

CH1101 : Elements of Chemistry

Satvik Saha, 19MS154

August 15, 2019

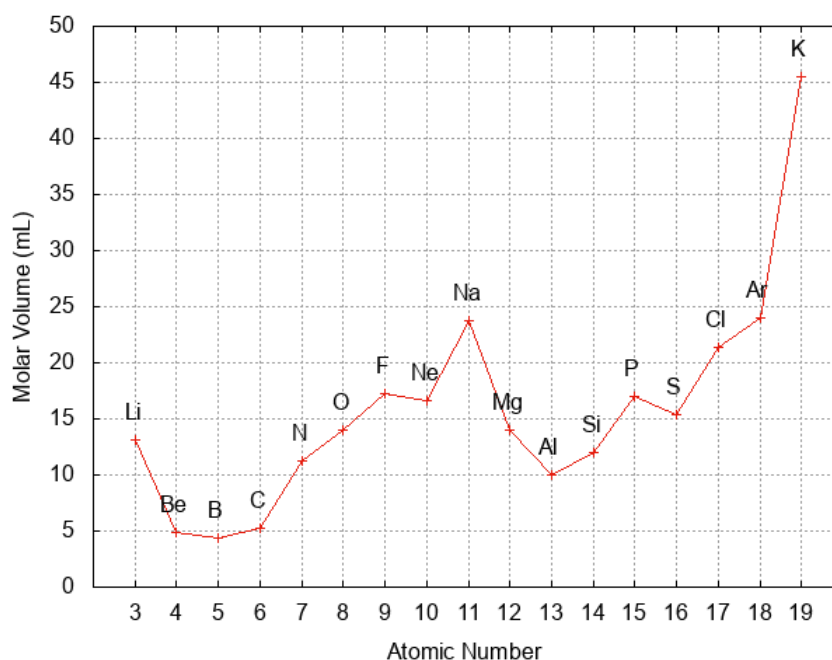
- Listing the elements in ascending order of atomic weights, we observe a periodicity of 5 (with some gaps) in their physical states, electrical conductivities and chemical reactivities.

Bh ²	Ik ⁵	Uc ⁶	Dt ⁸	Bc ¹¹
Al ¹⁴	Ye ¹⁵	Sk ¹⁷	X ^{~19}	On ²⁰
E ²³	Zw ²⁸	Dr ³⁰	Fq ³²	Fn ³⁶

We may conclude that the element E²³ may be a gas with very low electrical conductivity and very low chemical reactivity.

Similarly, we may predict the existence of a new element X having an atomic weight in the range 17 – 20, which may be a hard, high melting solid with very high electrical conductivity and high chemical reactivity.

- We will use the relation $V_m = M/\rho$ between the the molar volume V_m , the molar mass M and the density ρ .



We observe that the molar volume has a general upward trend. It peaks sharply at Li, Na, K (Group 1), and has valleys at B, Al (Group 3).

- The power of Mendeleev's periodic table lies in its predictive nature. Seeing the gaps in his table, Mendeleev predicted the existence of new elements, such as 'eka-boron', 'eka-aluminium' and 'eka-silicon', along with their physical and chemical properties with stunning accuracy. He was also able to correct inaccuracies in the then known atomic weights of elements using this device.
- We will use $c = f\lambda$ and $E = hf$.

Frequency f	Wavelength λ	Energy E	Event
3.8×10^{14} Hz	7.9×10^{-7} m	2.5×10^{-19} J	Heating food (infrared)
5.0×10^{14} Hz	6.0×10^{-7} m	3.3×10^{-19} J	Reading (visible light)
3.0×10^{11} Hz	1.0×10^{-3} m	2.0×10^{-22} J	Making popcorn (microwave)
1.2×10^{17} Hz	2.5×10^{-9} m	7.9×10^{-17} J	Dental (X-ray)

5. We will use $\lambda = h/p$, $p = mv$. An O_2 molecule weighs $32 \text{ amu} \approx 5.3 \times 10^{-26} \text{ kg}$. Thus, its momentum is $2.5 \times 10^{-23} \text{ kg m/s}$, and its de Broglie wavelength is $2.6 \times 10^{-11} \text{ m} = 26 \text{ pm}$. Clearly, this is a small fraction (10.7 %) of the molecular length of O_2 .
6. A UV photon will obey the relation $E = hc/\lambda$.
 - (a) Each photon has an energy of $E = 4990 \text{ kJ}/N_A \approx 8.3 \times 10^{-18} \text{ J}$. Thus, we have $\lambda = hc/E \approx 24 \text{ nm}$.
 - (b) A 500 nm photon will have an energy of $hc/\lambda \approx 4.0 \times 10^{-19} \text{ J}$. 21 such photons would have an energy just exceeding that of a UV photon.
 - (c) Although 25 such photons carry a total energy more than that of a single UV photon, they cannot induce mutation in a strand of DNA. This is because exactly the right amount of energy must be supplied to the π -bond in a thymine base in DNA for it to break, and thus mutate. The breaking of such a bond involves the absorption of the photon by an electron in a bonding molecular orbital, promoting it to an antibonding orbital. Such a promotion requires just the right amount of energy – the energy difference between the two orbitals.