THERMODYNAMICS-02

1. Two blocks of the same metal having same mass and at temperature T_1 and T_2, respectively. are brought in contact with each other and allowed to attain thermal equilibrium at constant pressure. The change in entropy, ΔS, for this process is :

(1) $2C_P \ln\left(\frac{T_1+T_2}{4T_1T_2}\right)$ (2) $2C_P \ln\left[\frac{(T_1+T_2)^{\frac{1}{2}}}{T_1T_2}\right]$

(3) $C_P \ln\left[\frac{(T_1+T_2)^2}{4T_1T_2}\right]$ (4) $2C_P \ln\left[\frac{T_1+T_2}{2T_1T_2}\right]$

2. For the chemical reaction $X \rightleftharpoons Y$, the standard reaction Gibbs energy depends on temperature T (in K) as :

$$\Delta_r G^o \text{ (in kJ mol}^{-1}) = 120 - \frac{3}{8}T$$

The major component of the reaction mixture at T is :

(1) X if T = 315 K

(2) X if T = 350 K

(3) Y if T = 300 K

(4) Y if T = 280 K

3. The INCORRECT match in the following is

(1) $\Delta G^o < 0$, $K < 1$ (2) $\Delta G^o = 0$, $K = 1$

(3) $\Delta G^o > 0$, $K < 1$ (4) $\Delta G^o < 0$, $K > 1$

4. A process will be spontaneous at all temperatures if :-

(1) $\Delta H > 0$ and $\Delta S < 0$

(2) $\Delta H < 0$ and $\Delta S > 0$

(3) $\Delta H > 0$ and $\Delta S > 0$

(4) $\Delta H < 0$ and $\Delta S < 0$

5. For the equilibrium,

$2H_2O \rightleftharpoons H_3O^+ + OH^-$, the value of ΔG^o at 298 K is approximately :-

(1) –80 kJ mol^{-1}

(2) –100 kJ mol^{-1}

(3) 100 kJ mol^{-1}

(4) 80 kJ mol^{-1}

6. The standard reaction Gibbs energy for a chemical reaction at an absolute temperature T is given by

$$\Delta_r G^o = A - BT$$

Where A and B are non-zero constants. Which of the following is TRUE about this reaction ?

(1) Exothermic if B < 0

(2) Exothermic if A > 0 and B < 0

(3) Endothermic if A < 0 and B > 0

(4) Endothermic if A > 0

7. The reaction, $MgO(s) + C(s) \rightarrow Mg(S) + CO(g)$, for which $\Delta_r H^o = +\ 491.1$ kJ mol^{-1} and $\Delta_r S^o = 198.0$ JK^{-1} mol^{-1}, is not feasible at 298 K. Temperature above which reaction will be feasible is :-

(1) 1890.0 K (2) 2480.3 K

(3) 2040.5 K (4) 2380.5 K

8. A process has $\Delta H = 200\ Jmol^{-1}$ and $\Delta S = 40\ JK^{-1}mol^{-1}$. Out of the values given below, choose the minimum temperature above which the process will be spontaneous :

(1) 5 K (2) 4 K (3) 20 K (4) 12 K

9. The entropy change associated with the conversion of 1 kg of ice at 273 K to water vapours at 383 K is :

(Specific heat of water liquid and water vapour are 4.2 kJ K^{-1} kg^{-1} and 2.0 kJ K^{-1} kg^{-1} ; heat of liquid fusion and vapourisation of water are 344 kJ kg^{-1} and 2491 kJ kg^{-1}, respectively).

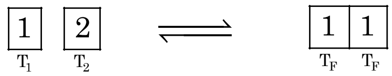
(log 273 = 2.436, log 373 = 2.572, log 383 = 2.583)

(1) 7.90 kJ kg^{-1} K^{-1} (2) 2.64 kJ kg^{-1} K^{-1}

(3) 8.49 kJ kg^{-1} K^{-1} (4) 9.26 kJ kg^{-1} K^{-1}

SOLUTION

1. Ans.(3)



Heat lost by block - I = Heat gained by block -II

$Cm(T_f - T_1) = C_m (T_2 - T_f)$

$T_f = \frac{T_1 + T_2}{2}$

$\Delta S_1 = Cp \ln \frac{T_f}{T_1}$

$\Delta S_T = Cp \ln \left(\frac{T_f}{T_1}\right) + Cp\ln\left(\frac{T_f}{T_2}\right)$

$\Delta S_T = Cp \ln \left(\frac{T_f^{\,2}}{T_1 . T_2}\right)$

2. Ans. (1)

At equilibrium

$120 - \frac{3}{8}T = 0$

$\Rightarrow T = 320$ K

If T < 320 K $\Rightarrow \Delta G = +ve \Rightarrow$ X is major product

If T > 320 K $\Rightarrow \Delta G = -ve \Rightarrow$ Y is major product.

3. Ans.(1)

$\Delta G^o = -RT \ln k$

if $K < 1 \Rightarrow \Delta G^o > 0$

4. Ans.(2)

$\Delta G = \Delta H - T\Delta S$

for spontaneous process at all temp. $\Delta G < 0$ and it is possible when $\Delta H < 0$ and $\Delta S > 0$.

5. Ans. (4)

$2H_2O = H_3O^+ + OH^-$ $K = 10^{-14}$

$\Delta G^\circ = -RT\ \ell n\ K$

$= \frac{-8.314}{1000} \times 298 \times \ell n 10^{-14}$

= 80 KJ/Mole

6. Ans. (4)

Compare with $\Delta G = \Delta H - T\Delta S$

7. Ans. (2)

$T_{eq} = \frac{\Delta H}{\Delta S}$

$= \frac{491.1 \times 1000}{198}$

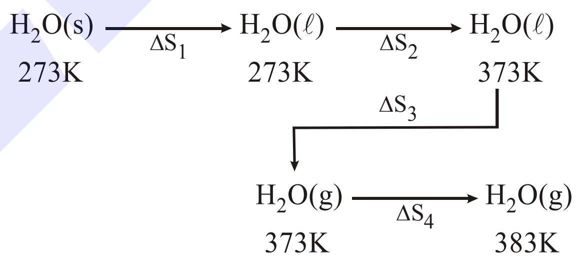
= 2480.3 K

8. Ans. (1)

$\Delta G = \Delta H - T\Delta S$

$T = \frac{\Delta H}{\Delta S} = \frac{200}{40} = 5K$

9. Ans. (4)



$\Delta S_1 = \frac{\Delta H_{fusion}}{273} = \frac{334}{273} = 1.22$

$\Delta S_2 = 4.2\ell N\left(\frac{373}{273}\right) = 1.31$

$\Delta S_3 = \frac{\Delta H_{vap}}{373} = \frac{2491}{373} = 6.67$

$\Delta S_4 = 2.0\ell n\left(\frac{383}{373}\right) = 0.05$

$\Delta S_{total} = 9.26$ kJ kg^{-1} K^{-1}