The Periodic Table As Music

Ian Beardsley (Oct 6, 2021)
Physics, University of Oregon

Genesis Project · California · 2021

1. **Abstract** We demonstrate the periodic table for artificial intelligence (AI) elements Arsenic to Iron either elements of semiconductors for transistor technology or conductors for electrical wire, adhere to a musical scheme. We want to describe life in terms of these AI elements.

2. Nickel and Beryllium Alpha decay is the decay of elements where a helium nucleus is ejected from an element (alpha particles). This happens with atoms heavier than nickel because the atom has to be heavy enough that the internal repulsion of protons is high enough that the binding force has trouble holding them together. However, interestingly beryllium-8 is an exception; it is much lighter than nickel. Beryllium-8 was determined by Fred Hoyle to make carbon in nuclear synthesis in stars by combining with helium. He sought to find the process by which carbon is created because the Universe needs to make it if we are to have life as we know it.

3. The Theory We pull these AI elements out of the periodic table of the elements to make an AI periodic table:

	13	14	15
2	B		
3	Al	Si	P
4	Ga	Ge	As

We now notice we can make a 3 by 3 matrix of it, which lends itself to to the curl of a vector field, by including biological elements carbon C (above Si):

$$\begin{pmatrix} \vec{i} & \vec{j} & \overrightarrow{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ (-C \cdot P)y & (Si \cdot Ga)z & (Ge \cdot As)y \end{pmatrix} =$$

$$(Ge \cdot As - Si \cdot Ga)\vec{i} + (C \cdot P)\overrightarrow{k} =$$

$$\left[(72.64)(74.92) - (28.09)(69.72)\right]\vec{i} + \left[(12.01)(30.97)\right]\overrightarrow{k}$$

Which resulted in Stokes theorem (Beardsley, Essays In Cosmic Archaeology Volume 3):

$$\sqrt[5]{\int_{Si}^{Ge}\int_{Si}^{Ge} \nabla \times \overrightarrow{u} \cdot d\,\overrightarrow{a}} = exp\left(\frac{1}{Ge - Si}\int_{Si}^{Ge} ln(x)dx\right)$$

Where

$$\nabla \times \overrightarrow{u} = (Ge \cdot As - Si \cdot Ga)\overrightarrow{i} + (C \cdot P)\overrightarrow{k}$$

$$d\overrightarrow{a} = \left(zdydz\overrightarrow{i} + ydydz\overrightarrow{k}\right)$$

$$\overrightarrow{u} = (-C \cdot P)y\overrightarrow{i} + (Si \cdot Ge)z\overrightarrow{j} + (Ga \cdot As)y\overrightarrow{k}$$

We were then able to write this with product notation

$$\sqrt[5]{\int_{Si}^{Ge}\int_{Si}^{Ge} \nabla \times \overrightarrow{u} \cdot d\overrightarrow{a}} = \sqrt[n]{\prod_{i=1}^{n} x_i}$$

While we have the AI BioMatrix

B.	C.	N.
Al.	Si.	P.
Ga.	Ge.	As.

Which we used to formulate a similar equation (Beardsley, Essays In Cosmic Archaeology Volume 2)

We can form another 3X3 matrix we will call the electronics matrix (Beardsley, Cosmic Archaeology, Volume Three):

Ni.	Cu.	Zn.
Pd.	Ag.	Cd.
Pt.	Au.	Hg.

We can remove the 5th root sign in the above equation by noticing

$$\prod_{i=1}^{5} x_i = Si \cdot Ge \cdot Cu \cdot Ag \cdot Au$$

=(28.085)(72.64)(12.085)(107.8682)(196.9657)=

$$523{,}818{,}646.5\frac{g^5}{mol^5}$$

Where we have substituted carbon (C=12.01) the core biological element for copper (Cu).

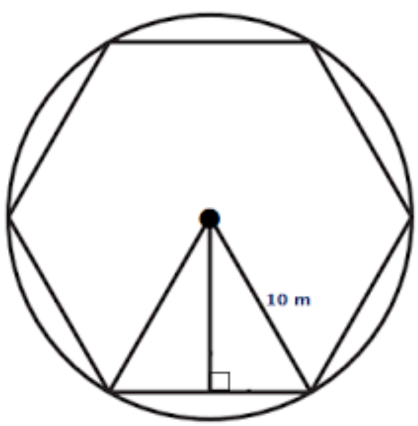
But since we have:

$$\int_{Si}^{Ge}\int_{Si}^{Ge}\nabla\times\overrightarrow{u}\cdot d\overrightarrow{a}=170{,}535{,}359.662(g/mol)^5$$ [1]

We take the ratio and have

$$\frac{523{,}818{,}646.5}{170{,}535{,}359.662}=3.0716$$

Almost exactly 3 which is the ratio of the perimeter of regular hexagon to its diameter used to estimate pi in ancient times by inscribing it in a circle:



Perimeter=6

Diameter=2

6/2=3

$$\pi=3.141...$$

Thus we have the following equation…

---

[1] See Appendix 1

$$\pi \int_{Si}^{Ge} \int_{Si}^{Ge} \nabla \times \overrightarrow{u} \cdot d\overrightarrow{a} = \prod_{i=1}^{5} x_i$$

4. Musical Intervals The western tonal system divides up the tonic to double its frequency in 12 tones. But the musical key is defined by the pattern that is only eight of these tones. Thus at times we must skip a tone (a note). In fact, to comprise the tones of a major or minor key we play the maximum number of whole steps (the skipping of a note). Since twelve divided by two is six and we need eight tones two of them must be a half step (where we don't skip a note). In the major key this is wholestep—wholestep—halfstep. The minor key begins wholestep-halfstep.

We guess that the periodic table of the elements is music (See Figure 1). To do this I am interested in starting at arsenic (As) because it is a semiconductor doping agent. We then skip germanium (Ge) an element doped with arsenic to make negative (n-type) germanium, and go to the next element to the left after the germanium to have gone a whole step and landed on the other doping agent gallium (Ga) which in contrast makes positive (p-type) germanium. Then we continue with another whole step to make a major key and it is copper (Cu) the most abundant practical conductor used for making electrical wire. Now we have to go a half a step which takes us to nickel (Ni) which like copper is perfect because it is the element beyond which alpha decay can happen (emits) an alpha particle (helium nucleus) when heated (Beryllium an exception). Now we go a whole step as is done in the major key and this lands us on iron (Fe). This is good because stars on the main sequence have luminosities in terms solar luminosities L related to their mass M in solar masses given by

$$L = M^{3.5}$$

But we notice the molar mass of gold (Au) divided by iron (Fe) is 3.5 yielding

$$L = M^{\frac{Au}{Fe}}$$

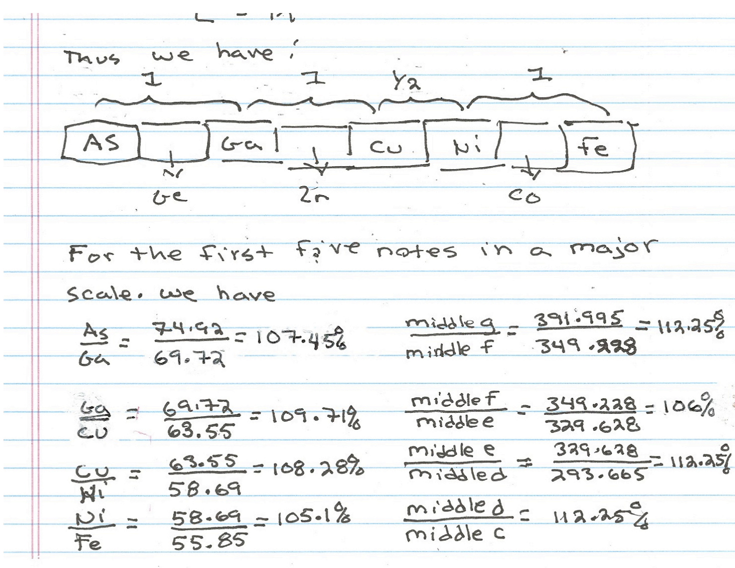


Figure 1: The elements as musical intervals.

We see whether or not we take a whole step in the periodic table for these elements we get a ratio between successive terms that is always around 107.635. We look at the musical scale taking C major since the notes are all natural. We have

C. D. E. F. G. A. B. C.

We have the halfstep - between E and F - is 106% where for the whole steps it is 112.25%. The geometric mean between these gives

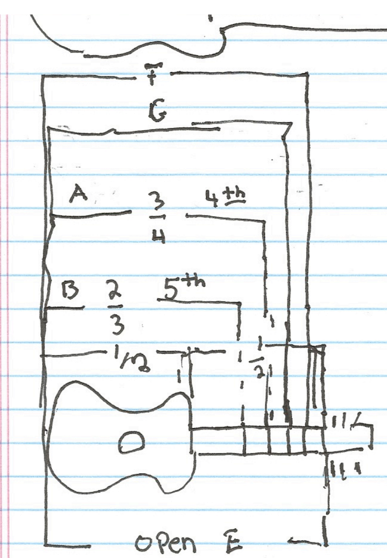
$$\sqrt{(106)(112.25)} = 109.0802457$$

Which is very close to our 107.635 and we have

109.08024-107.635=1.44524

(109.08024)/107.635=1.013427231

Why look at these elements by molar mass in terms of musical notes? By making the halfsteps that change in pitch by the same amount for each step as well as these half steps being such that 12 of them is an octave, then they land on frequencies such that every other note in a scale makes the interval of a third and three of them defining what is called a triad and they land on harmonic intervals such as the 4th, and the 5th (See Figure 2). These add more constructively as vibrating waves than say other intervals that are more dissonant. We can relate these changes in frequency to changes in string length such as 3/4 and 2/3 which may have something to offer in terms of physical construction of matter: We see our half step for the elements occurs for nickel to copper, which is what we want!



originally, like in gregorian chants, changing the pitch by an interval of a 5th was exactly shortening the open E string to 2/3 its length, and changing the pitch by a 4th was shortening the string length to 3/4. But Bach decided to make the pitch from E to F, F to G, G to A, and A to B... be equal. This he did because the 4th note approximately lands on string length 3/4 and string length 2/3, a 5th. while in the old system a scale was more resonant, his equal temperment as he called it allowed for composing in one key to transpose to another key.

Figure 2: String length as related to frequency.

5. Elemental Scales So let's do a more thorough analysis with increase in note frequency increasing as molar mass frequency increases (See Figures 3 and 4). We have

$$\frac{Kr}{Br}=\frac{83.80}{79.90}=104.88 \qquad \frac{C}{B}=\frac{523.25}{493.88}=105.9467887$$

$$\frac{Br}{Si}=\frac{79.90}{78.96}=101.19 \qquad \frac{B}{A^\sharp}=\frac{49.88}{466.164}=105.9455471$$

$$\frac{Se}{As}=\frac{78.96}{74.92}=105.39 \qquad \frac{A^\sharp}{A}=\frac{466.164}{440}=105.946$$

We see here the result the ratios between successive elements by molar mass is about the same as successive half steps between notes (cycles per second). In a minor scale we start at Fe then skip cobalt (Co) to make a whole step to nickel (Ni). This is a percent change of

$$\frac{Ni}{Fe}=\frac{58.69}{55.85}=105.085 \qquad \frac{E}{D}=\frac{329.628}{293.665}=112.25$$

We see the whole step from Ni to Fe is 105% about a musical half step like C/B=106%. For this to be a minor scale the next step is a half step from Ni to Cu, which gives

$$\frac{Cu}{Ni}=\frac{63.55}{58.69}=108.28 \qquad \frac{F}{E}=\frac{349.228}{329.628}=106$$

Our whole steps are E/D=112% and (112+106)/2=109% putting the elemental half step of Cu/Ni the average between a musical whole step and a musical half step. In the minor pentatonic we have whole steps and an interval of a minor third. This is

$$\frac{Zn}{Co}=\frac{F^\sharp}{D^\sharp}\longrightarrow\frac{65.39}{58.93}=111=\frac{369.944}{311.127}=119$$

Thus the minor third for these elements is about a musical whole step (112).

We see choosing Iron (Fe) is wise as our starting point because as we said for a main sequence star

$$L=M^{\frac{Au}{Fe}}$$

And, this makes the last element krypton which being in the last column of the periodic table (group 18) is an inert gas — so it is like the the note C which is the reference point for music in the western system of music theory. Krypton being in group 18 and an inert gas because of this, is an elemental reference point in the periodic table because for example for carbon (C) we have 18-14=4 valence electrons to acquire noble gas electron configuration. Our pentatonic scale is the notes

D sharp, F sharp, G sharp, A sharp,…

Which are elements

Co, Zn, Ge, Se,…

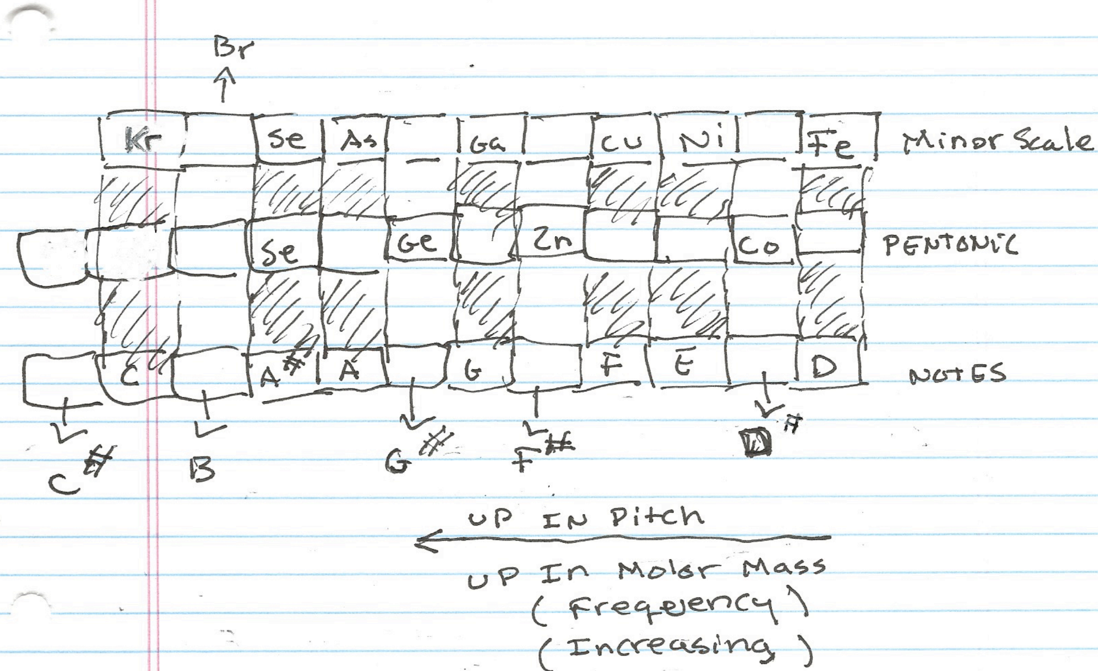
And these are the notes outside of the minor scale beginning at Fe. But we can start our minor pentatonic on Fe, which corresponds to a different key. We have minor pentatonic 2 is:

D, E, F, G, A,…

Which are elements

Fe, Cu, Ga, As,…

We find that in both pentatonic scales, 1 and 2 the intervals of a minor third (Zn/Co and Cu/Fe) are very close to the musical whole steps which are are a changes of 112%. Figures 3 and 4…



Element	Molar Mass	Note	
Fe	55.85	D	293.665
Co	58.93	D#	311.127
Ni	58.69	E	329.628
Cu	63.55	F	349.228
Zn	65.39	F#	369.994
Ga	69.72	G	391.995
Ge	72.64	G#	415.305
As	74.92	A	440
Se	78.96	A#	466.164
Br	79.90	B	493.88
Kr	83.80	C	523.25

Figure 3: Molar mass and Hz

Pentatonic 1.

$$\frac{Se}{Ge} = \frac{78.96}{72.64} = 108.7\%$$

$$\frac{Ge}{Zn} = \frac{72.64}{65.39} = 111.1\%$$

$$\frac{Zn}{Co} = \frac{65.39}{58.93} = 111\%$$

Pentatonic 2

$$\frac{As}{Ga} = \frac{74.92}{69.72} = 107.4584\%$$

$$\frac{Ga}{Cu} = \frac{69.72}{63.55} = 109.71\%$$

$$\frac{Cu}{Fe} = \frac{63.55}{55.85} = 113.787\%$$

Thus in both pentatonic 1 and 2 the intervals of a minor third ($\frac{Zn}{Co}$, and $\frac{Cu}{Fe}$) Are very close to musical whole steps which are about 112%.

Figure 4: Minor pentatonics in two different keys.

6. Length and Frequency

Reduce the string length to 2/3 its open length and that is an interval of a fifth. That is a change in frequency of D=293.665 Hz to B=493.88 Hz. Reduce the string length to 3/4 its open length and that is a change in frequency from D=293.665 Hz to A=440 Hz, which is an interval of a fourth. Cut the string length in half and you double the frequency. Which is an octave. We have

$$\frac{1}{2} = 2$$

$$\frac{2}{3} = \frac{493.88}{391.995} = 1.681 = \Phi$$

$$\Phi = \frac{\sqrt{5}+1}{2} = \frac{1}{\phi} = \frac{1}{\phi} = \frac{\sqrt{5}-1}{2} \approx 3/2$$

Where Φ is the golden ratio and ϕ is the golden ratio conjugate. And,…

$$\frac{3}{4} = \frac{440}{293.665} = 1.2599 = \frac{4}{3} = 1.5$$

Thus, we see string length is inversely proportional to frequency. There are two equations for string length, which we can examine by looking at a guitar (See figure 5). From the bridge of a guitar to the fret, where the open string length is s we have:

$$l = \frac{s}{2^{n/12}}$$

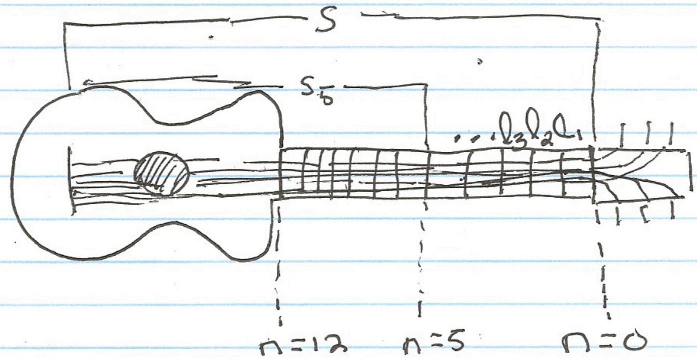
And

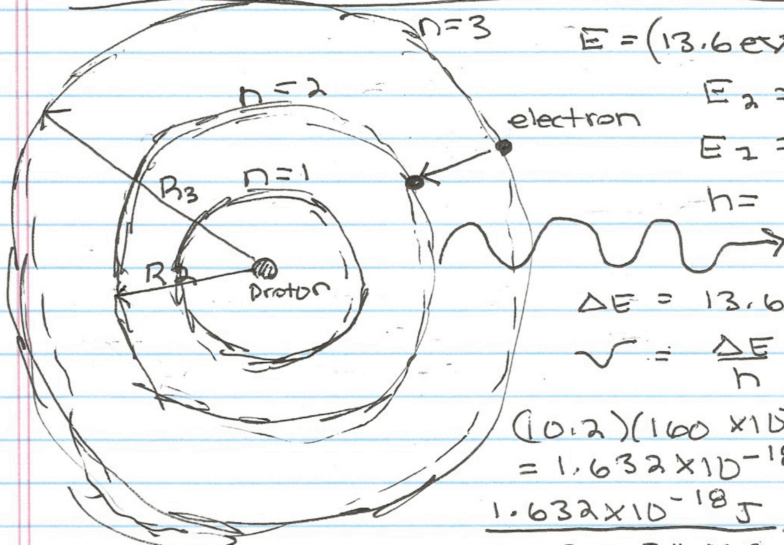
$$l_i = \frac{s_i}{17.817}$$

Where s is the string length from the bridge to the nut and the nut is l_0, fret 1 is l_1, fret 2 is l_2,… l_1 is the distance from l_0, and l_2 is the distance from l_1, and so on…

The 3/2 is an approximation to the the golden ratio (Phi).

We can think of electron orbits in a hydrogen atom as frequencies related to length as well because for a drop in orbit a photon is emitted that has a frequency associated with it. The change in orbit is like the change in the length of a string. Since the n=3 orbit is a distance of R3=4.761E-10m from the nucleus and R2=2.116E-10m we have R3/R2=2.25. But the Energy at E3 is E3=-13.6eV/9, and at E2 it is -13.6eV/4. This is a ratio of 4/9=0.444 and 1/0.444==2.25, thus there is an inverse relationship between length and frequency in the atom (See Fig. 5).





$E = (13.6\,eV)\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

$E_2 = 13.6\,eV / 4$

$E_1 = 13.6\,eV / 1$

$h = 6.63 \times 10^{-34}$

$\Delta E = h\nu$

$\Delta E = 13.6 - 3.4 = 10.2\,eV$

$\nu = \frac{\Delta E}{h} = \frac{10.2\,eV}{6.63 \times 10^{-34}}$

$(10.2)(1.60 \times 10^{-19}\ J/s)$

$= 1.632 \times 10^{-18}$

$\frac{1.632 \times 10^{-18}\,J}{6.63\,E{-34}\ J \cdot s} = 2.46E15\ Hz$

$c = 3 \times 10^{8}\,m/s$ $\quad \lambda = 1.22E{-7}\ m$ is ultraviolet.

Bohr radius $a_0 = 5.291772E{-11}\,m$

$R_2 = 2.116\,E{-10}\,m \quad R_3 = 4.761E{-10}\ m$

$\frac{R_3}{R_2} = 2.25 \quad \frac{E_1}{E_2} = 4 \quad \frac{E_2}{E_3} = \frac{\frac{1}{4}}{\frac{1}{9}} = \frac{9}{4} \quad \frac{E_3}{E_2} = \frac{4}{9} = 0.444$

$\frac{1}{0.444} = 2.25$ length is in inverse proportion to frequency

7. Discussion

I find this equation very beautiful

$$\pi \int_{Si}^{Ge} \int_{Si}^{Ge} \nabla \times \vec{u} \cdot d\,\vec{a} = \prod_{i=1}^{5} x_i$$

Because on the left side we have what I call the AI matrix:

B.	C.	N.
Al.	Si.	P.
Ga.	Ge.	As.

Because it builds the u vector

$$\vec{u} = (C \cdot P)y\vec{i} + (Si \cdot Ge)z\vec{j} + (Ga \cdot As)y\vec{k}$$

And and on the right side we have the what I call the electronics matrix:

Ni.	Cu.	Zn.
Pd.	Ag.	Cd.
Pt.	Au.	Hg.

And in that on the left we have a double integral multiplied by pi, over an area and on the right we have a product operator. Essentially the beauty is in the integral calculus on the left connecting the AI matrix to the electronics matrix on the right with the product calculus. We have to ask why this holds for the molar masses of these elements. It has a geometric representation in that it is flux of the curl of a vector field through a surface with the product of five elements on the right. This is built from Stokes theorem for these semiconductor and electronics matrices. What could have brought about the physical properties of these elements such that this relationship between surface and line holds which we see in its manifestation as

$$\sqrt[5]{\int_{Si}^{Ge} \int_{Si}^{Ge} \nabla \times \vec{u} \cdot d\,\vec{a}} = exp\left(\frac{1}{Ge - Si} \int_{Si}^{Ge} ln(x)dx\right)$$

$$\prod_{i=1}^{5} x_i = Si \cdot Ge \cdot C \cdot Ag \cdot Au$$

Where we have the finest transistor elements Si and Ge to the the left of the core biological life element C and on the right of it the finest conductors for electronics wire Ag, and Au. What force was behind the creation of these elements such that these theorems hold for them, and does it serve a purpose, and if it does is there a reason for it?

This question has been the reason for finding in this paper how the atoms which are elements might be music theory, because these equations seem to be music.

8**. Conclusion**: We may be able to explain the structure of matter at its basis - the elements - in terms of music theory. The reason perhaps the electron orbits might be described by music is that musical intervals are in ratios that don't interfere with one another, which may what is meant by sonority. Further In our finding of a Stokes theorem representation of semiconductor and electronics matrices we see the categories of biological and electronics elements may be mathematical constructs not just chemical. Why?

They seem to be reconciling

$$A = \frac{1}{2}aP$$

For a hexagon (a is its apothem, P its perimeter) with

$$A = \pi r^2$$

For a circle, in that

$$\frac{523{,}818{,}646.5}{170{,}535{,}359.662} = 3.0716$$

$$\frac{3.141 + 3.00}{2} = 3.0705$$

As we show using the most accurate data available in Appendix 1 which are accurate to at least 3 places after the decimal except germanium.

Appendix 1

Ge=72.64
As=74.9216
Si=28.085
Ga=69.723
C=12.011
P=30.97376200

$$(Ge \cdot As - Si \cdot Ga)\vec{i} + (C \cdot P)\vec{k} =$$

$$\left[(72.64)(74.9216) - (28.085)(69.723)\right]\vec{i} + \left[(12.011)(30.97376200)\right]\vec{k} =$$

$$3{,}484.134569\left(\frac{g}{mol}\right)^2\vec{i} + 372.025855\left(\frac{g}{mol}\right)^2\vec{k}$$

$$\int_{Si}^{Ge}\int_{Si}^{Ge}\left(3{,}484.134569\left(\frac{g}{mol}\right)^2\vec{i} + 372.025855\left(\frac{g}{mol}\right)^2\vec{k}\right)\cdot\left(zdydz\vec{i} + ydydz\vec{k}\right)$$

$$\int_{Si}^{Ge}\int_{Si}^{Ge}\left(3{,}484.134569\left(\frac{g}{mol}\right)^2 \cdot zdzdy + 372.025855\left(\frac{g}{mol}\right)^2 \cdot ydzdy\right)$$

$$\int_{Si}^{Ge} 3{,}484.134569\left(\frac{(72.64 - 28.085)^2}{2}\right)dy + \int_{Si}^{Ge} 372.025855y \cdot (72.64 - 28.085)dy$$

$$3458261.42924\left(\frac{g}{mol}\right)^4(72.64 - 28.085) + 16575.6119695\left(\frac{g}{mol}\right)^3\left(\frac{(72.64 - 28.085)^2}{2}\right)$$

=154,082,837.980+16,452,521.6822=

$$170{,}535{,}359.662\left(\frac{g}{mol}\right)^5$$

$$\prod_{i=1}^{5} x_i = Si \cdot Ge \cdot C \cdot Ag \cdot Au =$$

(28.085)(72.64)(12.085)(107.8682)(196.9657)=

$$523{,}818{,}646.5\frac{g^5}{mol^5}$$

Where we have substituted carbon C=12.01 for copper Cu. We use Cu, Ag, Au because they are the middle column of our electronics matrix, they are the finest conductors used for electrical wire. We use C, Si, Ge because they are the middle column of our AI Biomatrix. Si and Ge are the primary semiconductor elements used in transistor technology (Artificial Intelligence) and C is the core element of biological life. We have

$$\frac{523{,}818{,}646.5}{170{,}535{,}359.662} = 3.0716$$

$$\pi = 3.141...$$

Perimeter/Diameter of regular hexagon = 3.00

$$\frac{3.141 + 3.00}{2} = 3.0705$$

That same value as our 3.0716 if taken at two places after the decimal.

The Author