

Indium



Aalto-yliopisto
Kemian tekniikan
korkeakoulu

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Table of contents

- 1) What is Indium?
- 2) Chemistry of Indium
- 3) Compounds and Applications

Discovery

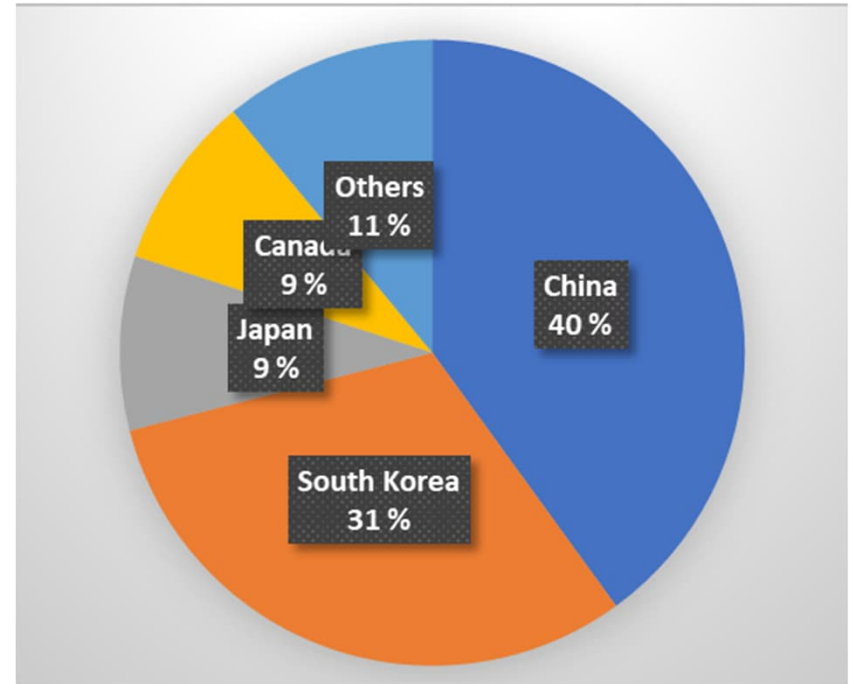
- 1863
- Ferdinand Reich & Hieronymus Richter
- Indicum = Indigo → **Indium**
- "Crying metal"



https://commons.wikimedia.org/wiki/File:Ingot_of_40_grams_of_indium.jpg

Indium on Earth

- Mined along with Zinc
- Indium tin oxide – 45 % of indium usage.
- **Critical applications:** LCDs, touch screens, solar panels, variety of sensors, semiconductors



Data: Royal Society of Chemistry/Chart: Jenna Wallius

Crustal abundance

Indium: 0.052 ppm

Silver: 0.055 ppm

Gold: 0.0013 ppm

(Royal Society of Chemistry)

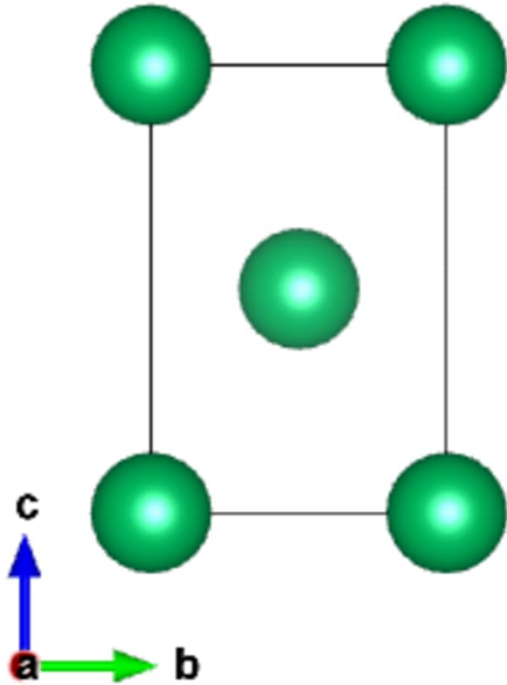
Chemistry

Indium in Periodic Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
1	H Hydrogen 1.008																		2	He Helium 4.0026
2	3 Li Lithium 6.94	4 Be Beryllium 9.0122											5 B Boron 10.81	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		
3	11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminium 26.982	14 Si Silicon 28.085	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948		
4	19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	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 72.630	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798		
5	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 95.95	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		
6	55 Cs Caesium 132.91	56 Ba Barium 137.33	57-71 Lanthanoids	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 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)		
7	87 Fr Francium (223)	88 Ra Radium (226)	89-103 Actinoids	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Sg Seaborgium (269)	107 Bh Bohrium (270)	108 Hs Hassium (277)	109 Mt Meitnerium (278)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (282)	112 Cn Copernicium (285)	113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (290)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)		
	For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.																			
	6 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 (266)					

- **Group:** 13
- **Atomic number:** 49
- **Molar mass:** 114.82 g/mol
- **Electron configuration:** [Kr] 4d¹⁰5s²5p¹

Properties of the element

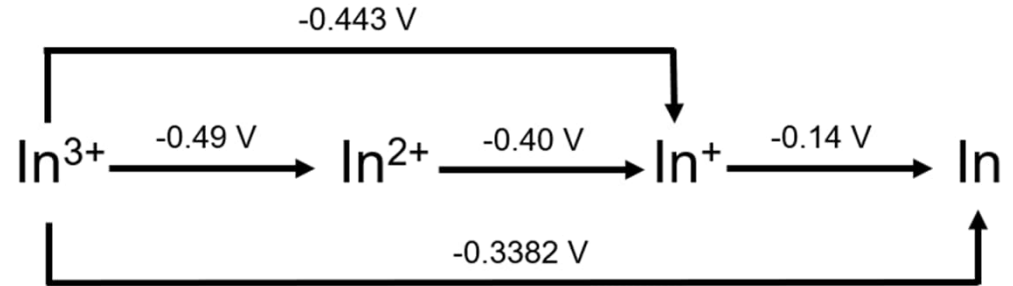


Melting point	156.60 °C	
Hardness (Mohs Brinell)	1.2	8.83 Mpa
Electronegativity	1.78	
Atomic radius	142 pm	
Thermal conductivity	82 W/(m K)	
Electrical conductivity	1.2 · 10 ⁷ S/m (Conductor)	
Critical Temperature	3.41 K	
Magnetism	Diamagnetic	
Crystal structure	Centered tetragonal	
Space group	I4/mmm	

Oxidation states of Indium

Latimer diagram

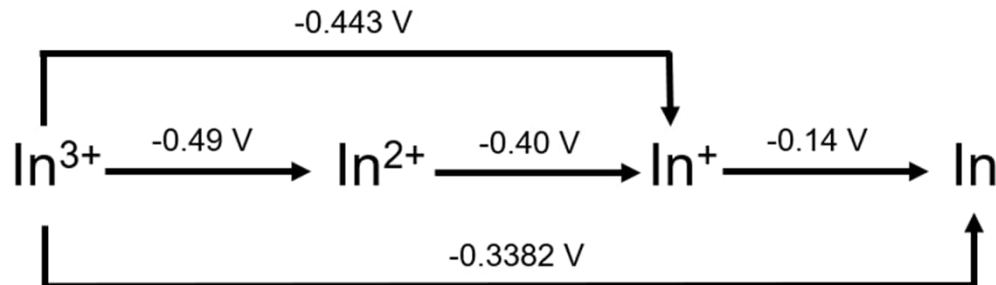
- Possible oxidation states are 0, +1, +2, and +3



Oxidation states of Indium

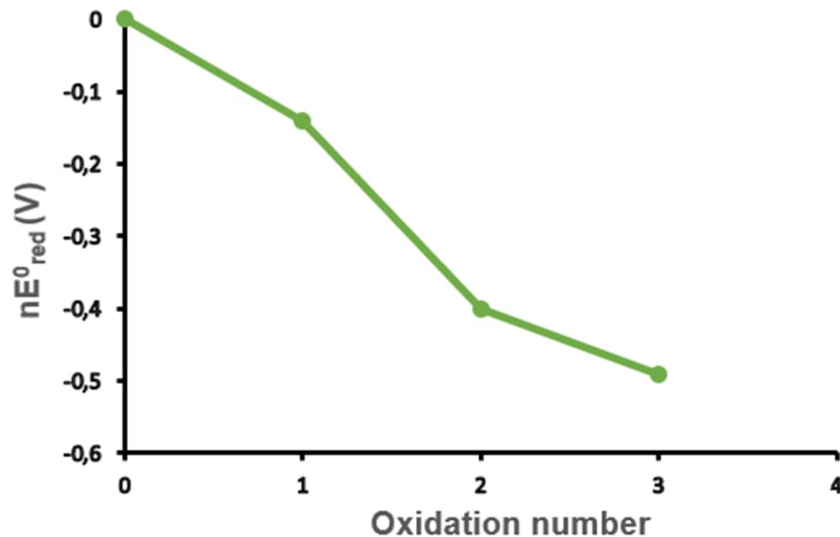
Latimer diagram

- Possible oxidation states are 0, +1, +2, and +3



Frost diagram

- +3 is the most stable oxidation state
- In^{+} tends to disproportionate



Oxidation states of Indium

Indium

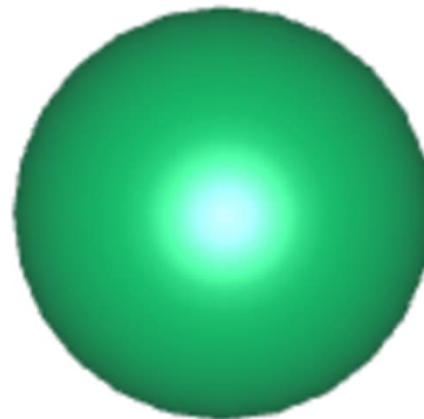
[Kr] 4d¹⁰5s²5p¹



142 pm

Indium(III)

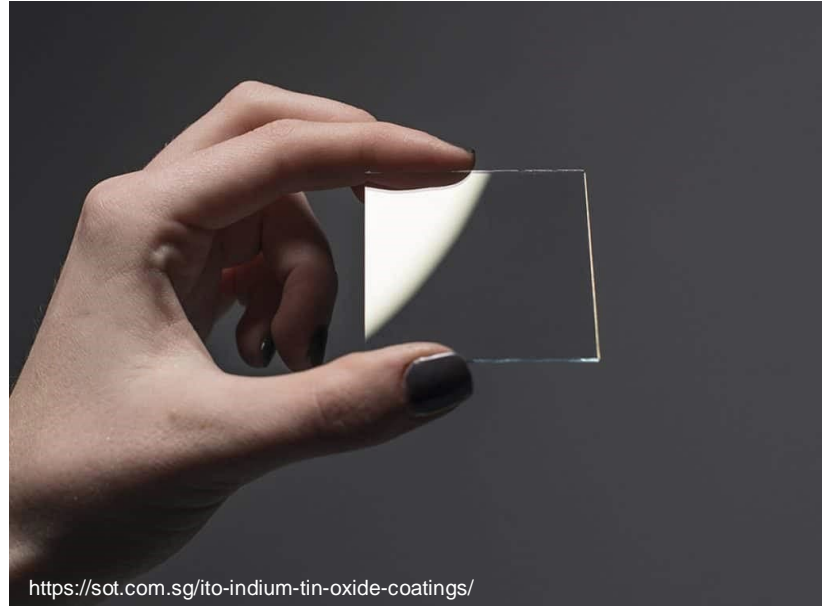
[Kr] 4d¹⁰



94 pm

Compounds and Applications

Indium oxide and Indium tin oxide (ITO)

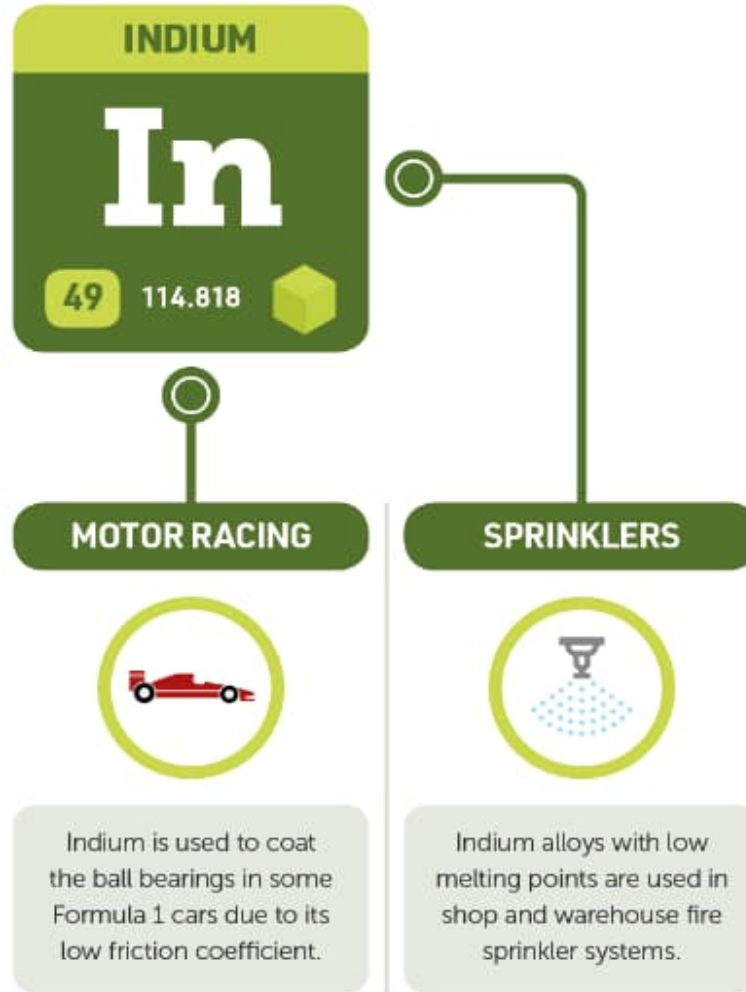


Indium tin oxide (ITO)

in tv screens, touch screens, solar panels and more

- **Large bandgap** → transparency
- **Tin-doped** → conductiveness

Transparency + Conductiveness = Rare combination



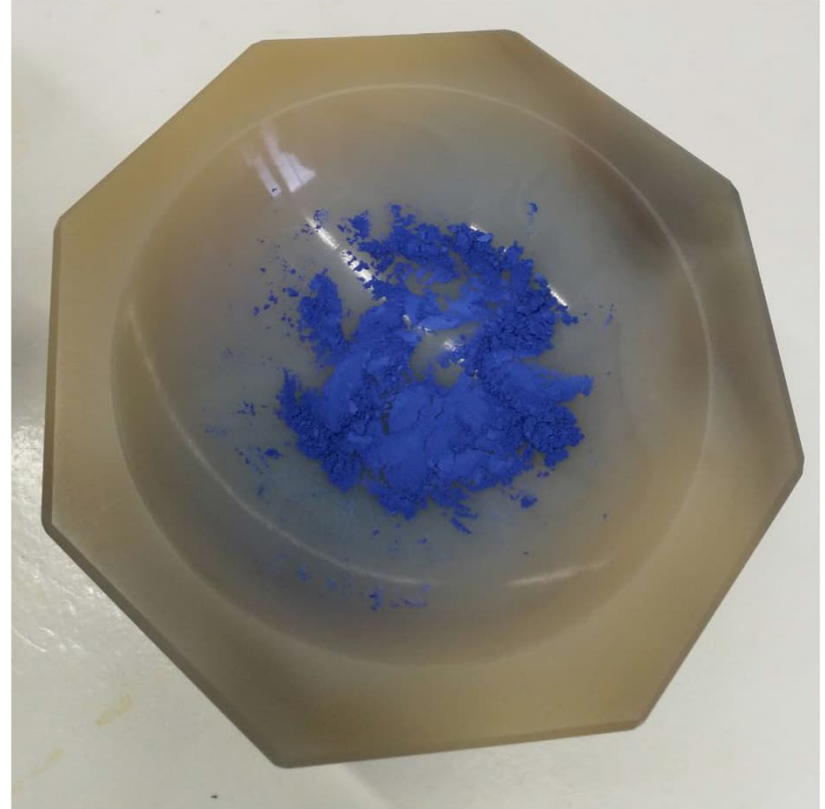
Other applications

Semiconductors:

- InP
- InSb
- InGaN
- InGaAsN

Pigments: $\text{YIn}_{1-x}\text{Mn}_x\text{O}_3$

- Best results with small x values
- Non-toxic
- Laboratory Work in Inorganic Chemistry



Picture: Matilda Antila

Conclusion and Future Aspects

- Indium is rare and soft metal with low melting point
- Many of the In-based compounds are semiconductive
- Indium tin oxide is the most important compound
- Better recycling processes
- Potential replacements (Graphene, silver nanowires..)

Questions?

Sources

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