# THERMODYNAMICS I$^{st}$ LAW

## Exercise-1

**Marked Questions may have for Revision Questions.**

## PART - I : SUBJECTIVE QUESTIONS

### Section (A) : Basic definitions

**A-1.** Categorize these properties into state and path functions.
(a) Internal energy (b) Volume (c) Heat (d) Enthalpy
(e) Temperature (f) Work (g) Molar heat capacity

**A-2.** Categorize these properties into extensive and intensive
(a) Temperature (b) Internal energy (c) Heat (d) Density
(e) Molar volume (f) molar enthalpy (g) viscosity

**A-3.** Identify the state functions and path functions.
(a) The potential energy of a book in shelf.
(b) The heat evolved when a cube of sugar is oxidized to $CO_{2(g)}$ and $H_2O_{(g)}$.
(c) The work accomplished in burning a litre of gasoline.

### Section (B) : Thermodynamics processes & graph

**Draw the P-V diagram for the following cyclic processes**

**B-1.** Isothermal expansion from state A to B, isochoric pressure increment from B to C, isothermal contraction from C to D, isobaric contraction from D $\rightarrow$ A.

**B-2.** Isobaric expansion from A $\rightarrow$ B, isochoric pressure increase from B $\rightarrow$ C, isobaric compression from C $\rightarrow$ D, isochoric pressure drop from D $\rightarrow$ A.

**B-3.** Isobaric expansion from A $\rightarrow$ B, isochoric pressure drop from B $\rightarrow$ C, isothermal compression C $\rightarrow$ A.

### Section (C) : Work calculation

**C-1.** Calculate the work done by 0.1 mole of a gas at $27^0$ C to double its volume at constant pressure (in isobaric process) (R = 2 cal $mol^{-1}$ $K^{-1}$)

**C-2.** Calculate the work done during isothermal reversible expansion of one mole ideal gas from 10 atm to 1 atm at 300 K.

**C-3.** At 25ºC, a 0.01 mole sample of a gas is compressed in volume from 4.0 L to 1.0 L at constant temperature. What is work done for this process if the external pressure is 4.0 bar ?

### Section (D) : Heat & Internal energy

**D-1.** Calculate the heat necessary to raise the temperature of 60 g of aluminimum from 35ºC to 55ºC. Molar heat capacity of Al is 24 $mole^{-1}$ $K^{-1}$.

**D-2.** In a container, two mole of a diatomic ideal gas is allowed to expand against 1 atm pressure & volume change from 2 litre to 5 litre isobarically then calculate change in internal enrgy.

### Section (E) : First law of thermodynamics

**E-1.** The work done by a system is 8 joule, when 40 joule heat is supplied to it. What is the increase in internal energy of system.

**E-2.** A gas expands from 2 L to 6 L against a constant pressure of 0.5 atm on absorbing 200 J of heat. Calculate the change in internal energy.

## Section (F) : Adiabatic, isothermal, polytropic & free expansion processes

**F-1.** One mole of an ideal monoatomic gas $\left(\gamma = \frac{5}{3}\right)$ is mixed with one mole of a diatomic gas $\left(\gamma = \frac{7}{5}\right)$. ($\gamma$ denotes the ratio of specific heat at constant pressure, to that at constant volume) find $\gamma$ for the mixture ?

**F-2.** A piston freely move in a insulated cylinder from volume 5 lit to 10 lit then calculate work done & heat during this expansion.

## Section (G) : Enthalpy

**G-1.** If 1.0 kcal of heat is added to 1.2 L of $O_2$ in a cylinder at constant pressure of 1 atm, the volume increases to 1.5 L. Calculate $\Delta U$ and $\Delta H$ of the process. (1 L-atm = 100 J, 1 cal = 4.2 J)

**G-2.** 10 g of argon gas is compressed isothermally and reversibly at a temperature of 27ºC from 10 L to 5L. Calculate enthalpy change. Assume ideal behaviour ($\Delta H$) for this process R = 2.0 cal $K^{-1}$ $mol^{-1}$. $\log_{10}2$ = 0.30 (Atomic mass of Ar = 40)

## Section (H) : Phase transition

**H-1.** What is $\Delta U$ when 2.0 mole of liquid water vaporises at 100ºC ? The heat of vaporisation ($\Delta H_{vap.}$) of water at 100ºC is 40.66 $KJmol^{-1}$.

# PART - II : ONLY ONE OPTION CORRECT TYPE

## Section (A) : Basic definitions

**A-1.** Warming ammonium chloride with sodium hydroxide in a test tube is an example of :
(A) Closed system (B) Isolated system (C) Open system (D) None of these

**A-2.** Out of boiling point (I), entropy (II), pH (III) and e.m.f. of a cell (IV), intensive properties are :
(A) I, II (B) I, II, III (C) I, III, IV (D) All of the above

**A-3.** In which case bodies become hot due to mechanical energy losses
(i) Rub our hands for sometime (ii) Two vehicles collide with each other
(iii) Aeroplane crash (iv) Sliding of legs on roof surface
(v) Transfer of energy from hot body to cold body
(A) 5 (B) 4 (C) 3 (D) 2

**A-4.** Predict the total number of intensive properties :
(i) Free energy (ii) Critical density (iii) Viscosity (iv) Specific heat capacity
(v) molar heat capacity (vi) Kinetic energy (vii) Specific gravity (viii) Dielectric constant
(ix) pH
(A) 9 (B) 8 (C) 7 (D) 6

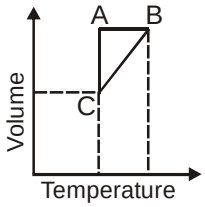
**A-5.** An ideal gas filled at pressure of 2 atm and temp of 300 K, in a balloon is kept in vacuum with in a large insulated container. Wall of balloon is punctured then container temperature :
(A) Decreases (B) Increases (C) Remain constant (D) Unpredictable

## Section (B) : Thermodynamics processes & graph

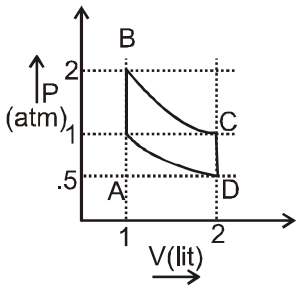
**B-1.** A gaseous system changes from state A ($P_1$, $V_1$, $T_1$) to B ($P_2$, $V_2$, $T_2$), B to C ($P_3$, $V_3$, $T_3$) and finally from C to A. The whole process may be called :
(A) Reversible process (B) Cyclic process
(C) Isobaric process (D) Spontaneous process

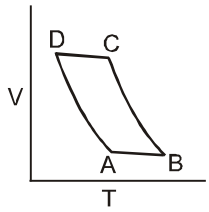
**B-2.** A well stoppered thermos flask contains some ice cubes. This is an example of a-
(A) Closed system (B) Open system
(C) Isolated system (D) Non-thermodynamic system

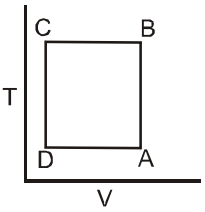
**B-3.** Five moles of a gas is put through a series of changes as shown graphicallay in a cyclic process the A → B, B → C and C → A respectively are
(A) Isochoric, Isobaric, Isothermal
(B) Isobaric, Isochoric, Isothermal
(C) Isothermal, Isobaric, Isochoric
(D) Isochoric, Isothermal, Isobaric

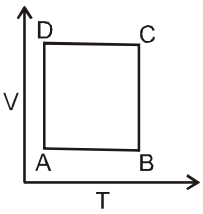


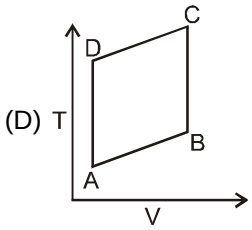

**B-4.** A cyclic process ABCD is shown in P-V diagram for an ideal gas. Which of the diagram represent the same process.



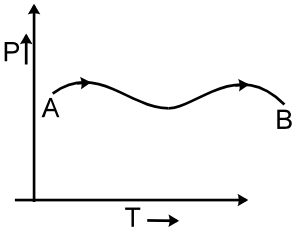

(A) 


(B) 


(C) 


(D) 


**B-5.** The P–T graph as given below was observed for a process on an ideal gas, which of the following statement is true.
(A) w = +ve, ΔH = +ve
(B) w = –ve, ΔH = – ve
(C) w = –ve, ΔH = + ve
(D) w = +ve, ΔH = –ve

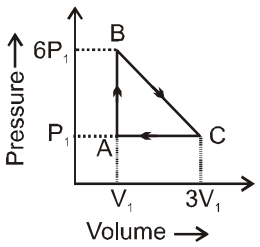



## Section (C) : Work Calculation

**C-1.** A thermodynamic system goes from states (i) $P_1$, V to $2P_1$, V (ii) P, $V_1$ to P, $2V_1$. Then work done in the two cases is
(A) Zero, Zero (B) Zero, – $PV_1$ (C) – $PV_1$, Zero (D) –$PV_1$, –$P_1V_1$

**C-2.** The work done in ergs for the reversible expansion of one mole of an ideal gas from a volume of 10 litres to 20 litres at 25ºC is :
(A) – 2.303 × 298 × 0.082 log2 (B) – 298 × $10^7$ × 8.31 × 2.303 log2
(C) – 2.303 × 298 × 0.082 log0.5 (D) – 8.31 × $10^7$ × 298 × 2.303 log0.5

**C-3.** An ideal gas is taken around the cycle ABCA as shown in P-V diagram. The net work done by the gas during the cycle is equal to :
(A) $12P_1V_1$
(B) $6P_1V_1$
(C) $5P_1V_1$
(D) $P_1V_1$




## Section (D) : Heat & Internal energy

**D-1.** For freezing of liquid in a system :
(A) q = 0 (B) q > 0
(C) q < 0 (D) q > 0 or q < 0 (depending on the nature of liquid)

**D-2.** For 2 mole of an ideal gas; the relation between $C_p$ & $C_v$ (non-molar) are :
(A) $C_p – C_v = 2R$ (B) $C_v – C_p = 2R$ (C) $C_p – C_v = R$ (D) $C_v – C_p = R$

## Section (E) : First law of thermodynamics

**E-1.** A system absorb 600J of heat and does work equivalent to 300J on its surroundings. The change in internal energy is
(A) 300 J (B) 400 J (C) 500 J (D) 600 J

**E-2.** In an isochoric process the increase in internal energy is
(A) Equal to the heat absorbed (B) Equal to the heat evolved
(C) Equal to the work done (D) Equal to the sum of the heat absorbed and work done

**E-3.** In an isothermal expansion of an ideal gas. Select wrong statement :
(A) there is no change in the temperature of the gas
(B) there is no change in the internal energy of the gas
(C) the work done by the gas is equal to the heat supplied to the gas
(D) the work done by the gas is equal to the change in its internal energy

**E-4.** A system undergoes a process which absorbed 0.5 kJ of heat and undergoing an expansion against external pressure of 1 atm, during the process change in internal energy is 300 J. Then predict the change in volume (lit.)
(A) 1 (B) 2 (C) 3 (D) 4

**E-5.** When two moles of Hydrogen atoms join together to form a mole of hydrogen molecules in a closed rigid vessel with diathermic walls.

$$H(g) + H(g) \longrightarrow H_2(g)$$

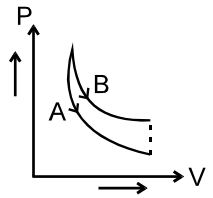
(A) $w < 0$ (B) $\Delta U$ = negative (C) $q_{system}$ = positive (D) $q_{surrounding}$ = negative

## Section (F) : Adiabatic, isothermal, polytropic & free expansion processes

**F-1.** The temperature of the system decreases in an
(A) Adiabatic compression (B) Isothermal compression
(C) Isothermal expansion (D) Adiabatic expansion

**F-2.** 1 mole of $NH_3$ gas at 27°C is expanded in reversible adiabatic condition to make volume 8 times ($\gamma$ = 1.33). Final temperature and work done respectively are :
(A) 150 K, 900 cal (B) 150 K, 400 cal (C) 250 K, 1000 cal (D) 200 K, 800 cal

**F-3.** In figure, A and B are two adiabatic curves for two different gases. Then A and B corresponds to :
(A) Ar and He respectively
(B) He and $H_2$ respectively
(C) $O_2$ and $H_2$ respectively
(D) $H_2$ and He respectively




## Section (G) : Enthalpy

**G-1.** One mole of non-ideal gas undergoes a change of state (1.0 atm, 3.0 L, 200 K) to (4.0 atm, 5.0 L, 250 K) with a change in internal energy ($\Delta U$) = 40 L-atm. The change in enthalpy of the process in L-atm ;
(A) 43 (B) 57 (C) 42 (D) None of these

**G-2.** For the isothermal expansion of an ideal gas
(A) U and H increases (B) U increases but H decreases
(C) H increases but U decreases (D) U and H are unaltered

**G-3.** A vessel contains 100 litres of a liquid X. Heat is supplied to the liquid in such a fashion that, Heat given = change in enthalpy. The volume of the liquid increases by 2 litres. If the external pressure is one atm, and 202.6 Joules of heat were supplied then, [U - total internal energy]
(A) $\Delta U = 0$ , $\Delta H = 0$ (B) $\Delta U = +202.6$ J , $\Delta H = +202.6$ J
(C) $\Delta U = -202.6$J, $\Delta H = -202.6$J (D) $\Delta U = 0$, $\Delta H = +202.6$J

## Section (H) : Phase transition

**H-1.** $H_2O(s) \longrightarrow H_2O(\square)$
This phase transition is carried out at constant temp and pressure then work done during the process :
(A) $W < 0$ (B) $W > 0$ (C) $W = 0$ (D) can't detamined

**H-2.** At 1 atm pressure n mole of water (0ºC) is forzen to ice(0ºC) then heat transfer is :
(A) $n\Delta H_{fusion}$ (B) $-n\,\Delta H_{fusion}$ (C) $nC_{v,m}\Delta T$ (D) $\Delta H_{fusion}$

# PART - III : MATCH THE COLUMN

**1.** Match the column:

| | **Columm-I** | | **Columm-II** |
|---|---|---|---|
| (A) | Reversible isothermal expansion of an ideal gas | (p) | $w = -2.303\ nRT \log\left(\frac{V_2}{V_1}\right)$ |
| (B) | Reversible adiabatic compression of an ideal gas | (q) | $PV^{\gamma}$ = constant |
| (C) | Irreversible adiabatic expansion of an ideal gas | (r) | $w = \frac{nR}{(\gamma-1)}(T_2 - T_1)$ |
| (D) | Irreversible isothermal compression of an ideal gas | (s) | $\Delta H = 0$ |

**2.** Match the column:

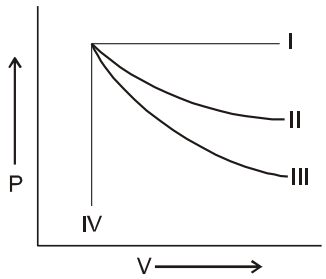
| | **Column-I** | | **Column-II** |
|---|---|---|---|
| (A) | A process carried out infinitesimally slowly | (p) | Adiabatic |
| (B) | A process in which no heat enters or leaves the system | (q) | $\Delta E = 0, \Delta H = 0$ |
| (C) | A process carried out at constant temperature | (r) | Reversible |
| (D) | Cyclic process | (s) | Isothermal |

# Exercise-2

# PART - I : ONLY ONE OPTION CORRECT TYPE

**1.** In which one of the following sets, all the properties belong to same category (all extensive or all intensive)?
(A) Mass, volume, pressure (B) Temperature, pressure, volume
(C) Heat capacity, density, entropy (D) Enthalpy, internal energy, volume.

**2.**



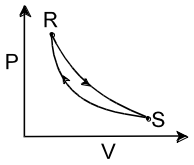

The plots between P and V which represent isochoric and isobaric process respectively :
(A) I, II (B) IV, I (C) I, IV (D) II, III

**3.** Match the enteries of column I with appropriate entries of column II and choose the correct option out of the four options (A), (B), (C) and (D).

| | **Column-I** | | **Column-II** |
|---|---|---|---|
| (X) | Isothermal | (p) | $\Delta T = 0$ |
| (Y) | Isobaric | (q) | $\Delta V = 0$ |
| (Z) | Adiabatic | (r) | $\Delta P = 0$ |
| (W) | Isochoric | (s) | $q = 0$ |

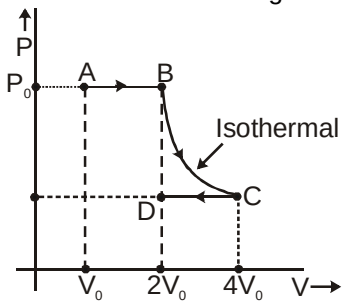
(A) X–p, Y–q, Z-r, W-x (B) X–p, Y–r, Z-s, W-q (C) X–s, Y–p, Z-r, W-q (D) X–s, Y–p, Z-q, W-r

**4.** Consider the cyclic process R → S → R as shown in the Fig. You are told that one of the path is adiabatic and the other one isothermal. Which one of the following is(are) true?




(A) Process R → S is isothermal
(B) Process S → R is adiabatic
(C) Process R → S is adiabatic
(D) Such a graph is not possible

**5.** Work for the following process ABCD on a monoatomic gas is :




(A) $w = -2 P_0 V_0 \ln 2$, (B) $w = -2 P_0 V_0 \ln 4$,
(C) $w = -P_0 V_0 (1+ \ln 2)$, (D) $w = -P_0 V_0 \ln 2$,

**6.** 50 L of a certain liquid is confined in a piston system at the external pressure 100 atm. This pressure is suddenly released and liquid is expanded against the constant atmospheric pressure, volume of the liquid increases by 1 L and the final pressure on the liquid is 10 atm. Find the workdone.
(A) 1L.atm (B) 5 L.atm (C) 500 L.atm (D) 50 L.atm

**7.** Which one of the following equations does not correctly represent the first law of thermodynamics for the given process in ideal gas ?
(A) Isothermal process : q = – w (B) Cyclic process : q = – w
(C) Adiabatic process : $\Delta E = q$ (D) Expansion of a gas into vacuum : $\Delta E = q$

**8.** One mole of an ideal gas $\left(C_{v,m} = \frac{5}{2}R\right)$ at 300 K and 5 atm is expanded adiabatically to a final pressure of 2 atm against a constant pressure of 2 atm. Final temperature of the gas is :
(A) 270 K (B) 273 K (C) 248.5 K (D) 200 K

**9.** The magnitudes of enthalpy changes for irreversible adiabatic expansion of a gas from 1L to 2L is $\Delta H_1$ and for reversible adiabatic expansion for the same expansion is $\Delta H_2$. Then
(A) $\Delta H_1 > \Delta H_2$
(B) $\Delta H_1 < \Delta H_2$
(C) $\Delta H_1 = \Delta H_2$, enthalpy being a state function ($\Delta H_1 = \Delta H_2$½
(D) $\Delta H_1 = \Delta E_1$ & $\Delta H_2 = \Delta E_2$ where $\Delta E_1$ & $\Delta E_2$ are magnitudes of change in internal energy of gas in these expansions respectively.

## PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

**1.** How many statements are false ?
(i) Thermodynamics is concerned only with total energy of the system.
(ii) I$^{st}$ law of thermodynamics can be applied on the individual particle enclosed in vessel.
(iii) Many thermodynamic properties can not be measured absolutely, so change in thermodynamic property is required for calculation.
(iv) Feasibility of any chemical reaction can not be explained by thermodynamics.
(v) When surrounding is always in equilibrium with the system, the process called reversible.
(vi) Thermodynamics predict the time of attain the equilibrium.

**2.** How many of the following physical properties are extensive :
(i) Free energy (ii) vapour pressure (iii) mole (iv) Kinetic energy
(v) Entropy (vi) Internal energy (vii) Enthalpy (viii) specific heat capacity
(ix) Coefficient of viscosity (x) Total heat capacity

**3.** How many of the following are state function :
(i) Internal energy (ii) Heat (iii) Enthalpy (iv) Entropy
(v) Pressure (vi) Temp. (vii) volume (viii) Work
(ix) specific heat capacity (x) molar heat capacity

**4.** Two moles of He gas ($\gamma$ = 5/3) are initially at temp 27ºC and occupy a volume of 20 litres. The gas is first expanded at constant pressure until its volume is doubled. Then it undergoes reversible adiabatic change, until the volume become 110 lit, then predict the value of T/100 (where T is the final temperature, $\left(\frac{4}{11}\right)^{2/3} = \frac{1}{2}$)

**5.** A sample of an ideal gas is expanded from 1dm$^3$ to 3 dm$^3$ in a reversible process for which P = KV$^3$ , with K = 1/5 (atm/dm$^3$), what is work done by gas (L atm).

**6.** The valve on a cylinder containing initially 1 liters of an ideal gas at 7 atm and 25ºC is opened to the atmosphere, Whose the pressure is 760 torr and the temperature is 25ºC. Assuming that the process is isothermal, how much work (in L.atm) is done on the atmosphere by the action of expansion ?

**7.** The work done (in Cal) in adiabatic compression of 2 mole of an ideal monoatomic gas by constant external pressure of 2 atm starting from intial pressure of 1 atm and initial temperature of 30 K (R = 2 cal/mol-degree)

**8.** One mole of a non-ideal gas undergoes a change of state (2.0 atm, 3.0 L, 95 K) $\rightarrow$ (4.0 atm, 5.0 L, 245 K) with a change in internal energy, $\Delta$U=30.0 L. atm. Calculate change in enthalpy of the process in L. atm.

## PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

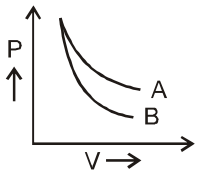
**1.** Which of the following properties of a system are intensive ?
(A) color (B) kinetic energy per mole
(C) X (where X = U + H) (D) specific volume (volume per unit mass)

**2.** Choose the correct statement :
(A) system and surrounding are always separated by a real or imaginary boundary.
(B) perfectly isolated system can never be created.
(C) in reversible process, energy change in each step can be reversed.
(D) irreversible process is also called quasi-equilibrium state.

**3.** In an isothermal expansion of a gaseous sample, the correct relation is : (consider w (work) with sign according to new IUPAC convention)
[The reversible and irreversible processes are carried out between same initial and final states.]
(A) $w_{rev} > w_{irrev}$ (B) $w_{irrev} > w_{rev}$ (C) $q_{rev} < q_{irrev}$ (D) $\Delta E_{rev} = \Delta E_{irrev}$

**4.** During the isothermal expansion of an ideal gas :
(A) The internal energy remains unaffected (B) The temperature remains constant
(C) The enthalpy remains unaffected (D) The enthalpy increases

**5.** P-V plot for two gases (assuming ideal) during adiabatic processes are given in the figure. Plot A and plot B should correspond respectively to :
(A) He and $H_2$
(B) $H_2$ and He
(C) $SO_3$and $CO_2$
(D) $N_2$ and Ar



**6.** An ideal gas undergoes adiabatic expansion against constant external pressure. Which of the following is incorrect :
(A) Temperature of the system decreases.
(B) The relation $PV^{\gamma}$ = constant will be valid (where P and V are gas variables)
(C) $\Delta E + P_{ext}\Delta V = 0$
(D) Enthalpy of the gas remains unchanged.

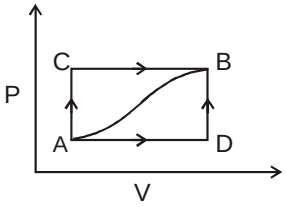
**7.** For the sublimation of a solid at 1 atm, which of the following may be correct
(A) $\Delta U > 0$ at low temperature (B) $q > 0$
(C) $\Delta U < 0$ at high temperature (D) $\Delta H > 0$

## PART - IV : COMPREHENSION

**Read the following passage carefully and answer the questions.**

**Comprehension #**

When a system is taken from state A to state B along path ACB as shown in figure below, 80 J of heat flows into the system and the system does 30 J of work.




**1.** How much heat flows into the system along path ADB if the work done by the system is 10 J :
(A) 40 J (B) 60 J (C) 80 J (D) 100 J

**2.** When the system is returned from state B to A along the curved path, the work done on the system is 20 J. Does the system absorb or liberate heat and by how much ?
(A) –70 J ; heat is liberated. (B) –60 J ; heat is liberated.
(C) +70 J ; heat is absorbed. (D) +60 J ; heat is absorbed.

**3.** If $E_D - E_A = +40$J, the heat absorbed in the processes AD and DB are respectively :
(A) $q_{AD} = 30$ J and $q_{DB} = -90$ J (B) $q_{AD} = +60$ J and $q_{DB} = 0$ J
(C) $q_{AD} = -30$ J and $q_{DB} = 90$ J (D) $q_{AD} = +50$ J and $q_{DB} = 10$ J

# Exercise-3

*** Marked Questions may have more than one correct option.**

## PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

**1.** The given reaction

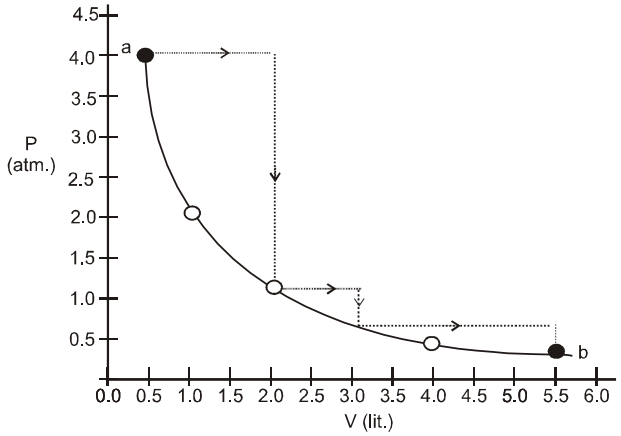
$$2CO + O_2 \longrightarrow 2CO_2 \qquad \Delta H = -560 \text{ kJ}$$
2moles 1 mole

is carried out in one litre container, if the pressure in the container gets changes from 70 atm to 40 atm as reaction gets completed. Calculate $\Delta U$ of the reaction. [1L atm = 0.1 kJ] **[JEE 2006, 6/184]**

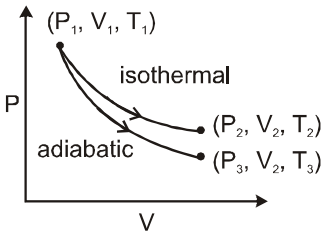
**2.*** Among the following, the state function(s) is(are) : **[JEE 2009, 4/160]**
(A) Internal energy (B) Irreversible expansion work
(C) Reversible expansion work (D) Molar enthalpy

**3.*** Among the following, the intensive property is (properties are) : **[JEE 2010, 3/163]**
(A) molar conductivity (B) electromotive force
(C) resistance (D) heat capacity

**4.** One mole of an ideal gas is taken from **a** and **b** along two paths denoted by the solid and the dashed lines as shown in the graph below. If the work done along the solid line path is $w_s$ and that along the dotted line path is $w_d$, then the integer closest to the ratio $w_d$ / $w_s$ is : **[JEE 2010, 3/163]**




**5.*** The reversible expansion of an ideal gas under adiabatic and isothermal conditions is shown in the figure. Which of the following statement(s) is (are) correct ? **[JEE 2012, 4/136]**



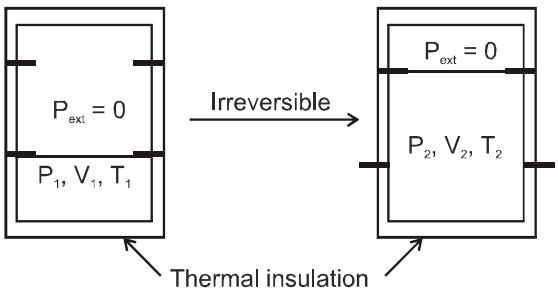

(A) $T_1 = T_2$

(B) $T_3 > T_1$

(C) $w_{isothermal} > w_{adiabatic}$

(D) $\Delta U_{isothermal} > \Delta U_{adiabatic}$

**6.*** An ideal gas in a thermally insulated vessel at internal pressure = $P_1$, volume = $V_1$ and absolute temperature = $T_1$ expands irreversibly against zero external pressure, as shown in the diagram. The final internal pressure, volume and absolute temperature of the gas are $P_2$, $V_2$ and $T_2$, respectively. For this expansion, **[JEE(Advanced) 2014, 3/120]**




(A) q = 0 (B) $T_2 = T_1$ (C) $P_2V_2 = P_1V_1$ (D) $P_2V_2^{\gamma} = P_1V_1^{\gamma}$

**7.*** An ideal gas is expanded from ($p_1$, $V_1$, $T_1$) to ($p_2$, $V_2$, $T_2$) under different conditions. The correct statement(s) among the following is (are) **[JEE(Advanced) 2017, 4/122]**

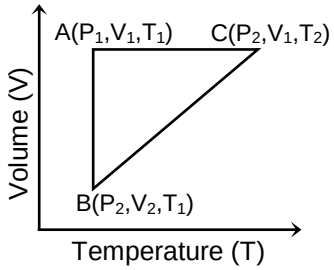
(A) The work done by the gas is less when it is expanded reversibly from $V_1$ to $V_2$ under adiabatic conditions as compared to that when expanded reversibly from $V_1$ to $V_2$ under isothermal conditions

(B) The change in internal energy of the gas is (i) zero, if it is expanded reversibly with $T_1 = T_2$, and (ii) positive, if it is expanded reversibly under adiabatic conditions with $T_1 \neq T_2$

(C) If the expansion is carried out freely, it is simultaneously both isothermal as well as adiabatic

(D) The work done on the gas is maximum when it is compressed irreversibly from ($p_2$, $V_2$) to ($p_1$, $V_1$) against constant pressure $p_1$

**8.*** A reversible cyclic process for an ideal gas is shown below. Here, P, V, and T are pressure, volume and temperature, respectively. The thermodynamic parameters q, w, H and U are heat, work, enthalpy and internal energy, respectively.




The correct option(s) is (are) **[JEE(Advanced) 2018, 4/120]**

(A) $q_{AC} = \Delta U_{BC}$ and $w_{AB} = P_2 (V_2 - V_1)$ (B) $W_{BC} = P_2 (V_2 - V_1)$ and $q_{BC} = \Delta H_{AC}$

(C) $\Delta H_{CA} < \Delta U_{CA}$ and $q_{AC} = \Delta U_{BC}$ (D) $q_{BC} = \Delta H_{AC}$ and $\Delta H_{CA} > \Delta U_{CA}$

# PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

## JEE-MAIN OFFLINE PROBLEMS

**1.** Assuming that water vapour is an ideal gas, the internal energy change ($\Delta U$) when 1 mol of water is vapourised at 1 bar pressure and 100°C, (Given : Molar enthalpy of vapourization of water at 1 bar and 373 K=41 kJmol$^{-1}$ and R = 8.3 J mol$^{-1}$ K$^{-1}$) will be : **[AIEEE 2007, 3/120]**

(1) 37.904 kJ mol$^{-1}$ (2) 41.00 kJ mol$^{-1}$ (3) 4.100 kJ mol$^{-1}$ (4) 3.7904 mol$^{-1}$

**2.** A piston filled with 0.04 mol of an ideal gas expands reversibly from 50.0 mL to 375 mL at a constant temperature of 37.0ºC. As it does so, it absorbs 208 J of heat. The values of q and w for the process will be: (R = 8.314 J/mol K) (ln 7.5 = 2.01) **[JEE 2013, (Main), 4/120]**

(R = 8.314 J/mol K) (ln 7.5 = 2.01)

(1) q = +208 J, w = – 208 J (2) q = –208 J, w = – 208 J

(3) q = –208 J, w = + 208 J (4) q = +208 J, w = + 208 J

**3.** $\Delta U$ equal to : **[JEE(Main) 2017, 4/120]**

(1) Isobaric work (2) Adiabatic work (3) Isothermal work (4) Isochoric work

## JEE-MAIN ONLINE PROBLEMS

**1.** If 100 mole of $H_2O_2$ decompose at 1 bar and 300 K, the work done (kJ) by one mole of $O_2$(g) as it expands against 1 bar pressure is : **[JEE(Main) 2016 Online (10-04-16), 4/120]**

$2H_2O_2(l) \rightleftharpoons 2H_2O(l) + O_2(g)$ (R = 8.3 J K$^{-1}$ mol$^{-1}$)

(1) 498.00 (2) 62.25 (3) 124.50 (4) 249.00

**2.** A gas undergoes change from state A to state B. In this process, the heat absorbed and work done by the gas is 5 J and 8 J, respectively. Now gas is brought back to A by another process during, which 3 J of heat is evolved. In this reverse process of B to A : **[JEE(Main) 2017 Online (09-04-17), 4/120]**

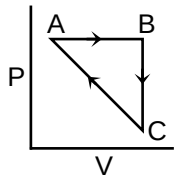
(1) 10 J of the work will be done by the surrounding on gas.

(2) 10 J of the work will be done by the gas.

(3) 6 J of the work will be done by the surrounding on gas.

(4) 6 J of the work will be done by the gas.

**3.** An ideal gas undergoes a cyclic process as shown in Figure. **[JEE(Main) 2018 Online (15-04-18), 4/120]**




$\Delta U_{BC} = -5$ kJ mol$^{-1}$, $q_{AB} = 2$ kJ mol$^{-1}$

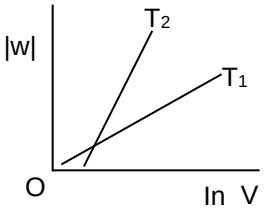
$W_{AB} = -5$ kJ mol$^{-1}$, $W_{CA} = 3$ kJ mol$^{-1}$

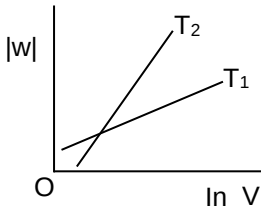
Heat absorbed by the system during process CA is :

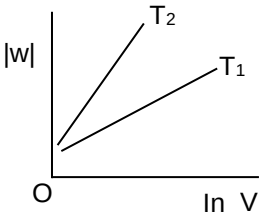
(1) – 5 kJ mol$^{-1}$ (2) + 5 kJ mol$^{-1}$

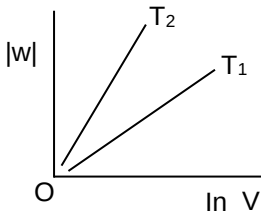
(3) 18 kJ mol$^{-1}$ (4) – 18 kJ mol$^{-1}$

**4.** Consider the reversible isothermal expansion of an ideal gas in a closed system at two different temperatures $T_1$ and $T_2$ ($T_1 < T_2$). The correct graphical depiction of the dependence of work done (w) on the final volume (V) is : **[JEE(Main) 2019 Online (09-01-19), 4/120]**

(1) 


(2) 

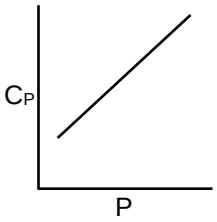

(3) 

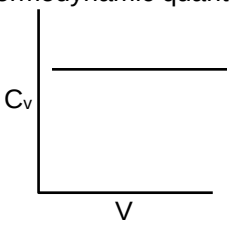

(4) 

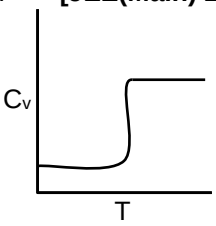

**5.** An ideal gas undergoes isothermal compression from 5 $m^3$ to 1 $m^3$ against a constant external pressure of 4 $Nm^{-2}$. Heat released in this process is used to increase the temperature of 1 mole of Al. If molar heat capacity of Al is 24 J $mol^{-1}K^{-1}$, the temperature of Al increases by:
**[JEE(Main) 2019 Online (10-01-19), 4/120]**

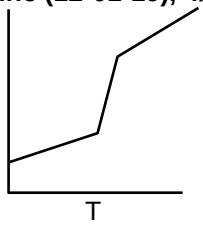
(1) $\frac{3}{2}$ K (2) $\frac{2}{3}$ K (3) 1 K (4) 2 K

**6.** For a diatomic ideal gas in a closed system, which of the following plots does not correctly describe the relation between various thermodynamic quantities ? **[JEE(Main) 2019 Online (12-01-19), 4/120]**

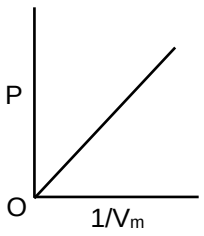
(1) 

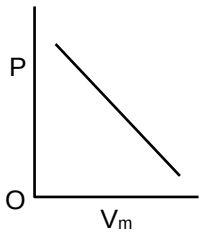

(2) 

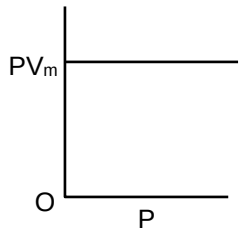

(3) 

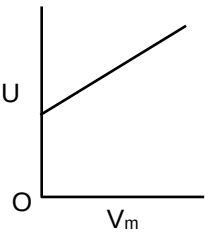

(4) 


**7.** The combination of plots which does not represents isothermal expansion of an ideal gas is:
**[JEE(Main) 2019 Online (12-01-19), 4/120]**

(A) 


(B) 


(C) 


(D) 


(1) (B) and (C) (2) (A) and (C) (3) (A) and (D) (4) (B) and (D)

# Answers

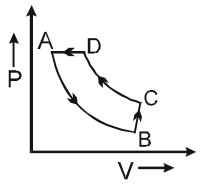
## EXERCISE - 1

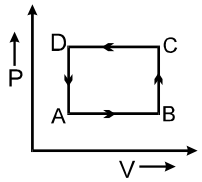
### PART - I

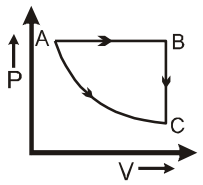
**A-1.** State function : (a) (b) (d) (e) ; Path function : (c) (f) (g)

**A-2.** Extensive Property : (b) (c) ; Intensive Property : (a) (d) (e) (f) (g)

**A-3.** (a) Potential energy is state function.
(b) Heat is a path function because a part of it may be used in work.
(c) Work is not a state function.

**B-1.** 


**B-2.** 


**B-3.** 


**C-1.** 60 cal. **C-2.** – 5744.4 J **C-3.** $1.2 \times 10^3$ J **D-1.** 1.066 kJ

**D-2.** 760 J **E-1.** 32 J **E-2.** – 2.6 J **F-1.** $\frac{3}{2}$

**F-2.** W = 0 ; q = 0 **G-1.** $\Delta U$ = 4170 J, $\Delta H$ = 1 kcal **G-2.** Zero **H-1.** $\Delta U$ = 75.12 kJ

### PART - II

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **A-1.** | (C) | **A-2.** | (C) | **A-3.** | (B) | **A-4.** | (C) | **A-5.** | (C) |
| **B-1.** | (B) | **B-2.** | (C) | **B-3.** | (A) | **B-4.** | (C) | **B-5.** | (C) |
| **C-1.** | (B) | **C-2.** | (B) | **C-3.** | (C) | **D-1.** | (C) | **D-2.** | (A) |
| **E-1.** | (A) | **E-2.** | (A) | **E-3.** | (D) | **E-4.** | (B) | **E-5.** | (B) |
| **F-1.** | (D) | **F-2.** | (A) | **F-3.** | (B) | **G-1.** | (B) | **G-2.** | (D) |
| **G-3.** | (D) | **H-1.** | (B) | **H-2.** | (B) | | | | |

### PART – III

**1.** (A – p, s) ; (B – q, r) ; (C – r) ; (D – s) **2.** (A – r) ; (B – p) ; (C – s) ; (D – q)

## EXERCISE – 2

### PART - I

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** | (D) | **2.** | (B) | **3.** | (B) | **4.** | (D) | **5.** | (A) |
| **6.** | (A) | **7.** | (C) | **8.** | (C) | **9.** | (B) | | |

### PART – II

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **1.** | 4 (i, ii, iv, vi) | **2.** | 7 (i, iii, iv, v, vi, vii, x) | **3.** | 6 (i, iii, iv, v, vi, vii) | | |
| **4.** | 3 | **5.** | 4 | **6.** | 6 | **7.** | 72 | **8.** | 44 |

### PART - III

**1.** (ABD) **2.** (ABC) **3.** (BD) **4.** (ABC) **5.** (BCD)

**6.** (BD) **7.** (ABCD)

### PART – IV

**1.** (B) **2.** (A) **3.** (D)

## EXERCISE – 3

### PART – I

**1.** $\Delta H = \Delta U + \Delta(PV)$

so, $\Delta U = \Delta H - \Delta(PV) = -560 - [40 - 70]$ (L atm) = $(-560 + 30 \times 0.1)$ kJ = – 557 kJ.

**2.** (AD) **3.** (AB) **4.** 2 **5.** (AD) **6.** (ABC)

**7.** (ACD) **8.** (BC)

### PART – II

#### JEE-MAIN OFFLINE PROBLEMS

**1.** (1) **2.** (1) **3.** (2)

#### JEE-MAIN ONLINE PROBLEMS

**1.** (3) **2.** (3) **3.** (2) **4.** (4) **5.** (2)

**6.** (1) **7.** (4)