Cheers to IYPT 2019: International Year of the Periodic Table of Chemical Elements

Metin Karayılan

Brains & Brews – Borderlands Brewing Co. –April 29th, 2019
Acknowledgements

Dr. Iman Daryaei  
SAzACS past chair  

Executive Committee Members

Kristen Watts

Josh Hoskinson

American Chemical Society
Tentative Outline

- Nuclear fusion
- Quantum mechanics
- Transuranium elements
- Bose-Einstein condensation
KISS Principle!!

KEEP CALM  
AND  
KEEP IT SIMPLE
Making words out of elements in the Periodic Table!!
Can you write your name by only using elements in the Periodic Table (without cheating!)?
<table>
<thead>
<tr>
<th>Periods</th>
<th>Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H, He</td>
</tr>
<tr>
<td>2</td>
<td>Li, Be</td>
</tr>
<tr>
<td>3</td>
<td>B, C, N, O, F, Ne</td>
</tr>
<tr>
<td>4</td>
<td>Na, Mg, Al, Si, P, S, Cl, Ar</td>
</tr>
<tr>
<td>5</td>
<td>K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Kr</td>
</tr>
<tr>
<td>6</td>
<td>Rb, Sr, Y, Zr, Nb, Mo, Tc, Ru, Rh, Pd, Ag, Cd, In, Sn, Sb, Te, I, Xe</td>
</tr>
<tr>
<td>7</td>
<td>Cs, Ba, La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu</td>
</tr>
<tr>
<td>8</td>
<td>Hf, Ta, W, Re, Os, Ir, Pt, Au, Hg, Tl, Pb, Bi, Po, At, Rn</td>
</tr>
<tr>
<td>9</td>
<td>Fr, Ra, Rf, Db, Sg, Bh, Hs, Mt, Ds, Rg, Cn, Nh, Fl, Mc,Lv, Ts, Og</td>
</tr>
</tbody>
</table>

- Fictional Elements are added to make all words possible.
- Enter your name, your school, among class, anything.
- Save a lot of time for your own use.
- Order custom products or free-made with the links on each side.

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https://www.lmntology.com/
Right-click on the lo-resolution image above to save it for later use.

Mithril A durable silvery metal that is very light and easy to work, mined by Dwarves. From 'mithl', grey, and 'ril', glitter. (Middle Earth)

Etherium An extremely rare metal created by the sphinx Crucius the Mad. Vedalken wizards strive to infuse everything with etherium. (Magic: The Gathering)

Titanium A lustrous, white metal, very strong and light and physiologically inert. Used in aerospace and military. (L. titans, mythology)

Nitrogen A gas that makes up 78% of the earth’s air. Odorless and colorless, but important for life as fertilizer. (L. nitrum, native soda)
**Make any words out of Elements in the Periodic Table**

- **Enter Your Words Here**
- **Dictionary Hint**
- **Use Periodic Elements**
- **Use Colors**

- **Fictional Elements:**
  - NaNe
  - CaFeI
  - MnTbE

**Related Links and News**

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- **LMNTOLOGY.com**
- Elements.com

**Periodic Elements**

- **Calcium**
  - A rather hard, silvery metal found in the earth in many compounds and in bones and teeth. (L. calx, 'lime').

- **Iron**
  - A cheap, abundant metal used for ages. Important in blood. Alloys produce harder materials such as steel. (L. ferrum)

- **Iodine**
  - A bluish-black, lustrous solid that is a blue-violet gas. Found in seaweed and used in medicine. (Gr. iodes: violet)

- **Neon**
  - A rare gas that is very inert. Glows reddish orange when charged. (Gr. neos, 'new')

**Right-click on the lo-resolution image above to save it for later use.**

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- Beryllium
  - A light metal present in Aquamarine and Emerald gemstones. Used in hi-tech applications. (Gr. berylllos, beryl)

- Erbium
  - A soft, bright, silvery rare-earth metal. Gives pastel colors to ores. Few uses. (Ytterby, a town in Sweden)
### Elements

**Calcium**
A rather hard, silvery metal found in the earth in many compounds and in bones and teeth. (L. *calcis, lime*).

**Iron**
A cheap, abundant metal used for ages. Important in blood. Alloys produce harder materials such as steel. (L. *ferrum*).

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**Beryllium**
A light metal present in Aquamarine and Emerald gemstones. Used in hi-tech applications. (Gr. beryllos, beryl).

**Erbium**

**Germanium**
A gray-white metalloid, semiconductor used in electronics (L. Germania, Germany).

**Nickel**
A metal found in most meteorites, silvery white takes a polish. Used in alloys and for coins. (German Nickel, Satan).

**Uranium**
A heavy, naturally occurring, radioactive, silver-white metal softer than steel. Used for nuclear power. (Planet Uranus).

**Sulphur**
A pale yellow, odorless, brittle solid, which is insoluble in water. Strong odor as Sulfer oxides. (Sanskrit, sulvere; L. sulphur, brimstone).
Dmitri Ivanovich Mendeleev
- Russian chemist (1834-1907).
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- Showed periodic trends of the then-known elements based on their properties and atomic weights.
- Also predicted the properties of eight elements yet to be discovered.
Dmitri Ivanovich Mendeleev
## Dmitri Ivanovich Mendeleev

Mendeleev's 1871 periodic table

<table>
<thead>
<tr>
<th>Period</th>
<th>Group I</th>
<th>Group II</th>
<th>Group III</th>
<th>Group IV</th>
<th>Group V</th>
<th>Group VI</th>
<th>Group VII</th>
<th>Group VIII</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H</td>
<td>He</td>
<td>Li</td>
<td>Be</td>
<td>B</td>
<td>C</td>
<td>N</td>
<td>O</td>
</tr>
<tr>
<td>1</td>
<td>He</td>
<td>Mg</td>
<td>Al</td>
<td>Si</td>
<td>P</td>
<td>S</td>
<td>Cl</td>
<td>Ar</td>
</tr>
<tr>
<td>2</td>
<td>Na</td>
<td>K</td>
<td>Ca</td>
<td>Sc</td>
<td>Ti</td>
<td>V</td>
<td>Cr</td>
<td>Mn</td>
</tr>
<tr>
<td>3</td>
<td>Mg</td>
<td>Ca</td>
<td>Sr</td>
<td>Y</td>
<td>Zr</td>
<td>Nb</td>
<td>Mo</td>
<td>Tc</td>
</tr>
<tr>
<td>4</td>
<td>Al</td>
<td>Sc</td>
<td>Y</td>
<td>La</td>
<td>Hf</td>
<td>Ta</td>
<td>W</td>
<td>Re</td>
</tr>
<tr>
<td>5</td>
<td>Si</td>
<td>Ti</td>
<td>Zr</td>
<td>Nb</td>
<td>Tc</td>
<td>W</td>
<td>Re</td>
<td>Os</td>
</tr>
<tr>
<td>6</td>
<td>P</td>
<td>V</td>
<td>Mo</td>
<td>Tc</td>
<td>Ru</td>
<td>Rh</td>
<td>Pd</td>
<td>Ag</td>
</tr>
<tr>
<td>7</td>
<td>S</td>
<td>Cr</td>
<td>W</td>
<td>Re</td>
<td>Ir</td>
<td>Pt</td>
<td>Au</td>
<td>Hg</td>
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<tr>
<td>8</td>
<td>Cl</td>
<td>Mn</td>
<td>Re</td>
<td>Os</td>
<td>Rh</td>
<td>Pd</td>
<td>Ag</td>
<td>Cd</td>
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<tr>
<td>9</td>
<td>Ar</td>
<td>Fe</td>
<td>Au</td>
<td>Ir</td>
<td>Ru</td>
<td>Rh</td>
<td>Pd</td>
<td>Cu</td>
</tr>
<tr>
<td>10</td>
<td>Kr</td>
<td>Co</td>
<td>Au</td>
<td>Ir</td>
<td>Os</td>
<td>Ir</td>
<td>Pd</td>
<td>Cu</td>
</tr>
<tr>
<td>11</td>
<td>Br</td>
<td>Ni</td>
<td>Au</td>
<td>Ir</td>
<td>Os</td>
<td>Ir</td>
<td>Pd</td>
<td>Cu</td>
</tr>
<tr>
<td>12</td>
<td>Rb</td>
<td>Cu</td>
<td>Au</td>
<td>Ir</td>
<td>Os</td>
<td>Ir</td>
<td>Pd</td>
<td>Cu</td>
</tr>
</tbody>
</table>
- Mendeleev published his periodic table of all known elements (56 elements)

- And he predicted several new elements to complete the table (in 1871).

<table>
<thead>
<tr>
<th>#</th>
<th>Element</th>
<th>Mass Number</th>
<th>Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>?</td>
<td>eka-aluminium</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>?</td>
<td>eka-silicon</td>
<td>70</td>
<td></td>
</tr>
</tbody>
</table>
- Mendeleev published his periodic table of all known elements (56 elements)

- And he predicted several new elements to complete the table (in 1871).

**eka-aluminium** – Gallium (discovered in 1875)

**eka-silicon** – Germanium (isolated in 1886)
Dmitri Ivanovich Mendeleev

The 40% standard strength of Vodka approved by the royal government commission headed by Mendeleev in 1894 as the highest quality of Russian vodka.
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• Around 330 BCE, the **Greek philosopher Aristotle** proposed that everything is made up of a mixture of one or more *roots* that cannot be broken down into a simpler substance.
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- The four roots, which were later renamed as elements by Plato, were earth, water, air and fire.
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---

The Fifth Element
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• In 1864, the English chemist John Newlands classified the known elements into eight groups, based on their physical properties.

Dalton (1806): listing the known elements by atomic weight
• Around 330 BCE, the **Greek philosopher Aristotle** proposed that everything is made up of a mixture of one or more *roots* that cannot be broken down into a simpler substance.

• The four roots, which were later renamed as *elements* by **Plato**, were *earth*, *water*, *air* and *fire*.

• In 1864, the English chemist **John Newlands** classified the known elements into eight groups, based on their physical properties.

• In 1864, **Julius Lothar Meyer**, a German chemist, noted groups of similar chemical and physical properties repeated at periodic intervals if each element is arranged in the order of their *atomic weights*. 

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*Dalton* (1806): listing the known elements by atomic weight
In 1869, a few months later than Mendeleev, Meyer published a revised and expanded version of his 1864 table independently, which was similar to that published by Mendeleev.

<table>
<thead>
<tr>
<th></th>
<th>4 verthlig</th>
<th>3 verthlig</th>
<th>2 verthlig</th>
<th>1 verthlig</th>
<th>1 verthlig</th>
<th>2 verthlig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Differenz</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Li = 7,03</td>
<td>(Be = 9,37?)</td>
</tr>
<tr>
<td></td>
<td>C = 12,0</td>
<td>N = 14,04</td>
<td>O = 16,00</td>
<td>F = 19,0</td>
<td>Na = 23,05</td>
<td>Mg = 24,0</td>
</tr>
<tr>
<td>Differenz</td>
<td>16,5</td>
<td>16,96</td>
<td>16,07</td>
<td>16,46</td>
<td>16,08</td>
<td>16,0</td>
</tr>
<tr>
<td></td>
<td>Si = 28,5</td>
<td>P = 31,0</td>
<td>S = 32,07</td>
<td>Cl = 35,46</td>
<td>K = 39,13</td>
<td>Ca = 40,0</td>
</tr>
<tr>
<td>Differenz</td>
<td>89,1 /2 = 44,55</td>
<td>44,0</td>
<td>46,7</td>
<td>44,51</td>
<td>46,3</td>
<td>47,6</td>
</tr>
<tr>
<td></td>
<td>- As = 75,0</td>
<td>Se = 78,8</td>
<td>Br = 79,97</td>
<td>Rb = 85,4</td>
<td>Sr = 87,6</td>
<td></td>
</tr>
<tr>
<td>Differenz</td>
<td>89,1 /2 = 44,55</td>
<td>45,6</td>
<td>49,5</td>
<td>46,8</td>
<td>47,6</td>
<td>49,5</td>
</tr>
<tr>
<td></td>
<td>Sn = 117,6</td>
<td>Sb = 120,6</td>
<td>Te = 128,3</td>
<td>J = 126,8</td>
<td>Cs = 133,0</td>
<td>Ba = 137,1</td>
</tr>
<tr>
<td>Differenz</td>
<td>89,4 = 2'44,7</td>
<td>87,4 = 2'43,7</td>
<td>-</td>
<td>-</td>
<td>(71 = 2'35,5)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Pb = 207,0</td>
<td>Bi = 208,0</td>
<td>-</td>
<td>-</td>
<td>(Tl = 204?)</td>
<td>-</td>
</tr>
</tbody>
</table>

Julius Lothar Meyer's periodic table, published in "Die modernen Theorien der Chemie" (1864)

In 1882, both Meyer and Mendeleev received the Davy Medal from the Royal Society in recognition of their work on the Periodic Law.
Sir William Ramsay - a Scottish chemist

- Discovered the **noble gases** and received the **Nobel Prize in Chemistry** in 1904 "in recognition of his services in the discovery of the inert gaseous elements in air"
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- Ramsay investigated other atmospheric gases. His work in isolating argon, helium, neon, krypton, and xenon led to the development of a new section of the periodic table.
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- Ramsay investigated other atmospheric gases. His work in isolating argon, helium, neon, krypton, and xenon led to the development of a new section of the periodic table.

- When the entire group of noble gases was discovered, Ramsay added them to the table as Group 0, without disturbing the basic concept of the periodic table.
• The English physicist Henry Moseley found a relationship between the X-ray wavelength of an element and its atomic number (1910-1914).

• He was then able to re-sequence the periodic table by nuclear charge, rather than by atomic weight.
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• He died in World War I, at the age of 27.
The **GSI Helmholtz Centre for Heavy Ion Research** (German: *GSI Helmholtzzentrum für Schwerionenforschung*) is a research center in Darmstadt, Germany.

Elements discovered at GSI:
- Element 107 **bohrium** (1981),
- 109 **meitnerium** (1982),
- 108 **hassium** (1984),
- 110 **darmstadtium** (1994),
- 111 **roentgenium** (1994), and
- 112 **copernicium** (1996)
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Elements discovered at GSI:

The Joint Institute for Nuclear Research (JINR, Russian: Объединённый институт ядерных исследований, ОИЯИ), in Dubna, Moscow Russia.

Elements discovered at JINR:
1966 – element 102 (nobelium)
1999-2005 – elements 105 (dubnium), 113 (nihonium), 114 (flerovium), 115 (moscovium), 116 (livermorium), and 118 (oganesson)
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Yuri Oganessian

He is a Russian nuclear physicist of Armenian origin who is considered the world's leading researcher in superheavy chemical elements.
Lawrence Livermore National Laboratory (LLNL) is a federal research facility in Livermore, California, US and University of California, Berkeley
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Co-discoverers of new superheavy elements

113 (nihonium), 114 (flerovium), 115 (moscovium),
116 (livermorium, 117 (tennessine), and 118 (oganesson)

94 (Plutonium), 95 (americium), 96 (curium), 97
(berkelium), 98 (californium), 99 (einsteinium), 100
(fermium), 101 (mendelevium), 102 (nobelium), 103
(lawrencium), 106 (seaborgium)
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of ten transuranium elements earned him a share of the
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Seaborgium is the first element ever to have been officially named after a living person. The second element to be so named is oganesson, in 2016, after Yuri Oganessian.
What's your favorite element?
PERIODIC PLAYOFF

K Ag

American Chemical Society 2019
Display of the chemical elements, which are arranged by atomic number.

<table>
<thead>
<tr>
<th>Group Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H</td>
<td>He</td>
<td>Na</td>
<td>Li</td>
<td>Mg</td>
<td>Al</td>
<td>Si</td>
<td>P</td>
<td>S</td>
<td>Cl</td>
<td>Ar</td>
<td>Hf</td>
<td>Ta</td>
<td>W</td>
<td>Re</td>
<td>Os</td>
<td>Ir</td>
<td>Pt</td>
</tr>
<tr>
<td>2</td>
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<td>As</td>
<td>Se</td>
<td>Br</td>
<td>Kr</td>
</tr>
<tr>
<td>3</td>
<td>Rb</td>
<td>Sr</td>
<td>Y</td>
<td>Zr</td>
<td>Nb</td>
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<td>In</td>
<td>Sn</td>
<td>Sb</td>
<td>Te</td>
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<td>Xe</td>
</tr>
<tr>
<td>4</td>
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<td>Pb</td>
<td>Bi</td>
<td>Po</td>
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<td>Fr</td>
<td>Ra</td>
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<td>Nd</td>
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</tbody>
</table>
Modern Periodic Table – From Hydrogen-1 to Oganesson-118

The seven rows of the table, called **periods**
The columns, called **groups**, contain elements with similar chemical behaviors.
Modern Periodic Table – From Hydrogen-1 to Oganesson-118

The first 94 elements all occur naturally.
Women Scientists who contributed to the Periodic Table

MARIE CURIE

IDA NODDACK
Ida Noddack was a German chemist and physicist. With her husband Walter Noddack she discovered element 75, rhenium. She was nominated three times for the Nobel Prize in Chemistry.

In 1925, they published a paper and called the new elements rhenium (75) and masurium (43). They named the elements rhenium in respect of Ida's birthplace, and masurium in honor of his.

They were unable to isolate element 43 (Technetium).
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Darleane Christian Hoffman is an American nuclear chemist who was among the researchers who confirmed the existence of Seaborgium, element 106 (1974). She is a faculty senior scientist in the Nuclear Science Division of Lawrence Berkeley National Laboratory and a professor in the graduate school at UC Berkeley.
Marie Curie was a Polish and naturalized-French physicist and chemist who conducted pioneering research on radioactivity. She was the first woman to win a Nobel Prize, the first person and only woman to win twice, and the only person to win a Nobel Prize in two different sciences.
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The **GSI Helmholtz Centre for Heavy Ion Research** near **Darmstadt**, **Germany**, first created the element-109 (Meitnerium) in 1982. It is named after **Lise Meitner**.
"When I draw a molecule in China or in Argentina, it is the same molecule. People understand immediately without knowing Spanish or Chinese. That is beautiful. Our common goal is not about power or borders of the country, it is about bringing forward human knowledge."

Ben Feringa
2016
Nobel Prize in Chemistry
Many of the transuranic elements are named after recipients of the Nobel Prize (8), including:

- bohrium (Niels Bohr),
- curium (Marie and Pierre Curie),
- einsteinium (Albert Einstein),
- fermium (Enrico Fermi),
- lawrencium (Ernest Lawrence),
- roentgenium (Wilhelm Röntgen),
- rutherfordium (Ernest Rutherford),
- and seaborgium (Glenn T. Seaborg).
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Transuranic elements named in honor of scientists (6) who did not receive the prize include:
- copernicium (Nicolaus Copernicus),
- flerovium (Georgy Flyorov),
- meitnerium (Lise Meitner),
- mendelevium (Dmitri Mendeleev),
- nobelium (Alfred Nobel),
- and oganesson (Yuri Oganessian).
96 Curium
Curium is named after Marie Curie who discovered radium and polonium.

99 Einsteinium
Einsteinium was named for Albert Einstein, the famous physicist.

100 Fermium
Fermium was named after Enrico Fermi, who did work on nuclear reactions.

101 Mendelevium
Mendelevium was named for Dmitri Mendelev, inventor of the periodic table.

102 Nobelium
Nobelium is named for Alfred Nobel, for whom the Nobel Prize is also named.

103 Lawrencium
Lawrencium is named after Ernest O. Lawrence, the inventor of the cyclotron.
104 Rutherfordium
Rutherfordium is named for Ernest Rutherford, who discovered that elements have nuclei.

106 Seaborgium
Seaborgium is named for Glenn T. Seaborg, who helped discover many elements.

107 Bohrium
Bohrium is named for Niels Bohr, who did groundbreaking research on the atom.

109 Meitnerium
Meitnerium is named for Lise Meitner, who helped discover nuclear fission.

111 Roentgenium
Roentgenium is named for Wilhelm Conrad Röntgen, inventor of the X-ray.

112 Copernicium
Copernicium is named after Nicolaus Copernicus, the famous astronomer.
Which Elements Are Named for Places? Total 30

- Americium – America, the Americas
- Berkelium – University of California at Berkeley
- Californium – State of California and University of California at Berkeley
- Copper - probably named for Cyprus
- Darmstadtium – Darmstadt, Germany
- Dubnium – Dubna, Russia
- Erbium – Ytterby, a town in Sweden
- Europium – Europe
- Francium – France
- Gallium – Gallia, Latin for France. Also named for Lecoq de Boisbaudran, the element's discoverer (Lecoq in Latin is gallus)
- Germanium – Germany
- Hafnium – Hafnia, Latin for Copenhagen
- Hassium – Hesse, Germany
- Holmium – Holmia, Latin for Stockholm
- Lutetium – Lutecia, ancient name for Paris
- Magnesium – Magnesia prefecture in Thessaly, Greece
- Polonium – Poland
- Rhenium – Rhenus, Latin for Rhine, a German province
- Ruthenium – Ruthenia, Latin for Russia
- Scandium – Scandia, Latin for Scandinavia
- Strontium – Strontian, a town in Scotland
- Terbium – Ytterby, Sweden
- Thulium – Thule, a mythical island in the far north (Scandinavia?)
- Ytterbium – Ytterby, Sweden
- Yttrium – Ytterby, Sweden

Nihonium
Livermorium
Moscovium

Tennessine
2019 International Year of the Periodic Table
Timeline of Elements

Celebrating the discovery of elements
A collaborative University of Waterloo project
uwaterloo.ca/chemistry/timeline-of-elements
THE PERIODIC TABLE
with country and date of discovery

*dates, discoverers, etymologies and flags all from Wikipedia; etymology icons by SimpleIcons and Freepik from www.flaticon.com, licensed by CC 3.0 BY.
Top Elements Mined in the U.S.
the origins of the top elements mined in our 50 states,
and the essential role they play in our daily lives.

1. **Copper**: building construction
   The most substantial copper mines are located in Arizona, Utah, New Mexico, Nevada, and Montana

2. **Lithium**: most famous for its use in batteries - in Nevada
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5. **Iron Ore**: Without iron ore, we would have no steel
   Michigan and Minnesota take the top spots for iron ore production.
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9. **Molybdenum** - found in many alloys - useful in nuclear power plants and aircraft engines
The highest-producing molybdenum mines are found in Colorado

10. **Boron** - found in California
Fictional Elements in Comics

- Adamantium
- Vibrannium
- Kryptonite
- Unobtainium
Are you Dmitry Mendeleev, the father of the periodic table?

PERIODIC TABLE
I bet that bench is really unstable.
Acknowledgements

Southern Arizona ACS Local Section

Iman Daryaei
Ben Zarin
Laura Stratton
Chris Cabello
Steve Brown
Brooke Massani
Chuck Weidner
Grazyna Zreda
Trina Shartsis
Pedro Flores Gallardo

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Kristen Watts
Josh Hoskinson
Freddie Mercury vs. Lead (Led) Zeppelin