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Teaching Undergraduate Students through Connectivity

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ABSTRACT

In present time it is essential that science education should equip students with such knowledge and skills that they become scientifically literate citizens. Owing to this imperative the quality of teaching and learning chemistry has become an issue of prime concern. To meet these concerns the focus of chemistry teaching has been placed on the shoulders of knowledge providers, who are no others but teachers. Chemistry related disciplines are divided into several branches: Physical Chemistry, Organic Chemistry, Inorganic Chemistry and Analytical Chemistry. Physical Chemistry courses are often considered most difficult ones. The reason may be the specific requirement of extensive familiarity with mathematics and its descriptive role in Physical Sciences. In this presentation, some lessons pertaining to some fundamental Physical Chemistry aspects are being discussed. The matter pertains to fundamentals and derived concepts in Physical Chemistry like mass, force, pressure, volume etc. A holistic approach has been adopted to explain the basic issues of the subject.

INTRODUCTION

Teaching of various disciplines in Physical Chemistry requires the need to develop concepts so that students get accustomed to basic principles in such a way that the message gets ingrained in their minds. A deep insight into concepts provides capability to open new avenues for creating knowledge. Our presentation helps to circumvents human minds, invites and encourages discussions and promotes better understanding. In this paper, we present our efforts to highlight important Physical Chemistry related issues so that basic principles get correlated.

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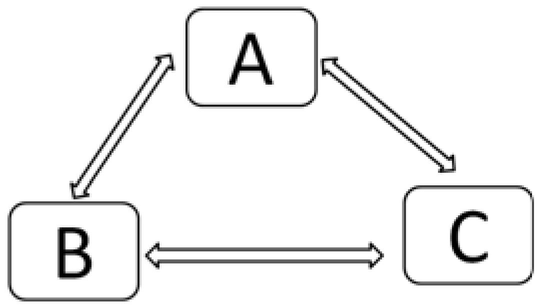
THERMODYNAMICS

Thermodynamics is the study of conversion of energy into work and heat and its relation to macroscopic variables such as temperature and pressure. There are various laws of thermodynamics.

Zeroth law of thermodynamics

The zeroth law of thermodynamics can be stated as

"If both of A and B are in thermal equilibrium with C, then A and B are also in thermal equilibrium with each other." A correlation diagram given below explains this statement with much clarity.

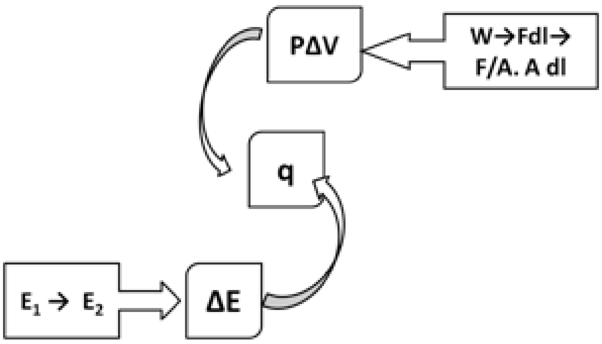


Zeroth Law of Thermodynamics

First law of thermodynamics

The first law of thermodynamics states "The increase in the internal energy of the system is equal to the amount of energy added by heating the system, minus the amount lost as a result of the work done by the system on its surroundings."

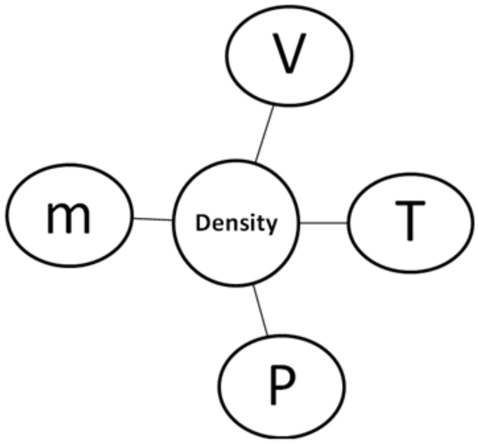
1st LAW OF THERMODYNAMICS



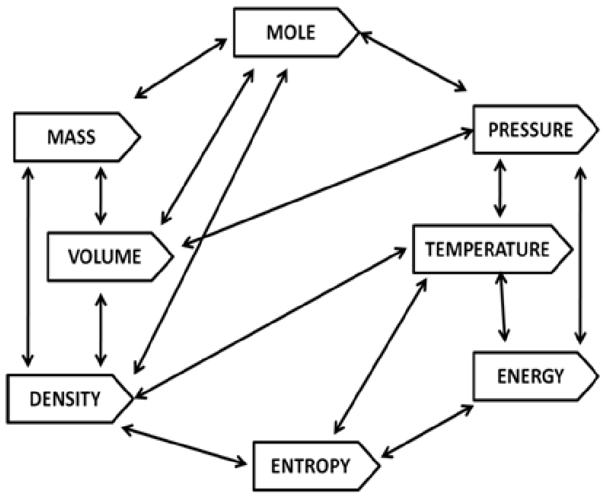
This diagram easily helps to correlate force, pressure and volume to heat q and resulting enhancement of energy.

Variables define the momentary condition of a thermodynamic system. Regardless of the intermediate states the total change in any state variable will be the same. These state variables are not isolated parameters but affect one another. For example:

The number of grams present in a mole changes with the nature of the object and ultimately the density of every object alters. An alteration in the temperature will also vary the density of the material as it alters the volume of the same gram of the substance. Thus, ice is denser than the liquid water at room temperature. Temperature not only modifies density but affects the entropy of the system. Thus by increasing temperature ice melts, its entropy increases and density also varies, thus we must correlate density to volume, temperature and entropy. But when the students are being taught, they are simply told that the density is the ratio of mass and volume and its formula is. The formula restricts us to thought that the density is only dependent on mass and volume but in reality this is not the case. How to answer this question that in what way density is related to temperature, pressure or even to force. The answer only comes when one appreciates the correlation explained below:



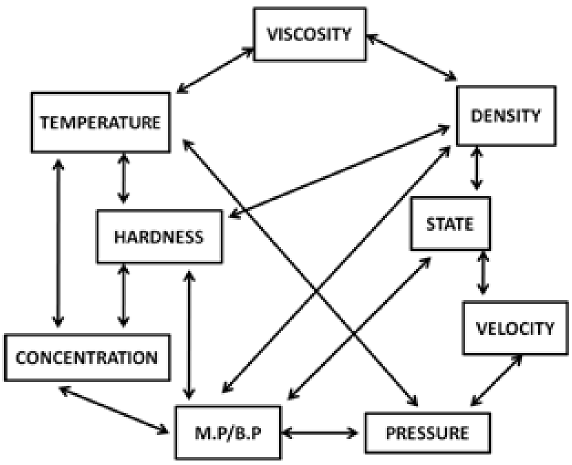
Almost all the thermodynamic variables affect each other either directly or indirectly. The dependency/correlation/linkage of different variables can be well demonstrated by the following diagram.



THERMODYNAMICS VARIABLES

INTENSIVE PROPERTIES

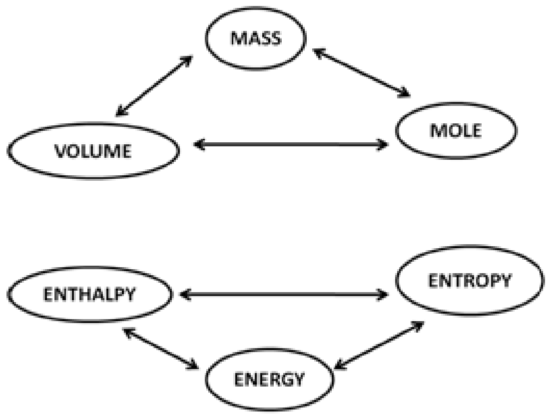
Those physical properties that do not depend on the system size or the amount of material in a system are called intensive properties. These properties are not independent of each other. The modification in one property alters the other; this can be demonstrated by correlation diagram comprising of these parameters, as given below:



INTENSIVE PROPERTIES

EXTENSIVE PROPERTIES

Some extensive properties are those physical properties that depend on the system size or the amount of material in a system. E.g. volume, mass, energy etc. If traditional method of teaching is being followed the knowledge of the students would be limited. For example the concepts of enthalpy will be restricted to its definition and equation i.e. $H = E+PV$, but with the help of a correlation diagrams, other factors can be defined, which are also responsible for modifying the enthalpy as shown below:

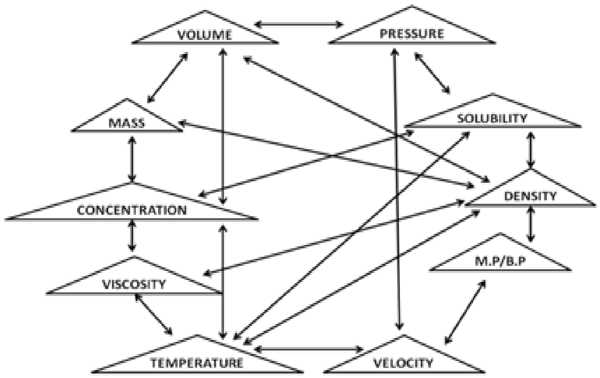


EXTENSIVE PROPERTIES

This diagram helps to understand parameters like molar mass and molar volume. This diagram helps to grasp 2nd law of thermodynamics.

OTHER PHYSICAL PROPERTIES

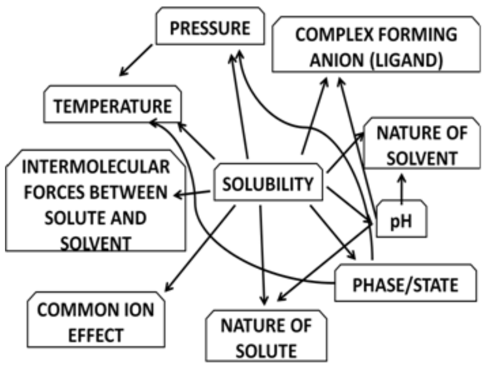
A physical property is any aspect of an object or substance that can be measured without changing its identity. Through correlation between different physical properties the relationship of various other physical parameters can be explained.



PHYSICAL PROPERTIES

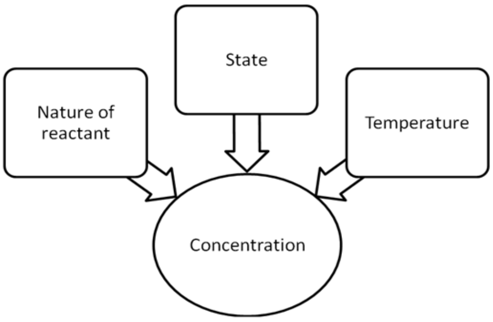
SOLUTION CHEMISTRY

Solution chemistry is one of the basic aspects of physical chemistry, the importance of which can not be ignored. Solubility is one of the essential features of solution chemistry. The solubility depends on a range of parameters, which also depend on each other. Understanding of this concept gets enhanced when a teacher adopts correlation methodology of constructing a diagram as shown below:



FACTORS AFFECTING SOLUBILITY

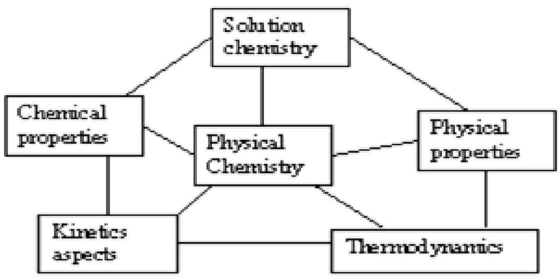
RATE OF CHEMICAL REACTION



FACTORS AFFECTING REACTION

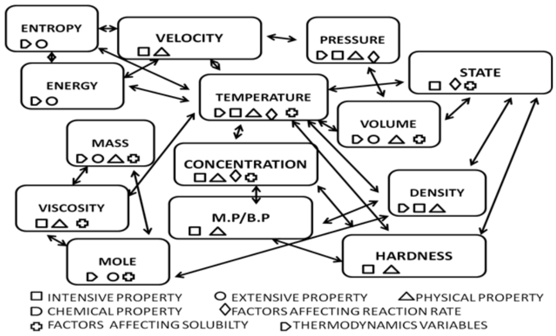
Are all of these fundamental aspects of Physical Chemistry, related to each other?

If the traditional method of teaching is continued, the student will not answer this question with confidence. The reason behind it is the basics of physical chemistry are being taught in an isolated manner and the connections among various concepts are not being brought into ensuing discussions. To show the real picture correlation method should be adopted. This method will develop the ability to think holistically and the student will grasp the clear picture of the subject. The following systemic diagram summarizes the inter links of concepts of physical chemistry and also explains the inter linkage between different issues discussed under the topic of Physical Chemistry.



Holistic perspective of teaching Physical Chemistry

The holistic perspective of teaching Physical Chemistry is demonstrated in the diagram below:



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