New Trends in Physicochemical Quantities and Units: A Coherent and Conceptual Approach to Learning and Teaching Chemistry

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COUNT: The number of balls in a beaker (exact).

MEASURE: Measure the length of the table (approximation).

Piece of stick, length $= l_1$
Length of the table $= l_2$

You have to count $\frac{l_2}{l_1}$ (approximately) (say 5)

Suppose l_1 is called Peter, the length is 5 Peter.

You can count exactly but you cannot measure exactly. *All measurements are approximations.*

PHYSICAL QUANTITIES: e.g., length (l), volume (V) electric current (I), etc.

CHEMICAL QUANTITIES: e.g., atomic number (Z), concentration (C) etc.

In general we refer to physical and chemical quantities as 'Physicochemical quantities.' Any physicochemical quantity can be expressed by the following relationship:

Physicochemical quantity = numerical value X unit
e.g., length (l) = 5 x m = 5 m

concentration (C) = 2.5 mol dm^{-3}

For any physicochemical quantity both the numerical value and the unit are equally important. For example, if c = a x b then a and b are equally important when calculating a value for c.

DIMENSION

Dimension is the property of a physical quantity which determines the additivity with another physical quantity. For example, time cannot be added to length. Why? Because they have different dimensions.

How many dimentionally independent quantities shall we have? It is up to each person to decide. In mechanics only three independent physical quantities which have their own dimensions are used, i.e., length (l), mass (m), time (t).

It is internationally agreed to have seven physical quantities which are 'dimentionally independent.' The seven physical qualities are:

length(l)
mass(m)
time(t)
electric current(I)
thermodynamic temperature(T)
amount of substance(n)
luminous intensity(I_v)

What is the dimension of length? The answer is *dimension of length*. That is why we say that the above seven physical qualities have their own dimensions.

UNITS

There are seven base units in the SI system. Their names and symbols are as follows:

Name of the physical quantity	Name of SI unit	Symbol for SI unit
length(l)	metre	m
mass(m)	kilogram	kg
time(t)	second	s
electric current(I)	ampere	A
thermodynamic temperature(T)	kelvin	K
amount of substance(n)	mole	mol
luminous intensity(I_v)	candela	cd

In addition to the above seven base units there are two supplementary base units. They are:

Name of the physical quantity	Name of SI unit	Symbol for SI unit
plane angle	radian	red
solid angle	steradian	sr

The SI unit for all other physicochemical quantities are *coherently* derived from the above SI base units. Examples are given below:

Name of the physical quantity and symbol	Name of SI unit	Symbol for SI unit	Derived SI unit
force(F)	Newton	N	1 N = 1kg m s^{-2}
pressure(P)	Pascal	Pa	1 Pa = 1 N m^{-2}
energy(E)	Joule	J	1 J = 1 N m = 1 kg m^2 s^{-2}
electric charge(Q)	Coulomb	C	1 C = 1 A s

COHERENT AND CONCEPTUAL APPROACH TO LEARNING AND TEACHING CHEMISTRY

There are two approaches for teaching or learning a subject (especially chemistry and physics)

1. Historical Approach: follows the various stages of historical development of the subject, e.g., behaviour of gases.

   sequence: Boyle's Law, Charles' Law, Avogadro's Law, etc.

2. Conceptual Approach: priority is given to concepts, e.g., behaviour of gases. Starting from ideal gas equation:

   $PV = nRT.$

The systematization of knowledge through a conceptual and coherent approach is based on the following:

1. Identification of basic principles, e.g., Principle of Additivity.
2. Identification of minimum number of terms, concepts, relationships laws, etc.
3. Development of framework of knowledge, e.g., Periodic Table and Electrochemical Series, etc.
4. Combination of concepts and relationships to create new concepts and relationships.

As an example, the basic mathematical relationships required for problem solving in chemistry (G.C.E. (AL) chemistry syllabus) has been identified. These are:

1. $M_r = \Sigma A_r$
2. $n = \frac{N}{L}$
3. $M = \frac{m}{n}$
4. $M = A_r \, \text{g mol}^{-1}$
   $M = M_r \, \text{g mol}^{-1}$
5. $P = \frac{w}{V}$
6. $C = \frac{n}{V}$

7. $y = \frac{m}{w}$

8. $x = \frac{n}{\Sigma n}$

9. $PV = nRT$

10. $K = \frac{[C]^c [D]^d}{[A]^a [B]^b}$

11. degree of dissociation (α) = $\frac{\text{amount dissociated}}{\text{initial amount}}$

12. $pH = -\log_{10} [H^+]$

13. $E_{cell} = E_{right} - E_{left}$

14. $P_A = P^o{}_A \times X_A$

15. $r = \frac{\Delta c}{\Delta t}$ or $\frac{\Delta n}{\Delta t}$ or $\frac{\Delta v}{\Delta t}$

16. $aA + bB \longrightarrow cC + dD$

$r = k[A]^m [B]^n$

17. $\Delta H = H_{products} - H_{reactants}$

18. $\Delta H_{total} = \Sigma\ \Delta H$

19. $M_r = d \times 2.016$

20. $M \times s = 26.5\ J\ K^{-1}\ mol^{-1}$

21. $A_r = E \times \text{valency}$

22. $E = mc^2$

23. $Q = I \times t$