

2012 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 – 20
Chemistry	21 – 30
Biology	31 – 45

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.

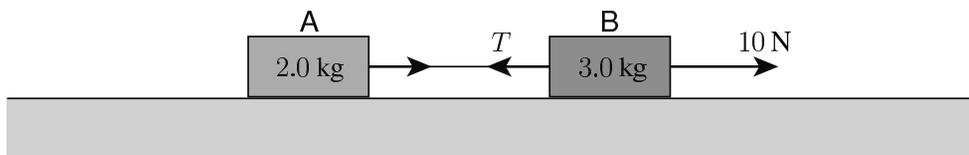
If you do not correctly fill in the appropriate oval, your answers will not be graded.

<Example>

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

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

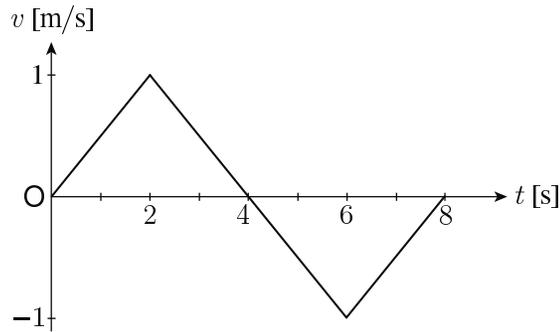
A As shown in the figure below, objects **A** (mass: 2.0 kg) and **B** (mass: 3.0 kg) are connected by a light, inelastic string and are placed on a smooth horizontal floor, and then **B** is pulled horizontally from its right side with a force of 10 N.



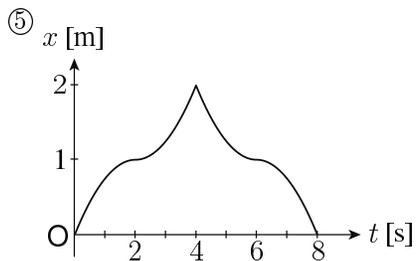
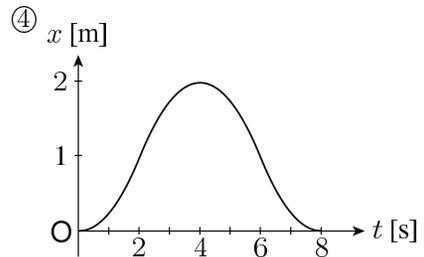
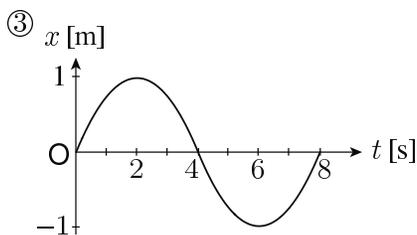
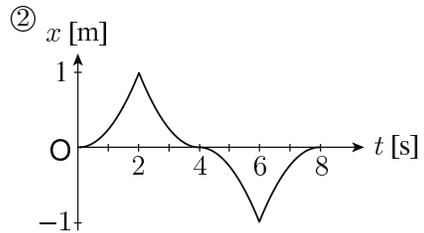
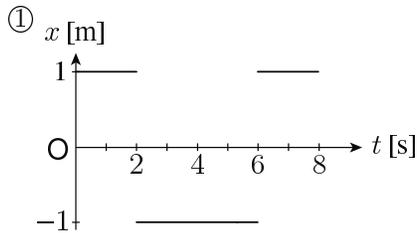
Q1 Let us define the magnitude of **A**'s acceleration as a and the magnitude of the string's tension as it pulls on **B** as T . From ①-④ below choose the combination that best indicates the values of a and T . **1**

	a [m/s ²]	T [N]
①	2.0	4.0
②	2.0	6.0
③	3.0	4.0
④	3.0	6.0

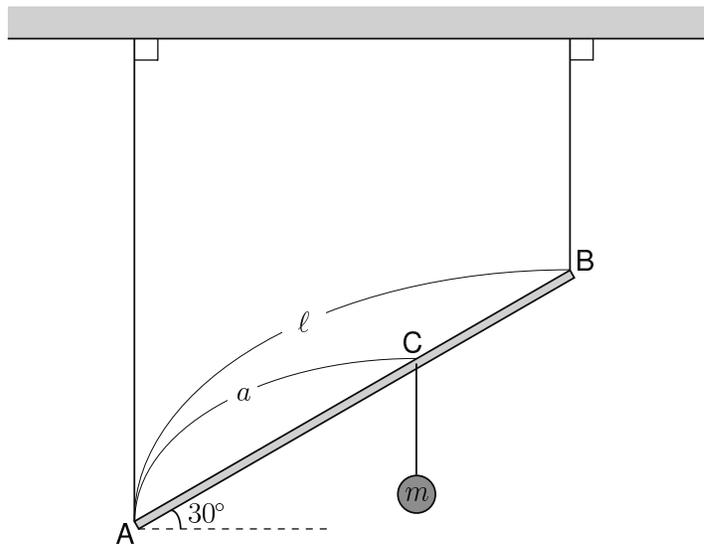
B Consider an object **A** that is moving in a straight line (the x -axis). At time $t = 0$ s, **A** is at the origin ($x = 0$ m). The velocity of **A**, v [m/s], changes with t [s] as shown in the figure below.



Q2 How does the position of **A** (x coordinate) change with t [s]? From ①-⑤ below choose the graph that best represents the relationship between x [m] and t [s]. 2



C As shown in the figure below, a light rod of length ℓ is suspended from a ceiling with light, inelastic strings attached to both of its ends (A, B) in a way that the rod makes an angle of 30° with the horizontal. Then, a weight of mass m is suspended from the rod at point C, which is distance a from A. The strings connecting A and B to the ceiling are aligned vertically.



Q3 What is the magnitude of the tension of the string connecting B to the ceiling? From ①-⑥ below choose the correct answer. **3**

① $\frac{a}{2\ell}mg$

② $\frac{\ell - a}{\ell}mg$

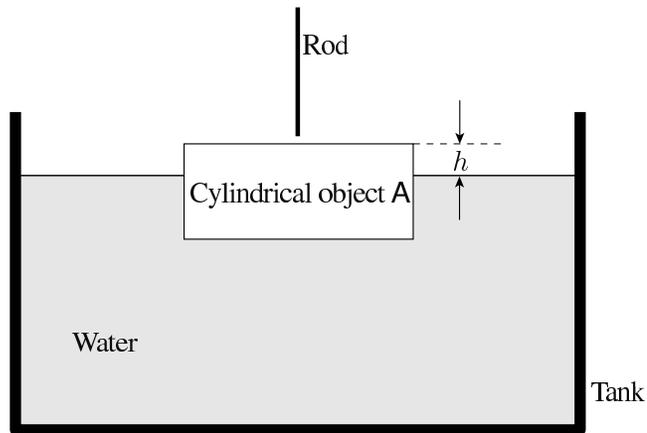
③ $\frac{a}{\ell}mg$

④ $\frac{\sqrt{3}a}{6\ell}mg$

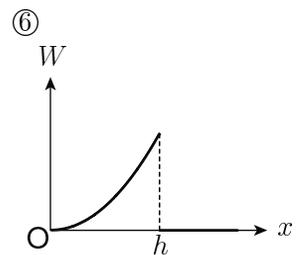
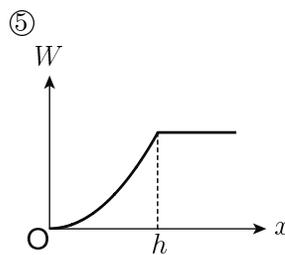
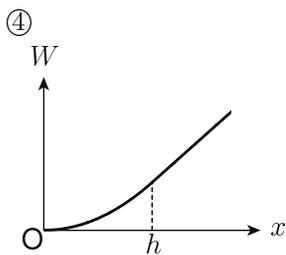
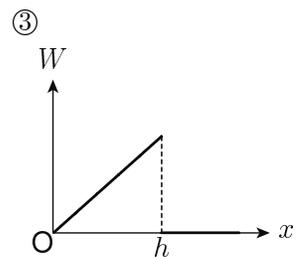
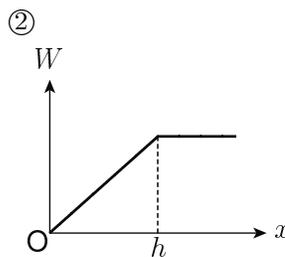
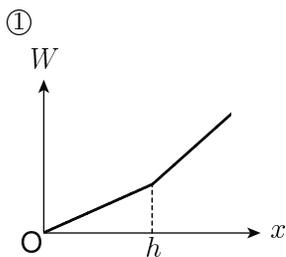
⑤ $\frac{\sqrt{3}(\ell - a)}{3\ell}mg$

⑥ $\frac{\sqrt{3}a}{3\ell}mg$

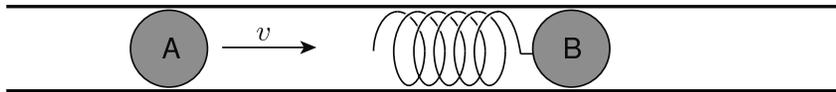
D As shown in the figure below, when cylindrical object **A** is placed in water in a tank, it floats horizontally on the surface of the water. The top of **A** is height h above the water's surface. Next, a thin rod is used to push the center of **A** vertically downward, so as to gently submerge **A** while keeping its top surface horizontal. The tank is sufficiently large and contains a sufficient amount of water.



Q4 From ①-⑥ below choose the graph that best represents the relationship between the distance x traveled vertically downward by **A** and the work W done on **A** by the rod's pushing force. **4**



E Small balls A and B, each of mass m , are placed inside a long horizontal cylinder. A light spring with spring constant k is attached to B. Both A and B can move smoothly through the cylinder. B is initially at rest. As shown in the figure below, A collides with the spring at speed v , and B begins to move as the spring starts to compress.



Q5 How much does the spring compress when at its maximum compression? From ①-⑤ below choose the correct answer. 5

① $\frac{v}{2} \sqrt{\frac{m}{k}}$

② $v \sqrt{\frac{m}{2k}}$

③ $v \sqrt{\frac{m}{k}}$

④ $v \sqrt{\frac{2m}{k}}$

⑤ $2v \sqrt{\frac{m}{k}}$

G As shown in Figure 1 below, a certain planet (mass: m_1) orbits a star (mass: M_1) with speed v_1 , in uniform circular motion with radius r_1 . As shown in Figure 2, another planet (mass: m_2) orbits a different star (mass: M_2) with speed v_2 , in uniform circular motion with radius r_2 . The mass of the stars is sufficiently greater than the mass of the planets. Thus the stars can be assumed to be at rest.

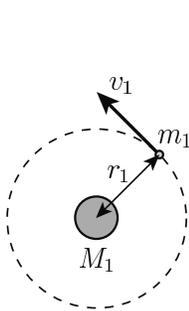


Figure 1

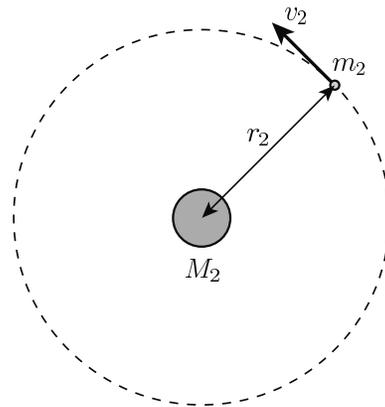


Figure 2

Q7 Under what condition would $v_1 = v_2$? From ①-⑥ below choose the best answer.

7

① $M_1 = M_2$

② $m_1 = m_2$

③ $M_1 m_1 = M_2 m_2$

④ $\frac{M_1}{r_1} = \frac{M_2}{r_2}$

⑤ $\frac{m_1}{r_1} = \frac{m_2}{r_2}$

⑥ $\frac{M_1 m_1}{r_1} = \frac{M_2 m_2}{r_2}$

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

A A 210-g piece of iron heated to 100°C is placed in 90 g of water at 20°C . The specific heat of water is $4.2 \text{ J}/(\text{g}\cdot\text{K})$, and the specific heat of iron is $0.45 \text{ J}/(\text{g}\cdot\text{K})$. There is no exchange of heat with the surroundings.

Q1 What is the temperature of the water after sufficient time elapses? From ①-④ below choose the best answer. **8** $^{\circ}\text{C}$

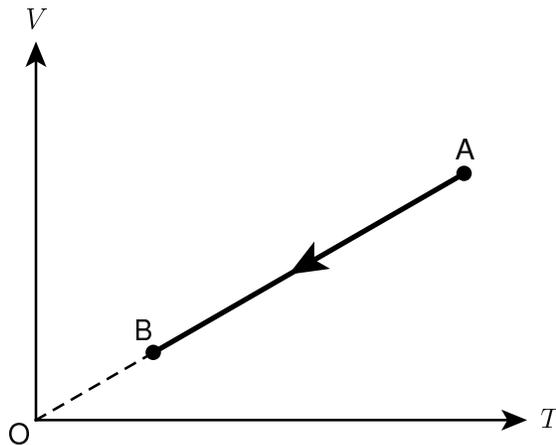
① 24

② 36

③ 48

④ 60

B As shown in the figure below, the state of a certain ideal gas is changed in the path $A \rightarrow B$. Absolute temperature T is taken on the horizontal axis, and volume V on the vertical axis.



Q2 What happens to the pressure p of the gas as a result of change of state $A \rightarrow B$? Also, does the gas absorb heat, or emit it? From ①-⑥ below choose the correct answer. 9

- ① The pressure p increases; the gas absorbs heat.
- ② The pressure p increases; the gas emits heat.
- ③ The pressure p decreases; the gas absorbs heat.
- ④ The pressure p decreases; the gas emits heat.
- ⑤ The pressure p does not change; the gas absorbs heat.
- ⑥ The pressure p does not change; the gas emits heat.

C As shown in Figure 1 below, objects A (heat capacity: C_A) and B (heat capacity: C_B) are placed in contact with each other and are enclosed in a heat insulator. Figure 2 shows the change in each object's temperature over time t .

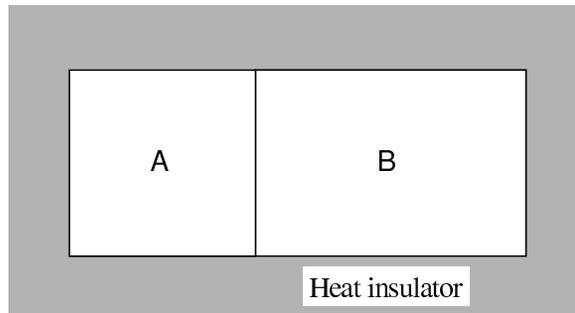


Figure 1

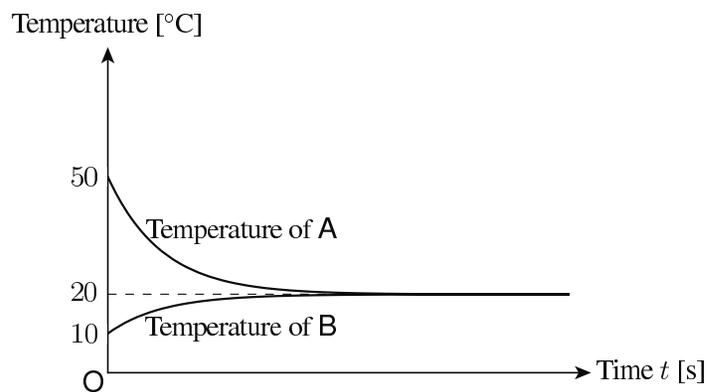


Figure 2

Q3 What is the value of $\frac{C_B}{C_A}$? From ①-④ below choose the best answer.

10

① 0.2

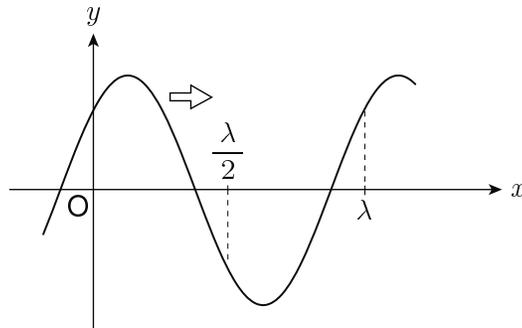
② 0.3

③ 3

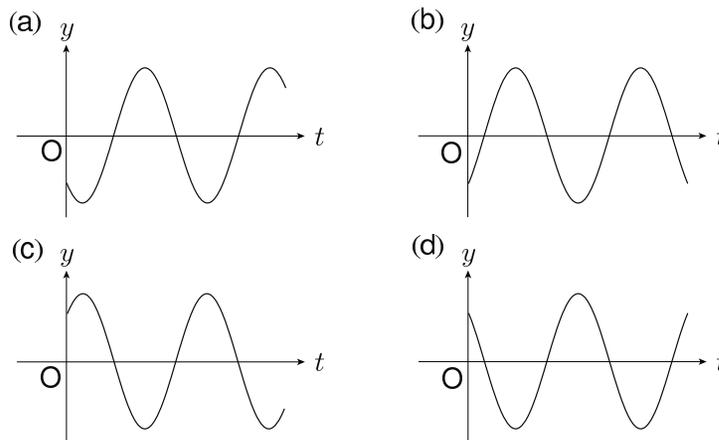
④ 5

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

A A sinusoidal wave with a wavelength λ is traveling along an x -axis in the positive direction. The figure below shows the relationship between the x -coordinate and the wave's displacement y , at time $t = 0$.

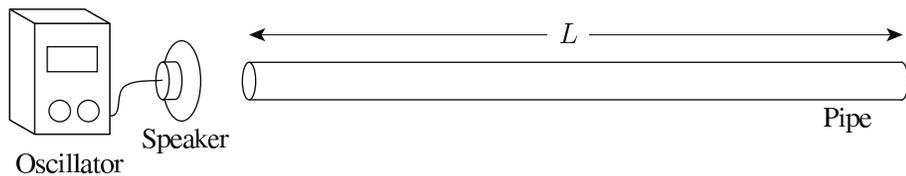


Q1 Figures (a)~(d) below are graphs that represent the change over time t of the displacement y of this wave at a certain position on the x -axis. From ①-④ below choose the combination that best indicates the change over time of y at $x = \frac{\lambda}{2}$ and at $x = \lambda$. 11



	①	②	③	④
$x = \frac{\lambda}{2}$	(a)	(a)	(b)	(b)
$x = \lambda$	(c)	(d)	(c)	(d)

- B** Sound of various frequencies is produced using a variable-frequency oscillator and a speaker. As shown in the figure below, a round pipe (length: L) is placed to the right of the speaker. The left end of the pipe is open. The sound volume is measured as the frequency is gradually increased from 0, and it is discovered that the sound volume becomes louder at certain frequencies. Assume that L is sufficiently long.



- Q2** We define the sound frequency as f where the sound volume first becomes louder. We find that the sound volume also becomes louder at frequencies $2f$, $3f$, and $4f$. What is the wavelength of the sound at frequency f ? Also, is the right end of the pipe open, or closed? From ①-⑥ below choose the best combination. 12

	Wavelength	Right end
①	L	open
②	L	closed
③	$2L$	open
④	$2L$	closed
⑤	$4L$	open
⑥	$4L$	closed

C White light incident on a certain glass prism produces differently colored bands of light on a screen, in the order shown in Figure 1 below. A hole in the same shape as the prism is made in a block of glass, and white light is directed to the hole through the glass in the manner shown in Figure 2.

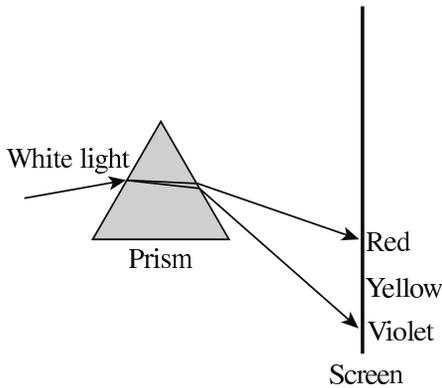


Figure 1

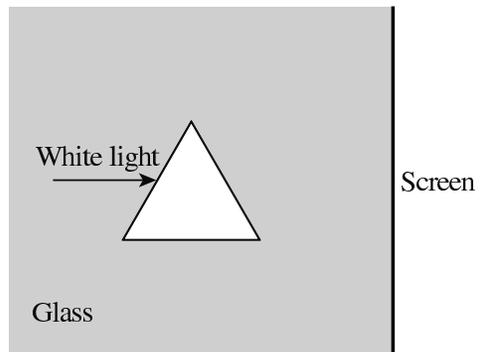


Figure 2

Q3 How do the colored light bands appear on the screen in Figure 2? From ①-④ below choose the best answer.

13

- ①

Red
Yellow
Violet

Screen
- ②

Violet
Yellow
Red

Screen
- ③

Red
Yellow
Violet

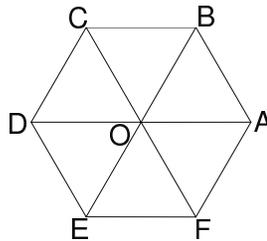
Screen
- ④

Violet
Yellow
Red

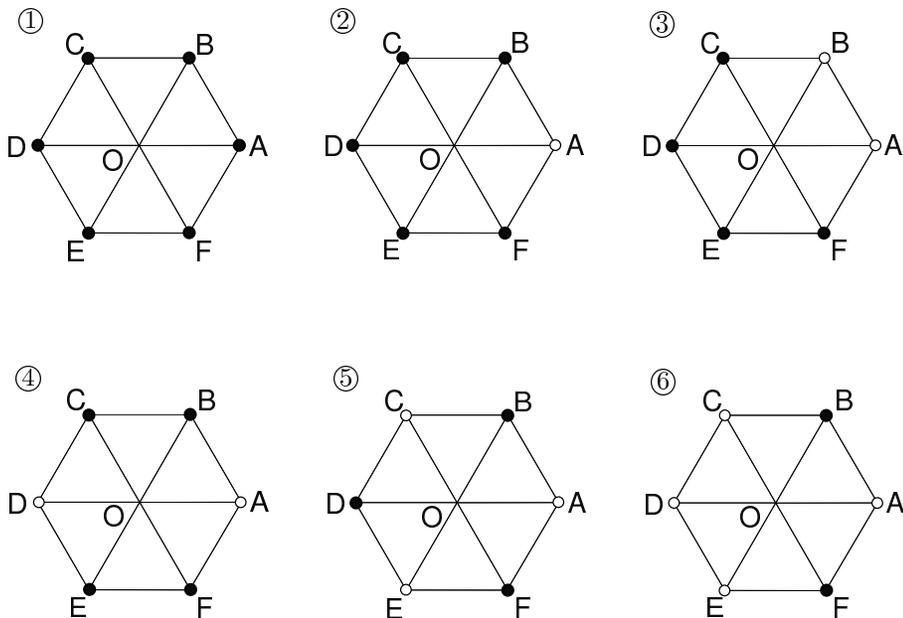
Screen

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

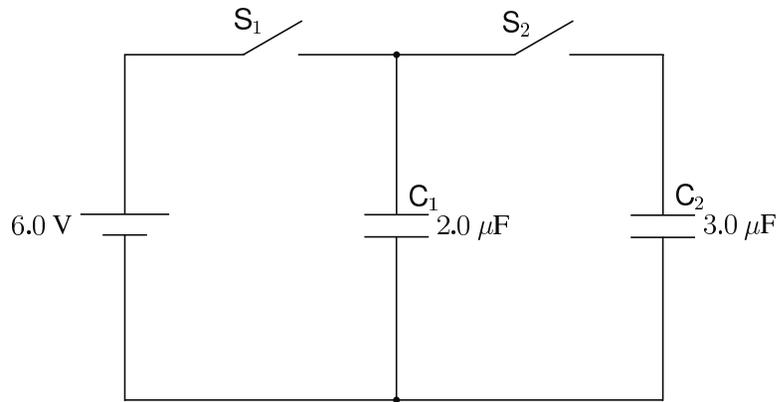
A Referring to the regular hexagon shown in the figure below, consider how the magnitude of the electric field at the hexagon's center **O** varies when positive electric charges of the same quantity of electricity are placed at vertices **A-F** in different patterns.



Q1 Of the figures shown in ①-⑥ below, which has the largest magnitude of electric field at **O**? From ①-⑥ below choose the correct answer, where ● on the vertices indicates the presence of a charge, and ○ indicates the absence of a charge. **14**



B As shown in the figure below, a circuit is formed from uncharged capacitor C_1 (capacitance: $2.0 \mu\text{F}$), uncharged capacitor C_2 (capacitance: $3.0 \mu\text{F}$), switches S_1 and S_2 , and a battery (electromotive force: 6.0 V). Initially, S_1 and S_2 are open. First, S_1 only is closed to charge C_1 . After C_1 is charged, S_1 is opened and S_2 is closed.



Q2 What does the electrical potential difference (in V) between the two plates of C_1 become?

From ①-④ below choose the best answer.

15 V

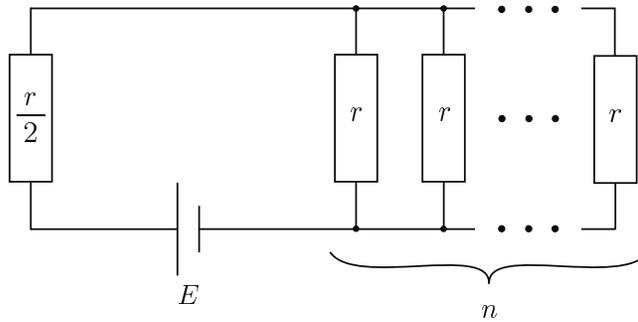
① 2.4

② 3.6

③ 6.0

④ 10

C As shown in the figure below, a resistor of resistance $\frac{r}{2}$ and n resistors of resistance r are connected to a battery (electromotive force: E). Internal resistance of the battery is negligible.



Q3 At what value of n would the amount of power consumed by all resistance- r resistors be the largest? From ①-④ below choose the correct answer. **16**

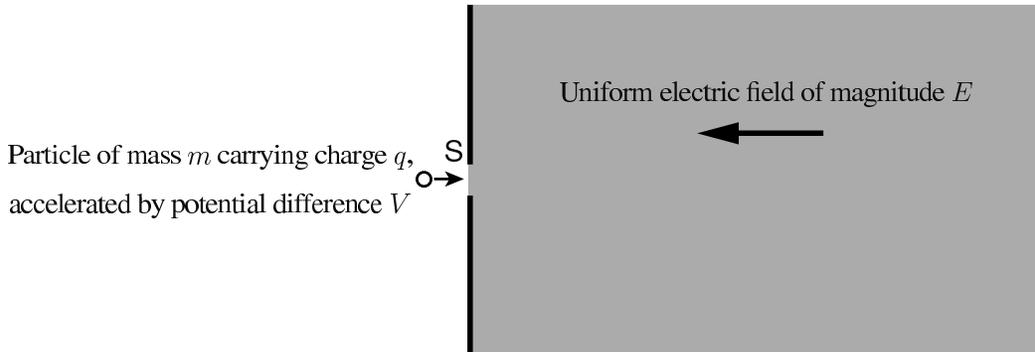
① 1

② 2

③ 3

④ 4

D A particle of mass m carrying charge $q (> 0)$ is accelerated from rest by electrical potential difference V so that it passes through slit **S** into a uniform electric field of magnitude E , in the direction opposite to the field's direction. The particle returns to **S** after time t elapses from the initial passage through **S**.



Q4 What is the magnitude of m ? From ①-⑦ below choose the correct answer.

17

① $\frac{8qE^2t^2}{V}$

② $\frac{4qE^2t^2}{V}$

③ $\frac{2qE^2t^2}{V}$

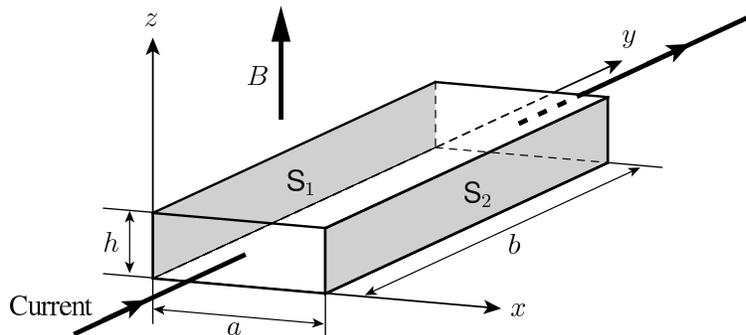
④ $\frac{qE^2t^2}{V}$

⑤ $\frac{qE^2t^2}{2V}$

⑥ $\frac{qE^2t^2}{4V}$

⑦ $\frac{qE^2t^2}{8V}$

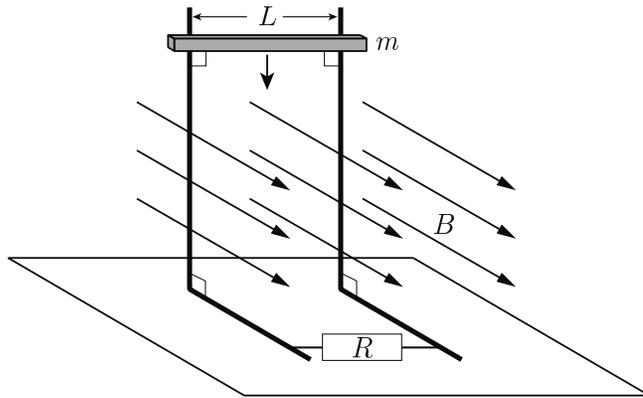
E As shown in the figure below, a cuboid electrical conductor (width: a ; length: b ; height: h) is placed in a uniform magnetic field where the magnitude of magnetic flux density is B in the positive direction of the z -axis. An electrical current is flowing through the conductor in the positive direction of the y -axis. The speed of electrons moving through the conductor is v .



Q5 An electrical potential difference occurs between sides S_1 and S_2 shown in the figure. Which side has the higher electrical potential? Also, how large is the absolute value of the potential difference? From ①-⑧ below choose the correct combination. **18**

	①	②	③	④	⑤	⑥	⑦	⑧
Side with higher electrical potential	S_1	S_1	S_1	S_1	S_2	S_2	S_2	S_2
Absolute value of potential difference	vBa	vBb	vBh	vB	vBa	vBb	vBh	vB

F As shown in the figure below, two conducting wires bent at right angles are placed on a horizontal surface so that one leg of each is vertical, and are connected to each other at one end by a resistor of resistance R . The wires are separated by distance L , and are in a uniform magnetic field whose magnitude of magnetic flux density is B , and whose direction is parallel to the horizontal legs of the wires. A conducting rod of mass m is released so that it constantly remains in contact with the vertical legs of the wires as it vertically falls. The conducting rod reaches a constant speed v_0 during its descent. Here, friction between the rod and the wires is negligible.



Q6 What is the magnitude of B ? From ①-④ below choose the correct answer, where the magnitude of acceleration due to gravity is g . **19**

- ① $\frac{mgR}{Lv_0}$ ② $\frac{mgR}{L^2v_0}$ ③ $\frac{1}{L}\sqrt{\frac{mgR}{v_0}}$ ④ $\sqrt{\frac{mgR}{Lv_0}}$

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 °C, 1.0×10^5 Pa (= 1.0 atm)

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

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

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

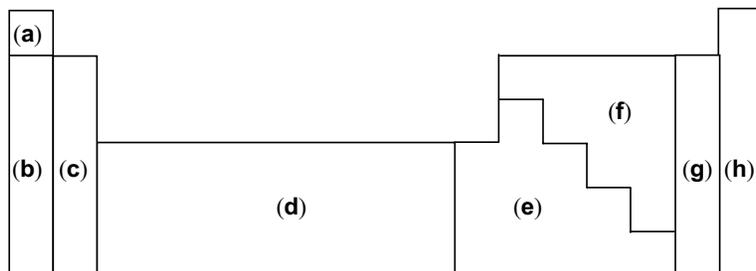
Faraday constant: $F = 9.65 \times 10^4$ C/mol

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

Q1 From the following ①-⑤ choose the one in which the two numbers concerning atoms or ions are different. 1

- ① the number of protons in ^{12}C and that of neutrons in ^{12}C
- ② the number of protons in ^{12}C and that in ^{13}C
- ③ the number of outermost shell electrons in Ca^{2+} and that in F^-
- ④ the number of neutrons in ^2H and that in ^4He
- ⑤ the total number of electrons in He and that in Li^+

Q2 The periodic table of elements is subdivided into (a)-(h) regions as is shown in the following figure. From the statements ①-⑥ below choose the one that is **not** correct. **2**



- ① The elements in region (b) are named alkali metals.
- ② Both Ca and Mg are in region (c).
- ③ Both Fe and Sn are in region (d).
- ④ All the elements in region (e) are main group elements.
- ⑤ All the elements in regions (f) and (g) are nonmetallic elements.
- ⑥ The elements in region (g) are named halogens.

Q3 From the following statements ①-⑤ on a water molecule choose the one that is **not** correct. **3**

- ① The number of electrons involved in covalent bonds within the molecule is 4.
- ② It has two unshared electron pairs.
- ③ Its molecular structure is linear.
- ④ It is a polar molecule.
- ⑤ It forms hydrogen bonds with hydrogen fluoride (HF) and methanol (CH₃OH).

Q4 Suppose 3.4 g of ammonia (NH₃) is dissolved in water to prepare 25 mL of aqueous ammonia. From the following ①-⑥ choose the closest value for the concentration (mol/L) of this aqueous solution. **4** mol/L

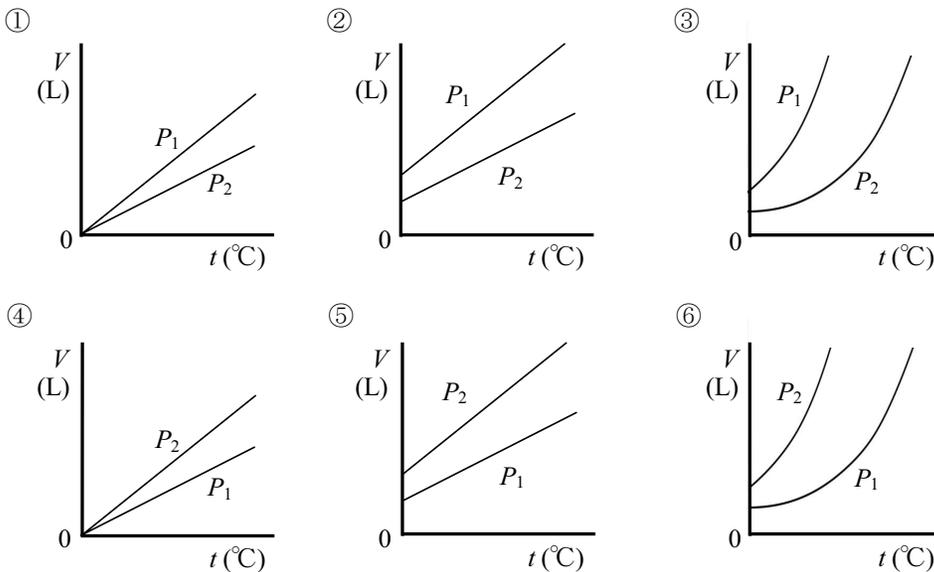
- ① 0.20 ② 0.50 ③ 0.80 ④ 2.0 ⑤ 5.0 ⑥ 8.0

Q5 Among the following molecules (a)-(g), two of these have double bond(s). From ①-⑥ below choose the correct combination. **5**

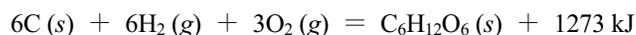
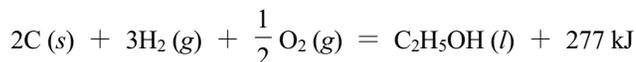
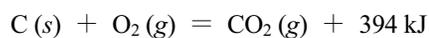
- | | |
|---|--------------------------------|
| (a) acetylene (ethyne) (C ₂ H ₂) | (b) ammonia (NH ₃) |
| (c) ethylene (ethene) (C ₂ H ₄) | (d) hydrogen chloride (HCl) |
| (e) chlorine (Cl ₂) | (f) nitrogen (N ₂) |
| (g) carbon dioxide (CO ₂) | |

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

Q6 The temperature t (°C) of 1 mol of an ideal gas was changed while its pressures P_1 (Pa) or P_2 (Pa) was kept constant. Assuming $P_1 < P_2$, choose from the following ①-⑥ the most appropriate graph representing the relation between t and the volume of the gas V (L). **6**



- Q7** The heats of formation of carbon dioxide (CO₂), ethanol (C₂H₅OH), and glucose (C₆H₁₂O₆) are represented by the following thermochemical equations, respectively.

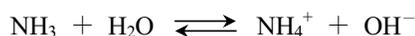


From ①-⑥ below choose the most appropriate value for Q in the following thermochemical equation for the reaction of glucose to form ethanol and carbon dioxide. **7** kJ



- ① 32 ② 35 ③ 47 ④ 60 ⑤ 69 ⑥ 95

- Q8** In its aqueous solution, ammonia (NH₃) exists in an equilibrium state as shown by the electrolytic dissociation below.



Which compound should be added to decrease the concentration of ammonium ion (NH₄⁺) in the aqueous solution? From the following ①-⑤ choose the most appropriate one. **8**

- ① C₂H₅OH ② CH₃COOH ③ NaCl ④ NaOH ⑤ NH₄Cl

- Q9** When 100 mL of 0.10 mol/L aqueous sodium hydroxide (NaOH (aq)) was added to 50 mL of 0.40 mol/L hydrochloric acid (HCl (aq)), 0.56 kJ of heat was generated. How much heat (kJ) will be generated when 100 mL of 0.30 mol/L aqueous sodium hydroxide is added to 50 mL of 0.40 mol/L hydrochloric acid? Choose from the following ①-⑥ the most appropriate value.

- 9** kJ
- ① 0.51 ② 0.72 ③ 1.1 ④ 1.6 ⑤ 2.1 ⑥ 3.2

Q10 How will the mass of the anode and that of the cathode change, respectively, when a lead storage battery is charged? From ①-⑤ in the following table choose the most appropriate combination.

10

	Cathode	Anode
①	increase	increase
②	increase	decrease
③	decrease	decrease
④	decrease	increase
⑤	no change	no change

Q11 From the following statements ①-⑤ on the properties of metals choose the most appropriate one.

11

- ① Silver (Ag) does not dissolve in concentrated nitric acid (conc. HNO_3).
- ② Aluminum (Al) does not dissolve in aqueous sodium hydroxide (NaOH (aq)).
- ③ Gold (Au) dissolves in concentrated sulfuric acid (conc. H_2SO_4).
- ④ Copper (Cu) dissolves in dilute hydrochloric acid (dil. HCl).
- ⑤ Iron (Fe) does not dissolve in concentrated nitric acid.

Q12 Procedures given in column **B** were performed to detect the ions in aqueous solutions given in column **A**. From ①-⑤ in the following table choose the one that is **not** correct for the results given in column **C**. **12**

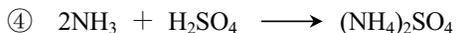
	A	B	C
①	Ag^+	Hydrochloric acid ($\text{HCl} (aq)$) was added.	White precipitates were formed.
②	Fe^{3+}	Aqueous sodium hydroxide ($\text{NaOH} (aq)$) was added little by little.	Reddish brown precipitates were formed which afterwards dissolved.
③	MnO_4^-	In the solution acidified with sulfuric acid, aqueous oxalic acid ($(\text{COOH})_2 (aq)$) was added and then heated.	The solution was decolorized.
④	Na^+	The flame reaction was performed.	The flame turned yellow.
⑤	SO_4^{2-}	Aqueous barium nitrate ($\text{Ba}(\text{NO}_3)_2 (aq)$) was added.	White precipitates were formed.

Q13 From ①-④ in the following table choose the correct reaction formula for what happens with each procedures. **13**

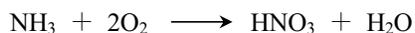
	Procedures	Reaction formulas
①	Aqueous sodium hydroxide is added to aqueous copper (II) sulfate.	$\text{CuSO}_4 + 2\text{NaOH} \longrightarrow \text{Cu}(\text{OH})_2 + \text{Na}_2\text{SO}_4$
②	Sodium hydrogencarbonate is thermally decomposed.	$\text{NaHCO}_3 \longrightarrow \text{NaOH} + \text{CO}_2$
③	Aqueous ammonia is added to aqueous silver nitrate in excess.	$2\text{AgNO}_3 + 2\text{NH}_3 + \text{H}_2\text{O} \longrightarrow \text{Ag}_2\text{O} + 2\text{NH}_4\text{NO}_3$
④	Calcium hydroxide is added to ammonium chloride and then heated.	$2\text{NH}_4\text{Cl} + \text{Ca}(\text{OH})_2 \longrightarrow 2\text{NH}_4\text{OH} + \text{CaCl}_2$

Q14 From the following reactions ①-⑤ choose the one that is an oxidation-reduction reaction.

14



Q15 The Ostwald process, an industrial process to synthesize nitric acid (HNO_3) from ammonia (NH_3), is represented by the following reaction formula.



How many kg of nitric acid will be obtained from 17 kg of ammonia by this reaction? From the following ①-⑤ choose the closest value.

15 kg

- ① 17 ② 33 ③ 50 ④ 63 ⑤ 86

Q16 From the following combination of compounds ①-⑤ choose the one in which the two compounds have the same empirical formula.

16

①	acetic acid	formaldehyde
②	acetic acid	formic acid
③	acetone	ethyl acetate
④	acetylsalicylic acid	methyl salicylate
⑤	ethylene glycol (1,2-ethanediol)	glycerin (1,2,3-propanetriol)

Q17 From the following compounds ①-⑤ choose the one in which all atoms in the molecule exist in one plane. **17**

- ① acetic acid ② benzene ③ cyclohexane
④ diethyl ether ⑤ methane

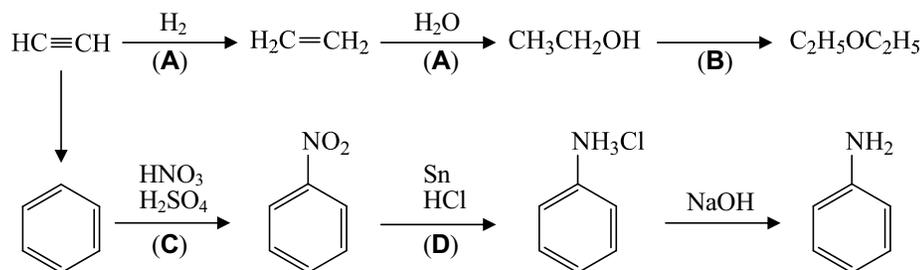
Q18 How many grams (g) of carbon dioxide (CO₂) and water (H₂O) will be formed when 0.264 g of an ester with the molecular formula C₄H₈O₂ is completely combusted? From ①-⑥ in the following table choose the most appropriate combination. **18**

	Carbon dioxide (g)	Water (g)
①	0.336	0.192
②	0.528	0.192
③	0.528	0.216
④	0.672	0.216
⑤	0.672	0.384
⑥	1.056	0.432

Q19 What are the general names of the reactions (A)-(D) in the following reaction paths?

From ①-⑥ in the table below choose the most appropriate combination.

19



	A	B	C	D
①	condensation	substitution	condensation	reduction
②	condensation	addition	addition	oxidation
③	condensation	addition	addition	reduction
④	addition	condensation	substitution	oxidation
⑤	addition	condensation	substitution	reduction
⑥	addition	substitution	condensation	oxidation

Q20 Benzoic acid and phenol were dissolved in diethyl ether, and the mixture was placed in a separatory funnel. One of the following aqueous solutions (**a**) or (**b**) was added to the mixture, the separatory funnel was vigorously shaken, and the contents were allowed to settle into two layers. In which layer, the upper layer or the lower layer, benzoic acid or phenol is mainly contained, respectively? From ①-⑥ in the table below choose the correct combination.

20

- (a) aqueous sodium hydroxide ($\text{NaOH} (aq)$)
 (b) aqueous sodium hydrogencarbonate ($\text{NaHCO}_3 (aq)$)

	a		b	
	Benzoic acid	Phenol	Benzoic acid	Phenol
①	upper layer	upper layer	upper layer	upper layer
②	upper layer	upper layer	upper layer	lower layer
③	upper layer	lower layer	upper layer	lower layer
④	lower layer	upper layer	lower layer	upper layer
⑤	lower layer	lower layer	lower layer	lower layer
⑥	lower layer	lower layer	lower layer	upper layer

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 From ①–④ below choose the statement that does **not** correctly describe an action or characteristic of cell membranes. 1

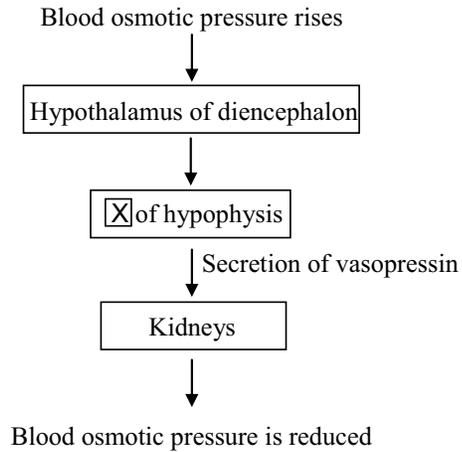
- ① The action whereby the cell membrane passes certain substances through its channels is called “active transport.”
- ② The action whereby substances are passed through the cell membrane through diffusion without the use of energy is called “passive transport.”
- ③ Certain proteins in the cell membrane function as hormone receptors.
- ④ In neurons, an action potential results from changes in the cell membrane’s permeability.

Q2 Statements (a)–(d) below describe animal tissues. From ①–⑧ below choose the combination that correctly indicates the statements that apply to nervous tissue and connective tissue, and indicates the germ layers from which these two types of tissue originate. **2**

- (a) Its composition includes cells with many complex protrusions.
- (b) Its cells are contractile and function when tissue or organs change shape.
- (c) It has a sheet structure in which cells are joined together.
- (d) Its cells do not stick together, and it has large amount of intercellular substances.

	Nervous tissue		Connective tissue	
	Applicable statement	Germ layer of origin	Applicable statement	Germ layer of origin
①	a	mesoderm	c	endoderm
②	a	mesoderm	d	ectoderm
③	a	ectoderm	c	ectoderm
④	a	ectoderm	d	mesoderm
⑤	b	endoderm	c	mesoderm
⑥	b	endoderm	d	ectoderm
⑦	b	mesoderm	c	endoderm
⑧	b	mesoderm	d	mesoderm

Q4 The figure below explains hormone-based osmoregulation of blood. Answer questions (1) and (2) below concerning this osmoregulation and hormones.



(1) What term fills blank X in the figure? Also, does the effect of vasopressin increase or decrease the amount of urine produced by the kidneys? From ①–④ below choose the correct combination. **5**

	X	Amount of urine
①	anterior lobe	increases
②	anterior lobe	decreases
③	posterior lobe	increases
④	posterior lobe	decreases

(2) Which two statements in (a)–(d) below correctly describe the secretion or effect of vasopressin? From ①–④ below choose the correct combination. 6

- (a) Vasopressin is secreted when a releasing hormone synthesized in the hypothalamus is transported to the hypophysis via the bloodstream.
- (b) Vasopressin is synthesized by neurosecretory cells of the hypothalamus, and is transported through axons to the hypophysis, where it is secreted.
- (c) Vasopressin has the effect of raising the blood pressure.
- (d) Vasopressin has the effect of lowering the blood pressure.

① a, c ② a, d ③ b, c ④ b, d

Q5 Statements (a)–(d) below describe the human pancreas. From ①–⑥ below choose the combination indicating the two statements that are correct. 7

- (a) Sympathetic nerves are distributed across the pancreas, but parasympathetic nerves are not.
- (b) The pancreas can detect changes in the blood glucose level.
- (c) The pancreas has endocrine and exocrine glands.
- (d) The pancreas secretes glucocorticoid from Langerhans' islet.

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

Q6 Muscle with the nerve attached (a nerve-muscle preparation) was removed from a frog and was connected to a device like the one shown in Figure 1 below. When an electrical stimulus was applied to the nerve one time, a contraction like that shown in Figure 2 was recorded. Answer questions (1) and (2) below concerning this.

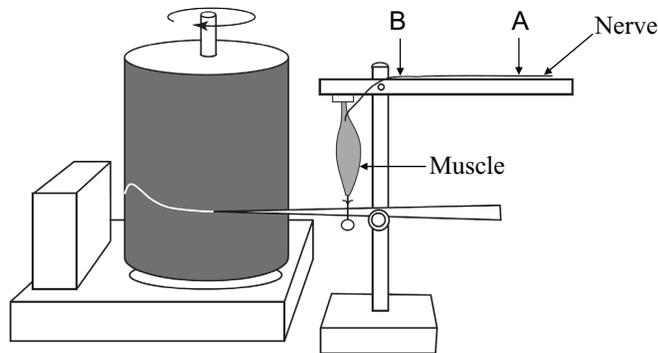


Figure 1

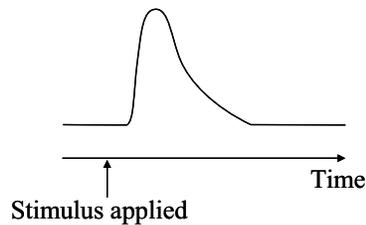


Figure 2

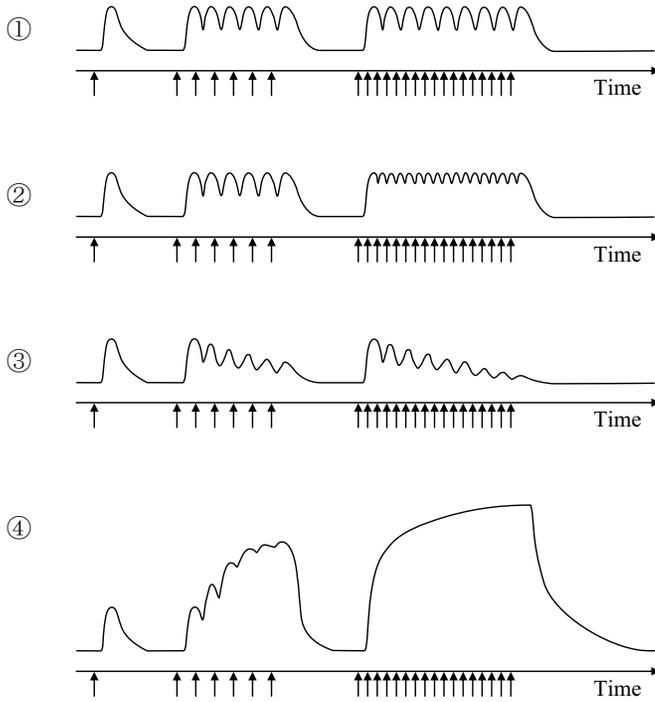
(1) When a stimulus was applied at point A in Figure 1, which is 65 mm from the muscle, a contraction occurred 5.2 milliseconds later. Next, a stimulus was applied at point B, 26 mm from the muscle. Based on these results, the conduction velocity of this nerve was determined to be 26 m/s. In the case of the stimulus applied at point B, how much time elapsed from stimulus to contraction? From ①–⑤ below choose the closest value. Note that one millisecond is 1/1000 of a second.

8

- ① 1.0 milliseconds ② 2.1 milliseconds ③ 2.7 milliseconds
 ④ 3.7 milliseconds ⑤ 5.2 milliseconds

(2) If stimuli are applied repeatedly at different intervals, what sort of contraction pattern would be recorded? From ①–④ below choose the best answer, where the arrows indicate the application of stimuli.

9



Q7 From ①–④ below choose the statement that does **not** correctly describe water absorption by plants or water transport inside plants. **10**

- ① The root hairs on the surface of roots are a part of epidermal cells; they increase the root's surface area, and absorb water and other substances from outside the plant.
- ② Water absorbed by the roots is transported throughout the plant via vessels. During transport, the water is able to move without interruption due to its cohesion (the attraction of water molecules to one another).
- ③ In the leaves, water migrates from the sieve tubes to the cells of palisade tissue and spongy tissue, after which it becomes water vapor released outside the plant from the stomata.
- ④ The guard cells that form stomata are a type of epidermal cell; they regulate transpiration by opening and closing the stomata as a result of changes in their turgor pressure.

Q8 The graph in Figure 1 below expresses the relationship between temperature and photosynthetic rate for when a certain plant is exposed to 20 kilolux and 3 kilolux of light. The graph in Figure 2 below expresses the relationship between light intensity and photosynthetic rate for when the same plant is kept at 20°C. The vertical axes of both graphs are in the same units.

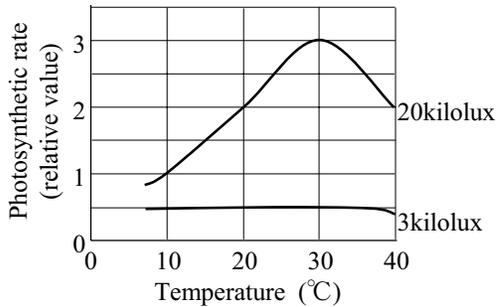


Figure 1

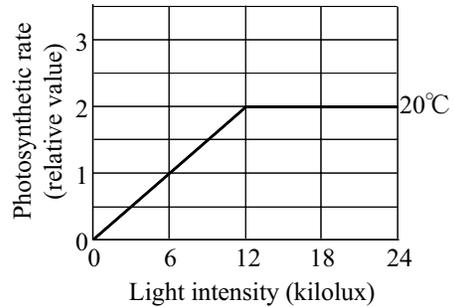
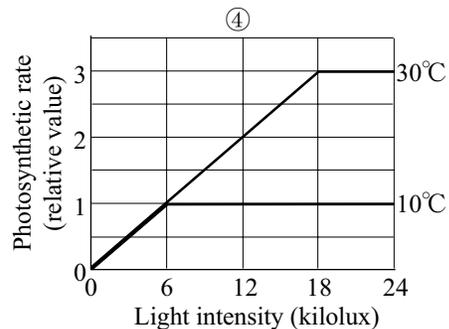
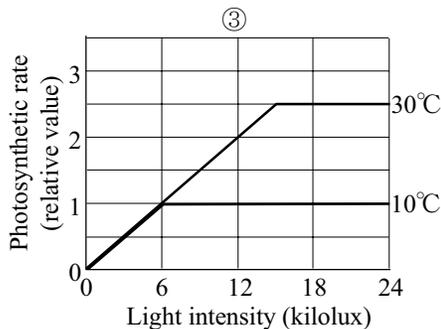
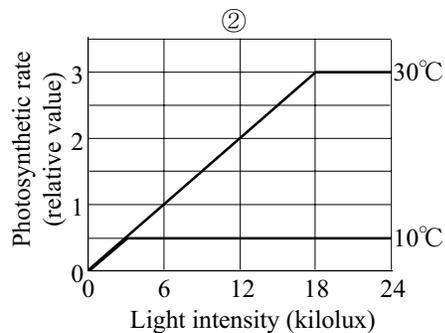
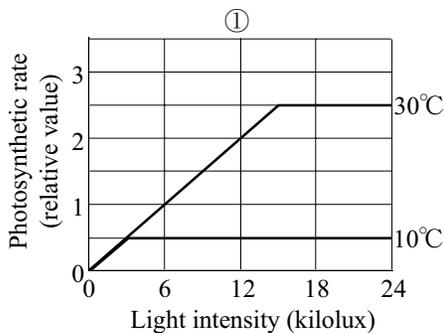


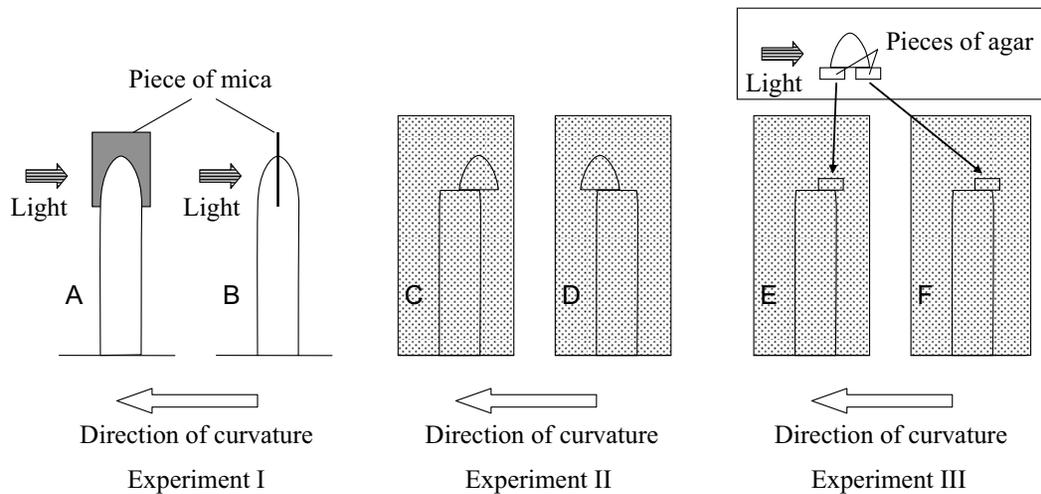
Figure 2

From ①–④ below choose the graph that best expresses the relationship between light intensity and photosynthetic rate at 10°C and 30°C. Assume that each graph's slope remains constant from the origin (light intensity: 0; photosynthetic rate: 0) to the light saturation point.

11



Q9 Common oat (*Avena sativa*) coleoptiles raised in a darkroom were used to perform Experiments I–III as shown in the figure below. From ①–⑧ on the following page choose the combination that correctly indicates the half of each experiment (A or B, C or D, E or F) in which curvature of the coleoptile to the left was greater than in the other half. 12



- Experiment I** A piece of mica was inserted in the tip of a coleoptile, and light was projected from the left, parallel to the mica (A). Similarly, another piece of mica was inserted in the tip of a different coleoptile, and light was projected from the left, perpendicular to the mica (B).
- Experiment II** The tips of two coleoptiles were completely severed. One tip was shifted to the right of the cut surface (C). The other tip was shifted to the left of the cut surface (D). Both coleoptiles were then raised in the darkroom.
- Experiment III** The tip of a coleoptile was cut off, placed on two pieces of agar, and light was projected on it from the left for a while. Next, the left-side piece of agar (E) and the right-side piece of agar (F) were each placed toward the right on the cut surface of a coleoptile whose tip was removed, and the two coleoptiles were kept in the darkroom.

	Experiment I	Experiment II	Experiment III
①	A	C	E
②	A	C	F
③	A	D	E
④	A	D	F
⑤	B	C	E
⑥	B	C	F
⑦	B	D	E
⑧	B	D	F

Q10 From ①–⑤ below choose the statement that does **not** correctly describe major substances in the composition of cells. **13**

- ① Water is generally the most abundant substance in the cell. As a solvent, it is used to dissolve various substances.
- ② Proteins are vital to the structure and functions of living organisms, and are a constituent of substances such as enzymes, antibodies, and a certain class of hormones. They are mainly composed of the elements C · H · O · N · S.
- ③ DNA and RNA are types of nucleic acid; DNA is the material of genes, and RNA is involved in protein synthesis. They are mainly composed of the elements C · H · O · N · P.
- ④ Carbohydrates include glucose, which is the cell's main source of energy, and cellulose, which is a constituent of the cell membrane. They are mainly composed of the elements C · H · O.
- ⑤ Phospholipids are a type of lipid, and are a constituent of the cell membrane.

Q11 From ①–⑧ below choose the combination of terms that correctly fills blanks **a** **c** in the following paragraphs describing respiration. **14**

Aerobic and anaerobic respiration are the two general forms of respiration, the extraction of energy through the breakdown of glucose. The process that is common to both is **a**. Of these two forms, **b** produces more ATP per glucose molecule.

Essentially, aerobic respiration is the same reaction as the combustion of glucose in air. However, in aerobic respiration the energy is produced gradually, while combustion is a rapid reaction that releases most of the energy as heat and light. Nevertheless, both reactions evolve **c** in the end.

	a	b	c
①	glycolysis	aerobic respiration	oxygen and water
②	glycolysis	aerobic respiration	carbon dioxide and water
③	glycolysis	anaerobic respiration	oxygen and water
④	glycolysis	anaerobic respiration	carbon dioxide and water
⑤	electron transport system	aerobic respiration	oxygen and water
⑥	electron transport system	aerobic respiration	carbon dioxide and water
⑦	electron transport system	anaerobic respiration	oxygen and water
⑧	electron transport system	anaerobic respiration	carbon dioxide and water

Q12 From ①–⑨ below choose the combination indicating the two statements in (a)–(e) below that correctly describe assimilation. **15**

- (a) Nitrogen fixation is a reaction that forms ammonia from nitrogen gas in the air; a representative example of organisms that fix nitrogen is clostridium, which is symbiotic with legumes.
- (b) Chemosynthesis often takes place in fungi, such as mold and mushrooms.
- (c) Since animals are incapable of carbon dioxide assimilation and nitrogen assimilation, they are referred to as heterotrophs.
- (d) Nitrogen assimilation is a reaction that forms amino acids and other organic nitrogen compounds from inorganic nitrogen compounds.
- (e) All organisms that carry out carbon dioxide assimilation require light energy, and form organic compounds from CO₂ and water.

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

Q13 From ①–⑤ below choose the statement that best describes the phenomenon that occurs when foreign matter invades the human body. **16**

- ① Foreign matter is broken down by thrombin at the site of the wound where it invaded.
- ② Fibrin released from blood platelets encloses the invading foreign matter in a blood clot.
- ③ Through the process of phagocytosis, macrophages and certain other cells engulf and degrade the invading foreign matter.
- ④ Antigens are produced to counter the invading foreign matter, and immunity is developed.
- ⑤ When an allergy arises from invasion by foreign matter, the foreign matter is eliminated.

Q14 From ①–⑨ below choose the combination indicating the two statements in (a)–(e) below that correctly describe the expression of genetic information in eukaryotes. **17**

- (a) In addition to messenger RNA (mRNA), RNA comes in other forms such as transfer RNA (tRNA) and ribosomal RNA (rRNA); the form that holds the information for the amino acid sequence of proteins is tRNA.
- (b) An enzyme called RNA polymerase functions during transcription, the process by which DNA base sequences are transcribed.
- (c) DNA base sequences consist of introns, which are regions that actually code for protein synthesis, and exons, which do not serve as genetic information.
- (d) Splicing is a process occurring in the nucleus that removes introns from the transcribed RNA and joins together the remaining exons.
- (e) Transcription takes place on the ribosomes in the cytoplasm; this is where tRNA with the anticodons complementary to the mRNA codons binds.

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

Q15 Nuclei were removed from epithelial cells of the intestine of an albino African clawed frog (*Xenopus laevis*) tailbud stage embryo and were transplanted in denucleated unfertilized eggs from a wild-type female. Some of the eggs that received a nuclear transplant normally developed into adults. From ①–⑧ below choose the combination indicating the two statements in (a)–(f) below that correctly describe the results of this experiment. Note that albinos have white skin since they genetically lack the ability to produce melanin pigment.

18

- (a) The frogs that developed were all wild-type individuals of the same sex.
- (b) The frogs that developed were all wild-type individuals of both sexes.
- (c) The frogs that developed were all albino individuals of the same sex.
- (d) The frogs that developed were all albino individuals of both sexes.
- (e) The frogs that developed were all genetically the same.
- (f) The frogs that developed were all genetically different.

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

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.