AL-Mustaqbal University College
Department of Medical Physics
The Second Stage
Thermodynamics and Heat
Dr. Rusul Abdul Ameer

كلية المستقبل الجامعة
قسم الفيزياء الطبية
المرحلة الثانية
الديناميكيا الحرارية

Lecture .4

Work

Mechanical work (w) is definition as multiply the force **F** by distance **L** or pressure by change in the volume work can be expressed as:

$$W = F \Delta L \text{ ---------- (1)}$$

Where **w** represent work that product by effect force **F** on the system by distance ΔL .

Suppose that a gas is contained inside a cylinder with a weightless moving piston and its do not has mass , surface friction, surface area (A) at certain conditions of size, pressure and temperature. When the gas expands, the piston is pushed up against pressure opposite to the direction of change, performed work against the surround and since pressure is the force exerted on the unit Area

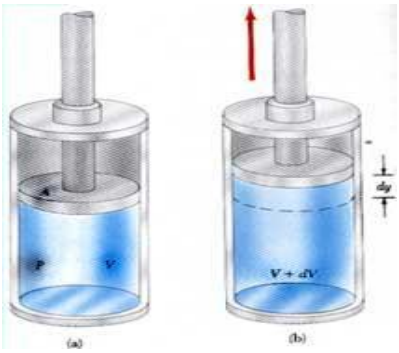

Figure shows gas expansion against external pressure (P)

$$P = F / A \text{ , } F = P.A \text{ ---------- (2)}$$

Thus, the work performed as a result of expansion is:

$$W = P.A. \Delta L \text{ ---- ---------- (3)}$$

As the piston moves in an opposite direction to the force direction, the change in volume Δ **V** Equivalent to multiplying the section area **A** in displacement Δ **L** Preceded by a negative sign:

$$\Delta V = - A \Delta L \qquad \text{---------- (4)}$$

therefore the work performed as shown :

$$W = - P \ \Delta V = - P (V_2 - V_1) \text{ ---------- (5)}$$

where : V_1 is the primary volume of gas , V_2 is the final volume of gas.

A negative signal indicates that the system energy decreases when the volume increases, Means that the system is performed works on the surround . The value of the work depends on external pressure (P):

* If the value of (P) equal to zero, that is, the gas expands against the vacuum, the work is equal to zero.

* If the value of (P) positive, the work is given according to equation $W = - P \Delta V$

* If the value of (P) is smaller than gas pressure , the gas expands against the Surround and ($V_2 > V_1$), therefore the value of **W** is Negative, ie, the system performed work on the surround.

* If the pressure of the surround is greater than the pressure of the gas, the gas will shrink and become ($V_1 > V_2$), and the value of **W** is Positive , that is, the surround performed work on the system.

Example :

If ideal gas is extended at 25 ° C from (2 L to 5 L) at constant pressure, calculate the work performed when the gas expands:

1- Against vacuum
2- Against constant pressure (3atom) .

Solution :

1- Since the opposite pressure is zero and according to the equation of the work:

$W = - P (V_2 - V_1) = 0 (5 - 2) =$ Zero

2- When the opposite pressure = - 3atom is:

W = - P (V2 - V1) = - 3 (5 - 2) = - 9 atm. L

= -9 atm. L x 101.3 = 911.7 J .

Example :

The ideal gas extended from (15 L to 25 L), and the final pressure is 2 atom, Calculate :(**A**) Work in unit (L. atom), (**b**) Work in Joule unit(J) , (**c**) What is the significance of the signal of the value of the Work?

Solution

To resolve this example follow the relationship $w = - P\Delta V$

$w = - P (V_2 - V_1)$

(a) Work in L. atom unit

$w = - P (V_2 - V_1)$

w = - 2 atom (25 L - 15 L)

w = - 20 atom .L

(b) Work in Joule unit (J)

1 L .atom = 101.325 J

w = - 20 atom .L

= - 20x101.325

w = - 2026.5 J

(c) The working signal is negative, which means that the system make work on the surrounding medium

1 kJ = 1000 J

1 J = 1 $x10^{-3}$ Kg

Therefore W= -2.0265KJ

Example : Calculate the work done when melting 50 gm of iron in hydrochloric acid $25^{\circ}{}^{0}$C When the reaction occurs :1- in a closed vessel 2- in an open vessel ??

Solution :

Reaction equation: Fe (s) + 2 HCl (aq) $\rightarrow$ $FeCl_2$ (aq) + H_2 (g)

One mole of gas is produced from a single iron mole reaction and when the original size of the system is neglected:

$P \Delta V = PV = n RT$

1-When the vessel is closed, the gas does not expand ($W = - P \Delta V = 0$)

2- When the vessel is open - $W = - P \Delta V = - (n (H_2)) RT$

Number of hydrogen moles = number of iron moles = 50/56 = 0.89 mole

R = 8.314 J / K . mole, T = 298 K

W = 0.89 x 8.314 x 298 = 2.2 K J

Work done when fixed volume : $\Delta V = 0$)

$W = P \Delta V = 0$

Work done when fixed pressure:

$W = - P (V_2 - V_1)$