Exercise-1

Marked Questions can be used as Revision Questions.

PART - I : SUBJECTIVE QUESTIONS

Section (A) : Kinetic Theory of Gases

A-1. Find the average momentum of molecules of hydrogen gas in a container at temperature 300 K.

A-2. A cubical container having each side as □ is filled with a gas having N molecules in the container. Mass of each molecule is m. If we assume that at every instant half of the molecules are moving towards the positive x-axis and half of the molecules are moving towards the negative x-axis. Two walls of the container are perpendicular to the x-axis. Find the net force acting on the two walls given? Assume that all the molecules are moving with speed v_0.

Section (B) : Root mean square speed, Kinetic Energy and equation of state

B-1. The speeds of three molecules are 3V, 4V and 5V respectively. Find their rms speed.

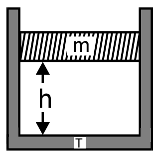
B-2. At room temperature (300 K), the rms speed of the molecules of a certain diatomic gas is found to be 1930 m/s. Can you guess name of the gas ? Find the temperature at which the rms speed is double of the speed in part one (R = 25/3 J/mol – k)

B-3. A gas is filled in a rigid container at pressure P_0. If the mass of each molecule is halved keeping the total number of molecules same and their r.m.s. speed is doubled then find the new pressure.

B-4. Butane gas burns in air according to the following reaction, $2C_4H_{10} + 13\ O_2 \longrightarrow 10\ H_2O + 8\ CO_2$. Suppose the initial and final temperatures are equal and high enough so that all reactants and products act as perfect gases. Two moles of butane are mixed with 13 moles of oxygen and then completely reacted. Find the final pressure (if the volume remains unchanged and the pressure before reaction is P_0) ?

B-5. At a pressure of 3 atm air (treated as an ideal gas) is pumped into the tubes of a cycle rickshaw. The volume of each tube at given pressure is 0.004 m^3. One of the tubes gets punctured and the volume of the tube reduces to 0.0008 m^3. Find the number of moles of air that have leaked out? Assume that the temperature remains constant at 300 K. (R = 25/3 J mol^{-1} K^{-1})

B–6. (i) A conducting cylinder whose inside diameter is 4.00 cm contains air compressed by a piston of mass m = 13.0 kg, which can slide freely in the cylinder shown in the figure.
The entire arrangement is immersed in a water bath whose temperature can be controlled. The system is initially in equilibrium at temperature t_i = 20°C. The initial height of the piston above the bottom of the cylinder is h_i = 4.00 cm. $P_{atm} = 1 \times 10^5$ N/m^2 and g = 10 m/s^2. If the temperature of the water bath is gradually increased to a final temperature t_f = 100°C. Find the height h_f of the piston (in cm) at that instant?



(ii) In the above question, if we again start from the initial conditions and the temperature is again gradually raised, and weights are added to the piston to keep its height fixed at h_i. Find the value of the added mass when the final temperature becomes t_f = 100°C?

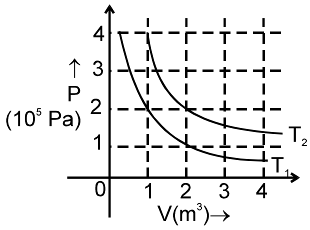
Section (C) : Maxwell's distribution of speed

C-1. Find the temperature at which average speed of oxygen molecule be sufficient so as to escape from the earth? (Escape speed from the earth is 11.0 km/sec, R = 25/3 J-$mol^{-1}K^{-1}$).

C-2. Find the average of magnitude of linear momentum of helium molecules in a sample of helium gas at temperature of 150 π K. Mass of a helium molecules = (166/3) × 10^{-27} kg and R = 25/3 J-mol^{-1} K^{-1}

C-3. The mean speed of the molecules of a hydrogen sample equals the mean speed of the molecules of helium sample. Calculate the ratio of the temperature of the hydrogen sample to the temperature of the helium sample.

C-4. The following graph shows two isotherms for a fixed mass of an ideal gas. Find the ratio of r.m.s. speed of the molecules at temperatures T_1 amd T_2 ?



Section (D) : Law of equipartition and internal energy

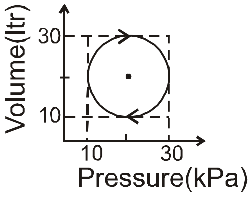
D-1. 16 g of oxygen at 37ºC is mixed with 14 g of nitrogen at 27ºC. Find the temperature of the mixture?

D-2. 0.040 g of He is kept in a closed container initially at 100.0ºC. The container is now heated. Neglecting the expansion of the container, calculate the temperature at which the internal energy is increased by 12J. $\left[R = \frac{25}{3} J - mol^{-1} - k^{-1}\right]$

D-3. Show that the internal energy of the air (treated as an ideal gas) contained in a room remains constant as the temperature changes between day and night. Assume that the atmospheric pressure around remains constant and the air in the room maintains this pressure by communicating with the surrounding through the windows etc.

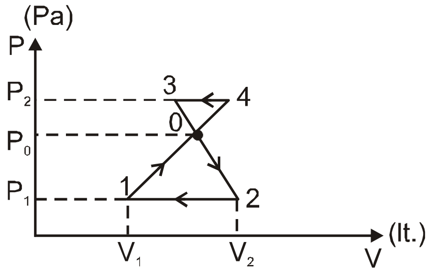
Section (E) : Calculation of work

E-1. Find the work done by gas going through a cyclic process shown in figure?



E-2. An ideal gas is compressed at constant pressure of 10^5 Pa until its volume is halved. If the initial volume of the gas as 3.0×10^{-2} m^3, find the work done on the gas?

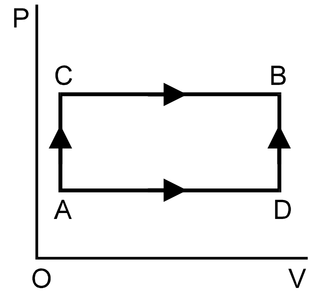
E-3. Find the work done by an ideal gas during a closed cycle $1 \to 4 \to 3 \to 2 \to 1$ shown in figure if $P_1 = 10^5$ Pa, $P_0 = 3 \times 10^5$ Pa, $P_2 = 4 \times 10^5$ Pa, $V_2 - V_1 = 10$ litre, and segments 4-3 and 2-1 of the cycle are parallel to the V-axis ?



E-4. Find the expression for the work done by a system undergoing isothermal compression (or expansion) from volume V_1 to V_2 at temperature T_0 for a gas which obeys the van der waals equation of state, $(p + an^2 / V^2)(V - bn) = nRT$?

Section (F) : First Law of thermodynamics

F-1. In given figure, when a thermodynamic system is taken from state A to state B via path ACB, 100 cal of heat given to the system and 60 cal work is done by the gas. Along the path ADB, the work done by the gas is 20 cal. Find the heat flowing into the system in this case?

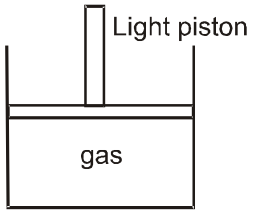


F-2. A cylinder fitted with a piston contains an ideal monoatomic gas at a temperature of 400 K. The piston is held fixed while heat ΔQ is given to the gas, It is found the temperature of the gas has increased by 20 K. In an isobaric process the same ΔQ heat is supplied slowly to it. Find the change in temperature in the second process?

F-3. When 1 g of water at 0ºC and 1×10^5 N m^{-2} pressure is converted into ice of volume 1.091 cm^3, find the work done by water ? (ρ_w = 1 gm/cm^3)

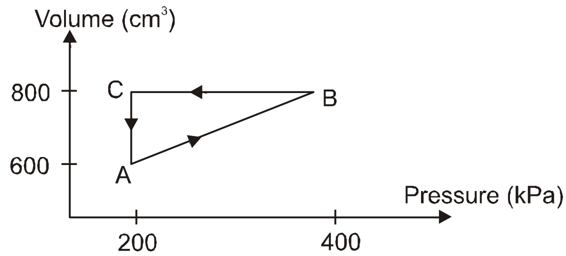
F-4. An ideal gas is taken through a cyclic thermodynamic process through four steps. The amounts of heat involved in these steps are Q_1 = 5960 J, Q_2 = – 5585 J, Q_3 = – 2980 J and Q_4 = 3645 J respectively. The corresponding works involved are W_1 = 2200 J, W_2 = – 825 J, W_3 = – 1100 J and W_4 respectively.
(i) Find the value of W_4.
(ii) What is the efficiency of the cycle ?

F-5. In given figure, gas is slowly heated for sometime. During the process, the increase in internal energy of the gas is 10 J and the piston is found to move out by 25 cm, then find the amount of heat supplied. The area of cross-section of cylinder = 40 cm^2 and atmospheric pressure = 100 kPa

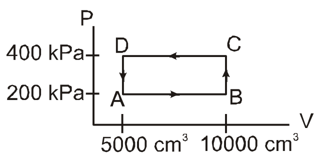


F-6. Find the change in the internal energy of 2kg of water as it is heated from 0ºC to 4ºC. The specific heat capacity of water is 4200 J/kg-K and its densities at 0ºC and 4ºC are 999.9kg/m^3 and 1000 kg/m^3 respectively. Atmospheric pressure = 10^5 Pa.

F-7. In given figure, An ideal gas a gas is taken through a cyclic process ABCA, calculate the value of mechanical equivalent of heat (J) when 4.8 cal of heat is given in the process ?



F-8. In given figure, one mole of an ideal gas (γ = 7/5) is taken through the cyclic process ABCDA. Take $R = \frac{25}{3}$ J/mol–K



(a) Find the temperature of the gas in states A, B, C and D.

(b) Find the amount of heat supplied/released in processes AB, BC, CD and DA.

(c) Find work done by gas during cyclic process.

Section (G) : Specific heat capacities of gases

G-1. If γ be the ratio of specific heats (C_p & C_v) for a perfect gas, Find the number of degrees of freedom of a molecule of the gas? :

G-2. Internal energy of two moles of an ideal gas at a temperature of 127ºC is 1200 R. Then find the molar specific heat of the gas at constant pressure?

G-3. Ideal monoatomic gas is taken through a process dQ = 2dU. Find the molar heat capacity (in terms of R) for the process ? (where dQ is heat supplied and dU is change in internal energy)

G-4. Calculate the value of mechanical equivalent of heat from the following data. Specific heat capacity of air at constant volume and at constant pressure are 4.93 cal/mol–K and 6.90 cal/mol–K respectively. Gas constant R = 8.3 J/mol–K.

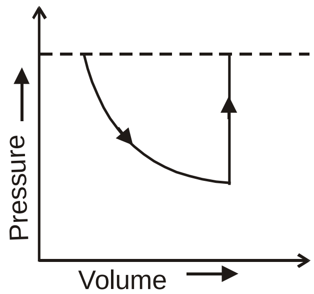
G-5. When 100 J of heat is given to an ideal gas it expands from 200 cm^3 to 400 cm^3 at a constant pressure of 3×10^5 Pa. Calculate (a) the change in internal energy of the gas, (b) the number of moles in the gas if the initial temperature is 400 K, (c) the molar heat capacity C_p at constant pressure and (d) the molar heat capacity C_v at constant volume. $\left[R = \frac{25}{3} J/mol - k\right]$

G-6. The temperature of 5 mol of a gas which was held at constant volume was changed from 100ºC to 120ºC. The changes in internal energy was found to be 80 J. Find the molar heat capacity of the gas at constant volume?

G-7. For a gas, γ = 9/7. What is the number of degrees of freedom of the molecules of this gas ?

Section (H) : Adiabatic process and free expansion

H-1. In given figure, a sample of an ideal gas initially having internal energy U_1 is allowed to expand adiabatically performing work W. Heat Q is then supplied to it, keeping the volume constant at its new value, until the pressure rised to its original value. The internal energy is then U_2.



Find the increase in internal energy ($U_2 - U_1$) ?

H-2. One mole of an ideal monoatomic gas $\left(\gamma = \frac{5}{3}\right)$ is mixed with one mole of a diatomic gas $\left(\gamma = \frac{7}{5}\right)$. ($\gamma$ denotes the ratio of specific heat at constant pressure, to that at constant volume) find γ for the mixture ?

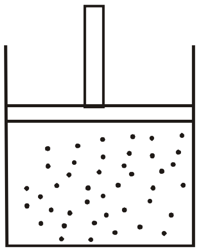
H-3. The pressure and density of a diatomic gas $\left(\gamma = \frac{7}{5}\right)$ change adiabatically from (P, d) to (P′, d′). If $\frac{d'}{d}$ = 32, then find the value of $\frac{P'}{P}$?

H-4. An ideal gas ($\gamma = \frac{5}{3}$) is adiabatically compressed from 640 cm^3 to 80 cm^3. If the initial pressure is P then find the final pressure?

H-5. In an adiabatic process, the pressure is increased by $\frac{2}{3}\%$. If $\gamma = \frac{3}{2}$, then find the decreases in volume (approximately)?

H-6. An ideal gas at pressure 4×10^5 Pa and temperature 400 K occupies 100 cc. It is adiabatically expanded to double of its original volume. Calculate (a) the final pressure, (b) final temperature and (c) work done by the gas in the process ($\gamma = 1.5$) :

H-7. In fig, the walls of the container and the piston are weakly conducting. The initial pressure, volume and temperture of the gas are 200 K Pa, 800 cm^3 and 100 K resp. Find the pressure and the temperature of the gas if it is (a) slowly compressed (b) suddenly compressed to 200 cm^3 ($\gamma = 1.5$).



H-8. When the state of a system changes form A to B adiabatically the work done on the system is 322 Joule. If the state of the same system is changed from A to B by another process, and heat required is 50 calories of heat is required then find work done on the system in this process? (J = 4.2 J/cal)

Section (I) : Polytropic Process

I-1. Find the molar heat capacity (in terms of R) of a monoatomic ideal gas undergoing the process : $PV^{1/2}$ = constant ?

I-2. If Q amount of heat is given to a diatomic ideal gas in a process in which the gas perform a work $\frac{2Q}{3}$ on its surrounding. Find the molar heat capacity (in terms of R) for the process.

I-3. One mole of a gas expands with temperature T such that its volume, $V = kT^2$, where k is a constant. If the temperature of the gas changes by 60º C then find the work done by the gas? (R = 25/3 J/mol-K).

Section (J) : For jee-main

J-1 A Carnot engine takes 10^3 kilocalories of heat from a reservoir at 627ºC and exhausts it to a sink at 27ºC. What will be the efficiency of the engine ?

J-2 In the above problem, what will be the work performed by the engine ?

J-3 The efficiency of Carnot's engine is 50%. The temperature of its sink is 7ºC. To increase its efficiency to 70%. What is the increase in temperature of the source ?

J-4 A Carnot engine work as refrigerator in between 0ºC and 27ºC. How much energy is needed to freeze 10 kg ice at 0ºC.

J-5 What is the work efficiency coefficient in above question ?

J-6 A Carnot engine works as a refrigerator in between 250K and 300K. If it acquires 750 calories from heat source at low temperature, then what is the heat generated at higher temperature. (in calories)?

PART - II : ONLY ONE OPTION CORRECT TYPE

Section (A) : Kinetic Theory of gases

A-1. When an ideal gas is compressed isothermally then its pressure increases because :
(A) its potential energy decreases
(B) its kinetic energy increases and molecules move apart
(C) its number of collisions per unit area with walls of container increases
(D) molecular energy increases

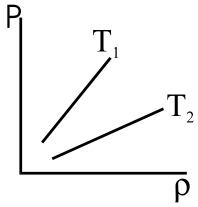
A-2. Which of the following is correct for the molecules of a gas in thermal equilibrium ?

(A) All have the same speed
(B) All have different speeds which remain constant
(C) They have a certain constant average speed
(D) They do not collide with one another.

Section (B) : Root mean square speed, Kinetic Energy and Equation of state

B-1. The temperature at which the r.m.s velocity of oxygen molecules equal that of nitrogen molecules at 100ºC is nearly :
(A) 426.3 K (B) 456.3 K (C) 436.3 K (D) 446.3 K

B-2. Figure shows graphs of pressure vs density for an ideal gas at two temperatures T_1 and T_2.



(A) $T_1 > T_2$ (B) $T_1 = T_2$ (C) $T_1 < T_2$ (D) any of the three is possible

B-3. Suppose a container is evacuated to leave just one molecule of a gas in it. Let ν_{mp} and ν_{av} represent the most probable speed and the average speed of the gas, then
(A) $\nu_{mp} > \nu_{av}$ (B) $\nu_{mp} < \nu_{av}$ (C) $\nu_{mp} = \nu_{av}$ (D) none of these

B-4. The average speed of nitrogen molecules in a gas is v. If the temperature is doubled and the N_2 molecule dissociate into nitrogen atoms, then the average speed will be
(A) v (B) v $\sqrt{2}$ (C) 2 v (D) 4v

B-5. Four containers are filled with monoatomic ideal gases. For each container, the number of moles, the mass of an individual atom and the rms speed of the atoms are expressed in terms of n, m and v_{rms} respectively. If T_A, T_B, T_C and T_D are their temperatures respectively then which one of the options correctly represents the order ?

	A	B	C	D
Number of moles	n	3n	2n	n
Mass	4m	m	3m	2m
Rms speed	V_{rms}	$2V_{rms}$	V_{rms}	$2V_{rms}$
Temperature	T_A	T_B	T_C	T_D

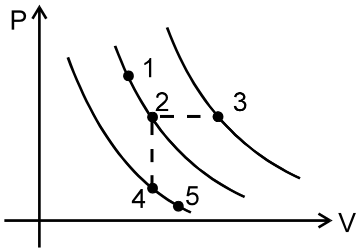
(A) $T_B = T_C > T_A > T_D$ (B) $T_D > T_A > T_C > T_B$ (C) $T_D > T_A = T_B > T_C$ (D) $T_B > T_C > T_A > T_D$

B-6. For a gas sample with N_0 number of molecules, function N(V) is given by : $N(V) = \frac{dN}{dV} = \left(\frac{3\ \ N_0}{V_0^3}\right)V^2$ for $0 < V < V_0$ and N(V) = 0 for $V > V_0$. Where dN is number of molecules in speed range V to V+ dV. The rms speed of the molecules is :
(A) $\sqrt{\frac{2}{5}}V_0$ (B) $\sqrt{\frac{3}{5}}V_0$ (C) $\sqrt{2}V_0$ (D) $\sqrt{3}V_0$

Section (C) : Maxwell's distribution of speed

C-1. Three closed vessels A, B, and C are at the same temperature T and contain gases which obey the Maxwell distribution of speed. Vessel A contains only O_2, B only N_2 and C a mixture of equal quantities of O_2 and N_2. If the average speed of O_2 molecules in vessel A is V_1, that of the N_2 molecules in vessel B is V_2, the average speed of the O_2 molecules in vessel C will be :
(A) $(V_1 + V_2)/2$ (B) V_1 (C) $(V_1V_2)^{1/2}$ (D) $\frac{V_1}{2}$

C-2. A certain gas is taken to the five states represented by dots in the graph. The plotted lines are isotherms. Order of the most probable speed v_p of the molecules at these five states is :



(A) $V_{P\text{ at }3} > V_{P\text{ at }1} = V_{P\text{ at }2} > V_{P\text{ at }4} = V_{P\text{ at }5}$
(B) $V_{P\text{ at }1} > V_{P\text{ at }2} = V_{P\text{ at }3} > V_{P\text{ at }4} > V_{P\text{ at }5}$
(C) $V_{P\text{ at }3} > V_{P\text{ at }2} = V_{P\text{ at }4} > V_{P\text{ at }1} > V_{P\text{ at }5}$
(D) Insufficient information to predict the result.

Section (D) : Law of equipartition and internal energy

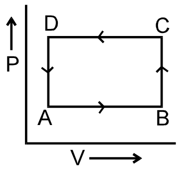
D-1. The pressure of an ideal gas is written as $E = \frac{3PV}{2}$. Here E stands for
(A) average translational kinetic energy
(B) rotational kinetic energy
(C) total kinetic energy.
(D) None of these

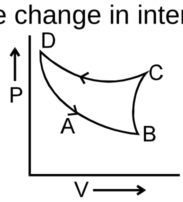
D-2. The quantities which remain same for all ideal gases at the same temperature is/are ?
(A) the kinetic energy of equal moles of gas
(B) the kinetic energy of equal mass of gas
(C) the number of molecules of equal moles of gas
(D) the number of molecules of equal mass of gas

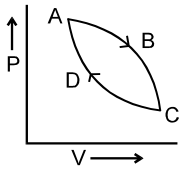
D-3. The quantity $\frac{2U}{fkT}$ represents (where U = internal energy of gas)
(A) mass of the gas
(B) kinetic energy of the gas
(C) number of moles of the gas
(D) number of molecules in the gas

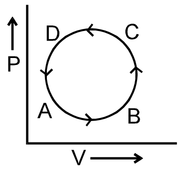
Section (E) : Calculation of work

E-1. In the following figures (1) to (4), variation of volume by change of pressure is shown. A gas is taken along the path ABCDA. The change in internal energy of the gas will be:

(1) 

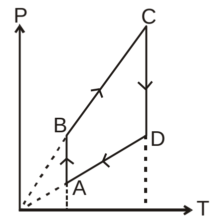
(2) 

(3) 

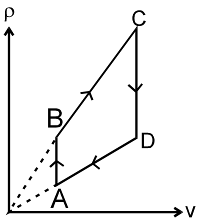
(4) 

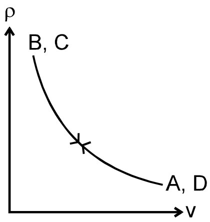
(A) positive in all cases from (1) to (4)
(B) positive in cases (1), (2) and (3) but zero in case (4)
(C) negative in cases (1), (2) and (3) but zero in case (4)
(D) zero in all the four cases.

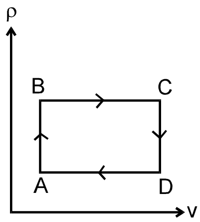
E-2. Pressure versus temperature graph of an ideal gas is as shown in figure.

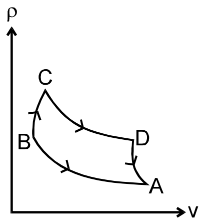


Corresponding density (ρ) versus volume (v) graph will be :

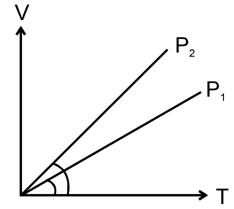
(A) 

(B) 

(C) 

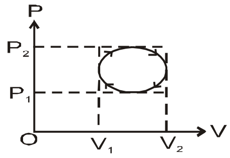
(D) 

E-3. In the following V-T diagram what is the relation between P_1 and P_2 :



(A) $P_2 = P_1$ (B) $P_2 > P_1$ (C) $P_2 < P_1$ (D) cannot be predicted

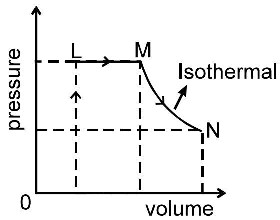
E-4. In a cyclic process shown on the P – V diagram the magnitude of the work done is :



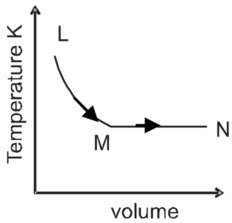
(A) $\pi\left(\frac{P_2 - P_1}{2}\right)^2$ (B) $\pi\left(\frac{V_2 - V_1}{2}\right)^2$

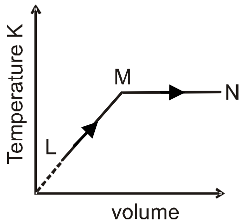
(C) $\frac{\pi}{4}\,(P_2 - P_1)\,(V_2 - V_1)$ (D) $\pi\,(P_2V_2 - P_1V_1)$

E-5. A fixed mass of an ideal gas undergoes changes of pressure and volume starting at L, as shown in Figure.



Which of the following is correct :

(A)


(B)


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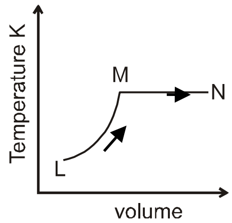

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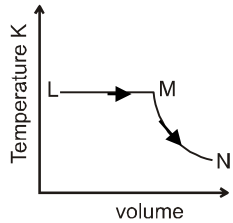
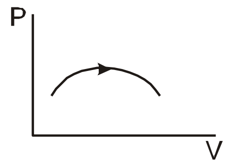
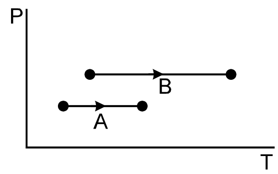


E-6. In figure, P-V curve of an ideal gas is given. During the process, the cumulative work done by the gas



(A) continuously increases
(B) continuously decreases
(C) first increases then decreases
(D) first decreases then increases

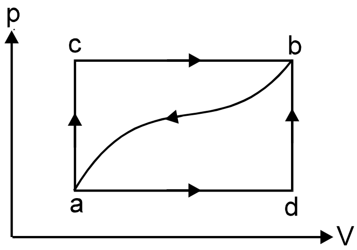
E-7. In given figure, let ΔW_1 and ΔW_2 be the work done by the gas in process A and B respectively then (given change in volume is same in both process)



(A) $\Delta W_1 > \Delta W_2$
(B) $\Delta W_1 = \Delta W_2$
(C) $\Delta W_1 < \Delta W_2$
(D) Nothing can be said about the relation between ΔW_1 and ΔW_2

Section (F) : First law of thermodynamics

F-1. When a system is taken from state 'a' to state 'b' along the path 'acb', it is found that a quantity of heat Q = 200 J is absorbed by the system and a work W = 80J is done by it. Along the path 'adb', Q = 144J. The work done along the path 'adb' is



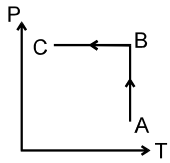
(A) 6J (B) 12 J (C) 18 J (D) 24 J

F-2. In the above question, if the work done on the system along the curved path ‘ba’ is 52J, heat abosrbed is
(A) – 140 J (B) – 172 J (C) 140 J (D) 172 J

F-3. In above question, if U_a = 40J, value of $U_b$will be
(A) – 50 J (B) 100 J (C) – 120 J (D) 160 J

F-4. In above question, if U_d = 88 J, heat absorbed for the path ‘db’ is
(A) – 72 J (B) 72 J (C) 144 J (D) – 144 J

F-5. Ideal gas is taken through process shown in figure:



(A) In process AB, work done by system is positive
(B) In process AB, heat is rejected out of the system.
(C) In process AB, internal energy increases
(D) In process AB internal energy decreases and in process BC internal energy increases.

Section (G) : Specific heat capacities of gases

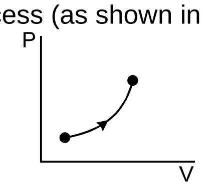
G-1. The value of the ratio C_p/C_v for hydrogen is 1.67 at 30 K but decreases to 1.4 at 300 K as more degrees of freedom become active. During this rise in temperature (assume H_2 as ideal gas),
(A) C_p remains constant but C_v increases
(B) C_p decreases but C_v increases
(C) Both C_p and C_v decrease by the same amount
(D) Both C_p and C_v increase by the same amount

G-2. Boiling water is changing into steam. Under this condition, the specific heat of water is
(A) zero (B) one (C) Infinite (D) less than one

G-3. For an ideal gas, the heat capacity at constant pressure is larger than than that at constant volume because
(A) positive work is done during expansion of the gas by the external pressure
(B) positive work is done during expasion by the gas against external pressure
(C) positive work is done during expansion by the gas against intermolecular forces of attraction
(D) more collisions occur per unit time when volume is kept constant.

G-4. A gas has :
(A) one specific heat only (B) two specific heats only
(C) infinite number of specific heats (D) no specific heat

G-5. If molar heat capacity of the given process (as shown in figure) is C, then



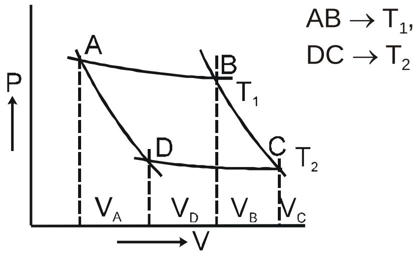
(A) $C < C_v$ (B) $C = 0$ (C) $C > C_v$ (D) $C = C_v$

G-6. For small positive coefficient of expansion in case of solid,
(A) $C_p - C_v = R$ (B) $C_p - C_v = 2R$
(C) C_p is slightly greater than C_v (D) C_p is slightly less than C_v

Section (H) : Adiabatic process and free expansion

H-1. A gas is contained in a metallic cylinder fitted with a piston. The gas is suddenly compressed by pushing piston downward and is maintained at this position. After this process, as time passes the pressure of the gas in the cylinder
(A) increases
(B) decreases
(C) remains constant
(D) increases or decreases depending on the nature of the gas.

H-2. In the following P–V diagram of an ideal gas, AB and CD are isothermal where as BC and DA are adiabatic process. The value of V_B/V_C is



(A) $= V_A/V_D$ (B) $< V_A/V_D$ (C) $> V_A/V_D$ (D) cannot say

H-3. Two samples 1 and 2 are initially kept in the same state. The sample 1 is expanded through an isothermal process where as sample 2 through an adiabatic process upto the same final volume. The final temperature in process 1 and 2 are T_1 and T_2 respectively, then
(A) $T_1 > T_2$ (B) $T_1 = T_2$
(C) $T_1 < T_2$ (D) The relation between T_1 and T_2 cannot be deduced.

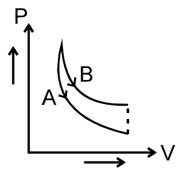
H-4. Let P_1 and P_2 be the final pressure of the samples 1 and 2 respectively in the previous question then :
(A) $P_1 < P_2$ (B) $P_1 = P_2$
(C) $P_1 > P_2$ (D) The relation between P_1 and P_2 cannot be deduced.

H-5. Let ΔW_1 and ΔW_2 be the work done by the systems 1 and 2 respectively in the previous question then :
(A) $\Delta W_1 > \Delta W_2$ (B) $\Delta W_1 = \Delta W_2$
(C) $\Delta W_1 < \Delta W_2$ (D) The relation between W_1 and W_2 cannot be deduced.

H-6. When an ideal gas undergoes an adiabatic change causing a temparture change ΔT
(i) there is no heat gained or lost by the gas
(ii) the work done by the gas is equal to change in internal energy
(iii) the change in internal energy per mole of the gas is $C_v\,\Delta T$, where C_v is the molar heat capacity at constnat volume.
(A) (i), (ii), (iii) correct (B) (i), (ii) correct (C) (i), (iii) correct (D) (i) correct

H-7. A given quantity of a gas is at pressure P and absolute temperature T. The isothermal bulk modulus of the gas is:
(A) $\frac{2}{3}P$ (B) P (C) $\frac{3}{2}P$ (D) 2P

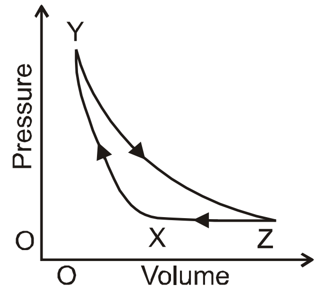
H-8. In figure, A and B are two adiabatic curves for two different gases. Then A and B corresponds to :



(A) Ar and He respectively (B) He and H_2 respectively
(C) O_2 and H_2 respectively (D) H_2 and He respectively

H-9. In given figure, a fixed mass of an ideal gas undergoes the change represented by XYZX below. Which one of the following sets could describe these of changes ?

	XY	YZ	ZX
(A)	isothermal expansion	adiabatic compression	compression at constant pressure
(B)	adiabatic expansion	isothermal compression	pressure reduction constant volume
(C)	isothermal compression	adiabatic expansion	compression at constant pressure
(D)	adiabatic compression	isothermal expansion	compression at constant pressure



H-10. During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its absolute temperature. The ratio C_p/C_v for the gas is : **[AIEEE - 2003, 4/300]**

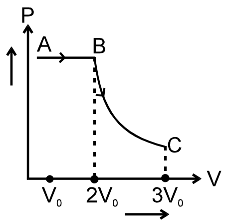
(A) 4/3 (B) 2 (C) 5/3 (D) 3/2

Section (I) : Polytrotic Process

I-1. A gas undergoes a process in which its pressure P and volume V are related as VP^n = constant. The bulk modulus of the gas in the process is :

(A) nP (B) $P^{1/n}$ (C) P/n (D) P^n

I-2. One mole of a gas is subjected to two process AB and BC, one after the other as shown in the figure. BC is represented by PV^n = constant. We can conclude that (where T = temperature, W = work done by gas, V = volume and U = internal energy).



(A) $T_A = T_B = T_C$ (B) $V_A < V_B$, $P_B < P_C$ (C) $W_{AB} < W_{BC}$ (D) $U_A < U_B$

I-3. The molar heat capacity C for an ideal gas going through a process is given by $C = \frac{a}{T}$, where 'a' is a constant. If $\gamma = \frac{C_p}{C_v}$, the work done by one mole of gas during heating from T_0 to ηT_0 will be :

(A) $a \ell n\, \eta$ (B) $\frac{1}{a\ell n\eta}$ (C) $a\ell n\eta - \left(\frac{\eta-1}{\gamma-1}\right)RT_0$ (D) $a\ell n\eta - (\gamma-1)RT_0$

I-4. One mole of an ideal gas undergoes a process in which $T = T_0 + aV^3$, where T_0 and 'a' are positive constants and V is volume. The volume for which pressure will be minimum is

(A) $\left(\frac{T_0}{2a}\right)^{1/3}$ (B) $\left(\frac{T_0}{3a}\right)^{1/3}$ (C) $\left(\frac{a}{2T_0}\right)^{2/3}$ (D) $\left(\frac{a}{3T_0}\right)^{2/3}$

I-5. In the above question, minimum pressure attainable is

(A) $\frac{3}{4}\left(a^{5/3}R^{2/3}T_0^{2/3}\right)2^{1/3}$ (B) $\frac{3}{2}\left(a^{2/3}RT_0^{2/3}\right)3^{1/2}$ (C) $\frac{3}{2}\left(a^{1/2}R^{2/3}T_0^{3/4}\right)4^{1/3}$ (D) $\frac{3}{2}\left(a^{1/3}RT_0^{2/3}\right)2^{1/3}$

I-6. In a certain gas, the ratio of the speed of sound and root mean square speed is $\sqrt{\frac{5}{9}}$. The molar heat capacity of the gas in a process given by PT = constant is (Take R = 2 cal/mole K). Treat the gas as ideal.

(A) $\frac{R}{2}$ (B) $\frac{3R}{2}$ (C) $\frac{5R}{2}$ (D) $\frac{7R}{2}$

I-7. A polytropic process for an ideal gas is represented by equation PV^n = constant. If γ is ratio of specific heats $\left(\frac{C_p}{C_v}\right)$, then value of n for which molar heat capacity of the process is negative, is given as :

(A) $\gamma > n$ (B) $\gamma > n > 1$ (C) $n > \gamma$ (D) none, as it is not possible

Section (J) : For JEE Main

J-1. A Carnot working between 300K and 600K has work output of 800 J per cycle. What is amount of heat energy supplied to the engine form source per cycle

(A) 1800 J/cycle (B) 1000 J/cycle (C) 2000 J/cycle (D) 1600 J/cycle

J-2. The coefficient of performance of a carnot refrigertor working between 30° C and 0° C is

(A) 10 (B) 1 (C) 9 (D) 0

J-3. If the door of a refrigerator is kept open then which of the following is ture

(A) Room is cooled (B) Room is heated

(C) Room is either cooled or heated (D) Room is neither cooled nor heated

J-4.✍ A scientist says that the efficiency of his heat engine which operates at source temperature 127°C and sink temperature 27° C is 26% then

(A) It is impossible (B) It is possible but less probable

(C) It is quite probable (D) Data are incomplete

J-5.✍ "Heat cannot be itself flow from a body at lower temperature to a body at higher temperature" is a statement or consequence of : **[AIEEE - 2003, 4/300]**

(A) second law of thermodynamics (B) conservation of momentum

(C) conservation of mass (D) first law of thermodynamics

PART - III : MATCH THE COLUMN

1. An ideal monoatomic gas undergoes different types of processes which are described in column-I. Match the corresponding effects in column-II. The letters have usual meaning.

Column-I	**Column-II**
(A) $P = 2V^2$	(p) If volume increases then temperature will also increases.
(B) PV^2 = constant	(q) If volume increases then temperature will decreases.
(C) $C = C_V + 2R$	(r) For expansion, heat will have to be supplied to the gas.
(D) $C = C_V - 2R$	(s) If temperature increases then work done by gas is positive.

2.✍ The figures given below show different processes (relating pressure P and volume V) for a given amount for an ideal gas. W is work done by the gas and ΔQ is heat absorbed by the gas.

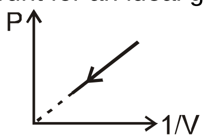


fig (i)

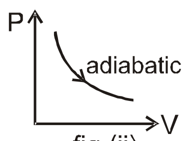


fig (ii)

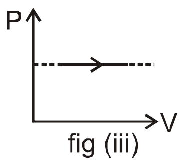


fig (iii)

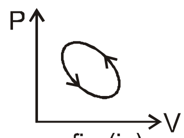


fig (iv)

Column-I	**Column-II**
(A) In Figure (i)	(p) $\Delta Q > 0$.
(B) In Figure (ii)	(q) $W < 0$.
(C) In Figure (iii)	(r) $\Delta Q < 0$.
(D) In Figure (iv) (for complete cycle)	(s) $W > 0$.

Exercise-2

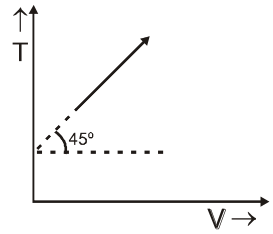
✍ ***Marked Questions can be used as Revision Questions.***

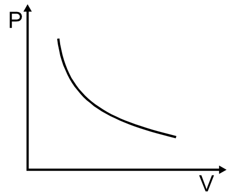
PART - I : ONLY ONE OPTION CORRECT TYPE

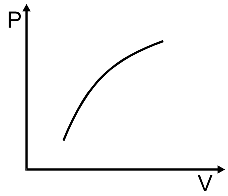
1. The molar heat capacity at constant presure of nitrogen gas at STP is nearly 3.5 R. Now when the temperature is increased, it gradually increases and approaches 4.5 R. The most appropriate reason for this behaviour is that at high temperatures

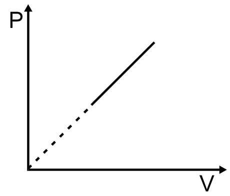
(A) nitrogen does not behave as an ideal gas (B) nitrogen molecules dissociate in atoms
(C) the molecules collides more frequently (D) molecular vibration gradually become effective

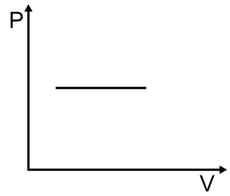
2. The given curve represents the variation of temperature as a function of volume for one mole of an ideal gas. Which of the following curves best represents the variation of pressure as a function of volume ?



(A)


(B)


(C)


(D)


3. Consider a hypothetical gas with molecules that can move along only a single axis. The following table gives four situations, the velocities in meter per second of such a gas having four molecules. The plus and minus sign refer to the direction of the velocity along the axis.

Situation	Velocities			
a	–2	+3	–4	+5
b	+1	–3	+4	–6
c	+2	+3	+4	+5
d	+3	+3	–4	–5

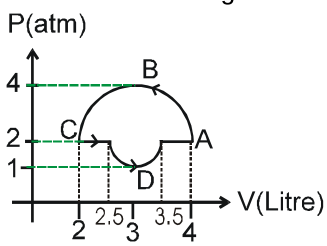
In which situation root-mean-square speed of the molecules is greatest

(A) a (B) b (C) c (D) d

4. The value of $C_P - C_v$ is 1.09 R for a gas sample in state A and is 1.00 R in state B. Let T_A, T_B denote the temperature and P_A and P_B denote the pressure of the states A and B respectively. Then

(A) $P_A < P_B$ and $T_A > T_B$ (B) $P_A > P_B$ and $T_A > T_B$ (C) $P_A = P_B$ and $T_A < T_B$ (D) $P_A > P_B$ and $T_A < T_B$

5. Find work done by the gas in the process shown in figure :

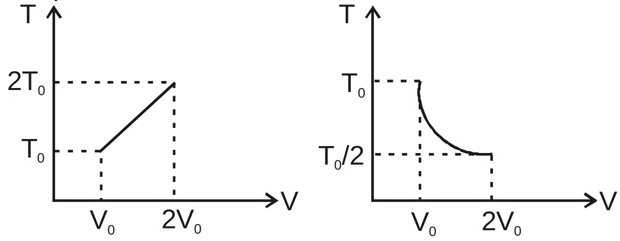


(A) $\frac{5}{2}\pi$ atm L (B) $\frac{5}{2}$ atm L (C) $-\frac{3}{2}\pi$ atm L (D) $-\frac{5}{4}\pi$ atm L

6. An ideal monoatomic gas is initially in state 1 with pressure P_1 = 20 atm and volume V_1 = 1500 cm^3. It is then taken to state 2 with pressure $P_2 = 1.5\ P_1$ and volume $V_2 = 2V_1$. The change in internal energy from state 1 to state 2 is equal to

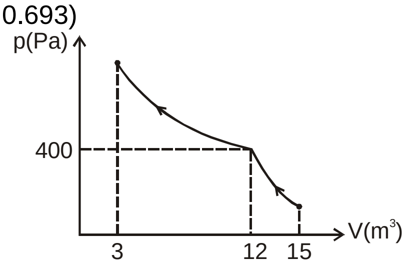
(A) 2000 J (B) 3000 J (C) 6000 J (D) 9000 J

7. For two thermodynamic process temperature and volume diagram are given. In first process, it is a straight line having initial and final coordinates as (V_0, T_0) and ($2V_0$, $2T_0$), where as in second process it is a rectangular hyperbola having initial and final coordinates (V_0, T_0) and ($2V_0$, $T_0/2$). Then ratio of work done ($W_1 : W_2$) in the two processes must be



(A) 1 : 2 (B) 2 : 1 (C) 1 : 1 (D) None of these

8. Curve in the figure shows an adiabatic compression of an ideal gas from 15 m^3 to 12 m^3, followed by an isothermal compression to a final volume of 3.0 m^3. There are 2.0 moles of the gas. Total heat supplied to the gas is equal to : ($\ell n2 = 0.693$)

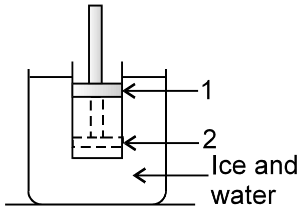


(A) 4521 J (B) –4521 J (C) –6653 J (D) –8476 J

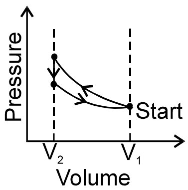
9. P_i, V_i are initial pressure and volumes and V_f is final volume of a gas in a thermodynamic process respectively. If PV^n = constant, then the amount of work done by gas is : ($\gamma = C_p/C_v$). Assume same, initial state & same final volume in all processes.

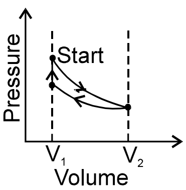
(A) minimum for $n = \gamma$ (B) minimum for n = 1 (C) minimum for n = 0 (D) minimum for $n = \frac{1}{\gamma}$

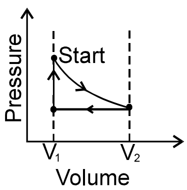
10. Figure shows a conducting cylinder containing gas and closed by a movable piston. The cylinder is submerged in an ice-water mixture. The piston is quickly pushed down from position (1) to position (2). The piston is held at position (2) until the gas is again at 0°C and then is slowly raised back to position (1).



P-V diagram for the above process will be

(A)


(B)


(C)


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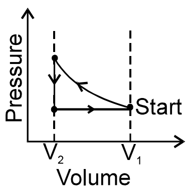
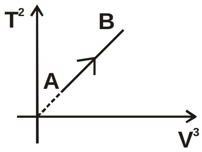


11. Two different ideal diatomic gases A and B are initially in the same state. A and B are then expanded to same final volume through adiabatic and isothermal process respectively. If P_A, P_B and T_A, T_B represents the final pressure and temperatures of A and B respectively then:

(A) $P_A < P_B$ and $T_A < T_B$ (B) $P_A > P_B$ and $T_A > T_B$
(C) $P_A > P_B$ and $T_A < T_B$ (D) $P_A < P_B$ and $T_A > T_B$

12. If ideal diatomic gas follows the process, as shown in graph, where T is temperature in kelvin and V is volume (m^3), then molar heat capacity for this process will be [in terms of gas constant R] :



(A) $\frac{7R}{2}$ (B) 5R (C) $\frac{19R}{6}$ D) $\frac{11R}{2}$

13. A mono–atomic ideal gas is compressed from volume V to V/2 through various process. For which of the following processes final pressure will be maximum :
(A) isobaric (B) isothermal (C) adiabatic (D) PV^2 = constant

14. 4 moles of H_2 at 500 K is mixed with 2 moles of He at 400K .The mixture attains a temperature T and volume V. Now the mixture is compressed adiabatically to a volume V' and temperature T'. If $\frac{T'}{T} = \left(\frac{V}{V'}\right)^n$, find the value of 13n.
(A) 4 (B) 6 (C) 5 (D) 13

15. A coal based thermal power plant producing electricity operates between the temperatures 27ºC and 227ºC. The plant works at 80% of its maximum theoretical efficiency. Complete burring of 1 kg of coal yields 3600 KJ of heat. A house needs 10 units of electricity each day. Coal used for supplying the amount of energy for the house in one year is **[Olympiad 2014 (stage –1)]**
(A) 1141 kg (B) 580 kg (C) 605 kg (D) 765 kg

16. Two identical rooms in a house are connected by an open doorway. The temperatures in the two rooms are maintained at two different values. Therefore
(A) The room with higher temperature contains more amount of air.
(B) The room with lower temperature contains more amount of air.
(C) Both the rooms contain the same amount of air.
(D) The room with higher pressure contains more amount of air.

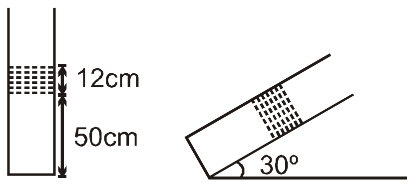
17. A gas is made to undergo a change of state from an initial state to a final state along different paths by adiabatic process only. Therefore.
(A) The work done is different for different paths
(B) The work done is the same for all paths
(C) There is no work done as there is no transfer of energy
(D) The total internal energy of the system will not change

18._ Two moles of hydrogen are mixed with n moles of helium. The root mean square speed of gas molecules in the mixture is $\sqrt{2}$ times the speed of sound in the mixture. Then n is. **[Olympiad (Stage-1) 2017]**
(A) 3 (B) 2 (C) 1.5 (D) 2.5

PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

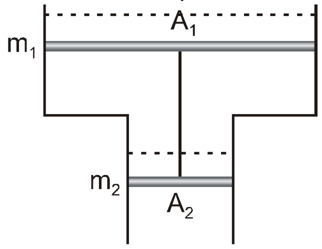
1. A vessel of volume V = 5 litre contains 1.4 g nitrogen and 0.4 g of He at 1500 K. If 30% of the nitrogen molecules are disassociated into atoms then the gas pressure bcomes $\frac{N}{8}\times10^5$ N/m^2. Find N (Assume T constant). $\left[R = \frac{25}{3} J/mol\ K\right]$

2. In given figure, an ideal gas is trapped between a mercury column and the closed end of a uniform vertical tube. The upper end of the tube is open to the atmosphere. Initialy the lengths of the mercury column and the trapped air column are 12 cm and 50 cm respectively. When the tube is tilted slowly in a vertical plane through an angle of 30º with horizontal then the new length of air column is $\frac{x}{41}$ m. Find x. Assuming the temperature to remain constant. (P_{atm} =76 cm of Hg)



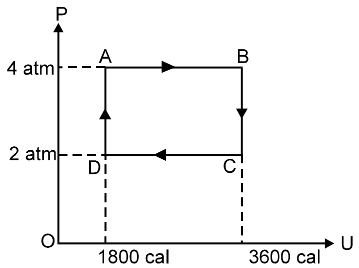
3. Two vessels A and B, thermally insulated, contain an ideal monoatomic gas. A small tube fitted with a valve connects these vessels. Initially the vessel A has 2 litres of gas at 300 K and 2×10^5 N m^{-2} pressure while vessel B has 4 litres of gas at 350 K and 4×10^5 Nm^{-2} pressure. The valve is now opened and the system reaches equilibrium in pressure and temperature. The new pressure will be $\frac{310}{93} \times 10^n$ (N/m^2). Find n.

4. Consider a vertical tube open at both ends. The tube consists of two parts, each of different cross-sections and each part having a piston which can move smoothly in respective tubes. The two pistons are joined together by an inextensible wire. The combined mass of the two piston is 5 kg and area of cross-section of the upper piston is 10 cm^2 greater than that of the lower piston. Amount of gas enclosed by the pistons is one mole. When the gas is heated slowly, pistons move by 50 cm as shown in figure. The rise in the temperature of the gas, in the form $\frac{X}{R}$ K where R is universal gas constant. Use g = 10 m/s^2 and outside pressure = 10^5 N/m^2). Fill value of X.

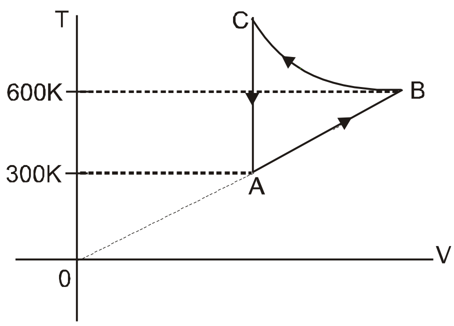


5. When 2g of gas A is introduced into an evacuated flask kept at 25^{0}C the pressure is found to be 1atm. If 3 g of another gas B is then added to the same flask the total pressure becomes 1.5atm. The ratio of molecular weight of A and B is 1 : n. Find n.

6. Two moles of an ideal monoatomic gas undergo a cyclic process which is indicated on a P-U diagram, where U is the internal energy of the gas. The work done by the gas in the cycle is k × 10^2 ln 2. Find k.



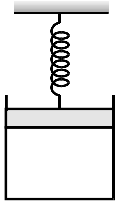
7. In figure, a sample of 3 moles of an ideal gas is undergoing through a cyclic process ABCA. A total of 1500 J of heat is withdrawn from the sample in the process. The work done by the gas during the part BC is –P kJ. FIND P. (R = $\frac{25}{3}$ J/mole K)



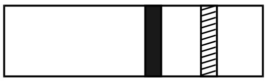
8. During the expansion process the volume of the gas changes from 4m^3 to 6m^3 while the pressure changes according to P = 30V + 100 where pressure is in Pa and volume is in m^3. The work done by gas is N ×10^2 J. Find N.

9. A balloon containing an ideal gas has a volume of 10 liter and temperature of 17ºC. If it is heated slowly to 75ºC, the work done by the gas inside the balloon is 2 × 10^x J. Find x. (neglect elasticity of the balloon and take atmospheric pressure as 10^5 Pa).

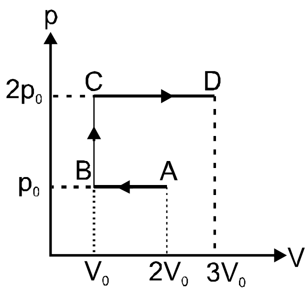
10. One mole of an ideal gas is kept enclosed under a light piston (area=10^{-2} m^2) connected by a compressed spring (spring constant 100 N/m). The volume of gas is 0.83 m^3 and its temperature is 100K. The gas is heated so that it compresses the spring further by 0.1 m. The work done by the gas in the process is N×10^{-1} J. Find N. (Take R = 8.3 J/K-mole and suppose there is no atmosphere).



11. An adiabatic cylindrical tube is fitted with an adiabatic separator as shown in figure. Initially separator is in equilibrium and divides a tube in two equal parts. The separator can be slide into the tube by an external mechanism. An ideal gas (γ = 1.5) is injected in the two sides at equal pressures and temperatures. Now separator is slid to a position where it divides the tube in the ratio 7 : 3. The ratio of the temperatures in the two parts of the vessel is $\sqrt{n} : \sqrt{7}$ find n.



12. P–V indicator diagram for a given sample of monoatomic ideal gas is shown in figure. If the average molar specific heat capacity of the system for the process ABCD is $\frac{xR}{4}$ than find value of x : (R is a universal gas constant)



PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. In a mixture of nitrogen and helium kept at room tempertaure. As compared to a helium molecule nitrogen molecule hits the wall

(A) With greater average speed (B) with smaller average speed
(C) with greater average kinetic energy (D) with smaller average kinetic energy.

2. Consider a collision between an argon molecule and a nitrogen molecule in a mixture of argon and nitrogen kept at room temperature. Which of the following are possible ?

(A) The kinetic energies of both the molecules decrease.
(B) The kinetic energies of both the molecules increase
(C) The kinetic energy of the argon molecule increases and that of the nitrogen molecules decrease.
(D) The kinetic energy of the nitrogen molecules increases and that of the argon molecule decrease.

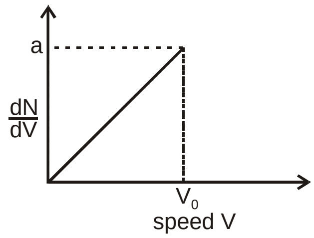
3. An ideal gas of one mole is kept in a rigid container of negligible heat capacity. If 25 J of heat is supplied the gas temperature raises by 2°C. Then the gas may be

(A) helium (B) argon (C) oxygen (D) carbon dioxide

4. Pick the correct statement (s) :

(A) The rms translational speed for all ideal-gas molecules at the same temperature is not the same but it depends on the mass.
(B) Each particle in a gas has average translational kinetic energy and the equation $\frac{1}{2}mv^2_{rms} = \frac{3}{2}kT$ establishes the relationship between the average translational kinetic energy per particle and temperature of an ideal gas. It can be concluded that single particle has a temperature.
(C) Temperature of an ideal gas is doubled from 100°C to 200°C. The average kinetic energy of each particle is also doubled.
(D) It is possible for both the pressure and volume of a monoatomic ideal gas to change simultaneously without causing the internal energy of the gas to change.

5. Graph shows a hypothetical speed distribution for a sample of N gas particle (for $V > V_0$; $\frac{dN}{dV} = 0$)



(A) The value of aV_0 is 2N.
(B) The ratio V_{avg}/V_0 is equal to 2/3.
(C) The ratio V_{rms}/V_0 is equal to $1/\sqrt{2}$.
(D) Three fourth of the total particle has a speed between 0.5 V_0 and V_0.

6. A system undergoes a cyclic process in which it absorbs Q_1 heat and gives out Q_2 heat. The efficiency of the process is η and work done is W. Select correct statement:

(A) $W = Q_1 - Q_2$ (B) $\eta = \frac{W}{Q_1}$ (C) $\eta = \frac{Q_2}{Q_1}$ (D) $\eta = 1 - \frac{Q_2}{Q_1}$

7. The pressure P and volume V of an ideal gas both decreases in a process.
(A) The work done by the gas is negative
(B) The work done by the gas is positive
(C) The temperature of the gas must decrease
(D) Heat supplied to the gas is equal to the change in internal energy.

8. An ideal gas can be taken from initial state 1 to final state 2 by two different process. Let ΔQ and W represent the heat given and work done by the system. Then which quantities is/are same in both process (where ΔU = internal energy of gas)
(A) ΔQ (B) W (C) ΔU (D) ΔQ - W

9. The following sets of values for C_v and C_p of an ideal gas have been reported by different students. The units are cal mole^{-1} K^{-1}. Which of these sets is most reliable ?
(A) $C_v = 3$, $C_p = 5$ (B) $C_v = 4$, $C_p = 6$ (C) $C_v = 3$, $C_p = 2$ (D) $C_v = 3$, $C_p = 4.2$

10. For an ideal gas :
(A) the change in internal energy in a constant pressure process from temperature T_1 to T_2 is equal to $nC_v(T_2 - T_1)$, where C_v is the molar specific heat at constant volume and n the number of moles of the gas.
(B) the change in internal energy of the gas and the work done by the gas are equal in magnitude in an adiabatic process.
(C) the internal energy does not change in an isothermal process.
(D) no heat is added or removed in an adiabatic process.

11. A gaseous mixture consists of equal number of moles of two ideal gases having adiabatic exponents γ_1 and γ_2 and molar specific heats at constant volume C_{v_1} and C_{v_2} respectively. Which of the following statements is/are correct ?
(A) Adiabatic exponent for gaseous mixture is equal to $\frac{\gamma_1 + \gamma_2}{2}$
(B) Molar specific heat at constant volume for gaseous mixture is equal to $\frac{C_{v_1} + C_{v_2}}{2}$
(C) Molar specific heat at constant pressure for gaseous mixture is equal to $\frac{C_{v_1} + C_{v_2} + R}{2}$
(D) Adiabatic exponent for gaseous mixture is $1 + \frac{2R}{C_{v_1} + C_{v_2}}$

12. Let n_1 and n_2 moles of two different ideal gases be mixed. If adiabatic coefficient of the two gases are γ_1 and γ_2 respectively, then adiabatic coefficient γ of the mixture is given through the relation

(A) $(n_1 + n_2)\gamma = n_1\gamma_1 + n_1\gamma_2$ (B) $\frac{(n_1+n_2)}{\gamma-1} = \frac{n_1}{\gamma_1-1} + \frac{n_2}{\gamma_2-1}$ **[Olympiad 2011-12]**

(C) $(n_1+n_2)\ \frac{\gamma}{\gamma-1} = n_1\frac{\gamma_1}{\gamma_1-1} + n_2\frac{\gamma_2}{\gamma_2-1}$ (D) $(n_1 + n_2)(\gamma-1) = n_1(\gamma_1 - 1) + n_2(\gamma_2 - 1)$

13. An ideal gas can be expanded from an initial state to a certain volume through two different processes (i) PV^2 = constant and (ii) $P = KV^2$ where K is a positive constant. Then

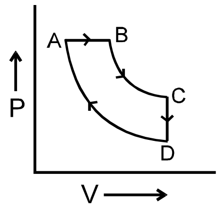
(A) Final temperature in (i) will be greater then in (ii)

(B) Final temperature in (ii) will be greater then in (i)

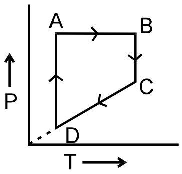
(C) Total heat given to the gas in (i) case is greater than in (ii)

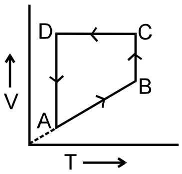
(D) Total heat given to the gas in (ii) case is greater than in (i)

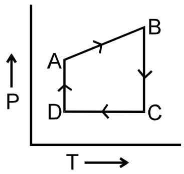
14. A cyclic process ABCD is shown in the P–V diagram. (BC and DA are isothermal)

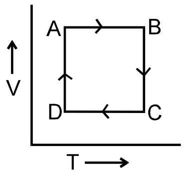


Which of the following curves represents the same process?

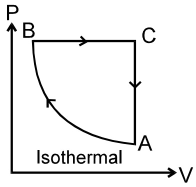
(A) 

(B) 

(C) 

(D) 

15. A cyclic process of an ideal monoatomic gas is shown in figure. The correct statement is (are) :



(A) Work done by gas in process AB is more than that of the process BC.

(B) net heat energy has been supplied to the system.

(C) temperature of the gas is maximum in state B.

(D) in process CA, heat energy is rejected out by system.

16. A gas kept in a container, if the container is of finite conductivity, then the process

(A) must be very nearly adiabatic (B) must be very nearly isothermal

(C) may be very nearly adiabatic (D) may be very nearly isothermal

17. Oxygen, nitrogen and helium gas are kept in three identical adiabatic containers P, Q and R respectively at equal pressure. When the gases are pushed to half their original volumes. (Initial temperature is same)

(A) The final temperature in the three containers will be the same.

(B) The final pressures in the three containers will be the same.

(C) The pressure of oxygen and nitrogen will be the same but that of helium will be different.

(D) The temperature of oxygen and nitrogen will be the same but that of helium will be different

18. During an experiment, an ideal gas is found to obey a condition $\frac{P^2}{\rho}$ = constant [ρ = density of the gas]. The gas is initially at temperature T, pressure P and density ρ. The gas expands such that density changes to $\frac{\rho}{2}$

(A) The pressure of the gas changes to $\sqrt{2}$ P.

(B) The temperature of the gas changes to $\sqrt{2}$ T.

(C) The graph of the above process on the P-T diagram is parabola.

(D) The graph of the above process on the P-T diagram is hyperbola.

19. Which of the following statement/s in case of a thermodynamic process is /are correct ?

[Olympiad 2015 (stage-1)]

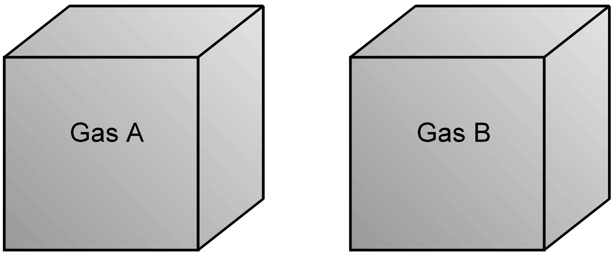
(A) ΔE_{int} = W indicates an adiabatic process
(B) ΔE_{int} = Q suggests an isochoric process
(C) ΔE_{int} = 0 is true for a cyclic process
(D) ΔE_{int} = -W indicates an adiabatic

20._ If a system is made to undergo a change from an initial state to a final state by adiabatic process only, then **[Olympiad (Stage-1) 2017]**
(A) the work done is different for different paths connecting the two states
(B) there is no work done since there is no transfer of heat
(C) the internal energy of the system will change
(D) the work done is the same for all adiabatic paths.

PART - IV : COMPREHENSION

Comprehension # 1

Two closed identical conducting containers are found in the laboratory of an old scientist. For the verification of the gas some experiments are performed on the two boxes and the results are noted.



Experiment -1:
When the two containers are weighed W_A = 225 g, W_B = 160 g and mass of evacuated container W_C = 100 g.

Experiment -2:
When the two containers are given same amount of heat same temperature rise is recorded. The pressure changes found are ΔP_A = 2.5 atm. ΔP_B = 1.5 atm.

Required data for unknown gas :

Mono (molar mass)	He 4g	Ne 20g	Ar 40 g	Kr 84 g	Xe 131 g	Rd 222 g
Dia (molar mass)	H_2 2g	F_2 19 g	N_2 28g	O_2 32g	Cl_2 71 g	

1. Identify the type of gas filled in container A and B respectively.
(A) Mono, Mono (B) Dia, Dia (C) Mono, Dia (D) Dia, Mono.

2. Identify the gas filled in the container A and B.
(A) N_2, Ne (B) He, H_2 (C) O_2, Ar (D) Ar, O_2

3. Total number of molecules in 'A' (here N_A = Avagadro number)
(A) $\frac{125}{64}N_A$ (B) 3.125 N_A (C) $\frac{125}{28}N_A$ (D) 31.25 N_A

4. The initial internal energy of the gas in container 'A', If the container were at room temperature 300K initially
(A) 1406.25 cal (B) 1000 cal (C) 2812.5 cal (D) none of these

Comprehension # 2

A mono atomic ideal gas is filled in a non conducting container. The gas can be compressed by a movable non conducting piston. The gas is compressed slowly to 12.5% of its initial volume.

5. The percentage increase in the temperature of the gas is
(A) 400% (B) 300% (C) – 87.5% (D) 0%

6. The ratio of initial adiabatic bulk modulus of the gas to the final value of adiabatic bulk modulus of the gas is

(A) 32 (B) 1 (C) 1/32 (D) 4

7. ✍ The ratio of work done by the gas to the change in internal energy of the gas is

(A) 1 (B) –1 (C) ∞ (D) 0

Comprehension # 3

An ideal gas initially at pressure p_0 undergoes a free expansion (expansion against vaccum under adiabatic conditions) until its volume is 3 times its initial volume. The gas is next adiabatically compressed back to its original volume. The pressure after compression is $3^{2/3}$ p_0.

8. The pressure of the gas after the free expansion is :

(A) $\frac{p_0}{3}$ (B) $p_0^{1/3}$ (C) p_0 (D) $3p_0$

9. The gas

(A) is monoatomic.
(B) is diatomic.
(C) is polyatomic.
(D) type is not possible to decide from the given information.

10. What is the ratio of the average kinetic energy per molecule in the final state to that in the initial state ?

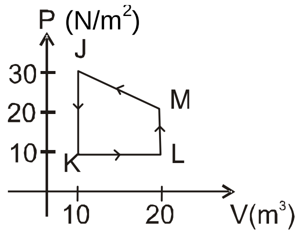
(A) 1 (B) $3^{2/3}$ (C) $3^{1/3}$ (D) $3^{1/6}$

Exercise-3

✍ ***Marked Questions can be used as Revision Questions.***
**** Marked Questions may have more than one correct option.***

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. Match the following for the given process : **[JEE 2006, 6/184]**



(A) Process J $\to$ K (p) W > 0
(B) Process K $\to$ L (q) W < 0
(C) Process L $\to$ M (r) Q > 0
(D) Process M $\to$ J (s) Q < 0

2. **Statement-1 :** The total translational kinetic energy of all the molecules of a given mass of an ideal gas is 1.5 times the product of its pressure and its volume. Because **[JEE 2007; 3/162)]**

Statement-2 : The molecules of a gas collide with each other and the velocities of the molecules change due to the collision.

(A) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1

(B) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

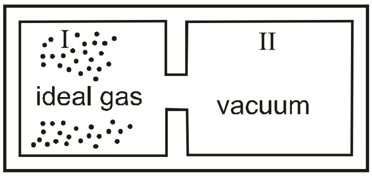
3. An ideal gas is expanding such that PT^2 = constant. The coefficient of volume expansion of the gas is

(A) $\frac{1}{T}$ (B) $\frac{2}{T}$ (C) $\frac{3}{T}$ (D) $\frac{4}{T}$ **[JEE 2008' 3/163]**

4. **Column I** contains a list of processes involving expansion of an ideal gas. Match this with **Column II** describing the thermodynamic change during this process. Indicate your answer by darkening the appropriate bubbles of the 4 × 4 matrix given in the ORS. **[JEE 2008' 6/163]**

Column I

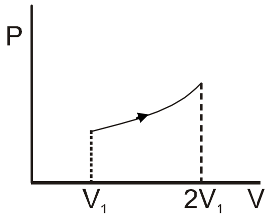
(A) An insulated container has two chambers separated by a valve. Chamber I contains an ideal gas and the Chamber II has vacuum. The valve is opened.



(B) An ideal monoatomic gas expands to twice its original volume such that its pressure $P \propto \frac{1}{V^2}$, where V is the volume of the gas.

(C) An ideal monoatomic gas expands to twice its original volume such that its pressure $P \propto \frac{1}{V^{4/3}}$, where V is its volume

(D) An ideal monoatomic gas expands such that its pressure P and volume V follows the behaviour shown in the graph



Column II

(p) The temperature of the gas decreases

(q) The temperature of the gas increases or remains constant

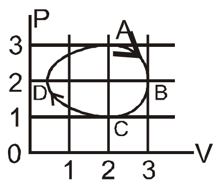
(r) The gas loses heat

(s) The gas gains heat

5.* C_v and C_p denote the molar specific heat capacities of a gas at constant volume and constant pressure, respectively. Then **[JEE, 2009, 4/160, –1]**

(A) $C_p - C_v$ is larger for a diatomic ideal gas than for a monoatomic ideal gas
(B) $C_p + C_v$ is larger for a diatomic ideal gas than for a monoatomic ideal gas
(C) C_p/C_v is larger for a diatomic ideal gas than for a monoatomic ideal gas
(D) $C_p.C_v$ is larger for a diatomic ideal gas than for a monoatomic ideal gas

6.* The figure shows the P-V plot of an ideal gas taken through a cycle ABCDA. The part ABC is a semi-circle and CDA is half of an ellipse. Then, **[JEE, 2009, 4/160, –1]**

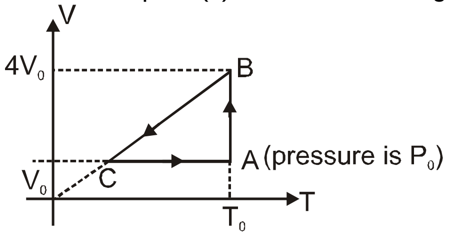


(A) the process during the path A → B is isothermal
(B) heat flows out of the gas during the path B → C → D
(C) work done during the path A → B → C is zero
(D) positive work is done by the gas in the cycle ABCDA

7. A real gas behaves like an ideal gas if its **[JEE, 2010, 3/163, –1]**

(A) pressure and temperature are both high
(B) pressure and temperature are both low
(C) pressure is high and temperature is low
(D) pressure is low and temperature is high

8.* One mole of an ideal gas in initial state A undergoes a cyclic process ABCA, as shown in the figure. Its pressure at A is P_0. Choose the correct option(s) from the following : **[JEE, 2010, 3/163]**



(A) Internal energies at A and B are the same (B) Work done by the gas in process AB is $P_0V_0 \ln 4$

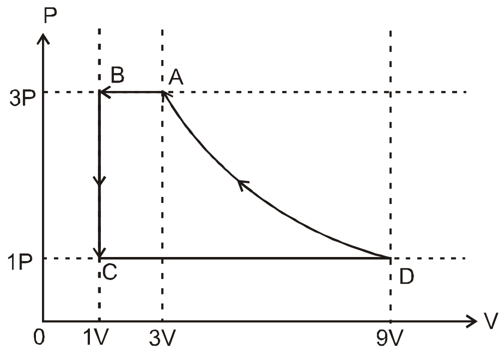
(C) Pressure at C is $\frac{P_0}{4}$ (D) Temperature at C is $\frac{T_0}{4}$

9.✍ A diatomic ideal gas is compressed adiabatically to $\frac{1}{32}$ of its initial volume. If the initial temperature of the gas is T_i (in Kelvin) and the final temperature is aT_i, the value of a is : **[JEE, 2010, 3/163]**

10. 5.6 liter of helium gas at STP is adiabatically compressed to 0.7 liter. Taking the initial temperature to be T_1, the work done in the process is : **[JEE, 2011, 3/160, –1]**

(A) $\frac{9}{8}RT_1$ (B) $\frac{3}{2}RT_1$ (C) $\frac{15}{8}RT_1$ (D) $\frac{9}{2}RT_1$

11. One mole of a monatomic ideal gas is taken through a cycle ABCDA as shown in the P-V diagram. Column II gives the characteristics involved in the cycle. Match them with each of the processes given in Column I. **[JEE, 2011, 8/160]**



Column I	**Column II**
(A) Process $A \to B$	(p) Internal energy decreases
(B) Process $B \to C$	(q) Internal energy increases
(C) Process $C \to D$	(r) Heat is lost
(D) Process $D \to A$	(s) Heat is gained
	(t) Work is done on the gas.

12. A mixture of 2 moles of helium gas (atomic mass = 4 amu), and 1 mole of argon gas (atomic mass = 40 amu) is kept at 300 K in a container. The ratio of the rms speeds $\left(\frac{v_{rms}(\text{helium})}{v_{rms}(\text{argon})}\right)$ is :

[IIT-JEE 2012, P-1 : 3/70, –1]

(A) 0.32 (B) 0.45 (C) 2.24 (D) 3.16

13. Two moles of ideal helium gas are in a rubber balloon at 30° C. The balloon is fully expandable and can be assumed to require no energy in its expansion. The temperature of the gas in the balloon is slowly changed to 35°C.The amount of heat required in raising the temperature is nearly
(take R = 8.31 J/mol.K) **[IIT-JEE 2012, Paper-2 : 3/66, –1]**

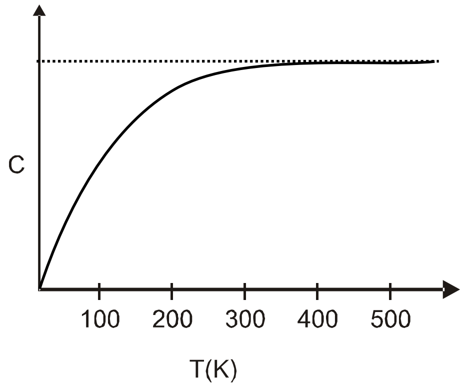
(A) 62J (B) 104 J (C) 124 J (D) 208 J

14.✍ Two non-reactive monoatomic ideal gases have their atomic masses in the ratio 2 : 3. The ratio of their partial pressures, when enclosed in a vessel kept at a constant temperature, is 4 : 3. The ratio of their densities is: **[JEE (Advanced) 2013, 3/60,–1]**

(A) 1 : 4 (B) 1 : 2 (C) 6 : 9 (D) 8 : 9

15.* The figure below shows the variation of specific heat capacity (C) of a solid as a function of temperature (T). The temperature is increased continuously from 0 to 500 K at a constant rate. Ignoring any volume change, the following statement(s) is (are) correct to a reasonable approximation.

[JEE (Advanced) 2013, 2/60, –1]



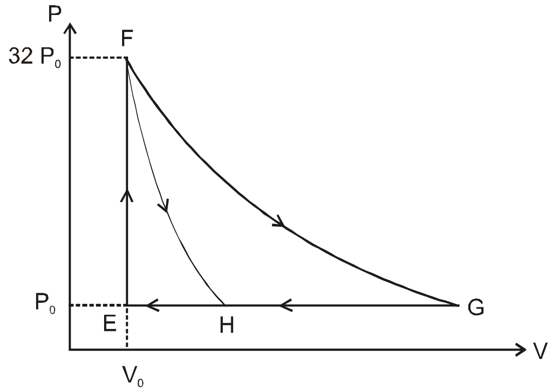
(A) the rate at which heat is absorbed in the range 0–100 K varies linearly with temperature T.

(B) heat absorbed in increasing the temperature from 0–100 K is less than the heat required for increasing the temperature from 400–500 K.

(C) there is no change in the rate of heat absorbtion in the range 400–500 K.

(D) the rate of heat absorption increases in the range 200–300 K.

16. One mole of a monatomic ideal gas is taken along two cyclic processes $E \rightarrow F \rightarrow G \rightarrow E$ and $E \rightarrow F \rightarrow H \rightarrow E$ as shown in the PV diagram. The processes involved are purely isochoric, isobaric, isothermal or adiabatic.



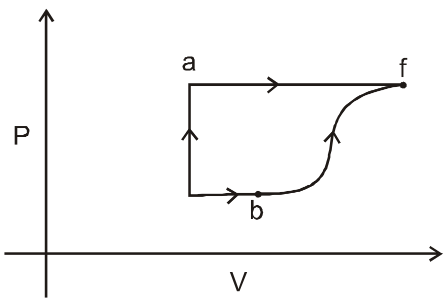
Match the paths in List I with the magnitudes of the work done in List II and select the correct answer using the codes given below the lists. **[JEE (Advanced) 2013 ; 9/60]**

List I		**List II**
P. $G \rightarrow E$	1.	$160\ P_0V_0\ \ln 2$
Q. $G \rightarrow H$	2.	$36\ P_0V_0$
R. $F \rightarrow H$	3.	$24\ P_0V_0$
S. $F \rightarrow G$	4.	$31\ P_0V_0$

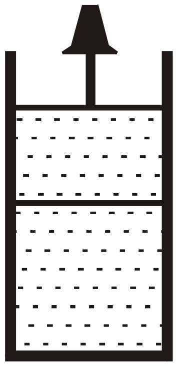
Codes :

	P	Q	R	S
(A)	4	3	2	1
(B)	4	3	1	2
(C)	3	1	2	4
(D)	1	3	2	4

17. A thermodynamic system is taken form an initial state i with internal energy U_i = 100 J to the final state f along two different paths iaf and ibf, as schematically shown in the figure. The work done by the system along the paths af, ib and bf are W_{af} = 200 J, W_{ib} = 50 J and W_{bf} = 100 J respectively. The heat supplied to the system along the path iaf, ib and bf are Q_{iaf},Q_{bf} and Q_{ib} respectively.If the internal energy of the sytem in the state b is U_b = 200 J and Q_{iaf} = 500 J, the ratio Q_{bf}/Q_{ib} is: **[JEE (Advanced) 2014,P-1, 3/60]**



Paragraph For Questions 18 to 19



In the figure a container is shown to have a movable (without friction) piston on top. The container and the piston are all made of perfectly insulating material allowing no heat transfer between outside and inside the container. The container is divided into two compartments by a rigid partition made of a thermally conducting material that allows slow transfer of heat.

The lower compartment of the container is filled with 2 moles of an ideal monatomic gas at 700 K and the upper compartment is filled with 2 moles of an ideal diatomic gas at 400 K. The heat capacities per mole of an ideal monatomic gas are $C_V = \frac{3}{2}R$, $C_P = \frac{5}{2}R$, and those for an ideal diatomic gas are $C_V = \frac{5}{2}R$, $C_P = \frac{7}{2}R$.

18. Consider the partition to be rigidly fixed so that it does not move. When equilibrium is achieved, the final temperature of the gases will be : **[JEE (Advanced) 2014, 3/60, –1]**

(A) 550 K (B) 525 K (C) 513 K (D) 490 K

19. Now consider the partition to be free to move without friction so that the pressure of gases in both compartments is the same. Then total work done by the gases till the time they achieve equilibrium will be : **[JEE (Advanced) 2014, 3/60, –1]**

(A) 250 R (B) 200 R (C) 100 R (D) –100 R

20.* A container of fixed volume has a mixture of one mole of hydrogen and one mole of helium in equilibrium at temperature T. Assuming the gases are ideal, the correct statement(s) is (are) **[JEE (Advanced) 2015 ; 4/88, –2]**

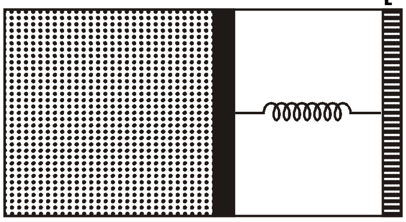
(A) The average energy per mole of the gas mixture is 2RT.

(B) The ratio speed of sound in the gas mixture to that in helium gas is $\sqrt{6/5}$.

(C) The ratio of the rms speed of helium atoms to that of hydrogen molecules is 1/2.

(D) The ratio of the rms speed of helium atoms to that of hydrogen molecules is $1/\sqrt{2}$.

21.* An ideal monoatomic gas is confined in a horizontal cylinder by a spring loaded piston (as shown in the figure). Initially the gas is at temperature T_1, pressure P_1 and volume V_1 and the spring is in its relaxed state. the gas is then heated very slowly to temperature T_2, pressure P_2 and volume V_2. During this process the piston moves out by a distance x. Ignoring the friction between the piston and the cylinder, the correct statement(s) is(are) **[JEE (Advanced) 2015 ; P-2,4/88, –2]**



(A) If $V_2 = 2V_1$ and $T_2 = 3T$, then the energy stored in the spring is $\frac{1}{4}P_1V_1$

(B) If $V_2 = 2V_1$ and $T_2 = 3T_1$, then the change in internal energy is $3P_1V_1$

(C) If $V_2 = 3V_1$ and $T_2 = 4T_1$, then the work done by the gas is $\frac{7}{3}P_1V_1$

(D) If $V_2 = 3V_1$ and $T_2 = 4T_1$, then the heat supplied to the gas is $\frac{17}{6}P_1V_1$

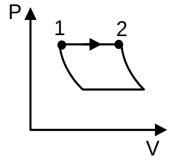
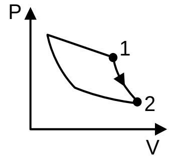
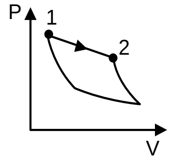
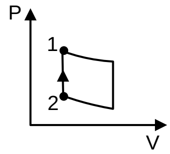
22. A gas is enclosed in a cylinder with a movable frictionless piston. Its initial thermodynamic state at pressure $P_i = 10^5$ Pa and volume $V_i = 10^{-3}$ m^3 changes to a final state at $P_f = (1/32) \times 10^5$ Pa and $V_f = 8 \times 10^{-3}$ m^3 in an adiabatic quasi-static process, such that P^3V^5 = constant. Consider another thermodynamic process that brings the system from the same initial state to the same final state in two steps : an isobaric expansion at P_i followed by an isochoric (isovolumetric) process at volume V_f. The amount of heat supplied to the system in the two-step process is approximately. **[JEE (Advanced) 2016; P-2, 3/62, –1]**

(A) 112 J (B) 294 J (C) 588 J (D) 813 J

Answer Q.23, Q.24 and Q.25 by appropriately matching the information given in the three columns of the following table.

An ideal gas is undergoing a cyclic thermodynamic process in different ways as shown in the corresponding P – V diagrams in column 3 of the table. Consider only the path from state 1 to state 2.

W denotes the corresponding work done on the system. The equations and plots in the table have standard notations as used in thermodynamic process. Here γ is the ratio of heat capacities at constant pressure and constant volume. The number of moles in the gas is n.

	Column-1		Column-2		Column-3
(I)	$W_{1\to2} = \frac{1}{\gamma-1}(P_2V_2 - P_1V_1)$	(i)	Isothermal	(P)	
(II)	$W_{1\to2} = -PV_2 + PV_1$	(ii)	Isochoric	(Q)	
(III)	$W_{1\to2} = 0$	(iii)	Isobaric	(R)	
(IV)	$W_{1\to2} = -nRT\ln\left(\frac{V_2}{V_1}\right)$	(iv)	Adiabatic	(S)	

23. Which of the following options is the only correct representation of a process in which $\Delta U = \Delta Q - P\Delta V$? **[JEE (Advanced) 2017; P-1, 3/61, –1]**

(A) (II) (iii) (P) (B) (II) (iii) (S) (C) (III) (iii) (P) (D) (II) (iv) (R)

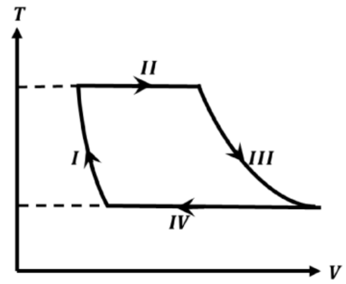
24. Which one of the following options is the correct combination ? **[JEE (Advanced) 2017;P-1, 3/61, –1]**

(A) (II) (iv) (P) (B) (IV) (ii) (S) (C) (II) (iv) (R) (D) (III) (ii) (S)

25. Which one of the following options correctly represents a thermodynamics process that is used as a correction in the determination of the speed of sound in an ideal gas ?
[JEE (Advanced) 2017; P-1, 3/61, –1]

(A) (III) (iv) (R) (B) (I) (ii) (Q) (C) (IV) (ii) (R) (D) (I) (iv) (Q)

26*. One mole of a monatomic ideal gas undergoes a cyclic process as shown in the figure (where V is the volume and T is the temperature). Which of the statements below is (are) true?
[JEE Advanced 2018; P-1, 4/60, –2]

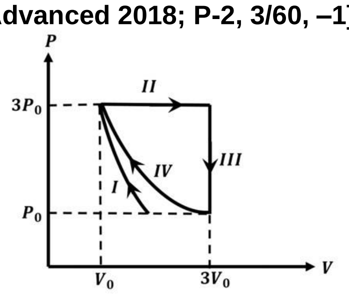


(A) Process I is an isochoric process (B) In process II, gas absorbs heat
(C) In process IV, gas releases heat (D) Processes I and III are **not** isobaric

27. One mole of a monatomic ideal gas undergoes an adiabatic expansion in which its volume becomes eight times its initial value. If the initial temperature of the gas is 100 K and the universal gas constant 8.0J $mol^{-1}K^{-1}$, the decrease in its internal energy, in Joule, is____. **[JEE Advanced 2018; P-2, 3/60]**

28. One mole of a monatomic ideal gas undergoes four thermodynamic processes as shown schematically in the PV-diagram below. Among these four processes, one is isobaric, one is isochoric, one is isothermal and one is adiabatic. Match the processes mentioned in List-1 with the corresponding statements in List-II. **[JEE Advanced 2018; P-2, 3/60, –1]**

	List-I		List-II
P.	In process I	1.	Work done by the gas is zero
Q.	In process II	2.	Temperature of the gas remains unchanged



R. In process III 3. **No** heat is exchanged between the gas and its surroundings

S. In process IV 4. Work done by the gas is $6P_0V_0$

(A) P → 4; Q → 3; R → 1; S → 2 (B) P → 1; Q → 3; R → 2; S → 4

(C) P → 3; Q → 4; R → 1; S → 2 (D) P → 3; Q → 4; R → 2; S → 1

PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. Two rigid boxes containing different ideal gases are placed on a table. Box A contains one mole of nitrogen at temperature T_0, while box B contains one mole of helium at temperature $(7/3)T_0$. The boxes are then put into thermal contact with each other, and heat flows between them until the gases reach a common final temperature. (Ignore the heat capacity of boxes). Then, the final temperature of the gases, T_f in terms of T_0 is : **[AIEEE - 2006, 4½/180]**

(1) $T_f = \frac{3}{7}T_0$ (2) $T_f = \frac{7}{3}T_0$ (3) $T_f = \frac{3}{2}T_0$ (4) $T_f = \frac{5}{2}T_0$

2. The work of 146 kJ is performed in order to compress one kilo mole of a gas adiabatically and in this process the temperature of the gas increases by 7 ºC. The gas is (R = 8.3 J mol^{-1} K^{-1}) **[AIEEE - 2006, 3/180]**

(1) diatomic (2) triatomic

(3) mixture of monoatomic and diatomic (4) monoatomic

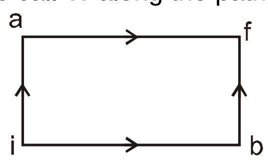
3. A Carnot engine, having an efficiency of $\eta = 1/10$ as heat engine, is used as a refrigerator. If the work done on the system is 10 J, the amount of energy absorbed from the reservoir at lower temperature is **[AIEEE - 2007, 3/120]**

(1) 99 J (2) 90 J (3) 1 J (4) 100 J

4. If C_p and C_v denote the specific heats of nitrogen per unit mass at constant pressure and constant volume respectively, then **[AIEEE - 2007, 3/120]**

(1) $C_p - C_v = R/28$ (2) $C_p - C_v = R/14$ (3) $C_p - C_v = R$ (4) $C_p - C_v = 28R$

5. When a system is taken from state i to state f along the path iaf, it is found that Q = 50 cal and W = 20 cal. Along the path ibf Q = 36 cal. W along the path ibf is : **[AIEEE - 2007, 3/120]**



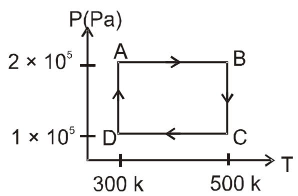
(1) 6 cal (2) 16 cal (3) 66 cal (4) 14 cal

6. An insulated container of gas has two chambers separated by an insulating partition. One of the chambers has volume V_1 and contains ideal gas at pressure p_1 and temperature T_1. The other chamber has volume V_2 and contains ideal gas at pressure p_2 and temperature T_2. If the partition is removed without doing any work on the gas, the final equilibrium temperature of the gas in the container will be – **[AIEEE - 2008, 3/105]**

(1) $\frac{T_1T_2(p_1V_1+p_2V_2)}{p_1V_1T_2+p_2V_2T_1}$ (2) $\frac{p_1V_1T_1+p_2V_2T_2}{p_1V_1+p_2V_2}$ (3) $\frac{p_1V_1T_2+p_2V_2T_1}{p_1V_1+p_2V_2}$ (4) $\frac{T_1T_2(p_1V_1+p_2V_2)}{p_1V_1T_1+p_2V_2T_2}$

Directions : Question number 7, 8 and 9 are based on the following paragraph.

Two moles of helium gas are taken over the cycle ABCDA, as shown in the P-T diagram. **[AIEEE - 2009, 4×3/144]**



7. Assume the gas to be ideal the magnitude of work done on the gas in taking it from A to B is :

(1) 200 R (2) 300 R (3) 400 R (4) 500 R

8. The work done on the gas in taking it from D to A is

(1) –414 R (2) + 414 R (3) – 690 R (4) + 690 R

9. The magnitude of net work done on the gas in the cycle ABCDA is:
(1) Zero (2) 276 R (3) 1076 R (4) 1904 R

10. One kg of a diatomic gas is at a pressure of 8×10^4 N/m^2. The density of the gas is 4 kg/m^3. What is the energy of the gas due to its thermal rnotion? **[AIEEE - 2009, 4/144]**
(1) 5×10^4J (2) 6×10^4J (3) 7×10^4J (4) 3×10^4J

11. A diatomic ideal gas is used in a Carnot engine as the working substance. If during the adiabatic expansion part of the cycle the volume of the gas increases from V to 32 V, the efficiency of the engine is : **[AIEEE - 2010, 4/144, –1]**
(1) 0.5 (2) 0.75 (3) 0.99 (4) 0.25

12. 100g of water is heated from 30ºC to 50ºC ignoring the slight expansion of the water, the change in its internal energy is (specific heat of water is 4184 J/Kg/K) : **[AIEEE - 2011, 4/120, –1]**
(1) 4.2 kJ (2) 8.4 kJ (3) 84 kJ (4) 2.1 kJ

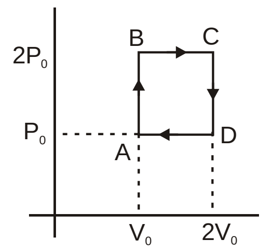
13. A Carnot engine operating between temperatures T_1 and T_2 has effeiciency 1/6. When T_2 is lowered by 62 K, its efficiency increases to 1/3. Then T_1 and T_2 are, respectively : **[AIEEE - 2011, 4/120, –1]**
(1) 372 K and 310 K (2) 372 K and 330 K (3) 330 K and 268 K (4) 310 K and 248 K

14. Three perfect gases at absolute temperature T_1, T_2 and T_3 are mixed. The masses of molecules are m_1,m_2 and m_3 and the number of molecules are n_1,n_2 and n_3 respectively. Assuming no loss of energy, the final temperature of the mixture is : **[AIEEE - 2011, 4/120, –1]**
(1) $\frac{(T_1+T_2+T_3)}{3}$ (2) $\frac{n_1T_1+n_2T_2+n_3T_3}{n_1+n_2+n_3}$ (3) $\frac{n_1T_1^2+n_2T_2^2+n_3T_3^2}{n_1T_1+n_2T_2+n_3T_3}$ (4) $\frac{n_1^2T_1^2+n_2^2T_2^2+n_3^2T_3^2}{n_1T_1+n_2T_2+n_3T_3}$

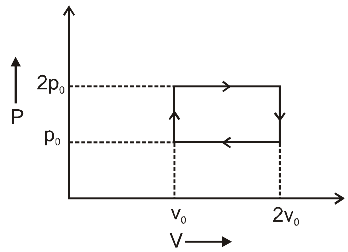
15. A thermally insulated vessel contains an ideal gas of molecular mass M and ratio of specific heats γ. It is moving with speed v and is suddenly brought to rest. Assuming no heat is lost to the surroundings, its temperature increases by : **[AIEEE - 2011, 4/120, –1]**
(1) $\frac{(\gamma-1)}{2(\gamma+1)R}Mv^2K$ (2) $\frac{(\gamma-1)}{2\gamma R}Mv^2K$ (3) $\frac{\gamma Mv^2}{2R}K$ (4) $\frac{(\gamma-1)}{2R}Mv^2K$

16. A container with insulating walls is divided into equal parts by a partition fitted with a valve. One part is filled with an ideal gas at a pressure P and temperature T, whereas the other part is completely evacuated. If the valve is suddenly opened, the pressure and temperature of the gas will be :
[AIEEE 2011, 11 May; 4/120, –1]
(1) $\frac{P}{2},\frac{T}{2}$ (2) P, T (3) P, $\frac{T}{2}$ (4) $\frac{P}{2}$, T

17. Helium gas goes through a cycle ABCDA (consisting of two isochoric and isobaric lines) as shown in figure. Efficiency of this cycle is nearly : (Assume the gas to be close to ideal gas) **[AIEEE 2012 ; 4/120, –1]**
(1) 15.4% (2) 9.1%
(3) 10.5% (4) 12.5%



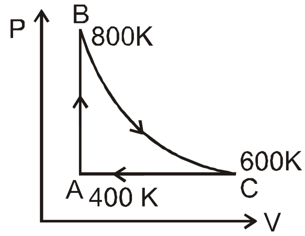
18. The above p-v diagram represents the thermodynamic cycle of an engine, operating with an ideal monoatomic gas. The amount of heat, extracted from the source in a single cycle is : **[JEE (Main) 2013, 4/120, –1]**
(1) p_0v_0 (2) $\left(\frac{13}{2}\right)p_0v_0$
(3) $\left(\frac{11}{2}\right)p_0v_0$ (4) $4p_0v_0$



19. An ideal gas enclosed in a vertical cylindrical container supports a freely moving piston of mass M. The piston and the cylinder have equal cross sectional area A. When the piston is in equilibrium, the volume of the gas is V_0 and its pressure is P_0. The piston is slightly displaced from the equilibrium position and released. Assuming that the system is completely isolated from its surrounding, the piston executes a simple harmonic motion with frequency : **[JEE (Main) 2013, 4/120]**

(1) $\frac{1}{2\pi}\frac{A\gamma P_0}{V_0 M}$ (2) $\frac{1}{2\pi}\frac{V_0 M P_0}{A^2\gamma}$ (3) $\frac{1}{2\pi}\sqrt{\frac{A^2\gamma P_0}{MV_0}}$ (4) $\frac{1}{2\pi}\sqrt{\frac{MV_0}{A\gamma P_0}}$

20. One mole of diatomic ideal gas undergoes a cyclic process ABC as shown in figure. The process BC is adiabatic. The temperatures at A, B and C are 400K, 800K and 600 K respectively. Choose the correct statement : **[JEE (Main) 2014, 4/120,–1]**



(1) The change in internal energy in whole cyclic process is 250 R.
(2) The change in internal energy in the process CA is 700 R
(3) The change in internal energy in the process AB is – 350 R
(4) The change in internal energy in the process BC is – 500 R

21. An open glass tube is immersed in mercury in such a way that a length of 8 cm extends above the mercury level. The open end of the tube is then closed and sealed and the tube is raised vertically up by additional 46 cm. What will be length of the air column above mercury in the tube now ?
(Atmospheric pressure = 76 cm of Hg) **[JEE (Main) 2014, 4/120,–1]**
(1) 16 cm (2) 22 cm (3) 38 cm (4) 6 cm

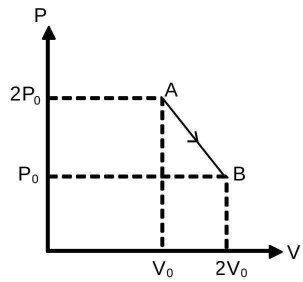
22. Consider a spherical shell of radius R at temperature T. The black body radiation inside it can be considered as an ideal gas of photons with internal energy per unit volume $u = \frac{U}{V} \propto T^4$ and pressure $P = \frac{1}{3}\left(\frac{U}{V}\right)$. If the shell now undergoes an adiabatic expansion the relation between T and R is **[JEE (Main) 2015; 4/120, –1]**
(1) $T \propto e^{-R}$ (2) $T \propto e^{-3R}$ (3) $T \propto 1/R$ (4) $T \propto 1/R^3$

23. A solid body of constant heat capacity 1 J/°C is being heated by keeping it in contact with reservoirs in two ways:
(i) Sequentially keeping in contact with 2 reservoirs such that each reservoir supplies same amount of heat.
(ii) Sequentially keeping in contact with 8 reservoirs such that each reservoir supplies same amount of heat.
In both the cases body is brought from initial temperature 100°C to final temperature 200°C. Entropy changes of the body in the two cases respectively is **[JEE (Main) 2015 ; 4/120, –1]**
(1) ℓn 2, 4ℓn2 (2) ℓn 2, ℓn 2 (3) ℓn 2, 2 ℓn 2 (4) 2 ℓn 2, 8 ℓn 2

24. Consider an ideal gas confined in an isolated closed chamber. As the gas undegoes an adiabatic expansion, the average time of collision between molecules increases as V^q, where V is the volume of the gas. The value of q is : $\left(\gamma = \frac{C_P}{C_V}\right)$ **[JEE (Main) 2015 ; 4/120, –1]**
(1) $\frac{3\gamma+5}{6}$ (2) $\frac{3\gamma-5}{6}$ (3) $\frac{\gamma+1}{2}$ (4) $\frac{\gamma-1}{2}$

25. An ideal gas undergoes a quasi static, reversible process in which its molar heat capacity C remains constant. If during this process the relation of pressure P and volume V is given by PV^n = constant, then n is given by (Here Cp and C_V are molar specific heat at constant pressure and constant volume, respectively) : **[JEE (Main) 2016, 4/120, –1]**
(1) $n = \frac{C - C_p}{C - C_V}$ (2) $n = \frac{C_p - C}{C - C_V}$ (3) $n = \frac{C - C_V}{C - C_p}$ (4) $n = \frac{C_p}{C_V}$

26. 'n' moles of an ideal gas undergoes a process A → B as shown in the figure. The maximum temperature of the gas during the process will be : **[JEE (Main) 2016, 4/120, –1]**



(1) $\frac{3P_0V_0}{2nR}$ (2) $\frac{9P_0V_0}{2nR}$
(3) $\frac{9P_0V_0}{nR}$ (4) $\frac{9P_0V_0}{4nR}$

27. C_p and C_v are specific heats at constant pressure and constant volume respectively. It is observed that
$C_p - C_v$ = a for hydrogen gas
$C_p - C_v$ = b for nitrogen gas
The correct relation between a and b is : **[JEE (Main) 2017, 4/120, –1]**
(1) a = 28 b (2) $a = \frac{1}{14}b$ (3) a = b (4) a = 14 b

28. The temperature of an open room of volume 30 m^3 increased from 17ºC to 27ºC due to the sunshine. The atmospheric pressure in the room remains 1×10^5 Pa. If n_i and n_f are the number of molecules in the room before and after heating, then $n_f - n_i$ will be : **[JEE (Main) 2017, 4/120, –1]**

(1) -2.5×10^{25} (2) -1.61×10^{23} (3) 1.38×10^{23} (4) 2.5×10^{25}

29. Two moles of an ideal monoatomic gas occupies a volume V at 27°C. The gas expands adiabatically to a volume 2V. Calculate (a) the final temperature of the gas and (b) change in its internal energy. **[JEE (Main) 2018; 4/120, –1]**

(1) (a) 189 K (b) –2.7 kJ (2) (a) 195 K (b) 2.7 kJ
(3) (a) 189 K (b) 2.7 kJ (4) (a) 195 K (b) –2.7 kj

Answers

EXERCISE-1

PART - I

Section (A) :

A-1 zero **A-2.** $\left(\frac{mv_0^2}{\ell}\right)$N

Section (B) :

B-1. $\sqrt{\frac{50}{3}}$ V **B-2.** H_2, 1200 K

B-3. $2P_0$ **B-4.** $\frac{6P_0}{5}$ **B-5.** $\frac{112}{250}$ mole

B-6. (i) $\frac{1492}{293}$ cm (ii) $\frac{320\pi}{293}\left(1+\frac{13}{4\pi}\right)$ kg

Section (C) :

C-1. $\frac{1452\pi}{25}\times 10^3$ K **C-2.** $\frac{83}{3\sqrt{10}}\times 10^{-23}$ kg-m/s

C-3. 1 : 2 **C-4.** 1 : $\sqrt{2}$

Section (D) :

D-1. 32ºC **D-2.** 196ºC

D-3. $U=\frac{fnRT}{2}=\frac{f}{2}PV=\frac{f}{2}P_{atm}\,.\,V_{room}$ = constant.

Section (E) :

E-1. $-100\,\pi$J **E-2.** 1500J

E-3. 750J

E-4. $nRT_0\,\ell n\left(\frac{V_2-nb}{V_1-nb}\right)+an^2\left(\frac{V_1-V_2}{V_1V_2}\right)$

Section (F) :

F-1. 60 cal **F-2.** 12 K **F-3.** 0.0091 J

F-4. (i) 765 J; (ii) $\frac{208}{1921}$

F-5. 110 J **F-6.** (33600 + 0.02) J

F-7. 25/6 J/cal

F-8. (a) 120 K, 240 K, 480 K, 240 K,
(b) 3500 J, 5000 J, 7000 J, 2500 J
(c) –1000 J

Section (G) :

G-1. $\frac{2}{\gamma-1}$ **G-2.** 2.5 R **G-3.** 3 R

G-4. 4.2J/cal

G-5. (a) 40 J (b) $\frac{9}{500}$ moles
(c) $\frac{125}{9}$ J/mol–K (d) $\frac{50}{9}$ J/mol–K

G-6. 0.8 JK^{-1} **G-7.** 7

Section (H) :

H-1. Q – W **H-2.** $\frac{3}{2}$ **H-3.** 128

H-4. 32P **H-5.** 4/9 %

H-6. (a) $\sqrt{2}\times 10^5$ Pa (b) $200\sqrt{2}$ K
(c) $40(2-\sqrt{2})$ J

H-7. (a) 800 kPa, 100 K (b) 1600 kPa, 200 K

H-8. 112 joule

Section (I) :

I-1. $\frac{7}{2}$R **I-2.** 7.5 R **I-3.** 1000 J

Section (J) :

J-1 66.6 % **J-2** 2.8×10^6 Joule
J-3 373.3 K **J-4** 879 kcal
J-5 10.13 **J-6** 900 Calories

PART - II

Section (A) :

A-1. (C) **A-2.** (C)

Section (B) :

B-1. (A) **B-2.** (A) **B-3.** (C)
B-4. (C) **B-5.** (C) **B-6.** (B)

Section (C) :

C-1. (B) **C-2.** (A)

Section (D) :

D-1. (A) **D-2.** (C) **D-3.** (D)

Section (E) :

E-1. (D) **E-2.** (B) **E-3.** (C)
E-4. (C) **E-5.** (B) **E-6.** (A)
E-7. (C)

Section (F) :

F-1. (D) **F-2.** (B) **F-3.** (D)
F-4. (B) **F-5.** (B)

Section (G) :

G-1. (D) **G-2.** (C) **G-3.** (B)
G-4. (C) **G-5.** (C) **G-6.** (C)

Section (H) :

H-1. (B) **H-2.** (A) **H-3.** (A)
H-4. (C) **H-5.** (A) **H-6.** (C)
H-7. (B) **H-8.** (B) **H-9.** (D)
H-10. (D)

Section (I) :

I-1.	(C)	**I-2.**	(D)	**I-3.**	(C)
I-4.	(A)	**I-5.**	(D)	**I-6.**	(D)
I-7.	(B)				

Section (J) :

J-1.	(D)	**J-2.**	(C)	**J-3.**	(B)
J-4.	(A)	**J-5.**	(A)		

PART - III

1. (A) → p, r, s ; (B) → q ; (C) → p, r, s ; (D) → q, r

2. (A) → p, s ; (B) → s ; (C) → p, s ; (D) → q, r

EXERCISE-2

PART - I

1.	(D)	**2.**	(A)	**3.**	(B)
4.	(D)	**5.**	(D)	**6.**	(D)
7.	(B)	**8.**	(C)	**9.**	(A)
10.	(A)	**11.**	(A)	**12.**	(C)
13.	(D)	**14.**	(B)	**15.**	(A)
16.	(B)	**17.**	(B)	**18.**	(B)

PART - II

1.	33	**2.**	22	**3.**	5
4.	75	**5.**	3	**6.**	12
7.	9	**8.**	5	**9.**	2
10.	15	**11.**	3	**12.**	9

PART - III

1.	(BC)	**2.**	(CD)	**3.**	(AB)
4.	(AD)	**5.**	(ABCD)	**6.**	(ABD)
7.	(AC)	**8.**	(CD)	**9.**	(AB)
10.	(ABCD)	**11.**	(BD)	**12.**	(BC)
13.	(BD)	**14.**	(AB)	**15.**	(BD)
16.	(CD)	**17.**	(CD)	**18.**	(BD)
19.	(BCD)	**20.**	(CD)		

PART - IV

1.	(C)	**2.**	(D)	**3.**	(B)
4.	(C)	**5.**	(B)	**6.**	(C)
7.	(B)	**8.**	(A)	**9.**	(A)
10.	(B)				

EXERCISE-3

PART - I

1. (A) → s; (B) → p, r; (C) → r; (D) → q, s

2.	(B)			**3.**	(C)

4. (A) → (q); (B) → (p, r); (C) → p,s; (D) → (q, s)

5.	(BD)	**6.**	(BD)	**7.**	(D)
8.	(ABCD)	**9.**	4	**10.**	(A)

11. (A) → p,r,t; (B) → p,r; (C) → q,s; (D) → r, t

12.	(D)	**13.**	(D)	**14**	(D)
15.	(BCD)	**16.**	(A)	**17.**	2
18.	(D)	**19.**	(D)	**20.**	(ABD)
21.	(ABC)	**22.**	(C)	**23.**	(A)
24.	(D)	**25.**	(D)	**26.**	(BCD)
27.	900 J	**28.**	(C)		

PART - II

1.	(3)	**2.**	(1)	**3.**	(2)
4.	(1)	**5.**	(1)	**6.**	(1)
7.	(3)	**8.**	(2)	**9.**	(2)
10.	(1)	**11.**	(2)	**12.**	(2)
13.	(1)	**14.**	(2)	**15.**	(4)
16.	(4)	**17.**	(1)	**18.**	(2)
19.	(3)	**20.**	(4)	**21.**	(1)
22.	(3)	**23.**	(2)	**24.**	(3)
25.	(1)	**26.**	(4)	**27.**	(4)
28.	(1)	**29.**	(1)		