Code: Phy/HnT/O-S/003

Heat – Calorimetry & Laws of Thermodynamics : Objective and Subjective Questions (Typical)

No of Questions: 67 **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-67.**

Q-01	The specific heat capacity of a body depends on (a) The heat given (b) The temperature raised (c) The mass of the body (d) The material of the body
Q-02	Water equivalent of a body in heat is measured in (a) kg (b) Calorie (c) Kelvin (d) m^3
Q-03	When a hot liquid is mixed with a cold liquid, the tenmperature of the mixture is (a) First decreases and then becomes constant (b) First increases ansd then become constant (c) Continuously increases (d) Is undefined for some time and then becomes nearly constant
Q-04	Which of the following pairs represent units of the same physical quantity? (a) Kelvin and Joule (b) Kelvin and Calorie (c) Newton and Calorie (d) Joule and Calorie
Q-05	Which of the following pairs of physical quantities may be represented in the same unit? (a) Heat and Temperature (b) Temperature and Mole (c) Heat and work (d) Specific heat and Heat
Q-06	Two bodies at different temperatures are mixed in a calorimeter. Which of the following quantities remains conserved? (a) Sum of the temperatures of the two bodies (b) Total heat of the two bodies (c) Total internal energy of the two bodies (d) Internal energy of each body

Q-07	The mechanical equivalent of heat (a) Has the same dimension as heat (b) Has the same dimension as work (c) Has the same dimension as energy (d) Is Dimensionless
Q-08	The heat capacity of a body depends on (a) The heat given (b) The temperature raised (c) The mass of the body (d) Material of the body
Q-09	The ratio of specific heat capacity to molar heat of a body (a) Is a unviersal constant (b) Depends on the mass of the body (c) Depends on the molecular weight of the body (d) Is dimensionless
Q-10	If heat is supplied to a solid, its temperature (a) Must increase (b) May increase (c) May remain constant (d) May decrease
Q-11	The temperature of a solid object is observed to be constant. In this period (a) Heat may have been supplied to the body (b) Heat may have been extracted from the body (c) No heat is supplied to the body (d) No heat is extracted from the body
Q-12	The temperature of an object is observed to raise in a period. In this period (a) Heat is certainly supplied to it (b) Heat is certainly not supplied to it (c) Heat may have been supplied to it (d) Work may have been done on it
Q-13	Heat and work are equivalent. This means, (a) When we supply heat to a body we do work on it. (b) When we do work on a body we supply heat to it. (c) The temperature of a body can be increased by doing work on it. (d) A body kept at rest may set into motion along a line by supplying heat to it.
Q-14	An aluminium vessel of mass 0.5 kg contains 0.2 kg of water at 20^0C. A block of iron of mass 0.2 kg at 100^0C is gently put into the water. Find the equilibrium temperature of the mixture. Specific heat capacities of aluminium, iron and water are 910 J $kg^{-1}K^{-1}$, 470 J $kg^{-1}K^{-1}$ and 4200 J $kg^{-1}K^{-1}$ respectively.
Q-15	A piece of iron of mass 100 g is kept inside a furnace for a long time and then put in a calorimeter of water equivalent 10 g containing 240 g of water at 20^0C. The mixture attains an equilibrium temperature of 60^0C. Find the temperature of the furnace. Specific heat capacity of iron is 470 J $kg^{-1}K^{-1}$.
Q-16	The temperature of equal masses of three different liquids A, B and C are 12^0C, 19^0C and 28^0C respectively. The temperasture when A and B are mixed is 16^0C, and when B and C are mixed, it is 23^0C. What will will be the temperature when A and C are mixed?
Q-17	Four $2cm \times 2cm \times 2cm$ ice cubes are taken out from a refrigerature and put in 200 ml of a drink at 10^0C. (a) Find the temperature of the drink when thermal equilibrium is attained in it. (b) If the ice cubes do not melt completely, find the amount melted. Assume that no heat is lost to the outside of the drink and the container has negligible heat capacity. Given that density of the ice is 900 $kg.m^{-3}$, density of the drink is is 1000 $kg.m^{-3}$, specific heat capacity of the drink is 4200 $J.kg^{-1}K^{-1}$ and latent heat of fusion of ice is 3.4×10^5 J. kg^{-1} .

Q-18	Indian style of cooling drinking water is to keep it in a pitcher having porous walls. Water comes to the outer surface very slowly and evaporates. Most of the energy needed for evaporation is taken from the water itself and water is cooled down. Assume that a pitcher contains 100 kg of water and 0.2 g of water comes out per second. Assuming no backward heat transfer from the at=osphere to the water, calculate the time in which the temperature decreases by 5^0C. Specific heat capacity of water is 4200 J.kg^{-1}C^{-1} and latent heat of vapourization is 2.27×10^6 J. kg^{-1} .
Q-19	A cube of iron having density 8×10^3 kg. m^{-3}, and specific heat capacity 470 J.kg. K^{-1} is heated to a high temperature and is placed on a large block of ice at 0^0C. The cube melts the ice below it, displaces the water and sinks. In final equilibrium position, its upper surface just goes inside the ice. Calculate the initial temperature of the cube. Neglect any loss of heat outside the ice and the cube. The density of the ice is is 900 kg.m^{-3} and latent heat of fusion of ice is 3.36×10^5 J.kg^{-1}.
Q-20	1 kg of ice at 0^0C is mixed with 1 kg of steam at 100^0C. What will be composition of the system when thermal equilibrium is reached? Latent heat of fusion of ice is 3.36×10^5 J.kg^{-1} and latent heat of evaporation of water is 2.26×10^6 J.kg^{-1}.
Q-21	Calculate the time required to heat 20 kg of water from 10^0C to 35^0C using an immersion water heater rated 1000 W. Assume that 80% of power input is used to heat the water. Specific haet capacity of water is 4200 J.kg^{-1}K^{-1}.
Q-22	On a winter day the temperature of the tap water is 20^0C, whereas room tempearture is 5^0C. Water is stored in a tank of capacity 0.5 m^3 for household use. If it were possible to use the heat liberated by water to lift a 10 kg mass vertically, how high can it belifted as the water comes to room temperature? Take $g = 10\text{m}\times\text{s}^{-2}$.
Q-23	A bullet of mass 20 g enters into a fixed wooden block with a speed of 40 m.s^{-1} and stops in it. Find change in internal energy during the process.
Q-24	A 50 kg man is running at a speed of 18 km.h^{-1}. If all the kinetic energy of the man can be used to increase the temerature of water from 20^0C to 30^0C, how much water can be heated with this energy?
Q-25	A brick weighing 4.0 kg is dropped into a 1.0 m deep river from a height of 2.0 m. Assuming that 80 % of the gravitational potential energy is finally converted into thermal energy, find this thermal energy in calorie.
Q-26	A van of mass 1500 kg travelling at a speed of 54 km.h^{-1} is stopped in 10 s. Assuming that all the mechanical energy lost appears as thermal energy in a the brake mechanism, find the average rate of production of thermal energy in cal.s^{-1}.
Q-27	A block of mass 100 g slides on a rough horizontal surface. If the speed of the block decreases from 10 m.s^{-1} to 5 m.s^{-1}, find the thermal energy developed in the process.
Q-28	Two blocks of masses 10 kg and 20 kg moving at 10 m.s^{-1} to 20 m.s^{-1} respectively in opposite directions, approach each other and collide. If the collision is completely inelastic, find the thermal energy developed in the process.
Q-29	A ball is dropped on a floor from a height of 2.0 m. After the collision it rises to a height of 1.5 m. Assume that 40% of mechanical energy lost goes as thermal energy into the ball. Calculate the rise in the temperature of the ball in the collision. Specific Heat capacity of the ball per unit of mass is 800 J.K^{-1}.
Q-30	A copper cube of mass 200 g slides down on a rough inclined plane of inclinitation 37^0 at a constant speed. Assume that any loss in mechanical energy goes into the copper block as its thermal energy. Find the increase in the temperature of the block as it slides down through 60 cm. Specific heat capacity of copper is 420 J.kg^{-}1.K^{-1}.

Q-31 A metal block of density 6000 kg.m^{-3} and mass 1.2 kg is suspended through a spring of spring-constant 200 N/.m . The spring-block system is dipped in water kept in vessel. The water has a mass of 260 g and the block is at a height 40 cm above the bottom of the vessel. If the support to the spring is broken, what will be the rise in the temperature of the water. Specific heat capacity of the block is 250 J.kg^{-1}.K^{-1}. And that of water is 4200 J.kg^{-1}.K^{-1} . Heat capacities of the vessel and the spring are negligible.

Q-32 The first law of Thermodynamics is a statement of

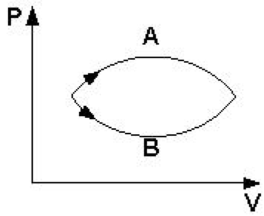
(a) Conservation of heat
(b) Conservation of work
(c) Conservation of momentum
(d) Conservation of energy

Q-33 If heat is supplied to an ideal gas in an isothermal process,

(a) The internal energy of the gas will increase
(b) The gas will do positive work
(c) The gas will do negative work
(d) The said process is not possible\

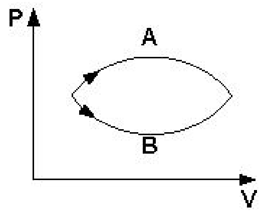
Q-34 Figure shows two processes A and B on a system. Let ΔQ_1 and ΔQ_2 be the heat given to the system in process A and B respectively. Then

(a) $\Delta Q_1 > \Delta Q_2$ (b) $\Delta Q_1 = \Delta Q_2$ (c) $\Delta Q_1 < \Delta Q_2$ (d) $\Delta Q_1 \le \Delta Q_2$



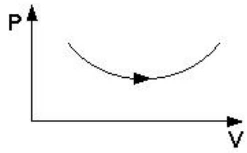
Q-35 In the figure two processes A and B are shown. Let ΔU_1 and ΔU_2 be changes in the internal energy of the system in the process A and B respectively. Then

(a) $\Delta U_1 > \Delta U_2$ (b) $\Delta U_1 = \Delta U_2$ (c) $\Delta U_1 < \Delta U_2$ (d) $\Delta U_1 \ne \Delta U_2$



Q-36 Consider the process shown in figure. During the process, the work done by the system

(a) Continuously increases
(b) Continuously decreases
(c) First increases and then decreases
(d) First decreases and then incrteases.



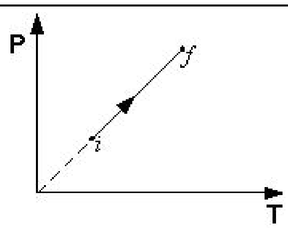
Q-37 Consider the following two statements-

(A) If heat is added to a system, its temperature must increase
(B) If positive work is done by a system in a thermodynamic process, its volume must increase.

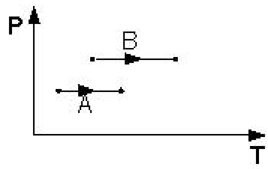
(a) Both A and B are correct
(b) A is correct but B is wrong
(c) B is correct but A is wrong
(d) Both A and B are wrong

Q-38 An ideal gas goes from state ***i*** to the state ***f*** as shown in the figure. The work done by the gas during the process

(a) Is positive (b) Is negative
(c) is Zero (d) Cannot be obtianed from this information



Q-39 Consider two processes A and B on a system as shown in the figure. The volumes in the initial states are the same in the two process, and volumes in the final states are also the same. Let ΔW_1 and ΔW_2 are the work done by the system in the processes A and B respectively.



(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

Q-40 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 the time passes the pressure of the gas in the cylinder

(a) Increases (b) Decreases

(c) Remains constant (d) Increases or decreases depending on the nar=ture of the gas

Q-41 The pressure p and volume V of an ideal gas both increase in a process

(a) Such a process is not possible

(b) The work done by the system is positive

(c) The temperature of the system must increase

(d) Heat supplied to the gas is equal to the change in the internal energy.

Q-42 In a process on a system, the initial pressure and volume are equal to the final pressure and volume.

(a) The initial temperature must be equal to the final temperature

(b) The initial internal energy must be equal to the final internal energy.

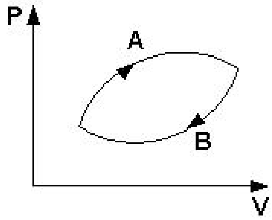
(c) The net heat given to the system in the process must be zero

(d) The net work done by the system in the process must be zero

Q-43 A system can be taken from 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 the both the methods?

(a) ΔQ (b) ΔW (c) $\Delta Q + \Delta W$ (d) $\Delta Q - \Delta W$

Q-44 In the figure ΔU_1 and ΔU_2 be the change in internal energy in processes A and B respectively. ΔQ be the net heat given to the system in the process $A + B$ and ΔW be the net work done by the system in the process $A + B$



(a) $\Delta U_1 + \Delta U_2 = 0$ (b) $\Delta U_1 - \Delta U_2 = 0$

(c) $\Delta Q + \Delta W = 0$ (d) $\Delta Q - \Delta W = 0$

Q-45 The internal energy of an ideal gas decreases by the same amount as the work done by the system

(a) The process must be adiabatic (b) The process must be isothermal

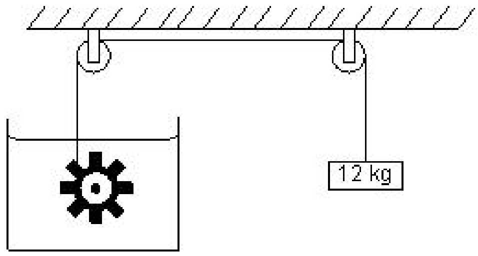
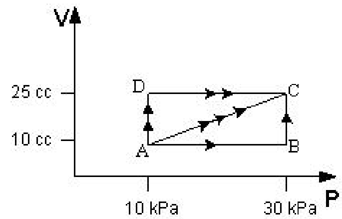
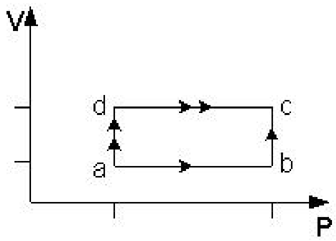
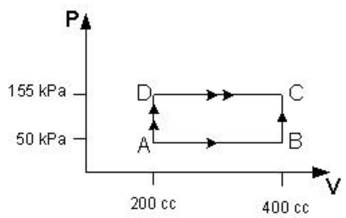
(c) The process must be isobaric (d) The temperature must decrease

Q-46 A thermally insulated, closed copper vessel contains water at 15^0C. When the vessel is shaken vigorously for 15 minutes, the temperature rises by 17^0C. The mass of the vessel is 100 g and that of the water is 200 g. The specific heat capacities of copper and water are 420 J.kg^{-1}.K^{-1} and 4200 J.kg^{-1}.K^{-1} respectively. Neglect any thermal expansion.

(a) How much heat is transferred to the liquid-vessel system?

(b) How much work has been done on this system?

(c) How much is the increase in internal energy of the system?

Q-47	Figure shows a paddle wheel coupled to a mass of 12 kg through fixed frictionless pulleys. The paddle is immersed in a liquid of heat capacity 4200 $J.K^{-1}$ kept in an adiabatic container. Consider a time interval in which the 12 kg block falls slowly through 70 cm. (a) How much heat is given to the liquid? (b) How much work is done on the liquid? (c) Calculate the rise in the temperature of the liquid neglecting the heat capacity of the container and the paddle? 
Q-48	A 100 kg block is started with a speed of 2.0 $m.s^{-1}$ on a long, rough belt kept fixed in a horizontal position. The coefficient of kinetic friction between the block and the belt is 0.20. (a) Calculate the change in internal energy of the block-belt system as the block comes to a stop on the belt. (b) Consider the situation from a frame of reference moving at 2.0 $m.s^{-1}$ along the initial velocity of the block. As seen from this frame, the block is gently put on a moving belt and in due time the block starts moving with the belt at 2.0 $m.s^{-1}$. Calculate the increase in the kinetic energy of the block as it stops slipping past the belt. (c) Find the work done in this frame by the external force holding the belt.
Q-49	Calculate the change in internal energy of a gas kept in a rigid container when 100 J of heat is supllied to it.
Q-50	The pressure of gas changes linearly with volume from 10 kPa, 200 cc to 50 kPA, 50 cc. (a) Calculate the work done by the gas. (b) If no heat is supplied or extracted from the gas, what is the change in the internal energy of the gas?
Q-51	An ideal gas is taken from an initial state *i* to a final state *f* in such a way that the ratio of the pressure to the absolute temperature remains constant. What will be the work done by the gas ?
Q-52	Figure shows three paths which a gas can be taken from the state *A* to the state C. Calculate the work done by the gas in each of the three paths. 
Q-53	When a system is taken through the process *abc* as shown in the figure, 80 J of heat is absorbed by the system and 30 J of work is done by it. If the system does 10 J of work during theprocess *adc* how much heat flows into it during the process? 
Q-54	50 cal of heat should be supplied to take a system from the state *A* to the state *C* through the path *ABC* as shown in the figure. Find the quantity of heat to be supplied to take it from *A* to C via *ADC*. 

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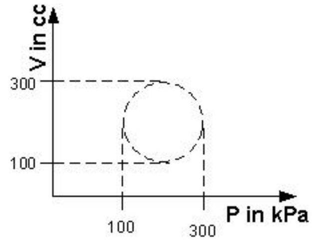
<tr><td>Q-55</td><td>Calculate the heat absorbed by a system in going through the cyclic process shown in the figure.

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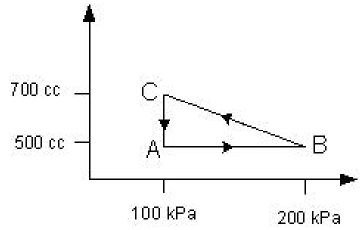
<tr><td>Q-56</td><td>A gas is taken through a cyclic process ABCA as shown in the figure. If 2.4 cal of heat is given in the process, what is the value of J?

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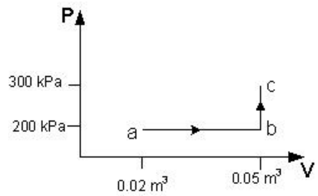
<tr><td>Q-57</td><td>A substance is taken through the process abc as shown in the figure. If internal energy of the substance increases by 5 kJ and heat of 2625 cal is given to the system, calculate J.

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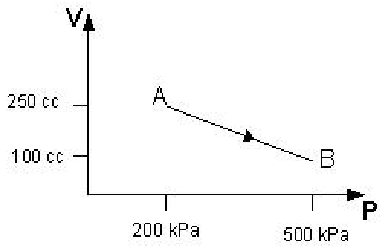
<tr><td>Q-58</td><td>A gas is taken along the path AB as shown in the figure. If 70 cal of heat is extracted from the gas in the process, calculate the change in the internal energy of the system.

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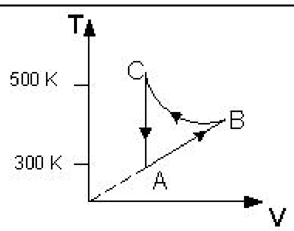
<tr><td>Q-59</td><td>The internal energy of a gas is given by $U = 1.5pV$. It expands from 100 cm^3 to 200 cm^3 against a pressure 1.0×10^5 Pa. Calculate the heat absorbed by the gas in the process.</td></tr>
<tr><td>Q-60</td><td>A sample of gas is enclosed in a cylindrical vessel fitted with a frictionless piston. The gas is slowly heated for some time. During the process, 10 J of heat is supplied and the piston is found to move out 10 cm. Find increase in the internal energy of the gas. The area of cross-section of the cylinder is 4 cm^2 and atmospheric pressure is 100 kPa.</td></tr>
<tr><td>Q-61</td><td>A sample of gas is initially at a pressure of 100 kPa and its volume is 2.0 m^3. The pressure is kept constant and the volume is changed from 2.0 m^3 to 2.5 m^3. Its volume is now kept constant and pressure is increased from 100 kPa to 200 kPa. The gas is brought back to its initial state, the pressure varying linearly with volume.
(a) Whether heat is supplied to or extracted from the gas in the complete cycle?
(b) How much heat was supplied or extracted?</td></tr>
<tr><td>Q-62</td><td>Consider the cyclic process ABCA shown in the figure performed on a sample of 2.0 mol of an ideal gas.
A total of 1200 J of heat is withdrawn from the sample in the process. Find the work done by the gas during the part BC.

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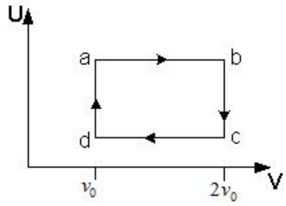
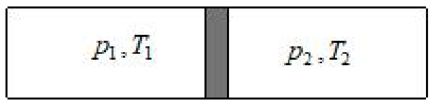
Q-63 In the figure is shown the variation in the internal energy U with volume V of 2.0 mol of an ideal gas in a cyclic process ***abcda***. The temperature of the gas at ***b*** and c are 500 K and 300 K respectively. Calculate the heat absorbed by the gas during the process.



Q-64 Find the change in the internal energy of 2 kg of water as it is heated from 0^0C to 4^0C. The specific heat capacity of water is 4200 $J.kg^{-1}.K^{-1}$ and its densities at 0^0C and 4^0C are 999.9 $kg.m^{-3}$ and 1000 $kg.m^{-3}$ respectively. Atmospheric pressure is 10^5 Pa.

Q-65 Calculate the increase in the internal energy of 10 g of water when it is heated from 0^0C to 100^0C and converted into steam at 100 kPa. The density of steam is 0.6 $kg.m^{-3}$. Specific heat capacity of vapourization of water is $2.25\times10^6 J.kg^{-1}$.

Q-66 Figure shows a cylindrical tube of volume V with adiabatic wall containing ideal gas. The internal energy of this ideal gas is given by 1.5 nRT. The tube is divided into two equal parts by a fixed diathermic wall. Initially the pressure and the temperature are p_1 and T_1 on the left and p_2 and T_2 on the right. The system is left for sufficient time so that the temperature becomes equal on the two sides.



(a) How much work has been done by the gas on the left part?
(b) Find the final pressures on the two sides.
(c) Find the final temperature.
(d) How much heat has flown from gas on the right to the gas on the left?

Q-67 An adiabatic vessel of total volume V is divided into two equal parts by a conducting seperator. The seperator is fixed in this position. The part on the left contains one mole of an ideal gas (U = 1.5 nRT), and the part on the right contains two moles of the same gas. Intially the pressure on each side is p. The system is left for sufficient time so that a steady state is reached. Find –

(a) The work done by the gas in the left part during the process.
(b) The temperature on the two sides in the beginning.
(c) The final common temperature reached by the gases.
(d) The heat given by gas in the right part
(e) The increase in the internal energy of the gas in the left part.

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