

**GENESIS TUTORIALS**

**Institute for CSIR-UGC-NET/JRF, GATE & IIT-JAM**

***Assignment-Chemical Thermodynamics***

1 For one mole of an ideal gas

[GATE 2004]

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

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

2. for an ideal gas,  $\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_P \left(\frac{\partial P}{\partial V}\right)_T =$

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

3. For a system of constant composition, the pressure (P) is given by-

- (a)  $-\left(\frac{dU}{dS}\right)_V$                       (b)  $-\left(\frac{dU}{dV}\right)_S$                       (c)  $\left(\frac{dV}{dS}\right)_T$                       (d)  $\left(\frac{dU}{dV}\right)_T$                       **(CSIR DEC 2011,PART B)**

4. For an ideal gas

[GATE 2010]

- (a)  $\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial T}{\partial V}\right)_P \left(\frac{\partial V}{\partial P}\right)_T = 0$                       (b)  $\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial T}{\partial V}\right)_P \left(\frac{\partial V}{\partial P}\right)_T = -1$   
 (c)  $\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial T}{\partial V}\right)_P \left(\frac{\partial V}{\partial P}\right)_T = +1$                       (d)  $\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial T}{\partial V}\right)_P \left(\frac{\partial V}{\partial P}\right)_T = +2$

5. The correct thermodynamic relation among the following is – **(CSIR Dec 2013, Part B)**

- (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)  $\left(\frac{\partial A}{\partial V}\right)_S = -S$

6. Match the List-I (Maxwell relation) with List-II (Thermodynamic relations) 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.  $dH = TdS + VdP$

$$(D) - \left(\frac{\partial S}{\partial V}\right)_T = - \left(\frac{\partial P}{\partial T}\right)_V \quad 4. dU = TdS - PdV$$

A      B      C      D

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

7. Indicate which of the following relations is not correct – **(CSIR JUNE 2012, PART C)**

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

8. The maxwell's relationship derived from the equation  $dG = VdP - SdT$  is

(a)  $\left(\frac{\partial V}{\partial T}\right)_P = \left(\frac{\partial P}{\partial S}\right)_V$       (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)  $\left(\frac{\partial P}{\partial V}\right)_T = \left(\frac{\partial T}{\partial S}\right)_P$     **(CSIR Dec 2013, PART C)**

9. 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

10. In thermodynamics, a property is called extensive property if its value is additive. Which of the following is not an extensive property? **(University Of Hyderabad 2012)**

- (a) Mass      (b) Volume      (c) Heat Capacity      (d) Specific heat capacity

11. 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

**(GATE 2010)**

12. False statement about the state function is:

- (a) The change in the value of state function depends only on initial and final state (not on the path)
- (b) All the thermodynamic properties does not satisfy the requirement of state function as chemical potential
- (c) The state function has an exact differential
- (d) The cyclic integral involving a state function is zero

13. Match the following

- |   |          |
|---|----------|
| 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>(GATE 2004)</b> |
| (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  |                    |

14. Which of the following thermodynamic relation (s) is/are correct? **(IIT-JAM 2015)**

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

15. The total entropy (S) and Helmholtz free energy (A) changes in a spontaneous process at constant temperature and volume would be - **(IISC 2008)**

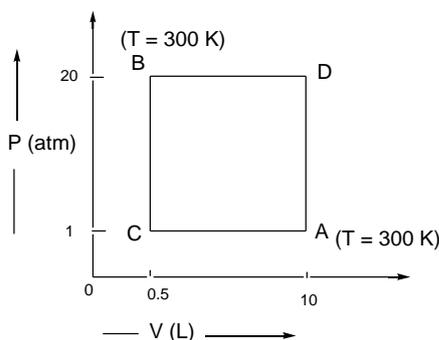
- (a)  $\Delta S < 0$  and  $\Delta A > 0$
- (b)  $\Delta S > 0$  and  $\Delta A = 0$

- (c)  $\Delta S > 0$  and  $\Delta A < 0$                       (d)  $\Delta S = 0$  and  $\Delta A = 0$
16. For a reaction to be spontaneous, the difference in Gibbs free energy between the products and reactants should be negative at **(IISC 2012)**
- (a) Constant V and T                      (b) Constant P and T  
(c) Constant P and V                      (d) Constant S and V
17. A process is carried out at constant volume and at constant entropy. It will be spontaneous if- **(CSIR JUNE 2011, PART B)**
- (a)  $\Delta G < 0$                       (b)  $\Delta H < 0$                       (c)  $\Delta A < 0$                       (d)  $\Delta U < 0$
18. The criterion of spontaneity of a process is- **(GATE 2000)**
- (a)  $\Delta S_{\text{sys}} > 0$                       (b)  $\Delta S_{\text{surr}} > 0$   
(c)  $\Delta S_{\text{sys}} + \Delta S_{\text{surr}} > 0$                       (d)  $\Delta S_{\text{sys}} - \Delta S_{\text{surr}} > 0$
19. Choose the correct criterion of spontaneity in terms of the properties of the system alone- **(GATE 2001)**
- (a)  $(\partial S)_{U,V} > 0$                       (b)  $(\partial S)_{T,P} > 0$                       (c)  $(\partial S)_{H,P} < 0$                       (d)  $(\partial S)_{T,V} > 0$
20. The definition of the thermodynamic temperature comes from the- **(IISC 2005)**
- (a) Zeroth law of thermodynamics  
(b) First law of thermodynamics  
(c) Second law of thermodynamics  
(d) Third law of thermodynamics
21. In an adiabatic system, the work done to change its state from A to B is- **(GATE 2005)**
- (a) dependent on path from A to B  
(b) independent on path from A to B  
(c) path dependence is related to particulars of states A and B  
(d) path dependence is related to both states A and B and choice of path
22. Isobaric thermal expansion coefficient  $\alpha$  for an ideal gas is:
- (a)  $\frac{1}{T}$                       (b)  $\frac{1}{P}$                       (c) P                      (d) T

23. The temperature of 54 g of water is raised from 15°C to 75°C at constant pressure. The change in enthalpy of the system (given that  $C_{p,m}$  of water = 75 JK<sup>-1</sup>mol<sup>-1</sup>) is –
- (a) 4.5 KJ      (b) 13.5 KJ      (c) 9.0 KJ      (d) 18.0KJ      **(GATE 2007)**
24. When 229 J of energy is supplied to 3 moles of a gas at constant pressure; the temperature of the gas increases by 2.55 K. Calculate  $C_p$  and  $C_v$  for the gas, assuming ideal behaviour.
- 2 marks (GATE 1996)**
25. The heat capacity of 10 moles of an ideal gas at a certain temperature is 300 JK<sup>-1</sup> at constant pressure. The heat capacity of the same gas at the same temperature and at constant volume would be-
- (CSIR DECEMBER 2013, PART C)**
- (a) 383 JK<sup>-1</sup>      (b) 217 JK<sup>-1</sup>      (c) 134 JK<sup>-1</sup>      (d) 466 JK<sup>-1</sup>
26. Show that for 'n' moles of a vander Waals gas,  $\left(\frac{\partial U}{\partial V}\right)_T = \frac{n^2 a}{V^2}$       **(IIT-JAM 2012)**
27. The internal pressure of one mole of a vander waals gas is equal to-      **(GATE 1996)**
- (a) Zero      (b)  $b^2$       (c)  $\frac{a}{V^2}$       (d)  $b - \left(\frac{a}{RT}\right)$
28. The internal pressure of a vanderwaal gas is -      **(GATE 2003)**
- (a) independent of the molar volume  
(b) inversely proportional to the molar volume  
(c) inversely proportional to the square of the molar volume  
(d) directly proportional to the molar volume
29. The internal pressure,  $\pi_T = T \left(\frac{\partial p}{\partial T}\right)_V - p$  for one mole a Vander waals gas is
- (a)  $\frac{a}{V^2}$       (b)  $\frac{a}{V^2} \left(\frac{RT}{V-b}\right)$       (c) zero      (d)  $\left(\frac{RT}{V-b}\right)$       **(GATE 2005)**
30. 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  $\frac{\partial H}{\partial p} > 0$

### COMMON Data For Questions 31 and 32

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



(GATE 2006)

31. The work done (in atm-L) on the gas in the process is-

- (a) 9.5                      (b) 99.75                      (c) 190                      (d)  $10 \ln(20)$

32. For the above process-

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

33. For a reversible isothermal expansion of a perfect (ideal) gas, which particular set of the following statements is correct- **(BHU 2013)**

- (a)  $q > 0, W > 0, \Delta U = 0$  and  $\Delta H = 0$                       (b)  $q > 0, W < 0, \Delta U = 0$  and  $\Delta H > 0$   
 (c)  $q > 0, W < 0, \Delta U = 0$  and  $\Delta H = 0$                       (d)  $q > 0, W < 0, \Delta U < 0$  and  $\Delta H = 0$

34. One mole of an ideal gas expands from 10 atm against a constant pressure of 2 atm at 298K. The magnitude of work done by the gas is- **(IISc 2011)**

- (a) 1981 J                      (b) 3988 J                      (c) 991 J                      (d) 7282 J

35. One mole of an ideal gas expands from 5 atm against a constant pressure of 1 atm at 298K. The magnitude of work done by the gas is- **(IISc 2010)**

- (a) 1981 J                      (b) 3988 J                      (c) 991 J                      (d) 7282 J

36. When 1 mole of an ideal gas is heated at constant volume, the temperature is raised from 298K to 308K. Heat supplied to the gas is 500J. Then which statement is correct:

- (a)  $q = W = 500J, \Delta U = 0$                       (b)  $q = -W = 500J, \Delta U = 0$   
 (c)  $q = \Delta U = 500J, W = 0$                       (d)  $\Delta U = 0, q = W = -500J$

37. For an isothermal free expansion of an ideal gas into vacuum, which one of the following set of values is correct? **(IIT-JAM 2015)**

- (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)  $\Delta U < 0, q = 0, w < 0$

38. Five moles of an ideal gas at  $P=10\text{atm}$  and  $T=300\text{K}$  expanded irreversibly and isothermally against an external pressure of 2 atm until equilibrium is attained. The work done in the process is: **(IISc 2008)**
- (a) -9.86 Litre atm      (b) -98.6 Litre atm  
 (c) -19.7 Litre atm      (d) -39.4 Litre atm
39. For which of the following processes,  $q = 0$ ,  $w=0$ ,  $\Delta U=0$  and  $\Delta H=0$ ? **(BHU 2011)**
- (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
40. One mole of a vanderwaals 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)  $RT \ln \frac{V_2}{V_1} + a (V_2 - V_1)$       (b)  $-RT \ln \frac{V_2-b}{V_1-b} + a \left( \frac{1}{V_1} - \frac{1}{V_2} \right)$   
 (c)  $RT \ln \frac{P_2}{P_1}$       (d)  $RT \ln \frac{V_2-b}{V_1-b} - \left( \frac{1}{V_1} - \frac{1}{V_2} \right)$  **(IIT-JAM 2011)**
41. One mole of an ideal gas ( $C_v = 1.5R$ ) at a temperature of 500K is compressed from 1 atm to 2 atm by a reversible isothermal path. Subsequently it is expanded back to 1 atm by a reversible adiabatic path. The volume of the final state in litre is-
- (a) 15.6      (b) 20.5      (c) 31.1      (d) 41.0 **(GATE 2004)**
42. Which statement is wrong:
- (a) Reversible process are ideal which can be carried out theoretically  
 (b) Irreversible process are real, all spontaneous process occur in nature are irreversible process  
 (c) Reversible process and irreversible process can be completed in finite time  
 (d) Criteria for reversibility is-

$$\oint W = 0$$

And for irreversibility is

$$\oint W \neq 0$$

43. For a reversible adiabatic compression which relationship is true:

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

44. For a reversible adiabatic expansion of an ideal gas, the plot of  $\log P$  vs  $\log V$  is a straight line

$$\left[ \gamma = \frac{C_p}{C_v} \right]$$

(CSIR 2009)

- (a) of slope  $\gamma$       (b) of slope  $-\gamma$       (c) parallel to  $\log P$  axis      (d) of slope  $-1$

45. The Joule Thomson experiment is an example of which of the following process

1. Isothermal process
2. Isoenthalpic process
3. Adiabatic process
4. Isochoric process

Select the correct answer using the code given below-

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

46. 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)  $\frac{\text{atm}}{\text{litre}}$       (b)  $\text{litre} \frac{\text{atm}}{\text{mole}}$       (c)  $\frac{\text{liter}}{\text{mole}}$       (d)  $\text{litre atm mole}^{-2}$

47. The change in temperature and change in pressure may be expressed as

- (a)  $\Delta T = -\frac{(\delta H)}{C_p} \Delta P$       (b)  $\Delta T = -\frac{(\delta H)}{C_p} \Delta P$   
 (c)  $\Delta P = -\frac{(\delta H)}{C_p} \Delta T$       (d)  $\Delta P = -\frac{(\delta H)}{C_p} \Delta P$

48. For reversible adiabatic expansion of an ideal gas

$$T = \text{constant} \cdot P^x$$

The value of 'x' is:

- (a)  $\gamma$       (b)  $\frac{1}{\gamma} - 1$       (c)  $1 - \frac{1}{\gamma}$       (d)  $1 - \gamma$

49. In isothermal process

- (a) temperature increases gradually (b) volume remains constant  
 (c) pressure remains constant (d) change in internal energy is zero

50. During throttling process

- (a) internal energy does not change (b) pressure does not change  
 (c) entropy does not change (d) enthalpy does not change

51. The gas constant (R) is equal to the

- (a) sum of two specific heat (b) difference of two specific heat  
 (c) product of two specific heat (d) ratio of two specific heat

52. The relation between volume change in an isothermal process ( $\Delta V_i$ ) and an adiabatic process ( $\Delta V_a$ ) for a pressure change from  $P_1$  to  $P_2$  is **(GATE 1998)**

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

53. If a gas obey the equation of state  $P(V-nb) = nRT$ , the ratio  $(C_p - C_v) / (C_p - C_v)_{ideal}$  is

- (a)  $> 1$  (b)  $< 1$  (c) 1 (d) (1-b) **(GATE 2008)**

54. Given that

$$C_p - C_v = \frac{\alpha^2 TV}{K_T} \text{ where } \alpha = \frac{1}{V} \left( \frac{\partial V}{\partial T} \right)_P \text{ and } K_T = -\frac{1}{V} \left( \frac{\partial V}{\partial P} \right)_T$$

For a pure substance show that  $C_p - C_v = R$  for one mole of an ideal gas **(IIT-JAM - 2008)**

55. The value of  $\frac{C_p}{C_v}$  for an ideal monatomic gas is expected to be **(IISc 2006)**

- (a)  $\frac{5}{3}$  (b) 1 (c)  $\frac{7}{5}$  (d)  $\frac{5}{4}$

56. A fixed mass of an ideal gas undergoes a reversible adiabatic expansion. In these process the temperature of a gas **(IISc 2006)**

- (a) Increase (b) Decrease (c) Remain unchanged  
 (d) can increase or decrease depending upon the molecular weight

57. Work done in increasing the temperature of 1 mole of a gas by  $1^\circ\text{C}$  at constant pressure

- (a) 2R (b) R (c) 3R (d)  $\frac{R}{2}$  **(IISc 2006)**

58. For a cyclic process performed by an ideal gas change in some thermodynamic function are Zero. Indicate the set at which all the function are zero **(IIT-JAM-2007)**
- (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)  $\Delta E, \Delta S, \Delta H, \Delta A$
59. The correct order of entropy for various states of  $\text{CO}_2$  is **(IIT-JAM-2016)**
- (a)  $\text{CO}_2(\text{s}) > \text{CO}_2(\text{l}) > \text{CO}_2(\text{g})$       (b)  $\text{CO}_2(\text{l}) > \text{CO}_2(\text{s}) > \text{CO}_2(\text{g})$   
(c)  $\text{CO}_2(\text{g}) > \text{CO}_2(\text{l}) > \text{CO}_2(\text{s})$       (d)  $\text{CO}_2(\text{g}) > \text{CO}_2(\text{s}) > \text{CO}_2(\text{l})$
60.  $0.1 \text{ dm}^3$  of an ideal gas at  $300\text{K}$  &  $1 \text{ bar}$  compressed adiabatically to  $8 \text{ bar}$ . It is then cooled at constant volume & further expanded isothermally as to reach the condition from which it is started. Calculate the pressure at the end of constant volume cooling
- Given that  $C_p = 14.3 \frac{\text{KJ}}{\text{Kg-k}}$ ,  $C_v = 10.2 \frac{\text{KJ}}{\text{Kg-k}}$
61.  $20 \text{ gm}$  of nitrogen at  $300\text{K}$  is compressed reversibly & adiabatically from  $20 \text{ dm}^3$  to  $10 \text{ dm}^3$ . Calculate  $q, W, \Delta H, \Delta U$  ? given  $C_v = \frac{5}{2} R$
62. Two mole of an ideal gas is expanded isothermally & reversibly from  $1\text{L}$  to  $10 \text{ L}$  at  $300\text{K}$ . The enthalpy change (in  $\text{kJ}$ ) for the process is
- (a)  $11.4 \text{ kJ}$       (b)  $-11.4 \text{ kJ}$       (c)  $0 \text{ kJ}$       (d)  $4.8 \text{ kJ}$
63. An ideal gas expands in volume from  $1 \times 10^{-3} \text{ m}^3$  to  $1 \times 10^{-2} \text{ m}^3$  at  $300\text{K}$  against a constant pressure of  $1 \times 10^5 \text{ Nm}^{-2}$ . The work done is-
- (a)  $-900\text{J}$       (b)  $-900\text{kJ}$       (c)  $270\text{kJ}$       (d)  $900\text{kJ}$
64. The change in internal energy of  $1 \text{ mole}$  of  ${}_{36}\text{Kr}$  in isothermal expansion is-
- (a)  $18 \text{ cal}$       (b)  $30 \text{ cal}$       (c)  $1800 \text{ cal}$       (d)  $0$
65. Consider the following statement
1. The boyle temp. for a vander wall gas is  $T_B = \frac{a}{2Rb}$
  2. The inversion tem. is given by equation  $T_i = \frac{2a}{Rb}$
  3. The Joule-Thomson coefficient for an ideal gas is zero
  4.  $\text{H}_2$  &  $\text{He}$  show cooling at ordinary temp. of these
- The correct statement is
- (a) 1, 4      (b) 2, 3      (c) 1, 2, 3      (d) 2, 3, 4

66. The relation of free energy change with temperature and pressure is-

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

67. For a cyclic process-

- (a)  $\Delta U = 0$       (b)  $\Delta H = 0$       (c) both  $\Delta H = 0$  &  $\Delta U = 0$       (d) None of these

68. If the inversion temp. of a gas is  $-80^\circ\text{C}$  then it will produce cooling under Joule – Thomson effect at

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

69. The Joule-Thomson coefficient ( $\mu_{J,T}$ ) for a gas is

- (a)  $\mu_{J,T} = \left(\frac{\delta H}{\delta P}\right)_T$       (b)  $\mu_{J,T} = \left(\frac{\delta T}{\delta P}\right)_H$       (c)  $\mu_{J,T} = \left(\frac{\delta P}{\delta T}\right)_H$       (d)  $\mu_{J,T} = \left(\frac{\delta U}{\delta V}\right)_T$

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

- (a)  $\left(\frac{\delta H}{\delta P}\right)_T < 0$  means  $T\left(\frac{\delta V}{\delta T}\right)_P < V$       (b)  $\left(\frac{\delta H}{\delta P}\right)_T > 0$  means  $T\left(\frac{\delta V}{\delta T}\right)_P < V$   
(c)  $\left(\frac{\delta H}{\delta P}\right)_T < 0$  means  $T\left(\frac{\delta V}{\delta T}\right)_P > 0$       (d)  $\left(\frac{\delta H}{\delta P}\right)_T > 0$  means  $T\left(\frac{\delta V}{\delta T}\right)_P > V$

71. Among the following system that would require the least amount of thermal energy to bring its temperature  $80^\circ\text{C}$  **(GATE 2009)**

- (a) 200 gm of water at  $40^\circ\text{C}$       (b) 100 gm of water at  $20^\circ\text{C}$   
(c) 150 gm of water at  $50^\circ\text{C}$       (d) 300 gm water at  $30^\circ\text{C}$

72. Work done in free expansion process

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

73. A system containing of 2 mole of argon expands adiabatically & reversibly from a volume of 5.0 L & temperature of 373K to a volume of 20 litre. If  $C_v$  of argon is  $\frac{3nR}{2}$  then final temperature is

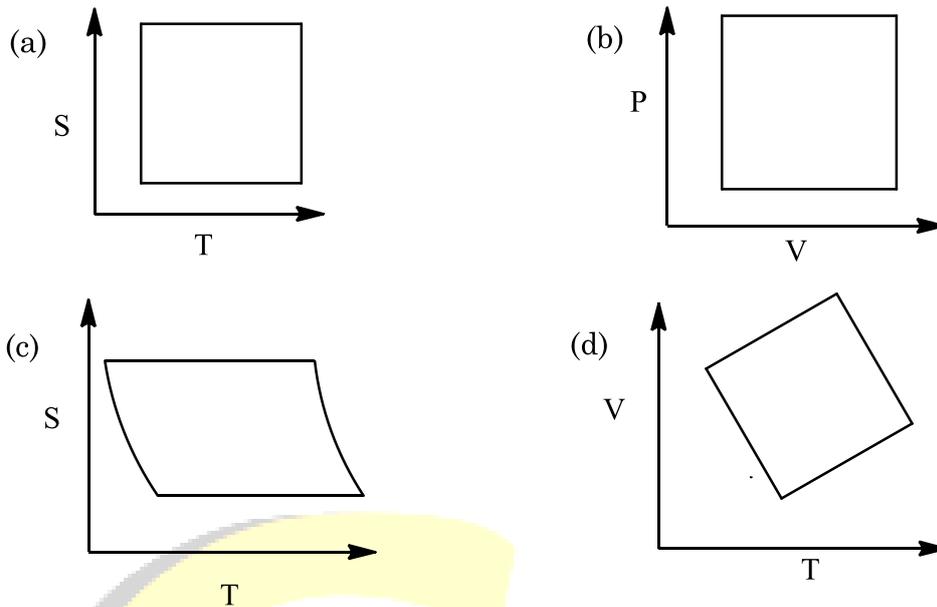
- (a) 173K      (b) 148K      (c) 193K      (d) 130K

74. The efficiency of a Carnot Engine working reversibly between the temperature  $T_c$  and  $T_h$  is given by-

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

75. The plot that describes a carnot cycle is-

(IIT-JAM 2011)



76. A carnot cycle operates on a temperature difference of 200K. One third of the heat absorbed from the source at  $T_2$  is discharged as waste heat to the sink at  $T_1$ . The cycle does 400J of work. Calculate  $q_1$ ,  $q_2$ ,  $T_1$  and  $T_2$ . (GATE 1996)

77. A carnot engine produces 3.5 KJ of work for every 11 KJ of heat supplied during an isothermal expansion stroke. If the compression stroke of the engine is executed at 300K, determine the temperature during the isothermal expansion? How much energy is lost during the compression? (IISc 2003)

78. Liquid Helium boils at about  $-269^\circ\text{C}$  and liquid Hydrogen boils at  $-253^\circ\text{C}$ . The efficiency of a reversible engine operating between heat reservoirs at these temperatures-

- (a) 20 %                      (b) 80 %                      (c) 10 %                      (d) 90 %                      (BHU 2014)

79. Suppose the coldest reservoir we have at hand is at  $10^\circ\text{C}$ . If we want a heat engine that is atleast 90 % efficient, the minimum temperature required for the hot reservoir is-

- (a) 1800K                      (b) 2880K                      (c) 2800K                      (d) 2830K

80. Two moles of a monatomic perfect gas initially at 4.0 bars and  $47^\circ\text{C}$  undergoes reversible expansion in an insulated container. The temperature at which the pressure reduces to 3.0 bars is- (IISc 2001, GATE 2001)

- (a) 200K                      (b) 285K                      (c) 310K                      (d) 320K

81. The amount of reversible work done to compress one mol of an ideal gas from 100atm, 300K to a final volume that is half the initial volume is- (IISc 2009)

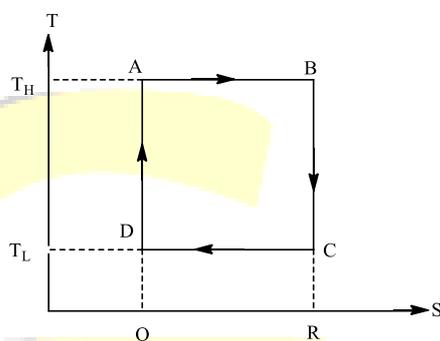
- (a) 2.53 KJ                      (b) 1.73 KJ                      (c) 5.85 KJ                      (d) 4.73 KJ

82. There are two containers having two moles of Ar each at a temperature of 298 K and a pressure of 1 bar. Both are heated such that they gain 1KJ of energy each. First container was heated at constant volume and second was heated at constant P. The final temperatures in the two containers will respectively be:

- (a) 298 K and 350 K
- (b) 350K and 400K
- (c) 338 K and 322 K
- (d) 350K and 350K

(IISc 2010)

83. The operation of a carnot engine between a high temperature  $T_H$  & a low Temperature  $T_L$  is shown next in term of temperature T & entropy S of some working fluid. (IISc 2010)



Among the following statement about this figure, the one that is not true is

- (a) The net work done by the system is the area ABRQ-DCRQ
- (b) The step  $C \rightarrow D$  corresponds to an isothermal expansion of the working fluid.
- (c) The heat deposit by the system in the thermal reservoir at  $T_L$  is the area DCRQ
- (d) Both the steps  $D \rightarrow A$  &  $B \rightarrow C$  describe adiabatic process

84. A carnot engine takes up 90 J of heat from the source kept at 300K, the correct statement is (CSIR DECEMBER 2012, Part B)

- (a) it transfer 60J of heat to the sink at 200K
- (b) it transfer 50J of heat to the sink at 200K
- (c) it transfer 60J of heat to the sink at 250K
- (d) it transfer 50J of heat to the sink at 250K

85. A heat engine operate between 1000K & 600K. The heat discharge into the cold sink, in a reversible process, when 5kJ of heat is supplied by the hot source, is

- (a) 2kJ
  - (b) 2.5kJ
  - (c) 3kJ
  - (d) 5.5kJ
- (BHU 2011)

86. A carnot engine produce 3.5 kJ of work for every 20 kJ of heat supplied during an isothermal expansion stroke. If the compression of the engine is executed at 300K, the temperature during the isothermal stroke is **(IISc 2008)**
- (a) 440K      (b) 364K      (c) 160K      (d) 236K
87. The coefficient of performance of a perfect refrigerator working reversibly between the temperature  $T_C$  &  $T_H$  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)  $\frac{T_H}{T_H - T_C}$
88. A carnot engine operate between 600 & 800 K & absorb 2000 calories from the source per cycle. The work done (in cal.) per cycle is **(GATE 1998)**
- (a) 1000      (b) 500      (c) 666      (d) 2000
89. The potential energy of interaction between two ions in an ionic compound is given by  $U = 1389.4 \left[ \frac{Z_1 Z_2}{r/\text{\AA}} \right]$  kJ mol<sup>-1</sup>. Assuming that CaCl<sub>2</sub> is linear molecule of length 5.6Å, the potential energy for CaCl<sub>2</sub> molecule in kJ mol<sup>-1</sup> is \_\_\_\_\_ **(IIT-JAM 2016)**
90. A carnot engine operate at 55% efficiency. The temperature of reject steam is 105°C then the absolute temp. of input steam is \_\_\_\_\_ **(GATE 2014)**
91. The work done during the free expansion of one mole of an ideal gas at 27°C to twice of its original volume is ( $RT = 2494 \text{ J mol}^{-1}$ ,  $\ln 2 = 0.7$ ,  $\log 2 = 0.3$ ) **(IIT-JAM 2010)**
- (a) 1746 J mole<sup>-1</sup>      (b) -1746 J mole<sup>-1</sup>      (c) Zero      (d) 748.2 J mole<sup>-1</sup>
92. The Work involved in isothermal reversible expansion from  $V_i$  to  $V_f$  of n moles of an ideal gas is **(CSIR DECEMBER 2013, Part C)**
- (a)  $W = -nRT \ln\left(\frac{V_f}{V_i}\right)$       (b)  $W = nRT\left(\frac{V_f}{V_i}\right)$
- (c)  $W = -nRT\left(\frac{V_f}{V_i}\right)$       (d)  $W = nRT \log\left(\frac{V_f}{V_i}\right)$
93. The molar internal energy of a gas at temp. 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)  $U_m(T) = U_m(0) + \frac{5RT}{2}$  (linear molecule, translation & rotation only)
- (c)  $U_m(T) = U_m(0) + \frac{3RT}{2}$  (Non-linear molecule, translation & rotation only)
- (d)  $U_m(T) = U_m(0) + RT$  (Non-linear molecule, translation only) **(IIT-JAM-2010)**

94. According to the equipartition principle of energy the molar heat capacity at constant volume for  $\text{CO}_2$ ,  $\text{SO}_2$ ,  $\text{H}_2\text{O}$  gases follows the trend **(IIT-JAM-2014)**  
(a)  $\text{CO}_2 = \text{SO}_2 = \text{H}_2\text{O}$  (b)  $\text{CO}_2 > \text{SO}_2 = \text{H}_2\text{O}$  (c)  $\text{H}_2\text{O} > \text{SO}_2 = \text{CO}_2$  (d)  $\text{CO}_2 = \text{SO}_2 > \text{H}_2\text{O}$
95. According to the equipartition theorem, the heat capacity of HF at constant volume will be **(IISc 2001)**  
(a)  $\frac{3}{2}R$  (b)  $5R$  (c)  $\frac{7}{2}R$  (d)  $6R$
96. According to the equipartition theorem, the rotational contribution to the specific heat  $C_v$  of a linear molecule is **(IISc 2005)**  
(a)  $\left(\frac{3}{2}\right)R$  (b)  $\left(\frac{5}{2}\right)R$  (c)  $2R$  (d)  $R$
97. Total No. of Vibrational degree of freedom of  $\text{H}_2\text{O}_2$  is **(GATE 2002)**  
(a) 7 (b) 6 (c) 4 (d) 9
98. The No. of normal mode of vibration in benzene molecule **(UNIV. OF HYDERABAD, 2015)**  
(a) 6 (b) 30 (c) 12 (d) 36
99. According to the equipartition principle, the predicted high temperature limiting value of the molar heat capacity at constant volume for  $\text{C}_2\text{H}_2$  is **(IIT-JAM-2015)**  
(a)  $5.5 R$  (b)  $6.0 R$  (c)  $9.0 R$  (d)  $9.5 R$
100. The No. of modes of vibration possessed by acetylene molecule is **(IISc 2009)**  
(a) 1 (b) 7 (c) 6 (d) 3
101. Heat capacity of a species is independent of temperature, if it is **(CSIR June 2015, Part B)**  
(a) Tetra atomic (b) tri atomic  
(c) diatomic (d) mono atomic
102. For a mono atomic gas, the ratio of the molar heat capacity  $\frac{C_p}{C_v}$  is equal to **(IISc 2008)**  
(a) 1 (b)  $\frac{7}{5}$  (c)  $\frac{3}{2}$  (d)  $\frac{5}{3}$
103. (i) Write the expression for the Vibrational contribution to the total energy of  $\text{CH}_4(\text{g})$  at 500K. All the vibration modes are active at this temperature **(IIT-Jam-2009)**  
(ii) Calculate the total internal energy of one mole of the gas at this temperature
104. The molar entropy of a molecule having three possible orientations at absolute zero is- **(IISc 2012, IISc 2010)**  
(a)  $5.76 \text{ J K}^{-1}\text{mole}^{-1}$  (b)  $9.13 \text{ J K}^{-1}\text{mole}^{-1}$

- (c)  $24.9 \text{ J K}^{-1}\text{mole}^{-1}$  (d)  $3.96 \text{ J K}^{-1}\text{mole}^{-1}$
105. The vapour pressure of toluene at  $100^\circ\text{C}$  assuming that trouton's rule is obeyed. Given that the boiling point of toluene is  $110^\circ\text{C}$ - **(IISc 2002)**
- (a) 753 mm (b) 573 mm (c) 760 mm (d) 366 mm
106. The entropy change associated with the freezing of 1 mole of water at  $0^\circ\text{C}$  and 1 atm (heat of fusion under these conditions is  $6.0 \text{ KJ/mole}$ ) is- **(GATE 1999)**
- (a)  $-6 \text{ JK}^{-1}$  (b)  $-22 \text{ JK}^{-1}$  (c)  $+22 \text{ JK}^{-1}$  (d)  $+6 \text{ JK}^{-1}$
107. Ten moles of a gas is allowed to expand from a state A at 10 atm and 300K, to a state B at 100 atm and 600K. If the value of  $C_p$  is  $29.92 \text{ J K}^{-1} \text{ mole}^{-1}$ . Calculate the entropy change of this process. **(GATE 1998)**
108. The standard entropy of crystalline carbon monoxide (in  $\text{J mole}^{-1}$ ) at 0K is around-  
(a) 0.03 (b) 2.50 (c) zero (d) 5.76 **(GATE 2005)**
109. The change in entropy when two moles of argon gas are heated at constant volume from 300 K to 500K is- **(GATE 2010)**
- (a)  $-12.74 \text{ J K}^{-1}\text{mole}^{-1}$  (b)  $-6.37 \text{ J K}^{-1}\text{mole}^{-1}$   
(c)  $6.37 \text{ J K}^{-1}\text{mole}^{-1}$  (d)  $12.74 \text{ J K}^{-1}\text{mole}^{-1}$
110. Calculate  $\Delta S$  for 3 moles of an ideal gas which is heated and compressed from 300K and 1 bar to 400K and 5 bar. (Given:  $C_{p,m} = \frac{7R}{2}$ )
111. The entropy of mixing of 4 moles of  $\text{O}_2$  and 2 moles of  $\text{N}_2$ , assuming the gases to be ideal, is-  
(a)  $31.75 \text{ JK}^{-1}$  (b)  $63.5 \text{ JK}^{-1}$  (c)  $-31.75 \text{ JK}^{-1}$  (d)  $-63.5 \text{ JK}^{-1}$
112. The vapour pressure of toluene at  $100^\circ\text{C}$  assuming that trouton's rule is obeyed. Given that the boiling point of toluene is  $110^\circ\text{C}$ -  
(a) 753 mm (b) 573 mm (c) 760 mm (d) 366 mm
113. Consider the following statements:
- I. Entropy of universe is continually increasing.  
II. Total entropy change for a reversible isothermal cycle is zero.  
III.  $\Delta S_{\text{mix}} = 0$  for ideal gases.  
IV. Entropy is unavailable work
- Correct statement is:



(a) Temperature below 464 K      (b) Temperature above 464 K

(c) No temperature      (d) All temperatures

122. The molar entropy of crystalline CO at absolute zero is- **(GATE 2009)**

(a) Zero      (b)  $-R \ln 2$       (c)  $R \ln 2$       (d)  $2R \ln 2$

123.  $\left(\frac{\partial G}{\partial P}\right)_T =$  **(GATE 2011)**

(a)  $V$       (b)  $S$       (c)  $-S$       (d)  $-V$

124. For the process

1 Ar (300K, 1 bar)  $\rightarrow$  1 Ar (200K, 10 bar) **(GATE 2011)**

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

(a)  $-27.57 \text{ J K}^{-1} \text{ mole}^{-1}$       (b)  $27.57 \text{ J K}^{-1} \text{ mole}^{-1}$   
(c)  $-24.20 \text{ J K}^{-1} \text{ mole}^{-1}$       (d)  $24.20 \text{ J K}^{-1} \text{ mole}^{-1}$

125. The vander waals constant  $a$  and  $b$  of  $\text{CO}_2$  are  $3.64 \text{ L}^2 \text{ bar mol}^{-2}$  and  $0.04 \text{ L mol}^{-1}$ , respectively. The value of  $R$  is  $0.083 \text{ bar dm}^3 \text{ mol}^{-1} \text{ K}^{-1}$ . If one mole of  $\text{CO}_2$  is confined to a volume of  $0.15 \text{ L}$  at  $300 \text{ K}$ , then the pressure (in bar) exerted by the gas, is \_\_\_\_\_

Answer: 60-66 **(GATE 2014)**

126. 1 mole of  $\text{CO}_2$ , 1 mole of  $\text{N}_2$  and 2 mole of  $\text{O}_2$  were mixed at  $300 \text{ K}$ . The entropy of mixing is- **(CSIR DECEMBER 2011, Part C)**

(a)  $6R \ln 2$       (b)  $8R \ln 2$       (c)  $8R \frac{\ln 2}{300}$       (d)  $16R \ln 2$

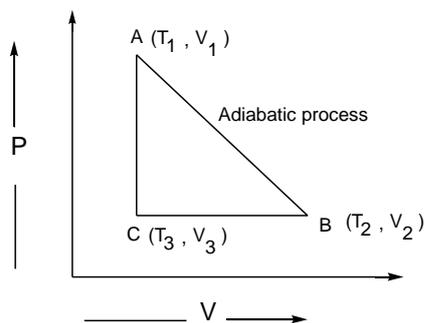
127. For an ideal solution formed by mixing of pure liquids A and B- **(IIT-JAM 2005)**

(a)  $\Delta H_{\text{mixing}} = 0$       (b)  $\Delta H_{\text{mixing}} < 0$       (c)  $\Delta H_{\text{mixing}} > 0$       (d)  $\Delta S_{\text{mixing}} = 0$

128. When  $100 \text{ g}$  of water is reversibly heated from  $50^\circ \text{C}$  to  $75^\circ \text{C}$  at  $1 \text{ atm}$ , the change in entropy ( $\text{J K}^{-1}$ ) of the universe is- **(IIT-JAM 2008)**

(a)  $-0.31$       (b)  $0.31$       (c)  $0$       (d)  $3.1$

129. Consider the process of a system along the path shown in the figure.  $\Delta S$  (B  $\rightarrow$  C) for one mole of an ideal gas is then given by-



(CSIR JUNE 2015, Part C)

- (a)  $R \ln \frac{T_1}{T_3}$       (b)  $R \ln \frac{T_3}{T_1}$       (c)  $R \ln \frac{V_2}{V_1}$       (d)  $R \ln \frac{V_1}{V_2}$

130. For an irreversible adiabatic expansion of a perfect gas from volume  $V_i$  to  $V_f$ , the change in energy of the gas is- (IISc 2001)

- (a)  $nR \ln (V_f / V_i)$       (b) zero  
 (c) less than zero      (d) greater than zero

131. The  $\Delta H^\circ$  for the reaction  $\text{CO(g)} + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$  at 400 K in  $\text{kJ mol}^{-1}$  is\_\_

Given at 298 K:

(IIT JAM 2016)

	$\Delta H_f^\circ$ $\text{kJ mol}^{-1}$	$C_p^\circ$ $\text{J mol}^{-1} \text{K}^{-1}$
$\text{O}_2$	0	29.4
CO	-110	29.1
$\text{CO}_2$	-394	37.1

132.  $\left(\frac{dH}{dP}\right)_T$  has the dimension of-

(CSIR JUNE 2016, PART B)

- (a) Pressure      (b) Volume      (c) Temperature      (d) Heat capacity

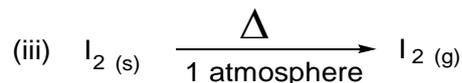
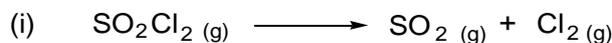
133. Consider a container of volume 5.0 L that is divided into two compartments of equal size. In the left compartment, there is nitrogen at 1.0 atm and  $25^\circ\text{C}$ ; in the right compartment there is hydrogen at the same temperature and pressure. What will happen when the partition is removed? (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

134. The change in entropy for the following transformations is respectively:

(+ indicates increases, – indicates decreases and 0 indicates no change) (IIT-JAM 2014)



(iv) Adiabatic reversible expansion of an ideal gas

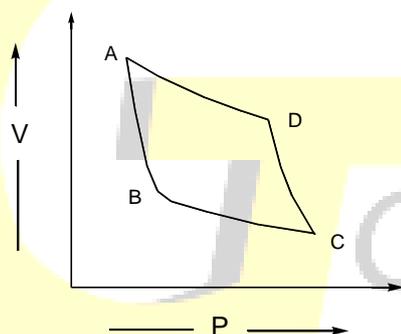
(a) +, –, 0, +

(b) +, –, 0, 0

(c) –, +, +, 0

(d) +, –, +, 0

135. The figure below describes how a carnot engine works. It starts from the adiabatic compression step denoted by-



(CSIR JUNE 2016, PartC)

(a) AB

(b) BC

(c) DC

(d) AD

136. For a binary mixture of ideal gas, free energy of mixing is given by (TIFR 2016)

$\Delta G_{\text{mix}} = nRT [x \ln x + (1-x) \ln (1-x)]$ , where x is the mole fraction of one of the components. What are the enthalpy and entropy of mixing of this system?

(a)  $\Delta H_{\text{mix}} > 0$  and  $\Delta S_{\text{mix}} > 0$

(b)  $\Delta H_{\text{mix}} < 0$  and  $\Delta S_{\text{mix}} < 0$

(c)  $\Delta H_{\text{mix}} = 0$  and  $\Delta S_{\text{mix}} > 0$

(d)  $\Delta H_{\text{mix}} > 0$  and  $\Delta S_{\text{mix}} = 0$

137. Calculate the change in entropy when 1 mol of solid iodine,  $\text{I}_2$ , 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  $54.44 \text{ JK}^{-1}\text{mol}^{-1}$  and of liquid iodine is  $80.67 \text{ JK}^{-1}\text{mol}^{-1}$ . The melting temperature of iodine is 387 K, and the molar enthalpy of fusion of iodine is  $7.87 \text{ kJ mol}^{-1}$ . (TIFR 2014)

(a)  $8.6 \text{ J K}^{-1}\text{mol}^{-1}$

(b)  $28.9 \text{ JK}^{-1}\text{mol}^{-1}$

(c)  $20.3 \text{ J K}^{-1}\text{mol}^{-1}$

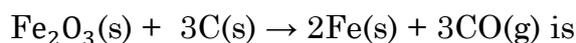
(d)  $11.7 \text{ J K}^{-1}\text{mol}^{-1}$

138. Which of the following is/are implied by the second law of thermodynamics ?

- (a)  $\Delta S > \int_A^B \frac{dq(\text{irreversible})}{T}$  for an irreversible process  $A \rightarrow B$  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 the above

139. The value of  $\Delta U - \Delta H$  for the reaction

(CSIR DECEMBER 2015, Part B)



- (a)  $-3RT$
- (b)  $+3RT$
- (c)  $+RT$
- (d)  $-RT$

140. If the pressure  $p$  (system) is greater than the  $p$  (surrounding), then-

- (a) Work is done on the system by the surroundings
- (b) Work is done on the surrounding by the system
- (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

(CSIR DECEMBER 2015, Part B)

141.  $\Delta H$  of a reaction is equal to slope of the plot of

(CSIR DECEMBER 2015, Part B)

- (a)  $\Delta G$  versus  $\left(\frac{1}{T}\right)$
- (b)  $\Delta G$  versus  $T$
- (c)  $\left(\frac{\Delta G}{T}\right)$  versus  $T$
- (d)  $\left(\frac{\Delta G}{T}\right)$  versus  $\left(\frac{1}{T}\right)$

142. A reversible expansion of 1.0 mole of an ideal gas is carried out from 1.0 L to 4.0 L under isothermal condition at 300K.  $\Delta G$  for this process is-

- (a)  $300R \ln 2$
- (b)  $600R \ln 2$
- (c)  $-600R \ln 2$
- (d)  $-300R \ln 2$

(CSIR DECEMBER 2015, Part B)

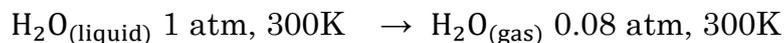
143. The non-spontaneous process among the following is

- (a) vapourisation of superheated water at  $105^\circ\text{C}$  and 1 atm pressure
- (b) expansion of gas into vacuum
- (c) freezing of supercooled water at  $-10^\circ\text{C}$  and 1 atm pressure
- (d) freezing of water at  $0^\circ\text{C}$  and 1 atm pressure -

(CSIR DECEMBER 2015, Part C)

144. Calculate the entropy change when liquid water at  $-10^{\circ}\text{C}$  is transformed into solid water at  $-10^{\circ}\text{C}$ . Given heat of fusion =  $6008.2 \text{ J mol}^{-1}$ ,  $C_{p(s)} = 36.4 \text{ J K}^{-1}\text{mole}^{-1}$ ,  $C_{p(\text{liquid})} = 75.312 \text{ J K}^{-1}\text{mole}^{-1}$ .

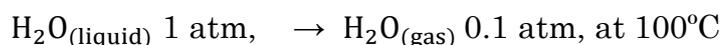
145. Calculate the entropy change for



$$\Delta H_{\text{vap}} = 40668 \text{ J mole}^{-1}, C_{p(\text{liquid})} = 75.312 \text{ J K}^{-1} \text{ mole}^{-1},$$

$$C_{p(\text{gas})} = 35.982 \text{ J K}^{-1}\text{mole}^{-1}$$

146. Calculate the entropy change for the transformation



$$\Delta H_{\text{vap}} \text{ for H}_2\text{O is } 40670 \text{ J mole}^{-1}$$

**(GATE 1996), 2 MARKS**

147. If for a reaction both  $\Delta H$  and  $\Delta S$  are negative, the reaction proceeds in the forward direction at .....temperature. **(GATE 1997)**

148. If  $\Delta G^{\circ}$  is zero for a reaction, then **(GATE 1997)**

- (a)  $\Delta H = 0$       (b)  $\Delta S = 0$       (c)  $K_{(\text{equilibrium constant})} = 0$       (d)  $K = 1$

149. The entropy change associated with the freezing of 1 mole of water at  $0^{\circ}\text{C}$  and 1 atm (heat of fusion under these condition is  $6.0 \text{ KJ/mole}$ ) is- **(GATE 1999)**

- (a)  $-6 \text{ J K}^{-1}$       (b)  $-22 \text{ J K}^{-1}$       (c)  $+22 \text{ J K}^{-1}$       (d)  $+6 \text{ J K}^{-1}$

150. For the reaction  $2 \text{Cl}_{(\text{g})} \rightarrow \text{Cl}_{2(\text{g})}$

The thermodynamic properties-

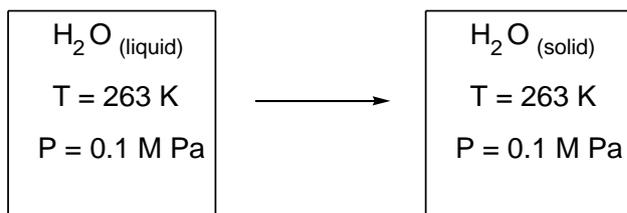
- (a)  $\Delta G$ ,  $\Delta H$  and  $\Delta S$  are positive  
 (b)  $\Delta G$ ,  $\Delta H$  and  $\Delta S$  are negative  
 (c)  $\Delta G$  and  $\Delta H$  are negative and  $\Delta S$  is positive  
 (d)  $\Delta G$  is negative and  $\Delta H$  and  $\Delta S$  are positive

151. For which of the following cases  $\Delta S = \frac{\Delta H}{T}$  **(GATE 1994)**

- (a) A process for which  $\Delta C_p = 0$   
 (b) An adiabatic process  
 (c) A constant pressure process  
 (d) An isothermal reversible phase transition

152. Calculate  $\Delta H_m$  and  $\Delta S_m$  for the process

(IIT-JAM 2010, 15 MARKS)



Assume that at 273 K, the molar enthalpy of fusion of ice is  $6006 \text{ J mole}^{-1}$ , the heat capacity  $C_{p,m(s)}$  of ice is  $38 \text{ J K}^{-1}\text{mole}^{-1}$  and heat capacity  $C_{p,m(\text{liquid})}$  of ice is  $76 \text{ J K}^{-1}\text{mole}^{-1}$ . Consider the heat capacities to be constants (Given  $\ln 263 = 5.57$  and  $\ln 273 = 5.61$ )

153. Calculate the third law entropy of a substance at 350K using the following data-

(i) Heat capacity of solid from 0K to normal melting point 200K

$$C_{p,m(s)} = [0.035 T + 0.0012 T^2] \text{ J K}^{-1} \text{ mole}^{-1}$$

(ii) Enthalpy of fusion =  $7.5 \text{ KJ mole}^{-1}$

(iii) Heat capacity of liquid from 200K to normal boiling point 300K-

$$C_{p,m(l)} = [60 + 0.016 T] \text{ J K}^{-1} \text{ mole}^{-1}$$

(iv) Enthalpy of vapourisation =  $30 \text{ KJ mole}^{-1}$

(v) Heat capacity of gas from 300K to 350K at 1 atm

$$C_{p,m(g)} = 50.0 \text{ J K}^{-1} \text{ mole}^{-1}$$

154. One mole of a substance is heated from 300K to 400K at constant pressure. The  $C_p$  of the substance is given by  $C_p (\text{J K}^{-1} \text{ mole}^{-1}) = 5 + 0.1T$ . The change in entropy, in  $\text{J K}^{-1} \text{ mole}^{-1}$ , of the substance is..... (GATE 2015, NAT)

155. The two moles of an ideal gas is expanded isothermally and reversibly from 5 to 1 bar at 298K. The change in the entropy ( $\text{J K}^{-1} \text{ mole}^{-1}$ ) of the system is.....

(IIT-JAM 2015, NAT)

156. The molar residual entropy of a crystal in which the molecules can adopt 6 orientations of equal energy at 0K is- (JNU PhD Entrance 2009)

(a)  $29.78 \text{ J K}^{-1} \text{ mole}^{-1}$

(b)  $14.89 \text{ J K}^{-1} \text{ mole}^{-1}$

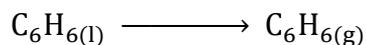
(c)  $0 \text{ J K}^{-1} \text{ mole}^{-1}$

(d) cannot be estimated

157. If  $U$  is a function of  $V$  and  $T$ ,  $\left(\frac{\partial U}{\partial T}\right)_P$ , is equal to  $(\pi$  and  $\alpha$  are the internal pressure and the coefficient of thermal expansion, respectively) (CSIR JUNE 2016, Part C)

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

158. If the enthalpy and entropy changes for the following process- **(IISc 2012)**



Are, respectively,  $33.90 \text{ KJ mol}^{-1}$  and  $96.4 \text{ J K}^{-1} \text{ mol}^{-1}$ . The temperature at which the vapour pressure of  $C_6H_6(g)$  is 35 torr will be –

- (a) 352 K                      (b) 507 K                      (c) 278 K                      (d) 273 K

159. For Water,  $\Delta H_{\text{vap}} \approx 41 \text{ KJ mole}^{-1}$ . The molar entropy of vapourisation at 1 atm pressure is approximately- **(CSIR DEC 2012, Part B)**

- (a)  $410 \text{ J K}^{-1} \text{ mol}^{-1}$                       (b)  $110 \text{ J K}^{-1} \text{ mol}^{-1}$   
 (c)  $41 \text{ J K}^{-1} \text{ mol}^{-1}$                       (d)  $11 \text{ J K}^{-1} \text{ mol}^{-1}$

160. The correct form of trouton's rule is- **(JNU, PhD 2009)**

- (a)  $\Delta S = \frac{\Delta H_{\text{vap}}}{T}$                       (b)  $\Delta S_{\text{vap}} = T \Delta H_{\text{vap}}$   
 (c)  $\Delta H_{\text{vap}} = \frac{\Delta S_{\text{vap}}}{T}$                       (d)  $\frac{\Delta S_{\text{vap}}}{\Delta H_{\text{vap}}} = R$

161. The constant volume molar heat capacity  $C_v$  of a solid is approximately given by the formula  $C_v = aT^3$ , where a is a constant. What is the change in entropy of 7.8 g of Al when it is heated at constant volume from 10K to 20K? **(IISc Int. PhD 2010)**

- (a) 700 a                      (b) 7000 a                      (c) 2333 a                      (d) 1400 a

162. A piece of Iron weighing 72.4g is heated to  $100^\circ\text{C}$  and dropped into 100 g of water kept at  $10^\circ\text{C}$ . Calculate the final temperature of water, if no heat was lost to the surrounding. Take specific heats of Iron and water as  $0.449 \text{ JK}^{-1}\text{g}^{-1}$  and  $4.18 \text{ JK}^{-1}\text{g}^{-1}$ , respectively

- (a)  $33^\circ\text{C}$                       (b)  $16.5^\circ\text{C}$                       (c)  $8.25^\circ\text{C}$                       (d) 4.125                      **(IISc Int. PhD 2009)**

163. The heat from the combustion of 1.00 g of benzene in the liquid state (for which the standard enthalpy of combustion is  $-3268 \text{ KJ mol}^{-1}$ ) is absorbed by 100g of water at  $0^\circ\text{C}$ . The final temperature of water is: **(IISc Int. PhD 2009)**

(The heat capacity of water =  $4.184 \text{ JK}^{-1}\text{g}^{-1}$ )

- (a)  $45.3^\circ\text{C}$                       (b)  $62.0^\circ\text{C}$                       (c)  $81.8^\circ\text{C}$                       (d)  $100^\circ\text{C}$

164. When 1.0 KJ of energy is added to 5.0 L of an ideal gas, the gas expands against a constant external pressure of 1.0 bar to a finite volume of 8.0 L. The change in internal energy,  $\Delta U$ , of the gas is:

(You may assume that 1.0 L bar = 0.1 KJ)

(IISc Int. PhD 2010)

- (a) 0.3 KJ                      (b) 0.7 KJ                      (c) 1.0 KJ                      (d) 1.8 KJ

165. The vapour pressure of benzene is 5333Pa at 7.6°C and 53330Pa at 60.6°C. Calculate the heat of vapourisation of Benzene and normal boiling point of Benzene.

(IIT-JAM 2014, 5 Marks)

166. For the Liquid  $\rightleftharpoons$  Vapour equilibrium of a substance,  $\frac{dP}{dT}$  at 1 bar and 400 K is  $8 \times 10^{-3}$  bar K<sup>-1</sup>. If the molar volume in the vapour form is 200L mole<sup>-1</sup> and the molar volume in the liquid form is negligible, the molar enthalpy of vapourisation is (1 bar L = 100J)

(CSIR DECEMBER 2011, Part C)

- (a) 640 KJ mole<sup>-1</sup>                      (b) 100 KJ mole<sup>-1</sup>                      (c) 80 KJ mole<sup>-1</sup>                      (d) 64 KJ mole<sup>-1</sup>

167. The vapour pressure of Benzaldehyde at 154°C is 400torr and its normal boiling point at 1 atmosphere is 179°C. Its molar enthalpy of vapourisation is-

(IISc 2007)

- (a) 41.2 KJ mole<sup>-1</sup>                      (b) 25.0 KJ mole<sup>-1</sup>                      (c) 400 KJ mole<sup>-1</sup>                      (d) - 41.2 KJ mole<sup>-1</sup>

168. The vapour pressure of water are 529 and 760torr respectively at 363 K and 373 K. The average value of enthalpy of vaporisation (in KJ/mole) of water between 363 and 373 K is-

(GATE 2005)

- (a) 42.50                      (b) 40.80                      (c) - 40.65                      (b) - 40.80

169. Ether boils at 33.5°C at one atmosphere pressure. At what temperature will it boil at a pressure of 750 mm (Given that heat of vaporisation of Ether is 369.86 Joules per gram)

**Answer: 32.9°C**

170. The specific volume of liquid water is 1.001 mL g<sup>-1</sup> and that of ice is 1.0907 mL g<sup>-1</sup> at 0°C. if the heat of fusion of ice at this temperature is 333.88 J g<sup>-1</sup>, the rate of change of change of melting point of ice with pressure in deg atm<sup>-1</sup> will be-

(GATE 2007)

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

171. The vapour pressure of water at 95°C and 100°C are 634 and 760mm respectively. Calculate the molar heat of vaporisation  $\Delta H_{\text{vap}}$  of water between 95°C and 100°C.

**Answer: 41.38KJ/mole**

172. At what pressure will ice melt at - 1.0°C assuming that  $\Delta H_{\text{fus}}$  is independent of pressure and is equal to 6.0095 KJ mole<sup>-1</sup>? Given that the density of water is 0.9998 g cm<sup>-3</sup> and that of ice is 0.917 g cm<sup>-3</sup>.

**Answer: 134.9 atmospheres**

173. Estimate the pressure necessary to melt ice at -10°C if the molar volume of liquid water is 18.01 mL and molar volume of ice is 19.64 mL. The entropy change for the melting

process is  $16.3 \text{ J K}^{-1}$ . Assume that the molar volumes and entropy change remain constant in this temperature range. (Given:  $100\text{J} = 1\text{L bar}$ )(IIT-JAM 2012, 6 MARKS)

174. Calculate the free energy change ( $\Delta G$ ) which occurs when 1 mole of an ideal gas expands reversibly isothermally at  $27^\circ\text{C}$  from an initial volume of  $50 \text{ dm}^3$  to  $1000\text{dm}^3$ .

**Answer: - 7.47 KJ mole<sup>-1</sup>**

175. The free energy change ( $\Delta G$ ) of 1 mole of an ideal gas that is compressed isothermally from 1 atm to 2 atm is- **(GATE 2009)**

- (a)  $RT \ln 2$                       (b)  $- 2 RT$                       (c)  $- RT \ln 2$                       (d)  $2 RT$

176. The enthalpy of reaction ( $\Delta H$ ) for the formation of ammonia according to the reaction

$\text{N}_2 + 3 \text{H}_2 \rightarrow 2 \text{NH}_3$  at  $27^\circ\text{C}$  was found to be  $-91.94\text{KJ}$ . What will be the enthalpy of the reaction ( $\Delta H$ ) at  $50^\circ\text{C}$ ? The molar heat capacities at constant pressure and  $27^\circ\text{C}$  for  $\text{N}_2$ ,  $\text{H}_2$  and  $\text{NH}_3$  are  $28.45$ ,  $28.32$  and  $37.07 \text{ J K}^{-1}\text{mole}^{-1}$  respectively.

**Answer:  $\Delta H_{50^\circ\text{C}} = -92.84 \text{ KJ}$**

177.  $\Delta H^\circ_{298\text{K}}$  for the reaction  $\text{C}_2\text{H}_4\text{O}_{(g)} \rightarrow \text{CH}_4_{(g)} + \text{CO}_{(g)}$  is  $-16.0 \text{ KJ}$ . From the given data, evaluate the temperature at which  $\Delta H$  will be zero **(GATE 2003)**

Substance	$\text{C}_2\text{H}_4\text{O}_{(g)}$	$\text{CH}_4_{(g)}$	$\text{CO}_{(g)}$
$C_p \text{ (JK}^{-1}\text{mole}^{-1}\text{)}$	50	36	30

- (a)  $1298 \text{ K}$                       (b)  $1000 \text{ K}$                       (c)  $1298^\circ\text{C}$                       (d)  $1100^\circ\text{C}$

178. Calculate  $\Delta H^\circ_{373\text{K}}$  for the reaction



$$C_{p,m}(\text{NO}_{2(g)}) / \text{J K}^{-1}\text{mole}^{-1} = 27.78 + 30.85 \times 10^{-3} \text{ T}$$

$$C_{p,m}(\text{N}_{2(g)}) / \text{J K}^{-1}\text{mole}^{-1} = 28.46 + 2.26 \times 10^{-3} \text{ T}$$

$$C_{p,m}(\text{O}_{2(g)}) / \text{J K}^{-1}\text{mole}^{-1} = 26.85 + 8.49 \times 10^{-3} \text{ T}$$

179. Consider the following reaction and use the data given below-



Substance	$\text{N}_{2(g)}$	$\text{H}_{2(g)}$	$\text{NH}_{3(g)}$
$C_p \text{ (JK}^{-1}\text{mole}^{-1}\text{)}$	29.1	28.8	35.1

Assuming  $C_p$  to be independent of temperature, the reaction at  $100^\circ\text{C}$  compared to that at  $25^\circ\text{C}$  will be- **(GATE 2001, IISc 2001)**

- (a) endothermic      (b) less exothermic      (c) more exothermic      (d) having  $\Delta H^\circ = 0$

180. Calculate  $\Delta H^\circ_{373K}$  for the reaction



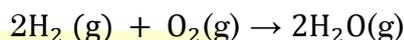
$$C_{p,m} (NO_{2(g)}) / \text{J K}^{-1} \text{mole}^{-1} = 37.20 \quad C_{p,m} (N_{2(g)}) / \text{J K}^{-1} \text{mole}^{-1} = 29.13$$

$$C_{p,m} (O_{2(g)}) / \text{J K}^{-1} \text{mole}^{-1} = 29.36$$

181. The standard enthalpy of formation ( $\Delta_f H^\circ_{300K}$ ) at 1 bar and 300K for the formation of  $CF_2ClCF_2Cl_{(g)}$  from its constituent elements in the standard state is  $-900 \text{ KJ mole}^{-1}$ . Given  $R = 8.3 \text{ JK}^{-1} \text{ mole}^{-1}$ , the standard internal energy of formation ( $\Delta_f U^\circ_{300K}$ ) at the same pressure and temperature is-  
**(IIT-JAM 2012)**

- (a)  $-905 \text{ KJ mole}^{-1}$       (b)  $-895 \text{ KJ mole}^{-1}$   
 (c)  $895 \text{ KJ mole}^{-1}$       (d)  $905 \text{ KJ mole}^{-1}$

182. The following reaction is carried out at 1 atm and 300 K **(IIT-JAM 2013)**



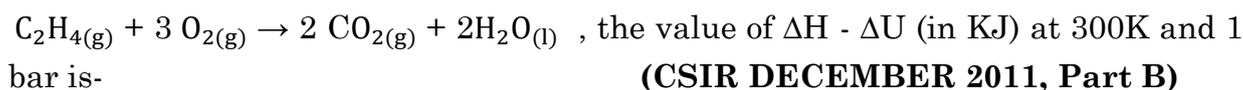
$\Delta U$  for the above reaction is 550 kJ. Assuming ideal gas behavior for  $H_2$  and  $O_2$ , calculate the value of  $\Delta H$ . The value of gas constant,  $R = 0.082 \text{ L atm mol}^{-1} \text{ K}^{-1} = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$ .  
**[Given: The volume of 1 mole of liquid water is 18 mL under the above reaction condition]**

183. Consider ideal mixing of 2 moles of toluene and 2 moles of benzene at 1 atm and 300K. Calculate the values of  $\Delta_{mix} V$ ,  $\Delta_{mix} U$ ,  $\Delta_{mix} H$ ,  $\Delta_{mix} G$  and  $\Delta_{mix} S$  for the process ( $\ln 2 = 0.69$ )  
**(IIT-JAM 2012)**

184. The enthalpy of vaporisation ( $\Delta_{vap} H$ ) is zero at- **(IIT-JAM 2012)**

- (a) Boyle temperature      (b) Critical temperature  
 (c) Inversion temperature      (d) Boiling temperature

185. For the reaction



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

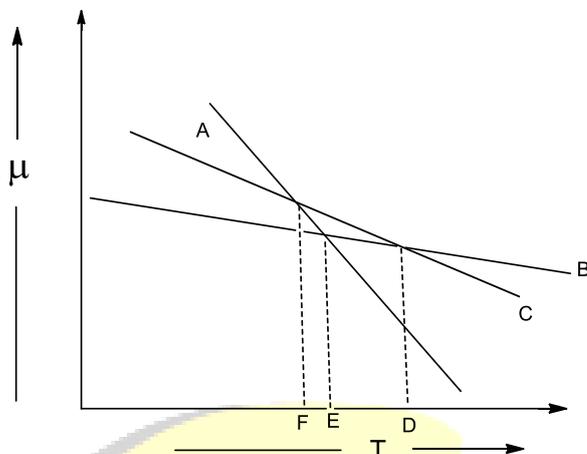
186. For the reaction  $X_2O_{4(l)} \rightarrow 2 XO_{2(g)}$  at 298K, given the values  $\Delta U = 9 \text{ KJ}$  and  $\Delta S = 84 \text{ JK}^{-1}$ ,  $\Delta G$  is-  
**(GATE 2013)**

- (a)  $-11.08 \text{ KJ}$       (b)  $+11.08 \text{ KJ}$       (c)  $-13.55 \text{ KJ}$       (d)  $+13.55 \text{ KJ}$

187. The expression which represents the chemical potential of the  $i^{\text{th}}$  species ( $\mu_i$ ) in a mixture ( $i \neq j$ ) is: **(GATE 2007)**
- (a)  $\left(\frac{dE}{dn_i}\right)_{s, v, n_j}$                       (b)  $\left(\frac{dA}{dn_i}\right)_{s, v, n_j}$   
(c)  $\left(\frac{dH}{dn_i}\right)_{s, v, n_j}$                       (d)  $\left(\frac{dG}{dn_i}\right)_{s, v, n_j}$
188. The chemical potential ( $\mu_i$ ) of the  $i^{\text{th}}$  compound is defined as **(CSIR Dec. 2015, Part C)**
- (a)  $\mu_i = \left(\frac{dU}{dn_i}\right)_{T,P}$       (b)  $\mu_i = \left(\frac{dH}{dn_i}\right)_{T,P}$       (c)  $\mu_i = \left(\frac{dA}{dn_i}\right)_{T,P}$       (d)  $\mu_i = \left(\frac{dG}{dn_i}\right)_{T,P}$
189. The chemical potential of a component,  $\mu_i$  in a given mixture is-
- (a)  $\left(\frac{dG}{dn_i}\right)_{T,V,n_j}$       (b)  $\left(\frac{dG}{dn_i}\right)_{T,P,n_j}$       (c)  $\left(\frac{dG}{dn_i}\right)_{T,P,n_i}$       (d)  $\left(\frac{dG}{dn_i}\right)$
190. A thermodynamic equation that relates the chemical potential to the composition of a mixture is known as- **(CSIR JUNE 2015, Part C)**
- (a) Gibbs-Helmholtz equation                      (b) Gibbs-Duhem equation  
(c) Joule-Thomson equation                      (d) Debye-Huckel equation
191. At constant temperature, the change of chemical potential with change in pressure is equal to- **(BHU 2016)**
- (a) Entropy                      (b) Partial molar enthalpy  
(c) Partial molar volume                      (d) Free energy
192. Absolute entropy of a substance can be calculated using- **(BHU 2016)**
- (a) Zeroth law of thermodynamics  
(b) First law of thermodynamics  
(c) Second law of thermodynamics  
(d) Third law of thermodynamics

**Statement for Linked Answer type Questions: Q193 and Q194**

In the  $\mu$  vs  $T$  diagram for different phases of the same substance at one atmospheric pressure, the lines A, B and C compound to-



193. Based on the above diagram-

**(GATE 2010)**

- (a) A represents the change in chemical potential as a function of temperature for solid phase, B for the liquid and C for the gas.
- (b) A represents the change in chemical potential as a function of temperature for liquid phase, B for the gas and C for the solid.
- (c) A represents the change in chemical potential as a function of temperature for gas phase, B for the liquid and C for the solid.
- (d) A represents the change in chemical potential as a function of temperature for gas phase, B for the solid and C for the liquid.

194. From the same diagram-

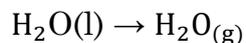
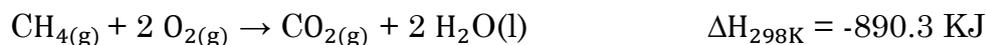
**(GATE 2010)**

- (a) D represents boiling point, E sublimation point and F melting point
  - (b) E represents boiling point, D sublimation point and F melting point
  - (c) E represents melting point, F sublimation point and D boiling point
  - (d) D represents melting point, F boiling point and E sublimation point
195.  $H_2$  gas mixed with air at  $25^\circ C$  under a pressure of 1 atm and exploded in a closed vessel. The enthalpy of reaction at constant volume is  $-240.6$  KJ at 298K. Calculate the explosion temperature under adiabatic condition.

$$C_v \text{ for water } 39.06 \text{ JK}^{-1}$$

$$C_v \text{ for } N_2 = 26.40 \text{ JK}^{-1}$$

196. In a Bunsen burner, CH<sub>4</sub> gas is premixed with sufficient air to allow complete combustion and at the flame temperature, water is converted into steam using the following thermochemical data



Calculate the flame temperature. Assume that the gaseous products behave ideally.

$\sum C_p = 41.8 \text{ JK}^{-1} \text{ mole}^{-1}$  and the initial temperature = 25°C

Answer: 2042K

197 (a) Calculate the adiabatic flame temperature for the following reaction carried out under constant volume condition



(b) If the above reaction is carried out using air, what would be the flame temperature (air to be taken as 80% N<sub>2</sub> and 20% O<sub>2</sub>).

Given:  $C_{p,m}(\text{CO}_2, \text{g}) = 36.29 \text{ J K}^{-1} \text{ mole}^{-1}$

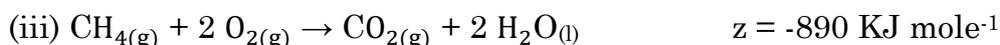
$C_{p,m}(\text{H}_2\text{O}, \text{g}) = 33.58 \text{ J K}^{-1} \text{ mole}^{-1}$

$C_{p,m}(\text{N}_2, \text{g}) = 29.29 \text{ J K}^{-1} \text{ mole}^{-1}$

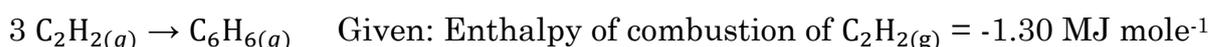
198. From the following thermochemical equations, calculate the enthalpy of formation of cane sugar (C<sub>12</sub>H<sub>22</sub>O<sub>11</sub>)



199. Calculate the heat of formation of methane with the help of following thermochemical equations- **(CSIR NET DECEMBER 2010)**



200. Calculate the enthalpy change of the following reaction-



And that of  $C_6H_6(g) = -3.302 \text{ MJ mole}^{-1}$

201. Using the combustion data given below, compute the enthalpy of formation of isoprene(g) and its resonance energy. Given  $\Delta H_f$  (from bond enthalpies) =  $103.31 \text{ KJ mole}^{-1}$

Given data: Enthalpy of combustion of isoprene(g) ( $\Delta H_c = -3120 \text{ KJ mole}^{-1}$ )

Enthalpy of formation of  $CO_2(g)$  ( $\Delta H_f = -393.71 \text{ KJ mole}^{-1}$ )

Enthalpy of formation of  $H_2O(l)$  ( $\Delta H_f = -285.77 \text{ KJ mole}^{-1}$ )

202. Conversion of Diamond  $\rightarrow$  Graphite is-

- (a) Endothermic (b) Exothermic  
 (c) May be exothermic or endothermic (d) Neither exothermic nor endothermic

203. Set up a Born-Haber cycle to find the lattice energy of NaCl crystal.

Given:  $\Delta H_f(\text{NaCl}) = -410.87 \text{ KJ mole}^{-1}$

Ionisation enthalpy of Na =  $495.80 \text{ KJ mole}^{-1}$

Electron affinity of chlorine =  $-365.26 \text{ KJ mole}^{-1}$

Sublimation enthalpy of Na =  $317.57 \text{ KJ mole}^{-1}$

Dissociation enthalpy of  $Cl_2 = 241.84 \text{ KJ mole}^{-1}$

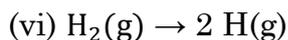
204. Calculate the lattice enthalpy of  $NaCl(g)$  in  $\text{KJ mole}^{-1}$  using a Born-Haber cycle.  $\Delta H$  for the following are given in  $\text{KJ mole}^{-1}$ ; Sublimation of  $Na(s) = +89$ , ionisation of  $Na(g) = +425$ , (IISc 2011)

Dissociation of  $Cl_2(g) = +244$ , Electron affinity of  $Cl(g) = -355$ , formation of  $NaCl(s) = -438$

- (a) 1438 (b) 719 (c) -719 (d) 3595

205. Obtain (i) the molar heat of formation of  $CH_4(g)$  and (ii) the average C-H bond energy, to the nearest Kilojoule (KJ) from the given data: (IIT-JAM 2009)

	$\Delta H \text{ (KJ mole}^{-1}\text{)}$
(i) $CH_4(g) \rightarrow CH_3(g) + H(g)$	435
(ii) $CH_3(g) \rightarrow CH_2(g) + H(g)$	444
(iii) $CH_2(g) \rightarrow CH(g) + H(g)$	444
(vi) $CH(g) \rightarrow C(g) + H(g)$	339
(v) $C(\text{graphite}) \rightarrow C(g)$	717



436

206. The enthalpy change,  $\Delta H$ , for the following process are given in  $\text{KJ mole}^{-1}$ :

Ionisation enthalpy of K =  $425 \text{ KJ mole}^{-1}$  **(IISc 2010)**

Electron affinity of chlorine =  $-355 \text{ KJ mole}^{-1}$

Sublimation enthalpy of  $\text{K}_{(\text{s})}$  =  $89 \text{ KJ mole}^{-1}$

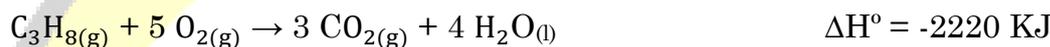
Formation of  $\text{KCl}_{(\text{s})}$  =  $-438 \text{ KJ mole}^{-1}$

Dissociation of  $\text{Cl}_{2(\text{s})}$  =  $244 \text{ KJ mole}^{-1}$

Using a Born-Haber cycle, the lattice enthalpy of  $\text{KCl}_{(\text{s})}$  is calculated to be-

- (a) 719 (b) 0 (c) -719 (d) 1438

207. Given the following data **(IISc 2005)**



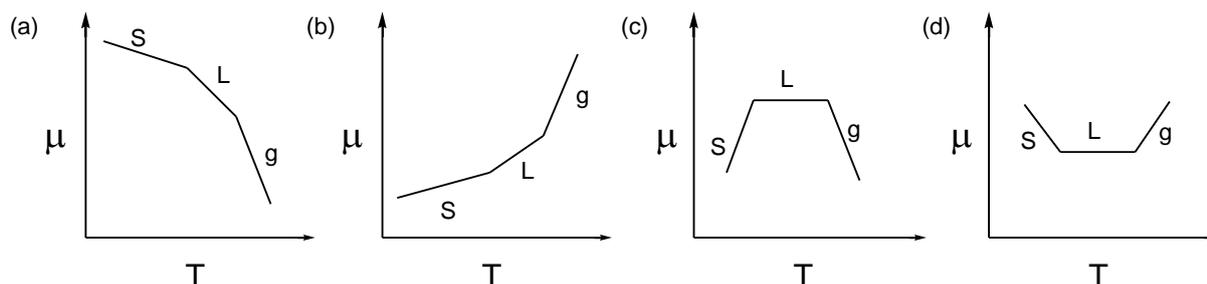
The molar heat of formation of  $\text{C}_3\text{H}_{8(\text{g})}$  i.e.  $3 \text{C}_{(\text{s})} + 4 \text{H}_{2(\text{g})} \rightarrow \text{C}_3\text{H}_{8(\text{g})}$

- (a) -106 KJ (b) -1540 KJ  
 (c) -180 KJ (d) 180 KJ

208. The enthalpy of fusion of ice at 273K is  $6.01 \text{ KJ mole}^{-1}$  and the enthalpy of vapourisation of water at 273K is  $44.83 \text{ KJ mole}^{-1}$ . The enthalpy of sublimation (in  $\text{KJ mole}^{-1}$ ) of ice at 273K is.....

**Answer: 50 to 52 (GATE 2014, NAT)**

209. Of the following plots, the correct representation of chemical potential ( $\mu$ ) against absolute temperature (T) for a pure substance is (S, L, g denote solid, liquid and gas phases, respectively) **(GATE 2014)**



210. The ionic radii of  $\text{Cs}^+$  and  $\text{Cl}^-$  ions are 181 and 167 pm, respectively. The Born exponents for the He, Ne, Ar, Kr and Xe configurations are 5, 7, 9, 10 and 12 respectively. If the value  $\left[\frac{A\text{Ne}^2}{4\pi\epsilon_0}\right]$  is  $2.45 \times 10^{-4} \text{ J m}$ , the lattice energy (in  $\text{KJ mole}^{-1}$ ) of  $\text{CsCl}$  according to Born-Landé equation is.....

Answer: - 638.0 to -636.0

(JAM 2015, NAT)

211. Calculate the lattice energy of  $\text{NaCl}$  crystal from the following data:

$$A = 1.7476, r_0 = 2.814 \text{ \AA}, n = 8$$

212. Calculate the lattice energy of  $\text{KCl}$  when  $a_0 = 628 \text{ pm}$ ,  $n$  (exponent of repulsion term) = 9 and  $A = 1.746$ .

213. The activity of 2.5 moles of a substance changes from 0.05 to 0.35. What would be the change in its free energy at  $27^\circ\text{C}$ ? ( $\log 7 = 0.845$ )

Answer: 12.14 KJ

214. Which of the following is not true for real gases?

(BHU 2013)

(a)  $\Delta G = nRT \ln \left(\frac{f_2}{f_1}\right)$       (b)  $\lim_{p \rightarrow 0} \left(\frac{f}{p}\right) = 1$

(c)  $\gamma = \frac{a}{p}$       (d)  $\Delta G = nRT \ln \left(\frac{P_2}{P_1}\right)$

215. Fugacity of a gas in a mixture is equal to the product of its mole fraction in the mixture and its fugacity in the pure state at a total pressure of the mixture. This is in accordance with-

(BHU 2013)

(a) Lewis-Randall rule

(b) Konovalov's First Rule

(c) Konovalov's second Rule

(d) Mathematical form of duhem-Margules equation

216. At any temperature  $T$ , the fugacity coefficient ( $\gamma$ ) is given by

$$\ln \gamma = \int_0^p \frac{Z-1}{p} dp \quad \text{(GATE 2010)}$$

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

(a)  $\frac{RT}{bp}$

(b)  $e^{\frac{RT}{bp}}$

(c)  $\frac{bP}{RT}$

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

217. The fugacity of a certain gas at 200K and 50 bars is 25 bar. The difference of its chemical potential from that of a perfect gas in the same state is-

(BHU 2011)

(a)  $200R \ln 25$

(b)  $200R \ln 2$

(c)  $-200R \ln 2$

(d)  $-200R \ln 25$

218. The fugacity coefficient  $\phi$  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  $p(V_m - b) = RT$

- (a)  $p \ln \left(\frac{V_m}{RT}\right)$       (b)  $pe^{\left(\frac{b}{RT}\right)}$       (c)  $pe^{-\left(\frac{bp}{RT}\right)}$       (d)  $pe^{\left(\frac{bp}{RT}\right)}$       **(GATE 2004)**

219. At high pressure, the fugacity coefficient of a real gas is greater than one because-

- (a) attractive term overweighs the repulsive term      **(CSIR DEC 2014, Part C)**  
 (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 terms

220. 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  $\left(\frac{dH}{dP}\right)_T$       **(CSIR DECEMBER 2016, PART C)**

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

221. The parameter which always decreases during a spontaneous process at constant  $S$  and  $V$  is-      **(CSIR DECEMBER 2016, PART B)**

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

222. The partial derivative  $\left(\frac{\partial T}{\partial V}\right)_P$  is equal to      **(CSIR DECEMBER 2016, PART C)**

- (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)  $-\left(\frac{\partial P}{\partial S}\right)_H$

223. The enthalpy of formation for  $\text{CH}_4$  (g),  $\text{C}$ (g) and  $\text{H}$ (g) are  $-75$ ,  $717$  and  $218 \text{ kJ mol}^{-1}$ , respectively. The enthalpy of the C-H bond in  $\text{kJ mol}^{-1}$  is. \_\_\_\_\_ **(IIT JAM 2016)**

ANSWER-  $-417.0$  to  $-415.0$

224. The number of normal modes of vibration in naphthalene is      **(IIT JAM 2017)**

- (a) 55      (b) 54      (c) 48      (d) 49

225. At  $298\text{K}$  and  $1 \text{ atm}$ , 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  $\text{kJ mol}^{-1}$ ) for the conversion of one mole of propene to one mole of cyclopropane is \_\_\_\_\_ **ANSWER: 33 (NAT) (IIT JAM 2017)**

226. Consider an isothermal reversible compression of one mole of an ideal gas in which the pressure of the system is increased from  $5 \text{ atm}$  to  $30 \text{ atm}$  at  $300\text{K}$ . The entropy change of the surroundings (in  $\text{J K}^{-1}$ ) is \_\_\_\_\_ (final answer should be rounded off to two decimal places)      **(IIT JAM 2017)**

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

ANSWER 14.80 to 15.00

227. The CORRECT expression(s) for isothermal expansion of 1 mol of an ideal gas is(are) **(MSQ) (IIT JAM 2018)**

(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)  $\Delta S = R \ln \frac{V_{\text{final}}}{V_{\text{initial}}}$

228. For the reaction  $\text{H}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$ , the following information is given

$T = 300 \text{ K}$

$\Delta \bar{H}^\circ = -285 \text{ kJ mol}^{-1}$        $\bar{S}_{\text{H}_2\text{O}}^\circ(\text{l}) = 70 \text{ JK}^{-1} \text{ mol}^{-1}$

$\bar{S}_{\text{O}_2}^\circ(\text{g}) = 204 \text{ JK}^{-1} \text{ mol}^{-1}$        $\bar{S}_{\text{H}_2}^\circ(\text{g}) = 130 \text{ JK}^{-1} \text{ mol}^{-1}$

$\Delta \bar{S}_{\text{universe}}^\circ$  for the reaction is \_\_\_\_\_  $\text{JK}^{-1} \text{ mol}^{-1}$  **(IIT JAM 2018)**

Answer 786 to 790

229. 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)

230. At 1 bar and 298K, for the process  $\text{A}(\text{s}) \rightarrow \text{A}(\text{l})$ , the  $\Delta G$  is  $200 \text{ J mol}^{-1}$  and  $\Delta V_{\text{m}}$  is  $-2 \times 10^{-6} \text{ m}^3 \text{ mol}^{-1}$ . The minimum pressure, in bar, at which the process becomes spontaneous at 298K is \_\_\_\_\_. (1 bar =  $10^5 \text{ Pa}$ ). **[GATE 2016]**

231. 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)  $-\left(\frac{\partial A}{\partial V}\right)_T$       (iv)  $-\left(\frac{\partial A}{\partial T}\right)_V$

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

232. Consider an ideal gas of volume  $V$  at temperature  $T$  and pressure  $P$ . If the entropy of the gas is  $S$ , the partial derivative  $\left(\frac{\partial P}{\partial S}\right)_V$  is equal to **[GATE 2017]**

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

233. The Gibbs free energy of mixing is denoted as  $\Delta G_{\text{mix}}$ . 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 behavior, the value of  $\frac{\Delta G_{\text{mix}}}{RT}$  is \_\_\_\_\_. (up to two decimal places) **[GATE 2017]**

234. The molar heat capacity of a substance is represented in the temperature range 298K to 400K by the empirical relation  $C_{p,m} = 14 + bT \text{ J K}^{-1} \text{ mol}^{-1}$ , where b is a constant. The molar enthalpy change when the substance is heated from 300K to 350K is  $2 \text{ kJ mol}^{-1}$ . The value of b is \_\_\_\_\_  $\text{J K}^{-2} \text{ mol}^{-1}$ . (Upto two decimal places)  
 Answer 0.07 to 0.09 **[GATE 2018]**
235. 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 \_\_\_\_\_  $\text{J K}^{-1}$  (Up to one decimal place. Use  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ )  
 Answer 22.0 to 24.0 **[GATE 2018]**
236. The enthalpy of vaporization of a liquid at its boiling point ( $T_b = 200 \text{ K}$ ) is  $15.3 \text{ kJ mol}^{-1}$ . If the molar volumes of the liquid and the vapour at 200 K are 110 and  $12000 \text{ cm}^3 \text{ mol}^{-1}$ , respectively, then the slope  $\frac{dP}{dT}$  of the liquid-vapour boundary is \_\_\_\_\_  $\text{kPa K}^{-1}$  (Upto two decimal places. Note :  $1 \text{ Pa} = 1 \text{ J m}^{-3}$ )  
 Answer 6.20 to 6.60 **[GATE 2018]**
237. The correct statement for any cyclic thermodynamic process is  
 (a)  $\oint dq = 0$  (b)  $\oint dw = 0$   
 (c)  $\oint dU = 0$  (d)  $\oint Vdq = 0$  **(CSIR JUNE 2017, PART B)**
238. The fugacity of a real gas is less than the 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,  $T > T_b$  **(CSIR JUNE 2017, PART C)**
239. The minimum work required by an engine to transfer 5 J of heat from a reservoir at 100 K to one at 300 K is **(CSIR JUNE 2017, PART C)**  
 (a) 5 J (b) 10 J (c) 15 J (d) 20 J
240. Enthalpy is equal to **(CSIR DECEMBER 2017, PART B)**  
 (a)  $TS + PV + \sum \mu_i n_i$  (b)  $TS + \sum \mu_i n_i$  (c)  $\sum \mu_i n_i$  (d)  $PV + \sum \mu_i n_i$
241. In stretching of a rubber band, **(CSIR DECEMBER 2017, PART C)**  
 $dG = Vdp - SdT + fdL$   
 Which of the following relations is 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)  $\left(\frac{\partial S}{\partial L}\right)_{p,T} = -\left(\frac{\partial f}{\partial p}\right)_{T,L}$

242. The change in entropy for the reversible adiabatic process is  
 (a) Maximum (b) Minimum  
 (c) Zero (d) positive **(CSIR JUNE 2018, PART B)**
243. 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.  $\left(\frac{\partial U}{\partial V}\right)_T$  (in kbar) for water at 320 K and 1 bar will be **(CSIR JUNE 2018, PART C)**  
 (a) 2.4 (b) 1.2 (c) 0.6 (d) 12.0
244. The value of  $C_v$  for 1 mole of  $\text{N}_2$  gas predicted from the principle of equipartition of energy, ignoring vibrational contribution, is \_\_\_\_\_  $\text{JK}^{-1} \text{mol}^{-1}$  (rounded up to two decimal places)  $[\text{R} = 8.3 \text{JK}^{-1} \text{mol}^{-1}]$  **[JAM 2018]**
245. Intensive variable(s) is/are **[JAM 2017]**  
 (a) Temperature (b) Volume (c) Pressure (d) Density
246. 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)  $dU = VdP - SdT$  **(CSIR Dec 2018, PART B)**
247. Entropy of a perfect gas is  
 (a) independent of  $V$  (b) proportional to  $V$ .  
 (c) proportional to  $\ln V$ . (d) proportional to  $V^2$ . **(CSIR Dec 2018, PART C)**
248. The one mole of a mono-atomic ideal gas is transformed from 300 K and 2 atm to 600K and 4 atm. The entropy change for this process is **(CSIR June 2019, PART B)**  
 (a)  $\left(\frac{3}{2}\right) \text{R} \ln 2$  (b)  $\left(\frac{1}{2}\right) \text{R} \ln 2$  (c)  $\left(\frac{7}{2}\right) \text{R} \ln 2$  (d)  $\left(\frac{5}{2}\right) \text{R} \ln 2$
249. A sample of two moles of  $\text{O}_2(\text{g})$  (assumed ideal) at 500 K is expanded from 5L to 50 L under adiabatic and reversible conditions. The change in its internal energy (in kJ) is close to ( $\text{R} = 8.3 \text{J K}^{-1} \text{mol}^{-1}$ ,  $C_{v,m} = \frac{5}{2} \text{R}$ ) **(CSIR June 2019, PART C)**  
 (a) -22.5 (b) -12.5 (c) -19.1 (d) -7.5
250. A non ideal gas follows the equation: **(CSIR June 2019, PART C)**

$$P = \frac{RT}{V_m} \left[ 1 + \frac{B}{V_m} \right]$$

Where  $B$  is a function of temperature only. The deviation in internal energy from that of an ideal gas,  $U - U_{\text{ideal}}$ , is given by

(a)  $\frac{-RT}{V_m} \left(\frac{\partial B}{\partial T}\right)_V$       (b)  $\frac{-RT^2}{V_m} \left(\frac{\partial B}{\partial T}\right)_V$       (c)  $\frac{-RT^2}{V_m} B$       (d)  $\frac{-RT}{V_m} B$

251. 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

[JAM 2019]

252. The unit of the constant 'a' in van der Waals equation of state of a real gas can be expressed as

[JAM 2019]

- (a)  $m^6 \text{ Pa mol}^{-2}$       (b)  $m^6 \text{ J mol}^{-2}$       (c)  $m^3 \text{ Pa mol}^{-2}$       (d)  $m^3 \text{ J mol}^{-2}$

253. 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 \_\_\_\_\_  $\text{kJ mol}^{-1}$ . (Round off to one decimal place) [Given: Gas constant (R) = 8.3  $\text{J k}^{-1}\text{mol}^{-1}$ ]

[JAM 2019]

254. An ideal gas occupies an unknown volume V liters (L) at a pressure of 12 atm. The gas is expanded isothermally against a constant external pressure of 2 atm so that its final volume becomes 3 L. The work involved for this expansion process is \_\_\_ cal. (Round off to two decimal places).

[GATE 2019]

(Gas constant  $R = 0.082 \text{ L atm mol}^{-1} \text{ K}^{-1} = 2 \text{ cal mol}^{-1} \text{ K}^{-1}$ )

255. The entropy change for the melting of 'x' moles of ice (heat of fusion is 80  $\text{cal g}^{-1}$ ) at 273 K and 1 atm pressure is 28.80  $\text{cal K}^{-1}$ . The value of 'x' is \_\_\_ (Round off to one decimal place)(Molecular weight of water = 18g/mol)

[GATE 2019]

256. The normal boiling point of a compound (X) is 350 K (heat of vaporization,  $\Delta_{\text{vap}} H = 30 \text{ kJ mol}^{-1}$ ). The pressure required to boil 'X' at 300K is \_\_\_ Torr. (Round off to two decimal places)

[GATE 2019]

(Ignore the temperature variation of  $\Delta_{\text{vap}} H$ ; Gas constant  $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$  and 1 atm = 760 Torr)

257. Assume that the temperature (T) dependence of  $\Delta G$  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,  $\Delta C_p$ ?

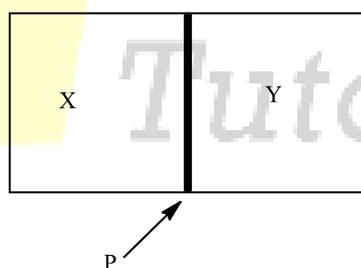
- (a)  $\frac{x}{T}$       (b)  $-y$       (c)  $-2zT$       (d) Insufficient information

258. During isothermal expansion of an ideal gas which of the following happen: [TIFR 2017]

- (i) Temperature does not change  
 (ii) Process is spontaneous  
 (iii) The energy of the system does not change  
 (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)

259. Two compartments X and Y are separated by an impermeable partition P. In the compartment X, the following reaction is going on in a solvent S, while the compartment Y contains only the solvent S: [TIFR 2017]

Contents of both the compartments are continuously and vigorously stirred. After the reaction in the compartment X has reached equilibrium, the concentrations of  $A_2$ ,  $B_2$  and AB are measured and the equilibrium constant calculated. Then the partition is quickly removed. After waiting for a very long time, all the concentrations are measured again, and the new value of the equilibrium constant calculated. What is the most appropriate statement you can make about the result of this experiment? Assume that the chemicals are behaving ideally and the temperature is kept constant.



- (a) The concentrations of all the chemicals and the equilibrium constant will be less than their values before the partition was removed.  
 (b) After removing the partition, the concentrations of  $A_2$  and  $B_2$  will increase, and that of AB will decrease.  
 (c) After removing the partition, the concentrations of  $A_2$  and  $B_2$  will decrease, and that of AB will increase.  
 (d) After removing the partition, the concentrations of all the chemicals will decrease

260. 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:

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

[TIFR 2018]

261. Water boils at a temperature of 373 K and atmospheric pressure of 1 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 0.5 atm? [TIFR 2019]

(a) 270 K

(b) 354 K

(c) 373 K

(d) 403 K

262. According to the laws of thermodynamics for which of the following processes is the entropy of a system equal to zero [TIFR 2019]

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

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

(c) Reversible process

(d) Irreversible process