Exercise - V (JEE PROBLEMS)

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

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

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

4. Select the correct alternative.A vessel contains 1 mole of O_2 gas (molar mass 32) at a temperature T. The pressure of the gas is P. An identical vessel containing one mole of He gas (molar mass 4) at a temperature 2T has a pressure of :
(A) P/8 (B) P (C) 2P (D) 8P

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

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

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

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

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

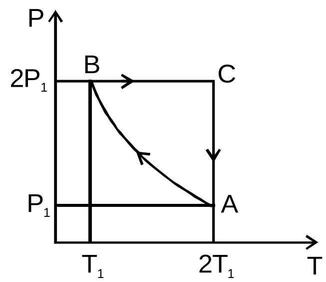
10. During the melting of a slab of ice at 273 K at atmospheric pressutre : **[JEE’98]**
(A) positive work is done by the ice-water system on the atmosphere.
(B) positive work is done on the ice-water system by the atmosphere
(C) the internal energy of the ice-water system increases
(D) the internal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

11. The ratio of the speed of sound in nitrogen gas to that in helium gas, at 300 K is
(A) $\sqrt{(2/7)}$ (B) $\sqrt{(1/7)}$
(C) $(\sqrt{3})/5$ (D) $(\sqrt{6}/5)$ **[JEE’ 99]**

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

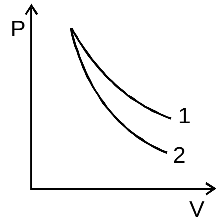
13. A weightless piston divides a thermally insulated cylinder into two parts of volumes V and 3V.2 moles of an ideal gas at pressure P = 2 atmosphere are confined to the part with volume V = 1 litre. The remainder of the cylinder is evacuated. The piston is now released and the gas expands to fill the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

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



(a) the work done on the gas in the process AB and
(b) the heat absorbed or released by the gas in each of the processes. Give answers in terms of the gas constant R. **[JEE' 2000]**

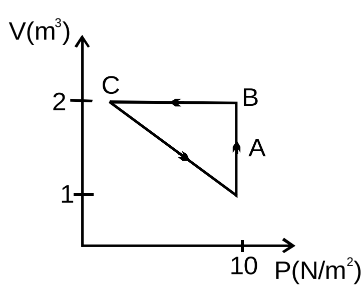
15. P-V plots for two gases during adiabatic processes are shown in the figure. Plots 1 and 2 should correspond respectively to



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

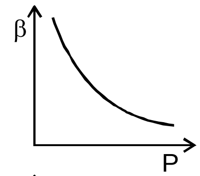
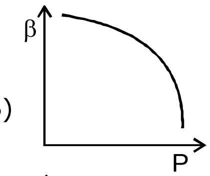
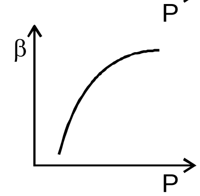
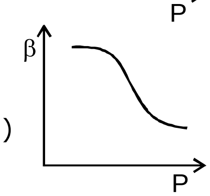
16. In a given process on an ideal gas, dW = 0 and dQ < 0. then for the gas **[JEE' 2001]**
(A) the temperature will decrease
(B) the volume will increase
(C) the pressure will remain constant
(D) the temperature will increase

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



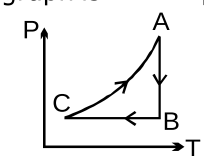
(A) – 5J (B) –10J
(C) –15J (D) –20J

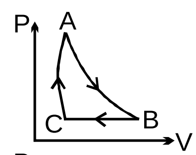
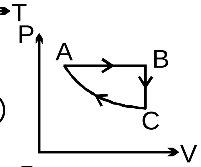
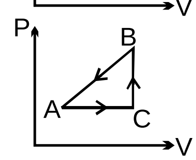
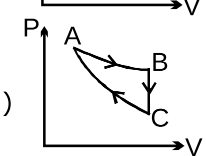
18. Which of the following graphs correctly represents the variation of $\beta = -(dV/dP)/V$ with P for an ideal gas at constant temperature ?

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

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

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

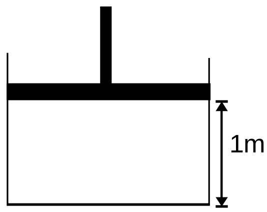


(A) 
(B) 
(C) 
(D) 

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

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

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

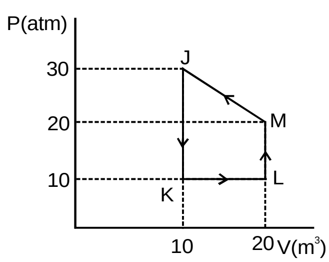


24. An ideal gas is filled in a closed rigid and thermally insulated container. A coil of 100 Ω resistor carrying current 1A for 5 minutes supplies heat to the gas. The change in internal energy of the gas is
(A) 10 KJ (B) 20 KJ (C) 30 KJ (D) 0 KJ
[JEE' 2004 (Scr)]

25. When the pressure is changed from $p_1 = 1.01 \times 10^5$ Pa to $P_2 = 1.165 \times 10^5$ Pa then the volume changes by 10% the bulk modulus is
(A) 1.55×10^5 Pa (B) 0.0015×10^5 Pa
(C) 0.015×10^5 Pa (D) none of these
[JEE' 2004 (Scr)]

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

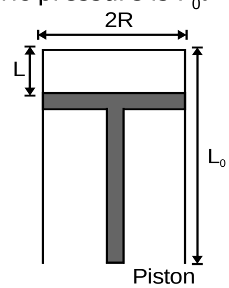
27. Match the following for the given process :



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

[JEE 2006]

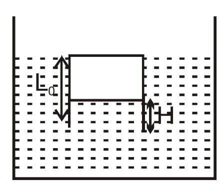
Paragraph for Question Nos. 28 to 30 (3 questions)
A fixed thermally conducting cylinder has radius R and length L_0. The cylinder is open at its bottom and has a small hole at its top. A piston of mass M is held at a distance L from the top surface, as shown in the figure. The atmospheric pressure is P_0.



28. The piston is now pulled out slowly and held at a distnace 2L from the top. The pressure in the cylinder between its top and the piston will then be
[JEE 2007]
(A) P_0 (B) $P_0/2$
(C) $\frac{P_0}{2}+\frac{Mg}{\pi R^2}$ (D) $\frac{P_0}{2}-\frac{Mg}{\pi R^2}$

29. While the piston is at a distance 2L from the top, the hole at the top is sealed. The piston is then released, to a position where it can stay in equilibrium. In this condition, the distance of the piston from the top is
(A) $\left(\frac{2P_0\pi R^2}{\pi R^2 P_0 + Mg}\right)(2L)$ (B) $\left(\frac{P_0\pi R^2 - Mg}{\pi R^2 P_0}\right)(2L)$
(C) $\left(\frac{P_0\pi R^2 + Mg}{\pi R^2 P_0}\right)(2L)$ (D) $\left(\frac{P_0\pi R^2}{\pi R^2 P_0 - Mg}\right)(2L)$
[JEE 2007]

30. The piston is taken completely out of the cylinder. The hole at the top is sealed. A water tank is brought below the cylinder and put in a position so that the water surface in the tank is at the same level as the top of the cylinder as shown in the figure. The density of the water is ρ. In equilibrium, the height H of the water column in the cylinder satisfies
[JEE 2007]



(A) $\rho g(L_0 - H)^2 + P_0(L_0 - H) + L_0P_0 = 0$
(B) $\rho g(L_0 - H)^2 - P_0(L_0 - H) - L_0P_0 = 0$
(C) $\rho g(L_0 - H)^2 + P_0(L_0 - H) - L_0P_0 = 0$
(D) $\rho g(L_0 - H)^2 - P_0(L_0 - H) + L_0P_0 = 0$

31.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

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

[JEE 2007]

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

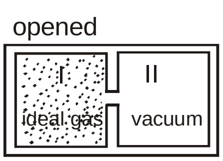
(A) $\frac{1}{T}$ (B) $\frac{2}{T}$ (C) $\frac{3}{T}$ (D) $\frac{4}{T}$

[JEE 2008]

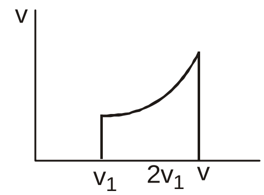
33.Column I Contains a list of processes involving expansion of an ideal gas. Match this with **Column II** describing the thermodynamic change during this process. Indicate your answer by darkening the appropriate bubbles of the 4×4 matrix given in the ORS.

[JEE 2008]

Column I	**Column II**
(A) An insulated container has two chambers separated a valve. Chamber I contains an ideal gas the Chamber II has vacaum. The valve is opened.	(p) The temperature of the by gas decreases



(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	(q) The temperature of the gas increase or remains constant
(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	(r) The gas loses heat
(D) An ideal monoatomic gas expands such that its pressure P and volume V follows the behaviour shown in the graph	(s) The gas gains heat



34. C_v and C_p denote the molar specific heat capacities of a gas at constant volume and constant pressure, respectively. Then **[JEE 2009]**

(A) $C_p - C_v$ is larger for a diatomic ideal gas than for a monoatomic ideal gas

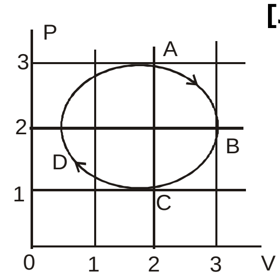
(B) $C_p + C_v$ is larger for a diatomic ideal gas than for a monoatomic ideal gas

(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

35. The figure shows the P–V plot of an ideal gas taken through a cycle ABCDA. The part ABCis a semicircle and CDA is half of an ellipse. Then,

[JEE 2009]



(A) the process during the path $A \to B$ is isothermal

(B) heat flows out of the gas during the path $B \to C \to D$

(C) work done during the path $A \to B \to C$ is zero

(D) positive work is done by the gas in the cycle ABCDA

36. This section contains 2 questions. Each questions contains statements given in two columns, which have to be matched. The statements in **Column I** are labelled A, B, C and D, while the statements in **Column II** are labelled p, q, r, s and t. Any given statement in **Column I** can have correct matching with one or more statement(s) in **Column II**. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following example :

If the correct matches are A – *p*, *s* and *t*; B – *q* and *r* ; C – *p* and *q*; and D – *s* and *t*; then the correct darkening of bubbles will look like the following.

Column II gives certain systems undergoing a process. **Column I** suggests changes in some of the parameters related to the system. Match the statements in **Column I** to the appropriate process(es) from **Column II**. **[JEE 2009]**

Column I	Column II
(A) The energy of the system is increased	(P) System: A capacitor Initially uncharged increased Process: It is connected to a battery
(B) Mechanical energy is provided to the system, which is converted into energy of random motion of its parts	(Q) System : A gas in an adiabatic container fitted with an adiabatic piston Process : The gas is compressed by pushing the piston
(C) Internal energy of the system is converted into its mechanical energy.	(R) System : a gas in a rigid container Process : The gas gets cooled due to colder atmosphere surrounding it
(D) Mass of the system is decreased	(S) System : A heavy nucleus initially at rest Process : The nucleus fissions into two fragments of nearly equal masses and some neutrons are emitted
	(T) System : A resistive wire loop Process : The loop is placed in a time varying magnetic field perpendicular to its plane.

37. A real gas behaves like an ideal gas if its

(A) pressure and temperature are both high

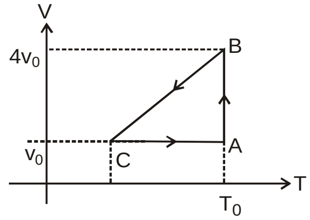
(B) pressure and temperature are both low

(C) pressure is high and temperature is low

(D) pressure is low and temperature is high

[JEE 2010]

38. One mole of an ideal gas in initial sate 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]**



(A) Internal energies at A and B are the same.

(B) Work done by the gas in process AB is $P_0V_0 \ \ell n\ 4$

(C) Pressure at C is $P_0/4$ (D) Temperature at C is $T_0/4$

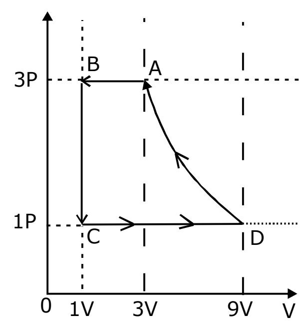
39. A diatomic ideal gas is compressed adiabatically to 1/32 of its initial volume. In the initial temperature of the gas is T_1 (in Kelvin) and the final temperature is aT_1. the value of a is **[JEE 2010]**

40. 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

(A) 9/8 RT_1 (B) 3/2 RT_1 (C) 15/8 RT_1 (D)9/2 RT_1

[JEE 2011]

41. 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 :



Column I	Column II
(A) Process A $\rightarrow$ B	(P) Internal energy decreases
(B) Process B $\rightarrow$ C	(Q) Internal energy increases
(C) Process C $\rightarrow$ D	(R) Heat is lost
(D) Process D $\rightarrow$ A	(S) Heat is gained
	(T) Work is done on the gas

[JEE 2011]

42. 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 **[JEE 2012]**

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

43. 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)

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

[JEE 2012]