

modynamics Assignment ussion || Part-2

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THERMODYNAMICS IIT JAM

MULTIPLE CHOICE TYPE QUESTIONS

- Q. 1. For an isothermal free expansion of an ideal gas into vacuum, which one of the following set of values is correct?
 (A) $\Delta U = 0, q > 0, w < 0$
 (B) $\Delta U > 0, q > 0, w = 0$
 (C) $\Delta U = 0, q = 0, w = 0$
 (D) $\Delta U < 0, q = 0, w < 0$
- Q. 2. Which of the following thermodynamic relation(s) is/are correct? (Multiple Select Question)
 (A) $\left(\frac{\partial T}{\partial V}\right)_S = \left(\frac{\partial P}{\partial S}\right)_V$
 (B) $\left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$
 (C) $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$
 (D) $\left(\frac{\partial S}{\partial P}\right)_T = \left(\frac{\partial V}{\partial T}\right)_P$
- Q. 3. According to the equipartition principle, the predicted high temperature limiting value of the molar heat capacity at constant volume for C_2H_2 is
 (A) 5.5 R
 (B) 6.0 R
 (C) 9.0 R
 (D) 9.5 R
- Q. 4. Intensive variable(s) is/are (Multiple Select Question)
 (A) temperature
 (B) volume
 (C) pressure
 (D) density
- Q. 5. The CORRECT expression that corresponds to reversible and adiabatic expansion of an ideal gas
 (A) $\Delta U = 0$
 (B) $\Delta H = 0$
 (C) $\Delta S = 0$
 (D) $\Delta G = 0$
- Q. 6. The CORRECT expression(s) for isothermal expansion of 1 mol of an ideal gas is(are) (Multiple Select Question)
 (A) $\Delta A = RT \ln \frac{V_{\text{initial}}}{V_{\text{final}}}$
 (B) $\Delta G = RT \ln \frac{V_{\text{initial}}}{V_{\text{final}}}$
 (C) $\Delta H = RT \ln \frac{V_{\text{final}}}{V_{\text{initial}}}$
 (D) $\Delta S = RT \ln \frac{V_{\text{final}}}{V_{\text{initial}}}$
- Q. 7. For an ideal solution formed by mixing of pure liquids A and B
 (A) $\Delta H_{\text{mixing}} = 0$
 (B) $\Delta H_{\text{mixing}} < 0$
 (C) $\Delta H_{\text{mixing}} > 0$
 (D) $\Delta S_{\text{mixing}} = 0$

- Q. 8. The molar heat capacity at constant volume of a colourless gas is found to be $25 \text{ J mol}^{-1} \text{ K}^{-1}$ at room temperature. The gas must be
 (A) N_2 (B) O_2
 (C) CO_2 (D) SO_2
- Q. 9. For a cyclic process performed by an ideal gas, changes in some thermodynamic functions are zero. Indicate the set in which all the functions are zero.
 (A) $w, \Delta E, \Delta H, \Delta G$ (B) $q, \Delta S, \Delta H, \Delta A$
 (C) $q, \Delta E, \Delta S, \Delta G$ (D) $\Delta E, \Delta S, \Delta H, \Delta A$
- Q. 10. When one mole of ice is converted to water at 0°C and 1 atm, the work done (L atm) is
 (A) 1.1×10^{-4} (B) 2.0×10^{-3}
 (C) 2.0×10^{-4} (D) 1.1×10^{-5}
- Q. 11. When 100 g of water is reversibly heated from 50°C to 75°C at 1 atm, the change in entropy (J K^{-1}) of the universe is
 (A) -0.31 (B) 0.31
 (C) 0 (D) 3.1
- Q. 12. The molar internal energy of a gas at temperature T is $U_m(T)$. The molar internal energy at $T = 0$ is $U_m(0)$. The correct expression that relates these two with appropriate contributions is
 (A) $U_m(T) = U_m(0) + 3RT$ [linear molecule, translation only]
 (B) $U_m(T) = U_m(0) + \frac{5}{2}RT$ [linear molecule, translation and rotation only]
 (C) $U_m(T) = U_m(0) + \frac{3}{2}RT$ [non-linear molecule, translation and rotation only]
 (D) $U_m(T) = U_m(0) + RT$ [non-linear molecule, translation only]
- Q. 13. The work done during the free expansion of one mole of an ideal gas at 27°C to twice its original volume is (given: $RT = 2494 \text{ J mol}^{-1}$, $\ln 2 = 0.7$, $\log 2 = 0.3$)
 (A) 1746 J mol^{-1} (B) -1746 J mol^{-1}
 (C) zero (D) 748.2 J mol^{-1}
- Q. 14. Based on the principle of equipartition of energy, the molar heat capacity of CO_2 at constant volume $C_{v,m}$ is
 (A) $3.5 R$ (B) $6 R$
 (C) $6.5 R$ (D) $9 R$

Q. 15. One mole of a van der Waals gas undergoes reversible isothermal transformation from an initial volume V_1 to a final volume V_2 . The expression for the work done is

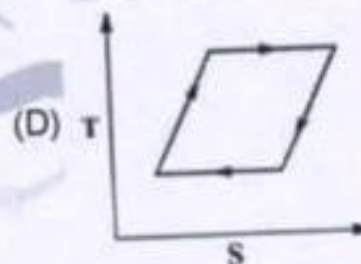
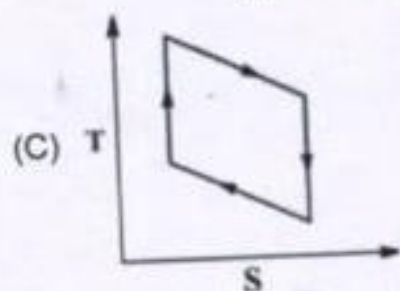
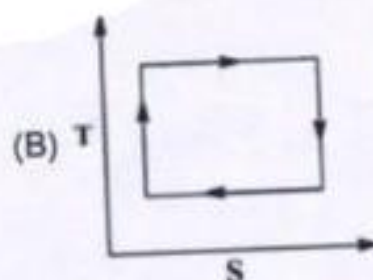
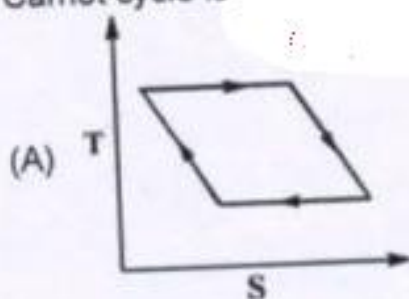
(A) $RT \ln \frac{V_2}{V_1} + a(V_2 - V_1)$

(C) $RT \ln \frac{P_2}{P_1}$

(B) $RT \ln \frac{V_2 - b}{V_1 - b} + a \left(\frac{1}{V_1} - \frac{1}{V_2} \right)$

(D) $RT \ln \frac{V_2 - b}{V_1 - b} - a \left(\frac{1}{V_1} - \frac{1}{V_2} \right)$

Q. 16. The graph that represents the temperature (T) – entropy (S) variation of a Carnot cycle is



Q. 17. The thermodynamic criterion for spontaneity of a process in a system under constant volume and temperature and in the absence of any work other than expansion work (if any) is

- (A) change in entropy is positive
- (B) change in enthalpy is negative
- (C) change in Helmholtz free energy is negative
- (D) change in Gibbs free energy is negative

Q. 18. One mole of an ideal gas is subjected to an isothermal increase in pressure from 100 kPa to 1000 kPa at 300 K. the change in Gibbs free energy of the system is _____ kJ mol^{-1} . (Round off to one decimal place) [Given: Gas constant (R) = $8.3 \text{ J K}^{-1} \text{ mol}^{-1}$]

Q. 19. Match List-I with List-II and select the correct answer using the code given below the lists (the symbols have their usual meaning)

List-I

A. dU

B. dH

C. dA

D. dG

(A) A - 2, B - 4, C - 3, D - 1

(C) A - 2, B - 3, C - 4, D - 1

List-II

1. $VdP - SdT$

2. $TdS - PdV$

3. $-PdV - SdT$

4. $TdS + VdP$

(B) A - 1, B - 3, C - 4, D - 2

(D) A - 1, B - 4, C - 3, D - 2

Q. 20. For a van der Waals gas, the partial derivative $\left(\frac{\partial U}{\partial V}\right)_T$ is

Options

(A) $\frac{V_m}{a}$

(C) $\frac{a}{V_m^2}$

(B) $\frac{V_m^2}{a}$

(D) $\frac{a}{V_m}$

Q. 21. A monoatomic perfect gas undergoes expansion from (p_1, V_1) to (p_2, V_2) under isothermal or adiabatic conditions. The pressure of the gas will fall more rapidly under adiabatic conditions because

Options:

(A) $p \propto \frac{1}{V}$

(C) $p \propto \frac{1}{V^{3/2}}$

(B) $p \propto \frac{1}{V^{7/5}}$

(D) $p \propto \frac{1}{V^{5/3}}$

Q. 22. For a gas that obeys following equation of state $P(V - b) = RT$, where b is constant and R is an universal gas constant, which of the following is right:

(A) $\left(\frac{\partial U}{\partial V}\right)_T = b$

(C) $\left(\frac{\partial U}{\partial V}\right)_T = P$

(B) $\left(\frac{\partial U}{\partial V}\right)_T = R$

(D) $\left(\frac{\partial U}{\partial V}\right)_T = 0$

Q. 23. The internal pressure of a van der Waals gas is:

(A) independent of the molar volume

(B) inversely proportional to the molar volume

(C) inversely proportional to square of the molar volume

(D) directly proportional to the molar volume

Q. 24. The criterion for spontaneous change in terms of the state function is:

(A) $dU_{S,V} \geq 0$

(C) $dS_{U,V} \geq 0$

(B) $dA_{T,V} \geq 0$

(D) $dG_{T,V} \leq 0$

Q. 25. Among W (work), Q (heat), U (internal energy) and S (entropy)

(A) W and U are path functions but Q and S are state functions

- (B) W and S are path functions but Q and U are state functions
 (C) S and U are path functions but Q and W are state functions
 (D) W and Q are path functions but U and S are state functions

Q. 26. Which one of the following defines the absolute temperature of a system?

- (A) $\left(\frac{\partial U}{\partial S}\right)_V$ (B) $\left(\frac{\partial A}{\partial S}\right)_V$
 (C) $\left(\frac{\partial H}{\partial S}\right)_V$ (D) $\left(\frac{\partial G}{\partial S}\right)_V$

Q. 27. For a system subjected to only P – V work, entropy is given by

- (I) $-\left(\frac{\partial G}{\partial T}\right)_P$ (II) $\left(\frac{\partial G}{\partial P}\right)_T$
 (III) $-\left(\frac{\partial A}{\partial V}\right)_T$ (IV) $-\left(\frac{\partial A}{\partial T}\right)_V$
 (A) I and II (B) I and IV
 (C) I only (D) II only

Q. 28. Consider an ideal gas of volume V at temperature T and pressure P. If the entropy of the gas is S, the partial derivative $(\partial P / \partial S)_V$ is equal to

- (A) $(\partial T / \partial P)_S$ (B) $(\partial T / \partial V)_P$
 (C) $-(\partial T / \partial V)_S$ (D) $(\partial T / \partial S)_P$

Q. 29. An extensive property of a thermodynamic system among the following is

- (A) Pressure (B) Temperature
 (C) Volume (D) Concentration

Q. 30. Which of the following information will be necessary to calculate the change in entropy of a reversible process?

- (A) Pressure (B) Volume
 (C) Internal energy (D) Temperature

Q. 31. In thermodynamics, a property is called extensive if its value is additive. Which of the following is not an extensive property?

- (A) Mass (B) Volume
 (C) Heat capacity (D) Specific heat

Q. 32. In a process of expansion of a gas, the change in the internal energy was found equal to the heat involved alone. Which of the following is implied by this?

- (A) The gas was expanded isothermally
 (B) The process was carried out at constant volume
 (C) The gas was expanded under constant pressure
 (D) The expansion was carried out irreversibly

- Q. 33. The Joule-Thomson process is
 (A) isothermal (B) isobaric
 (C) isochoric (D) isoenthalpic
- Q. 34. A perfect gas expands reversibly at a constant temperature of 298 K so that its volume doubles. What is the change in the molar internal energy of the gas?
 (A) + 2.27 kJ/mol (B) 0 J/mol
 (C) + 1.72 kJ/mol (D) - 2.27 kJ/mol
- Q. 35. Given the q is the heat transferred to a system, w is the work done on the system and ΔU is the change in internal energy of the system, which of the following is correct?
 (A) For an isothermal process, $q = +w$
 (B) For an isochoric process, $\Delta U = -q$
 (C) For an adiabatic process, $\Delta U = -w$
 (D) For a cyclic process, $q = -w$
- Q. 36. The total number of rotational and vibrational degrees of freedom for $H_2C=CH-CH_3$ are respectively:
 (A) 0 and 21 (B) 1 and 21
 (C) 3 and 21 (D) 2 and 22
- Q. 37. Argon gas (assumed to be ideal) is expanded reversibly and adiabatically from a volume of 50 L to 200 L. If the initial temperature is 300 K then the final temperature would be:
 (A) 75 K (B) 37.5 K
 (C) 119 K (D) 200 K
- Q. 38. For which of the following process $q = 0, w = 0, \Delta U = 0, \Delta H = 0$?
 (A) Reversible isothermal process in a perfect gas
 (B) Reversible adiabatic process in a perfect gas
 (C) Adiabatic expansion of a perfect gas into vacuum
 (D) Reversible constant volume process in a perfect gas
- Q. 39. The intensive properties among these quantities is:
 (A) Mass (B) Volume
 (C) Mass/Volume (D) Enthalpy
- Q. 40. If the entropy change $dS_{UV} > 0$ (where U = internal energy and V = volume) then the process would be:
 (A) Spontaneous (B) Reversible
 (C) Exothermic (D) None of the above
- Q. 41. The correct for Clausius-Clapeyron equation is
 (A) $dP/dT = \Delta H/T\Delta V$ (B) $dV/dT = \Delta H/T\Delta V$
 (C) $dT/dP = \Delta H/V\Delta T$ (D) $dP/dT = \Delta T(P_2 - P_1)$

- Q. 42. The change in entropy when one mole of an ideal gas is compressed to one fourth of its initial volume and simultaneously heated to twice its initial pressure is
 (A) $(C_V - R)\ln 4$ (B) $(C_V - 2R)\ln 2$
 (C) $(C_V - 2R)\ln 4$ (D) $(C_V + 2R)\ln 2$
- Q. 43. Which one of the following is the correct thermodynamic equation of state?
 (A) $dG = (\partial G / \partial P)_T dP + (\partial G / \partial T)_P dT$ (B) $(\partial U / \partial V)_T = P + T(\partial P / \partial T)_V$
 (C) $dU = (\partial U / \partial V)_S dV + (\partial U / \partial S)_V dS$ (D) $(\partial H / \partial P)_T = V - T(\partial V / \partial T)_{P,n}$
- Q. 44. The entropy of vaporization of a liquid is $100 \text{ J mol}^{-1} \text{ K}^{-1}$ and it boils at 300 K . What would be the value of ΔH_{vap} ?
 (A) 3.0 kJ mol^{-1} (B) 30.0 kJ mol^{-1}
 (C) 300 kJ mol^{-1} (D) 3000 kJ mol^{-1}
- Q. 45. In the Joule-Thomson expansion of real gas at inversion temperature, the Joule-Thomson coefficient:
 (A) will be negative if the gas cools post expansion
 (B) will be positive if the gas gets heated post expansion
 (C) will be zero if $[\partial(PV) / \partial P]_T$ is positive
 (D) is zero
- Q. 46. What will be the slope of the plot of $\log P$ vs $\log V$ for a reversible adiabatic expansion of an ideal gas? [$\gamma = C_P / C_V$]
 (A) γ (B) $-\gamma$
 (C) zero (D) -1
- Q. 47. Using the data provided, calculate the multiple bond energy (kJ mol^{-1}) of a $\text{C}\equiv\text{C}$ bond in C_2H_2 . That energy is (take the bond energy of a $\text{C}-\text{H}$ bond as 350 kJ mol^{-1})
 $2\text{C(s)} + \text{H}_2(\text{g}) \longrightarrow \text{C}_2\text{H}_2(\text{g}) \quad \Delta H = 225 \text{ kJ mol}^{-1}$
 $2\text{C(s)} \longrightarrow 2\text{C(g)} \quad \Delta H = 1410 \text{ kJ mol}^{-1}$
 $\text{H}_2(\text{g}) \longrightarrow 2\text{H(g)} \quad \Delta H = 330 \text{ kJ mol}^{-1}$
 (A) 1165 (B) 837
 (C) 865 (D) 815
- Q. 48. The standard enthalpies of formation of $\text{CO}_2(\text{g})$, $\text{H}_2\text{O(l)}$ and glucose(s) at 25°C are -400 kJ/mol , -300 kJ/mol and -1300 kJ/mol , respectively. The standard enthalpy of combustion per gram of glucose at 25°C is
 (A) $+2900 \text{ kJ}$ (B) -2900 kJ
 (C) -16.11 kJ (D) $+16.11 \text{ kJ}$

Q. 49. The heats of combustion of carbon and carbon monoxide are -393.5 and $-283.5 \text{ kJ mol}^{-1}$, respectively. The heat of formation (in kJ) of carbon monoxide per mole is:

- (A) 110.5 (B) 676.5
(C) -676.5 (D) -110.5

Q. 50. The change in chemical potential (in J) of one mole of an ideal gas, when it is compressed isothermally at 300 K from 1.0 atm to 2.0 atm, is closest to ($\ln 2 = 0.69$)

- (A) 1225 (B) 1725
(C) 2425 (D) 2725

Q. 51. One mole of a mono-atomic ideal gas is transformed from 300 K and 2 atm to 600 K and 4 atm. The entropy change for this process is

- (A) $\frac{3}{2}R \ln 2$ (B) $\frac{1}{2}R \ln 2$
(C) $\frac{7}{2}R \ln 2$ (D) $\frac{5}{2}R \ln 2$

Q. 52. A sample of 2.0 moles of $\text{O}_2(\text{g})$ (assumed ideal) at 500 K is expanded from 5 L to 50 L under adiabatic and reversible conditions. The change in its internal energy (in kJ) is close to

$$\left(R = 8.3 \text{ JK}^{-1} \text{ mol}^{-1}; C_{V,m} = \frac{5}{2}R \right)$$

- (A) -22.5 (B) -12.5
(C) -19.1 (D) -7.5

Q. 53. For a closed system in the absence of non-PV work, the correct statement is

- (A) $dU = TdS - PdV$ (B) $dG = VdP + SdT$
(C) $dU = TdS + PdV$ (D) $dU = VdP - SdT$

Q. 54. At 300 K, the thermal expansion coefficient and the isothermal compressibility of liquid water are $2 \times 10^{-4} \text{ K}^{-1}$ and $5 \times 10^{-5} \text{ bar}^{-1}$, respectively $\left(\frac{\partial U}{\partial V} \right)$ (in K bar)

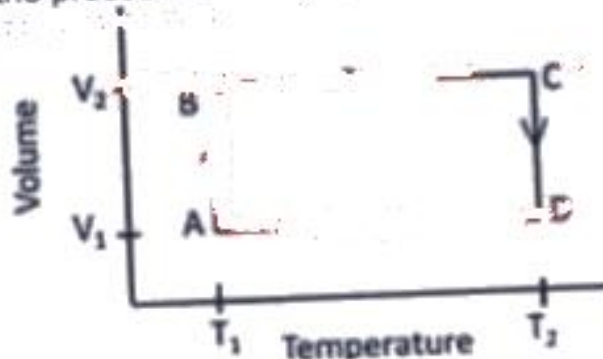
for water at 300 K and 1 bar will be

- (A) 2.4 (B) 1.2
(C) 0.6 (D) 12.0

Q. 55. The change in entropy for reversible adiabatic process is

- (A) Maximum (B) Minimum
(C) Zero (D) Positive

- Q. 56. One mole of an ideal gas undergoes a cyclic process (ABCD) starting from point A through 4 reversible steps as shown in the figure. Total work done in the process is



- (A) $R(T_1 - T_2) \frac{V_2}{V_1}$
 (B) $R(T_1 + T_2) \ln \frac{V_2}{V_1}$
 (C) $R(T_1 + T_2) \ln \frac{V_1}{V_2}$
 (D) $R(T_2 - T_1) \ln \frac{V_2}{V_1}$

- Q. 57. The correct statement for any cyclic thermodynamic process is

- (A) $\oint dq = 0$
 (B) $\oint dw = 0$
 (C) $\oint dU = 0$
 (D) $\oint Vdq = 0$

- Q. 58. The minimum work required by an engine to transfer 5 J of heat from a reservoir at 100 K to one at 300 K

- (A) 5 J
 (B) 10 J
 (C) 15 J
 (D) 20 J

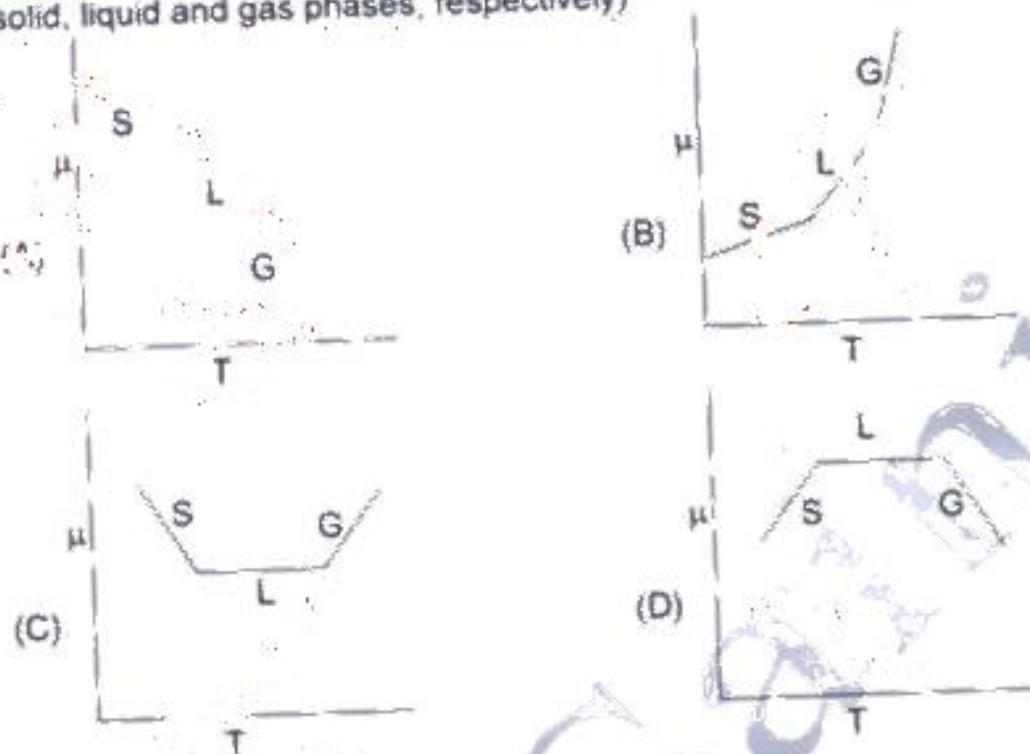
- Q. 59. Of the following inequalities, the criterion/criteria for spontaneity of a chemical reaction is/are

- (i) $(\Delta G)_{T,P} < 0$
 (ii) $(\Delta U)_{S,V} > 0$
 (iii) $(\Delta S)_{U,V} > 0$
 (A) (i) only
 (B) (ii) or (iv)
 (C) (i) and (ii)
 (D) (i) and (iii)

- Q. 60. Which of the following properties are characteristic of an ideal solution?

- (i) $(\Delta_{\text{mix}} G)_{T,P}$ is negative
 (ii) $(\Delta_{\text{mix}} S)_{T,P}$ is positive
 (iii) $(\Delta_{\text{mix}} V)_{T,P}$ is positive
 (iv) $(\Delta_{\text{mix}} H)_{T,P}$ is negative
 (A) (i) and (ii)
 (B) (ii) and (iii)
 (C) (i) and (iii)
 (D) (iii) and (iv)

- Q. 61. Of the following plots, the correct representation of chemical potential (μ) against absolute temperature (T) for a pure substance is (S, L and G denote solid, liquid and gas phases, respectively)



- Q. 62. A reversible expansion of 1.0 mol of an ideal gas is carried out from 1.0 L to 4.0 L under isothermal condition at 300 K. ΔG for this process is
 (A) $300 R \ln 2$
 (B) $600 R \ln 2$
 (C) $-600 R \ln 2$
 (D) $-300 R \ln 2$

- Q. 63. The entropy of mixing of 10 moles of helium and 10 moles of oxygen at constant temperature and pressure, assuming both to be ideal gases is
 (A) 115.3 JK^{-1}
 (B) 5.8 JK^{-1}
 (C) 382.9 JK^{-1}
 (D) 230.6 JK^{-1}

- Q. 64. The free energy change (ΔG) of 1 mole of an ideal gas that is compressed isothermally from 1 atm to 2 atm is
 (A) $RT \ln 2$
 (B) $-2RT$
 (C) $-RT \ln 2$
 (D) $2RT$

- Q. 65. Calculate the work done when 1 mol of an ideal gas is compressed reversibly from 1.00 bar to 5.00 bar at a constant temperature of 300 K.
 (A) -14.01 kJ
 (B) $+18.02 \text{ kJ}$
 (C) 4.01 kJ
 (D) -8.02 kJ

- Calculate the work done when 1 mol of an ideal gas is expanded reversibly from 20.0 dm^3 to 40.0 dm^3 at a constant temperature of 300 K.
 (A) 7.78 kJ
 (B) -1.73 kJ
 (C) 11.73 kJ
 (D) -4.78 kJ

- Q. 67. If the internal energy of an ideal gas decreases by the same amount as the work done by the system, the process is
 (A) cyclic (B) isothermal
 (C) adiabatic (D) isolated
- Q. 68. When heat is supplied to an ideal gas in an isothermal process, the
 (A) gas will do positive work
 (B) gas will do negative work
 (C) kinetic energy of the gas will increase
 (D) gas will not obey the law of conservation of energy
- Q. 69. The molar heat capacity of water in equilibrium with ice at constant pressure is
 (A) negative (B) zero
 (C) infinity (D) $40.45 \text{ kJ K}^{-1} \text{ mol}^{-1}$
- Q. 70. The mathematical formulation of the first law of thermodynamics, in differential form, is
 (A) $\sum du = 0$ (isolated system)
 (B) $du = dq - dw$ (closed system)
 (C) $du = dq - dw + \sum \mu_i dn_i$ (open system)
 (D) All of these
- Q. 71. Calculate the final temperature of a sample of a monoatomic gas that is expanded reversibly and adiabatically from 500 mL at 300 K to 2.00 L.
 (A) 119 K (B) 150 K
 (C) 300 K (D) 20 K
- Q. 72. The change in entropy when the pressure of a perfect gas is changed isothermally from p_1 to p_2 is
 (A) $\Delta S = nR \ln(p_1 + p_2)$ (B) $\Delta S = nR \ln(p_2 / p_1)$
 (C) $\Delta S = nR \ln(p_1 / p_2)$ (D) $\Delta S = nR \ln\left(\frac{p_1 + p_2}{p_2}\right)$
- Q. 73. In which of the following processes does the entropy decrease?
 (A) The dissolving of sodium chloride in water
 (B) The evaporation of water
 (C) The conversion of $\text{CO}_2(\text{g})$ into dry ice
 (D) When a dozen marbles are taken out of a small bag and dropped around
- Q. 74. The total entropy change for irreversible process is given by
 (A) $\Delta S_{\text{total}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}} = 0$
 (B) $\Delta S_{\text{total}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}} = nR \ln V_2 / V_1$
 (C) $\Delta S_{\text{total}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}} = nR \ln V_2 / V_1 + C_v dT$
 (D) $\Delta S_{\text{total}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}} = nR \ln V_1 / V_2$

Q. 75. Which of the following expression represents Gibbs-Helmholtz equation?

(A) $\Delta G^\circ = \Delta H^\circ + T \left[\frac{\partial(\Delta G^\circ)}{\partial T} \right]_P$

(B) $\left[\frac{\partial(\Delta G^\circ)}{\partial T} \right]_P = -\frac{\Delta H^\circ}{T^2}$

(C) $\left[\frac{\partial(\Delta G^\circ / T)}{\partial(1/T)} \right]_P = \Delta H^\circ$

(D) $\left[\frac{\partial(\Delta G^\circ / T)}{\partial T} \right]_P = -\Delta H^\circ$

Q. 76. The differential form of thermodynamic energies u , H and G can be represented by

(A) $du = TdS - PdV$

(B) $dH = TdS + VdP$

(C) $dG = -SdT + VdP$

(D) None of these

Q. 77. Which of the following mathematical relations are correct for an ideal gas?

(A) $\left(\frac{\partial H}{\partial V} \right)_T = 0$

(B) $\left(\frac{\partial H}{\partial P} \right)_T = 0$

(C) $C_p - C_v > R$

(D) $\left(\frac{\partial H}{\partial T} \right)_P = 0$

Q. 78. An adiabatic process is one in which

(A) all energy is transferred as heat

(B) no energy is transferred as heat

(C) the temperature of a gas decreases in a reversible adiabatic expansion

(D)

Q. 79. Which of the following statements are correct?

(A) The work done by the system on the surroundings is negative

(B) The work done on the system by the surroundings is positive

(C) The heat absorbed by the system from the surroundings is positive

(D) The heat absorbed by the surroundings from the system is negative

Q. 80. Which of the following is a path function as well as an extensive property?

(A) Temperature

(B) Internal energy

(C) Molar heat capacity

(D) Heat capacity

Q. 81. For ideal diatomic gases,

(A) $C_p = (7/2)R$

(B) $C_p = (3/2)R$

(C) $C_v = (5/2)R$

(D) $C_v = (3/2)R$

Q. 82. In the following table, which of the options are correct?

ΔH	ΔS	Nature of reaction
(A) (-)	(+)	Spontaneous at all temperatures
(B) (+)	(-)	Nonspontaneous regardless of temperatures
(C) (+)	(+)	Spontaneous only at high temperatures
(D) (-)	(-)	Spontaneous only at low temperatures

Q. 83. The internal energy of a system (V = volume, T = temperature, P = pressure, S = entropy) is function of

- (A) V and T (B) V and S
(C) P and T (D) P and S

Q. 84. Which of the following is not an extensive property?

- (A) Mass (B) Volume
(C) Heat capacity (D) Specific heat

Q. 85. The equation that is **not true** for mixing of two ideal gases at constant temperature and pressure is

- (A) $\Delta U_{\text{mix}} = 0$ (B) $\Delta S_{\text{mix}} = 0$
(C) $\Delta H_{\text{mix}} = 0$ (D) $q_{\text{mix}} = 0$

Q. 86. The isobaric thermal expansion coefficient of an ideal gas (T = temperature, V = volume) is

- (A) $1/T$ (B) $1/T^2$
(C) $1/V$ (D) $1/V^2$

Q. 87. The amount of energy (per mole of a monoatomic gas) that will increase by increasing the temperature by one degree at constant volume is

- (A) $C_p - C_v$ (B) R
(C) $3/2R$ (D) $C_v + R$

Q. 88. The ratio of specific heat of gases at constant pressure (C_p) and constant volume (C_v) of N_2 molecule is:

- (A) 1.667 (B) 1.400
(C) 1.330 (D) 1.520

Q. 89. The total heat content of a system at constant pressure is known as:

- (A) Enthalpy (B) Entropy
(C) Internal energy (D) Activation energy

Q. 90. For $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, the expression for ΔH is:

- (A) $\Delta U + 2RT$ (B) $\Delta U + RT$
(C) $\Delta U - 2RT$ (D) $\Delta U - RT$

Q. 91. The maximum efficiency of a Carnot engine operating between 100°C to 200°C will be:

- (A) 21.85% (B) 21.14%
(C) 22.14% (D) 20.14%

Q. 92. Which one of the following changes will necessarily lead to a non-spontaneous change?

- (A) Positive ΔH and positive ΔS (B) Negative ΔH and negative ΔS
(C) Positive ΔH and negative ΔS (D) Negative ΔH and positive ΔS

Q. 93. $\left(\frac{\partial U}{\partial V}\right)_T$ for an ideal gas is:

- (A) positive (B) negative
(C) zero (D) infinite

Q. 94. The equation connecting molar heat capacity at constant pressure to molar heat capacity at constant volume for an ideal gas is:

- (A) $C_p = \frac{C_v}{R}$ (B) $C_p = \frac{R}{C_v}$
(C) $C_p = R \times C_v$ (D) $C_p = R + C_v$

Q. 95. Which of the following equation is **not** correct?

- (A) $\left(\frac{\partial T}{\partial V}\right)_S = \left(\frac{\partial P}{\partial S}\right)_V$ (B) $\left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$
(C) $\left(\frac{\partial S}{\partial P}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_P$ (D) $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$

Q. 96. What is the efficiency of a Carnot engine that operates in between 100°C and 0°C ?

- (A) 100.0% (B) 26.8%
(C) 78.3% (D) 51.2%

Q. 97. Which one of the following is **not true** for a Joule-Thomson expansion process?

- (A) It is isoenthalpic (B) $\mu_{JT} = 0$ for the ideal gases
(C) $\mu_{JT} > 0$ for all the temperatures
(D) $\mu_{JT} < 0$ for all the temperatures

Q. 98. Which of the following relations is true for mixing of two ideal gases? (H is enthalpy, G is Gibbs free energy, V is volume, S is entropy)

- (A) $\Delta H = 0$; $\Delta V > 0$ (B) $\Delta H = 0$; $\Delta S > 0$
(C) $\Delta H = 0$; $\Delta G > 0$ (D) $\Delta H = 0$; $\Delta G < 0$

- Q. 99. The entropy change in a reversible adiabatic process is
 (A) 0 (B) ∞
 (C) $C_V (T_2 - T_1)$ (D) $R \ln \left(\frac{V_1}{V_2} \right)$
- Q. 100. Following the equipartition principle of energy, the molar heat capacity at constant volume for $\text{CO}_2(\text{g})$, $\text{SO}_2(\text{g})$ and $\text{NO}_2(\text{g})$ gas follows the trend
 (A) $\text{CO}_2 = \text{SO}_2 = \text{NO}_2$ (B) $\text{CO}_2 = \text{SO}_2 > \text{NO}_2$
 (C) $\text{CO}_2 > \text{SO}_2 = \text{NO}_2$ (D) $\text{CO}_2 = \text{NO}_2 > \text{SO}_2$
- Q. 101. The work done during the free expansion of 1 mole of an ideal gas at 27°C to thrice the original value is (given, $\ln 3 = 1.1$)
 (A) 2132 J mol^{-1} (B) -2132 J mol^{-1}
 (C) 4264 J mol^{-1} (D) zero
- Q. 102. The correct order of entropy for various states of CO_2 is
 (A) $\text{CO}_2(\text{s}) > \text{CO}_2(\ell) > \text{CO}_2(\text{g})$ (B) $\text{CO}_2(\ell) > \text{CO}_2(\text{s}) > \text{CO}_2(\text{g})$
 (C) $\text{CO}_2(\text{g}) > \text{CO}_2(\ell) > \text{CO}_2(\text{s})$ (D) $\text{CO}_2(\text{g}) > \text{CO}_2(\text{s}) > \text{CO}_2(\ell)$
- Q. 103. Use the following data to calculate the lattice enthalpy at 298 K of potassium iodide, $\text{KI}(\text{s})$. All values refer to a temperature of 298 K.
 Enthalpy of sublimation of $\text{K}(\text{s})$: $+81 \text{ kJ mol}^{-1}$
 Ionization enthalpy of $\text{K}(\text{g})$: $+418 \text{ kJ mol}^{-1}$
 Enthalpy of atomization of $\text{I}_2(\text{g})$: $+214 \text{ kJ mol}^{-1}$
 Enthalpy of electron attachment to $\text{I}(\text{g})$: -295 kJ mol^{-1}
 Enthalpy of formation of $\text{KI}(\text{s})$ for $\text{K}(\text{s})$ and $\frac{1}{2}\text{I}_2(\text{g})$: -328 kJ mol^{-1}
 (A) 746 kJ mol^{-1} (B) 680 kJ mol^{-1}
 (C) 573 kJ mol^{-1} (D) 639 kJ mol^{-1}
- Q. 104. What is the relation between temperature (T) and pressure (P) for an adiabatic process?
 (A) $\left(\frac{T_2}{T_1} \right) = \left(\frac{P_2}{P_1} \right)^{\frac{\gamma}{\gamma-1}}$ (B) $\left(\frac{T_2}{T_1} \right) = \left(\frac{P_2}{P_1} \right)^{\frac{1}{\gamma-1}}$
 (C) $\left(\frac{T_2}{T_1} \right) = \left(\frac{P_2}{P_1} \right)^{\gamma-1}$ (D) $\left(\frac{T_2}{T_1} \right) = \left(\frac{P_2}{P_1} \right)^{\frac{\gamma-1}{\gamma}}$

- Q. 105. If n_1 and n_2 represent moles of two components and μ_1 and μ_2 their chemical potentials, then the Gibbs-Duhem equation for this binary system will be:
 (A) $n_1 d\mu_2 + n_2 d\mu_1 = 0$ (B) $n_1 d\mu_1 + n_2 d\mu_2 = 0$
 (C) $n_1 d\mu_1 + n_2 d\mu_2 > 0$ (D) $n_1 d\mu_1 - n_2 d\mu_2 = 0$
- Q. 106. Which of the following thermodynamic functions of mixing is **not** correct for an ideal solution?
 (A) $\Delta S_{mix} = -R \sum n_i \ln x_i$ (B) $\Delta G_{mix} = 0$
 (C) $\Delta H_{mix} = 0$ (D) $\Delta V_{mix} = 0$
- Q. 107. Which one of the following is **correct** for an ideal gas?
 (A) $\left(\frac{\partial U}{\partial T}\right)_V = 0$ (B) $\left(\frac{\partial P}{\partial T}\right)_V = 0$
 (C) $\left(\frac{\partial V}{\partial T}\right)_P = 0$ (D) $\left(\frac{\partial U}{\partial V}\right)_T = 0$
- Q. 108. Which one of the following relationship is the correct one for entropy of mixing (ΔS_{mix}) of a binary ideal solution?
 (A) $\Delta S_{mix} = -(n_A R \ln x_A + n_B R \ln x_B)$ (B) $\Delta S_{mix} = (n_A R \ln x_A + n_B R \ln x_B)$
 (C) $\Delta S_{mix} = n_A \ln \frac{x_A}{R} + n_B \ln \frac{x_B}{R}$ (D) $\Delta S_{mix} = R \ln \frac{x_A}{n_A} - R \ln \frac{x_B}{n_B}$
- Q. 109. The variation of chemical potential with pressure is expressed as:
 (A) $\left(\frac{\partial \mu_i}{\partial P}\right)_{T, n_j} = \bar{S}_i$ (B) $\left(\frac{\partial \mu_i}{\partial P}\right)_{T, n_j} = \bar{G}_i$
 (C) $\left(\frac{\partial \mu_i}{\partial P}\right)_{T, n_j} = \bar{V}_i$ (D) $\left(\frac{\partial \mu_i}{\partial P}\right)_{T, n_j} = -\bar{S}_i$
- Q. 110. Which of the following conditions is necessary for a reaction to be spontaneous?
 (A) $\Delta S_{surr} + \Delta S_{sys} > 0$ (B) $\Delta S_{surr} + \Delta S_{sys} < 0$
 (C) $\Delta S_{surr} - \Delta S_{sys} > 0$ (D) $\Delta S_{sys} > 0$
- Q. 111. 2.0 mol of $H_2(g)$ are mixed with 2.0 mol of $N_2(g)$ both at 298 K. Assuming perfect behaviour, the change in entropy of the gases upon mixing is
 (A) $-2R \ln 0.5$ (B) 0
 (C) $-4R \ln 0.5$ (D) $2R \ln 2$
- Q. 112. From Maxwell's relation it can be said that $\left(\frac{\partial S}{\partial V}\right)_T$ is equal to
 (A) P/T (B) T/P
 (C) PT (D) R/V

Q. 113. The Maxwell's relationship derived from the equation $dG = VdP - SdT$ is

- (A) $\left(\frac{\partial V}{\partial T}\right)_P = \left(\frac{\partial S}{\partial P}\right)_T$ (B) $\left(\frac{\partial P}{\partial V}\right)_T = \left(\frac{\partial T}{\partial S}\right)_P$
 (C) $\left(\frac{\partial V}{\partial T}\right)_P = -\left(\frac{\partial S}{\partial P}\right)_T$ (D) $\left(\frac{\partial P}{\partial V}\right)_T = -\left(\frac{\partial T}{\partial S}\right)_P$

Q. 114. What will the minimum amount of work required to operate a refrigerator which removed 1000 cal heat at 0°C and rejects at 50°C ?

- (A) 63.91 cal (B) 93.13 cal
 (C) 183.15 cal (D) 154.79 cal

Q. 115. For a liquid $\Delta H_{\text{vap}} = 9325 \text{ J mol}^{-1}$. The ΔS during boiling at 100°C at 1 atm pressure is;

- (A) $15 \text{ JK}^{-1} \text{ mol}^{-1}$ (B) $25 \text{ JK}^{-1} \text{ mol}^{-1}$
 (C) $46.63 \text{ JK}^{-1} \text{ mol}^{-1}$ (D) $93.25 \text{ JK}^{-1} \text{ mol}^{-1}$

Q. 116. The Maxwell's relationship derived from the equation $dE = TdS - PdV$ is

- (A) $\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$ (B) $\left(\frac{\partial P}{\partial V}\right)_T = -\left(\frac{\partial T}{\partial S}\right)_P$
 (C) $\left(\frac{\partial V}{\partial T}\right)_P = -\left(\frac{\partial S}{\partial P}\right)_T$ (D) None of these

Q. 117. Work done in a free expansion process is

- (A) zero (B) minimum
 (C) maximum (D) positive

Numerical Answer Type Questions

Q. 118. For the reaction, $\text{CuSO}_4(\text{aq}) + \text{ZnS} \rightarrow \text{ZnSO}_4(\text{aq}) + \text{Cu(s)}$, the value of ΔG° (in kJ mol^{-1}) is _____ (Round off to the nearest integer)

(Reduction potential: $\text{Cu}^{2+}(\text{aq}) / \text{Cu(s)} = +0.34 \text{ V}$; $\text{Zn}^{2+}(\text{aq}) / \text{Zn(s)} = -0.76 \text{ V}$)
 (Faraday constant = 96485 C mol^{-1})

Q. 119. The value of C_V for 1 mol of N_2 gas predicted from the principle of equipartition of energy ignoring vibrational contribution, is _____ $\text{J K}^{-1} \text{ mol}^{-1}$ (Rounded up to two decimal places). [$R = 8.3 \text{ JK}^{-1} \text{ mol}^{-1}$]

Q. 120. One mole of an ideal gas is compressed from 5 L to 2 L at constant temperature. The change in entropy, in JK^{-1} , of the gas is _____ ($R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$)

- Q. 121. The heat of formation of MgO at 300 K and 1 bar pressure is $-600.60 \text{ kJ mol}^{-1}$. The free energy (in kJ mol^{-1}) of formation of MgO at 280 K is.....(Round off to nearest integer).

Given: In the range 280 – 300 K, the constant pressure heat capacities (C_p) and molar entropies (S_m) are:

	Mg	O ₂	MgO
C_p (in $\text{J mol}^{-1} \text{K}^{-1}$)	24.9	29.4	27.0
S_m (in $\text{J mol}^{-1} \text{K}^{-1}$)	0	205.2	0

- Q. 122. One mole of a substance is heated from 300 K to 400 K at constant pressure. The C_p of the substance is given by, $C_p (\text{J K}^{-1} \text{mol}^{-1}) = 5 + 0.1T$. The change in entropy, in $\text{J K}^{-1} \text{mol}^{-1}$, of the substance is _____

- Q. 123. The enthalpy of fusion of ice at 273 K is 6.01 kJ mol^{-1} and the enthalpy of vaporization of water at 273 K is $44.83 \text{ kJ mol}^{-1}$, the enthalpy of sublimation (in kJ mol^{-1}) of ice at 273 K, is _____

- Q. 124. Consider the reaction $\text{CO(g)} + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$. The value of ΔU for the reaction at 300 K is $-281.8 \text{ kJ mol}^{-1}$. The value of ΔH at same temperature is _____ kJ mol^{-1} (round up to the first decimal place).

$$[R = 8.3 \text{ J K}^{-1} \text{mol}^{-1}]$$

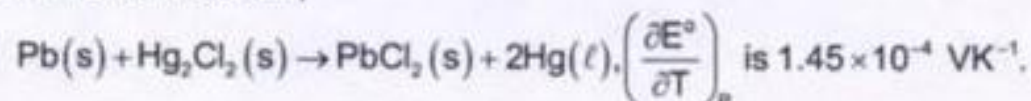
- Q. 125. At 298 K and 1 atm, the molar enthalpies of combustion of cyclopropane and propene are $-2091 \text{ kJ mol}^{-1}$ and $-2058 \text{ kJ mol}^{-1}$, respectively. The enthalpy change in (kJ mol^{-1}) for the conversion of one mole of propene to one mole of cyclopropane is _____

- Q. 126. The enthalpy of formation for $\text{CH}_4(\text{g})$, C(g) and H(g) are $-75,717$ and 218 kJ mol^{-1} , respectively. The enthalpy of the C – H bond in kJ mol^{-1} is _____.

- Q. 127. The emf of a standard cadmium cell is 1.02 V at 300 K. The temperature coefficient of the cell is $-5.0 \times 10^{-5} \text{ V K}^{-1}$. The value of ΔH° for the cell is _____ kJ mol^{-1} (rounded up to two decimal places).

$$[1F = 96500 \text{ C mol}^{-1}]$$

Q. 128. For a cell reaction,



The entropy change (in $\text{J mol}^{-1} \text{ K}^{-1}$) for the reaction is _____

[Given : $1F = 96500 \text{ C mol}^{-1}$]

Q. 129. Consider an isothermal reversible compression of one mole of an ideal gas in which the pressure of the system is increased from 5 atm to 30 atm at 300 K. The entropy change of the surroundings (in JK^{-1}) is _____. (Final answer should be rounded off to two decimal places.)

[Given : $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$]

Q. 130. Two moles of an ideal gas is expanded isothermally and reversibly from 5 to 1 bar at 298 K. The change in the entropy (in J K^{-1}) of the system is _____

Q. 131. The change in entropy when two moles of Argon gas are heated at constant volume from 300 K to 500 K is.....

Q. 132. An engine absorbs heat at a temperature of 1000 K and rejects heat at 600 K. If the engine operates at maximum possible efficiency, the amount of work performed by the engine, for 2000 J heat input is

Q. 133. A Carnot engine operates between 600 and 800 K and absorbs 2000 cal from the source per cycle. The work done (in cal) per cycle is

Q. 134. A Carnot engine works between the temperature 300 K and 400 K and takes 6 KJ energy. Then what is the work done.

Q. 135. A Carnot engine at 55% efficiency. If the temperature of rejected steam is 105°C . Then the absolute temperature of the input steam is _____

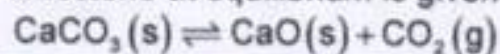
Q. 136. At 300 K, 2 moles of an ideal gas expand reversibly and isothermally from 1 L to 10 L. What is the entropy change for the process. Give your answer in $\text{Cal K}^{-1} \text{ mol}^{-1}$.

Q. 137. A reversible heat engine absorbs 20 kJ of heat from a source at 500 K and dissipates it to the reservoir at 400 K. The efficiency of the heat engine is _____%.

Q. 138. 2 L of a gas at 1 atm pressure is reversibly heated to reach a final volume of 3.5 L. The absolute value of the work done on the gas (rounded off to the nearest integer) is _____ Joules.

Q. 139. When three moles of helium is mixed with one mole of neon at constant temperature at pressure (25°C, 1 atm), the entropy of mixing (in J K^{-1} , rounded off to two decimal places) is _____
 [Given : $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$]

Q. 140. The thermodynamic data at 298 K for the decomposition reaction of limestone at equilibrium is given below



Thermodynamic quantity	$\text{CaCO}_3(\text{s})$	$\text{CaO}(\text{s})$	$\text{CO}_2(\text{g})$
$\mu^\circ (\text{kJ mol}^{-1})$	-1128.8	-604.0	-394.4
$\Delta H_f^\circ (\text{kJ mol}^{-1})$	-1206.9	-635.1	-393.5

The partial pressure of $\text{CO}_2(\text{g})$ in atm evolved on heating limestone (rounded off to two decimal places) at 1200 K is _____.

[Given : $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$]