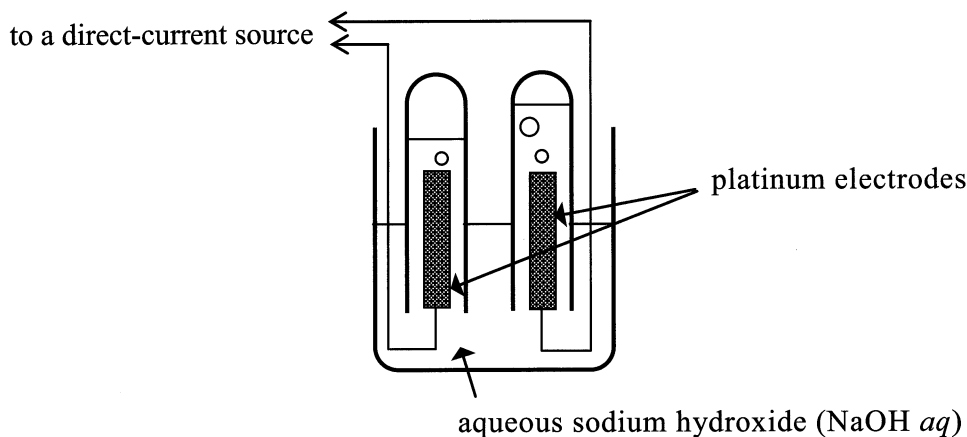
	a	b	c
①	no shift	shift to the left	no shift
②	no shift	no shift	shift to the right
③	shift to the left	no shift	shift to the left
④	shift to the left	shift to the right	shift to the right
⑤	shift to the right	shift to the right	shift to the left
⑥	shift to the right	shift to the left	no shift

Q9 Of the substances (a)–(d) involved in the following reaction, which ones act as bases? From ①–④ below choose the correct combination. **9**



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

Q10 Water was electrolyzed with the equipment shown in the following figure. From ①—④ below choose the correct one for the statement on the volume of hydrogen (H_2) at the standard state generated by this experiment. Assume that the amount of applied electricity is equal for all experiments. **10**



- ① If the concentration of aqueous sodium hydroxide ($NaOH\ aq$) is doubled, the volume of the hydrogen generated is doubled.
- ② If the aqueous sodium hydroxide is replaced with aqueous sodium chloride ($NaCl\ aq$), the volume of the hydrogen generated does not change.
- ③ If the area of the electrodes is halved, the volume of the hydrogen generated is halved.
- ④ If the distance between two electrodes is doubled, the volume of the generated hydrogen is halved.

Q11 From ①—⑧ below choose the correct one as the combination of “true” and “false” judgments on the following statements (a)—(c) concerning acids and bases. 11

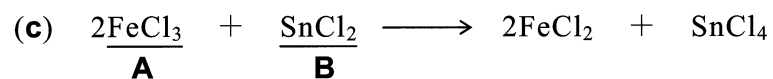
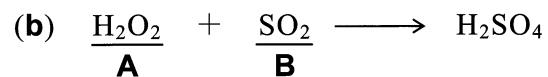
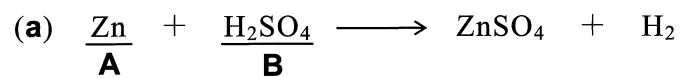
- (a) At the end point of all neutralization reactions, the pH is 7.
- (b) If 0.001 mol/L aqueous hydrochloric acid (HCl *aq*) is diluted a hundred times with water, the pH of the resulting solution is 5.
- (c) If aqueous sodium hydroxide (NaOH *aq*) with pH = 12 is diluted a hundred times with water, the pH of the resulting solution is 10.

	a	b	c
①	true	true	true
②	true	true	false
③	true	false	true
④	false	true	true
⑤	true	false	false
⑥	false	true	false
⑦	false	false	true
⑧	false	false	false

Q12 Which substance, **A** or **B**, acts as an oxidizing agent in the following reactions (a)–(c)?

From ①–⑥ below choose the correct combination.

12



	a	b	c
①	A	A	A
②	A	A	B
③	A	B	A
④	B	A	A
⑤	B	B	A
⑥	B	B	B

Q13 From ①—⑥ below choose the most appropriate combination of gases CO, HCl, and H₂S, each of which is compatible with one of the following statements (a)—(c).

13

- (a) It is slightly soluble in water, and the solution is weakly acidic.
- (b) It forms a white fume when reacted with ammonia (NH₃).
- (c) It burns in air. When the resultant gas is introduced in lime water, the water becomes cloudy.

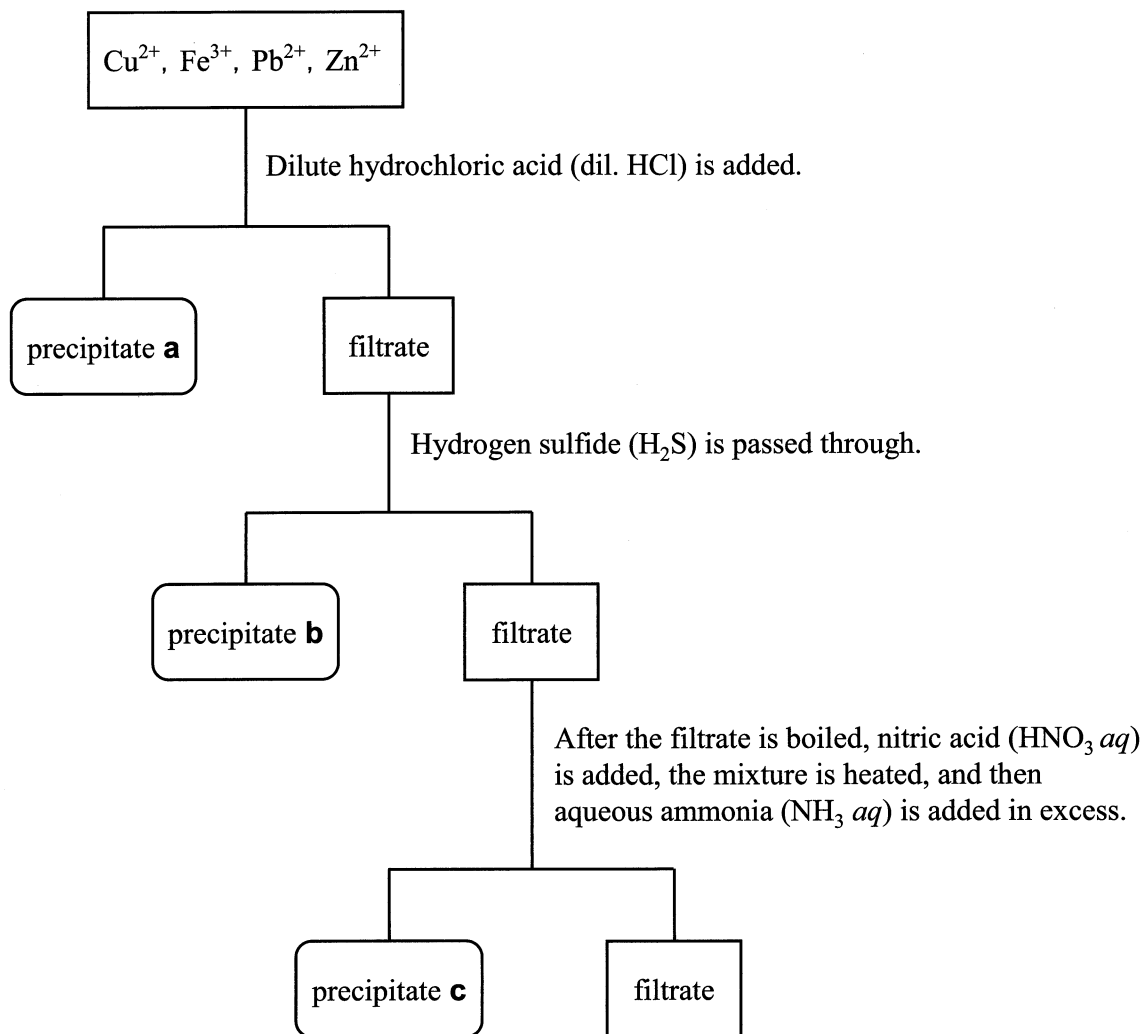
	a	b	c
①	HCl	CO	H ₂ S
②	HCl	H ₂ S	CO
③	H ₂ S	HCl	CO
④	H ₂ S	CO	HCl
⑤	CO	HCl	H ₂ S
⑥	CO	H ₂ S	HCl

Q14 From the statements ①—⑤ below concerning both metallic sodium (Na) and metallic potassium (K), choose the one that is not correct.

14

- ① They have a metallic silvery white luster and a low density, and are relatively soft.
- ② They are very reactive and exhibit a strong oxidizing action.
- ③ Because they react with water vigorously, they are stored in petroleum.
- ④ They exhibit characteristic flame reactions.
- ⑤ Their hydroxides are readily soluble in water, and exhibit strong basicity.

Q15 From an aqueous solution containing metallic ions Cu^{2+} , Fe^{3+} , Pb^{2+} , and Zn^{2+} , metallic ions are separated as their precipitates by the procedures shown in the figure. From ①—⑥ below choose the most appropriate combination of metallic ions that are mainly contained in each precipitate **a—c**. **15**



	a	b	c
①	Pb^{2+}	Cu^{2+}	Fe^{3+}
②	Pb^{2+}	Fe^{3+}	Cu^{2+}
③	Pb^{2+}	Zn^{2+}	Fe^{3+}
④	Zn^{2+}	Cu^{2+}	Fe^{3+}
⑤	Zn^{2+}	Fe^{3+}	Cu^{2+}
⑥	Zn^{2+}	Pb^{2+}	Cu^{2+}

Q16 The equal masses of methane (CH_4) and methanol (CH_3OH) are completely combusted, respectively. Comparisons are made with regard to the amount of oxygen (O_2) necessary and the amount of carbon dioxide (CO_2) generated. From ①—⑥ below choose the combination of correct ones out of statements (a)—(e). **16**

- (a) The mass of oxygen necessary for the reaction is less for methane.
- (b) The mass of oxygen necessary for the reaction is more for methane.
- (c) The mass of carbon dioxide generated by the reaction from methane is half of that from methanol.
- (d) The mass of carbon dioxide generated by the reaction from methane is equal to that from methanol.
- (e) The mass of carbon dioxide generated by the reaction from methane is twice of that from methanol.

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

Q17 Of the following compounds (a)—(d), how many of them have structural isomers?
From ①—④ below choose the correct number. **17**

- (a) acetic acid
- (b) acetone (2-propanone)
- (c) ethyl alcohol (ethanol)
- (d) propane

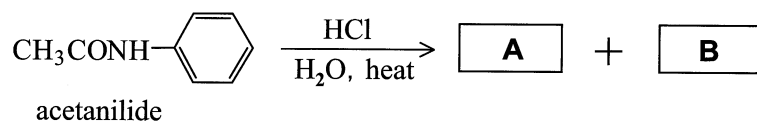
① 1 ② 2 ③ 3 ④ 4

Q18 Of the compounds having a double bond and with the molecular formula C_5H_{10} , how many of them have *cis-trans* isomers? From ①—⑤ below choose the correct number.

18

- ① 1 ② 2 ③ 3 ④ 4 ⑤ 0

Q19 When acetanilide is heated in an aqueous solution acidified with hydrochloric acid, hydrolysis takes place.



From ①—⑥ below choose the most appropriate combination of **A** and **B** as the products of this reaction.

19

	A	B
①	CH_4	aniline
②	CH_4	chlorobenzene
③	CH_3CONH_2	aniline hydrochloride
④	CH_3CONH_2	chlorobenzene
⑤	CH_3COOH	aniline
⑥	CH_3COOH	aniline hydrochloride

Q20 Suppose there is a solution of benzoic acid (C_6H_5COOH), aniline ($C_6H_5NH_2$), and phenol (C_6H_5OH) dissolved in diethyl ether ($(C_2H_5)_2O$). Which compound is extracted from the ether layer to the aqueous layer when the following solutions (a) or (b) is added to the ether solution and vigorously shaken? From ①—⑥ below choose the most appropriate combination of extracted compounds. **20**

(a) dilute hydrochloric acid (dil. HCl)

(b) aqueous sodium hydrogencarbonate ($NaHCO_3$ aq)

	a	b
①	aniline	aniline
②	aniline	phenol
③	aniline	benzoic acid
④	phenol	aniline
⑤	phenol	phenol
⑥	phenol	benzoic acid

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 the left-hand side of 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 Various types of protein are synthesized inside cells. Some proteins, such as digestive enzymes and antibodies, are secreted outside the cells. From ①–⑥ below choose the combination that correctly identifies the intracellular structure described by each of the following statements, (a) and (b). 1

(a) It is the site of protein synthesis inside the cell.

(b) It is involved in secretion outside the cell.

	(a)	(b)
①	mitochondrion	ribosome
②	mitochondrion	Golgi body
③	Golgi body	ribosome
④	Golgi body	centrosome
⑤	ribosome	mitochondrion
⑥	ribosome	Golgi body

Q2 The life cycle of eukaryotic cells, which repeatedly undergo cell division, can be largely divided into interphase, during which changes in chromosomes are not observable with a light microscope, and the mitotic phase, during which changes in chromosomes are observable. The mitotic phase is subdivided into prophase, metaphase, anaphase, and telophase.

From ①–⑥ below choose the statement that correctly describes DNA replication and the period of the phases.

2

- ① DNA is replicated during prophase, in which the chromosomes become short and thick; of all the phases in the mitotic phase, prophase takes the most time to complete.
- ② DNA is replicated during prophase, in which the chromosomes become short and thick; of all the phases in the mitotic phase, prophase takes the least time to complete.
- ③ DNA is replicated during telophase, which takes place after the chromosomes separate; of all the phases in the mitotic phase, telophase takes the most time to complete.
- ④ DNA is replicated during telophase, which takes place after the chromosomes separate; of all the phases in the mitotic phase, telophase takes the least time to complete.
- ⑤ DNA is replicated during interphase, in which changes in chromosomes are not observable; interphase takes more time to complete than does the mitotic phase.
- ⑥ DNA is replicated during interphase, in which changes in chromosomes are not observable; interphase takes less time to complete than does the mitotic phase.

Q3 Chicken skin is mainly composed of corium and epidermis. Skin on the back forms feathers, while skin on the legs forms scales.

In an experiment, samples of feather-forming back skin and scale-forming leg skin were cut away from a chicken embryo, and the corium and epidermis of each sample were separated. Next, four different combinations of corium and epidermis were cultured, resulting in the formation of feathers or scales in each case, as indicated in the table below.

From ①–⑥ below choose the statement that correctly describes these results.

3

Corium/epidermis combination	Object formed
Back corium + back epidermis	feathers
Leg corium + leg epidermis	scales
Back corium + leg epidermis	feathers
Leg corium + back epidermis	scales

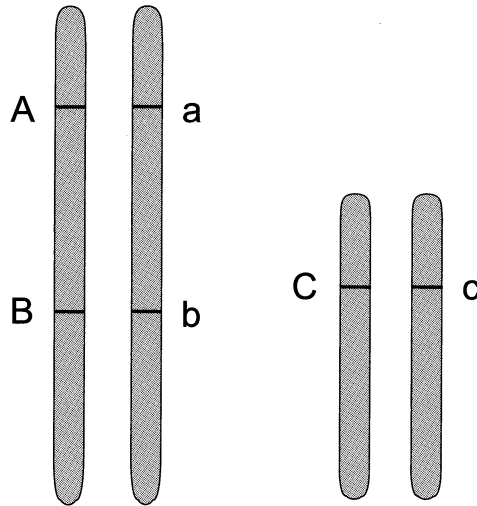
- ① The epidermis, which is mesodermic, differentiated independently from the corium, which is also mesodermic.
- ② The epidermis, which is ectodermic, differentiated independently from the corium, which is mesodermic.
- ③ The epidermis, which is ectodermic, differentiated independently from the corium, which is also ectodermic.
- ④ The epidermis, which is mesodermic, was induced to differentiate by the corium, which is also mesodermic.
- ⑤ The epidermis, which is ectodermic, was induced to differentiate by the corium, which is mesodermic.
- ⑥ The epidermis, which is ectodermic, was induced to differentiate by the corium, which is also ectodermic.

Q4 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

ABC : ABc : AbC : Abc : aBC : aBc : abC : abc

in gametes produced by this organism? From ①–⑥ below choose the correct answer.

4



- ① 1 : 1 : 4 : 4 : 4 : 4 : 1 : 1
- ② 1 : 1 : 8 : 8 : 8 : 8 : 1 : 1
- ③ 4 : 4 : 1 : 1 : 1 : 1 : 4 : 4
- ④ 4 : 4 : 1 : 1 : 4 : 4 : 1 : 1
- ⑤ 8 : 1 : 8 : 1 : 8 : 1 : 8 : 1
- ⑥ 8 : 8 : 1 : 1 : 1 : 1 : 8 : 8

Q5 The concentration ratio of certain substances in the human kidney’s urine formation process is expressed as follows.

$$\text{Concentration ratio} = \frac{\text{Concentration in urine (\%)}}{\text{Concentration in blood plasma (\%)}}$$

The table below lists the concentration ratio of five blood plasma constituents in a healthy human. From ①–⑥ below choose the combination that correctly indicates the constituent described by each of statements (a) and (b) below. **5**

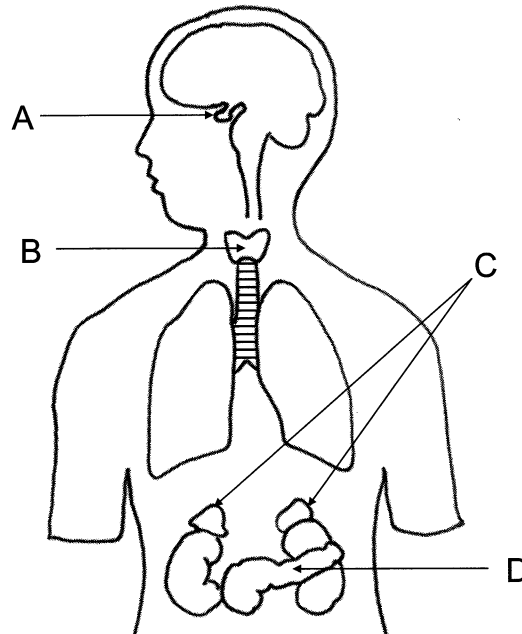
Blood plasma constituent	Concentration ratio
protein	0
glucose	0
sodium ions (Na ⁺)	1
urea	67
creatinine	75

- (a) It is reabsorbed 100%.
- (b) Its reabsorption rate is nearly the same as that of water.

	(a)	(b)
①	protein	sodium ions
②	glucose	sodium ions
③	protein	urea
④	glucose	urea
⑤	protein	creatinine
⑥	glucose	creatinine

Q6 In the following figure, A–D indicate the human organs in which endocrine glands reside.

Answer questions (1) and (2) below concerning this.



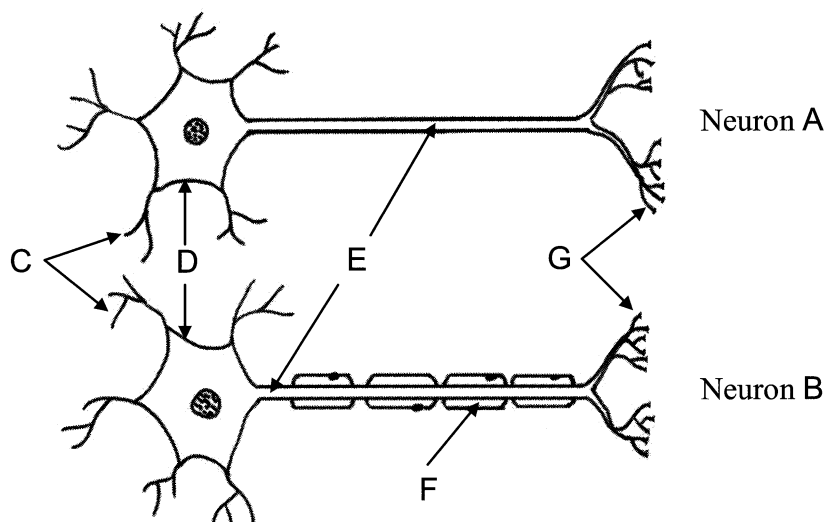
(1) From ①–⑥ below choose the answer that correctly indicates the pathway by which glucocorticoid secretion is stimulated. 6

- ① hypothalamus → sympathetic nerve → B
- ② hypothalamus → sympathetic nerve → C
- ③ hypothalamus → sympathetic nerve → D
- ④ hypothalamus → A → B
- ⑤ hypothalamus → A → C
- ⑥ hypothalamus → A → D

(2) From ①–⑤ below choose the statement that correctly describes the function of glucocorticoid. 7

- ① It stimulates the breakdown of glycogen stored in the liver into glucose.
- ② It stimulates the reabsorption of sodium ions (Na^+) in the kidneys.
- ③ It increases the concentration of calcium ions (Ca^{2+}) in blood.
- ④ It stimulates the synthesis of glucose from protein.
- ⑤ It stimulates the uptake and consumption of sugars by cells.

Q7 The following figure schematically represents two structurally different neurons. Answer questions (1) and (2) below concerning this.



(1) From ①–⑤ below choose the statement that correctly describes the property of F in the figure, and the conduction velocity of excitation in the two neurons. 8

- ① F readily conducts electricity; the conduction velocity of excitation is greater in neuron A.
- ② F readily conducts electricity; the conduction velocity of excitation is greater in neuron B.
- ③ F does not readily conduct electricity; the conduction velocity of excitation is greater in neuron A.
- ④ F does not readily conduct electricity; the conduction velocity of excitation is greater in neuron B.
- ⑤ F is unrelated to the degree of electrical conductivity; there is no difference in conduction velocity between neurons A and B.

- (2) From ①–⑥ below choose the combination that correctly indicates which of parts C–G in the figure releases or takes up neurotransmitters. 9

	Releases neurotransmitters	Takes up neurotransmitters
①	C	G
②	C	E, F
③	D	C, G
④	D	E, G
⑤	G	C, D
⑥	G	C, E

Q8 Immunity can be classified into humoral immunity, which is based on the activity of antibodies, and cellular immunity, in which T-cells and other immune cells directly eliminate antigens. From ①–⑥ below choose the combination that correctly indicates which type of immunity is described by each of statements (a)–(d) below. **10**

- (a) Certain types of pollen can act as antigens that cause allergic reactions, such as watery eyes and a runny nose.
- (b) Serotherapy is a treatment for disease that involves injecting patients with antiserum, which is blood serum taken from a horse or other animal previously injected with antigens. It is used to treat, among other things, venomous snake bites.
- (c) When skin or other tissue from one mouse is transplanted onto another mouse, the transplant normally is recognized as foreign material and consequently sloughs off.
- (d) In a tuberculin reaction, the site where a person was injected with *Mycobacterium tuberculosis* protein becomes red and swollen one or two days later, indicating that the person has been previously infected with tuberculosis.

	Humoral immunity	Cellular immunity
①	d	a, b, c
②	a, b	c, d
③	c, d	a, b
④	a, c	b, d
⑤	b, d	a, c
⑥	a, b, c	d

Q9 From ①–⑥ below choose the statement that does **not** correctly describe leaf stomata of such plants as tobacco and lettuce. 11

- ① In order for a stoma to open, the turgor pressure must increase inside the pair of guard cells that border it.
- ② Unlike other epidermal cells, guard cells contain chloroplasts.
- ③ When the plant becomes deficient in water, abscisic acid is formed and sent to the stalk and leaves; this leads to a decrease in the guard cells' turgor pressure, resulting in the closing of the stomata.
- ④ When photosynthesis occurs vigorously, the opening of stomata enables the plant to take in carbon dioxide and release oxygen and water vapor.
- ⑤ Carbon dioxide and nitrogen entering through stomata are absorbed by the plant and used for carbon dioxide assimilation and nitrogen assimilation.
- ⑥ In environments with good growing conditions, stomata open during the day, when the leaves are exposed to light, and close when night falls.

Q10 The following experiment was performed to study the relationship between temperature and the amount of gas evolved in alcoholic fermentation.

100 ml of 10% glucose solution was boiled to remove dissolved gases, and then was restored to room temperature. Next, 5 g of dry yeast was added to form a fermentation liquor. The fermentation liquor was drawn into six syringes in equal amounts, and each syringe's liquor was kept at a different temperature: 20°C, 30°C, 40°C, 50°C, 60°C, and 70°C. After ten minutes passed, the volume of gas evolved in each syringe was measured. The results are listed in the table below.

From ①–④ below choose the statement that correctly describes this experiment.

12

Temperature (°C)	20	30	40	50	60	70
Amount of gas evolved (ml)	0.5	3.0	6.7	6.1	3.8	0.6

- ① The dissolved gases were removed from the glucose solution before the addition of dry yeast in order to prevent reaction between them and the glucose.
- ② If the experiment were repeated with an acid or a base added to the fermentation liquor, the results would be nearly the same as those of the original experiment.
- ③ The amount of gas evolved at 70°C is low because the enzyme involved in the reaction becomes inactivated.
- ④ The amount of gas evolved at 20°C is low because the enzyme involved in the reaction becomes denatured.

Q11 From ①–⑤ below choose the statement that does **not** correctly describe photosynthesis or chemosynthesis in bacteria. 13

- ① Photosynthetic bacteria absorb light energy to perform photosynthesis, using bacteriochlorophyll as their photosynthetic pigment.
- ② Green sulfur bacteria and purple sulfur bacteria are types of photosynthetic bacteria.
- ③ Photosynthetic bacteria fix carbon dioxide and release oxygen through photosynthesis.
- ④ Instead of using light energy, chemosynthetic bacteria use chemical energy obtained from their oxidation of inorganic substances.
- ⑤ Nitrate bacteria are a type of chemosynthetic bacteria that assimilate carbon dioxide using chemical energy.

Q12 From ①–④ below choose the statement that correctly describes semiconservative DNA replication. 14

- ① M. Meselson and F. Stahl proved the hypothesis of semiconservative DNA replication in an experiment using different isotopes of carbon contained in DNA bases.
- ② DNA replication during cell proliferation occurs semiconservatively in eukaryotes, but never occurs semiconservatively in prokaryotes.
- ③ After the two strands of double-stranded DNA separate, each serves as a template for the creation of a new nucleotide chain that has a complementary base sequence.
- ④ The two new single strands of DNA created in semiconservative replication have the same base sequence.

Q13 The sixth amino acid in the β chain of normal hemoglobin is glutamic acid. However, in sickle cell anemia, it is substituted with valine. As a result of this difference, erythrocytes become deformed in low-oxygen conditions.

From ①–⑤ below choose the statement that correctly describes this case of amino acid substitution.

15

- ① The amino acid substitution occurs because part of the DNA base sequence is different from the normal base sequence.
- ② The amino acid substitution occurs because a base substitution always takes place during DNA replication.
- ③ The amino acid substitution occurs because a base substitution always takes place during the synthesis of mRNA through transcription.
- ④ The amino acid substitution occurs because valine is specified for the glutamic acid codon in the translation process.
- ⑤ The amino acid substitution occurs because glutamic acid is replaced with valine when the post-translation polypeptide chain forms the three-dimensional structure of protein.

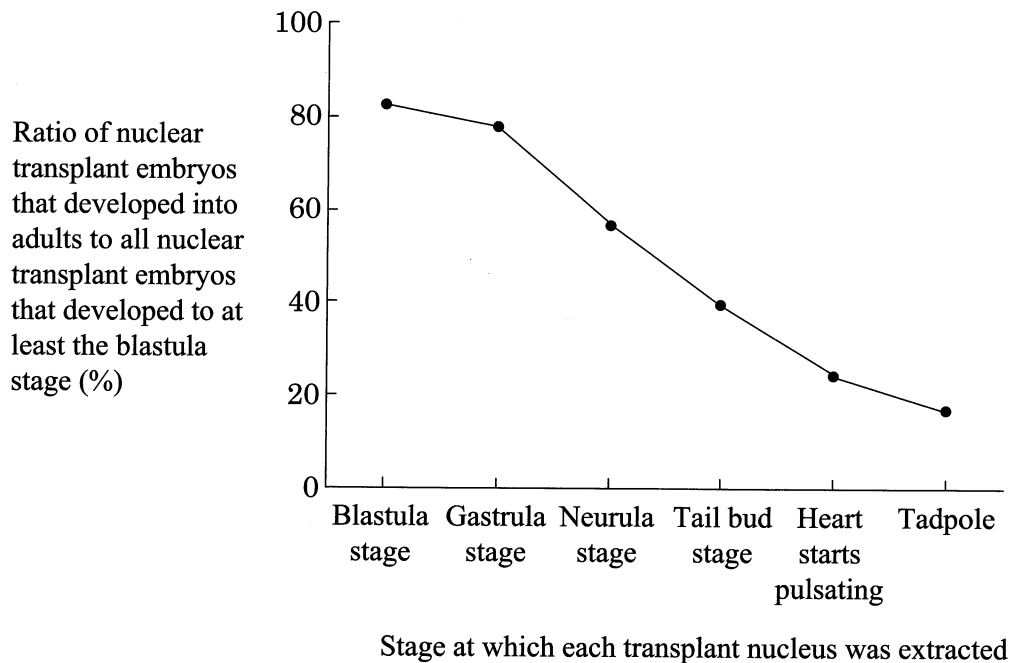
Q14 Statements (a)–(e) below concern homeotic genes and their function. From ①–⑥ below choose the combination indicating the two statements that are correct. 16

- (a) Phenylketonuria is an example of the alteration of a homeotic gene.
- (b) The formation of two pairs of wings on the thorax of *Drosophila melanogaster* is an example of the alteration of a homeotic gene.
- (c) Homeotic genes are regulatory genes, so they do not contain genetic information for proteins.
- (d) The reason why each segment of an insect body has a distinctive structure is that a specific homeotic gene(s) is expressed for each segment.
- (e) Homeotic genes function in the development of insect bodies, but are not found in vertebrates.

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

Q15 The following nuclear transplantation experiment was performed using the African clawed frog (*Xenopus laevis*). Referring to the results of this experiment, from ①–④ below choose the statement that correctly describes cell differentiation and genes. 17

Nuclei were extracted from the cells of embryos and larvae at various developmental stages, and were transplanted to denucleated unfertilized eggs. The following graph shows, for each developmental stage of the donor embryos/larvae, the ratio of nuclear transplant embryos that developed into adults to all nuclear transplant embryos that developed to at least the blastula stage.



- ① As cell differentiation progresses, each differentiating cell gradually loses its genes.
- ② As cell differentiation progresses, the number of genes in each differentiating cell gradually increases.
- ③ Differentiated cells develop into various types of cells because they possess different genes.
- ④ The nuclei of differentiated cells possess the same gene set as fertilized eggs.

Q16 From ①–⑤ below choose the statement that correctly describes the structure of proteins, or the structure of the amino acids that form them. **18**

- ① The most common amino acid structure is a central nitrogen atom bonded with a carboxyl group, an amino group, a hydrogen atom, and a side chain.
- ② There are 30 types of amino acid side chains, and hence there are 30 types of amino acids.
- ③ The bonds between amino acids are peptide bonds, in which one carbon dioxide molecule is released from the bonding of a carboxyl group with an amino group.
- ④ Proteins have a complex three-dimensional structure resulting from the folding of polypeptides; proteins that have different amino acid sequences also have different three-dimensional structures.
- ⑤ In some proteins, two or more polypeptides combine to form a tertiary structure.

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 the left-hand side of your answer sheet.

Do not take this question booklet out of the room.