**Phase and equilibrium**

Below definition states that the entropy of an isolated system with will tend to increase at constant U and V.

dSU,V 0

At equilibrium, the entropy of the system maximizes-------dSU,V =0

State of the system

S

At equilibrium, dSU,V=0

This can also be demonstrated by the plot above. At fixed T and U, entropy of the system will reach a maximum at which the first derivative is 0 and d2SU,V 0.

At the same time, the following equalities are provided at equilibrium:

dU=0, dA=0, dG=0 but unlike entropy, internal energy, they tend to attain their minimum at eu

Considering isolated systems having ***multiple phases*** (phase 1 and 2), the equilibrium criteria can be derived by the following equations. Let’s atart with the derivative form

dS=

Since the system is totally isolated, total internal energy, total volume and the total number of moles of for system are all constant (but phases can exchange material and energy):

U=U1+U2 = contant

V=V1+V2  = contant

N=N1+N2  = contant

Their derivatives will give:

0= dU1+dU2 0=dV1+dV2  0=dN1+dN2

Writing the relation for entropy for an isolated system comprising two different phases at the equilibrium:

dS= =0

Since dU1= – dU2, dV1= – dV2, dN1 = – dN2

+

which makes

……… thermal equilibrium

……………….mechanical equilibrium

……………chemical equilibrium

**Degrees of Freedom Analysis for the systems with multiple phases**

It is essential to answer this question; how many properties are needed to define the state of a system at equilibrium. Then we have to refer to the following equation:

F = C +2 – P

C represents the number of components, P respresents the number of phases and F is the degrees of freedom. For a system having 2 components and 2 phases at equilibrium, F will be equal to 2. This means that two properties will be enough to define the state of the system such as T and P.

**References:**

Ismail Tosun, “The Thermodynamics of Phase and Reaction Equilibria”, 2012, Elsevier.

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