* **Expansion of an ideal gas and changes in thermodynamic properties:-**

With the help of 1st law of thermody-namics it is possible to calculate changes in thermodynamic properties such as $q, w, \Delta U$ & ΔH when an ideal gas undergoes expansion. The expansion may be isothermal or adiabatic and the process of expansion may be carried out reversibly or irreversibly.

1) **Iso thermal Expansion :-**

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a). **Calculation of ΔU --**

In isothermal process, temperature remains constant. ($T = 0$) and U depends on P. so, $\Delta U = 0$.

b). **Calculation of ΔH --**

Since,

$$H = U + PV$$

Notes

$$\Delta H = \Delta \left(U + PV \right)$$
$$= \Delta U + \Delta PV$$
$$= \Delta U + \Delta n RT$$

$$\Delta V = 0 \quad \& \quad T = 0.$$

$$\therefore \quad \Delta H = 0.$$

c). **Calculation of q & ω :—**

from 1st law of Thermodynamics

$$\Delta U = q + \omega.$$

$$\Delta U = 0.$$

$$\therefore \quad q = -\omega$$

d). **Work done in reversible isother-mal expansion :—**

$$W = -n RT \ln \frac{V_2}{V_1}$$

$$W = -2.303 \, n RT \log \frac{V_2}{V_1}$$

& $\quad q = 2.303 \, n RT \log \frac{V_2}{V_1}$

Since, $\quad P_1 V_1 = P_2 V_2$

$$\frac{V_2}{V_1} = \frac{P_1}{P_2}$$

$$W = -2.303 \, nRT \log \frac{P_1}{P_2}$$

$$q = 2.303 \, nRT \log \frac{P_1}{P_2}$$

e). Work done in reversible isothermal Compression :-

$$W = -nRT \ln \frac{V_1}{V_2}$$

$$W = -2.303 \, nRT \log \frac{V_1}{V_2}$$

& $q = 2.303 \, nRT \log \frac{V_1}{V_2}$

Since, $\quad \dfrac{V_1}{V_2} = \dfrac{P_2}{P_1}$

$$W = -2.303 \, nRT \log \frac{P_2}{P_1}$$

& $q = 2.303 \, nRT \log \frac{P_2}{P_1}$

2). Adiabatic Expansion :-

In adiabatic expansion, no heat is allowed to entre or leave the system. hence, $q = 0$.

from Ist law of thermodynamics —

$$\Delta U = q + w$$

$$q = 0$$

$$\Delta U = w.$$

a). Calculation of ΔU :-

We know that, the molar heat capacity at constant volume of an ideal gas is given by-

$$C_v = \left(\frac{\partial U}{\partial T}\right)_V$$

or

$$dU = C_v dT$$

or

$$\Delta U = C_v \Delta T$$

$$\Delta U = C_v (T_2 - T_1) \qquad (\text{for } 1 \text{ mol})$$

for n-mol.

$$\Delta U = n C_v (T_2 - T_1)$$

3). Calculations of ΔH :-

The molar heat Capacity at constant pressure of an ideal gas is given by -

$$C_p = \left(\frac{\partial H}{\partial T}\right)_p$$

$\Rightarrow$ $dH = C_p dT$

$\Rightarrow$ $\Delta H = C_p \Delta T$

$\Delta H = C_p (T_2 - T_1)$ (for 1-mol)

for n-mol

$$\Delta H = n C_p (T_2 - T_1)$$

4). Calculation of ω :-

Since, process is adiabatic. So, $q = 0$.

$$\Delta U = \omega = C_v (T_2 - T_1)$$

$$\Delta U = \omega = n C_v (T_2 - T_1)$$