AL-Mustaqbal University College
Department of Medical Physics
The Second Stage
Thermodynamics and Heat
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Lecture .6

Special cases of the equation $\Delta H = \Delta E + P\Delta V$

1) Reactions involving gaseous substances

Where **($n_R \neq n_P$)** and in which the volume changes are large and cannot be neglected, and by imposing the behavior of gases ideally,

$$PV_R = n_R\, RT$$

$$PV_P = n_p\, RT$$

Where :

n_R : Number of gas moles produced.

n_R : Number of gas moles interacting (At constant pressure and temperature) .

T : Temperature in kelvin (K).

R : The general Fixed of gases (8.314 J / K. Mole) .

From the equation: $\Delta H = \Delta E + P\Delta V$

We will modify $P\Delta V$ as follows:

$$P\Delta V = P\,(V_P - V_R)$$

$$P\Delta V = P\,V_P - P\,V_R$$

$$P\,\Delta V = n_P\,RT - n_R\,RT$$

$$P\,\Delta V = RT\,(n_P - n_R)$$

$$P\,\Delta V = \Delta n_{(g)}\,RT$$

Compensate the last equation in equation $\Delta H = \Delta E + P\Delta V$,therefore we get on :

$$\Delta H = \Delta E + \Delta n_{(g)}\,RT$$

2) Reactions in which interacting and resulting gases are involved)

Where ($\mathbf{n_P} = \mathbf{n_R}$) and therefore the value of $\Delta \mathbf{n} = 0$

Then the equation: $\mathbf{\Delta H = \Delta E + P\Delta V}$

From the equation: $\mathbf{\Delta H = \Delta E + \Delta n \; RT}$

Since $\Delta \mathbf{n} = 0$

$\therefore \mathbf{\Delta H = \Delta E}$

3) Reactions involving solid or liquid substances only (not involving gas substances):

In which the volume changes are small $\Delta V=0$ and therefore can be neglected, then the equation: $\mathbf{\Delta H = \Delta E + P\Delta V}$

since $\Delta \mathbf{n} = 0$

$\therefore \mathbf{\Delta H = \Delta E}$

Example :

Calculating the change in the internal energy of the reaction:

$Zn_{(s)} + H_2SO_{4\,(L)}\ ZnSO_{4\,(aq)} + H_{2\,(g)}$

If the released heat is 34200 Cal of zinc at (17 ° C)

Note that (R = 2 Cal / mole .K)

Solution :

$\Delta n = 1 - 0 = 1$

Applying the relationship $\Delta H = \Delta E + \Delta n\ RT$

$\Delta E = \Delta H - n\ RT$

$\Delta E = [(-34200\ Cal) - (1x\ 2\ x\ (17 + 273)]$

$\Delta E = -34780\ Cal$

Example :

If the change in internal energy is equal to -333kJ for the following interaction:

$NH_4Cl_{(aq)} + NaNO_{2\,(aq)} \rightarrow N_{2\,(g)} + 2H_2O_{(L)} + NaCl_{(aq)}$

When one mole of N_2 is produced, if the production of one mole of nitrogen makes the system increase by 22.4 L, at one air pressure. Calculate the change in the Enthalpy interaction?

Solution :

$\Delta E = - 333 \times 10^3$ J, P = 1 atom , $\Delta V = 22.4$ L

$P \Delta V = 1$ atom X 22.4 L = 22.4 L. atom

22.4 L. atom X 101.325 J / L. atom = = 2269.68 J

Applying the relationship: $\Delta H = \Delta E + P\Delta V$

$\Delta H = [(- 333 \times 10^3) + (1 \times 22.4)\ 101.325]$

$\Delta H = - 330730.88$ J

$\Delta H = - 330.73$ kJ

Example :

If the heat associated with combustion of one molten gasoline is equal to(-3264.3) kJ at a fixed volume and temperature (298K) , Calculate the change in the enthalpy of the reaction (ΔH), if you know that gasoline burns with oxygen equation:

$C_6H_{6\,(L)} + 7.5\ O_{2\,(g)} \rightarrow 6CO_2\,(g) + 3H_2O\,(L)$

Note that the value of (R = 8.314 J / mole . K).

Solution :

The amount of heat at a fixed volume reflects the internal energy:

$q_v = \Delta E$

$\Delta E = - 3264.3 \times 10^3$ J

$\Delta n = n_p - n_R = 6 - 7.5 = - 1.5$

$\Delta H = \Delta E + \Delta n\, RT$

$\Delta H = (- 3264.3 \times 10^3 \text{ J}) + (- 1.5 \text{ mole} \times 8.314 \text{J / K. mole} \times 298 \text{ K})$

$\Delta H = - 3268016.358$ J

$\Delta H = - 3268.02$ kJ