ENERGY BALANCE FOR CLOSED SYSTEMS

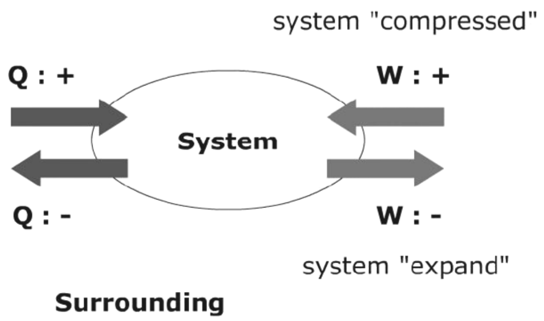
System can be

- Open: mass and energy can transfer between the system and surroundings
- Closed :energy can transfer between system and surroundings, but **NOT** mass
- Isolated :neither mass nor energy can transfer between the system and surroundings.

Since no streams enter or leave a closed system, no internal energy is transported across All energy exchange between a closed system and its surroundings then appears as heat and work, and the total energy change of the surroundings equals the net energy transferred to or from it as heat and work.

Δ (Energy of the surroundings) = $\pm Q \pm W$ (2-1)

Sign of Q and W depends on which direction of transfer



The energy of system :Δ*(energy of the system)* = $\Delta U + \Delta E_k + \Delta E_p$ (2-2)

By equating equations (2-1) and (2-2) : $\Delta U + \Delta E_k + \Delta E_p = \pm Q \pm W$ (2-3)

Closed systems often undergo processes that cause no change in the system other than in its *internal* energy. For such processes :

$$\Delta U^t = Q - W \quad \text{Or} \quad dU^t = dQ - dW$$

(2-4)

Hint

Properties, such as volume V^t and internal energy U^t depend on the quantity of material in a system; such properties are said to be *extensive*. In contrast, temperature and pressure, the principal thermodynamic coordinates for homogeneous fluids, are independent of the quantity of material, and are known as *intensive* properties. An alternative means of expression for the extensive properties of a homogeneous system, such as V^t and U^t, is:

$V^t = m\,V$ or $V^t = nV$, and $U^t = m\,U$ or $U^t = nU$

Although V^t and U^t for a homogeneous system of arbitrary size are extensive properties, specific and molar volume V (or density) and specific and molar internal energy U are intensive.

Foe closed system of *n* moles

$$\Delta (n U) = n \Delta U = Q - W \quad \text{or} \quad d(n U) = n\, dU = dQ - dW$$

In this form , these equations show explicitly the amount of substance comprising the system

Ex: Water flows over waterfall 100 m in height , take 1 kg of water as the system and assume that it does not exchange energy with its surroundings.

a) What is the potential energy of water at the top of falls with respect to the base of the falls?
b) What is the kinetics energy of water just before it strikes bottom ?
c) After 1 Kg of water enters the river below the falls , what change has occurred in its state?

THERMODYNAMIC STATE AND STATE FUNCTIONS

In thermodynamics , there are two types of quantities ; those which depend on path and those are not. there are many examples of quantities which do not depend on path , e.g. temperature , pressure , specific volume. They depend only on present conditions, however reached. Such quantities are known as *state functions*. We know from experience that for a homogeneous pure substance fixing two of these properties automatically fixes all the others, and thus determines its thermodynamic state. When two of them are held at fixed values for a homogeneous pure substance, the thermodynamic state of the substance is fully determined. This means that a state function, such as specific internal energy, is a property that always has a value; it may therefore be expressed mathematically as a function of other thermodynamic properties, such as temperature and pressure, or temperature and density, and its values may be identified with points on a graph.
The differential of a state function represents an infinitesimal change in its value. Integration of such a differential results in a finite difference between two of its values, e.g.:

$$\int_{P_1}^{P_2} dP = P_2 - P_1 = \Delta P$$

Work and heat ,on the other hand are not state function ,since they depend on path they cannot identify with points on a graph but they represented by areas, The differentials of heat and work are not changes, but are infinitesimal amounts. When integrated, these differentials give not finite changes, but finite amounts. Thus,

$$\int dQ = Q$$

State function represents a property of a system and always has value , while work and heat appear only when changes are caused in system by process , which required time.

There are two classes of properties

a) Extensive ; depend on quantity of material involved (U ,H , ..)
b) Intensive ; independent of quantity of material (T , p ,..)

Ex : when a system is taken from state *a* to state *b* in the below figure along *acb* , 100 J of heat flows into the system and the system does 40 J of work

a) How much heat flows into the system along path aeb if the work done by the system is 20 J?
b) The system returns from *b* to *a* along path *bda* . If the work done on the system is 30 J , does the system adsorb or liberate heat? How much ?