Exercise-1

✍ Marked Questions can be used as Revision Questions.

OBJECTIVE QUESTION

Section (A) : Kinetic Theory of gases

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

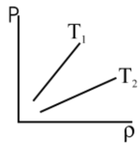
A-2. Which of the following quantities is zero on an average for the molecules of an ideal gas in equilibrium ?
(1) kinetic energy (2) momentum (3) density (4) speed

A-3. The average momentum of a molecule in a sample of an ideal gas depends on
(1) temperature (2) number of moles (3) volume (4) none of these

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

B-1. A gas behaves more closely as an ideal gas at
(1) low pressure and low temperature (2) low pressure and high temperature
(3) high pressure and low temperature (4) high pressure and high temperature

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



(1) $T_1 > T_2$
(2) $T_1 = T_2$
(3) $T_1 < T_2$
(4) any of the three is possible

B-3. Suppose a container is evacuated to leave just one molecule of a gas in it. Let v_a and v_{rms} represent the average speed and the rms speed of the gas.
(1) $v_a > v_{rms}$ (2) $v_a < v_{rms}$ (3) $v_a = v_{rms}$ (4) v_{rms} is undefined

B-4.✍ The rms speed of oxygen molecules in a gas is v. If the temperature is doubled and the O_2 molecule dissociate into oxygen atoms, the rms speed will become
(1) v (2) $v\sqrt{2}$ (3) $2v$ (4) $4v$

B-5. Consider a mixture of oxygen and hydrogen kept at room tempertaure. As compared to a hydrogen molecule an oxygen molecule hits the wall
(1) With greater average speed (2) with smaller average speed
(3) with greater average kinetic energy (4) with smaller average kinetic energy.

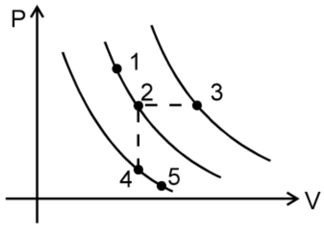
B-6. Consider the quantity MkT / pV of an ideal gas where M is the mass of the gas. It depends on the
(1) temperature of the gas (2) volume of the gas
(3) pressure of the gas (4) nature of the gas

Section (C) : Maxwell's distribution of velocities

C-1. The ratio of the mean speed of hydrogen molecules to the mean speed of nitrogen molecules in a sample containing a mixture of the two gases.

(1) $\sqrt{14}$ (2) $\sqrt{7}$ (3) $\sqrt{28}$ (4) None of these

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 :



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

Section (D) : Law of equipartition and internal energy

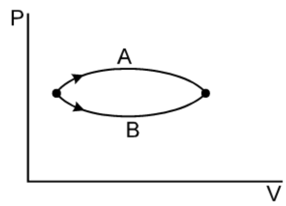
D-1. The pressure of an ideal gas is written as $E = \frac{3PV}{2}$. Here E stands for

(1) average translational kinetic energy (2) rotational kinetic energy
(3) total kinetic energy. (4) None of these

D-2. The quantities which remain same for all ideal gases at the same temperature is/are ?

(1) the kinetic energy of equal moles of gas
(2) the kinetic energy of equal mass of gas
(3) the number of molecules of equal moles of gas
(4) the number of molecules of equal mass of gas

D-3. Refer to fig. Let ΔU_1 and ΔU_2 be the changes in internal energy of an ideal gas in the processes A and B then



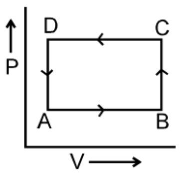
(1) $\Delta U_1 > \Delta U_2$ (2) $\Delta U_1 = \Delta U_2$
(3) $\Delta U_1 < \Delta U_2$ (4) $\Delta U_1 \neq \Delta U_2$

D-4. The quantity $\frac{2U}{fkT}$ represents (where U = internal energy of gas)

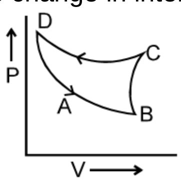
(1) mass of the gas (2) kinetic energy of the gas
(3) number of moles of the gas (4) number of molecules in the gas

Section (E) : Calculation of work

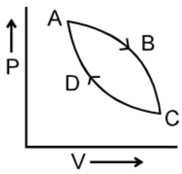
E-1. In the following figures (1) to (4), variation of volume by change of pressure is shown. A gas is taken along the path ABCDA. The change in internal energy of the gas will be:



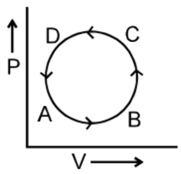
(1)



(2)



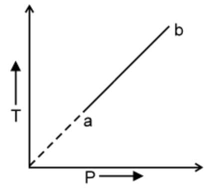
(3)



(4)

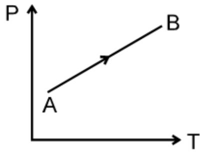
(1) positive in all cases from (1) to (4)
(2) positive in cases (1), (2) and (3) but zero in case (4)
(3) negative in cases (1), (2) and (3) but zero in case (4)
(4) zero in all the four cases.

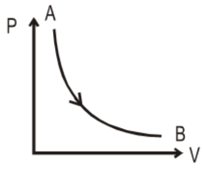
E-2. An ideal gas changes from state a to state b as shown in Fig. What is the work done by the gas in the process ?

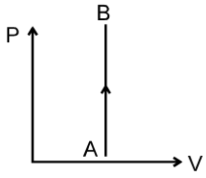


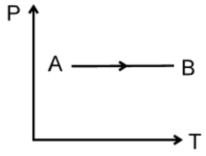
(1) zero (2) positive
(3) negative (4) infinite

E-3. The process $\Delta U = 0$, for an ideal gas can be best represented in the form of a graph :

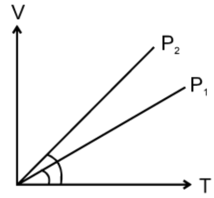
(1) 

(2) 

(3) 

(4) 

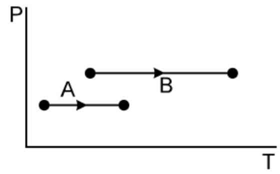
E-4. In the following V-T diagram what is the relation between P_1 and P_2 :



(1) $P_2 = P_1$
(2) $P_2 > P_1$
(3)$P_2 < P_1$
(4) cannot be predicted

E-5. In the isothermal expansion of an ideal gas. Select wrong statement:
(1) there is no change in the temperature of the gas
(2) there is no change in the internal energy of the gas
(3) the work done by the gas is equal to the heat supplied to the gas
(4) the work done by the gas is equal to the change in its internal energy

E-6. Consider two processes on a system as shown in fig. The volumes in the initial states are the same in the two porcesses and the volumes in the final states are also the same. Let ΔW_1 and ΔW_2 be the work done by the system in the processes A and B respectively.

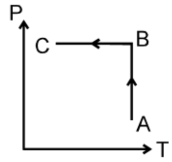


(1) $\Delta W_1 > \Delta W_2$ (2) $\Delta W_1 = \Delta W_2$ (3) $\Delta W_1 < \Delta W_2$
(4) Nothing can be said about the relation between ΔW_1 and ΔW_2

E-7. A mass of an ideal gas undergoes a reversible isothermal compression. Its molecules will then have compared with initial state, the same
(i) root mean square velocity (ii) mean mometum
(iii) mean kinetic energy
(1) (i), (ii), (iii) correct (2) (i), (ii) correct
(3) (ii), (iii) correct (4) (i) correct

Section (F) : First Law of thermodynamics

F-1. Ideal gas is taken through process shown in figure:



(1) In process AB, work done by system is positive
(2) In process AB, heat is rejected out of the system.
(3) In process AB, internal energy increases
(4) In process AB internal energy decreases and in process BC internal energy increases.

F-2. A system can be taken from the initial state p_1, V_1 to the final state p_2, V_2 by two different methods. Let ΔQ and ΔW represent the heat given to the system and the work done by the system. Which of the following must be the same in both the methods ?

(1) ΔQ (2) ΔW (3) $\Delta Q + \Delta W$ (4) $\Delta Q - \Delta W$

F-3. In isothermal process if heat is released from an ideal gas then,

(1) the internal energy of the gas will increase (2) the gas will do positive work

(3) the gas will do negative work (4) the given process is not possible

F-4. In an isothermal expansion of an ideal gas. Select wrong statement:

(1) there is no change in the temperature of the gas

(2) there is no change in the internal energy of the gas

(3) the work done by the gas is equal to the heat supplied to the gas

(4) the work done by the gas is equal to the change in its internal energy

Section (G) : Specific heat capacities of gases

G-1. 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 .

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

G-2. Boiling water is changing into steam. Under this condition, the specific heat of water is

(1) zero (2) one (3) Infinite (4) less than one

G-3. Supposing the distance between the atoms of a diatomic gas to be constant, its specific heat at constant volume per mole (gram mole) is

(1) $\frac{5}{2}R$ (2) $\frac{3}{2}R$ (3) R (4) $\frac{7}{2}R$

G-4. For an ideal gas, the heat capacity at constant pressure is larger than than that at constant volume because

(1) positive work is done during expansion of the gas by the external pressure

(2) positive work is done during expasion by the gas against external pressure

(3) positive work is done during expansion by the gas against intermolecular forces of attraction

(4) more collisions occur per unit time when volume is kept constant.

G-5. A gas has :

(1) one specific heat only (2) two specific heats only

(3) infinite number of specific heats (4) no specific heat

Section (H) : Adiabatic process and free expansion

H-1. A gas is contained in a metallic cylinder fitted with a piston. The piston is suddenly moved in to compress the gas and is maintained at this position. As time passes, after this pressure of the gas in the cylinder

(1) increases (2) decreases (3) remains constant

(4) increases or decreases depending on the nature of the gas.

H-2. Two sample A and B are initially kept in the same state. The sample A is expanded through an adiabatic process and the sample B through an isothermal process upto the same final volume. The final pressures in A and B are p_A and p_B respectively.
(1) $p_A > p_B$
(2) $p_A = p_B$
(3) $p_A < p_B$
(4) The relation between p_A and p_B cannot be deduced.

H-3. Let T_a and T_b be the final temperature of the samples A and B respectively in the previous question then
(1) $T_a < T_b$ (2) $T_a = T_b$ (3) $T_a > T_b$
(4) The relation between T_a and T_b cannot be deduced.

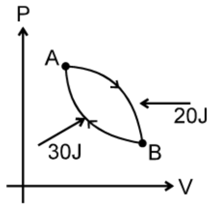
H-4. Let ΔW_a and ΔW_b be the work done by the systems A and B respectively in the previous question then
(1) $\Delta W_a > \Delta W_b$ (2) $\Delta W_a = \Delta W_b$ (3) $\Delta W_a < \Delta W_b$
(4) The relation between W_a and W_b cannot be deduced.

H-5. 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 gase is $C_v \Delta T$, where C_v is the molar heat capacity at constnat volume.
(1) (i), (ii), (iii) correct (2) (i), (ii) correct (3) (i), (iii) correct (4) (i) correct

H-6. The adiabatic bulk modulus of hydrogen gas ($\gamma = 1.4$) at NTP is :
(1) 1×10^5 N/m^2 (2) 1×10^{-5} N/m^2 (3) 1.4 N/m^2 (4) 1.4×10^5 N/m^2

H-7. A given quantity of a gas is at pressure P and absolute temperature T. The isothermal bulk modulus of the gas is:
(1) $\frac{2}{3}P$ (2) P (3) $\frac{3}{2}P$ (4) 2P

H-8. In a cyclic process shown in the figure an ideal gas is adiabatically taken from B and A, the work done on the gas during the process B → A is 30 J, when the gas is taken from A → B the heat absorbed by the gas is 20 J. The change in internal energy of the gas in the process A → B is :



(1) 20 J (2) – 30 J
(3) 50 J (4) – 10 J

H-9. An ideal gas is allowed to expand freely against a vacuum in a rigid insulated container. The gas undergoes:
(1) an increase in its internal energy
(2) a decrease in its internal energy
(3) neither an increase nor decrease in temperature or internal energy
(4) an increase in temperature

H-10. For free expansion of a gas in an adiabatic container which of the following is true ?
(1) Q = W = 0 and $\Delta U = 0$ (2) Q = 0, W > 0 and $\Delta U = Q$
(3) W = 0, Q > 0 and $\Delta U = Q$ (4) W = 0, Q < 0 and $\Delta U = 0$

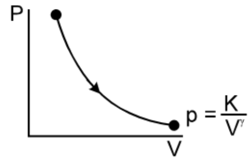
H-11. In an adiabatic process on a gas with $\gamma = 1.4$, the pressure is increased by 0.5%. The volume decreases by about

(1) 0.36% (2) 0.5% (3) 0.7& (4) 1%

H-12. 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 isothermal, W_2 if isobaric and W_3 if adiabatic, then :

(1) $W_2 > W_1 > W_3$ (2) $W_2 > W_3 > W_1$ (3) $W_1 > W_2 > W_3$ (4) $W_1 > W_3 > W_2$

H-13. The molar heat capacity for the process shown in fig. is



(1) $C = C_p$ (2) $C = C_v$
(3) $C > C_v$ (4) $C = 0$

Section (I) : Second Law of thermodynamics

I-1. A Carnot engine works between 600 K and 300 K. In each cycle of operations, the engine draws 1000 joule of energy from the source at 600 K. The efficiency of the engine is -

(1) 20% (2) 50% (3) 70% (4) 90%

I-2. In the above problem, the useful work done by the engine is -

(1) 100 joule (2) 500 joule (3) 1000 joule (4) 150 joule

I-3. In the above problem, the energy rejected to the sink is -

(1) 100 joule (2) 500 joule (3) 1000 joule (4) 300 joule

I-4. A Carnot engine works between ice point and steam point. Its efficiency will be -

(1) 26.81 % (2) 53.36 % (3) 71.23 % (4) 85.42 %

I-5. A Cannot engine works between 200ºC and 0ºC. Another Carnot engine works between 0ºC and –200ºC. In both cases the working substance absorbs 4 kilocalories of heat from the source. The efficiency of first engine will be -

(1) $\frac{100}{473}$ (2) $\frac{200}{473}$ (3) $\frac{200}{273}$ (4) $\frac{273}{373}$

I-6. In the above problem, the efficiency of second engine will be -

(1) $\frac{100}{273}$ (2) $\frac{173}{273}$ (3) $\frac{200}{273}$ (4) $\frac{273}{373}$

I-7. In the above problem, the ratio of efficiencies of two engines will be -

(1) 0.18 (2) 0.38 (3) 0.58 (4) 0.78

I-8. In the above problem, the mount of useful work done by the first engine is -

(1) 7.1×10^3 Joule (2) 3.8×10^4 Joule (3) 5.9×10^5 Joule (4) 9.3×10^6 Joule