2021 Examination for Japanese University Admission for International Students

Science (80 min.) [Physics, Chemistry, Biology]

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

Rules of Examination

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

II Rules and Information Concerning the Question Booklet

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

Subject	Pages
Physics	1-21
Chemistry	23-37
Biology	39-54

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

II Rules and Information Concerning the Answer Sheet

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

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

Examination registration number		*			*			
Name								

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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.

<	Exar	npl	e>		
解答科目 Subject					
物理 Physics	化 Chem	学 istry	生 Biol	物 logy	
	0		(

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

A Object A (mass: m_A) and object B (mass: m_B) are placed in contact with each other on a smooth horizontal surface. As shown in the figure below, a force of magnitude F_0 is applied to A in the horizontal direction to the right, and A and B begin moving as a unit with uniform acceleration. Let us denote as F the magnitude of the force exerted on A by B.



Q1 What is
$$\frac{F}{F_0}$$
? From (1)-(4) below choose the correct answer.

$$(1) \quad \frac{m_{\mathsf{A}}}{m_{\mathsf{A}} + m_{\mathsf{B}}} \qquad (2) \quad \frac{m_{\mathsf{B}}}{m_{\mathsf{A}} + m_{\mathsf{B}}} \qquad (3) \quad \frac{m_{\mathsf{A}} + m_{\mathsf{B}}}{m_{\mathsf{A}}} \qquad (4) \quad \frac{m_{\mathsf{A}} + m_{\mathsf{B}}}{m_{\mathsf{B}}}$$

1

2

B A small object of mass m is at rest on a smooth horizontal surface. A force acts on the object in a horizontal direction from time t = 0 to t = T. The direction of the force is constant, and its magnitude, F, changes with time t. The figure below is a graph showing the relationship between F and t. Let us denote as v_T the speed of the object at t = T.



Q2 What is v_T ? From (1)-(6) below choose the correct answer.

 ${f C}$ As shown in the figure below, a platform is fixed in place on a horizontal floor and has a smooth, sloped upper surface that forms an angle of 30° with the horizontal. A fixed pulley is attached to each end of the sloped surface. An object of mass 2m is held in place on the sloped surface and a string is attached to each side of the object. The strings are kept parallel to the sloped surface and placed over the pulleys. A weight of mass m is suspended from the string on the lower side, and a weight of mass 3m is suspended from the string on the higher side. The object is gently released and begins moving with uniform acceleration of magnitude a. The string is lightweight and inelastic, and the pulleys are lightweight and rotate smoothly.



Q3 What is a? From (1)-(6) below choose the correct answer.

- (4) $\frac{g}{3}$ (5) $\frac{g}{2}$ (6) $\frac{2g}{3}$

D As shown in Figure 1 below, small objects A (mass: 1.0 kg) and B (mass: 1.0 kg) are both moving to the right along the same line on a smooth horizontal floor. The speed of A and B is 2.0 m/s and 1.0 m/s, respectively. A and B collide, and subsequently A and B move to the right with speed v_A and v_B , respectively, as shown in Figure 2. Let us denote as e the coefficient of restitution between A and B. Given that the value of e is in the range $0 \le e \le 1$, we know that the value of v_A is in a range between a certain minimum and a certain maximum.





Figure 2

Q4 What is the minimum of v_A (in m/s)? From (1-5) below choose the best answer. 4 m/s



E As shown in Figure 1 below, a spring and a small object are placed on a smooth horizontal surface. The spring is at its natural length, with one end attached to a wall and the other end in contact with the object. As shown in Figure 2, the object is pushed so that the spring compresses distance L from its natural length, and is gently released. The object begins moving on the horizontal surface. Let us denote as K(x) the kinetic energy of the object when the spring is compressed distance x from its natural length.



Q5 From (1)-(6) below choose the graph that best represents the relationship between K(x) and x.



6

F As shown in the figure below, one end of a lightweight inelastic string of length ℓ is fixed in place at height $h(<\ell)$ above a smooth horizontal floor, and the other end is attached to a small object of mass m. The object is undergoing uniform circular motion on the floor with angular velocity ω , as the string remains taut. Let us denote as S the tension in the string.



Q6 What is S? From (1)-(6) below choose the correct answer.

(1) $mh\omega^2$ (2) $m\ell\omega^2$ (3) $m\sqrt{\ell^2 - h^2}\omega^2$ $m\ell^2 \omega^2$ $m(\ell^2 - h^2)\omega^2$

- \blacksquare Answer questions A (Q1), B (Q2), and C (Q3) below.
 - A Ice of 40 g at -10 °C is placed in water of 120 g at 20 °C. After sufficient time elapses, the mixture becomes water and ice at 0 °C. The specific heat of water is 4.2 J/(g·K), the specific heat of ice is 2.1 J/(g·K), and the heat of fusion of ice is $3.3 \times 10^2 \text{ J/g}$. Assume that there is no exchange of heat with the environment.
 - Q1 What is the mass of the remaining ice (in g)? From ①-⑦ below choose the best answer.

1	8.0	2	12	3	16	4	20
5	24	6	28	\overline{O}	32		

7 g

8

- **B** Consider a certain quantity of an ideal gas. Initially, the pressure, volume, and absolute temperature of the gas are p_0 , V_0 , and T_0 , respectively. While the pressure is kept constant, the absolute temperature of the gas is changed from T_0 to T (> T_0). Let us denote as W the work done on the gas by the environment in this process.
- Q2 What is W? From (1)-(4) below choose the correct answer.

$$\begin{array}{cccc} \textcircled{1} & \frac{p_0 V_0 (T_0 - T)}{T_0} & & & & & & \\ \textcircled{3} & \frac{p_0 V_0 (T_0 - T)}{T} & & & & & & \\ \hline \end{array} & & & & & & & \\ \textcircled{4} & \frac{p_0 V_0 (T - T_0)}{T} \end{array}$$

C As shown in the p-V diagram below, the state of a certain quantity of an ideal gas is changed from state A to state B in three pathways that go through different states (I, II, III). Let us denote as Q_{I} , Q_{II} , and Q_{III} the quantity of heat absorbed by the gas in the change passing through state I, II, and III, respectively.



Q3 What is the magnitude relationship among Q_{I}, Q_{II} , and Q_{III} ? From (1)-(5) below choose the correct answer.

 $(1) \quad Q_{\rm I} < Q_{\rm II} < Q_{\rm II} \qquad (2) \quad Q_{\rm III} < Q_{\rm I} < Q_{\rm I} \qquad (3) \quad Q_{\rm I} = Q_{\rm III} < Q_{\rm II}$

(4)
$$Q_{\rm II} < Q_{\rm I} = Q_{\rm III}$$
 (5) $Q_{\rm I} = Q_{\rm II} = Q_{\rm III}$

10 s

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

A A sinusoidal wave with a frequency of 10 Hz is propagating along an x-axis in the positive direction. The figure below is a graph representing the relationship between displacement of the medium, y, and position x at time t = 0 s. Let us denote as t_1 the first time at which the value of y at x = 10.0 cm reaches its positive maximum following t = 0 s.



Q1 What is t_1 (in s)? From (1)-(4) below choose the best answer.

(1) 2.5×10^{-2} (2) 5.0×10^{-2} (3) 7.5×10^{-2} (4) 1.0×10^{-1}

- **B** Consider two stretched strings, A and B, which have the same length, *a*, but different linear density. The tension of the strings is adjusted so that they have the same fundamental frequency. Next, the tension of A is changed by a factor of *s* without changing the length from *a*, and the length of B is changed to *b* without changing the tension. As a result, the strings have the same fundamental frequency. Assume that the linear density of each string does not change. Here, the speed of a wave traveling along a string is directly proportional to the $\frac{1}{2}$ power of the string's tension, and to the $-\frac{1}{2}$ power of the string's linear density.
- **Q2** What is s? From (1)-(6) below choose the best answer.

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C As shown in the figure below, air, glass A, and glass B are in contact with one another along parallel boundary planes. Here, the absolute refractive index of air, glass A, and glass B is 1.0, 1.7, and 1.5, respectively. When light is directed from the air into glass A at an angle of incidence of 60° , the light passes from glass A into glass B at angle of refraction θ .



Q3 What is $\sin \theta$? From (1)-(5) below choose the best answer.

12

(1) 0.17 (2) 0.29 (3) 0.33 (4) 0.58 (5) 0.88

 $\overline{\text{IV}}$ Answer questions A (Q1), B (Q2), C (Q3), D (Q4), E (Q5), and F (Q6) below.

A As shown in the figure below, point charges are fixed in place at vertices A, B, and D of the square ABCD. The quantity of electricity of each point charge is q(> 0) at A, and 2q at B and D. Next, a point charge with quantity of electricity Q is fixed in place at vertex C. As a result, the magnitude of the electrostatic force acting on the point charge at A becomes zero.



Q1 What is $\frac{Q}{q}$? From (1)-(6) below choose the correct answer.

(1) $\sqrt{2}$ (2) $2\sqrt{2}$ (3) $4\sqrt{2}$ (4) $-\sqrt{2}$ (5) $-2\sqrt{2}$ (6) $-4\sqrt{2}$ 13

B Resistor R, two capacitors with capacitance C and 2C, and switch S are connected as shown in the figure below. Initially, S is open, the capacitor with capacitance C is charged with quantity of electricity Q, and the capacitor with capacitance 2C is uncharged. Next, S is closed and electric current begins flowing through R. After sufficient time elapses, the current stops flowing through R.



Q2 What is the Joule heat evolved in R in the time from when S is closed to when the current stops flowing through R? From ①-④ below choose the best answer.



C Three resistors, all with the same resistance, and a battery are connected as shown in Figure 1 below. The total power consumption of the three resistors is P_1 . Next, the same three resistors and battery are connected as shown in Figure 2. This time, the total power consumption of the three resistors is P_2 . The internal resistance of the battery is negligible.



Figure 1



Figure 2

Q3 What is
$$\frac{P_1}{P_2}$$
? From (1)-(5) below choose the correct answer.
(1) $\frac{4}{9}$ (2) $\frac{2}{3}$ (3) 1 (4) $\frac{3}{2}$ (5) $\frac{9}{4}$

16

D As shown in the figure below, two sufficiently long straight conducting wires pass through x-axis points A (x = -a) and B (x = a) within this page, perpendicular to the page. An electric current with magnitude I flows in the wire passing through point A, and a current with magnitude 2I flows in the wire passing through point B. The direction of both currents is from the back of the page to the front. The magnitude of resulting magnetic field at position x = d on the x-axis is zero.



Q4 What is $\frac{d}{a}$? From (1)-(8) below choose the correct answer.

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

 (5) $\frac{1}{3}$ (6) $\frac{1}{2}$ (7) 2
 (8) 3

E As shown in the figure below, two conducting wires, which are of negligible mass and have the same length, are each connected at one end to Q and R, the ends of conducting rod QR, which has mass m and length ℓ . The other end of the wire connected to Q is connected to terminal P, and the other end of the wire connected to R is connected to terminal S, such that QR is suspended horizontally. P and S are fixed in place at positions separated by horizontal distance ℓ . An electric current of magnitude I is passed through the wires and conducting rod in the direction $P \rightarrow Q \rightarrow R \rightarrow S$, within a uniform magnetic field whose direction is vertically upward. The conducting rod comes to rest at a position where the wires remain straight and form angle θ with the downward vertical direction. Let us denote as g the magnitude of acceleration due to gravity.



- Q5 What is the magnitude of the magnetic field's magnetic flux density? From ①-⑥ below choose the correct answer.

F As shown in the figure below, a bar magnet is fixed in place above a horizontal floor, with its north pole vertically downward. Let us denote as O the point on the floor directly below the magnet. Let us also plot on the floor an *x*-axis whose origin is at O. A square coil is placed on the floor such that two sides are parallel to the *x*-axis and its center, C, is on the *x*-axis. The coil is moved in the positive direction of the *x*-axis with a constant speed of *v*. When, as shown, C is near O and moves away from O, an induced current *I* flows through the coil in a certain direction, and the magnetic field produced by the magnet exerts a force \vec{F} on the coil in a certain direction.



Q6 With respect to the figure, is the direction of I clockwise, or counterclockwise? Also, what is the direction of \overrightarrow{F} ? From (1)-(4) below choose the correct combination. **18**

	Direction of I	Direction of \overrightarrow{F}
1	clockwise	positive direction of x-axis
2	clockwise	negative direction of x-axis
3	counterclockwise	positive direction of x-axis
4	counterclockwise	negative direction of x-axis

- V Answer question A (Q1) below.
 - A Atomic nucleus $^{235}_{92}$ U absorbs a neutron and undergoes nuclear fission into $^{140}_{54}$ Xe and $^{94}_{38}$ Sr.
 - Q1 How many neutrons are released in this nuclear fission reaction? From ①-⑤ below choose the correct answer.
 - (1) 0 (2) 1 (3) 2 (4) 3 (5) 4

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.

Science-22

Chemistry



Q1 Concerning the following statements ①-⑤ on the constituent particles of matter, the number corresponding to the quantity described in column A is indicated in column B. Choose the one in which the number in column B is <u>not</u> correct.

	Α	В
(1)	number of electrons in hydrogen ion H ⁺	0
2	number of protons in He atom	2
3	number of electrons in the M shell of Na atom	2
4	number of valence electrons in C atom	4
5	number of neutrons in $^{37}_{17}$ Cl atom	20

- Q2 From the following molecules or ions ①-⑤, choose the one which has the largest number of shared electron pairs.
 - 1) ammonia
 - 2 nitrogen
 - ③ hydrogen sulfide
 - ④ oxonium ion
 - (5) ammonium ion

- Q3 From the following compounds ①-⑤, choose the one which does <u>not</u> have a planar molecular structure.
 - 1) benzene
 - 2 water
 - ③ naphthalene
 - (4) ammonia
 - 5 formaldehyde
- Q4 Suppose the following materials are in the solid state: carbon dioxide (CO₂), silicon dioxide (SiO₂), and calcium oxide (CaO). From ①-⑥ in the table below, choose the one in which each crystal is correctly classified.

	Carbon dioxide	Silicon dioxide	Calcium oxide
1	ionic crystal	covalent crystal	molecular crystal
2	ionic crystal	molecular crystal	covalent crystal
3	covalent crystal	ionic crystal	molecular crystal
4	covalent crystal	molecular crystal	ionic crystal
5	molecular crystal	ionic crystal	covalent crystal
6	molecular crystal	covalent crystal	ionic crystal

Q5 Hydrogen (H₂) is generated when magnesium (Mg) is reacted with hydrochloric acid (HCl) as shown below.

 $Mg + 2HCl \longrightarrow MgCl_2 + H_2$

The following table lists the volumes of generated hydrogen at 20 $^{\circ}$ C and 1.01 \times 10⁵ Pa when various masses of magnesium are added to react with 4.0 mL of hydrochloric acid of a certain concentration.

Mass of magnesium (g)	0.018	0.037	0.052	0.070	0.085
Volume of hydrogen (mL)	18	37	48	48	48

Assume that hydrogen is insoluble in water, and that the volume of 1.00 mol of the gas at this temperature and pressure is 24.0 L.

From ①-⑥ in the table below, choose the correct combination of the maximum mass of magnesium (g) that reacts with the hydrochloric acid used and the concentration of hydrochloric acid (mol/L).

	Maximum mass of magnesium (g)	Concentration of hydrochloric acid (mol/L)
1	0.048	0.25
2	0.048	0.50
3	0.048	1.0
4	0.051	0.25
5	0.051	0.50
6	0.051	1.0

Q6 Suppose that 1.0×10⁻³ mol of hydrogen (H₂) and 5.0×10⁻³ mol of oxygen (O₂) were placed in a closed container the volume of which was variable, and the gas mixture was ignited. The hydrogen was completely reacted, and waterdrops formed in the container. Suppose the volume of the container was gradually enlarged at a constant temperature of 33 °C so that all water (H₂O) in the container turned into water vapor. Calculate the volume of the container in L when all water in the container was vaporized. From ①-⑤ below choose the closest value. Assume that the vapor pressure of water at 33 °C is 5.0×10³ Pa.

0.50
 0.75
 1.0
 1.5
 2.0

Science-28

- Q7 From the salts ①-⑥ below choose the one which is compatible with both of the following statements a and b.
 - **a** It is a salt made from a divalent acid and a monovalent base.
 - **b** The pH of its aqueous solution is larger than 7.
 - ① barium chloride
 - ② sodium carbonate
 - ③ ammonium sulfate
 - ④ sodium acetate
 - 5 calcium nitrate
 - 6 potassium sulfate

Q8 0.200 mol/L aqueous potassium permanganate (KMnO4) is added to a solution acidified with sulfuric acid containing 50.0 mL of 0.300 mol/L aqueous hydrogen peroxide (H2O2) so that the hydrogen peroxide will completely be oxidized. Calculate the volume of aqueous potassium permanganate required in mL. From ①-⑤ below choose the closest value.

	(1)	15	② 30	③ 75	④ 150	⑤ 300
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Q9 When dilute sulfuric acid (H₂SO₄) was electrolyzed with the aid of platinum electrodes using the apparatus given in the following figure, 672 mL of gas at the standard state was generated in total at the anode and the cathode. Calculate the amount of electricity (in C) used. From ①-⑧ below choose the closest value.



\bigcirc	3.86×10^{2}	2	1.93×10^{3}	3	3.86×10^{3}	4	7.72×10^{3}
5	1.93×10^{4}	6	3.86×10^{4}	\bigcirc	7.72×10^{4}	8	9.65×10^{4}

10

Q10 When hydrogen iodide (HI) was placed in a closed container at constant temperature and pressure, the reaction represented by the following thermochemical equation took place to reach an equilibrium state:

$$2 \text{HI}(g) = \text{H}_2(g) + \text{I}_2(g) - 9 \text{ kJ}$$

Assume that HI, H₂, and I₂ are always in the gas state.

From the following statements (1-5) on this reaction choose the correct one.

- ① The amount of HI at the equilibrium state is twice as large as that of H₂.
- 2 The amount of H₂ and that of I₂ at the equilibrium state are not necessarily equal.
- ③ If the temperature is lowered, the amount of HI at the equilibrium state will increase.
- ④ If the pressure is lowered, the amount of HI at the equilibrium state will increase.
- 5 If a catalyst is added, the amount of HI at the equilibrium state will increase.
- Q11 From the following procedures ①-⑤, choose the one in which hydrogen (H2) is <u>not</u> generated.
 - ① Dilute hydrochloric acid (HCl) is added to copper (Cu).
 - 2 Water (H₂O) is added to calcium (Ca).
 - (3) Ethanol (C₂H₅OH) is added to sodium (Na).
 - ④ Aqueous sodium hydroxide (NaOH) is added to aluminum (Al).
 - ⑤ Aqueous sodium hydroxide is electrolyzed with the aid of platinum electrodes.

Science-32

- Q12 Among the following procedures a-f, there are two in which <u>no</u> reaction takes place.From ①-⑥ below choose that combination.
 - **a** Water (H₂O) is added to lithium (Li).
 - **b** Hydrochloric acid (HCl) is added to zinc (Zn).
 - **c** Hydrochloric acid is added to silver (Ag).
 - **d** Dilute nitric acid (HNO₃) is added to copper (Cu).
 - **e** Aqueous silver nitrate (AgNO₃) is added to copper.
 - **f** Aqueous iron(II) sulfate (FeSO₄) is added to platinum (Pt).

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

Q13 Among the following reactions a-d, there are two in which water acts as an acid. From①-⑥ below choose the correct combination.

a $HCl + H_2O \longrightarrow H_3O^+ + Cl^$ **b** $NH_3 + H_2O \longrightarrow NH_4^+ + OH^$ **c** $2Na + 2H_2O \longrightarrow 2NaOH + H_2$ **d** $CaO + H_2O \longrightarrow Ca(OH)_2$ (1) **a**, **b** (2) **a**, **c** (3) **a**, **d** (4) **b**, **c** (5) **b**, **d** (6) **c**, **d** Q14 From the following statements ①-⑤ on sulfur dioxide (SO₂), choose the one which is <u>not</u> correct.

- ① SO₂ can bleach pigments by its oxidizing property.
- 2 When SO₂ is passed through aqueous hydrogen sulfide (H₂S), the solution turns turbid and white.
- ③ SO₂ is a colorless and poisonous gas with an irritating smell.
- ④ SO₂ is soluble in water and the aqueous solution is weakly acidic.
- (5) When SO₂ is passed through aqueous potassium permanganate (KMnO₄) acidified with sulfuric acid, the red-purple color of potassium permanganate disappears.
- Q15 Suppose a colorless aqueous solution contains one kind of metal ion. This aqueous solution has following properties a-c. From ①-⑥ below choose the metal ion contained in this aqueous solution.
 - **a** Precipitates were formed when aqueous sodium hydroxide (NaOH) was added. The precipitates dissolved, however, when aqueous sodium hydroxide was further added.
 - **b** Precipitates were formed when aqueous ammonia (NH₃) was added. The precipitates dissolved, however, when aqueous ammonia was further added.
 - c Precipitates were not formed when aqueous sodium chloride (NaCl) was added.
 - $(1) \quad Ag^{+} \qquad (2) \quad Ca^{2+} \qquad (3) \quad Mg^{2+} \qquad (4) \quad Pb^{2+} \qquad (5) \quad Zn^{2+} \qquad (6) \quad Al^{3+} \\ \end{array}$

Q16 From ①-⑥ below choose the correct combination of numbers which are compatible with blanks A and B in the statements below.

Among the isomers of a compound whose molecular formula is C_3H_5Br , the number of these which possess a carbon-carbon double bond is \blacksquare . Some of these isomers yield products which possess an asymmetric carbon atom when the addition reaction of bromine (Br₂) to the double bond is carried out. The number of the isomer(s) that yield such products is \blacksquare .

	Α	В
1	3	1
2	3	2
3	4	1
4	4	2
5	5	1
6	5	2

17

Q17 From the following statements (1)-(4) on ethylene (ethene), choose the correct one.

- ① Ethylene is a colorless gas and is readily soluble in water.
- ② When a sufficient amount of ethylene is passed through bromine water, the color of the bromine water disappears.
- ③ When a sufficient amount of ethylene is passed through aqueous potassium permanganate (KMnO₄) acidified with sulfuric acid, permanganate ion (MnO₄⁻) is oxidized and its color disappears.
- ④ Polyethylene is produced by condensation polymerization of ethylene.

Q18 In the following table, column A describes chemical reactions and column B shows the products of these reactions. From ①-⑥ in the table below choose the one in which column B is <u>not</u> correct.



Q19 Compound A is a cyclic unsaturated hydrocarbon with a molecular weight of 80.

A cyclic saturated hydrocarbon with a molecular weight of 84 was obtained when hydrogen H_2 was added to **A** with the aid of a catalyst.

When a sufficient amount of bromine (Br₂) was reacted with **A**, a bromide of the cyclic saturated hydrocarbon was obtained. Calculate the molecular weight of the bromide. From 1-6 below choose the closest value.

1 160 2 240 3 320 4 400 5 480 6 600

Q20 Among the following polymer compounds a-e, two of them require formaldehyde when these are synthesized. From ①-⑧ below choose the correct combination.20

- **a** phenol resin
- **b** poly(ethylene terephthalate)
- c polystyrene
- **d** vinylon
- e poly(vinyl chloride)

(1)a, b 2 (3) a, d a, e (4)b, c (6) (7)(8) (5)b. d b. e c. d d. e

End of Chemistry questions. Leave the answer spaces $21 \sim 75$ 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.

Science-38

Biology



Q1 The following figure schematically represents the structure of ATP, which is involved in energy metabolism in cells. From (1)-(6) below choose the combination that correctly indicates the names of A - E in the figure.



	А	В	С	D	E
1	ribose	adenosine	phosphate	adenine	ADP
2	ribose	phosphate	ADP	adenosine	adenine
3	adenine	ADP	adenosine	ribose	phosphate
4	adenine	ribose	phosphate	adenosine	ADP
5	phosphate	ADP	ribose	adenine	adenosine
6	phosphate	adenine	ribose	ADP	adenosine

Science-40

Q2 The following table indicates whether certain structures are present or absent in eukaryotic cells or prokaryotic cells. Presence is represented by +, and absence is represented by -. From (1)-(6) below choose the combination that correctly identifies A - C in the table.

Cell	Eukaryotic cells		Drokorryotio colla
Structure	Animals	Plants	Flokal your cells
cell membrane	+	+	+
А	+	+	-
В	_	+	+
С	_	+	-

	А	В	С
1	chloroplast	cell wall	mitochondrion
2	chloroplast	mitochondrion	nuclear membrane
3	mitochondrion	chloroplast	nuclear membrane
4	mitochondrion	cell wall	chloroplast
5	cell wall	mitochondrion	chloroplast
6	cell wall	chloroplast	mitochondrion

Q3 During photosynthesis in plants, the following reactions $\mathbf{a} - \mathbf{c}$ take place in the processes at photosystem I , photosystem II , or the Calvin-Benson cycle. From (1)-(6) below choose the combination correctly indicating all reactions that occur in each process.

a: CO₂ is reduced to synthesize organic compounds.

- b: Electrons (e⁻) are transferred from H₂O and O₂ is released.
- **C**: Light energy is absorbed.

	Photosystem I	Photosystem II	Calvin-Benson cycle
1	а	b, c	С
2	a, b	С	a, c
3	b	b, c	а
4	b, c	С	a, b
5	С	a, c	b
6	С	b, c	а

- Q4 Many organisms are unable to directly use free nitrogen (N₂) in the air. However, there are some organisms that can reduce nitrogen to NH₄⁺; this process is called nitrogen fixation. From ①–⑤ below choose the combination correctly indicating organisms that fix nitrogen.
 - ① Nitrite forming bacteria, nitrate forming bacteria, root nodule bacteria, nostoc
 - 2 Nitrite forming bacteria, clostridium, azotobacter, nostoc
 - ③ Nostoc, clostridium, azotobacter, root nodule bacteria
 - ④ Nitrate forming bacteria, azotobacter, nostoc, root nodule bacteria
 - (5) Nitrite forming bacteria, root nodule bacteria, nostoc, clostridium

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Q5 The DNA of eukaryotes contains regions that are translated and regions that are not translated. From ①
-⑥ below choose the combination correctly indicating the terms used for those regions.

	Regions translated	Regions not translated
1	codons	exons
2	codons	introns
3	exons	codons
4	exons	introns
5	introns	codons
6	introns	exons

- Q6 The following statements I III describe the basic principle of the polymerase chain reaction (PCR). From ① ⑥ below choose the combination of terms that correctly fills blanks a c in the statements.
 - I An aqueous solution containing the target DNA is heated to approx. 95°C. This breaks the **a** between bases, thereby separating double-stranded DNA into single-stranded DNA.
 - II The temperature is lowered to approx. 55°C, so that the b binds to the 3' end of the region of DNA to be amplified; the base sequence of the b is complementary to that of the 3' end.
 - III The temperature is raised to approx. 72°C, and the DNA following the b is synthesized by c.

	а	b	С
1	hydrogen bonds	mRNA	DNA ligase
2	hydrogen bonds	primer	DNA polymerase
3	hydrogen bonds	tRNA	DNA polymerase
4	S-S bonds	mRNA	DNA ligase
5	S-S bonds	primer	DNA polymerase
6	S-S bonds	tRNA	DNA polymerase

Q7 The following figure schematically represents two pairs of alleles, A (a) and B (b), on chromosomes in the somatic cell of a certain organism; genes A and B, and genes a and b are linked. Assuming that recombination has taken place during gametogenesis of this organism, from ①–⑧ below choose the combination that correctly indicates the newly produced genotypes of the gametes regarding these two genes, and the phase in which recombination takes place.



	Newly produced genotypes of the gametes	Phase in which recombination takes place
1	AA, BB	meiosis I
2	AA, BB	meiosis II
3	Aa, Bb	meiosis I
4	Aa, Bb	meiosis II
5	AB, ab	meiosis I
6	AB, ab	meiosis II
\bigcirc	Ab, aB	meiosis I
8	Ab, aB	meiosis II

Q8 The following figure schematically represents a cross section of a frog embryo during the mid-gastrula stage. From ①-⑥ below choose the combination that correctly identifies the regions A – C in the figure.



	А	В	С
1	blastocoel	archenteron	endoderm
2	blastocoel	intestinal tract	endoderm
3	archenteron	blastocoel	mesoderm
4	archenteron	intestinal tract	mesoderm
5	intestinal tract	blastocoel	endoderm
6	intestinal tract	archenteron	endoderm

Q9 The following figure schematically represents the processes whereby a pollen grain and an embryo sac are formed in gametogenesis in angiosperms. At which of steps A - I in the figure does meiosis occur? Also, how many embryo sac mother cells are needed to form 40 seeds? From (1)-(8) below choose the correct combination. Assume that fertilization is successful in all cases.

	Steps where meiosis occurs	No. of embryo sac mother cells
1	A, B and E, F	10
2	A, B and E, F	40
3	A, B and G, H	10
4	A, B and G, H	40
5	C, D and E, F	10
6	C, D and E, F	40
\bigcirc	C, D and H, I	10
8	C, D and H, I	40

Q10 The following figure schematically represents the human circulatory system. A-F represent blood vessels, and the arrows indicate the direction of blood flow. I – III below each describe a characteristic of blood flowing through one of the blood vessels among A-F. From ①-⑧ below choose the combination that correctly indicates the blood vessels among A-F through which the blood described in I-III flows.



I : Blood with the lowest amount of nitrogen (N)-containing waste compounds such as urea

II: Blood with the highest amount of glucose immediately after eating

III: Blood with the largest amount of oxygen (O₂)

	Ι	П	Ш
\bigcirc	А	В	Е
2	А	В	F
3	А	С	Е
4	А	С	F
5	D	В	Е
6	D	В	F
\bigcirc	D	С	Е
8	D	С	F

- Q11 The following statements a d describe the human autonomic nervous system. From (1)-(6) below choose the combination indicating the two statements that are correct.
 - a Arrector pili muscles are innervated by both sympathetic nerves and parasympathetic nerves.
 - b Gastrointestinal peristalsis is stimulated by the activity of sympathetic nerves, and inhibited by the activity of parasympathetic nerves.
 - c Sympathetic nerves arise from the spinal cord.
 - d The center of the autonomic nervous system is located in the hypothalamus of the diencephalon.

① a,b ② a,c ③ a,d ④ b,c ⑤ b,d ⑥ c,d

Q12 The following figure schematically represents the cochlea of the human ear being stretched out. Answer questions (1) and (2) below concerning this.



- From ①-⑥ below choose the answer that correctly arranges regions A C of the figure in order of the sound frequency they receive, from high frequency to low.
 - (1) $A \rightarrow B \rightarrow C$ (2) $A \rightarrow C \rightarrow B$ (3) $B \rightarrow A \rightarrow C$ (4) $B \rightarrow C \rightarrow A$ (5) $C \rightarrow A \rightarrow B$ (6) $C \rightarrow B \rightarrow A$
- (2) What are regions D and E of the figure filled with? From ① ⑥ below choose the correct combination.

	D	E
1	lymph	blood
2	lymph	air
3	lymph	lymph
4	air	blood
5	air	air
6	air	lymph

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Q13 The following figure schematically represents an actin filament, which is involved in muscle contraction. Statements $\mathbf{a} - \mathbf{e}$ below each describe part of the muscle contraction process. Referring to the figure, from (1)-(6) below choose the answer that correctly arranges $\mathbf{a} - \mathbf{e}$ in the order in which they occur.



- a The structure of tropomyosin changes, enabling actin to bind with myosin.
- b Ca^{2+} binds with troponin.
- c Excitation is conducted to the sarcoplasmic reticulum, resulting in the release of Ca²⁺ in the cell from the sarcoplasmic reticulum.
- d The structure of troponin changes, leading to a change in the structure of tropomyosin.
- e The muscle begins contracting.
- $\textcircled{1} \quad a \mathop{\rightarrow} b \mathop{\rightarrow} c \mathop{\rightarrow} d \mathop{\rightarrow} e$
- $(2) \quad \mathbf{a} \rightarrow \mathbf{c} \rightarrow \mathbf{b} \rightarrow \mathbf{d} \rightarrow \mathbf{e}$
- (3) $b \rightarrow a \rightarrow d \rightarrow c \rightarrow e$
- (4) $b \rightarrow c \rightarrow d \rightarrow a \rightarrow e$
- $(5) \quad c \to a \to b \to d \to e$
- $\textcircled{6} \quad \mathsf{c} \to \mathsf{b} \to \mathsf{d} \to \mathsf{a} \to \mathsf{e}$

Q14 The following paragraph describes seed germination of rice. From ① – ⑥ below choose the combination of terms that correctly fills blanks a and b in the paragraph.

During seed germination, the plant hormone **a** is secreted from the embryo. The **a** stimulates the synthesis of amylase by acting on the aleurone layer, the tissue along the inner side of the seed coat. The amylase breaks down nutrients in the endosperm, which are absorbed by the embryo, resulting in invigoration of its metabolism. In contrast with **a**, **b** is a plant hormone known to inhibit seed germination.

	а	b
1	abscisic acid	auxin
2	abscisic acid	gibberellin
3	gibberellin	abscisic acid
4	gibberellin	auxin
5	auxin	abscisic acid
6	auxin	gibberellin

Q15 A survivorship curve is a graph that shows the decrease in the number of survivors in an organism population as time progresses from birth. The shapes of the survivorship curves differ depending on the species, and are largely divided into the three types shown in the following figure (curves A-C). Among the organisms listed in x and y below, which have a high fatality rate early in their lifespan (when they are young) and a lower fatality rate late in their lifespan (after they have aged)? Also, which curve among A-C represents their survivorship? From (1-6) below choose the correct combination.



Note: The total number of organisms born is scaled to 1,000 in this survivorship curve.

- x Monkeys, honey bees
- y Sardines, oysters

	Organisms	Curve
1	х	А
2	х	В
3	х	С
4	У	А
5	У	В
6	у	С

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Q16 The following table lists the energy balance (J/cm²-year) of each trophic level of a certain ecosystem. Excretion is not listed because it is negligible. The gross primary productivity of producers is 467.6 J/cm²-year. From (1) - (6) below choose the combination that correctly indicates the net primary production (J/cm²-year) of producers, and the quantity that fills blank **a** in the table. **17**

Trophic level	Feeding	Dead plant tissue, death	Respiration	Growth
Producers	62.2	11.8	98.3	295.3
Primary consumers	13.0	1.3	18.3	а
Secondary consumers	0	Minimal	7.6	5.4

	Net primary production	а		
\bigcirc	172.3	7.8		
2	172.3	29.6		
3	369.3	29.6		
4	369.3	47.9		
5	405.4	47.9		
6	405.4	49.2		

Q17 The following figure is a simplified representation of plant phylogeny. Statements x - z below describe characteristics of plants in the figure. From (1)-(6) below choose the combination that correctly match the statements with A - C in the figure. **18**



- x They have true roots, stems, and leaves, and their stems have vascular bundles.
- y Their ovules are contained in ovaries.
- z They form seeds.

	А	В	С
1	х	у	z
2	х	z	у
3	у	х	z
4	у	z	х
5	z	х	у
6	z	у	х

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End of Biology questions. Leave the answer spaces $\boxed{19} \sim \boxed{75}$ 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.