

CHEM-E4130

Neodymium(Nd)

Jiyoung Keskimaula
Juho Helminen
Marcus Olsio
7.Oct.2022





Content

- Element
- Chemistry
- Compounds
- Applications

Element

History of Neodymium



Origin of its Name:

The name of the element is derived from the Greek word “neos didymos” meaning new twin

Who discovered Nd:

1885 by Carl Auer von Welsbach

Where is Neodymium found?

Historically, a single mine in California produced most of the world’s rare earth minerals, but since the early 90s, China has become the world’s primary source.

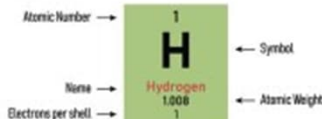


Element

What is **Neodymium**

Periodic Table of the Elements

1 IA 1 H Hydrogen 1.008 1																	18 VIIIA 2 He Helium 4.0026 2	
3 Li Lithium 6.941 2.1	4 IIA Be Beryllium 9.0122 1.9																	10 Ne Neon 20.180 2.8
11 Na Sodium 22.98976928 2.8.1	12 Mg Magnesium 24.305 2.8.2																	18 Ar Argon 39.948 2.8.6
19 K Potassium 39.0983 2.8.8.1	20 Ca Calcium 40.078 2.8.8.2	21 Sc Scandium 44.955910 2.8.9.2.1	22 Ti Titanium 47.88 2.8.9.2.2	23 V Vanadium 50.9415 2.8.9.2.3	24 Cr Chromium 51.9961 2.8.9.2.4	25 Mn Manganese 54.938044 2.8.9.2.5	26 Fe Iron 55.845 2.8.9.2.6	27 Co Cobalt 58.933 2.8.9.2.7	28 Ni Nickel 58.693 2.8.9.2.8	29 Cu Copper 63.546 2.8.9.2.9	30 Zn Zinc 65.38 2.8.9.2.10	31 Ga Gallium 69.723 2.8.9.2.11	32 Ge Germanium 72.630 2.8.9.2.12	33 As Arsenic 74.9216 2.8.9.2.13	34 Se Selenium 78.9718 2.8.9.2.14	35 Br Bromine 79.904 2.8.9.2.15	36 Kr Krypton 83.798 2.8.9.2.16	
37 Rb Rubidium 85.4678 2.8.9.4.1	38 Sr Strontium 87.62 2.8.9.4.2	39 Y Yttrium 88.90584 2.8.9.4.3	40 Zr Zirconium 91.224 2.8.9.4.4	41 Nb Niobium 92.90637 2.8.9.4.5	42 Mo Molybdenum 95.95 2.8.9.4.6	43 Tc Technetium 98 2.8.9.4.7	44 Ru Ruthenium 101.07 2.8.9.4.8	45 Rh Rhodium 102.91 2.8.9.4.9	46 Pd Palladium 106.42 2.8.9.4.10	47 Ag Silver 107.87 2.8.9.4.11	48 Cd Cadmium 112.41 2.8.9.4.12	49 In Indium 114.82 2.8.9.4.13	50 Sn Tin 118.71 2.8.9.4.14	51 Sb Antimony 121.76 2.8.9.4.15	52 Te Tellurium 127.60 2.8.9.4.16	53 I Iodine 126.905 2.8.9.4.17	54 Xe Xenon 131.29 2.8.9.4.18	
55 Cs Cesium 132.905451961 2.8.9.5.1	56 Ba Barium 137.33 2.8.9.5.2	57-71 Lanthanides	72 Hf Hafnium 178.49 2.8.9.5.3	73 Ta Tantalum 180.94788 2.8.9.5.4	74 W Tungsten 183.84 2.8.9.5.5	75 Re Rhenium 186.21 2.8.9.5.6	76 Os Osmium 190.23 2.8.9.5.7	77 Ir Iridium 192.22 2.8.9.5.8	78 Pt Platinum 195.08 2.8.9.5.9	79 Au Gold 196.967 2.8.9.5.10	80 Hg Mercury 200.59 2.8.9.5.11	81 Tl Thallium 204.38 2.8.9.5.12	82 Pb Lead 207.2 2.8.9.5.13	83 Bi Bismuth 208.98 2.8.9.5.14	84 Po Polonium 209 2.8.9.5.15	85 At Astatine 210 2.8.9.5.16	86 Rn Radon 222 2.8.9.5.17	
87 Fr Francium 223 2.8.9.5.18	88 Ra Radium 226 2.8.9.5.19	89-103 Actinides	104 Rf Rutherfordium 261 2.8.9.5.20	105 Db Dubnium 262 2.8.9.5.21	106 Sg Seaborgium 263 2.8.9.5.22	107 Bh Bohrium 264 2.8.9.5.23	108 Hs Hassium 265 2.8.9.5.24	109 Mt Meitnerium 266 2.8.9.5.25	110 Ds Darmstadtium 268 2.8.9.5.26	111 Rg Roentgenium 269 2.8.9.5.27	112 Cn Copernicium 277 2.8.9.5.28	113 Nh Nihonium 278 2.8.9.5.29	114 Fl Flerovium 277 2.8.9.5.30	115 Mc Moscovium 277 2.8.9.5.31	116 Lv Livermorium 276 2.8.9.5.32	117 Ts Tennessine 276 2.8.9.5.33	118 Og Oganesson 276 2.8.9.5.34	



State of matter (color of name)
GAS LIQUID SOLID UNKNOWN

Subcategory in the metal-metalloid-nonmetal trend (color of background)

- Alkali metals
- Lanthanides
- Metalloids
- Unknown chemical properties
- Alkaline earth metals
- Actinides
- Reactive nonmetals
- Transition metals
- Post-transition metals
- Noble gases

57 La Lanthanum 138.905 2.8.9.5.35	58 Ce Cerium 140.12 2.8.9.5.36	59 Pr Praseodymium 140.90765 2.8.9.5.37	60 Nd Neodymium 144.24 2.8.9.5.38	61 Pm Promethium 145 2.8.9.5.39	62 Sm Samarium 150.36 2.8.9.5.40	63 Eu Europium 151.964 2.8.9.5.41	64 Gd Gadolinium 157.25 2.8.9.5.42	65 Tb Terbium 158.925 2.8.9.5.43	66 Dy Dysprosium 162.50 2.8.9.5.44	67 Ho Holmium 164.93032 2.8.9.5.45	68 Er Erbium 167.259 2.8.9.5.46	69 Tm Thulium 168.934 2.8.9.5.47	70 Yb Ytterbium 173.054 2.8.9.5.48	71 Lu Lutetium 174.967 2.8.9.5.49
89 Ac Actinium 227 2.8.9.5.50	90 Th Thorium 232.04 2.8.9.5.51	91 Pa Protactinium 231.04 2.8.9.5.52	92 U Uranium 238.03 2.8.9.5.53	93 Np Neptunium 237.05 2.8.9.5.54	94 Pu Plutonium 244.06 2.8.9.5.55	95 Am Americium 243.06 2.8.9.5.56	96 Cm Curium 247.07 2.8.9.5.57	97 Bk Berkelium 247.07 2.8.9.5.58	98 Cf Californium 251.08 2.8.9.5.59	99 Es Einsteinium 252.08 2.8.9.5.60	100 Fm Fermium 257.10 2.8.9.5.61	101 Md Mendelevium 258.10 2.8.9.5.62	102 No Nobelium 259.10 2.8.9.5.63	103 Lr Lawrencium 262.10 2.8.9.5.64



ChemistryLearner.com

- **Atomic number: 60**
- **$[\text{Xe}] 4f^4 6s^2$**
- **Atomic weight: 144.243**
- **Lanthanides (f-block)**
- One of the rare-earth metals
- Melting point: 21 °C
- Boiling point: 3,074 °C

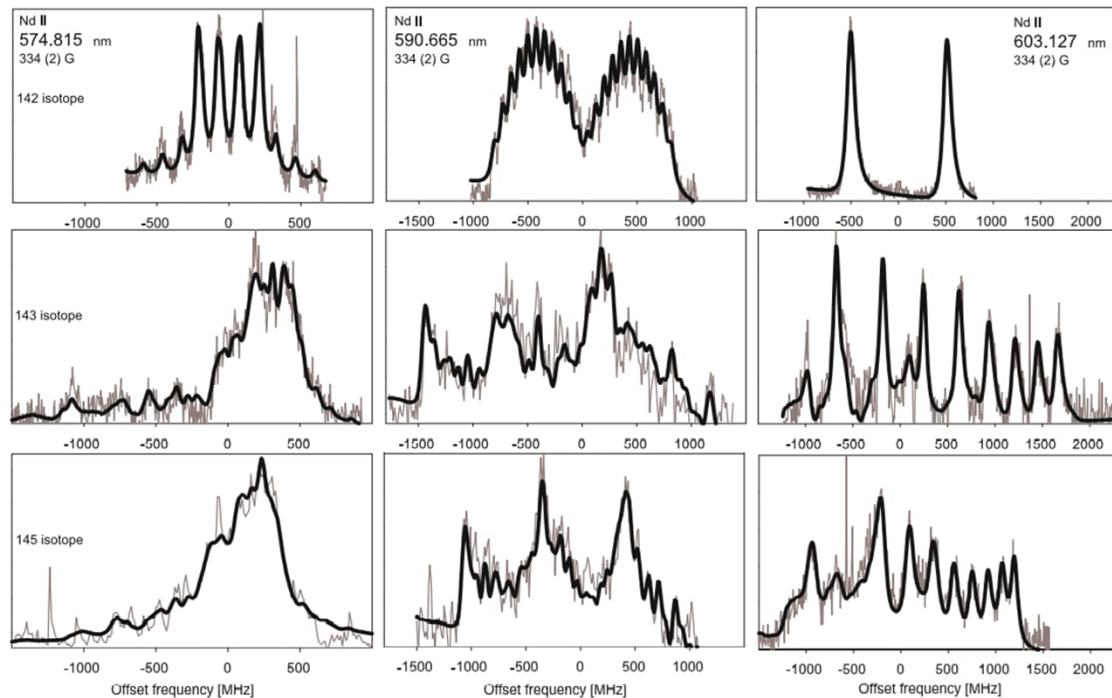
Chemistry

Properties and specifics of

Neodymium

Chemistry

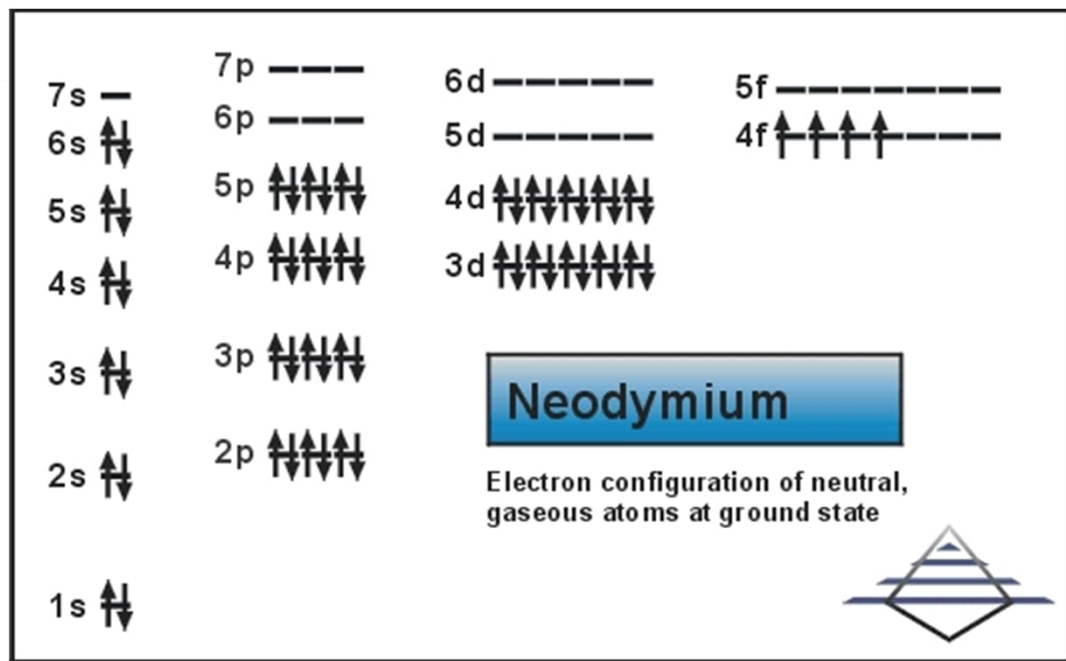
laser spectroscopy of Nd(II)



general info

Classification:	Neodymium is a lanthanide and rare earth metal
Color:	silvery-white
Atomic weight:	144.24
State:	solid
Melting point:	1016 °C, 1289 K
Boiling point:	3070 °C, 3343 K
Electrons:	60
Protons:	60
Neutrons in most abundant isotope:	82
Electron shells:	2,8,18,22,8,2
Electron configuration:	[Xe] 4f ⁴ 6s ²
Density @ 20°C:	7.0 g/cm ³

Crystal structure	hexagonal
Oxidation states	3 (mildly basic oxide)
Electronegativity	1.14 (Pauling scale)
Ionization energies (more)	1st: 533.1 kJ·mol ⁻¹
	2nd: 1040 kJ·mol ⁻¹
	3rd: 2130 kJ·mol ⁻¹
Atomic radius	185 pm
Atomic radius (calc.)	206 pm
Magnetic ordering	ferromagnetic
Electrical resistivity	(r.t.) (α, poly) 643 nΩ·m
Thermal conductivity	(300 K) 16.5 W·m ⁻¹ ·K ⁻¹
Thermal expansion	(r.t.) (α, poly) 9.6 μm/(m·K)
Speed of sound (thin rod)	(20 °C) 2330 m/s
Young's modulus	(α form) 41.4 GPa
Shear modulus	(α form) 16.3 GPa
Bulk modulus	(α form) 31.8 GPa
Poisson ratio	(α form) 0.281



Compounds

Examples of **Neodymium**
compounds

Compounds



- Used to dope glass
- Nd's sharp absorption bands cause the color change under different lighting conditions
- Purple in daylight, blue under fluorescent and greenish under trichromatic



https://commons.wikimedia.org/wiki/File:Neodymium_glass_light_bulb_under_fluorescent_and_incandescent_light.jpg



- An important intermediate in mineral processing
- Organic catalysis
- Nd-YAG laser



bastnäsite

<https://en.wikipedia.org/wiki/File:Basstnasite-155010.jpg>



- Also an intermediate in mineral processing, especially bastnäsite and parisite



parisite

<https://commons.wikimedia.org/wiki/File:Parisite-39471.jpg>



- Lasers and glass doping

Other noteworthy

- $\text{Nd}(\text{OH})_3$
- $\text{Nd}(\text{CH}_3\text{COO})_3$
- NdCl_2
- NdBr_3
- NdI_2
- NdI_3



$\text{Nd}_2(\text{SO}_4)_3$

[https://commons.wikimedia.org/wiki/File:Neodym\(III\)sulfat.JPG](https://commons.wikimedia.org/wiki/File:Neodym(III)sulfat.JPG)

Applications

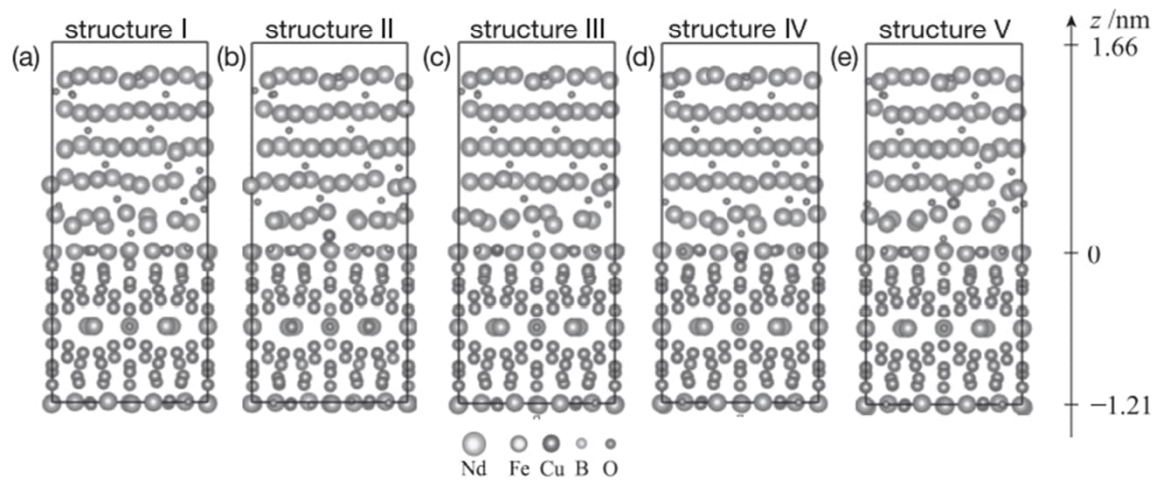
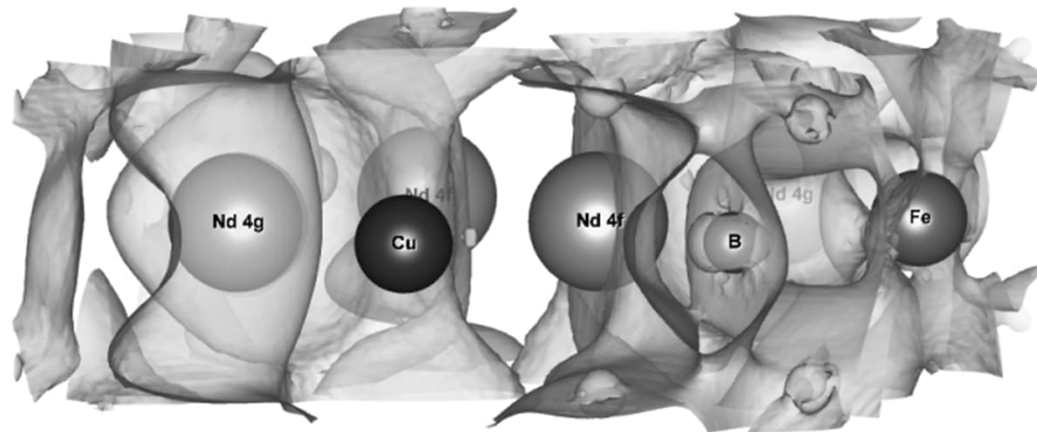
- Neodymium supermagnets
- Electron microscopy

Neodymium magnets

- New applications for Nd magnets are in wind power generators and electric car engines
- The high temperatures in such environments require further development of materials
- Improvement is possible by optimizing surface local magnetic sites in Nd-Fe-B magnets



Yoshihiro Gohda et. al, Electron Theory on Grain-Boundary Structures and Local Magnetic Properties of Neodymium Magnets, MATERIALS TRANSACTIONS, 2018, Volume 59, Issue 3, Pages 332-337, J-STAGE February 25, 2018, ISSN 1347-5320, Print ISSN 1345-9678, <https://doi.org/10.2320/matertrans.M2017258>



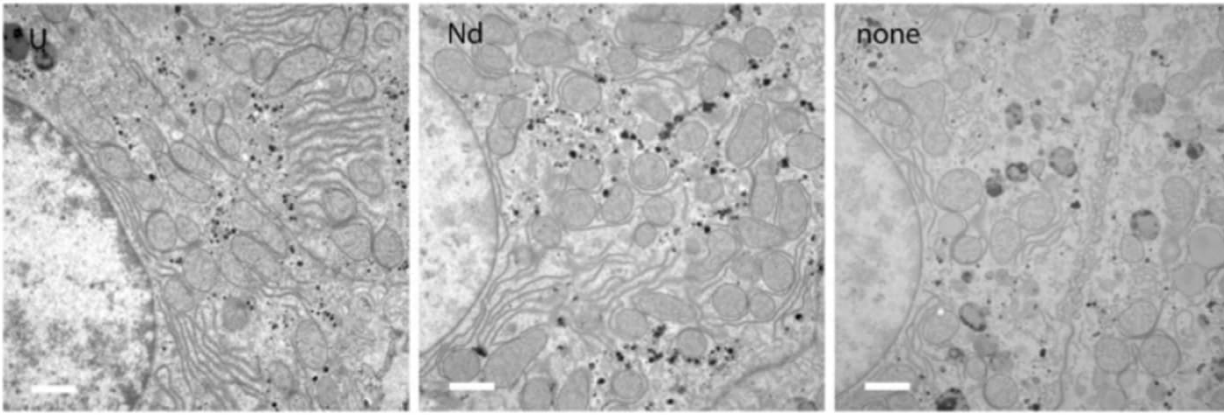
Nd as an alternative for uranium in electron microscopy

- Uranyl acetate is the most commonly used contrasting agent in electron microscopy in biochemistry
- Uranyl ions bind to phosphate and amino groups in proteins and lipids
- Heavy elements are more electron rich and appear darker in electron microscopy



Uranyl acetate
 $\text{UO}_2(\text{CH}_3\text{CO}_2)_2 \cdot (\text{H}_2\text{O}) \cdot \text{H}_2\text{O}$

https://en.wikipedia.org/wiki/File:Uranyl_Acetate_10_3_07.jpg



- Radioactivity is tolerable while external to the body (14-19 kBq/g), but both chemical toxicity and radioactivity make it very harmful inside the body
- Nd seems like a no-brainer, so why isn't it used?
 - solubility problems
 - availability
 - old habits die hard

Periodic Table of Elements

IA																IIA																IIIA																IVA																VA																VIA																VIIA																VIII																																																																																																																																																																															
1 H Hydrogen 1.01																2 He Helium 4.00																3 Li Lithium 6.94																4 Be Beryllium 9.01																5 B Boron 10.81																6 C Carbon 12.01																7 N Nitrogen 14.01																8 O Oxygen 16.00																9 F Fluorine 19.00																10 Ne Neon 20.18																																																																																																																																															
11 Na Sodium 22.99																12 Mg Magnesium 24.31																13 Al Aluminum 26.98																14 Si Silicon 28.09																15 P Phosphorus 30.97																16 S Sulfur 32.06																17 Cl Chlorine 35.45																18 Ar Argon 39.95																																																																																																																																																																															
19 K Potassium 39.10																20 Ca Calcium 40.08																21 Sc Scandium 44.96																22 Ti Titanium 47.87																23 V Vanadium 50.94																24 Cr Chromium 52.00																25 Mn Manganese 54.94																26 Fe Iron 55.85																27 Co Cobalt 58.93																28 Ni Nickel 58.69																29 Cu Copper 63.55																30 Zn Zinc 65.38																31 Ga Gallium 69.72																32 Ge Germanium 72.63																33 As Arsenic 74.92																34 Se Selenium 78.97																35 Br Bromine 79.90																36 Kr Krypton 83.80															
37 Rb Rubidium 85.47																38 Sr Strontium 87.62																39 Y Yttrium 88.91																40 Zr Zirconium 91.22																41 Nb Niobium 92.91																42 Mo Molybdenum 95.95																43 Tc Technetium (98)																44 Ru Ruthenium 101.07																45 Rh Rhodium 102.91																46 Pd Palladium 106.42																47 Ag Silver 107.87																48 Cd Cadmium 112.41																49 In Indium 114.82																50 Sn Tin 118.71																51 Sb Antimony 121.76																52 Te Tellurium 127.60																53 I Iodine 126.90																54 Xe Xenon 131.29															
55 Cs Cesium 132.91																56 Ba Barium 137.33																57-71 Lanthanides																72 Hf Hafnium 178.49																73 Ta Tantalum 180.95																74 W Tungsten 183.84																75 Re Rhenium 186.21																76 Os Osmium 190.23																77 Ir Iridium 192.22																78 Pt Platinum 195.08																79 Au Gold 196.97																80 Hg Mercury 200.59																81 Tl Thallium 204.38																82 Pb Lead 207.29																83 Bi Bismuth 208.98																84 Po Polonium (209)																85 At Astatine (210)																86 Rn Radon (222)															
87 Fr Francium (223)																88 Ra Radium (226)																89-103 Actinides																104 Rf Rutherfordium (261)																105 Db Dubnium (262)																106 Sg Seaborgium (263)																107 Bh Bohrium (264)																108 Hs Hassium (265)																109 Mt Meitnerium (266)																110 Ds Darmstadtium (267)																111 Rg Roentgenium (268)																112 Cn Copernicium (269)																113 Nh Nihonium (270)																114 Fl Flerovium (271)																115 Mc Moscovium (272)																116 Lv Livermorium (273)																117 Ts Tennessine (274)																118 Og Oganesson (274)															

57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.05	71 Lu Lutetium 174.97
89 Ac Actinium (227)	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (260)

Kuipers, J., Giepmans, B.N.G. Neodymium as an alternative contrast for uranium in electron microscopy. *Histochem Cell Biol* 153, 271–277 (2020). <https://doi.org/10.1007/s00418-020-01846-0>

Thank you for listening!

QUESTIONS?