2013年度日本政府（文部科学省）奨学金留学生選考試験

QUALIFYING EXAMINATION FOR APPLICANTS FOR JAPANESE GOVERNMENT (MONBUKAGAKUSHO) SCHOLARSHIPS 2013

学科試験　　問題

EXAMINATION QUESTIONS

(学部留学生)

UNDERGRADUATE STUDENTS

物　　理

PHYSICS

注意　☆試験時間は60分。

PLEASE NOTE: THE TEST PERIOD IS **60 MINUTES.**

Before you start, fill in the necessary details (nationality, examination number, name etc.) in the box at the top of the answer sheet page below.

For each question, select the correct answer and write the corresponding symbol in the space provided on the answer sheet.

1 Answer the following questions.

(1) There is a river with a current speed of V. A boat which is capable of sailing at the speed of $2V$ in still water is used to cross the river from point A to point B, as shown in Fig.1-1. The width of the river is L. Find the time the boat needs to cross the river when it goes from A to B along a straight line perpendicular to the river.

(a) $\frac{L}{V}$ (b) $\frac{2L}{V}$ (c) $\frac{L}{2V}$
(d) $\frac{\sqrt{3}L}{V}$ (e) $\frac{L}{\sqrt{3}V}$ (f) $\frac{\sqrt{5}L}{V}$
(g) $\frac{L}{\sqrt{5}V}$

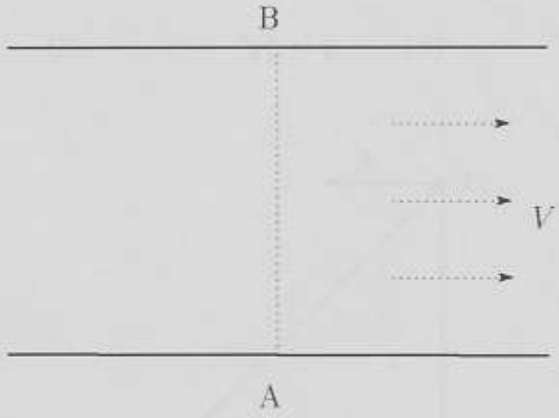

Fig. 1-1

(2) Kepler's third law, $T^2 = ka^3$, holds in the revolution of planets in the solar system, where T is the revolution period, a is the semimajor axis of the elliptical orbit, and k is a constant of proportionality. Choose the appropriate formula for k from below. The gravitation constant is G and the mass of the Sun is M.

(a)	GM	(b)	$\frac{G}{M}$	(c)	$\frac{M}{G}$
(d)	$\frac{1}{GM}$	(e)	$4\pi^2 GM$	(f)	$\frac{4\pi^2 G}{M}$
(g)	$\frac{4\pi^2 M}{G}$	(h)	$\frac{4\pi^2}{GM}$	(i)	$\frac{GM}{4\pi^2}$
(j)	$\frac{G}{4\pi^2 M}$	(k)	$\frac{M}{4\pi^2 G}$	(l)	$\frac{1}{4\pi^2 GM}$

(3) In Fig. 1-3, ABC is a rectangular equilateral triangle. An electric charge q is placed at A and an electric charge q' at B. The electric field at C is found to be parallel to the side AB, as shown by the arrow in the figure. Choose the appropriate formula from below which shows the relation between q and q' correctly.

(a)	$q = q'$	(b)	$q = -q'$	(c)	$q = \sqrt{2}q'$
(d)	$q = -\sqrt{2}q'$	(e)	$q = \frac{1}{\sqrt{2}}q'$	(f)	$q = -\frac{1}{\sqrt{2}}q'$
(g)	$q = \frac{1}{2}q'$	(h)	$q = -\frac{1}{2}q'$	(i)	$q = \frac{1}{2\sqrt{2}}q'$
(j)	$q = -\frac{1}{2\sqrt{2}}q'$	(k)	$q = \frac{1}{4}q'$	(l)	$q = -\frac{1}{4}q'$

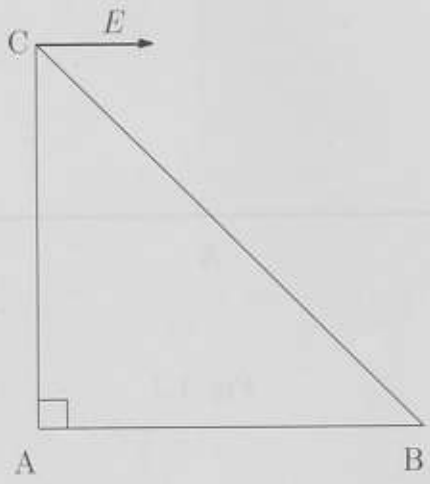

Fig. 1-3

(4) There is a cylinder laid down horizontally equipped with a piston which can move smoothly, as shown in Fig.1-4. An ideal gas of monoatomic molecules is contained in the cylinder. At the beginning, the volume of the gas was V and the pressure of the gas was equal to the atmospheric pressure p_0. When this gas was heated, the piston moved slowly and the volume of the gas increased to $\frac{3}{2}V$. Choose the correct formula which indicates the quantity of heat given to the gas, on condition that the pressure of the gas is always equal to the atmospheric pressure, and the exchanges of heat between the gas and the cylinder and between the gas and the piston are negligible.

(a) p_0V (b) $\frac{1}{2}p_0V$ (c) $\frac{1}{4}p_0V$

(d) $\frac{3}{2}p_0V$ (e) $\frac{3}{4}p_0V$ (f) $\frac{3}{8}p_0V$

(g) $\frac{5}{2}p_0V$ (h) $\frac{5}{4}p_0V$ (i) $\frac{5}{8}p_0V$

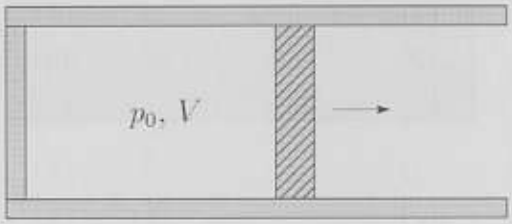

Fig. 1-4

(5) As seen in Fig.1-5, light with a wavelength of λ irradiates normally onto a thin film that has a thickness of d and a refraction index of n ($n > 1$). The thin film is placed in the air where the refraction index is unity. Choose the correct formula which holds when the light reflected at the upper surface of the thin film interferes constructively with the light reflected at the bottom surface. m indicates either 0 or positive integer numbers.

(a) $2d/n = \left(m + \frac{1}{2}\right)\lambda$ (b) $2dn = \left(m + \frac{1}{2}\right)\lambda$

(c) $2d/n = m\lambda$ (d) $2dn = m\lambda$

(e) $2\lambda/n = \left(m + \frac{1}{2}\right)d$ (f) $2\lambda n = \left(m + \frac{1}{2}\right)d$

(g) $2\lambda/n = md$ (h) $2\lambda n = md$

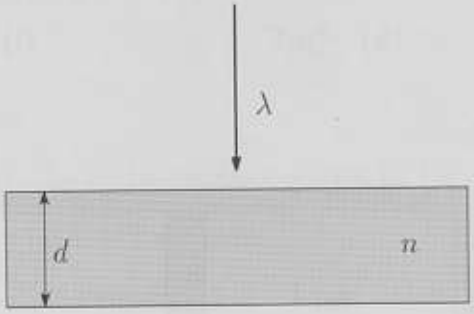

Fig. 1-5

2 Consider the circuit shown in Fig. 2-1, consisting of three capacitors C_1, C_2, C_3, two resistors R_1, R_2, two switches S_1, S_2, and a battery V. The capacitance of the capacitors C_1 and C_3 is 2×10^{-6} [F], and the capacitance of the capacitor C_2 is 4×10^{-6} [F]. The voltage of the battery V is 6 [V]. The internal resistance of the battery and the resistance of the switches may be ignored. Find numerical values appropriate for the open boxes from (1) to (5) from a list shown below. The same numerical value may be used more than once.

At the beginning, three capacitors were fully discharged. The switch S_1 was then closed while the switch S_2 was kept open. A long time after the switch S_1 was closed, the charge accumulated in the capacitor C_1 was [(1)] $\times10^{-6}$ [C], and the difference in voltage between the two plates of the capacitor C_1 was [(2)] [V]. Next, the switch S_2 was closed while the switch S_1 was opened. A long time after the switch S_2 was closed, the charge accumulation in the capacitor C_3 was [(3)] $\times10^{-6}$ [C]. The sum of the energy stored in the capacitors C_2 and C_3 was [(4)] $\times10^{-6}$ [J]. The total Joule heat generated in the resistor R_2 after the switch S_2 was closed amounts to [(5)] $\times10^{-6}$ [J].

(a)	2	(b)	4	(c)	8
(d)	16	(e)	32	(f)	$\frac{2}{3}$
(g)	$\frac{4}{3}$	(h)	$\frac{8}{3}$	(i)	$\frac{16}{3}$
(j)	$\frac{32}{3}$	(k)	$\frac{2}{9}$	(l)	$\frac{4}{9}$
(m)	$\frac{8}{9}$	(n)	$\frac{16}{9}$	(o)	$\frac{32}{9}$

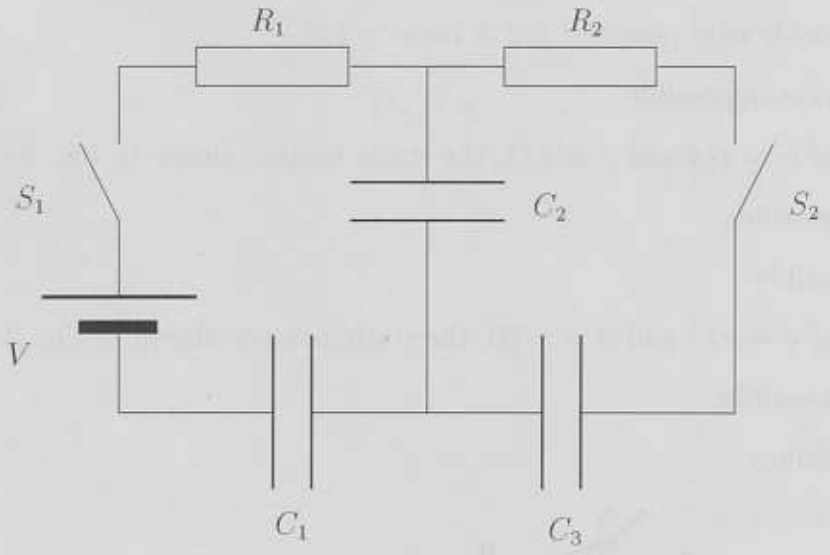

Fig. 2-1

3 A thin stiff uniform rectangular plate with width L ($L \equiv \overline{AB}$) is lying on two inclined surfaces as shown in Fig. 3–1. The angle between the horizontal surface and the left inclined surface is α, and that between the horizontal surface and the right inclined surface is β. It is assumed that the plate length is sufficiently larger than L and both edges of the plate are smooth enough to neglect friction.

(1) In case of $\alpha + \beta = \pi/2$, the static balance shown in Fig. 3–1 is

(a) possible only provided $\alpha \neq \beta$.

(b) always possible.

(c) always impossible.

(2) In case of $\alpha = \beta$, the static balance shown in Fig. 3–1 is

(a) possible only provided $\alpha < \pi/4$.

(b) possible only provided $\alpha \geq \pi/4$.

(c) always possible.

(d) always impossible.

(3) In case of $\alpha + \beta = \pi/4$, the static balance shown in Fig. 3–1 is

(a) possible only provided $1/2 > \tan\alpha$.

(b) possible only provided $\tan\alpha > 1/3$.

(c) possible only provided $\tan\alpha \geq 1/2$.

(d) possible only provided $1/3 \geq \tan\alpha$.

(e) possible only provided $1/2 > \tan\alpha > 1/3$.

(f) always impossible.

(4) In case of $\alpha = \pi/4$ and $\beta = \pi/3$, the static balance shown in Fig. 3–1 is

(a) impossible.

(b) possible.

(5) In case of $\alpha = \pi/4$ and $\beta = \pi/20$, the static balance shown in Fig. 3–1 is

(a) impossible.

(b) possible.

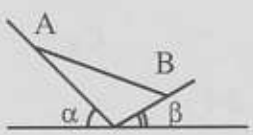

Fig. 3–1

4 A container holds a mixture of Oxygen gas and Nitrogen gas. The mass fraction of Oxygen is assumed to be 20% and that of Nitrogen 80%. The atomic weights of Oxygen and Nitrogen are 16 and 14 respectively.

(1) The volumetric fraction of Oxygen is approximately

(a) 22% (b) 20% (c) 18% (d) 16%

(2) If the sum of the mole number of Oxygen gas and that of Nitrogen gas is unity, then total mas of the gas is

(a) 0.0288 kg (b) 0.0287 kg (c) 0.0286 kg (d) 0.0285 kg

(3) If the said gas is at 273.15 K and 0.1013×10^6 Pa, the volume of the gas is approximately

(a) 0.0230 m^3 (b) 0.0224 m^3 (c) 0.0218 m^3

(4) The density of the mixture in the same condition is

(a) 1.30 kg/m^3 (b) 1.28 kg/m^3 (c) 1.26 kg/m^3

(5) The ratio of the specific heat at a constant pressure to that at a constant volume is

(a) 9/7 (b) 7/5 (c) 5/3 (d) other

5 An ambulance is approaching crossroads with a constant speed of 60 km/h.

(1) The sound speed in the air at 273.15 K and 288.15 K is denoted as T_0 and T_{15} respectively. Then the ratio T_{15}/T_0 is approximately

(a) 1.000 (b) 1.027 (c) 1.055

(2) The siren sound produced at the ambulance itself is assumed to be 440 Hz. Then the wavelength emitted forward at 288.15 K is approximately

(a) 0.71 m (b) 0.73 m (c) 0.77 m (d) 0.83 m

(3) The siren sound frequency detected by a person standing at the crossroads is approximately

(a) 419 Hz (b) 440 Hz (c) 462 Hz (d) 463 Hz (e) other