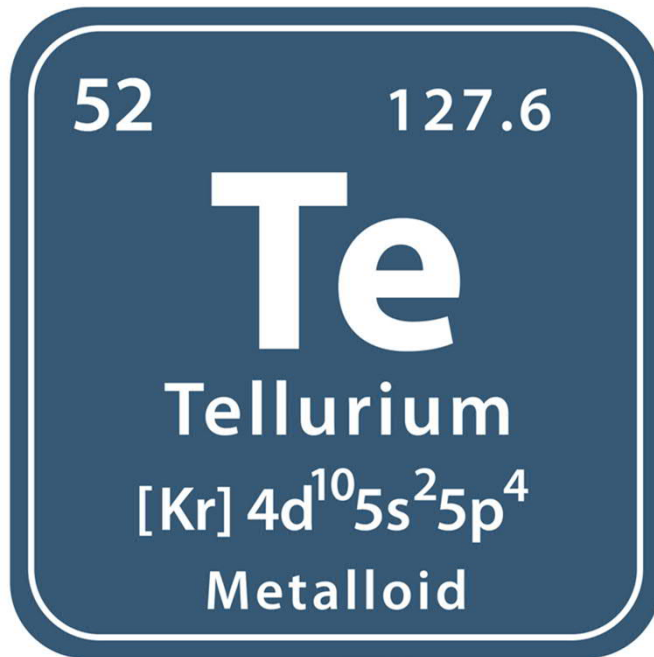


Tellurium



ChemistryLearner.com

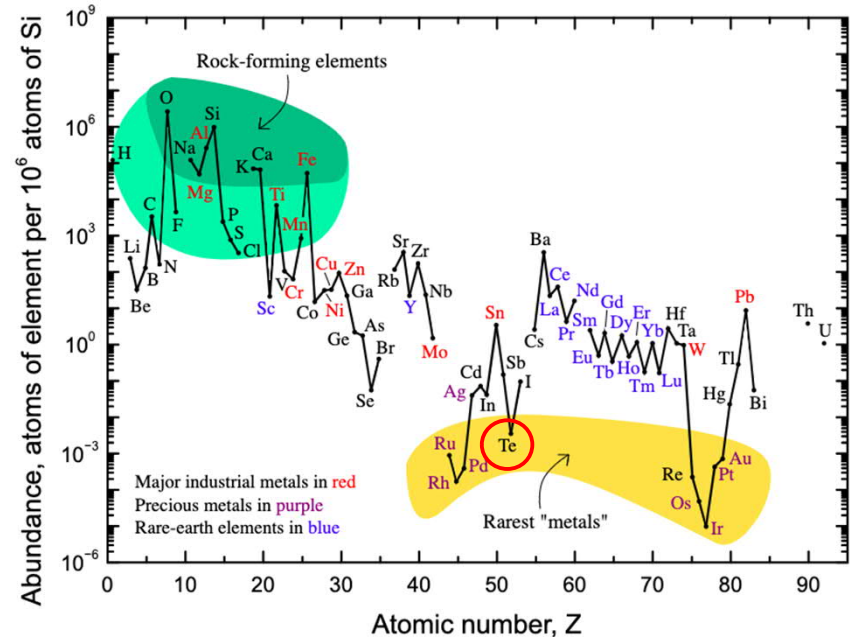
Tellurium

- Discovered in 17th century in Romania
- Name refers to earth (latin "tellus")
- Silvery-white appearance
- Brittle & easily pulverised
- Indicates varying conductivity with crystal alignment and increases with light exposure
- Can be doped with silver, copper, gold, tin, or other elements.
- Tellurium has no biological role.
- All tellurium compounds are highly toxic



Abundance and production

- One of the rarest elements on earth, but not as rare in the universe
- Crustal abundance 1 ppb
- Eight stable isotopes, most common Te-128, Te-130
- Mainly produced in China, Japan, Russia, Sweden (2019)
- Largest sources of tellurium is as a by-product of copper and lead production.
- Main applications: metallurgy, and semiconductor and electronics industry



References: Royal Society of Chemistry, website,
<https://www.rsc.org/periodic-table/element/52/tellurium>,
U.S. Geological Survey, Mineral Commodity Summaries, January 2020
<https://pubs.usgs.gov/periodicals/mcs2020/mcs2020-tellurium.pdf>
Image: Gordon B. Haxel, Sara Boore, and Susan Mayfield from USGS

Chemistry

- Metalloid
- Electron configuration:
 $[\text{Kr}] 4d^{10} 5s^2 5p^4$
- Oxidation states -2, +2, +4 and +6
- Atomic radius 137 pm
Ionic radius 221 pm (Te^{2-})

The image shows a periodic table with the element Tellurium (Te) highlighted in a green box. The box contains the atomic number 52, the symbol Te, and the name Tellurium. Below the box, the atomic weight 127.60 is displayed. The periodic table is color-coded by groups, and the highlighted element is located in the 52nd position.

1 H Hydrogen 1.008	2 He Helium 4.003																
3 Li Lithium 6.941	4 Be Beryllium 9.012	5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180										
11 Na Sodium 22.990	12 Mg Magnesium 24.305	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.948										
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 52.00	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.94	43 Tc Technetium 98	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.905	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.757	52 Te Tellurium 127.60	53 I Iodine 126.905	54 Xe Xenon 131.29
55 Cs Cesium 132.905	56 Ba Barium 137.327	57-71 Lanthanides	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.222	78 Pt Platinum 195.084	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.384	82 Pb Lead 207.2	83 Bi Bismuth 208.980	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 266	107 Bh Bohrium 264	108 Hs Hassium 277	109 Mt Meitnerium 268	110 Ds Darmstadtium 271	111 Rg Roentgenium 272	112 Cn Copernicium 285	113 Nh Nihonium 284	114 Fl Flerovium 289	115 Mc Moscovium 288	116 Lv Livermorium 293	117 Ts Tennessine 289	118 Og Oganesson 294
89 La Lanthanum 138.905	90 Ce Cerium 140.12	91 Pr Praseodymium 140.908	92 Nd Neodymium 144.24	93 Pm Promethium 145	94 Sm Samarium 150.36	95 Eu Europium 151.964	96 Gd Gadolinium 157.25	97 Tb Terbium 158.925	98 Dy Dysprosium 162.50	99 Ho Holmium 164.930	100 Er Erbium 167.259	101 Tm Thulium 168.934	102 Yb Ytterbium 173.054	103 Lu Lutetium 174.967			
101 Ac Actinium 227	102 Th Thorium 232.038	103 Pa Protactinium 231.036	104 U Uranium 238.029	105 Np Neptunium 237.048	106 Pu Plutonium 244.064	107 Am Americium 243.061	108 Cm Curium 247.070	109 Bk Berkelium 247.070	110 Cf Californium 251.083	111 Es Einsteinium 252.083	112 Fm Fermium 257.103	113 Md Mendelevium 258.103	114 No Nobelium 259.103	115 Lr Lawrencium 260.103			

Reference: Royal Society of Chemistry, website, <https://www.rsc.org/periodic-table/element/52/tellurium>

Image: <https://www.shutterstock.com/video/clip-1016995108-periodic-table-52-tellurium-element-sign-position>

COMPOUNDS

- Tellurium burns in oxygen and forms the dioxide (TeO_2)
- TeO_2 is unaffected by hydrochloric acid, but nitric acid oxidizes it to tellurous acid (H_2TeO_3).
- H_2TeO_3 reacts with the halogens to form halides.
- It also combines with most metals at high temperatures to form tellurides.
- No single use has been developed that creates a large demand.



Reference: Encyclopedia Britannica. (2020) <https://www.britannica.com/science/tellurium>.

Image: https://en.wikipedia-on-ipfs.org/wiki/Pyrotechnic_colorant.html

Compounds	Chemical formula	Color	Special properties	Chemical Applications
Tellurium dioxide	TeO ₂	white & pale yellow powder	amphoteric	reluctant glass former
Hydrogen telluride	H ₂ Te	Colourless gas	garlic odour, degrade at RT	not many uses, highly toxic
Sodium telluride	Na ₂ Te	white powder	sensitive to air	Reagents, organic synthesis



Reference: Tellurium dioxide, 2020

<https://www.guidechem.com/encyclopedia/tellurium-dioxide-dic409921.html>

Encyclopedia Britannica. (2020) <https://www.britannica.com/science/tellurium>.

Image: <https://en.wikipedia.org/wiki/>

Gold and Silver tellurium

- Found in nature from various gold ores
- both gold and silver in its structure
- The most common : Sylvanite AuTe_2
- Known as non-stoichiometric compound.
- It shows metallic conductivity
- Gold telluride Au_3Te_5 :
 - Superconductor at 1.62 K

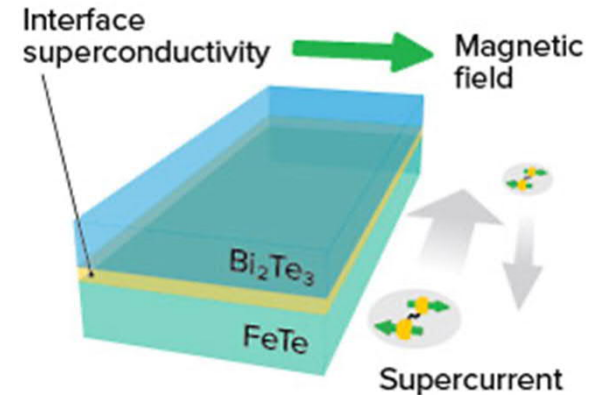


Reference: <https://www.miningmetalnews.com/20190802/1111/demands-tellurium-rare-element-are-rise>

Image: https://en.wikipedia.org/wiki/Gold_chalcogenides

Tellurium thin films

- Thin film grown by thermal vacuum evaporation.
- Sensor technology & photosensitive devices
- Excellent electrical and low thermal conductivity.
- Used in thermoelectric devices either as sources of electricity or for cooling purposes.
- Superconductivity



Reference: T siulyanu, Dumitru. (2011). Tellurium Thin Films in Sensor Technology. 363-. 10.1007/978-94-007-0903-4_38.

Janan H., S., & Abdulkhadhim A. H. (2014). Citeseerx.ist.psu.edu.

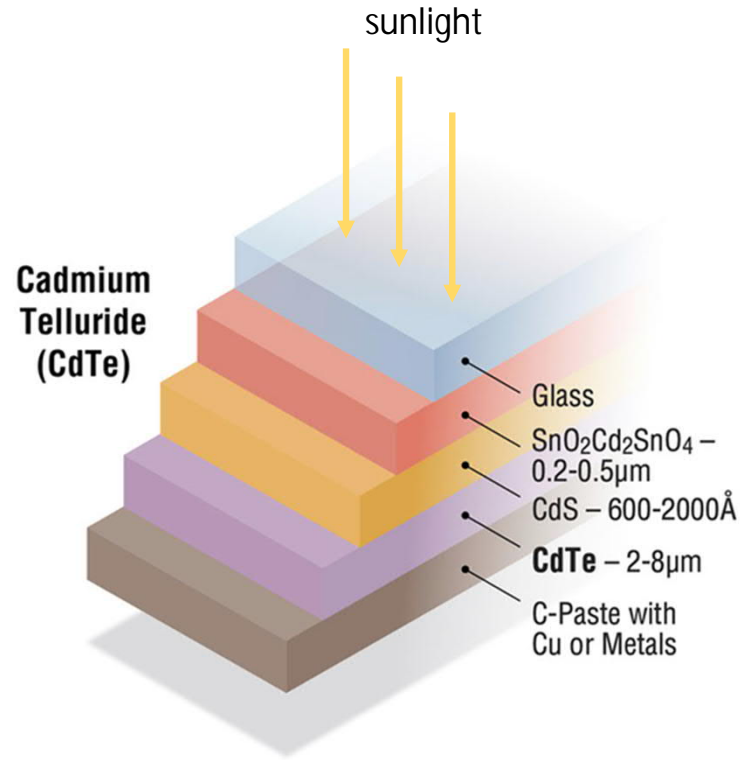
Zhao, C., Tan, C., Lien, DH. *et al.* Evaporated tellurium thin films for p-type field-effect transistors and circuits.

<https://doi.org/10.1038/s41565-019-0585-9>

Image: https://www.riken.jp/en/news_pubs/research_news/rr/20190830_FY20190024/

Cadmium telluride photovoltaics (PV)

- Thin film solar panel technology
- Can commercially compete with Si-based solar cells
 - Good efficiency (Up to 22 %)
 - Low cost
 - High optical absorption coefficient
 - Close to optimal direct band-gap (1.45 eV)
- Thin film techniques: close-spaced vapor transport (CSVT) and close-spaced sublimation (CSS)
- P-type CdTe and n-type CdS form p-n junction
 - The energy of the light can be converted into electricity



References: Bosio, A., Pasini, S., & Romeo, N. (2020). The History of Photovoltaics with Emphasis on CdTe Solar Cells and Modules. *Coatings*, 10(4), 344.

Image: Alfred Hicks/NREL.gov <https://understandssolar.com/thin-film-solar-panels>
Fthenakis, V., Athias, C., Blumenthal, A., Kulur, A., Magliozzo, J., & Ng, D. (2020). Sustainability evaluation of CdTe PV: An update. *Renewable and Sustainable Energy Reviews*, 123, 109776.

Tellurium as a rare element

- Considered as a technology-critical element
- Not used in many different applications (solar 40 %, thermoelectric production 30 %, metallurgy 15 %)
- Tellurium demand will most likely increase as the demand for solar energy increases
- Efficient recycling is important (also mitigate concerns on toxicity)

References: ALS Europe. Website. <https://www.alsglobal.se/en/environment/technology-critical-elements-analysis>

Fthenakis, V., Athias, C., Blumenthal, A., Kulur, A., Magliozzo, J., & Ng, D. (2020). Sustainability evaluation of CdTe PV: An update. *Renewable and Sustainable Energy Reviews*, 123, 109776.

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<https://doi.org/10.1038/s41565-019-0585-9>