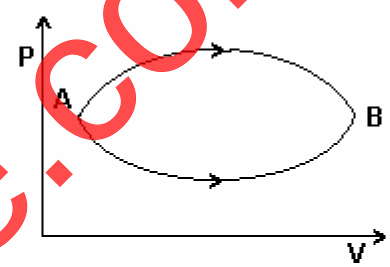
11 - HEAT AND THERMODYNAMICS
(including ideal gas and kinetic theory of gases)

(Answers at the end of all questions)

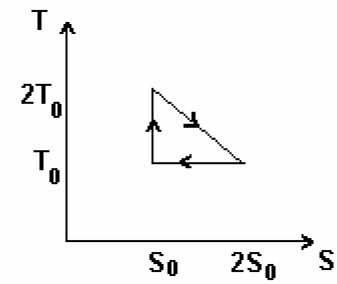
1) Which of the following is incorrect regarding the first law of thermodynamics ?
(a) It is the restatement of the principle of conservation of energy.
(b) It is not applicable to any cyclic process.
(c) It introduces the concept of entropy.
(d) It introduces the concept of the internal energy. [AIEEE 2005]

2) A system goes from A to B via two processes I and II as shown in figure. If ΔU_1 and ΔU_2 are the changes in internal energies in the processes I and II respectively, then



(a) relation between ΔU_1 and ΔU_2 cannot be determined
(b) $\Delta U_1 = \Delta U_2$ (c) $\Delta U_2 < \Delta U_1$ (d) $\Delta U_2 > \Delta U_1$
[AIEEE 2005]

3) The temperature – entropy diagram of a reversible engine cycle is given in the figure. Its efficiency is



(a) 1 / 4 (b) 1 / 2
(c) 2 / 3 (d) 1 / 3
[AIEEE 2005]

4) A gaseous mixture consists of 16 g of Helium and 16 g of oxygen. The ratio C_p / C_v of the mixture is
(a) 1.62 (b) 1.59 (c) 1.54 (d) 1.4 [AIEEE 2005]

5) Which of the following statements is correct for any thermodynamic system ?
(a) The internal energy changes in all processes.
(b) Internal energy and entropy are state functions.
(c) The change in entropy can never be zero.
(d) The work done in an adiabatic process is always zero. [AIEEE 2004]

6) One mole of ideal monatomic gas ($\gamma = 5/3$) is mixed with one mole of diatomic gas ($\gamma = 7/5$). What is γ for the mixture ?
(a) 3 / 2 (b) 23 / 15 (c) 35 / 23 (d) 4 / 3 [AIEEE 2004]

7) Two thermally insulated vessels 1 and 2 are filled with air at temperature (T_1, T_2), volume (V_1, V_2) and pressure (P_1, P_2) respectively. If the valve joining the two vessels is opened, the temperature inside he vessel at equilibrium will be

(a) $T_1 + T_2$ (b) $\dfrac{T_1 + T_2}{2}$ (c) $\dfrac{T_1 T_2 (P_1 V_1 + P_2 V_2)}{P_1 V_1 T_2 + P_2 V_2 T_1}$ (d) $\dfrac{T_1 T_2 (P_1 V_1 + P_2 V_2)}{P_1 V_1 T_1 + P_2 V_2 T2}$
[AIEEE 2004]

8) "Heat cannot by itself flow from a body at lower temperature to a body at higher temperature" is a statement as a consequence of
(a) conservation of mass (b) conservation of momentum
(c) first law of thermodynamics (d) second law of thermodynamics [AIEEE 2003]

9) 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
(a) 2 (b) 3 / 2 (c) 4 / 3 (d) 5 / 3 [AIEEE 2003]

10) A Carnot engine takes 3×10^6 cal. of heat from a reservoir at 627° C and gives it to a sink at 27° C. The work done by the engine is
(a) zero (b) 4.2×10^6 J (c) 8.4×10^6 J (d) 16.8×10^6 J [AIEEE 2003]

11) Which of the following parameters does not characterize the thermodynamic state of matter ?
(a) work (b) volume (c) pressure (d) temperature [AIEEE 2003]

12) For an isothermal expansion of a perfect gas, the value of $\Delta P / P$ is equal to
(a) $- \Delta V / V$ (b) $\gamma \Delta V / V$ (c) $- \gamma \Delta V / V$ (d) $- \gamma^2 \Delta V / V$ [AIEEE 2002]

13) The translational kinetic energy of gas molecules at temperature T for one mole of a gas is
(a) (3 / 2) RT (b) (9 / 2) RT (c) (1 / 3) RT (d) (5 / 2) RT [AIEEE 2002]

14) A gas at 300 K, enclosed in a container, is placed in a fast moving train. When the train is in motion, the temperature of the gas
(a) rises above 300 K (b) falls below 300 K
(c) remains unchanged (d) becomes unsteady [AIEEE 2002]

15) An ideal gas expands isothermally from 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) $P_3 = P_1$, $W = 0$ [IIT 2004]

16) Two rods, one of aluminium and the other made of steel, having initial length l_1 and l_2 are connected together to form a single rod of length $l_1 + l_2$. The coefficients of linear expansion for aluminium and steel are α_a and α_s respectively. If the lengthy of each rod increases by the same amount when their temperatures are raised by t° C, then the ratio $\frac{l_1}{l_1 + l_2}$ is equal to
(a) $\frac{\alpha_s}{\alpha_a}$ (b) $\frac{\alpha_a}{\alpha_s}$ (c) $\frac{\alpha_s}{\alpha_a + \alpha_s}$ (d) $\frac{\alpha_a}{\alpha_a + \alpha_s}$ [IIT 2003]

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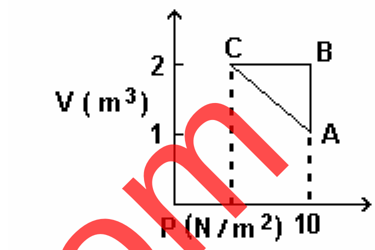
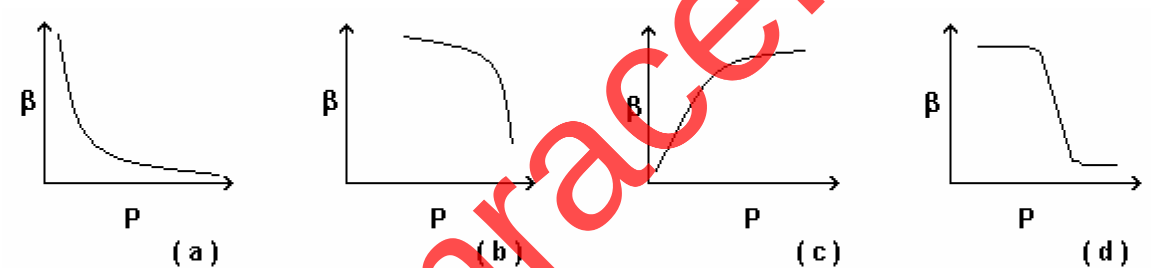
17) An ideal gas is taken through the cycle A $\rightarrow$ B $\rightarrow$ C $\rightarrow$ A, as shown in the figure. If the net heat supplied to the gas in the cycle is 5 J, the work done by the gas in the process C $\rightarrow$ A is



(a) - 5 J (b) - 10 J (c) - 15 J (d) - 20 J

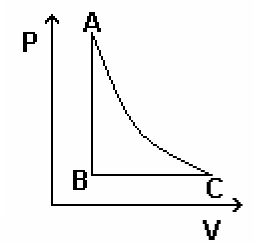
[IIT 2002]

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

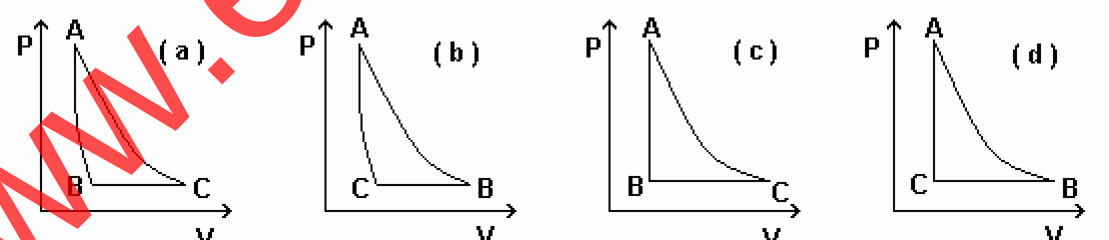


[IIT 2002]

19) The PT diagram for an ideal gas is shown in the figure, where AC is an adiabatic process. Which of the following is the corresponding PV diagram ?



[IIT 2003]

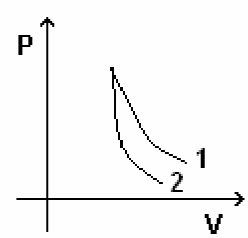


20) In a given process of an ideal gas, dW = 0 and dQ < 0. Then for the gas
(a) the temperature will decrease (b) the volume will increase
(c) the pressure will remain constant (d) the temperature will increase [IIT 2001]

21) 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

[IIT 2001]



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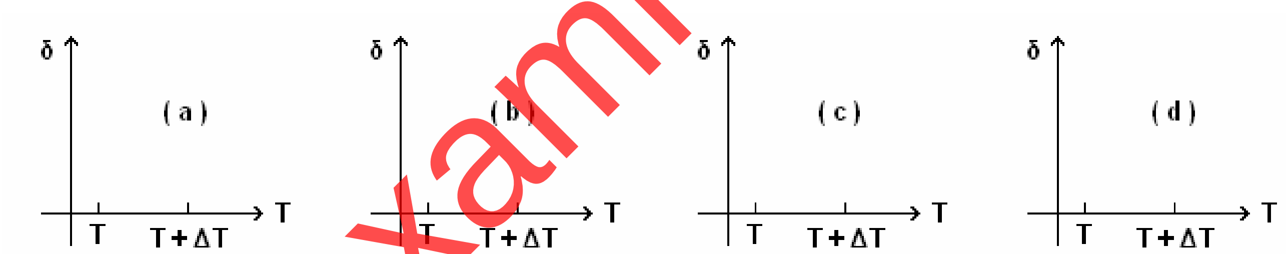
22) A monatomic ideal gas, initially at temperature T_1, is enclosed in a cylinder fitted with a frictionless piston, The gas is allowed to expand adiabatically to a temperature T_2 by releasing the piston suddenly. If L_1 and L_2 are the lengths of the gas column before and after expansion respectively, then T_1 / T_2 is given by

(a) $\left(\frac{L_1}{L_2}\right)^{\frac{2}{3}}$ (b) $\frac{L_1}{L_2}$ (c) $\frac{L_2}{L_1}$ (d) $\left(\frac{L_2}{L_1}\right)^{\frac{2}{3}}$ [IIT 2000]

23) Starting with the same initial conditions, an ideal gas expands from volume V_1 to V_2 in three different ways. The work done by the gas is W_1 if the process is purely isothermal, W_2 if purely isobaric and W_3 if purely adiabatic. Then

(a) $W_2 > W_1 > W_3$ (b) $W_2 > W_3 > W_1$
(c) $W_1 > W_2 > W_3$ (d) $W_1 > W_3 > W_2$ [IIT 2000]

24) An ideal gas is initially at temperature T and volume V. Its volume is increased by ΔV due to an increase in temperature ΔT, pressure remaining constant. The quantity $\delta = \Delta V / V\Delta T$ varies with temperature as [IIT 2000]



25) A gas mixture consists of 2 moles of oxygen and 4 moles of argon at temperature T. Neglecting all vibrational modes, the total internal energy of the system is
(a) 4 RT (b) 15 RT (c) 9 RT (d) 11 RT [IIT 1999]

26) Let $\bar{v}$, v_{rms} and v_p respectively denote the mean speed, root mean square speed and most probable speed of the molecules in an ideal monatomic gas at absolute temperature T. The mass of a molecule is m. Then

(a) no molecule can have energy greater than $\sqrt{2}\ v_{rms}$
(b) no molecule can have speed less than $v_p / \sqrt{2}$
(c) $v_p < \bar{v} < v_{rms}$
(d) the average kinetic energy of a molecule is $\frac{3}{4} m v_p^2$ [IIT 1998]

27) 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 to per N_2 molecule is
(a) 1 : 1 (b) 1 : 2 (c) 2 : 1
(d) depends on the moment of inertia of the two molecules [IIT 1998]

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28) 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 in A is 30 K, then the rise in temperature of the gas in B is
(a) 30 K (b) 18 K (c) 50 K (d) 42 K [IIT 1998]

29) 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 s now allowed to expand isothermally to the same final volume 2V. The changes in the pressure in A and B are found to be ΔP and $1.5\,\Delta P$ respectively. Then
(a) $4m_A = 9m_B$ (b) $2m_A = 3m_B$ (c) $3m_A = 2m_B$ (d) $9m_A = 4m_B$ [IIT 1998]

30) During the melting of a slab of ice at 273 K at atmospheric pressure
(a) positive work is done by he ice-water system on the atmosphere
(b) positive work is done by he ice-water system by the atmosphere
(c) the internal energy of the ice-water system increases
(d) the internal energy of the ice-water system decreases [IIT 1998]

31) A given quantity of an ideal 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 [IIT 1998]

32) 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) in eV at the same temperature is
(a) 0.0015 (b) 0.003 (c) 0.048 (d) 0.768 [IIT 1997]

33) 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 the gas (molar mass 4) at a temperature 2T has a pressure of
(a) P / 8 (b) P (c) 2P (d) 8P [IIT 1997]

34) 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, then at 480 K it becomes
(a) 4V (b) 2V (c) V / 2 (d) V / 4 [IIT 1996]

35) An ideal gas is taken from the state A (pressure P, volume V) to state B (pressure P / 2, volume 2V) along a straight line path in the P-V diagram. Select the correct statement (s) from the following:
(a) The work done by the gas in the process A to B exceeds that work that would be done by it f the system were taken from A to B along an isotherm.
(b) In the T-V diagram, the path AB becomes a part of a parabola.
(c) In the P-T diagram, the path AB becomes a part of a hyperbola.
(d) In going from A to B, the temperature T of the gas first increases to a maximum value and then decreases. [IIT 1993]

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36) Three closed vessels A, B and C are at the same temperature T and contain gases which obey the Maxwellian distribution law of velocities. 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 the 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 is

(a) $(V_1 + V_2) / 2$ (b) V_1 (c) $(V_1 V_2)^{1/2}$ (d) $\sqrt{(3kT / M)}$ [IIT 1992]

37) When an ideal diatomic gas is heated at constant pressure, the fraction of the heat energy supplied which increases the internal energy of the gas is

(a) 2 / 5 (b) 3 / 5 (c) 3 / 7 (d) 5 / 7 [IIT 1990]

38) For an ideal gas:

(a) the change in internal energy in a constant reassure 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 [IIT 1989]

39) If one mole of a monatomic gas ($\gamma = 5 / 3$) is mixed with one mole of a diatomic gas ($\gamma = 7 / 5$), the value of γ for the mixture is

(a) 1.40 (b) 1.50 (c) 1.53 (d) 3.07 [IIT 1988]

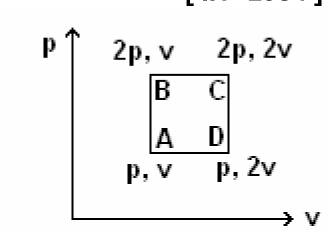
40) 70 calories of heat are required to raise the temperature of 2 moles of an ideal gas at constant pressure from 30° C to 35° C. he amount of heat required (in calories) to raise the temperature of the same gas through the same range (30° C to 35° C) at constant volume is

(a) 30 (b) 50 (c) 70 (d) 90 [IIT 1985]

41) At room temperature, the r.m.s. speed of the molecules of a certain diatomic gas is found to be 1930 m / s. The gas is

(a) H_2 (b) F_2 (c) O_2 (d) Cl_2 [IIT 1984]

42) An ideal monatomic gas is taken round the cycle ABCDA as shown in the p-v diagram. The work done during the cycle is



(a) pv (b) 2pv (c) $\frac{1}{2}$ pv (d) zero

[IIT 1983]

Answers

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
b,c	b	d	a	b	a	c	d	b	c	a	a	a	c	c	c	a	a	none	a	b

22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
d	a	c	d	c,d	a	d	c	b,c	b	c	c	b	a,b	d	d	a,b,c,d	c	b

41	42
a	a