Code: Phy/HnT/O-S/004

Heat – Specific Heat of Gases: Objective and Subjective Questions (Typical)

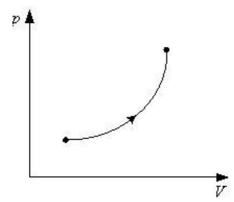
No of Questions: 55 **Time Allotted: 6 Hours**

All questions are compulsory

[Note: Figures are conceptual only and not to the scale]

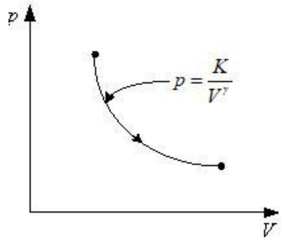
Guidelines:

1. **Take questions in Two parts in different time slots of Three hours each, with proper refreshing break of minimum two hours**
2. **Part One – covers Q-01 to Q-30; Part Two – Covers Q-31 to Q-55.**

Q-01	Work done by a sample of an ideal gas in a process A is double the work done in another process B. The temperature rises through the same amount in the two processes. If C_A and C_B be the molar heat capacities for the two processes, (a) $C_A = C_B$ (b) $C_A < C_B$ (c) $C_A > C_B$ (d) C_A and C_B cannot be defined.
Q-02	For a solid with a small expansion coefficient, (a) $C_P - C_V = R$ (b) $C_P = C_V$ (c) C_P is slightly greater than C_V (d) C_P is slightly less than C_V
Q-03	Value of $C_P - C_V$ is $1.00R$ for a gas sample in state A and is $1.08R$ in state B. Let p_A and p_B denote pressures, and T_A and T_B denote temperatures of the state A and B respectively. Most likely (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 $T_A = T_B$
Q-04	Let C_V and C_P denote molar heat capacities of an ideal gas at constant volume and pressure respectively. Which of the following is a universal constant ? (a) $\frac{C_P}{C_V}$ (b) $C_P C_V$ (c) $C_P - C_V$ (d) $C_P + C_V$
Q-05	70 calories of heat is required to raise the temperature of 2 mole of an ideal gas at constant pressure from 30^0C to 35^0C. The amount of heat required to raise the temperature of the same gas through the same range at constant volume is (a) 30 calories (b) 50 calories (c) 70 calories (d) 90 calories
Q-06	Process on a gas in which pressure and volume both change is shown in the figure. The molar heat capacity for this process is C. (a) $C = 0$ (b) $C = C_V$ (c) $C > C_V$ (d) $C < C_V$ 

Q-07 Molar heat capacity for process shown in the figure is

(a) $C = C_P$ (b) $C = C_V$ (c) $C > C_V$ (d) $C = 0$



Q-08 In an isothermal process on an ideal gas, the pressure increases by 0.5%. The volume decreases by about

(a) 0,25% (b) 0.5% (c) 0.7% (d) 1%

Q-09 In an adiabatic process on a gas $\gamma = 1.4$, the pressure is increased by 0.5%. The volume decreases by about

(a) 0.36% (b) 0.5% (c) 0.7% (d) 1%

Q-10 Two samples 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. Final volume of the samples is same. The final pressure in A and B are p_A and p_B respectively.

(a) $p_A > p_B$ (b) $p_A = p_B$ (c) $p_A < p_B$ (d) The relation between p_A and p_B cannot be deduced.

Q-11 Two samples 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. Final volume of the samples is same. Let T_A and T_B be the final temperatures of the samples A and B respectively.

(a) $T_A < T_B$ (b) $T_A = T_B$ (c) $T_A > T_B$ (d) The relation between T_A and T_B cannot be deduced.

Q-12 Two samples 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. Final volume of the samples is same. Let ΔW_A and ΔW_B be the work done by the systems A and B respectively.

(a) $\Delta W_A > \Delta W_B$ (b) $\Delta W_A = \Delta W_B$

(c) $\Delta W_A < \Delta W_B$ (d) The relation between ΔW_A and ΔW_B cannot be deduced.

Q-13 The molar heat capacity of oxygen gas at STP is nearly 2.5 R. As the temperature is increased, it gradually increases and approaches 3.5 R. The most appropriate reason for this behavior is that at high temperatures

(a) Oxygen does not behave as an ideal gas
(b) Oxygen molecules dissociate in atoms
(c) The molecules collide more frequently
(d) Molecular vibrations gradually become effective.

Q-14 A gas sample is kept in a container of finite conductivity is suddenly compressed. The process

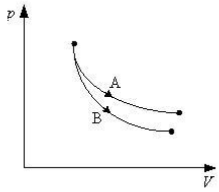
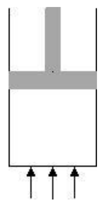
(a) Must be very nearly adiabatic
(b) Must be very nearly isothermal
(c) May be very nearly adiabatic
(d) May be very nearly isothermal

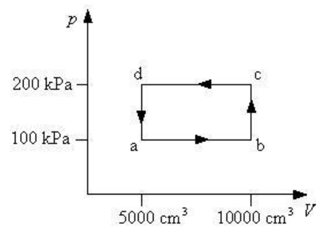
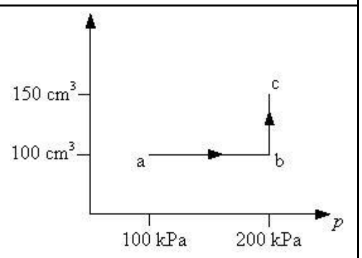
Q-15 Let Q and W denote the amount of heat given to an ideal gas and the work done by it in an isothermal process.

(a) $Q = 0$ (b) $W = 0$ (c) $Q \neq W$ (d) $Q = W$

Q-16 Let Q and W denote the amount of heat given to an ideal gas and the work done by it in an adiabatic process.

(a) $Q = 0$ (b) $W = 0$ (c) $Q = W$ (d) $Q \neq W$

Q-17	Consider the processes A and B shown in the figure. It is possible that (a) Both the processes are isothermal (b) Both the processes are adiabatic (c) A is isothermal and B is adiabatic (d) A is adiabatic and B is isothermal 
Q-18	Three identical adiabatic containers A, B and C contain helium, neon and oxygen respectively at equal pressure. The gases are pushed to half of their volumes. (a) The final temperatures in the three containers will be the same. (b) The final pressure in the three containers will be the same. (c) The pressures of helium and neon will be the same but that of oxygen will be different. (d) The temperatures of helium and neon will be the same but that of oxygen will be different
Q-19	A rigid container of negligible heat capacity contains one mole of an ideal gas. The temperature of the gas increases by 1^0C if 3.0 cal of heat is added to it. The gas may be (a) Helium (b) Argon (c) Oxygen (d) Carbon dioxide
Q-20	Four cylinders contain equal number of moles of argon, hydrogen, nitrogen and carbon dioxide at same temperature. The energy is minimum in (a) Argon (b) Hydrogen (c) Nitrogen (d) Carbon Dioxide
Q-21	A vessel containing one mole of a monatomic ideal gas (molecular weight =20 $g.mol^{-1}$) is moving on a floor at a speed of 50 $m.s^{-1}$. The vessel is stopped suddenly. Assuming that the mechanical energy lost has gone into internal energy of the gas, find the rise in its temperature.
Q-22	5 g of a gas is contained in a rigid container and is heated from 15^0C to 25^0C. Specific heat capacity of the gas at constant volume is 0.172 $cal.g^{-1}.^0C^{-1}$ and the mechanical equivalent of heat is 4.2 $J.cal^{-1}$. Calculate the change in the internal energy of the gas.
Q-23	Figure shows a cylindrical container containing oxygen $(\gamma = 1.4)$ and closed by a 50 kg frictionless piston. The area of cross-section is 100 cm^2, atmospheric pressure is 100 kPa and g is 10 $m.s^{-2}$. The cylinder is slowly heated for some time. Find the amount of heat supplied to the gas if piston moves out through a distance 20 cm. 
Q-24	The specific heat capacities of hydrogen at constant volume and constant pressure are 2.4 $cal.g^{-1}.^0C^{-1}$ and 3.4 $cal.g^{-1}.^0C^{-1}$ respectively. The molecular weight of hydrogen is 2 $g.mol^{-1}$ and the gas constant $R = 8.3\times10^7\ erg.^0C^{-1}\cdot mol^{-1}$. Calculate value of J.
Q-25	The ratio the molar heat capacities of an ideal gas is $\frac{C_P}{C_V} = \frac{7}{6}$. Calculate change in internal energy of 1.0 mol of the gas when its temperature is raised by 50 K (a) Keeping the pressure constant (b) Keeping volume constant (c) Process is adiabatic
Q-26	A sample of air weighing 1.18 g occupies $1.0\times10^3\ cm^3$ when kept at a 300 K and 1.0×10^5 Pa. When 2.0 cal of heat is added to it at constant volume, its temperature increases by 1^0C. Calculate the amount of heat needed to increase the temperature of air by 1^0C at constant pressure if mechanical equivalent of heat is 4.2×10^{-7} $erg.cal^{-1}$. Assume that air behaves as an ideal gas,

Q-27	An ideal gas expands from 100 cm^3 to 200 cm^3 at a constant pressure 2.0×10^5 Pa when 50 J of heat is added to it. Calculate – (a) The change in internal energy of the gas (b) The number of moles in the gas if initial temperature is 300 K, (c) The molar heat capacity C_P at constant pressure, (d) The molar heat capacity C_V at constant volume
Q-28	An amount Q of heat is added to a monatomic ideal gas in a process in which the gas performs a work $W=\frac{Q}{2}$ on its surrounding. Find the molar heat capacity for the process.
Q-29	An ideal gas is taken through a process in which the pressure and the volume are changed according to the equation $p=kV$. Show that the molar heat capacity of the gas for the process is given by $C=C_V+\frac{R}{2}$.
Q-30	An ideal gas $\left(\frac{C_P}{C_V}=\gamma\right)$ is taken through a process in which the pressure and volume vary as $p=aV^b$. Find the value of b for which the specific heat capacity in the process is zero.
Q-31	Two ideal gases have same value of $\frac{C_P}{C_V}=\gamma$. What will be the value of this ratio for a mixture of the two gases in the ratio 1:2 ?
Q-32	A mixture contains 1 mol of helium $\left(C_P=2.5R, C_V=1.5R\right)$ and 1 mol of hydrogen $\left(C_P=3.5R, C_V=2.5R\right)$. Calculate C_P, C_V and γ of the mixture.
Q-33	Half mole of an ideal gas $\left(\gamma=\frac{5}{3}\right)$ is taken through the cycle *abcda* as shown in the figure. Take $R=\frac{25}{3}$ $J.K^{-1}.mol^{-1}$. Find –  (a) The temperature of gas in the states *a, b, c*, and *d*. (b) The amount of heat supplied in the process *ab* and *bc*, (c) The amount of heat liberated in the process *cd* and *da*.
Q-34	An ideal gas $(\gamma=1.67)$ is taken through the process *abc* as shown in the figure. The temperature at the point a is 300 K. Calculate –  (a) The temperatures at b and c, (b) The work done in the process, (c) The amount of heat supplied in the path *ab* and in the path *bc*, (d) The change in internal energy of the gas in the process.
Q-35	In Joly's differential steam calorimeter, 3 g of an ideal gas is contained in a rigid closed sphere at 20^0C. The sphere is heated by steam at 100^0C and it is found that an extra 0.095 g of steam has condensed into water as the temperature of the gas becomes constant. Calculate the specific heat capacity of gas in $J.g^{-1}.K^{-1}$. The latent heat of vaporization of water is 540 $cal.g^{-1}$.
Q-36	The volume of an ideal gas $(\gamma=1.5)$ is changed adiabatically from 4.00 liters to 3.00 liters. Find the ratio of – (a) The final pressure to the initial pressure, (b) The final temperature to initial temperature

Q-37	An ideal gas at pressure 2.5×10^5 Pa and temperature 300 K occupies 100 cc. It is adiabatically compressed to half its original volume. Taking $\gamma=1.5$, calculate – (a) The final pressure, (b) The final temperature (c) The work done by the gas in the process.
Q-38	Air $(\gamma=1.4)$ is pumped at 2 atm pressure in a motor tyre at 20^0C. If the tyre suddenly burst, what would be the temperature of the air coming out of the tyre. Neglect any mixing with the atmospheric air.
Q-39	A gas is enclosed in a cylindrical can fitted with a piston. The wall of the can and the piston are adiabatic. The initial pressure, volume and temperature of the gas are 100 kPa, 400 cm^3 and 300 K respectively. The ratio of specific heat capacities of the gas is $\frac{C_P}{C_V}=1.5$. Find the pressure and temperature of the gas if it is (a) compressed s (b) slowly compressed to 100 cm^3.
Q-40	The initial pressure and volume of a given mass of a gas $\left(\frac{C_P}{C_V}=\gamma\right)$ are p_0 and V_0. The gas can exchange heat with the surrounding. (a) It is slowly compressed to a volume $\frac{V_0}{2}$ and then suddenly compressed to $\frac{V_0}{4}$ Find the final pressure. (b) If the gas is suddenly compressed from the volume V_0 to $\frac{V_0}{2}$, and then slowly compressed to $\frac{V_0}{4}$ what will be the final pressure?
Q-41	Consider a given sample of an ideal gas $\left(\frac{C_P}{C_V}=\lambda\right)$ having initial pressure p_0 and volume V_0. (a) The gas is isothermally taken to a pressure $\frac{p_0}{2}$ and from there adiabatically to a pressure $\frac{p_0}{4}$. Find the final volume. (b) The gas is brought back to its initial state. It is taken adiabatically to a pressure $\frac{p_0}{2}$ and from there isothermally to a pressure $\frac{p_0}{4}$. Find the final volume.
Q-42	A sample of an ideal gas $(\lambda=1.5)$ is compressed adiabatically from a volume of 150 cm^3 to 50 cm^3. The initial pressure and initial temperatures are 150 kPa and 300 K. Find – (a) The number of moles of the gas in the sample, (b) The molar heat capacity at constant volume, (c) The final pressure and temperature, (d) The work done by the gas in the process, (e) The change in the internal energy of the gas.
Q-43	Three samples A, B, and C of the same gas $(\lambda=1.5)$ have equal volumes and temperatures. The volume of each sample is doubled, the process being isothermal for A, adiabatic for B and isobaric for C. If the final pressures are equal for the three samples, find the ratio of the initial pressures.
Q-44	Two samples of the same gas have equal volumes and pressures. The gas in the sample A is expanded isothermally to double its volume and the sample B is expanded adiabatically to double its volume. If the work

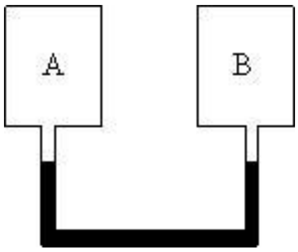
done by the gas is same for the two cases, show that γ satisfies the equation $1-2^{1-\gamma}=(\gamma-1)\ln 2$.

Q-45 1 liter of an ideal gas $(\lambda=1.5)$ at 300 K is suddenly compressed to half its original volume.

(a) Find the ratio of the final pressure to the initial pressure,
(b) If the original pressure is 100 kPa, find the work done by the gas in the process,
(c) What is the change in internal energy?
(d) What is the final temperature?
(e) The gas is now cooled to 300 K keeping its pressure constant. Calculate the work done during the process,
(f) The gas is now expanded isothermally to achieve its original volume of 1 liter. Calculate the work done by the gas,
(g) Calculate the total work done in the cycle.

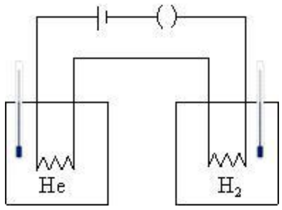
Q-46 Figure shows a cylindrical tube with adiabatic walls and fitted with adiabatic separator. The separator can be slid into the tube by an external mechanism. An ideal gas $(\lambda=1.5)$ is injected in the two sides at equal pressures and temperatures. The separator remains in equilibrium at the middle. It is now slid to a position where it divides the tube in the ratio 1:3. Find the ratio of the temperatures in the two parts of the tube.

Q-47 Figure shows two rigid vessels A and B, each of volume 200 cm^3 containing an ideal gas $(C_V=12.5 J.K^{-1}.mol^{-1})$. The vessels are connected to a manometer tube containing mercury. The pressure in both the vessels is 75 cm of mercury and the temperature is 300 K.



(a) Find the number of moles of gas in each vessel,
(b) 5.0 J of heat is supplied to the gas in the vessel A and 10 J of heat is supplied to the gas in vessel B. Assuming no appreciable transfer of heat from A to B, calculate the difference in the height of mercury in the two sides of the manometer. Gas constant $R=8.3 J\cdot K^{-1}\cdot mol^{-1}$.

Q-48 Figure shows two vessels with adiabatic walls one containing 0.1 g of helium $(\gamma=1.67, M=4 g\cdot mol^{-1})$ and the other containing some amount of hydrogen $(\gamma=1.4, M=2 g\cdot mol^{-1})$. Initially, the temperatures of the two gases are equal. The gases are electrically heated for some time during which equal amount of heat are given to the two gases. It is found that the temperatures rise through the same amount in the two vessels. Calculate the mass of hydrogen.



Q-49 Two vessels A and B of equal volume are connected by a narrow tube which can be closed by a valve. The vessels are fitted with pistons which which can be moved to change the volumes. Initially, the valve is open and the vessels contain an ideal gas $\left(\frac{C_P}{C_V}=\lambda\right)$ at atmospheric pressure p_0 and temperature T_0 . The walls of the vessel A are diathermic and those of B are adiabatic. The valve is now closed and the pistons are slowly pulled out to increase the volumes of the vessels to doubles the original value.

(a) Find the temperatures and pressures in the two vessels.
(b) The valve is now opened for sufficient time so that the gases acquire a common temperature and pressure. Find the new values of the temperature and pressure.

Q-50 Figure shows an adiabatic cylindrical tube of volume V_0 divided in two parts by a frictionless adiabatic separator. Initially, the separator is kept in the middle, an ideal gas at pressure p_1 and temperature T_1 is injected into the left part and another ideal gas at pressure

	p_2 and temperature T_2 is injected into the right part. $\frac{C_P}{C_V} = \gamma$ is same for both the gases. The separator is slid slowly and is released at a position where it can stay in equilibrium. Find- (a) The volume of the two parts, (b) The heat given to the gas in the left part, (c) The final common pressure of the gases.
Q-51	An adiabatic cylindrical tube of cross-sectional area 1 cm^2 is closed at one end and fitted with a piston at the other end. The tube contains 0.03 g of an ideal gas. At 1 atm pressure and at the temperature of the surrounding, the length of the gas column is 40 cm. The piston is suddenly pulled out to double the length of the column. The pressure of the gas falls to 0.355 atm. Find the speed of sound in the gas at atmospheric pressure.
Q-52	The speed of sound in hydrogen at 0^0C is 1280 $m.s^{-1}$. The density of hydrogen at STP is 0.089 $kg.m^{-3}$. Calculate the molar heat capacities C_p and C_v of hydrogen.
Q-53	4.0 g of helium occupies 22400 cm^3 at STP. The specific heat capacity of helium at constant pressure is 5.0 $cal.K^{-1}.mol^{-1}$. Calculate the speed of sound in helium at STP.
Q-54	An ideal gas having density 1.7×10^{-3} $g.cm^{-3}$ at a pressure 1.5×10^5 Pa is filled in Kundt tube. When gas is resonated at a frequency of 3.0 kHz nodes are formed at a separation of 6.0 cm. Calculate the molar heat capacities C_P and C_V of the gas.
Q-55	Standing waves of frequency 5.0 kHz are produced in a tube filled with oxygen at 300 K. The separation between consecutive nodes is 3.3 cm. Calculate the specific heat capacities C_P and C_V of the gas.

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