Chemical Thermodynamics

NET/JRF Previous Year's Question

Assignment 1

Q1. An ideal gas expands by following an equation PV^a = constant. In which case does one expect heating? **[NET June 2011]**

(a) $3 > a > 2$ (b) $2 > a > 1$ (c) $0 < a < 1$ (d) $-1 < a < 0$

Q2. The chemical potential of component 1 in a solution of binary mixture is $\mu_1 = \mu_1^0 + RT \ln P_1$, when p_1 is partial pressure of component 1 vapour phase. The standard state μ_1^0 is: **[NET June 2011]**

(a) Independent of temperature and pressure

(b) Depends on temperature and pressure both

(c) Depends on temperature only

(d) Depends on pressure only

Q3. For system of constant composition, the pressure (P) is given by. **[NET Dec. 2011]**

(a) $-\left(\frac{\partial U}{\partial S}\right)_V$ (b) $-\left(\frac{\partial U}{\partial V}\right)_S$ (c) $\left(\frac{\partial V}{\partial S}\right)_T$ (d) $\left(\frac{\partial U}{\partial V}\right)_T$

Q4. 1 mol of CO_2, 1 mol of N_2 and 2 mol of O_2 were mixed at 300K. the entropy of mixing is **[NET Dec. 2011]**

(a) $6\ R\ \ell n2$ (b) $8\ R\ \ell n2$ (c) $\frac{8R\ell n2}{300}$ (d) $16\ R\ \ell n2$

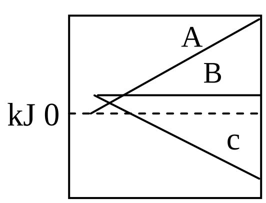
Q5. For the liquid $\rightleftharpoons$ vapour equilibrium of a substance $\frac{dP}{dT}$ at 1 bar and 400 K is $8\text{x}10^{-3}$ bar K^{-1}. If the molar volume in the vapour from is 200L mol^{-1} and the molar volume in the liquid form is negligible, the molar enthalpy of vapourisation is (1.0bar L = 100J) **[NET Dec. 2011]**

(a) 640 kJ mol^{-1} (b) 100 kJ mol^{-1} (c) 80 kJ mol^{-1} (d) 64 kJ mol^{-1}

Q6. For the reaction $C_2H_4\ (g) + 3O_2\ (g) \rightarrow 2CO_2\ (g) + 2H_2O\ (\ell)$, the value of $\Delta H - \Delta U$ (in kJ) at 300K and 1 bar is **[NET Dec. 2011]**

(a) -5.0 (b) 0.0 (c) 2.5 (d) 5.0

Q7. For the reaction $H_2O\ g + C\ graphite \rightleftharpoons CO\ g + H_2O\ g$, the value of , the variation of energy parameter $\Delta G^0, \Delta H^0$ and $T\Delta S^0$ of the reaction over a large temperature range is shown below. The correct identification of the curve is given by **[NET Dec. 2011]**



(a) $A \rightarrow \Delta G^0, B \rightarrow \Delta H^0, C \rightarrow T\Delta S^0$ (b) $A \rightarrow \Delta H^0, B \rightarrow \Delta G^0, C \rightarrow T\Delta S^0$

(c) $A \rightarrow \Delta G^0, B \rightarrow T\Delta S^0, C \rightarrow \Delta H^0$ (d) $A \rightarrow T\Delta S^0, B \rightarrow \Delta H^0, C \rightarrow \Delta G^0$

Q8. An ideal gas was subjected to a reversible, adiabatic expansion and then its initial volume was restored by a reversible, isothermal compression. If 'q' denotes the heat added to the system and 'w' teh work done by the system, then **[NET June 2012]**

(a) $W < 0, q < 0$ (b) $W > 0, q < 0$ (c) $W < 0, q > 0$ (d) $W > 0, q > 0$

Q9. Indicate which one of the following relations is NOT correct: **[NET June 2012]**

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

Q10. For water $\Delta H_{vap} \approx 41\ kJ\ mol^{-1}$The molar entropy of vaporization at 1 atm pressure is approximately. **[NET Dec. 2012]**

(a) $410 JK^{-1}mol^{-1}$ (b) $110 JK^{-1}mol^{-1}$ (c) $41 JK^{-1}mol^{-1}$ (d) $11 JK^{-1}mol$

Q11. A carnot takes up 90 J of heat from source kept at 300K. The correct statement among the following is **[NET Dec. 2012]**

(a) It transfers 60 J of heat to the sink at 200K

(b) It transfers 50J of heat to the sink at 200K

(c) It transfers 60J of heat to the sink at 250K

(d) It transfer 50J of heat to the sink at 250K

Q12. The internal pressure $(\partial U/\partial V)_T$ of a real gas is related to the compressibility factor Z=p$\bar{V}/RT$ by [$\bar{V}$ *is the molar volume*] **[NET Dec. 2012]**

(a) $(\partial U/\partial V)_T = RT\ (\partial Z/\partial V)_T$ (b) $(\partial U/\partial V)_T = RT / \bar{V}Z$

(c) $(\partial U/\partial V)_T = (RT^2/\bar{V})(\partial Z/\partial V)_V$ (d) $(\partial U/\partial V)_T = (\bar{V}/RT^2)(\partial Z/\partial T)_V$

Q13. The fugacity of a gas depends on pressure and the compressibility factor Z (=p$\bar{V}$/RT) through the relation ($\bar{V}$ is the molar volume)

$$f = p.\exp\left[\int_0^p \frac{Z-1}{p}\,dp\right]$$

For most gases at temperature T and up to moderate pressure, this equation shows that

(a) $f < p$, if $T \to 0$ (b) $f < p$, if $T \to \infty$ **[NET Dec. 2012]**

(c) $f > p$, if $T \to 0$ (d) $f = p$, if $T \to 0$

Q14. Which of the following statements is true for a cyclic process? **[NET June 2013]**

(a) $\oint dq = 0$ (b) $\oint dw = 0$

(c) Heat can be completely converted into work (d) Work can be completely converted into heat

Q15. The correct thermodynamics relation among the following is **[NET Dec. 2013]**

(a) $\left(\frac{\partial U}{\partial V}\right)_S = -P$ (b) $\left(\frac{\partial H}{\partial V}\right)_S = -P$ (c) $\left(\frac{\partial G}{\partial V}\right)_S = -P$ (d) $\left(\frac{\partial A}{\partial V}\right)_S = -S$

Q16. The heat capacity of 10mol of an ideal gas at a certain temperature is $300 JK^{-1}$ at constant pressure. The heat capacity of the same gas at the same temperature and at constant volume would be **[NET Dec. 2013]**

(a) $383 JK^{-1}$ (b) $217 JK^{-1}$ (c) $134 JK^{-1}$ (d) $466 JK^{-1}$

Q17. The Maxwell's relationship derived from the equation dG = VdP - SdT is **[NET Dec. 2013]**

(a) $\left(\frac{\partial V}{\partial T}\right)_P = \left(\frac{\partial S}{\partial P}\right)_P$ (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) $\left(\frac{\partial P}{\partial V}\right)_T = -\left(\frac{\partial T}{\partial S}\right)_P$

Q18. The chemical potential (μ_1) of the 1^{th} component is defined as **[NET Dec. 2013]**

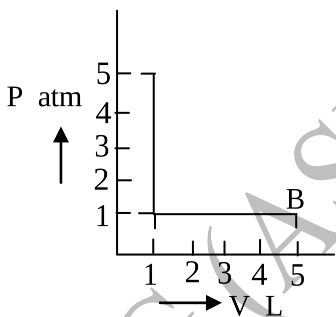
(a) $\mu_i = \left(\frac{\partial U}{\partial n_i}\right)_{T,P}$ (b) $\mu_i = \left(\frac{\partial H}{\partial n_i}\right)_{T,P}$ (c) $\mu_i = \left(\frac{\partial A}{\partial n_i}\right)_{T,P}$ (d) $\mu_i = \left(\frac{\partial G}{\partial n_i}\right)_{T,P}$

Q19. Work (w) involved in isothermal reversible expansion from V_i to V_f of n moles of an ideal gas is **[NET Dec. 2013]**

(a) $w = -nRT\ In\ \ V_f / V_i$ (b) $w = nRT\ In\ \ V_f / V_i$

(c) $w = -\ nRT\ \ V_f / V_i$ (d) $w = -nRT\log\ \ V_f / V_i$

Q20. The figure below represents the path followed by the gas during expansion from $A \longrightarrow B$. The work done is (L atm)



(a) 0 (b) 9 (c) 5 (d) 4

Q21. Two phases (α *and* β) of a species are in equilibrium. The correct relations observed among the variables, T, p and μ are **[NET June 2014]**

(a) $T_\alpha = T_\beta$, $p_\alpha \neq p_\beta$, $\mu_\alpha = \mu_\beta$

(b) $T_\alpha \neq T_\beta$, $p_\alpha = p_\beta$, $\mu_\alpha = \mu_\beta$

(c) $T_\alpha = T_\beta$, $p_\alpha = p_\beta$, $\mu_\alpha = \mu_\beta$

(d) $T_\alpha = T_\beta$, $p_\alpha = p_\beta$, $\mu_\alpha \neq \mu_\beta$

Q22. In a bomb calorimeter, the combustion of 0.5g of compound A (molar mass = 50 g mol^{-1}) increased the temperature by 4K. If the heat capacity of the calorimeter along with that of the material is 2.5 kJ K^{-1}, the molar internal energy of combustion, in kJ, is **[NET June 2014]**

(a) 1000 (b) -1000 (c) 20 (d) -20

Q23. For a process in closed system, temperature is equal to: **[NET Dec. 2014]**

(a) $\left(\frac{\partial H}{\partial P}\right)_S$ (b) $-\left(\frac{\partial A}{\partial V}\right)_T$ (c) $\left(\frac{\partial G}{\partial P}\right)_T$ (d) $\left(\frac{\partial H}{\partial S}\right)_P$

Q24. The exact differential df of a state function $f\ (x, y)$, among the following is **[NET Dec. 2014]**

(a) xdy (b) $dx\text{-}\frac{x}{y}\,dy$ (c) $ydx - xdy$ (d) $\frac{1}{y}dx - \frac{x}{y^2}\ dy$

Q25. Given the following two relations, $x_1 d\,\mu_1 + x_2 d\,\mu_2 = 0$ (A) **[NET Dec. 2014]**

and $x_1 d\bar{V}_1 + x_2 d\,\bar{V}_2 = 0$, (B)

For a binary liquid mixture at constant temperature and pressure, the true statement is that,

(a)Both the relations are correct

(b) Relation A is correct, but B is not

(c) Relation B is correct, but A is not

(d) Both the relations are incorrect, except for very dilute solution

Q26. At high pressure, the fugacity coefficient of a real gas is greater than one, because **[NET Dec. 2014]**

(a) Attractive term overweighs the repulsive term

(b) Repulsive term overweighs the attractive term

(c) Repulsive term is equal to the attractive term

(d) The system is independent of both the attractive and repulsive term

Q27. A thermodynamic equation that relates the chemical potential to the composition of a mixture is known as **[NET June 2015]**

(a) Gibb's – Helmholtz equation (b) Gibbs – Duhem equation

(c) Joule – Thomas equation (d) debye – Huckel equation

Q28. Heat capacity of a species is independent of temperature if it is **[NET June 2015]**

(a) tetraatomic (b) triatomic (c) diatomic (d) monoatomic

Q29. The value of ΔU - ΔH for the reaction $Fe_2O_3\,(s) + 3C\,(s) \rightarrow 2Fe\,(s) + 3CO\,(g)$ is **[NET Dec. 2015]**

(a) -3RT (b) + 3RT (c) +RT (d) –RT

Q30. If the pressure p (system) is greater than the p (surroundings), then **[NET Dec. 2015]**

(a) work is done on the system by the surroundings

(b) work is down on the surroundings by the systems

(c) work done on the system by the surroundings is equal to the work done on the surroundings by the system

(d) internal energy of the system increases

Q31. ΔH of a reaction is equal to slope of the plot of **[NET Dec. 2015]**

(a)ΔG versus (1/T) (b) ΔG versus T

(c) (ΔG / T) versus T (d) (ΔG / T) versus (1/ T)

Q32. 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 300K. ΔG for this process is **[NET Dec. 2015]**

(a) $300R\cdot$ In2 (b) $600R\cdot$ In2 (c) $-600R\cdot$ In 2 (d) $-300R\cdot$ In 2

Q33. The non-spontaneous process among the following is **[NET Dec. 2015]**

(a) vapourisation of superhead water at 105°C and 1 atm pressure

(a) expansion of a gas into vacuum freezing

(b) freezing of super cooled water at - 10°C and 1 atm pressure

(c) freezing of water at 0°C and 1 atm pressure

Q34. $\left(\frac{\partial H}{\partial P}\right)_T$ has the dimension of **[NET June 2016]**

(a) pressure (b) volume (c) temperature (d) heat capacity

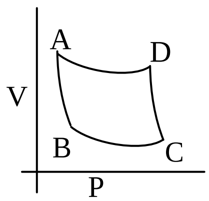
Q35. For an ideal gas at 300K **[NET June 2016]**

(a) $\left(\frac{\partial U}{\partial V}\right)_T = 0$ (b) $\left(\frac{\partial U}{\partial T}\right)_V = 0$ (c) $\left(\frac{\partial H}{\partial T}\right)_P = 0$ (d) $\left(\frac{\partial G}{\partial T}\right)_P = 0$

Q36. If U is a function of V and T, $\left(\frac{\partial U}{\partial T}\right)_P$ is equal to (π *and* α are the internal pressure and the coefficient of thermal expansion, respectively) **[NET June 2016]**

(a) C_p (b) C_v (c) $C_p - \pi V\alpha$ (d) $C_v + \pi V\alpha$

Q37. The figure below describes how a Camot engine works. It starts from the adiabatic compression step denoted by



(a) AB (b) BC (c) DC (d) AD

Q38. The parameter which always decreases during a spontaneous process at constant S and V, is

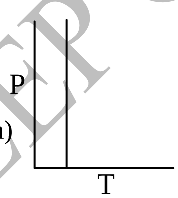
[NET Dec. 2016]

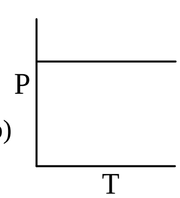
(a) U (b) H (c) C_p (d) q

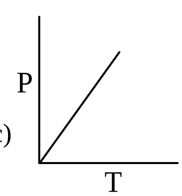
Q39. The equation of state for one mole of a gas is given by P (V-b) =RT, where b and R are constants. The value of $\left(\frac{\partial H}{\partial P}\right)_T$ is **[NET Dec. 2016]**

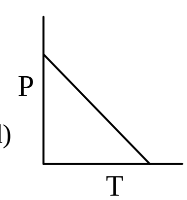
(a) $V - b$ (b) b (c) 0 (d) $\frac{RT}{P} + b$

Q40. The volume change in a phase transition is zero. From this, we may infer that the phase boundary is represented by

(a) 

(b) 

(c) 

(d) 

Q41. The partial derivative $\left(\frac{\partial T}{\partial V}\right)_P$ is equal to **[NET Dec. 2016]**

(a) $-\left(\frac{\partial P}{\partial S}\right)_T$ (b) $-\left(\frac{\partial P}{\partial S}\right)_V$ (c) $-\left(\frac{\partial P}{\partial S}\right)_n$ (d) $-\left(\frac{\partial P}{\partial S}\right)_H$

Q42. The minimum work required by an engine to transfer 5J of heat from a reservoir at 100K to one at 300K is **[NET June 2017]**

(a) 5J (b) 10J (c) 15J (d) 20J

Q43. The correct statement for any cyclic thermodynamic process is

(a) $\oint dq = 0$ (b) $\oint dw = 0$ (c) $\oint dU = 0$ (d) $\oint Vdq = 0$

Q44. The fugacity of real gas is less than pressure (P) of an ideal gas at the same temperature (T) only when (T_b is the Boyle temperature of the real gas)

(a) high $P, T < T_b$ (b) low $P, T < T_b$ (c) high $P, T > T_b$ (d) low $P, T > T_b$

Q45. In streching of a rubber band,

$$dG = Vdp - SdT + fdL$$

Which of the following relations in true

(a) $\left(\frac{\partial S}{\partial L}\right)_{p,T} = -\left(\frac{\partial f}{\partial T}\right)_{p,L}$ (b) $\left(\frac{\partial S}{\partial L}\right)_{p,T} = -\left(\frac{\partial f}{\partial V}\right)_{p,L}$

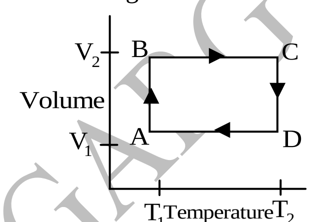
(c) $\left(\frac{\partial S}{\partial L}\right)_{p,T} = -\left(\frac{\partial V}{\partial T}\right)_{p,L}$ (d) $\left(\frac{\partial S}{\partial L}\right)_{p,T} = -\left(\frac{\partial f}{\partial P}\right)_{T,L}$

Q46. Enthalpy is equal to **[NET Dec. 2017]**

(a) $TS + PV + \sum u_i n_i$ (b) $TS + \sum u_i n_i$

(c) $\sum u_i n_i$ (d) $PV + \sum u_i n_i$

Q47. One mole of an ideal gas undergoes a cyclic process (ABCDA) starting from point A through 4 reversible steps as shown in the figure. Total work done in the process is **[NET Dec. 2017]**



(a) $R\ T_1 - T_2\ \frac{V_2}{V_1}$ (b) $R\ T_1 + T_2\ \frac{V_2}{V_1}$ (c) $R\ T_1 + T_2\ \ln\frac{V_2}{V_1}$ (d) $R\ T_2 + T_1\ \ln\frac{V_2}{V_1}$

Q48. The change in entropy for a reversible adiabatic process is **[NET June 2018]**

(a) maximum (b) minimum (c) zero (d) positive

Q49. At 300 K, the thermal expansion coefficient and the isothermal compressibility of liquid water are

$2\times10^4 K^{-1}$ and $5\times10^{-5} bar^{-1}$, respectively $\left(\frac{\partial U}{\partial V}\right)_T$ (in k bar) for water at 320 K and 1 bar will be

[NET June 2018]

(a) 2.4 (b) 1.2 (c) 0.6 (d) 12.0

Q50. For a closed system in the absence of non-PV work, the correct statement is **[NET Dec. 2018]**

(a) $dU = TdS - PdV$ (b) $dG = VdP + SdT$ (c) $dU = TdS + PdV$ (d) $dU = VdP - SdT$

Q51. Entropy of a perfect gas is **[NET Dec. 2018]**

(a) independent of V (b) proportional to V (c) proportional to ln V (d) proportional to V

Answer Key

1. (c)	2. (c)	3. (b)	4. (a)	5. (d)	6. (a)	7. (d)
8. (a)	9. (a)	10. (b)	11. (a)	12. (c)	13. (c)	14. (d)
15. (a)	16. (b)	17. (c)	18. (d)	19. (a)	20. (d)	21. (c)
22. (b)	23. (d)	24. (d)	25. (a)	26. (b)	27. (b)	28. (d)
29. (a)	30. (b)	31. (d)	32. (c)	33. (c)	34. (b)	35. (a)
36. (d)	37. (b)	38. (a)	39. (b)	40. (a)	41. (a)	42. (b)
43. (c)	44. (b)	45. (a)	46. (a)	47. (d)	48. (c)	49. (b)
50. (a)	51. (c)					

GATE Previous year's Paper

Q1. The criterion for the spontaneity of a process is: **[GATE 2000]**

(a) $\Delta S_{sys} > 0$ (b) $\Delta S_{surr} > 0$ (c) $\Delta S_{sys} + \Delta S_{surr} > 0$ (d) $\Delta S_{sys} - \Delta S_{surr} > 0$

Q2. ΔH and ΔE for the reaction $Fe_2O_3(s) + 3H_2(s) \rightarrow 2Fe(s) + 3H_2O(\ell)$ at constant temperature are related as **[GATE 2000]**

(a) $\Delta H = \Delta E$ (b) $\Delta H = \Delta E + RT$ (c) $\Delta H = \Delta E + 3RT$ (d) $\Delta H = \Delta E - 3RT$

Q3. For an ideal gas following adiabatic reversible expansion, plot of log P versus log V is linear with a slop equal to ($\gamma = C_p / C_v$): **[GATE 2000]**

(a) $1/\gamma$ (b) $-1/\gamma$ (c) γ (d) $-\gamma$

Q4. for an irreversible adiabatic expansion of a perfect gas from volume V_i to V_f the change in entropy of the gas is: **[GATE 2001]**

(a) nR In (V_f / V_i) (b) Zero (c) less than zero (d) greater than zero

Q5. Choose the correct criterion of spontaneity in term of the properties of the system alone. **[GATE 2001]**

(a) $(dS)_{U,V} > 0$ (b) $(dS)_{T,P} > 0$ (c) $(dS)_{H,P} < 0$ (d) $(dG)_{T,V} < 0$

Q6. Consider the following reaction and use the data given bellow **[GATE 2001]**

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ $\Delta H°$ (25°C) = - 92.2 kJ

Substance	N_2 (g)	H_2 (g)	NH_3 (g)
C_p / (J K^{-1} mol^{-1})	29.1	28.8	35.1

Assuming C_p to be independent of temperature, the reaction at 100°C compared to that at 25°C will be

(a) Endothermic (b) Less exothermic (c) More exothermic (d) Having $\Delta H° = 0$

Q7. Compared to C_2H_6 the value of a van der Waal's constants 'a' and 'b' for He will be **[GATE 2001]**

(a) both will be smaller

(b) ‘a’ will be larger but ‘b’ will be smaller

(c) ‘b’ will be larger but ‘a’ will be smaller

(d) both will be larger

Q8. Assuming that there is no chemical reaction, the change in entropy when 2 mole of N_2, 3 mols of H_2 and 2 mole of NH_3 are mixed at constant temperature is **[GATE 2002]**

(a) -62.79 JK^{-1} (b) 62.79 JK^{-1} (c) 125.58 JK^{-1} (d) -125.58 JK^{-1}

Q9. Adiabatic reversible expansion of a monoatomic gas (M) and a diatomic gas (D) at an initial temperature T_i, has been carried out independently from initial volume V_1 to final volume V_2. The final temperature (T_m for monoatomic and T_D for diatomic) attained will be **[GATE 2003]**

(a) $T_M = T_D > T_i$ (b) $T_M < T_D < T_i$ (c) $T_M > T_D > T_i$ (d) $T_D < T_M < T_i$

Q10. The rate of evaporation of a liquid is always faster at a higher temperature because **[GATE 2003]**

(a) The enthalpy of vaporisation is always endothermic

(b) The enthalpy of vaporisation is always exothermic

(c) The enthalpy of vaporisation is zero

(d) The internal pressure of the liquid is less than that of the gas

Q11. The internal pressure of a vander waals gas is: **[GATE 2003]**

(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.

Q12. For the reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$. Compute the entropy change (in J/K/mol) for the process and comment on the sign of the property **[GATE 2003]**

Data:

Species	NH_3 (g)	N_2 (g)	H_2 (g)
S° (J/K/mol)	192.3	191.5	130.6

(a) $\Delta S°$ = -37.65 J/K/mol; negative sign indicates that there is a decrease in the gaseous species during the reaction

(b) $\Delta S°$ = -198.7 J/K/mol; negative sign indicates that there is a decrease in the gaseous species during the reaction.

(c) $\Delta S°$ = - 31.25 J/K/mol; negative sign indicates that there is a decrease in the gaseous species during the reaction

(d) $\Delta S°$ = + 31.25 J/K/mol; the positive sign indicates that the reaction is spontaneous.

Q13. ΔH^0_{298} for the reaction $C_2H_4O(g) \rightarrow CH_4(g) + CO(g)$, **[GATE 2003]**

is – 16.0kJ. From the given data, evaluate the temperature at which ΔH will be zero.

Substance:	C_2H_4O (g)	CH_4 (g)	CH_4 (g)
C_p (J/K/mol)	50	36	30

(a) 1298K (b) 1000K (c) 1298°C (d) 1100°C

Q14. For the reaction, **[GATE 2003]**

$$2Cl\,(g) \rightarrow Cl_2\,(g)$$

The thermodynamics properties:

(a) ΔG, ΔH and ΔS are positive

(b) ΔG, ΔH and ΔS are negative

(c) ΔG and ΔH are negative and ΔS is positive

(d) ΔG is negative and ΔH and ΔS are positive.

Q15. The coefficient of performance of a perfect refrigerator working reversibly between the temperature T_c and T_h is given by **[GATE 2004]**

(a) $\frac{T_c - T_h}{T_c}$ (b) $\frac{T_h - T_c}{T_c}$ (c) $\frac{T_c}{T_h - T_c}$ (d) $\frac{T_h}{T_h - T_c}$

Q16. For one mole of an ideal gas $\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_P \left(\frac{\partial V}{\partial P}\right)_T =$ **[GATE 2004]**

(a) -1 (b) $-\frac{R^2}{P^2}$ (c) $+1$ (d) $\frac{R^2}{P^2}$

Q17. 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 temperature is **[GATE 2004]**

(a) $(C_v - R)$ In 4 (b) $(C_v - 2R)$ In 2 (c) $(C_v - 2R)$ In 4 (d) $(C_v + 2R)$ In 2

Q18. Match the following: **[GATE 2004]**

P. $\left(\frac{\partial U}{\partial S}\right)_V$ I. -A

Q. $\left(\frac{\partial U}{\partial V}\right)_S$ II. -S

R. $\left(\frac{\partial G}{\partial P}\right)_T$ III. -T

S. $\left(\frac{\partial G}{\partial T}\right)_P$ IV. P

V. H

VI. V

(a) P-III Q-IV R-VI S-II (b) P-III Q-I R-II S-V

(c) P-I Q-III R-V S-II (d) P-IV Q-III R-VI S-V

Q19. The criterion for spontaneous change in terms of the state functions is: **[GATE 2004]**

(a)$dU_{S,V} \geq 0$ (b) $dA_{T,V} \geq 0$ (c) $dS_{U,V} \geq 0$ (d) $dG_{T,V} \leq 0$

Q20. One mole of an ideal gas ($C_V = 1.5$ R) at a temperature 500 K is compressed from 1.0 atm to 2.0 atm by a reversible isothermal path. Subsequently, it is expanded back to 1.0 atm by a reversible adiabatic path. The volume of the final state in litre is: **[GATE 2004]**

(a) 15.6 (b) 20.5 (c) 31.1 (d) 41.0

Q21. The fugacity coefficient ϕ is given by $\ln\phi = \int_0^p \left(\frac{z-1}{p}\right)dp$ where z is the compressibility factor, and *p* the pressure. The fugacity of a gas governed by the gas law $p\,(V_m - b) = RT$ is **[GATE 2004]**

(a) $p\ln V_m/RT$ (b) $pe^{b/RT}$ (c) $pe^{-bp/RT}$ (d) $pe^{bp/RT}$

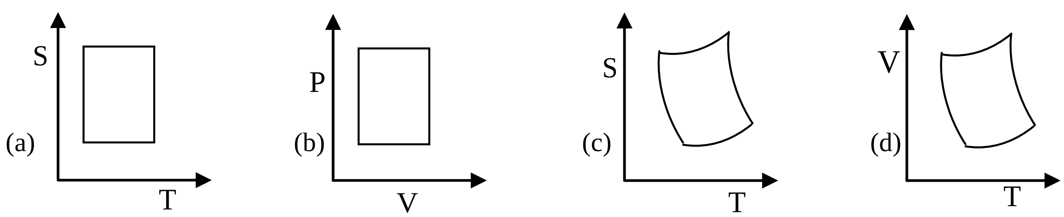
Q22. The internal pressure, $\pi_T = T\left(\frac{\partial P}{\partial T}\right)_V - P$ for one mole a Vander waals gas is: **[GATE 2005]**

(a) $\frac{a}{V^2}$ (b) $\frac{a}{V^2}\left(\frac{RT}{V-b}\right)$ (c) Zero (d) $\frac{RT}{V-b}$

Q23. Standard entropy of crystalline carbon monoxide (in J/mol) at 0 K is around **[GATE 2005]**

(a) 0.03 (b) 2.50 (c) Zero (d) 5.76

Q24. The plot that describes a Carnot cycle is: **[GATE 2006]**



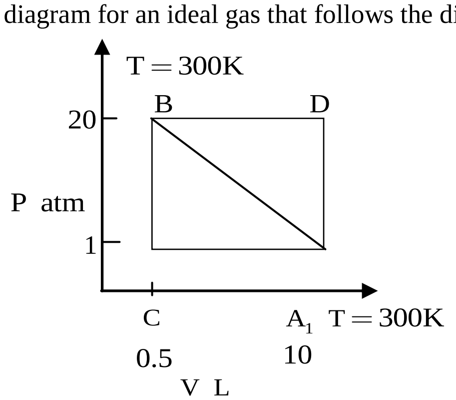
Q25. ΔS°_{univ} for the following reaction, at 298 K is: **[GATE 2006]**

$N_2 + 3H_2 \rightarrow {}_2NH_3$ $\Delta S^\circ_{sys} = -197\ JK^{-1}$, $\Delta H^\circ_{sys} = -91.8kj$

(a) -197 JK (b) 0 J K^{-1} (c) -308 J K^{-1} (d) 111 J K^{-1}

Common Data for Q. 27 and Q. 28 **[GATE 2006]**

Consider the following P-V diagram for an ideal gas that follows the diagonal path from A to B.



Q26. The work done (in atm – L) on the gas in the process is

(a) 9.5 (b) 99.75 (c) 190 (d) 10 1n (20)

Q27. For the above process,

(a) $\Delta H = W$ (b) $\Delta H = Q$ (c) $\Delta H = \Delta G$ (d) $\Delta H = \Delta E$

Q28. The expression which represents the chemical potential of the i^{th} species (μ_i) in a mixture ($i \neq j$) is: **[GATE 2007]**

(a) $(\partial E / \partial n_i)_{s,v,nj}$ (b) $(\partial H / \partial n_i)_{s,v,nj}$ (c) $(\partial A / \partial n_i)_{s,v,nj}$ (d) $(\partial G / \partial n_i)_{s,v,nj}$

Q29. The temperature of 54 g of water is raised from 15°C to 75°C at constant pressure. The change in the enthalpy of the system (given that $C_{p.m}$ of water = 75 JK^{-1} mol^{-1}) is: **[GATE 2007]**

(a) 4.5 kj (b) 13.5 kj (c) 9.0 kj (d) 18.0 kj

Q30. The specific volume of liquid water is 1.001 mL g^{-1} and that of ice is 1.0907 mL g^{-1} at °C. if the heat of fusion office at this temperature is 333.88 J g^{-1}, the rate of change of melting point of ice with pressure in deg atm^{-1} will be **[GATE 2007]**

(a) – 0.0075 (b) 0.0075 (c) 0.075 (d) – 0.075

Q31. The entropy of mixing of 10 moles of helium and 10 moles of oxygen at constant temperature and pressure, assuming both to be ideal gas, is: **[GATE 2007]**

(a) 115.3 JK^{-1} (b) 5.8 JK^{-1} (c) 382.9 JK^{-1} (d) 230.6 JK^{-1}

Q32. The dimension of Planck constant is (M, L and T denote mass, length and time respectively) **[GATE 2007]**

(a) ML^3T^{-2} (b) ML^2T^{-1} (c) $M^2L^{-1}T^{-1}$ (d) $M^{-1}L^2T^{-2}$

Q33. If a gas obeys the equation of state P (V – nb) = nRT, the ratio $\dfrac{C_P - C_V}{(C_P - C_V)_{ideal}}$ is: **[GATE 2009]**

(a) >1 (b) <1 (c) 1 (d) (1 – b)

Q34. The free energy change (ΔG) of 1 mole of an ideal gas that is compressed isothermally from 1 atm to 2 atm is: **[GATE 2009]**

(a) RT1n2 (b) – 2RT (c) – RT1n2 (d) 2RT

Q35. Given that the standard molar enthalpies of formation of NO(g) and NO_2 (g) are, respectively, 90.3 kJ mol^{-1} and 33.2 kJ mol^{-1}, the enthalpy change for the reaction 2 *NO* (g) + *O_2* (g) is **[GATE 2009]**

(a) 16.6 kJ (b) – 57.1 kJ (c) – 114.2 kJ (d) 57.1 kJ

Q36. Among the following the system that would require the least amount of thermal energy to bring its temperature to 80°C is: **[GATE 2009]**

(a) 200 gm of water at 40°C (b) 100 gm of water at 20°C

(c) 150 gm of water at 50°C (d) 300 gm of water at 30°C

Q37. The molar entropy of crystalline CO at absolute zero is: **[GATE 2010]**

(a)Zero (b) – R1n2 (c) R1n2 (d) 2R1n2

Q38. For an ideal gas **[GATE 2010]**

(a) $(\partial P / \partial T)_V (\partial T / \partial V)_P (\partial V / \partial P)_T = 0$ (b) $(\partial P / \partial T)_V (\partial T / \partial V)_P (\partial V / \partial P)_T = -1$

(c) $(\partial P / \partial T)_V (\partial T / \partial V)_P (\partial V / \partial P)_T = +1$ (d) $(\partial P / \partial T)_V (\partial T / \partial V)_P (\partial V / \partial P)_T = +2$

Q39. Among W (work), Q (heat), U(internal energy) and S(entropy) **[GATE 2010]**

(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.

Q40. The change in entropy when two moles of argon gas are heated at constant volume from 300 K to 500 K is: **[GATE 2010]**

(a) – 12.74 JK^{-1} mol^{-1} (b) – 6.37 JK^{-1} mol^{-1} (c) 6.37 JK^{-1} mol^{-1} (d) 12.74 JK^{-1} mol^{-1}

Q41. At any temperature T, the fugacity coefficient (γ) is given by **[GATE 2010]**

$$\ln \gamma = \int_0^P \frac{Z-1}{P'} dP'$$

Where Z is the compressibility factor. The fugacity coefficient of a real gas governed by equations of state, $P(V - b) = RT$ with 'b' a constant is given by

(a) $\frac{RT}{bP}$ (b) $e^{\frac{RT}{bP}}$ (c) $\frac{bP}{RT}$ (d) $e^{\frac{bP}{RT}}$

Q42. For the process **[GATE 2011]**

$$1\ Ar\ (300K,\ 1\ bar) \rightarrow 1\ Ar\ (200K,\ 10\ bar)$$

Assuming ideal gas behaviour, the change in molar entropy is:

(a) – 27.57 J K^{-1} mol^{-1} (b) + 27.57 J K^{-1} mol^{-1}

(c) – 24.20 J K^{-1} mol^{-1} (d) + 24.20 J K^{-1} mol^{-1}

Q43. For the reaction $X_2O_4\ (\ell) \rightarrow 2XO_2\ (g)$ at 298, given the values, **[GATE 2013]**

Given the values, $\Delta U = 9kj$ and $\Delta S = 84\ J\ K^{-1}$, ΔG is

(a) – 11.08 kJ (b) +11.08 kJ (c) – 13.55 kJ (d) +13.55 kJ

Q44. The change in enthalpy when 3 mol of liquid benzene transforms to the vapour state at its boiling temperature (80°C) and at 1 bar pressure is _______ kj. (Given, ΔH_v = 30.8 kj / mole) **[GATE 2013]**

Q45. At 273 K temperature, 1 atm pressure 1 mol of N_2 and 4 mol of N_2 are mixed together. What will be the entropy of mixing? **[GATE 2013]**

(a) 0.6908 x 10^{-23} JK^{-1} (b) 20.8028 JK^{-1}

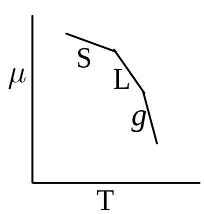
(c) 0 (d) 4.16057 JK^{-1}

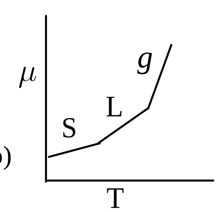
Q46. The maximum non – PV work that system can perform at constant P is **[GATE 2014]**

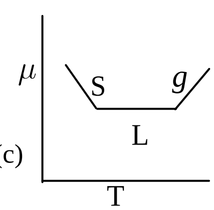
(a) ΔH (b) ΔG (c) ΔS (d) ΔA

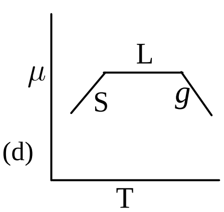
Q47. A Carnot engine operates at 55% efficiency. If the temperature of reject steam is 105°C, then the absolute temperature of input steam is ________ **[GATE 2014]**

Q48. 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) **[GATE 2014]**

(a) 

(b) 

(c) 

(d) 

Q49. The enthalpy of fusion of ice at 273K is 6.01 kJ mol^{-1} and the enthalpy of vaporization of water at 273K is 44.83 kJ mol^{-1}. The enthalpy of sublimation (in kJ mol^{-1}) of ice at 273K, is ______ **[GATE 2014]**

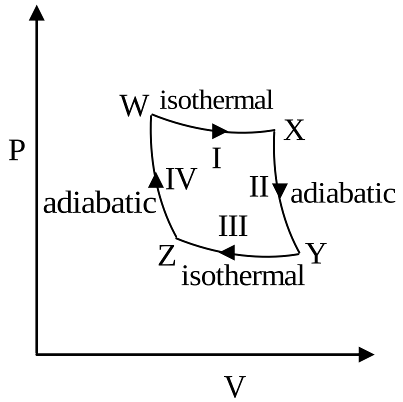
Q50. Which of the following properties are characteristics of an ideal solution? **[GATE 2015]**

(i) $(\Delta_{max} G)_{T,P}$ is negative (ii) $(\Delta_{max} S)_{T,P}$ is positive

(iii) $(\Delta_{max} V)_{T,P}$ is positive (iv) $(\Delta_{max} H)_{T,P}$ is negative

(a) (i) and (iv) (b) (i) and (ii) (c) (i) and (iii) (d) (iii) and (iv)

Q51.



From the above Carnot cycle undergone by an ideal gas, identify the processes in which the change in internal energy is **NON-ZERO.**

(a) I and II (b) II and IV (c) II and III (d) I and IV

Q52. Which one of the following defines the absolute temperature of a system? **[GATE 2015]**

(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) $\left(\frac{\partial G}{\partial S}\right)_V$

Q53. A liquid has vapor pressure of $2.02\text{x}10^3$ $N\ m^{-2}$ at 293 K and het of vaporization of 41 kJ mol^{-1}. The boiling point of the liquid (in Kelvin) is ____________ **[GATE 2015]**

Q54. The internal energy of an ideal gas follows the equation $U = 3.5\ PV + k$, where k is a constant. The gas expands from an initial volume of 0.25 m^3 to final volume of 0.86 m^3. If the initial pressure is 5 N m^{-2}, the change in internal energy (in joules) is (given $PV^{1,3}$ = constant) ____ **[GATE 2015]**

Q55. One mole of a substance is heated from 300K to 400K at constant pressure. The C_P of the substance is given by. C_P (JK^{-1} m^{-1}) = 5 + 0.1T. the change in entropy, in JK^{-1} mol^{-1}, of the substance is - _________________________ **[GATE 2015]**

Q56. The van der waals constant a and b of CO_2 are 3.69 L^2 bar mol^{-2} and 0.04 L mol^{-1}, respectively. The value of R is 0.083 bar dm^3 mol^{-1} K^{-1}. If one mole of CO_2 is confined to a volume of 0.15L at 300K, then the pressure (in bar) exerted by the gas, is **[GATE 2014]**

Q57. One mole of an ideal gas is compressed from 5L to 2L at constant temperature. The change in entropy, in J K^{-1}, of the gas is ______________ (R = 8.314 JK^{-1} mol^{-1}) **[GATE 2016]**

Q58. Of the following inequalities, the criteria for spontaneity of a chemical reaction is/are

(i) $(\Delta G)_{T,P} < 0$ (ii) $(\Delta U)_{S,V} > 0$ (iii) $(\Delta S)_{U,V} > 0$ **[GATE 2016]**

(a) (i) only (b) (ii) only (c) (i) and (ii) (d) (i) and (iii)

Q59. At 1 bar and 298K, for the process A (s) → A (ℓ), the ΔG is 200 J mol^{-1} and ΔV_m is – 2×10^{-6} m^3 mol^{-1}. The minimum pressure, in bar, at which the process becomes spontaneous at 298K is ______________ (1 bar = 10^5 Pa). **[GATE 2016]**

Q60. For a system subjected to only P – V work, entropy is given by **[GATE 2016]**

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

(a) I and II (b) I and IV (c) I only (d) II only

Q61. 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 **[GATE 2017]**

(a) $(\partial T/\partial P)_S$ (b) $(\partial T/\partial V)_P$ (c) - $(\partial T/\partial V)_S$ (d) $(\partial T/\partial S)_P$

Q62. The gibbs free energy of mixing is denoted as ΔG_{max} 1.0 mole of He, 3.0 moles of Ne and 2.0 moles of Ar are mixed at the same pressure and temperature. Assuming ideal gas behaviour, the value of ΔG_{max} / RT is _____________ (up to two decimal places) **[GATE 2017]**

Q63. Two moles of an ideal gas X and two moles of an ideal gas Y, initially at the same temperature and pressure, are mixed under isothermal-isobaric condition. The entropy change on mixing is

______________ JK^{-1}. (Upto one decimal place, Use $R = 8.31 JK^{-1} mol^{-1}$) **[GATE 2018]**

Q64. The molar heat capacity of a substance is represented in the temperature range 298K to 400K by the empirical relation $C_{p,m} = 14 + bT\ JK^{-1}mol^{-1}$, where b is a constant. The molar enthalpy change when the substance is heated from 300K to 350K is 2 kJ mol^{-1}. The value of b is

______________ $J\ K^{-2}mol^{-1}$ (Upto two decimal place)

Q65. The enthalpy of vaporization of a liquid at its boliling point $T_b = 200K$ is $15.3 kJmol^{-1}$. If the molar volumes of the liquid and the vapour at 200 K are 110 and $12000 cm^3\ mol^{-1}$, respectively, then the slope $\frac{dP}{dT}$ of the liquid-boundary is $kPa\ K^{-1}$______________

(Upto two decimal places. Note 1 Pa = 1 J m^{-1})

TIFR Previous Year's Question

Q1. Consider the formation of MgO(s). Assume that ΔH_r^0 and ΔS_r^0 are independent of temperature.

$Mg(s) + ½ O_2 (g) \rightarrow MgO(s)$

ΔH_r^0 = - 602 kJ/mol

ΔS_r^0 = - 108 J/K mol

Calculate ΔG_r^0 for the formation of MgO(s) at 0°C and is the reaction spontaneous or non-spontaneous at 0°C? **[TIFR 2010]**

(a) -573 kJ/mol, non-spontaneous (b) -573 kJ/mol, spontaneous

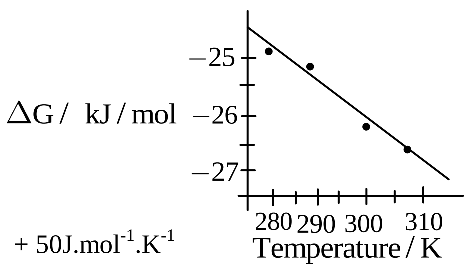
(C) 632 kJ/mol, non-spontaneous (d) -632 kJ/mol, spontaneous

Q2. Assume that a carnot engine is working in reverse in a refrigerator, with perfect thermodynamic efficiency. Calculate the amount of work needed (i) to freeze 100 g of water at 0°C, the temperature of the surrounding being 25°C; (ii) to withdraw the same amount of heat from a body at 10^{-5} K, the surrounding being at 1 K. (ΔH_{melt} = 0.01 kJ/mol) **[TIFR 2011]**

(a) (i) 601 kJ; (ii) 601 kJ (b) (i) 33.4 kJ; (ii) 33.4kJ

(C) (i) 3.06 kJ; (ii) 33.4 kJ (d) (i) 3.06 kJ; (ii) 33.4 x 10^{-5} kJ

Q3. A student has measured the standard free energy change of a certain chemical reaction as a function of temperature. The data and a linear fit to them are shown below. From this diagram, determine approximately the standard entropy of the reaction. (Assume that the standard entropy of the reaction is independent of temperature.) **[TIFR 2011]**



(a) + 50J.mol^{-1}.K^{-1} (b) + 75J.mol^{-1}.K^{-1}

(c) + 100J.mol^{-1}.K^{-1} (d) - 100J.mol^{-1}.K^{-1}

Q4. Consider a container of volume 5.0 L that is divided into two compartments of equal size. In the left compartment there is nitrogen at 1.0 atm and 25°C; in the right compartment there is hydrogen at the same temperature and pressure. What will happen when the partition is removed? **[TIFR 2012]**

(a) The entropy increases, and the free energy decreases.

(b) The entropy decreases, and the free energy decreases.

(c) The entropy increases, and the free energy increases.

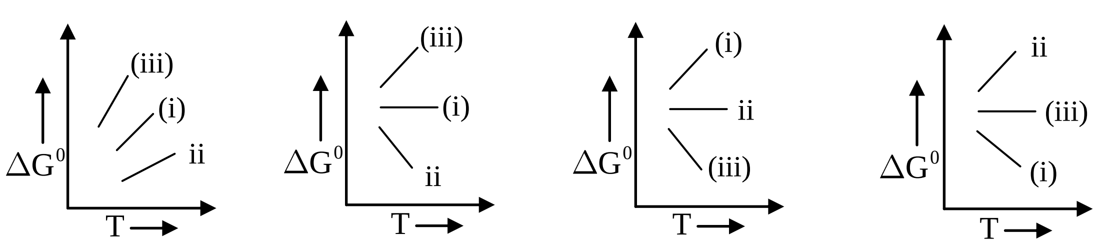
(d) The entropy decreases, and the free energy increases.

Q5. The standard Gibbs free energies of the following reaction, ΔG^0, have been determined at various temperatures. **[TIFR 2013]**

(i) $C(s) + O_2(g) \rightarrow CO_2(g)$ (ii) $C(s) + 1/2O_2(g) \rightarrow CO(g)$

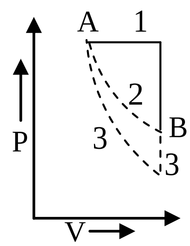
(iii) $CO(g) + 1/2O_2(g) \rightarrow CO_2(g)$

Which of the following plots would represent most likely the temperature dependence of ΔG^0?



(a) (b) (c) (d)

Q6. The state of 2 moles of an ideal gas is changed from the point A to the point B along three different paths, as shown in the following P-V diagram. If the change of entropy of the gas in changing its state from sate A to B along the path I is denoted ΔS_i, then which of the following statements is correct? **[TIFR 2013]**



(a) $\Delta S_1 > \Delta S_2 > \Delta S_3$ (b) $\Delta S_1 < \Delta S_2 < \Delta S_3$

(c) $\Delta S_1 \neq \Delta S_2 \neq \Delta S_3$ (d) $\Delta S_1 = \Delta S_2 = \Delta S_3$

Q7. A reaction has a negative (and approximately temperature independent) enthalpy change. It does not proceed spontaneously at room temperature (25˚C). at which of the following temperatures is the reaction more likely to become spontaneous? **[TIFR 2013]**

(a) -50˚C (b) 50˚C (c) 100˚C (d) 1000˚C

Q8. For the following reaction,

$$CO_2 + H_2O \rightarrow H_2CO_3$$

The entropy change (ΔS_{system}) was calculated to be – 96 JK^{-1} mol^{-1}. The enthalpy change (ΔH) was measured to be – 45 kJ K^{-1} mol^{-1}. This reaction is expected to be a spontaneous process. The total change in entropy ($\Delta S_{system+surroundings}$) is : **[TIFR 2014]**

(a) +54 JK^{-1} mol^{-1} (b) -96 J K^{-1} mol^{-1}

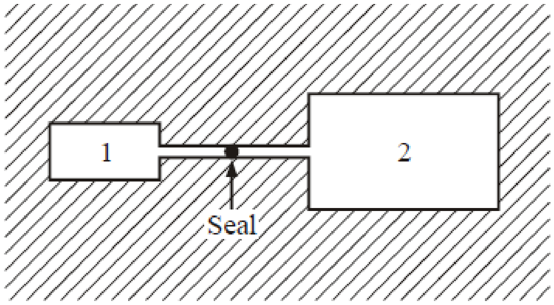
(c) -45096 J K^{-1} mol^{-1} (d) -44004 J K^{-1} mol^{-1}

Q9. Calculate the change in entropy when 1 mol of solid iodine, I_2, at a temperature of 360 K is heated at constant pressure to produce liquid iodine at a temperature of 410 K. the constant pressure molar heat capacity of solid iodine is 54.44 K^{-1} mol^{-1} and of liquid iodine is 80.67 J K^{-1} mol^{-1}. The melting temperature of iodine is 387 and the molar enthalpy of fusion of iodine is 7.87 kJ mol^{-1} **[TIFR 2014]**

(a) 8.6 J K^{-1} mol^{-1} (b) 28.9 JK^{-1} mol^{-1}

(c) 20.3 J K^{-1} mol^{-1} (c) 11.7 J K^{-1} mol^{-1}

Q10. In the following setup, two chambers 1 and 2 are enclosed by thermally insulated material. Chamber 1 contains an ideal gas at 100 atm. Chamber 2 is completely evacuated. The two chambers are separated by a breakable seal. Before the seal is broken, the temperature of the chamber 1 is $T_{1,initial}$. Then the seal is broken, and the gas is allowed to rush to chamber 2. The volume of chamber 2 is 100 times the volume of chamber 1. When the pressure in the two chambers becomes equal, their respective temperature is $T_{1,final}$ and $T_{2,final}$. Which of the following statements is true? **[TIFR 2015]**

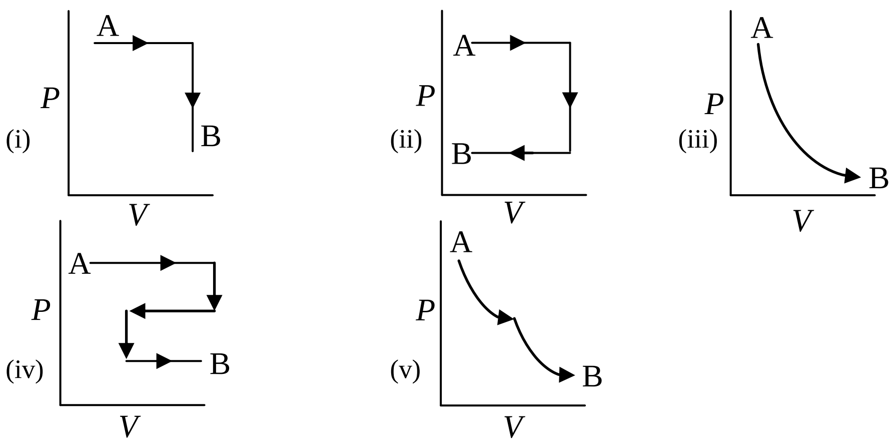


(a) $T_{1,final} = T_{2,final} = T_{1,final}$ (b) $T_{2,final} = T_{1,final} < T_{1,final}$

(c) $T_{2,final} < T_{1,initial}$, $T_{1,final} = T_{1,initial}$

(d) Only a Very small drop in temperature is expected. So $T_{1,final}$, $T_{2,final}$ will be approximately equal to $T_{1,initial.}$

Q11. The state of certain amount of a gas, not necessarily ideal, is changed from A to B in various hypothetical paths, as shown below. The total amount of the gas remains constant. Which of the following paths are physically realizable? **[TIFR 2015**



(a) All of them (b) Only (i), (ii) and (iii)

(c) Only (iii) and (v) (d) Only (i) and (iii)

Q12. Which of the following is/are implied by the second law of thermodynamics? **[TIFR 2016]**

(a) $\Delta S > \int_A^B dq$ (irreversible) / T for an irreversible process A → B at temperature T.

(b) $\Delta S > 0$ for an isolated system in the course of a spontaneous change

(c) Entropy of the universe always tends to maximum

(d) All of the above

Q13. The specific heat of a certain material monotonically increases with temperature. Two identical blocks of this material are kept at 50˚C and 100˚C, respectively. The two blocks are now brought in contact with each other. Assume that no heat is lost to the surrounding. When thermal equilibrium is reached after the two blocks are kept in contact, what would be the final temperature of the two blocks? **[TIFR 2016]**

(a) 75˚C (b) > 75˚C (c) < 75˚C

(d) T_f can be either more than or less than 75˚C, depending upon the precise variation of the specific heat with temperature.

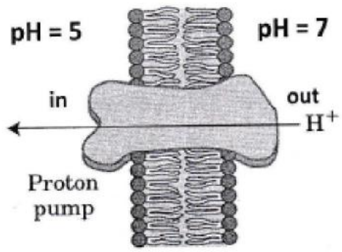
Q14. For an ideal gas in a closed system at constant temperature T, what are the values of $\frac{\partial U}{\partial V}$ and $\frac{\partial H}{\partial P}$?

[TIFR 2016]

(a) $\frac{\partial U}{\partial V}=0$ and $\frac{\partial H}{\partial P}=0$ (b) $\frac{\partial U}{\partial V}>0$ and $\frac{\partial H}{\partial P}<0$

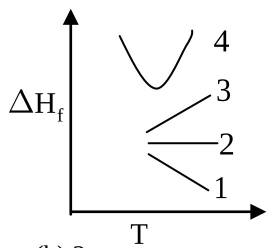
(c) $\frac{\partial U}{\partial V}<0$ and $\frac{\partial H}{\partial P}>0$ (d) $\frac{\partial U}{\partial V}>0$ and $\frac{\partial H}{\partial P}>0$

Q15. Proton pumps are ubiquitous in living organisms. They (shown in figure below) serve as an important regulator of pH gradient across momebrances, which lead to ATP synthesis. Calculate the amount of CHEMICAL worked one at temperature T by such a pump to maintain pH = 5 inside the cellular compartment against a neutral pH outside the membrane?



(a) 2RT (b) 2.303RT (c) 4.606RT (d) 23.3RT

Q16. The heat of formation (ΔH_f) for the reaction 2 Cu (s) + O_2 (g) → 2CuO (s) is measured and plotted as a function of temperature (T). of the 4 possible graphs shown below, which one would most likely represent the observed trend? **[TIFR 2017]**



(a) 1 (b) 2 (c) 3 (d) 4

Q17. During isothermal expansion of an ideal gas which of the following happen:

(i) Temperature does not change

(ii) Process is spontaneous

(iii) The energy of the system does not change **[TIFR 2017]**

(iv) Entropy increases

(a) (i) and (iii) only (b) (i), (ii), and (iv) only

(c) (i), (iii), and (iv) only (d) (i), (ii), (iii) and (iv)

Q18. Assume that the temperature (T) dependence of ΔG for a chemical reaction can be represented by an equation of the form? **[TIFR 2017]**

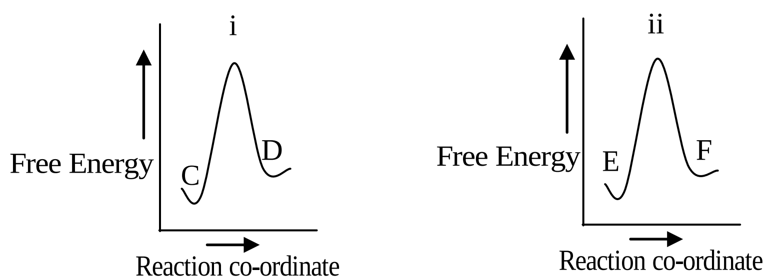
$$\Delta G = x + yT + zT^2$$

What is the expression for the heat capacity change at constant pressure, ΔG_P?

(a) x/T (b) $-y$ (c) $-2zT$ (d) Insufficient information

Q19. Suppose a reaction $A \longrightarrow B$ is slowly progressing in a closed vessel (no energy or material in supplied from the outside). To speed it up, you have the option of simultaneously carrying out a separate reaction inn the same vessel, which can be either be i) $C \longrightarrow D$ ii) $E \longrightarrow F$. The free energy diagram of the reaction

i) and ii) are given below in the figure below respectively. C and E as well as product D and F do not interact in any way with A or B. **[TIFR 2018]**



(a) $E \longrightarrow F$ (b) $C \longrightarrow D$

(c) Neither will affect the rate (d) Both can help equally

Q20. For a gas that obeys following equation of state $P(V-b) = RT,$ where b is a constant and R is an universal gas constant, which of the following is right: **[TIFR 2018]**

(a) $\left(\frac{\partial U}{\partial V}\right)_T = b$ (b) $\left(\frac{\partial U}{\partial V}\right)_T = R$ (c) $\left(\frac{\partial U}{\partial V}\right)_T = P$ (d) $\left(\frac{\partial U}{\partial V}\right)_T = 0$

Q21. According to the laws of thermodynamics for which of the following processes is entropy of a system equal to zero

(a) Irreversible process

(b) Endothermic process (heat is absorbed during the process)

(c) Reversible process

(d) Exothermic process (heat is released during the process)

Q22. The Gibbs free energy of a chemical reaction is given by $\Delta G = \Delta H - T\Delta S$, where ΔH is enthalpy change, ΔS is the entropy change and T is the temperature. The chemical reaction is said to occur spontaneously and unidirectionally if **[TIFR 2019]**

(a) $\Delta G = 0$ (b) $\Delta H = 0$ (c) $\Delta S = 0$ (d) $\Delta G < 0$

Q23. Water boils at a temperature of 373 K and atmospheric of I atm. Assuming a constant enthalpy of vaporization of 40.66 kJ/mol, what is the boiling temperature at a high altitude, where the pressure is 0.05 atm? **[TIFR 2019]**

(a) 270 K (b) 354 K (c) 403 K (d) 373 K

Answer Key

1. (b)	2. (d)	3. (b)	4. (a)	5. (b)	6. (d)	7.(a)
8.(a)	9.(b)	10.(a)	11.(a)	12.(d)	13.(b)	14.(a)
15.(c)	16.(c)	17.(d)	18.(c)	19.(a)	20.(d)	21.(c)
22.(d						

Other Examination Previous Year's Question

Q1. Match the List – I with List – II and select the correct answer

A. dU	1. VdP – SdT
B. dH	2. Tds – PdV
C. dA	3. –PdV – SdT
D. dG	4. TdS + VdP

Code:

(a) A – 2 B – 4 C – 3 D – 1 (b) A – 1 B – 3 C – 4 D – 2

(c) A – 2 B – 3 C – 4 D – 1 (d) A – 1 B – 4 C – 3 D – 2

Q2. One mole of an ideal gas at 300 K is expanded isothermally from an initial volume of 1 L to 10L. The ΔU for the process is (R = 2 cal /k - mole).

(a) 163.7 cal (b) zero (c) 138.1 cal (d) 9 liter-atm.

Q3. Two moles of an ideal gas is expanded isothermally and reverrisibly from 1 L to 10 L at 300K. The enthalpy change (in KJ) for the process is:

(a) 11.4 kJ (b) -11.4 kJ (c) 0 kJ (d) 4.8 kJ

Q4. The ratio $\frac{C_P}{C_V}$ is lowest for which of the following gas

(a) SO_2 (b) O_2 (c) N_2 (d) He

Q5. A carnot engine working between 127°C and 527°C absorbs 750 J heat from high temperature source. The efficiency of the engine will be

(a) 0.53 (b) 0.50 (c) 0.87 (d) 0.75

Q6. For gases $C_p - C_v$ = ?

(a) $-T\left(\frac{\partial P}{\partial T}\right)_V\left(\frac{\partial V}{\partial T}\right)_P$ (b) $+T\left(\frac{\partial P}{\partial T}\right)_V\left(\frac{\partial V}{\partial T}\right)_P$ (c) $T^2\left(\frac{\partial P}{\partial T}\right)_V$ (d) $T^2\left(\frac{\partial V}{\partial T}\right)_P$

Q7. Work done W on the system in reverrisible adiabatic compression for 1 mole of ideal gas.

(a) $W = -C_V \;\; T_2 + T_1$ (b) $W = C_P \left(\frac{T_2}{T_1}\right)$

(c) $W = C_v \left(\frac{T_2}{T_1}\right)$ (d) $W = C_V \;\; T_2 - T_1$

Q8. Which statement is wrong:
(a) Reverrisible process are ideal which can be carried out theoretically.
(b) Irreverrisible process are real, all spontaneous process occur in nature are irreverrisible process.
(c) Reverrisible process and irreverrisible process can be completed in finite time
(d) Criteria for reverrisible is $\oint W$ cyclic = 0, irreversibility $\oint W$ cyclic $\neq 0$

Q9. The realationship between volume change in isothermal and an adiabatic for a procedure change from P_1 to P_2

(a) $\Delta V_i > \Delta V_a$ (b) $\Delta V_i < \Delta V_a$ (c) $\Delta V_i = \Delta V_a$ (d) $\Delta V_i = \Delta V_a = 0$

Q10. The Euler theorem for dA = - PdV – SdT shows

(a) $-\left(\frac{\partial P}{\partial T}\right)_V = \left(\frac{\partial S}{\partial V}\right)_T$ (b) $\left(\frac{\partial P}{\partial T}\right)_V = \left(\frac{\partial S}{\partial V}\right)_T$ (c) $\left(\frac{\partial T}{\partial P}\right)_V = -\left(\frac{\partial V}{\partial S}\right)_T$ (d) $\left(\frac{\partial V}{\partial P}\right)_S = -\left(\frac{\partial P}{\partial V}\right)_S$

Q11. $\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_P \left(\frac{\partial P}{\partial V}\right)_T$ for an ideal gas is:

(a) $\frac{-R^2}{P^2}$ (b) -1 (C) $\frac{V}{T}$ (d) $\frac{-R^2}{V^2}$

Q12. If gas obey equation of state $\left(P+\frac{a}{v^2}\right)$ v-b . The ratio of $\frac{(C_P - C_V)_{ideal}}{(C_P - C_V)_{Real}}$ is:

(a) $\left(1+\frac{2a}{RTV}\right)$ (b) $\left(1+\frac{2a}{RTV}\right)^{-2}$ (c) $1-\frac{2a}{RTV}$ (d) 1

Q13. For a cyclic process:
(a) $\Delta U = 0$
(b) $\Delta H = 0$
(c) Both $\Delta U = 0$ and $\Delta H = 0$
(d) None of these

Q14 The vanderwaal equation is given by, $\left(P+\frac{n^2 a}{v^2}\right)$ v-nb $= nRT$. The ratio $\frac{a}{b}$ has a dimension of

(a) Atm/litre (b) litre atm/mole (c) litre/mole (d) litre atm mole^{-2}

Q15. The heat capacity of the following gas at room temperature are such that
(a) $NH_3 > CO_2 = O_2 = N_2 > Ar$
(b) $NH_3 = CO_2 > O_2 > N_2 > Ar$
(c) $NH_3 > CO_2 > O_2 = N_2 > Ar$
(d) $NH_3 > CO_2 > O_2 > N_2 > Ar$

Q16. If the inversion temperature of a gas is - 80°C then it will produce cooling under Joule – Thomson effect at

(a) 298 K (b) 273 K (c) 193 K (d) 173 K

Q17. Consider the following statement:

1. Temperature remains constant in an adiabatic as well as in isothermal process.
2. In a cyclic process $\Delta U = 0$
3. If C_P of reaction is zero then the enthalpy of the reaction does not vary with temperature. The correct statements are

(a) 1, 2, 3, (b) 2, 3 (c) 2 (d) 1 and 3

Q18. For heating in Joule Thomson coefficient which of the following option is true

(a) $\left(\frac{\partial H}{\partial P}\right)_T < 0$ means $T\left(\frac{\partial V}{\partial T}\right)_P < V$

(b) $\left(\frac{\partial H}{\partial P}\right)_T > 0$ means $T\left(\frac{\partial V}{\partial T}\right)_P < V$

(c) $\left(\frac{\partial H}{\partial P}\right)_T < 0$ means $T\left(\frac{\partial V}{\partial T}\right)_P > 0$

(d) $\left(\frac{\partial H}{\partial P}\right)_T > 0$ means $T\left(\frac{\partial V}{\partial T}\right)_P > V$

Q19. Match the List I (Maxewell realation) with List II (Thermodynamic relation) and select the answer using the codes given below:

List – I	**List – II**
A. $\left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$	1. $dG = VdP - SdT$
B. $\left(\frac{\partial S}{\partial P}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_P$	2. $dA = -SdT - PdV$
C. $\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$	3. $dH = TdS + VdP$
D. $\left(\frac{\partial S}{\partial V}\right)_T = -\left(\frac{\partial P}{\partial T}\right)_V$	4. $dU = TdS - PdV$

	A	B	C	D
(a)	1	3	4	2
(b)	3	1	4	2
(c)	3	1	2	4
(d)	1	3	2	4

Q20. Change in temperature and change in pressure may be expressed as

(a) $\Delta T = \frac{-\ \partial H/\partial P}{C_P}\Delta P$

(b) $\Delta P = \frac{-\ \partial H/\partial P}{C_P}\Delta T$

(b) $\Delta T = \frac{-\ \partial H/\partial T}{C_P}\Delta P$

(d) $\Delta P = \frac{-\ \partial H/\partial T}{C_P}\Delta P$

Q21. An isoentropic process is always

(a) Irreversible and adiabatic (b) reversible and isothermal

(c)frictionless and irreversible (d) reversible and adiabatic

(e) none of the above.

Q22. Work done in a free expansion process is

(a) Zero (b) minimum (c) maximum (d) positive

Q23. In a reversible adiabatic process the ratio (T_1/T_2) is equal to

(a) $\left(\frac{P_1}{P_2}\right)^{\frac{\gamma-1}{\gamma}}$ (b) $\left(\frac{V_1}{V_2}\right)^{\frac{\gamma-1}{\gamma}}$ (c) $V_1V_2^{\frac{\gamma-1}{2\gamma}}$ (d) $\left(\frac{V_2}{V_1}\right)^{\gamma}$

Q24. The moral heat capacity of water vapour at a constant 1.0 atm is represented by

$$C_P = 30.54 \text{ J/K – mole} + 0.01029 \text{ T J/K}^2 \text{ mole}$$

T is the kelvin in temperature. Find the amount of heat required to raise the temperature of 2.0 mole of water from 100°C to 500°C

(a) 29150 J (b) 12915 J (c) 26791 J (d) 31465 J

Q25. The correct form of Trouton's rule is

(a) $\Delta S_{vap} = \Delta H_{vap}/T$ (b) $\Delta H_{vap} = \Delta S_{vap}/P$

(c) $\Delta S_{vap} = T\Delta H_{vap}$ (d) $\Delta S_{vap}/\Delta H_{vap} = R$

Q26. Which of the following thermo dynamical relations are correct for one mole of an ideal gas?

(a) $\left(\frac{\partial U}{\partial V}\right)_T = 0$ (b) $\left(\frac{\partial H}{\partial V}\right)_T = 0$ (c) $\left(\frac{\partial C_V}{\partial V}\right)_T > 0$ (d) $\left(\frac{\partial P}{\partial T}\right)_V = 0$

Q27. If ΔH is the change in enthalpy and ΔE is the change in internal energy, then which one of the following is correct?

(a) ΔH is always less than ΔE
(b) ΔH is always greater than ΔE
(c) ΔH < ΔE only if the number of moles of gaseous products is greater than the number of moles of gaseous reactants.
(d) ΔH < ΔE only if the number of moles of gaseous products is the less than the number of moles of gaseous reactants.

Q28. Which one of the following statements is correct?

(a) Extensive properties are independent of the mass of the system.
(b) Potential energy is an extensive property.
(c) Intensive properties depend on the mass of the system.
(d) Density is an extensive property.

Q29. For an adiabatic process, what is the relation between temperature and pressure?

(a) $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\gamma-1}$ (b) $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\gamma-1}$ (c) $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{1}{\gamma-1}}$ (d) $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma}{\gamma-1}}$

Q30. Match the **List – I** with **List – II** and select the correct answer using the code given below the lists:

List – I	**List - II**
A. Reversible adiabatic expansion	1. ΔH = 0
B. Joule – Thomson expansion	2. ΔU = 0
C. Reversible evaporation of a liquid	3. ΔG = 0

At its normal boiling point

D. Adiabatic free expansion 4. $\Delta S = 0$

Code:

(a) A-2 B-1 C-3 D-4 (b) A-4 B-3 C-1 D-2
(c) A-2 B-3 C-1 D-4 (d) A-4 B-1 C-3 D-2

Q31. The definition of the thermodynamic temperatures comes from the

(a) Zeroth law of thermodynamics

(b) First law of thermodynamics

(c) Second law of tthermodynamics

(d) Third law of thermodynamics

Q32. Enthalpy change in spontaneous freezing of a liquid at constant pressure and freezing point

(a) Is always negative (b) Is always positive

(b) Is always zero (d) Can be zero, positive or negative.

Q33. The process at constant pressure and temperature which is always spontaneous is:

(a) Endothermic accompanied by increase in entropy

(b) Exothermic accompanied by decrease in entropy

(c) Exothermic accompanied by increase in entropy

(d) Endothermic accompanied by decrease in entropy

Q34. The value of C_p / C_v for an ideal monoatomic gas is expected to be

(a) 5/3 (b) 1 (c) 7/5 (d) 5/4

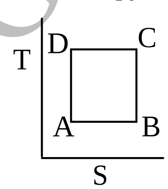
Q35. Work done in increasing the temperature of 1 mol of a gas by 1˚C at constant pressure is,

(a) 2R (b) R (c) 3R (d) R/2

Q36. The heat evolved in combustion of acetylene at 25˚C is 310.5 kcal/mol. If the enthalpy of formation of carbon dioxide is – 94.0 kcal/mol and that of water is – 68.3 kcal/mol, the enthalpy of formation of acetylene will be

(a) 65.3 kcal/mol (b) 54.2 kcal/mol (c) 85.2 kcal/mol (d) 108.3 kcal/mol

Q37. If the carnot cycle in entropy – temperature diagram looks as below.



Then the system rejects heat to the surroundings is going from

(a) B→A (b) A→B (c) D→C (d) C→D

Q38. Which of the following are the correct criteria for naturally occurring (spontaneous) processes?

(E = internal energy, S = Entropy, G = Gibb's free energy, A = Helmholtz free energy)

(a) $(\Delta G)_{T.V} \leq 0$ (b) $(\Delta A)_{T.P} \leq 0$ (c) $(\Delta S)_{E.P} \geq 0$ (d) $(\Delta E)_{S.V} \leq 0$

Q39. The compressibility factor for an ideal gas is:

(a) 1 (b) 1.5 (c) 2 (d) ∞

Q40. For which of the following cases $\Delta S = \Delta H/T$

(a) A process for which $\Delta C_P = 0$ (b) An adiabatic process

(b) A constant pressure process (d) An isothermal, reversible phase transition

Q41. For mixing of two ideal gases at $25\,^{0}C$ and 1 atm, which one of the following is incorrect?

(a) $\Delta T_{mix} = 0$ (b) $\Delta H_{mix} = 0$ (c) $\Delta V_{mix} = 0$ (d) $\Delta S_{mix} = 0$

Q42. The criterion for irreversibility for a process involving no work or pressure-volume work is:

(a) $(dS)_{V, U} < 0$ (b) $(dS)_{V, U} > 0$ (c) $(dS)_{T, P} < 0$ (d) $(dS)_{T, V} > 0$

Q43. For a pure substance, the slope of the plot of Gibbs free energy (G) against T at constant pressure is:

(a) S (b) –S (c) –H (d) $-C_P$

Q44. The entropy change associated with the freezing of 1 mole of water at 0°C and 1 atm (heat of fusion under these conditions is 6.0 kJ/ml) is:

(a) -6 J/K (b) -22 J/K (c) +22 J/K (d) +6 J/K

Q45. The amount of reversible work done to compress one mol of an ideal gas from 100 atm. 300 K to final volume that is half the initial volume is:

(a) 2.53 kJ (b) 1.73 kJ (c) 5.85 kJ (d) 4.73 kJ

Q49. The entropy changes for the reaction $4Fe + 3O_2 \rightarrow 2Fe_2O_3$ for which $\Delta H^0 = -164 kJ\ mol^{-1}$ (Given, molar entropy changes for Fe, O_2 and Fe_2O_3 are 27.3, 205.1 and 87.4 JK^{-1} at temperature 298K) is

(a) 5980 $JK^{-1}\ mol^{-1}$ (b) -549.5 $JK^{-1}\ mol^{-1}$ (c) 4980.7 $JK^{-1}\ mol^{-1}$ (d) -18.85 $JK^{-1}\ mol^{-1}$

Answer Key

1. (a)	2. (d)	3. (c)	4. (a)	5. (b)	6. (b)	7.(d)
8.(c)	9.(a)	10.(b)	11.(d)	12.(c)	13.(c)	14.(b)
15.(c)	16.(d)	17.(b)	18.(b)	19.(b)	20.(a)	21.(d)
22.(a)	23.(a)	23.(a)	24. (a)	25.(a)	26.(a)	27.(d)
29.(b)	30.(b)	31.(a)	32.(a)	33.(c)	34. (a)	35. (b)
36.(b)	37.(a)	38.(d)	39.(a)	40.(d)	41.(d)	42.(b)
43.(b)	44.(b)	45.(a)	46.(b)			