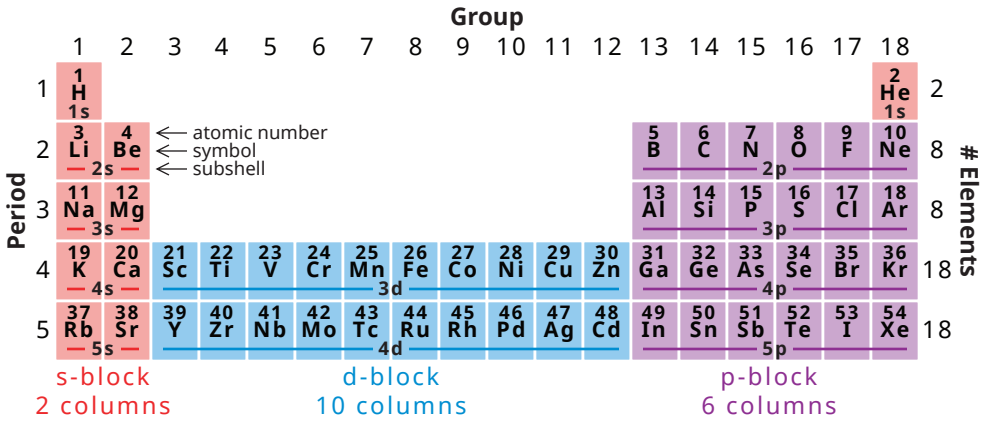
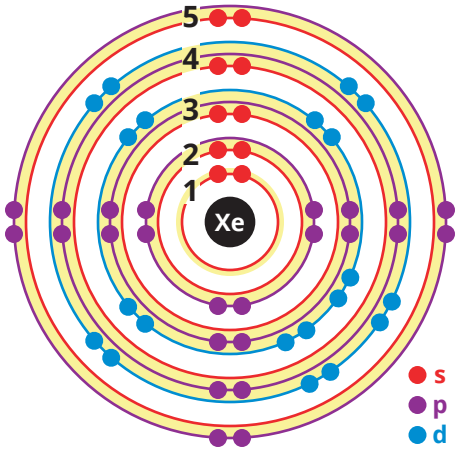
Happy 18th Birthday

Periodic Table of the Elements

The standard periodic table has **18** columns or groups — *it's all about shells.*

Periodic table, top five rows





Electron shells and subshells
Xenon, 54 electrons

The atomic number is the number of protons (+) in the nucleus; it is also the number of electrons (−) in an uncharged atom.

Electrons surround the nucleus in shells of increasing size.

Elements in the same group are similar because they have the same number of electrons in their outermost shell.

Shells are numbered **1**, **2**, **3**, ...
Subshells are lettered **s**, **p**, **d**, **f**, ...
Subshells in numeric order:
1s, **2s**, **2p**, **3s**, **3p**, **3d**, **4s**, **4p**, **4d**, **4f**, ...

Subshells contain orbitals.
Each orbital can hold 2 electrons.

Subshell	Orbitals	# Electrons
s	s_0	2
p	p_{-1} p_0 p_{+1}	6
d	d_{-2} d_{-1} d_0 d_{+1} d_{+2}	10

Subshells are filled in this order:

Period	Subshells	# Electrons	# Elements
1	**1s**	2	2
2	**2s**, **2p**	2+6	8
3	**3s**, **3p**	2+6	8
4	**4s**, **3d**, **4p**	2+10+6	18
5	**5s**, **4d**, **5p**	2+10+6	18

Lucas Numbers

18 is a Lucas number.

Fibonacci and Lucas numbers are partners.

Fibonacci: 1 1 2 3 5 8 13 21 34 55 89 ...
Lucas: 1 3 4 7 11 18 29 47 76 123 199 ...

Each number is the sum of the previous two.
$F_n = F_{n-1} + F_{n-2}$ $L_n = L_{n-1} + L_{n-2}$

The ratio of consecutive numbers approaches the golden ratio, ϕ.

$$\phi = \frac{1+\sqrt{5}}{2} = 1.618...$$

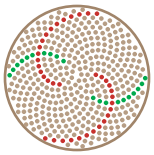
Play around with Fibonacci and Lucas numbers.
You will find that they are related in many ways, such as:

Add every other Fibonacci number:
1+2=3, 1+3=4, 2+5=7, 3+8=11, ...
It's the Lucas numbers!

Add every other Lucas number:
1+4=5, 3+7=10, 4+11=15, ...
It's the Fibonacci numbers times 5!

Double each Fibonacci number and add the next Fibonacci number:
2×1+1=3, 2×1+2=4, 2×2+3=7, ...
It's the Lucas numbers!

Multiply the Fibonacci numbers by the Lucas numbers:
1×1=1, 1×3=3, 2×4=8, 3×7=21, ...
It's every other Fibonacci number!



The numbers of spirals in a sunflower are *usually* consecutive Fibonacci numbers, but *occasionally* consecutive Lucas numbers!

Digit Algebra

18 = **9**+**9** and its reversal, **81** = **9**×**9**

This pattern works in any number base!

For example, base 9: 17 = 8+8 71 = 8×8
base 8: 16 = 7+7 61 = 7×7
base 16: 1E = F+F E1 = F×F

In general, for any base ***b***,
$\underline{1m} = n+n$ and $\underline{m1} = n \times n$,
where $n = b-1$ and $m = b-2$.

For example, if b=10, then n=9 and m=8.

Digits are underlined: $\underline{ijk}$ means $(i \times b^2)+(j \times b)+k$.
So, $\underline{1m} = (1 \times b)+m$ and $\underline{m1} = (m \times b)+1$.

Verify equation 1

$\underline{1m} = n+n$
$(1 \times b)+m = 2n$
$b+(b-2) = 2(b-1)$
$2b-2 = 2b-2$
✓

Verify equation 2

$\underline{m1} = n \times n$
$(m \times b)+1 = n \times n$
$((b-2) \times b)+1 = (b-1) \times (b-1)$
$b^2-2b+1 = b^2-2b+1$
✓

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