Heat and Gas

(1) Heat and Energy

-2006 4(1)-(3)

1 mol of air is stored in a container with an electric heater and a piston (Figure 5). P, V, T, R are the pressure, volume, absolute temperature and the gas constant. In this situation, we have

pV=nRT.

In this case, we consider the situation when the temperature is raised by 1K while keeping the pressure constant.

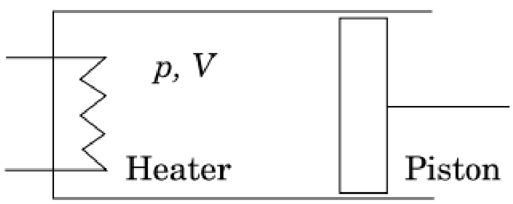


Figure 5

(1) What is the work done by this piston? (Choose a suitable option)

(a) $-R \times 1\,\mathrm{mol} \times 1\,\mathrm{K}$ (b) $R \times 1\,\mathrm{mol} \times 1\,\mathrm{K}$ (c) $0\,\mathrm{J}$

(d) $2R \times 1\,\mathrm{mol} \times 1\,\mathrm{K}$ (e) $-2R \times 1\,\mathrm{mol} \times 1\,\mathrm{K}$

(2) Let C be the molar heat capacitor under constant pressure, what is the amount of heat transferred?

(a) $R \times 1\,\mathrm{mol} \times 1\,\mathrm{K}$ (b) $-R \times 1\,\mathrm{mol} \times 1\,\mathrm{K}$ (c) $C \times 1\,\mathrm{mol} \times 1\,\mathrm{K}$

(d) $(C+R) \times 1\,\mathrm{mol} \times 1\,\mathrm{K}$ (e) $0\,\mathrm{J}$

(3) What is the suitable relationship?

(a) $C > R$ (b) $C = R$ (c) $R > C > 0.5R$

(d) $C = 0.5R$ (e) $0.5R > C$

-2007 1(3)

(3) A cylinder with a frictionless piston is placed horizontally in an atmosphere of pressure $1.0 \times 10^5 N/m^2$ as shown in Fig.3. A gas in the cylinder is initially at a temperature of 300 K with a volume of $6.0 \times 10^{-3} m^3$. Then, the gas is heated slowly to 400 K. How much work is done by the gas in this process?

(a) −500J (b) −300J (c) −200J

(d) 200J (e) 300J (f) 500J

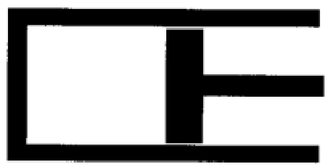


Fig. 3

-2008 4(2)(3)

4 A container of volume 10 ℓ includes 0.2 mol oxygen gas and 0.3 mol nitrogen gas. Assume the atomic weight of oxygen is 16 and that of nitrogen 14.

(2) Let the universal gas constant be R [$J \cdot mol^{-1} \cdot K^{-1}$]. Let the specific heat ratio be k, then for a single component gas, specific heat at a constant pressure c_p is given by $c_p = \frac{k}{k-1}R$. For a monoatomic molecule gas $k=5/3$, for a diatomic molecule gas $k=7/5$, and for a triatomic molecule gas $k=9/7$. The heat capacity (at a constant pressure) of oxygen in the container is

(a) $0.5R(J \cdot K^{-1})$ (b) $0.7R(J \cdot K^{-1})$ (c) $0.9R(J \cdot K^{-1})$

(3) The total heat capacity in the container (at a constant pressure) is approximately

(a) $0.62R(J \cdot K^{-1})$ (b) $0.87R(J \cdot K^{-1})$ (c) $1.0R(J \cdot K^{-1})$

(d) $1.25R(J \cdot K^{-1})$ (e) $1.75R(J \cdot K^{-1})$

-2009 4

4 Let the universal gas constant be R ($J \cdot K^{-1} \cdot mol^{-1}$). Let c_p ($J \cdot K^{-1} \cdot mol^{-1}$) and c_v ($J \cdot K^{-1} \cdot mol^{-1}$) be the specific heat of a gas at constant pressure and one at constant volume respectively. Circle the correct answers to questions (1)-(4).

For argon gas, Ar, the value $(c_p - c_v)/R$ is

(1) (a) 0, (b) 1/2, (c) 1, (d) 3/2, (e) 2

The value of c_v/R for Ar is

(2) (a) 1/2, (b) 1, (c) 3/2, (d) 2, (e) 5/2

The value of c_v/R for the diatomic gas N_2 is

(3) (a) equal to, (b) less than, (c) greater than

that for Ar.

The value of $(c_p - c_v)/R$ for N_2 is

(4) (a) equal to, (b) less than, (c) greater than

that for Ar.

-2010 IIA

A A copper container (mass: 100 g) holds 200 g of water. The temperature of the container and water is 20 ℃.

Q1 A 150-g piece of copper heated to 80 ℃ is placed in the water. The water is stirred thoroughly. After sufficient time elapses, to what temperature does the water change? From ①-⑤ below choose the best answer. Assume that no heat is transferred to or from the environment. The specific heat of water is 4.2 J/g·K, and the specific heat of copper is 0.40 J/g·K. $\boxed{8}$ ℃

① 23 ② 24 ③ 25

④ 26 ⑤ 27

-2010 IIC

C This question deals with the types of energy involved when a gasoline-powered automobile travels in a straight line on a level surface, and with how the energy is converted. Assume that brake friction is the only force involved in stopping the automobile.

From the time that an automobile begins moving until it reaches a constant speed, the $\boxed{\text{a}}$ from gasoline is converted to $\boxed{\text{b}}$ of the automobile. Then, when the brakes are applied to stop the automobile, the automobile's $\boxed{\text{b}}$ is completely converted to $\boxed{\text{c}}$. When this happens, energy is lost to the environment and cannot be reused. From the perspective of saving energy, it is necessary to convert some of the energy of braking into a form that can be reused when accelerating the automobile.

Q3 From ①-⑧ below choose the combination of terms that best fills blanks $\boxed{\text{a}}$, $\boxed{\text{b}}$, and $\boxed{\text{c}}$ in the paragraph above. **10**

	a	b	c
①	heat	electrical energy	heat
②	heat	electrical energy	work
③	heat	kinetic energy	heat
④	heat	kinetic energy	work
⑤	chemical energy	electrical energy	heat
⑥	chemical energy	electrical energy	work
⑦	chemical energy	kinetic energy	heat
⑧	chemical energy	kinetic energy	work

-2012 4(3)(4)

4 Air consists of approximately 78 % Nitrogen in volume, 21 % Oxygen, and 1 % Argon. The atomic weight of Nitrogen is approximately 14, that of Oxygen 16, and that of Argon 40.

Theoretically the ratio of the specific heat, c_p, at constant pressure to the specific heat, c_v, at constant volume is $5/3$ for mono-atomic gases, $7/5$ for diatomic gases, $9/7$ for triatomic gases. For a single component gas we have $c_p - c_v = R$, where R is a universal gas constant. Then for air, the value $(c_p - c_v)/R$ is

(3) (a) sufficiently larger than unity,

(b) approximately or exactly equal to unity,

(c) sufficiently smaller than unity.

The value c_p/c_v for air is approximately

(4) (a) 1.35, (b) 1.4, (c) 1.45, (d) 1.5, (e) 1.6 .

-2013 1(4)

(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) $\frac{5}{8}p_0V$

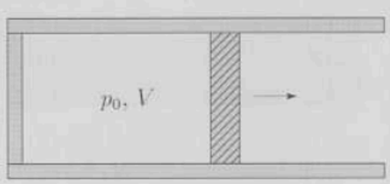


Fig. 1-4

-2013 4(5)

For a diatomic gas,

(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

-2015 4(2)-(4)

4. A cylinder is placed vertically in an atmosphere fitted with a frictionless piston of mass M, as shown in Fig. 4. One mole of a monatomic gas is contained in the cylinder. The cross-sectional area inside the cylinder is denoted as S, and the pressure of the atmosphere is denoted as p_0. Initially, the height of the gas in the cylinder is h, and the pressure of the gas is twice the pressure of the atmosphere, $2p_0$. The cylinder and the piston do not conduct heat. The gas may be regarded as an ideal gas. The acceleration of gravity is denoted as g, and the universal gas constant is denoted as R. Answer the following questions.

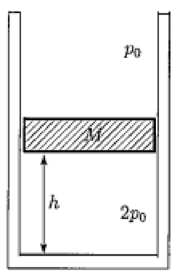


Fig. 4

(2) Find the initial temperature of the gas.

(a)	$\frac{p_0SR}{2}$	(b)	p_0SR	(c)	$2p_0SR$
(d)	$\frac{p_0S}{2R}$	(e)	$\frac{p_0S}{R}$	(f)	$\frac{2p_0S}{R}$
(g)	$\frac{p_0Sh}{2R}$	(h)	$\frac{p_0Sh}{R}$	(i)	$\frac{2p_0Sh}{R}$

(3) Heat the gas slowly, and the height of the gas increased from h to $\frac{3}{2}h$. Show the work done by the gas in this process.

(a)	$\frac{p_0Sh}{4}$	(b)	$\frac{p_0Sh}{2}$	(c)	p_0Sh
(d)	$2p_0Sh$	(e)	$4p_0h$	(f)	$\frac{p_0h}{4}$
(g)	$\frac{p_0h}{2}$	(h)	p_0h	(i)	$2p_0h$
(j)	$4p_0h$				

(4) In the process outlined in (3) above, indicate the amount of heat given from outside.

(a)	$\frac{p_0Sh}{5}$	(b)	$\frac{2p_0Sh}{5}$	(c)	p_0Sh
(d)	$\frac{5p_0Sh}{2}$	(e)	$5p_0Sh$	(f)	$\frac{p_0h}{5}$
(g)	$\frac{2p_0h}{5}$	(h)	p_0h	(i)	$\frac{5p_0h}{2}$
(j)	$5p_0h$				

-2016 1(2)

(2) A monatomic ideal gas expands from 100cm^3 to 200cm^3 at a constant pressure of 1.0×10^5 Pa. Find the change in the internal energy of the gas.

(a)	5J	(b)	10J	(c)	15J
(d)	50J	(e)	100J	(f)	150J

(2) Ideal Gas

-2007 4

4 The speed of sound in an ideal gas at rest is given by $\sqrt{\varkappa p/\rho}$, where $\varkappa$: specific heat ratio (≡ specific heat at constant pressure/specific heat at constant volume), p : pressure, ρ : density.

(1) Which of the following is correct?

(a) $0<\varkappa<\frac{1}{2}$ (b) $\varkappa=\frac{1}{2}$ (c) $\frac{1}{2}<\varkappa<1$

(d) $\varkappa=1$ (e) $1<\varkappa<2$

(2) Let the density of O_2 (oxygen gas) and that of N_2 (nitrogen gas) at 273.15 K and 1.0×10^5 Pa be $(\rho)_{O_2}$ and $(\rho)_{N_2}$ respectively. The molecular weights of O_2 and N_2 are approximately 32 and 28 respectively. Which of the following is correct?

(a) $(\rho)_{O_2}<(\rho)_{N_2}$ (b) $(\rho)_{O_2}=(\rho)_{N_2}$ (c) $(\rho)_{O_2}>(\rho)_{N_2}$

(3) Let the speed of sound in oxygen gas and in nitrogen gas be v_{O_2} and v_{N_2}. Which of the following is correct?

(a) $v_{O_2}<v_{N_2}$ (b) $v_{O_2}=v_{N_2}$ (c) $v_{O_2}>v_{N_2}$

(4) Let v_w be the speed of sound in water at 273.15 K and 1.0×10^5 Pa. Which of the following is correct?

(a) $v_w<v_{N_2}$ (b) $v_w=v_{N_2}$ (c) $v_w>v_{N_2}$

-2008 1(3)

(3) An air bubble of volume 1 cm³ is located in water at a depth of 50m beneath the surface where the temperature is 17℃. When the bubble goes up slowly to the surface where the temperature is 27℃, how much will its volume be? Take the atmospheric pressure to be 1 atm. Assume that the pressure increases 1 atm for every 10 m depth.

(a) 4.8 cm³ (b) 5.0 cm³ (c) 5.2 cm³

(d) 5.8 cm³ (e) 6.0 cm³ (f) 6.2 cm³

-2008 4(1)(4)

4 A container of volume 10 ℓ includes 0.2 mol oxygen gas and 0.3 mol nitrogen gas. Assume the atomic weight of oxygen is 16 and that of nitrogen 14.

(1) The total mass of the gas in the container is

(a) 7.4g (b) 10.6g (c) 11.6g (d) 14.8g

(4) Let the speed (root-mean-square speed) of an oxygen gas molecule be v_1, and that of a nitrogen gas molecule v_2. Which of the following holds?

(a) $v_1 > v_2$ (b) $v_1 = v_2$ (c) $v_1 < v_2$

-2010 IA

A As shown in Figure 1, two tanks of different cross-sectional areas are connected by a pipe. The tanks are filled with water, and openings A and B are tightly sealed with pistons that can move without friction. Initially, both pistons are in equilibrium at the same height. The cross-sectional area of B is n times larger than that of A.

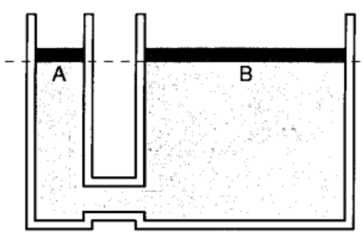


Figure 1

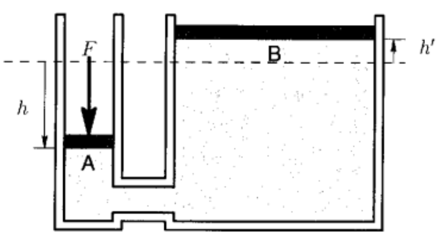


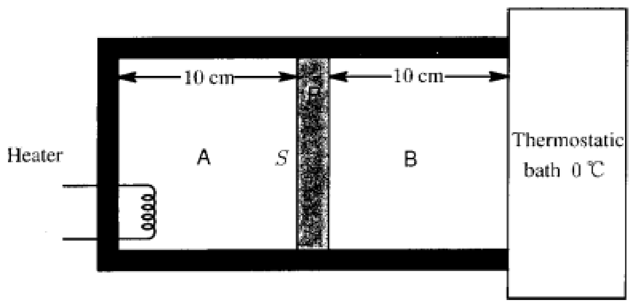
Figure 2

Q1 As shown in Figure 2, a force of magnitude F is applied vertically downward to the piston at A, causing it to move downward by distance h. As a result, the piston at B moves upward by distance h'. Next, a force of magnitude F' is applied vertically downward to the piston at B. As a result, both pistons return to their original positions shown in Figure 1. From ①-⑨ below choose the combination that correctly expresses h' and F'. $\boxed{1}$

	①	②	③	④	⑤	⑥	⑦	⑧	⑨
h'	$\frac{h}{\sqrt{n}}$	$\frac{h}{\sqrt{n}}$	$\frac{h}{\sqrt{n}}$	$\frac{h}{n}$	$\frac{h}{n}$	$\frac{h}{n}$	$\frac{h}{n^2}$	$\frac{h}{n^2}$	$\frac{h}{n^2}$
F'	$\sqrt{n}F$	nF	n^2F	$\sqrt{n}F$	nF	n^2F	$\sqrt{n}F$	nF	n^2F

-2010 IIB

B As shown in the figure below, an enclosed cylindrical container (cross-sectional area: S) is divided into two sections (A, B) by a piston (P). The length of each section is 10 cm. Each section contains a monatomic ideal gas at temperature 0 ℃ and pressure 1.0×10^5 Pa (both contain the same type of gas). The gas in B is in contact with a thermostatic bath at temperature 0 ℃, and does not change in temperature. The piston and container do not conduct heat. The area of contact between the piston and the container is tightly sealed and frictionless.



Q2 When the gas in A is heated to 57 ℃ using a heater, what distance is traveled by P? From ①-⑤ below choose the best answer. $\boxed{9}$ cm

① 0.1 ② 0.5 ③ 1

④ 5 ⑤ 10

-2012 4(1)(2)

4 Air consists of approximately 78 % Nitrogen in volume, 21 % Oxygen, and 1 % Argon. The atomic weight of Nitrogen is approximately 14, that of Oxygen 16, and that of Argon 40.

Nitrogen occupies air in weight by

(1) (a) 76 %, (b) 77 %, (c) 78 %, (d) 79 %.

The density of air at 0 °C, 0.1 MPa is

(2) (a) 0.65 kg/m^3, (b) 0.93 kg/m^3, (c) 1.29 kg/m^3, (d) 1.33 kg/m^3.

-2013 4(1)-(4)

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

-2014 1(3)

(3) There is a room of volume 100m^3. The pressure is kept constant at 1.0×10^5Pa. At 270K and this pressure, the density of air is 1.3kg/m^3. Find the mass of air that escapes when the temperature of the room increases from 270K to 300K.

(a)	0.13kg	(b)	1.3kg	(c)	13kg
(d)	0.12kg	(e)	1.2kg	(f)	12kg

-2015 1(3)

(3) An ideal gas is enclosed in a container with volume V and pressure P. The gas expands adiabatically into a vacuum. The volume changes from V to $V + V'$ in this process. Find the final pressure.

(a)	$\frac{V}{V+V'}P$	(b)	$\frac{V}{V'}P$	(c)	$\frac{V'}{V+V'}P$
(d)	$\frac{V+V'}{V}P$	(e)	$\frac{V+V'}{V'}P$	(f)	$\frac{V'}{V}P$

4. Two containers A and B of volume V are connected by a thin tube. A cock is equipped in the thin tube, and is closed initially. A gas of a pressure P and a temperature T is contained in the container A, and a gas of a pressure $2P$ and a temperature $3T$ is contained in the container B. Exchange of thermal energies between the gas and the containers may be ignored. The volume of the thin tube may be ignored. The gas may be considered as an ideal gas composed of monatomic molecules. The universal gas constant is denoted as R. Answer the following questions.

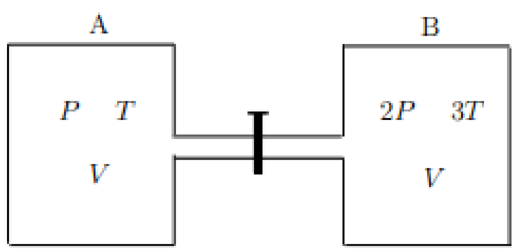


Fig. 4

(1) Find the number of moles of the gas contained in container A.

(a)	$\frac{VRT}{P}$	(b)	$\frac{PVT}{R}$	(c)	$\frac{RT}{PV}$
(d)	$\frac{VR}{PT}$	(e)	$\frac{PV}{RT}$	(f)	$\frac{R}{PVT}$

(2) What multiple of the number of moles of the gas contained in container A is there in container B?

(a)	6	(b)	3	(c)	2
(d)	$\frac{3}{2}$	(e)	1	(f)	$\frac{2}{3}$
(g)	$\frac{1}{2}$	(h)	$\frac{1}{3}$	(i)	$\frac{1}{6}$

(3) What multiple of the internal energy of the gas in container A is there in container B?

(a)	6	(b)	3	(c)	2
(d)	$\frac{3}{2}$	(e)	1	(f)	$\frac{2}{3}$
(g)	$\frac{1}{2}$	(h)	$\frac{1}{3}$	(i)	$\frac{1}{6}$

(4) After opening the cock, the gas in containers A and B eventually reaches equilibrium. Find the temperature of the gas in equilibrium.

(a)	$6T$	(b)	$\frac{9}{2}T$	(c)	$\frac{10}{3}T$
(d)	$3T$	(e)	$2T$	(f)	$\frac{9}{5}T$
(g)	$\frac{3}{2}T$	(h)	T	(i)	$\frac{3}{5}T$

(5) As in (4), when the gas reaches equilibrium after opening the cock, find the pressure of the gas.

(a)	$6P$	(b)	$\frac{9}{2}P$	(c)	$\frac{10}{3}P$
(d)	$3P$	(e)	$2P$	(f)	$\frac{9}{5}P$
(g)	$\frac{3}{2}P$	(h)	P	(i)	$\frac{3}{5}P$

-2017 1(2)

(2) A monatomic ideal gas expands at a constant pressure, P, from a volume of V_1 to a volume of V_2. Find the heat required for this process.

(a)	$\frac{1}{2}P(V_2 - V_1)$	(b)	$\frac{3}{2}P(V_2 - V_1)$	(c)	$P(V_2 - V_1)$
(d)	$\frac{5}{2}P(V_2 - V_1)$	(e)	PV_2	(f)	PV_1

4. A non-adiabatic cylinder with cross-sectional area A is placed at normal air pressure and is filled with an ideal gas as shown in Fig. 4(a). The cylinder is closed by an adiabatic piston with mass m. The pressure of the air is P and the temperature of the air is T. In equilibrium, the height of the piston is h from the bottom and the temperature of the gas is T. An object of mass M is placed on the piston, and the height of the piston becomes h_1 in equilibrium as shown in Fig. 4(b). The acceleration of gravity is denoted as g. Answer the following questions.

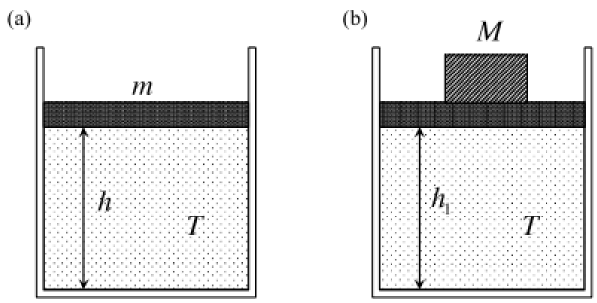


Fig. 4

(1) Find the expression of h_1.

(a) h (b) $\dfrac{PA+mg}{PA+(M+m)g}h$

(c) $\dfrac{mg}{PA+(M+m)g}h$ (d) $\dfrac{PA+(M+m)g}{PA+Mg}h$

(2) Find the work done on the gas by the air when the height of the piston changes from h to h_1.

(a) 0 (b) $\dfrac{Mg(PA+Mg)h}{PA+Mg}$ (c) $\dfrac{MgPAh}{PA}$

(d) $\dfrac{MgPAh}{PA+Mg}$ (e) $\dfrac{MgPAh}{PA+mg}$ (f) $\dfrac{MgPAh}{PA+(M+m)g}$

We then cover the system with adiabatic walls and remove the object with mass M. In equilibrium, the height of the piston becomes h_2.

(3) Find the temperature of the gas.

(a) T (b) $\dfrac{h}{h_2}T$ (c) $\dfrac{h_2+h}{h}T$

(d) $\dfrac{h}{h+h_2}T$ (e) $\dfrac{h_2}{h}T$ (f) $\dfrac{h_2+h}{h_2}T$

We then remove the adiabatic walls. In equilibrium, the height of the piston becomes h_3.

(4) Find the expression of h_3.

(a) h (b) h_2 (c) $2h$

(d) $2h_2$ (e) $h/2$ (f) $h_2/2$

-2020 4(1)

4. A hot air balloon of mass M is shown in Fig. 4. The volume of the air bag is V. Mass M does not include the mass of the air inside the bag. The bottom of the bag is open, and the air pressure inside the bag is equal to the surrounding air pressure, P. The burner sitting on the basket is used to heat the air inside the bag. The molar mass of air is denoted by m and the acceleration of gravity is denoted by g. The air is an ideal gas and the universal gas constant is denoted by R. The temperature of the surrounding air is T_0.

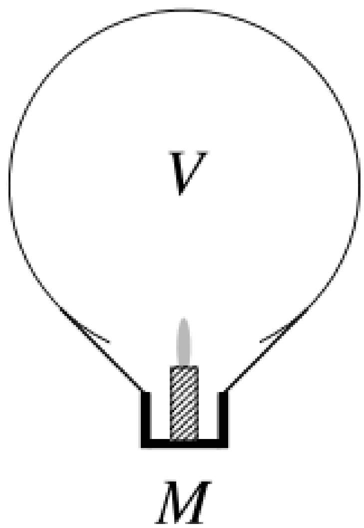


Fig. 4

After the air inside the bag is heated by the burner, the temperature of the air becomes T.

(1) Find the density of the air inside the bag.

(a)	$\dfrac{mP}{2RT}$	(b)	$\dfrac{mP}{RT}$	(c)	$\dfrac{2mP}{RT}$
(d)	$\dfrac{PV}{RT}$	(e)	$\dfrac{M}{V}$	(f)	$\dfrac{Mg}{V}$

(3) p-V Diagram

-2014 4

4. One mole of a monatomic ideal gas is taken through the cycle shown in Fig. 4. Starting from A where the pressure and the volume are p_0 and V_0, respectively, the state of the gas is changed through B, C, D, and returns to A. Answer the following questions.

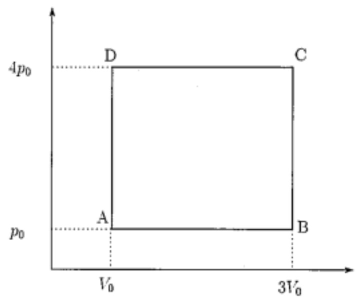


Fig. 4

(1) What multiple of the temperature at C is that at A?

(a)	$\frac{1}{12}$	(b)	$\frac{1}{4}$	(c)	$\frac{1}{3}$
(d)	1	(e)	3	(f)	4
(g)	12				

(2) Find the work done by the gas in the process A → B.

(a)	$\frac{1}{6}p_0V_0$	(b)	$\frac{1}{4}p_0V_0$	(c)	$\frac{1}{3}p_0V_0$
(d)	$\frac{1}{2}p_0V_0$	(e)	p_0V_0	(f)	$2p_0V_0$
(g)	$3p_0V_0$	(h)	$4p_0V_0$	(i)	$6p_0V_0$

(3) Choose the process in which the thermal heat the gas receives from outside is at a maximum, among four processes, A→B, B→C, C→D, and D→A.

(a)	A→B	(b)	B→C
(c)	C→D	(d)	D→A

(4) Find the thermal heat the gas receives from outside in the process of question (3).

(a)	$\frac{1}{2}p_0V_0$	(b)	p_0V_0	(c)	$\frac{3}{2}p_0V_0$
(d)	$\frac{9}{2}p_0V_0$	(e)	$\frac{13}{2}p_0V_0$	(f)	$\frac{21}{2}p_0V_0$
(g)	$\frac{27}{2}p_0V_0$	(h)	$\frac{31}{2}p_0V_0$	(i)	$\frac{35}{2}p_0V_0$

(5) Find the net thermal heat which the gas emits in the entire process from A to A through A→B→C→D→A.

(a)	$\frac{1}{2}p_0V_0$	(b)	p_0V_0	(c)	$\frac{3}{2}p_0V_0$
(d)	$\frac{9}{2}p_0V_0$	(e)	$5p_0V_0$	(f)	$6p_0V_0$
(g)	$\frac{27}{2}p_0V_0$	(h)	$\frac{31}{2}p_0V_0$	(i)	$19p_0V_0$

-2017 4

4. One mole of an ideal monatomic gas is taken through the cycle A $\to$ B $\to$ C $\to$ A as shown in Fig. 4. B $\to$ C is an isothermal process at temperature T_0, in which the gas absorbs the heat Q_0. The universal gas constant is denoted as R. Answer the following questions.

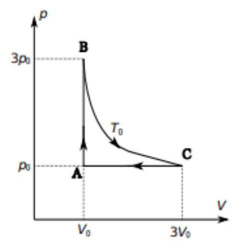


Fig. 4

(1) Find the temperature of the gas at A.

(a)	$\frac{1}{9}T_0$	(b)	$\frac{1}{3}T_0$	(c)	T_0
(d)	$3T_0$	(e)	$9T_0$		

(2) Find the heat absorbed by the gas in the process A $\to$ B.

(a)	$-2RT_0$	(b)	$-RT_0$	(c)	$-\frac{2}{3}RT_0$
(d)	0	(e)	$\frac{2}{3}RT_0$	(f)	RT_0
(g)	$2RT_0$	(h)	$-Q_0$	(i)	Q_0

(3) Find the work done by the gas in the process B $\to$ C.

(a)	$-2RT_0$	(b)	$-RT_0$	(c)	$-\frac{2}{3}RT_0$
(d)	0	(e)	$\frac{2}{3}RT_0$	(f)	RT_0
(g)	$2RT_0$	(h)	$-Q_0$	(i)	Q_0

(4) Find the work done by the gas in the process C $\to$ A.

(a)	$-2RT_0$	(b)	$-RT_0$	(c)	$-\frac{2}{3}RT_0$
(d)	0	(e)	$\frac{2}{3}RT_0$	(f)	RT_0
(g)	$2RT_0$	(h)	$-Q_0$	(i)	Q_0

(5) Select a correct relation for the sign of the net work W done by the gas and the net heat Q absorbed by the gas per cycle.

(a)	$W > 0, Q > 0$	(b)	$W = 0, Q > 0$	(c)	$W < 0, Q > 0$
(d)	$W > 0, Q = 0$	(e)	$W = 0, Q = 0$	(f)	$W < 0, Q = 0$
(g)	$W > 0, Q < 0$	(h)	$W = 0, Q < 0$	(i)	$W < 0, Q < 0$

-2018 4

4. One mole of a monatomic ideal gas is taken through the cycle shown in Fig. 4. In the process AB the gas pressure increases from P_0 to $4P_0$ at constant volume $V = V_0$. In the process BC the gas volume increases from V_0 to $4V_0$ at constant pressure $P = 4P_0$. In the process CD the gas pressure decreases from $4P_0$ to P_0 at constant volume $V = 4V_0$. In the process DA the gas volume decreases from $4V_0$ to V_0 at constant pressure $P = P_0$. The gas has a molar specific heat at constant volume, $C_V = 3R/2$ with R the universal gas constant. Answer the following questions.

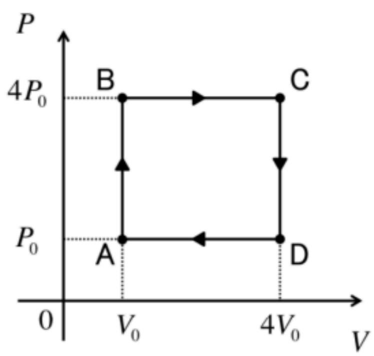


Fig. 4

(1) Find the thermal energy transferred into the system in the process AB.

(a) P_0V_0 (b) $3P_0V_0$ (c) $\frac{11}{2}P_0V_0$

(d) $\frac{9}{5}P_0V_0$ (e) $\frac{9}{2}P_0V_0$ (f) $\frac{7}{2}P_0V_0$

(2) Find the thermal energy transferred into the system in the process BC.

(a) $18P_0V_0$ (b) $24P_0V_0$ (c) $30P_0V_0$

(d) $\frac{25}{2}P_0V_0$ (e) $\frac{45}{2}P_0V_0$ (f) $\frac{75}{2}P_0V_0$

(3) Find the net work done by the gas per cycle.

(a) $16P_0V_0$ (b) $4P_0V_0$ (c) $3P_0V_0$

(d) $12P_0V_0$ (e) $15P_0V_0$ (f) $9P_0V_0$

(4) Find the thermal efficiency of the cycle.

(a) $\frac{3}{10}$ (b) $\frac{3}{5}$ (c) $\frac{2}{5}$

(d) $\frac{6}{23}$ (e) 0 (f) 1

-2020 1(5)

(5) An ideal gas undergoes the cycle shown in the P-V diagram of Fig. 1-5. Find the net thermal energy added to the system during one complete cycle.

(a) 0 (b) $\frac{1}{2}P_0V_0$ (c) P_0V_0

(d) $\frac{3}{2}P_0V_0$ (e) $2P_0V_0$ (f) $\frac{5}{2}P_0V_0$

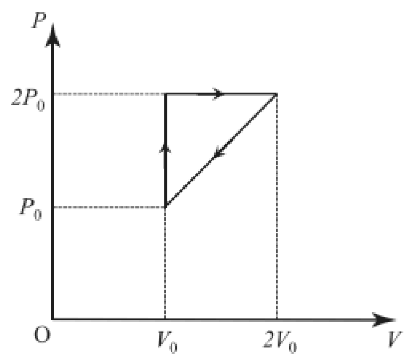


Fig. 1-5