विध्न विचारत भीरु जन, नहीं आरम्भे काम, विपति देख छोड़े तुरंत मध्यम मन कर श्याम।
पुरुष सिंह संकल्प कर, सहते विपति अनेक, 'बना' न छोड़े ध्येय को, रघुबर राखे टेक।।

रचितः मानव धर्म प्रणेता
सद्गुरु श्री रणछोड़दासजी महाराज

STUDY PACKAGE

This is TYPE 1 Package
please wait for Type 2

Subject : PHYSICS

Topic : K.T.G. & THERMODYNAMICS

Teko® CLASSES
.....the support

Index

Student's Name :______________________

Class :______________________

Roll No. :______________________

ADDRESS: R-1, Opp. Raiway Track,
New Corner Glass Building, Zone-2, M.P. NAGAR, Bhopal
☎ : (0755) 32 00 000, 98930 58881, www.tekoclasses.com

KEY CONCEPTS

Kinetic Theory Of Gases

1. Assumption of kinetic theory of gases

(1) A gas consist of particles called molecules which move randomly in all directions.
(2) These molecules obey Newton's law of motion.
(3) Size of molecule negligible in comparison to average separation between the molecules.
(4) The forces on molecule are negligible except at the time of collision.
(5) All collision between molecules or between molecules and wall are pefectly elastic. Time of collision is very small.
(6) For large number of molecules the density and distribution of molecules with different velocities are independent of position, direction and time.

2. Pressure of an ideal gas

$$\boxed{P = \frac{1}{3}\rho\,\overline{v}^2 = \frac{1}{3}\rho\,\overline{v}^2_{rms}}$$

Here $\overline{v}$ = mean square speed

v_{rms} = root mean square speed
ρ = density of gas

$$P = \frac{2}{3}\left(\frac{1}{2}\rho v^2_{rms}\right)$$

$$P = \frac{2}{3}E$$

$$E = \frac{3}{2}P$$

So total K.E. $\boxed{K = \frac{3}{2}PV}$

3. R.M.S. velocity – depends on tempearture only for any gas.

$$v_{rms} = \frac{\sqrt{v_1^2+v_2^2+v_3^2+.........+v_n^2}}{n}$$

$$P = \frac{1}{3}\rho v^2_{rms}$$

$$\boxed{v_{rms} = \sqrt{\frac{3P}{\rho}} = \sqrt{\frac{3RT}{M}}}$$

4. Most Probable velocity – velocity which maximum number of molecules may have

$$\boxed{v_{mp} = \sqrt{\frac{2RT}{M}}}$$

5. Average velocity

$$v_{avg} = \frac{\vec{v}_1+\vec{v}_2+.........+\vec{v}_n}{n} = 0$$

6. Average speed

$$\boxed{v_{avg} = \frac{|\vec{v}_1| + |\vec{v}_2| + |\vec{v}_3| + \ldots\ldots + |\vec{v}_n|.}{n} = \sqrt{\frac{8RT}{\pi M}}}$$

7. Ideal gas equation

$PV = nRT$ (container form of gas law/ pressure volume form)

$P = \left(\frac{\rho}{M}\right)RT$ (open atmosphere / pressure density form)

8. Graham's law of diffusion :–

When two gases at the same pressure and tempearture are allowed to diffuse into each other the rate of diffusion of each gas is inversely proportional to the square root of the density of the gas

$r \propto v_{rms}$ where r = rate of diffusion

so, $\boxed{\frac{r_1}{r_2} = \sqrt{\frac{\rho_2}{\rho_1}}}$

9. Degree of Freedom (f) – No. of ways in which a gas molecule can distribute its energy

10. Law of equipartition of energy : – Energy in each degree of freedom = 1/2 KT joules

If degree of freedom is f. Energy = $\frac{f}{2}$ KT joules.

$$U = \frac{f}{2}\, KTnN_A = \frac{f}{2}\, nRT$$

11. Degree of freedom(f) in different gas molecules

Molecules	Translational	Rotational
Monoatomic	3	0
Diatomic	3	2
Polyatomic	3	2 (linear molecule) 3 (non-linear molecule)

Translational energy for all type of molecules = $\frac{3}{2}$**(nRT)**

Law of Thermodynamics

1. Zeroth law of thermodynamics :– If two bodies A and B are in thermal equilibrium and A and C are also in thermal equilibrium.Then B and C are also in thermal equilibrium.

2. First law of Thermodynamics:– Energy conservation for gaseous system.

Heat supplied to the gas = Increment in internal energy + work done by the gas.

$\Delta Q = \Delta U + \Delta W$ ΔQ is +ve for heat supplied

in differential form $dQ = dU + dW$ ΔQ is –ve for heat rejected and $dQ = nCdT$ $\qquad$ C = molar specific heat

$C = C_P$ (constant pressure) ; $C = C_V$ = (constant volume)

$$dU = \frac{f}{2}\, nRdT$$

$$dW = \int_{v_1}^{v_2} P\, dv$$ (P = pressure of the gas of which work is to be calculated)

ΔW = +ve for work done by gas (in expansion of gas)

ΔW = –ve for work done on the gas (in contraction of gas)

Molar specific heat for a given process $C = \frac{f}{2} R + \frac{R\,PdV}{PdV + VdP} = C_V + \frac{R\,PdV}{PdV + VdP}$

Process	C	Monoatomic	Diatomic	Polyatomic
V = constant	$C_V = (f/2)R$	(3/2)R	(5/2)R	3R
P = constant	$C_P = \frac{f+2}{2}R$	(5/2)R	(7/2)R	4R

Mayor's Relation $C_P = C_V + R$

Note :– C of a gas depends on the process of that gas, which can be infinite in types.

Ratio of specific heat :– $\gamma = \frac{C_P}{C_V} = \frac{f+2}{f}$ $\xrightarrow{\text{monoatomic}}$ 5/3 = 1.67; $\xrightarrow{\text{diatomic}}$ 7/5 = 1.4; $\xrightarrow{\text{polyatomic}}$ 4/3 = 1.33

and $f = \frac{2}{\gamma - 1}$

$C_V = \frac{R}{\gamma - 1}$; $C_P = \frac{\gamma R}{\gamma - 1}$

<u>Isochoric Process (V= constant)</u>

$dV = 0 \Rightarrow dW = 0$

By FLT $dQ = dU = nC_V\, dT$

$$\boxed{Q = \int_{T_1}^{T_2} nC_v\, dT = nC_v(T_2 - T_1)}$$

* Be careful if $\Delta V = 0$ then not necessarily an Isochoric Process.

<u>Isobaric Process (P = constant)</u>

$dP = 0$

By FLT $dQ = dU + dW$

$n_{C_p}(T_2 - T_1) = (\frac{f}{2})nR(T_2 - T_1) + nR(T_2 - T_1)$

$$\boxed{W = nR(T_2 - T_1)}$$

* If $\Delta P = 0$ then not necessarily an Isobaric Process.

Isothermal Process (T = constant)

$dT = 0$, $dU = 0$

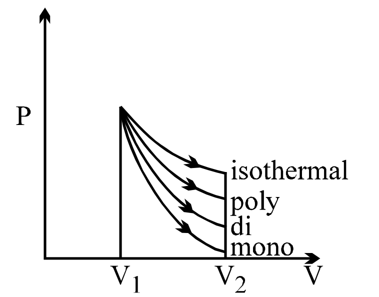
$$Q = W = (nRT)\int_{v_1}^{v_2} dV/V$$

$$\boxed{W = nRT\, ln\frac{V_2}{V_1} = nRT\, ln\frac{P_1}{P_2}}$$ $\left(\frac{V_2}{V_1} = \frac{P_1}{P_2} = \text{compression ratio}\right)$

Adiabatic Process dQ = 0 but if $\Delta Q = 0$, it is not necessaserily adibatic.

$dW = -dU$ By FLT

$$\boxed{W = \int_{T_1}^{T_2} \frac{nRdT}{\gamma - 1} = \frac{nR(T_1 - T_2)}{\gamma - 1} = \frac{P_1V_1 - P_2V_2}{\gamma - 1}}$$



Work done is least for monoatomic gas

So $PdV + VdP = (\gamma-1)$ ....(ii)

For Adiabatic Process PV^{γ} = constant

$$\left|\frac{dP}{dV}\right|_{adiabatic} = \gamma\left|\frac{dP}{dV}\right|_{isothermal}$$

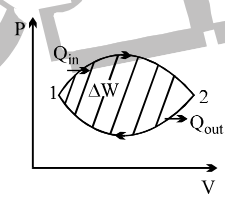
Polytropic process

PV^n = constant

$$\boxed{P = \frac{K}{V^n} \Rightarrow \frac{dP}{dV} = n\left|\frac{K}{V^{n+1}}\right|} \quad ; \qquad C = \frac{R}{\gamma-1} + \frac{R}{1-n}$$

So C is constant for polytropic process

Efficiency of a cyclic process



$\Delta U = 0$

so $\Delta Q = \Delta W$

Efficiency $\eta = \dfrac{\text{work done by gas}}{\text{heat input}}$

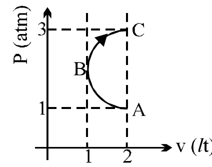
$$\eta = \frac{W}{Q_{in}} = 1 - \frac{Q_{out}}{Q_{in}}$$

TEKO CLASSES, Director : SUHAG R. KARIYA (S. R. K. Sir) PH: (0755)- 32 00 000, 0 98930 58881 , BHOPAL, (M.P.)

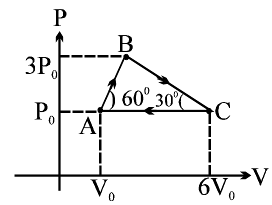
TEKO CLASSES, Director : SUHAG R. KARIYA (S. R. K. Sir) PH: (0755)- 32 00 000, 0 98930 58881 , BHOPAL, (M.P.)

EXERCISE – I

Q.1 In the P-V diagram shown in figure, ABC is a semicircle. Find the workdone in the process ABC.



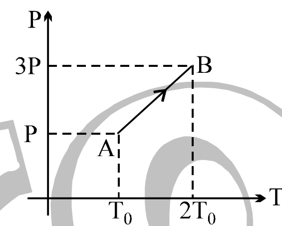
Q.2 Two moles of an ideal monoatomic gas undergone a cyclic process ABCA as shown in figure. Find the ratio of temperatures at B and A .



Q.3 The average degrees of freedom per molecules for a gas is 6. The gas performs 25 J of work when it expands at constant pressure. Find the heat absorbed by the gas .

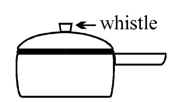
Q.4 1 mole of an ideal gas at initial temperature T was cooled isochorically till the gas pressure decreased n times. Then by an isobaric process, the gas was restored to the initial temperature T. Find the net heat absorbed by the gas in the whole process.

Q.5 Pressure versus temperature graph of an ideal gas is shown. Density of gas at point A is ρ_0. Find the density of gas at B.

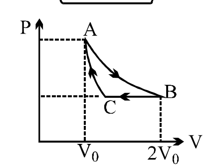


Q.6 PV-diagram of a monoatomic ideal gas is a straight line passing through origin. Find the molar heat capacity in the process.

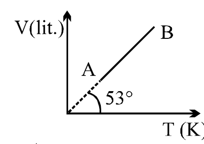
Q.7 An empty pressure cooker of volume 10 litres contains air at atmospheric pressure 10^5 Pa and temperature of 27°C. It contains a whistle which has area of 0.1 cm^2 and weight of 100 gm. What should be the temperature of air inside so that the whistle is just lifted up?



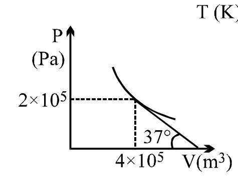
Q.8 In a cycle ABCA consisting of isothermal expansion AB, isobaric compression BC and adiabatic compression CA, find the efficiency of cycle (Given : $T_A = T_B = 400$ K, $\gamma = 1.5$)



Q.9 V-T curve for 2 moles of a gas is straight line as shown in the graph here. Find the pressure of gas at A.

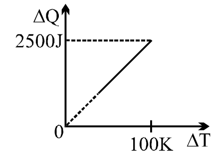


Q.10 P-V graph for an ideal gas undergoing polytropic process PV^m = constant is shown here.Find the value of m.



Q.11 Air at temperature of 400 K and atmospheric pressure is filled in a balloon of volume 1 m^3. If surrounding air is at temperature of 300 K, find the ratio of Buoyant force on balloon and weight of air inside

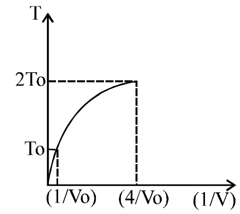
Q.12 One mole of a gas mixture is heated under constant pressure, and heat required ΔQ is plotted against temperature difference acquired. Find the value of γ for mixture.



Q.13 Ideal diatomic gas is taken through a process $\Delta Q = 2\Delta U$. Find the molar heat capacity for the process (where ΔQ is the heat supplied and ΔU is change in internal energy)

Q.14 A gas is undergoing an adiabatic process. At a certain stage A, the values of volume and temperature $\equiv (V_0, T_0)$ and the magnitude of the slope of V-T curve is m. Find the value of C_P and C_V.

Q.15 Figure shows a parabolic graph between T and $\dfrac{1}{V}$ for a mixture of a gas undergoing an adiabatic process. What is the ratio of V_{rms} and speed of sound in the mixture?



Q.16 The height of mercury is a faulty barometer is 75 cm and the tube above mercury having air is 10 cm long. The correct barometer reading is 76 cm. If the faulty barometer reads 74 cm, find the true barometer reading.

Q.17 A piston divides a closed gas cylinder into two parts. Initially the piston is kept pressed such that one part has a pressure P and volume 5V and the other part has pressure 8P and volume V. The piston is now left free. Find the new pressures and volumes for the adiabatic and isothermal processes. For this gas $\gamma = 1.5$.

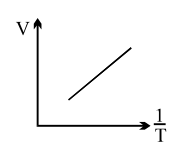
Q.18 A closed vessel of volume V_0 contains oxygen at a pressure P_0 and temperature T_0. Another closed vessel of the same volume V_0 contains helium at a pressure of P_0 and temperature $T_0/2$. Find the ratio of the masses of oxygen to the helium.

Q.19 A gas undergoes a process in which the pressure and volume are related by VP^n = constant. Find the bulk modulus of the gas.

Q.20 An ideal gas has a molar heat capacity C_V at constant volume. Find the molar heat capacity of this gas as a function of volume, if the gas undergoes the process : $T = T_0 e^{\alpha V}$.

Q.21 A standing wave of frequency 1000 Hz in a column of methane at 27°C produces nodes which are 20.4 cm apart. Find the ratio of heat capacity of methane at constant pressure to that at constant volume (Take gas constant, $R = 8.31\ J{\cdot}K^{-1}mol^{-1}$)

Q.22 One mole of an ideal monoatomic gas undergoes a process as shown in the figure. Find the molar specific heat of the gas in the process.



Q.23 One mole of an ideal gas is compressed from 0.5 lit to 0.25 lit. During the compression, 23.04×10^2 J of work is done on the gas and heat is removed to keep the temperature of the gas constant at all times. Find the temperature of the gas. (Take universal gas constant $R = 8.31\ J\ mol^{-1}K^{-1}$)

Q.24 A mixture of 4 gm helium and 28 gm of nitrogen in enclosed in a vessel of constant volume 300°K. Find the quantity of heat absorbed by the mixture to doubled the root mean velocity of its molecules. (R = Universal gas constant)

TEKO CLASSES, Director : SUHAG R. KARIYA (S. R. K. Sir) PH: (0755)- 32 00 000, 0 98930 58881 , BHOPAL, (M.P.)

Q.25 The pressure of an ideal gas changes with volumes as P = aV where 'a' is a constant. One moles of this gas is expanded to 3 times its original volume V_0. Find
(i) the heat transferred in the process.
(ii) the heat capacity of the gas.

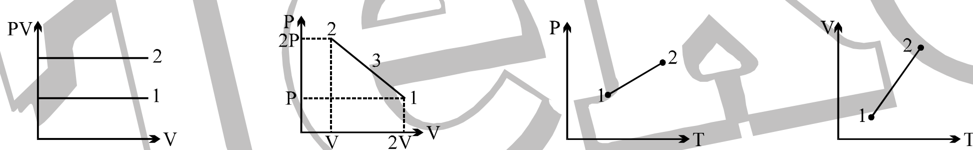
Q.26 If heat is added at constant volume, 6300 J of heat are required to raise the temperature of an ideal gas by 150 K. If instead, heat is added at constant pressure, 8800 joules are required for the same temperature change. When the temperature of the gas changes by 300 K. Determine the change is the internal energy of the gas.

Q.27 70 calorie of heat is required to raise the temperature of 2 mole of an ideal gas at constant pressure from 40°C to 45°C. Find the amount of heat required to raise the temperature of the same gas through the same range at constant volume (R = 2 cal/mol-K)

Q.28 The volume of one mole of an ideal gas with specific heat ratio γ is varied according to the law $V = \frac{a}{T^2}$, where a is a constant. Find the amount of heat obtained by the gas in this process if the gas temperature is increased by ΔT.

Q.29 Find the molecular mass of a gas if the specific heats of the gas are C_P=0.2 cal/gm°C and C_V = 0.15 cal/gm°C. [Take R = 2 cal/mole°C]

Q.30 Examine the following plots and predict whether in (i) $P_1 < P_2$ and $T_1 > T_2$, in (ii) $T_1 = T_2 < T_3$, in (iii) $V_1 > V_2$, in (iv) $P_1 > P_2$ or otherwise.



(i) (ii) (iii) (iv)

List of recommended questions from I.E. Irodov.

2.1 to 2.7, 2.10 to 2.13, 2.17, 2.27, 2.29 to 2.35, 2.37 to 2.40, 2.43, 2.46, 2.48, 2.49, 2.63 to 2.73, 2.116, 2.120, 2.122, 2.127

EXERCISE – II

Q.1 A barometer is faulty. When the true barometer reading are 73 and 75 cm of Hg, the faulty barometer reads 69 cm and 70 cm respectively.

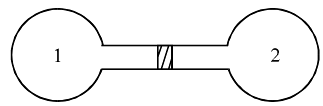
(i) What is the total length of the barometer tube?

(ii) What is the true reading when the faulty barometer reads 69.5 cm ?

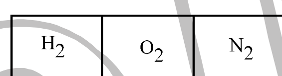
(iii) What is the faulty barometer reading when the true barometer reads 74 cm?

Q.2 Two bulbs of equal volume joined by a narrow tube of negligible volume contain hydrogen at 0°C and one atmospheric pressure. What is the pressure of the gas when one of the bulbs is immersed in steam at 100°C and the other in liquid oxygen at –190°C ? The volume of each bulb is 10^{-3}m^3 and density of hydrogen is 0.09 kg/m^3 at 0°C and at 1 atmosphere. What mass of hydrogen passes along the connecting tube?

Q.3 Two spherical flasks having a volume V_0 = 1.0 L each containing air are connected by a tube of diameter d = 6 mm and length l = 1 m. A small droplet of mercury contained in the tube is at its middle at 0°C. By what distance do the mercury droplets move if the flask 1 is heated by 2°C while flask 2 is cooled by 2°C. Ignore any expansion of flask wall.

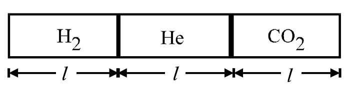


Q.4 A vessel of volume V = 30l is seperated into three equal parts by stationary semipermeable thin membranes as shown in the Figure. The left , middle and right parts are filled with m_{H_2} = 30g of hydorgen, m_{O_2} =160g of oxygen, and m_{N_2} = 70g of nitrogen respectively. The left partition lets through only hydrogen, while the right partition lets through hydrogen and nitrogen. What will be the pressure in each part of the vessel after the equilibrium has been set in if the vessel is kept at a constant temperature T = 300K?

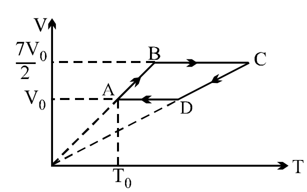


Q.5 A freely moving piston divides a vertical cylinder, closed at both ends, into two parts each containing 1 mole of air. In equilibrium, at T = 300 K, volume of the upper part is η = 4 times greater than the lower p part. At what temperature will the ratio of these volumes be equal to η' = 2?

Q.6 A non-conducting cylindrical vessel of length 3l is placed horizontally and is divided into three parts by two easily moving piston having low thermal conductivity as shown in figure. These parts contain H_2, He and CO_2 gas at initial temperatures θ_1 = 372°C, θ_2 = – 15°C and θ_3 = 157°C respectively. If initial length and pressure of each part are l and P_0 respectively, calculate final pressure and length of each part. Use : $\gamma_{CO_2} = 7/5$

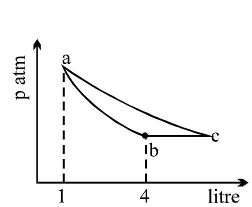


Q.7 A sample of an ideal non linear tri-atomic gas has a pressure P_0 and temperature T_0 taken through the cycle as shown starting from A. Pressure for process C → D is 3 times P_0. Calculate heat absorbed in the cycle and work done.



Q.8 RMS velocity of molecules of a di-atomic gas is to be increased to 1.5 times. Calculate ratio of initial volume to final volume, if it is done.
(i) Adiabatically ; (ii) Isobarically ; (iii) Calculate, also ratio of work done by gas during these processes.

Q.9 Figure shows three processes for an ideal gas. The temperature at 'a' is 600 K, pressure 16 atm and volume 1 litre. The volume at 'b' is 4 litre. Out of the two process ab and ac, one is adiabatic and he other is isothermal. The ratio of specific heats of the gas is 1.5. Answer the following :



(i) Which of ab and ac processes is adiabatic. Why?

(ii) Compute the pressure of the gas at b and c.

(iii) Compute the temperature at b and c.

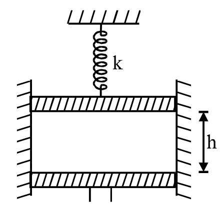
(iv) Compute the volume at c.

Q.10 Two vessels A and B both containing an ideal diatomic gas are connected together by a narrow tube of negligible volume fitted with a valve. A contains 5 mole of the gas at temperature 35°C and pressure $1.6 \times 10^5\ Nm^{-2}$, while B contains 2 moles of gas at temperature 17°C and pressure $8.3 \times 10^4\ Nm^{-2}$. The valve between the two vessel is opened to allow the contents to mix and achieve an equilibrium temperature of 27°C.

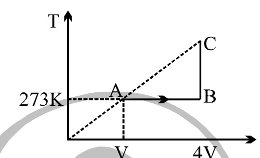
(i) Find the final pressure and the amount of heat transferred to the surrounding.

(ii) If the vessels along with the tube are perfectly insulated, calculate the final temperature and pressure.

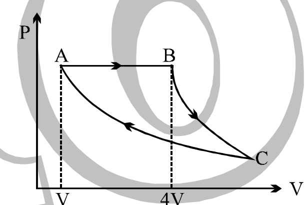
Q.11 An ideal gas at NTP is enclosed in a adiabatic vertical cylinder having area of cross section $A = 27\ cm^2$, between two light movable pistons as shown in the figure. Spring with force constant $k = 3700$ N/m is in a relaxed state initially. Now the lower piston is moved upwards a height h/2, h being the initial length of gas column. It is observed that the upper piston moves up by a distance h/16. Find h taking γ for the gas to be 1.5. Also find the final temperature of the gas.



Q.12 At a temperature of $T_0 = 273$°K, two moles of an ideal gas undergoes a process as shown. The total amount of heat imparted to the gas equals Q = 27.7 kJ. Determine the ratio of molar specific heat capacities.

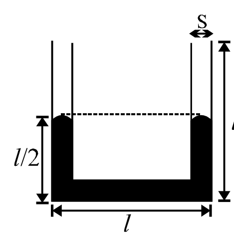


Q.13 A fixed mass of a gas is taken through a process $A \rightarrow B \rightarrow C \rightarrow A$. Here $A \rightarrow B$ is isobaric. $B \rightarrow C$ is adiabatic and $C \rightarrow A$ is isothermal. Find efficiency of the process. (take $\gamma = 1.5$)

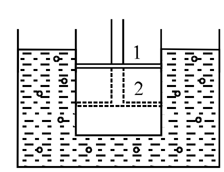


Q.14 A vessel of volume 30 litre is separated into three equal parts by stationary semipermeable membrane. The left, middle and right parts are filled with 30 gms of hydrogen, 160 gms of oxygen and 70 gms of nitrogen respectively. The left partition lets through only hydrogen while the right partition lets through hydrogen and nitrogen. If the temperature in all is 300 K find the ratio of pressure in the three compartments.

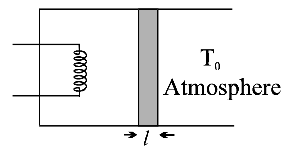
Q.15 A thin U–tube sealed at one end consists of three bends of length $l = 250$mm each, forming right angles. The vertical parts of the tube are filled with mercury to half the height as shown in the figure. All of mercury can be displaced from the tube by heating slowly the gas in the sealed end of the tube, which is separated from the atmospheric air by mercury. Determine the work A done by the gas thereby if the atmospheric pressure is $p_0 = 10^5$Pa, the density of mercury is $\rho_{mer} = 13.6 \times 10^3 kg/m^3$, and the cross-sectional area of the tube is $S = 1 cm^2$.



Q.16 A cylinder containing a gas is closed by a movable piston. The cylinder is submerged in an ice-water mixture. The piston is quickly pushed down from position 1 to position 2. The piston is held at position 2 until the gas is again at 0°C and then slowly raised back to position 1. Represent the whole process on P-V diagram. If m = 100 gm of ice are melted during the cycle, how much work is done on the gas. Latent heat of ice = 80 cal/gm.



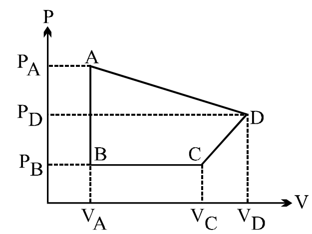
Q.17 An adiabatic vessel containing n moles of a ideal diatomic gas is fitted with a light conducting piston. The cross-sectional area, thickness and thermal conductivity of piston are A, *l* and K respectively. The other side of the piston is open to atmosphere of temperature T_0. Heat is supplied to the gas by means of an electric heater at a small constant rate q. Initial temperature of gas is T_0.



(a) Find the temperature of the gas as a function of time,
(b) Find the maximum temperature of the gas and
(c) What is the ratio of the maximum volume to the minimum volume?

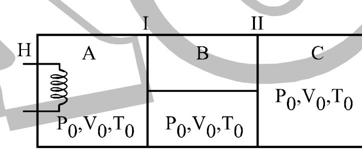
Q.18 A parallel beam of particles of mass m moving with velocities v impinges on a wall at an angle θ to its normal. The number of particles per unit volume in the beam is n. If the collision of particles with the wall is elastic, then find the pressure exerted by this beam on the wall.

Q.19 For the thermodynamic process shown in the figure.
$P_A = 1 \times 10^5$ Pa; $P_B = 0.3 \times 10^5$ Pa
$P_D = 0.6 \times 10^5$ Pa; $V_A = 0.20$ litre
$V_D = 1.30$ litre.



(a) Find the work performed by the system along path AD.
(b) In the total work done by the system along the path ADC is 85J find the volume at point C.
(c) How much work is performed by the system along the path CDA ?

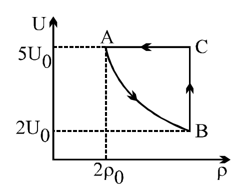
Q.20 The figure shows an insulated cylinder divided into three parts A, B and C. Pistons I and II are connected by a rigid rod and can move without friction inside the cylinder. Piston I is perfectly conducting while piston II is perfectly insulating. The initial state of the gas ($\gamma = 1.5$) present in each compartment A, B and C is as shown. Now, compartment A is slowly given heat through a heater H such that the final volume of C becomes $\frac{4V_0}{9}$. Assume the gas to be ideal and find.



(a) Final pressures in each compartment A, B and C
(b) Final temperatures in each compartment A, B and C
(c) Heat supplied by the heater
(d) Work done by gas in A and B.
(e) Heat flowing across piston I.

Q.21 How many atoms do the molecules of a gas consist of if γ increases 1.20 times when the vibrational degrees of freedom are "frozen" ? Assume that molecules are non linear.

Q.22 Figure shows the variation of the internal energy U with the density ρ of one mole of ideal monoatomic gas for a thermodynamic cycle ABCA. Here process AB is a part of rectangular hyperbola.



(a) Draw the P-V diagram for the above process.
(b) Find the net amount of heat absorbed by the system for the cyclic process.
(c) Find the work done in the process AB.

Q.23 An ideal monoatomic gas undergoes a process where its pressure is inversely proportional to its temperature.
(i) Calculate the specific heat for the process.
(ii) Find the work done by two moles of gas if the temperature changes from T_1 to T_2.

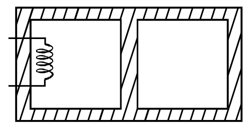
Q.24 An ideal diatomic gas undergoes a process in which its internal energy relates to the volume as

$U = a\sqrt{V}$, where α is a constant.

(a) Find the work performed by the gas and the amount of heat to be transferred to this gas to increase its internal energy by 100 J.

(b) Find the molar specific heat of the gas for this process.

Q.25 Two rectangular boxes shown in figure has a partition which can slide without friction along the length of the box. Initially each of the two chambers of the box has one mole of a monoatomic ideal gas ($\gamma = 5/3$) at a pressure p_0 volume V_0 and temperature T_0. The chamber on the left is slowly heated by an electric heater. The walls of the box and the partitions are thermally insulated. Heat loss through the lead wires of the heater is negligible. The gas in the left chamber expands, pushing the partition until the final pressure in both chambers becomes $243\ P_0/32$. Determine

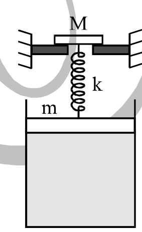


(i) the final temperature of the gas in each chamber and

(ii) the work-done by the gas in the right chamber.

Q.26 An adiabatic cylinder of length $2l$ and cross-sectional area A is closed at both ends. A freely moving non-conducting this piston divides the cylinder in two parts. The piston is connected with right end by a spring having force constat K and natural length l. Left part of the cylinder contains one mole of helium and right part contains 0.5 mole of each of helium and oxygen. If initial pressure of gas in each part is P_0, calculate heat supplied by the heating coil, connected to left part, to compress the spring through half of its natural length.

Q.27 0.01 moles of an ideal diatomic gas is enclosed in an adiabatic cylinder of cross-sectional area $A = 10^{-4} m^2$. In the arrangement shown, a block of mass M = 0.8 kg is placed on a horizontal support, and another block of mass m = 1 kg is suspended from a spring of stiffness constant k = 16 N/m. Initially, the spring is relaxed and the volume of the gas is $V = 1.4 \times 10^{-4}\ m^3$.



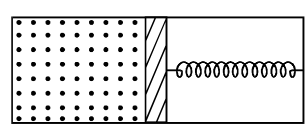
(a) Find the initial pressure of the gas.

(b) If block m is gently pushed down and released it oscillates harmonically, find its angular frequency of oscillation.

(c) When the gas in the cylinder is heated up the piston starts moving up and the spring gets compressed so that the block M is just lifted up. Determine the heat supplied.

Take atmospheric pressure $P_0 = 10^5\ Nm^{-2}$, $g = 10 m/s^2$.

Q.28 A thermally insulated vessel is divided into two parts by a heat-insulating piston which can move in the vessel without the friction. The left part of the vessel contains one mole of an ideal monatomic gas, & the right part is empty. The piston is connected to the right wall of the vessel through a spring whose length in free state is equal to the length of the vessel as shown in the figure. Determine the heat capacity C of the system, neglecting the heat capacities of the vessel, piston and spring.



EXERCIES – III

Q.1 The kinetic energy, due to translational motion, of most of the molecules of an ideal gas at absolute temperature T is ______ . [REE '94, 1]

Q.2 A vessel of volume 2×10^{-2} m^3 contains a mixture of hydrogen and helium at 47°C temperature and 4.15×10^5 N/m^2 pressure. The mass of the mixture is 10^{-2} kg. Calculate the masses of hydrogen and helium in the given mixture. [REE '94, 4]

Q.3 There are two vessels . Each of them contains one mole of a mono-atomic ideal gas . Initial volume of the gas in each vessel is 8.3×10^{-3} m^3 at 27°C . Equal amount of heat is supplied to each vessel . In one of the vessels, the volume of the gas is doubled isothermally, whereas the volume of the gas is held constant in the second vessel . The vessels are now connected to allow free mixing of the gas. Find the final temperature and pressure of the combined gas system . [REE '94, 6]

Q.4 An ideal gas with pressure P, volume V & temperature T is expanded isothermally to a volume 2V and a final pressure P_i . If the same gas is expanded adiabatically to a volume 2V, the final pressure is P_a. The ratio of the specific heats for the gas is 1.67 . The ratio P_a/P_i is ______ . [JEE '94, 2]

Q.5 An ideal gas is taken through a cyclic thermodynamic process through four steps. The amounts of heat involved in these steps are $Q_1 = 5960$ J, $Q_2 = -5585$ J, $Q_3 = -2980$ J and $Q_4 = 3645$ J respectively. The corresponding works involved are $W_1 = 2200$ J, $W_2 = -825$ J, $W_3 = -1100$ J and W_4 respectively.
(i) Find the value of W_4. (ii) What is the efficiency of the cycle ? [JEE '94, 6]

Q.6 A closed container of volume 0.02 m^3 contains a mixture of neon and argon gases, at a temperature of 27°C & pressure of 1×10^5 Nm^{-2} . The total mass of the mixture is 28 gm. If the gram molecular weights of neon and argon are 20 & 40 respectively, find the masses of the individual gases in the container, assuming them to be ideal. [Universal gas constant R = 8.314 J/mol K] [JEE '94, 6]

Q.7 A gaseous mixture enclosed in a vessel of volume V consists of one gram mole of a gas A with $\gamma = Cp/Cv = 5/3$ & another gas B $\gamma = 7/5$ with at a certain temperature T. The gram molecular weights of the gases A & B are 4 & 32 respectively. The gases A & B do not react with each other and are assumed to be ideal. The gaseous mixture follows the equation; $PV^{19/13}$ = const. in adiabatic processes.
(a) Find the number of gram moles of the gas B in the gaseous mixture.
(b) Compute the speed of sound in the gaseous mixture at T = 300 K.
(c) If T is raised by 1 K from 300 K, find the percentage change in the speed of sound in the gaseous mixture.
(d) The mixture is compressed adiabatically to 1/5 its initial volume V . Find the change in its adiabatic compressibility in terms of the given quantities. [JEE '95]

Q.8 The pressure in a monoatomic gas increases linearly from 4×10^5 N m^{-2} to 8×10^5 N m^{-2} when its volume increases from 0.2 m^3 to 0.5 m^3. Calculate the following: [REE '95, 5]
(a) work done by the gas, (b) increase in the internal energy, (c) amount of heat supplied,
(d) molar heat capacity of the gas.

Q.9 The temperature of an ideal gas is increased from 120 K to 480 K . If at 120 K the root-mean-square velocity of the gas molecules is v, at 480 K it becomes : [JEE '96, 2]
(A) 4v (B) 2v (C) v/2 (D) v/4

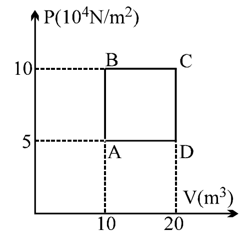
Q.10 At 27^{0}C two moles of an ideal monoatomic gas occupy a volume V. The gas expands adiabatically to a volume 2V. Calculate : (i) the final temperature of the gas , (ii) change in its internal energy & (iii) the work done by the gas during the process . [JEE '96, 5]

Q.11 There is a soap bubble of radius 2.4×10^{-4} m in air cylinder which is originally at the pressure of 10^5 Nm^{-2}. The air in the cylinder is now compressed isothermally until the radius of the bubble is halved. Calculate now the pressure of air in the cylinder. The surface tension of the soap film is 0.08 Nm^{-1}. [REE '96, 5]

Q.12 A vertical hollow cylinder contains an ideal gas. The gas is enclosed by a 5kg movable piston with an area of cross-section 5×10^{-3} m^2. Now, the gas is slowly heated from 300 K to 350K and the piston rises by 0.1 m. The piston is now clamped at this position and the gas is cooled back to 300 K. Find the difference between the heat energy added during heating process & energy lost during the cooling process.
[1 atm pressure = 10^5 N m^{-2}] [REE '96, 5]

Q.13 The average translational energy and the rms speed of molecules in a sample of oxygen gas at 300 K are 6.21×10^{-21} J & 484 m/s respectively. The corresponding values at 600 K are nearly (assuming ideal gas behaviour)
(A) 12.42×10^{-21} J, 968 m/s (B) 8.78×10^{-21} J, 684 m/s
(C) 6.21×10^{-21} J, 968 m/s (D) 12.42×10^{-21} J, 684 m/s [JEE '97, 1]

Q.14 A sample of 2 kg of monoatomic Helium (assumed ideal) is taken through the process ABC and another sample of 2 kg of the same gas is taken through the process ADC as in figure. Given, molecular mass of Helium = 4



(i) what is the temperature of Helium in each of the states A, B, C & D ?
(ii) Is there any way of telling afterwards which sample of Helium went through the process ABC and which went through the process ADC? Write Yes or No.
(iii) How much is the heat involved in each of the processes ABC ADC. [JEE '97, 5]

Q.15 The average translational kinetic energy of a molecule in a gas becomes equal to 1 eV at a temperature ______ . [REE '97, 1]

Q.16 Two moles of an ideal monoatomic gas are confined within a cylinder by a massless & frictionless spring loaded piston of cross-sectional area 4×10^{-3} m^2. The spring is, initially in its relaxed state. Now the gas is heated by an electric heated, placed inside the cylinder, for some time. During this time, the gas expands and does 50 J of work in moving the piston through a distance 0.10 m. The temperature of the gas increases by 50 K. Calculate the spring constant & the heat supplied by the heater. [REE '97, 5]

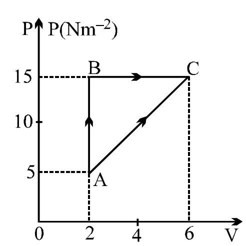
Q.17 Two vessels A & B, thermally insulated, contain an ideal monoatomic gas. A small tube fitted with a valve connects these vessels. Initially the vessel A has 2 litres of gas at 300 K and 2×10^5 Nm^{-2} pressure while vessel B has 4 litres of gas at 350 K & 4×10^5 N m^{-2} pressure. The valve is now opened and the system reaches equilibrium in pressure & temperature. Calculate the new pressure & temperature. [REE '97, 5]

Q.18 One mole of a diatomic ideal gas ($\gamma = 1.4$) is taken through a cyclic process starting from point A . The process $A \rightarrow B$ is an adiabatic compression. $B \rightarrow C$ is isobaric expansion. $C \rightarrow D$ an adiabatic expansion $D \rightarrow A$ is isochoric. The volume ratios are $V_a/V_b = 16$ and $V_c/V_b = 2$ & the temperature at A is $T_A = 300^0$K. Calculate the temperature of the gas at the points B & D and find the efficiency of the cycle.
[$(16^{0.4} = 3.03)$ $(1/8)^{0.4} = 0.435$] [JEE '97, 5]

Q.19 The average translational kinetic energy of O_2 (molar mass 32) molecules at a particluar temperature is 0.048 eV. The translational kinetic energy of N_2 (molar mass 28) molecules in eV at the same temperature is
(A) 0.0015 (B) 0.003 (C) 0.048 (D) 0.768 [JEE '97, 3]

Q.20 Select the correct alternative . [JEE '97, 3]
A vessel contains 1 mole of O_2 gas (molar mass 32) at a temperature T. The pressure of the gas is P. An identical vessel containing one mole of He gas (molar mass 4) at a temperature 2T has a pressure of:
(A) P/8 (B) P (C) 2P (D) 8P

Q.21 In the given figure an ideal gas changes its state from state A to state C by two paths ABC and AC. (a) Find the path along which work done is the least. (b) The internal energy of gas at A is 10J and amount of heat supplied to change its state to C through the path AC is 200J. Calculate the internal energy at C. (c) The internal energy of gas at state B is 20J. Find the amount of heat supplied to the gas from A to B. [REE '98]



Q.22 Two cylinders A and B fitted with pistons contain equal amounts of an ideal diatomic gas at 300K. The piston of A is free to move, while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of the gas is A is 30K, then rise in temperature of the gas in B is
(A)30K (B) 18K (C) 50K (D) 42K [JEE' 98]

Q.23 Two identical containers A and B with frictionless pistons contain the same ideal gas at the same temperature and the same volume V. The mass of the gas in A is m_A and that in B is m_B. The gas in each cylinder is now allowed to expand isothermally to the same final volume 2V. The change in the pressure in A and B are found to be ΔP and 1.5 ΔP respectively. Then [JEE' 98]
(A) $4m_A=9m_B$ (B) $2m_A=3m_B$ (C) $3m_A=2m_B$ (D) $9m_A=4m_B$

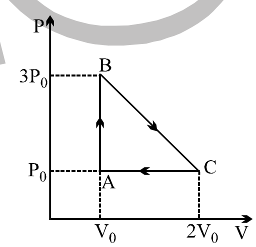
Q.24 A vessel contains a mixture of one mole of oxygen and two moles of nitrogen at 300K. The ratio of the average rotational kinetic energy per O_2 molecule the that per N_2 molecule is [JEE' 98]
(A) 1:1 (B) 1:2 (C) 2:1 (D) depend on the moment of inertia of two molecules.

Q.25 Let v_{av}, v_{rms} and v_p respectively denote mean speed, root mean square speed and the most probable speed of the molecule in an ideal monoatomic gas at absolute temperature T. The mass of a molecule is m then :
(A) no molecule can have speed greater than $\sqrt{2}\, v_{rms}$ [JEE'98]
(B) no molecule can have speed less than $v_p/\sqrt{2}$
(C) $v_p<v_{av}<v_{rms}$ (D) the average kinetic energy of a molecule is $3/4\, mv_p^2$

Q.26 A given quantity of an ideal gas is at pressure P and absolute temperature T. The isothermal bulk modulus of the gas is :
(A) 2P/3 (B) P (C) 3P/2 (D) 2P [JEE'98]

Q.27 During the melting of a slab of ice at 273K at atmospheric pressure:
(A) positive work is done by the ice-water system on the atmosphere.
(B) positive work is done on the ice-water system by the atmosphere
(C) the internal energy of the ice-water system increases
(D) the internal energy of ice-water system decreases. [JEE' 98]

Q.28 One mole of an ideal monoatomic gas is taken round the cyclic process ABCA as shown in figure, calculate
(a) the work done by the gas
(b) the heat rejected by the gas in the path CA and the heat absorbed by the gas in the path AB.
(c) the net heat absorbed by the gas in the path BC
(d) the maximum temperature attained by the gas during the cycle. [JEE' 98]



Q.29 The ratio of the speed of sound in nitrogen gas to that in helium gas, at 300K is
(A) √(2/7) (B) √(1/7) (C) (√3)/5 (D) (√6)/5 [JEE' 99]

Q.30 A gas mixture consists of 2 moles of oxygen and 4 moles of argon at temperature T. Neglecting all vibrational modes, the total internal energy of the system is
(A) 4 RT (B) 15 RT (C) 9 RT (D) 11 RT [JEE' 99]

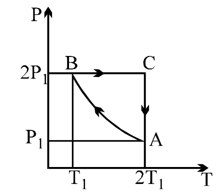
Q.31 Two moles of an ideal monoatomic gas, initially at pressure p_1 and volume V_1, undergo an adiabatic compression until its volume is V_2. Then the gas is given heat Q at constant volume V_2. (a) Sketch the complete process on a p-V diagram. (b) Find the total work done by the gas, the total change in its internal energy and the final temperature of the gas. [Given answers in terms of p_1, V_1, V_2, Q and R] [JEE' 99]

Q.32 A gas has molar heat capacity C = 37.35 J mole^{-1}K^{-1} in the process PT = constant. Find the number of degrees of freedom of molecules in the gas. [REE' 99]

Q.33 A weightless piston divides a thermally insulated cylinder into two parts of volumes V and 3V. 2 moles of an ideal gas at pressure P = 2 atmosphere are confined to the part with volume V = 1 litre. The remainder of the cylinder is evacuated. The piston is now released and the gas expands to fill the entire space of the cylinder. The piston is then pressed back to the initial position. Find the increase of internal energy in the process and final temperature of the gas. The ratio of the specific heat of the gas γ = 1.5.
[REE' 99]

TEKO CLASSES, Director : SUHAG R. KARIYA (S. R. K. Sir) PH: (0755)- 32 00 000, 0 98930 58881 , BHOPAL, (M.P.)

Q.34 Two moles of an ideal monatomic gas is taken through a cycle ABCA as shown in the P-T diagram. During the process AB, pressure and temperature of the gas vary such that PT = constant. If $T_1 = 300$ K, calculate:



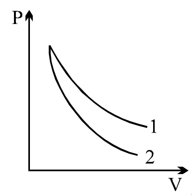
(a) the work done on the gas in the process AB and

(b) the heat absorbed or released by the gas in each of the processes. Give answers in terms of the gas constant R. [JEE' 2000]

Q.35 One mole of an ideal gas is heated isobarically from the freezing point to the boiling point of water each under normal pressure. Find out the work done by the gas and the change in its internal energy. The amount of heat involved is 1kJ. [REE' 2000]

Q.36 A vertical cylinder of cross-sectional area $0.1m^2$ closed at both ends is fitted with a fricitonless piston of mass M dividing the cylinder into two parts. Each part contains one mole of an ideal gas in equilibrium at 300K. The volume of the upper part is $0.1m^3$ and that of the lower part is $0.05m^3$. What force must be applied to the piston so that the volumes of the two parts remain unchanged when the temperature is increased to 500K? [REE' 2000]

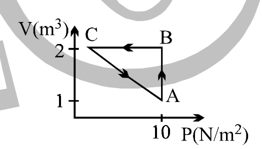
Q.37 P-V plots for two gases during adiabatic processes are shown in the figure. Plots 1 and 2 should correspond respectively to



(A) He and O_2 (B) O_2 and He
(C) He and Ar (D) O_2 and N_2
[JEE' 2001]

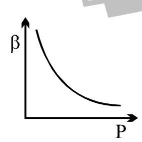
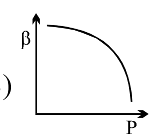
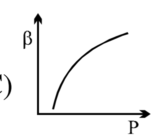
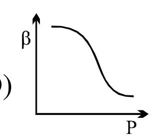
Q.38 In a given process on an ideal gas, dW = 0 and dQ < 0. then for the gas
(A) the temperature will decrease. (B) the volume will increase
(C) the pressure will remain constant (D) the temperature will increase [JEE' 2001]

Q.39 An ideal gas is taken through the cycle A $\rightarrow$ B $\rightarrow$ C $\rightarrow$ A, as shown in the figure. If the net heat supplied to the gas in the cycle is 5J, the work done by the gas in the process C $\rightarrow$ A is [JEE(Scr)2002]



(A) –5J (B) –10 J
(C) –15 J (D) –20 J

Q.40 Which of the following graphs correctly represents the variation of $\beta = -(dV/dP)/V$ with P for an ideal gas at constant temperature? [JEE (Scr)2002]

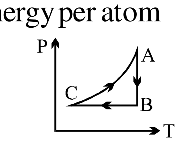
(A) 
(B) 
(C) 
(D) 

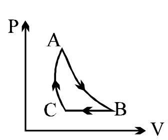
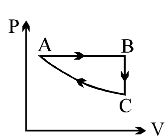
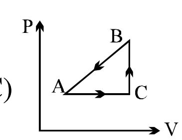
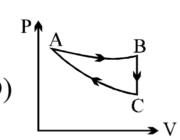
Q.41 A cubical box of side 1 meter contains helium gas (atomic weight 4) at a pressure of 100 N/m^2. During an observation time of 1 second, an atom travelling with the root mean square speed parallel to one of the edges of the cube, was found to make 500 hits with a particular wall, without any collision with other atoms. Take R = $25/3$ J/mol-K and k = 1.38×10^{-23} J/K. [JEE'2002]

(a) Evaluate the temperature of the gas ; (b) Evaluate the average kinetic energy per atom

(c) Evaluate the total mass of helium gas in the box.

Q.42 In the figure AC represent Adiabatic process. The corresponding PV graph is [JEE (Scr) 2003]

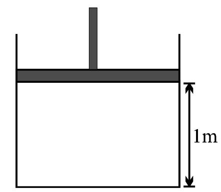


(A) 
(B) 
(C) 
(D) 

Q.43 An insulated container containing monoatomic gas of molar mass m is moving with a velocity v_0. If the container is suddenly stopped, find the change in temperature. [JEE 2003]

Q.44 An ideal gas expands isothermally from a volume V_1 to V_2 and then compressed to original volume V_1 adiabatically. Initial pressure is P_1 and final pressure is P_3. The total work done is W. Then
(A) $P_3 > P_1$, $W > 0$ (B) $P_3 < P_1$, $W < 0$ [JEE' 2004 (Scr)]
(C) $P_3 > P_1$, $W < 0$ (D) $P_3 = P_1$, $W = 0$

Q.45 The piston cylinder arrangement shown contains a diatomic gas at temperature 300 K. The cross-sectional area of the cylinder is 1 m^2. Initially the height of the piston above the base of the cylinder is 1 m. The temperature is now raised to 400 K at constant pressure. Find the new height of the piston above the base of the cylinder. If the piston is now brought back to its original height without any heat loss, find the new equilibrium temperature of the gas. You can leave the answer in fraction. [JEE' 2004]



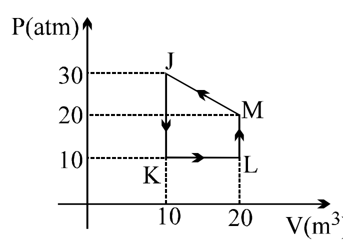
Q.46 An ideal gas is filled in a closed rigid and thermally insulated container. A coil of 100Ω resistor carrying current 1A for 5 minutes supplies heat to the gas. The change in internal energy of the gas is
(A) 10 KJ (B) 20 KJ (C) 30 KJ (D) 0 KJ
[JEE' 2005 (Scr)]

Q.47 When the pressure is changed from $p_1 = 1.01 \times 10^5$ Pa to $p_2 = 1.165 \times 10^5$ a then the volume changes by 10%. The bulk modulus is
(A) 1.55×10^5Pa (B) 0.0015×10^5Pa (C) 0.015×10^5Pa (D) none of these
[JEE' 2005 (Scr)]

Q.48 A cylinder of mass 1 kg is given heat of 20000 J at atmospheric pressure. If initially temperature of cylinder is 20°C, find
(a) final temperature of the cylinder
(b) work done by the cylinder.
(c) change in internal energy of the cylinder.
(Given that specific heat of cylinder = 400 J kg^{-1} $°C^{-1}$, Coefficient of volume expansion = 9×10^{-5} $°C^{-1}$, Atmospheric pressure = 10^5 N/m^2 and density of cylinder = 9000 kg/m^3) [JEE 2005]

Q.49 Match the following for the given process :

Column 1		Column 2
(A) Process J → K	(P)	w > 0
(B) Process K → L	(Q)	w < 0
(C) Process L → M	(R)	Q > 0
(D) Process M → J	(S)	Q < 0



[JEE 2006]

TEKO CLASSES, Director : SUHAG R. KARIYA (S. R. K. Sir) PH: (0755)- 32 00 000, 0 98930 58881 , BHOPAL, (M.P.)

ANSWER KEY

EXERCISE – I

Q.1 π/2atm-lt Q.2 27 : 4 Q.3 100 J Q.4 $RT\left[1-\frac{1}{n}\right]$

Q.5 $\frac{3}{2}\rho_0$ Q.6 2 R Q.7 327 °C Q.8 $1-\frac{3\left(1-\frac{1}{2^{1/3}}\right)}{\ln 2}$

Q.9 1.25×10^4 N/m^2 Q.10 1.5 Q.11 4/3 Q.12 1.5

Q.13 5R Q.14 $\frac{mRT_0}{V_0}\left(1+\frac{T_0 m}{V_0}\right)R$ Q.15 $\sqrt{2}$

Q.16 74.9 cm Q.17 1.84P, 10V/3, 8V/3 (adiabatic), 13P/6, 30V/13, 48V/13 (isothermal)

Q.18 4 : 1 Q.19 P/n Q.20 $C_V+\frac{R}{\alpha V}$ Q.21 16/15

Q.22 $\frac{R}{2}$ Q.23 400 K Q.24 3600 R

Q.25 (i) $\left(\frac{\gamma+1}{\gamma-1}\right)4aV_0^2$, (ii) $\left(\frac{\gamma+1}{\gamma-1}\right)\frac{R}{2}$ Q.26 12600 J Q.27 50 calorie

Q.28 $R\Delta T\left(\frac{3-2\gamma}{\gamma-1}\right)$

Q.29 the molar mass of the gas is 40 gm, the number of degrees of freedom of the gas molecules is 6

Q.30 (i) $P_1 < P_2$, $T_1 < T_2$; (ii) $T_1 = T_2 < T_3$; (iii) $V_2 > V_1$; (iv) $P_1 > P_2$

EXERCISE – II

Q.1 (i) 74 cm, (ii) 73.94 cm, (iii) 69.52 cm Q.2 0.497 atm, 0.0572 gm Q.3 0.263

Q.4 $p_1 = p_{H_2} \simeq 1.25\times10^6$ Pa ; $p_2 = p_{H_2}+p_{O_2}+p_{N_2} \simeq 2.8125\times10^6$ Pa ; $p_3 = p_{H_2}+p_{N_2} \simeq 1.5625\times10^6$ Pa

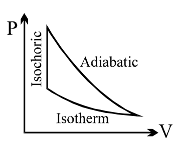
Q.5 750 K Q.6 $P=\frac{13}{12}P_0$, $l_1 = 0.6\,l$, $l_2 = 1.5\,l$, $l_3 = 0.9\,l$

Q.7 $31P_0V_0$; $-5P_0V_0$ Q.8 (i) 7.594, (ii) 4/9, (iii) – 2.5

Q.9 (ii) $P_b = P_c = 2$ atm, (iii) $T_b = 300$ K, $T_c = 600$ K, (iv) $V_c = 8$ litre

Q.10 (i) 1.263×10^5 Nm^{-2} ; 415 J, (ii) 302.8 K ; 1.275×10^5 Nm^{-2} Q.11 1.6 m, 364 K

Q.12 1.63 Q.13 $\frac{3-2\ln 2}{3}$ Q.14 4 : 9 : 5 Q.15 7.71 J

Q.16 8000 cal. 

Q.17 (a) $\frac{L}{kA}\left(q-qe^{-\frac{kAt}{nLC_P}}\right)+T_0$, (b) $T_0+\frac{qL}{kA}$, (c) $\frac{qL}{kAT_0}+1$

Q.18 $2\,mnv^2\cos^2\theta$

Q.19 (a) $W_{AD} = 88$ J, (b) $V_C = 1.223$ litre , (c) $W_{CDA} = -85$ J

Q.20 (a) Final pressure in A = $\frac{27}{8}P_0$ = Final pressure in C, Final pressure in B = $\frac{21}{4}P_0$

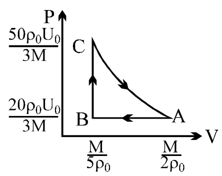
(b) Final temperature in A (and B) = $\frac{21}{4}T_0$, Final temperature in C = $\frac{3}{2}T_0$,

(c) $18\,P_0V_0$,

(d) work done by gas in A = $+P_0V_0$, work done by gas in B = 0,

(e) $\frac{17}{2}P_0V_0$

Q.21 four

Q.22 (a) 

, (b) $Q = \left(\frac{10}{3}\ln 2.5 - 2\right)U_0$, (c) $-2U_0$

Q.23 $\frac{7R}{2M}$, $4R(T_2 - T_1)$

Q.24 (a) 80 J, 180 J, (b) 4.5 R

Q.25 $T_1 = (207/16)\,T_0$; $T_2 = \frac{9}{4}T_0$, $-\frac{15}{8}P_0V_0$

Q.26 $\frac{5}{4}Kl^2 + \frac{1}{2}(13\sqrt{2} - 7)P_0Al$

Q.27 (a) 2×10^5 N/m^2 ; (b) 6 rad/s, (c) 75 J

Q.28 C = 2 R

EXERCISE – III

Q1. K T

Q2. $m_H = 2.5 \times 10^{-3}$ kg , $m_{He} = 7.5 \times 10^{-3}$ kg

Q3. 369.3 K, 2.462×10^5 Pa

Q4. $1/2^{0.67}$

Q5. (i) 765 J, (ii) 10.83%

Q6. 23.928 g ; 4.072 g

Q7. $n_B = 2$; 401 ms^{-1} ; 0.167 % ; -0.0248 V/T

Q8. (a) 1.8×10^5J ; (b) 4.8×10^5J ; (c) 6.6×10^5J ; (d) 17J/mol-K

Q9. B

Q10. (i) 189 K, (ii) –2767 J, (iii) 2767 J

Q11. 8.08 x 10^5 Pa

Q 12. 55 J

Q13. D

Q14. (i) $T_A = 120.33$ K, $T_B = 240.66$ K, $T_C = 481.32$ K, $T_D = 240.66$ K, (ii) No,
(iii) $\Delta Q_{ABC} = 3.25 \times 10^6$ J ; $\Delta Q_{ADC} = 2.75 \times 10^6$ J

Q15. 7730 K

Q16. 2000N/m, 1295J

Q17. 3.3×10^5 N/m^2, 338.71 K

Q18. $T_B = 909$ K, $T_D = 791$ K, $\eta = 61.4$ %

Q19. C

Q20. C

Q21. AC, 170 J, 10 J

Q22. D

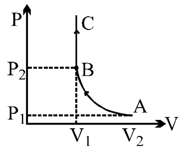
Q23. C Q24. A Q25. C, D Q26. B

Q27. B,C

Q28. (a) P_oV_o, (b) $5/2\ P_oV_o$, $3P_oV_o$, (c) $1/2\ P_oV_o$, (d) $T_{max} = 25/8\ P_oV_o/R$

Q29. C Q30. D

Q31. (a)



(b) $W = 3/2P_1V_1\left[1-\left(\frac{V_1}{V_2}\right)^{2/3}\right]$; $\Delta U = 3/2\ P_1V_1\left[\left(\frac{V_1}{V_2}\right)^{2/3}-1\right]+Q$, Final $T = \frac{Q}{3R}+\frac{P_1V_2}{2R}\left(\frac{V_1}{V_2}\right)^{5/3}$

Q32. 5 Q33. 400 J, $2\ T_0$

Q34. (a) 1200R, (b) $Q_{AB} = -2100R$, $Q_{BC} = 1500R$, $Q_{CA} = 1200\ R\ ln2$ Q35. W = 830 J, U=170 J

Q36. 1660 N Q37. B Q38. A Q.39 A

Q.40 A Q.41 160 K, 3.3×10^{-21} J, 0.3 gm Q 42. A

Q.43 $\Delta T = \frac{mv_0^{\ 2}}{3R}$ Q.44 C Q.45 $T_3 = 400\left(\frac{4}{3}\right)^{0.4}$ K

Q.46 C Q.47 A Q.48 (a) $T_{final} = 70°C$, (b) 0.05 J, (c) 19999.95 J

Q.49 (A) → S; (B) → P and R; (C) → R; (D) → Q and S