SYMMETRY

Properties of Some Technical Materials

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1 Periodic Table of Elements

Atomic number of a chemical element, is the number of protons in their nucleus.

The **atomic weight** of an element, is the average relative weight of atom of element referred to atom of carbon 12.

Isotopes are atoms of a element that in the atom's nucleus have the same number of protons, but different number of neutrons. Isotopes have the same atomic number but different atomic weight.

Periodic law states that properties of elements are approximatively periodic functions of their atomic numbers. See the diagrams below.

Elements of a column have a similar properties.

Elements along row gradually change properties.

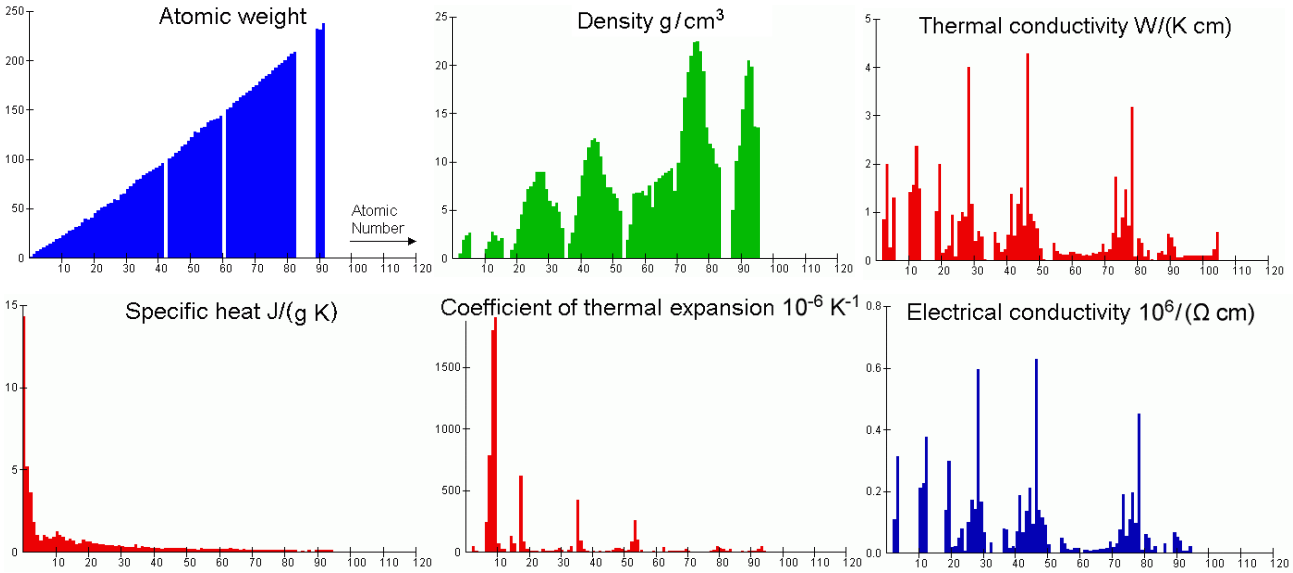
Periodic Table of Elements

Metals
Transition Metals
Alkali Earth Metals
Alkali Metals
Actinide Metals
Lanthanide Metals
Non-Metals
Halogens
Noble Gases

Atomic number
Atomic weight

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.0079																	2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.18
11 Na 22.99	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.066	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.88	23 V 50.941	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.693	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.8
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc (97.91)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.6	53 I 126.9	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261.1)	105 Db (262.1)	106 Sg (263.1)	107 Bh (262.1)	108 Hs (265.1)	109 Mt (266.1)	110 Uun (269)	111 Uuu (272)	112 Uub (277)						

Lanthanide Series	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (144.9)	62 Sm 150.36	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.5	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
Actinide Series	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244.1)	95 Am (243.1)	96 Cm (247.1)	97 Bk (247.1)	98 Cf (251.1)	99 Es (252.1)	100 Fm (257.1)	101 Md (258.1)	102 No (259.1)	103 Lr (262.1)



2 Elements

Properties at 20 ºC.

Element	Melting point (ITS-90) [°C]	Density [g/cm^3]	Tensile strength [MPa]	Young's modulus [3] [GPa]	Thermal conductivity [W/(K cm)]	Specific heat [J/(g K)]	Linear thermal expansion [10^{-6} K^{-1}]	Volume specific resistivity [µΩ m]	Temperature coefficient of resistivity [10^{-6} K^{-1}]	Standard reduction potential, E^O [V] [4]
Aluminum (Al)	**660.323** FP [1]	2.702	47.4 annealed	69	2.37 (2.21..2.51)	0.90	23.1	0.02826 pure 0.02655 99.99 %	4290	-1.66
Antimony (Sb)	630.7	6.684	11	78	0.243	0.21	8.46..11.4	0.3918	3600	+0.1
Bismuth (Bi)	271.3	9.8		31.7	0.0787	0.12	13.4	1.07..1.19	4000	+0.2
Carbon (C)	3825 sublimes	2.62		7.10	1.29 0.057 graphite	0.71	0.54..4.32	7.837 graphite	-500	
Chromium (Cr)	1857	7.19		248	0.937	0.45	6.1..8.2	0.1959	3000	-0.7
Copper (Cu)	**1084.62** FP	8.96	351 cold-drawn	117	4.01	0.38	16.6	0.0166 0.0171 electrolitic	**4270**	+0.34, +0.52
Gold (Au)	**1064.18** FP	19.32	124 cast	74	3.17	0.128	14.2	0.02463	3900	+1.50
Indium (In)	**156.5985** FP	7.31	2.62	10.8	0.816	0.23	25..33	0.0837	4700	
Iron (Fe)	1535	7.86	200..275	197	0.802	0.44	11.7	0.09579	6510	-0.44
Lead (Pb)	327.5	11.34	21	13.8	0.353	0.13	29.3	0.198..0.219	3360	-0.126
Mercury (Hg)	**-38.8344** TP [2]	**13.546** **13.534** @ 25ºC		22.1	0.0834	0.139	49	0.9579	900	+0.798
Molybdenum (Mo)	2617	10.2	690 sintered	276	1.38	0.25	5.4	0.0477.. 0.0517	ca 4000	
Nickel (Ni)	1453	8.90	482 annealed	214	0.907	0.44	12.8	0.09579 "A"	**6180**	-0.25
Palladium (Pd)	1552	12.02		127.1	0.718	0.24	11.9	0.1078	3770	+0.987
Platinum (Pt)	1772	21.45	120..130 annealed	147	0.716	0.13	8.8	0.0983..0.106 0.1486 commercial	**3927**	+1.2
Silicon (Si)	1410	2.33		110	0.83..1.48	0.71	2.15	2300 Ω m intrinsic	650 polycrystal	
Silver (Ag)	**961.78** FP	10.5	147..196	72	4.29	0.235	18.9..19.6	0.0147..0.0164	4100	+0.799
Tantalum (Ta)	2996	16.6		186	0.575	0.14	6.5	0.1240	3830	
Tin (Sn)	**231.928** FP	7.30	21.4 cast	41.4	0.666	0.227	20..25	0.1149	4700	-0.140
Titanium (Ti)	1658..1678	4.50	589..785	110	0.219	0.52	8.5	0.556..0.784	3500	-1.63
Tungsten (W)	3390..3430	19.3	3920	345	1.74	0.13	4.2..4.5	0. 0548..0.0551	**4600**	
Zinc (Zn)	**419.527** FP	7.14	134..160 hot-roled	83	1.16	0.39	17..40	0.05945 0.06158 roled	4190	-0.763

[1] FP: Freezing point. [2] TP: Triple point. [3] Greater number means smaller elasticity. [4] Electrochemical potential; at 25 ºC; greater number means more chemical inactivity.

3 Metal Alloys

Properties at 20 ºC.

Alloy	Melting point [°C]	Density [g/cm^3]	Tensile strength (ca) [MPa]	Young's modulus [3)] [GPa]	Broadest temperature range, continuous duty [°C]	Thermal conductivity (ca) [W/(K cm)]	Specific heat [J/(g K)]	Linear thermal expansion [10^{-6} K^{-1}]	Volume specific resistivity (ca) [µΩ m]	Temperature coefficient of resistivity [10^{-6} K^{-1}]
Aluminium alloys	587..642	2,7..2,8	60..670	71		1,3..1,8		20..24	0.029..0.14	
Brass (Cu-Zn)	ca 900	8.4..8.6	150..640	90	-20.. 250	0.9.. 2.3	0.34.. 0.48	18..21	0.047.. 0.14	170..2000
Bronze (Cu-Sn)	930..1060	7.8.. 8.9	147..820	ca 120	..400	0.21.. 0.85	0.25.. 0.42	18	0.036.. 0.25	
Constantan (Cu55-Ni45)	1270	8.9	400..500 annealed		..900	ca 0.4	0.41	15	0.45.. 0.52	-20..+60
Invar (Fe64-Ni36)	1500			148		0.11		1.5..1.7	0.46	
Kanthal A-1 (Fe-Cr-Al-Co)	ca 1500	7.10	750	275	..1375	0.16	0.46	11 @ <250 °C 15 @ <1000 °C	1.452	ca 5 <100 @ <1375 °C
Manganin (Cu-Mn12-Ni2)	960	8.4	390		..140	0.22	0.41	18	0.43	-10..+10
Solder Ag25-Cu41-Zn34	700..800	8.8	380							
Solder Ag44-Cu30-Zn26	675..735	9.1	400							
Solder Bi49-Pb18-Sn12-In21 (eutectic)	58	8.6	43.4					23		
Solder Sn-Pb37 (eutectic)	183	8.4	27..40	30.2		0.39.. 0.51	0.167	19..25	0.14	ca 3850
Solder Sn-Bi58 (eutectic)	138	8.6	60	12				14		
Solder Sn-In52 (eutectic)	118		11.9					20		
Steel stainless 304 (Fe72-Cr19-Ni9-Mn)		7.9	500..700 74 @ 600 °C	105	..900	0.135	0.51	17	0.6891.. 0.6897	ca 1160
Steel stainless 316 (Fe70-Cr17-Ni11-Mo2-Mn)		7.9	500..750 107 @ 600 °C	110	..900	0.15	0.51	16.5	0.750.. 0.767	ca 890
Steel	1400..1540	7.85	400..2000	ca 210	..(400..1000)	0.47	0.485	11.7..12.0	0.1..0.8	ca 7000

4 Non-Metals

Properties at 20 °C.

Material	Melting point [°C]	Density [g/cm^3]	Tensile strength [MPa]	Young's modulus [3] [GPa]	Broadest temperature range continous duty [°C]	Thermal conductivity [W/(K cm)]	Specific heat [J/(g K)]	Linear thermal expansion [10^{-6} K^{-1}]	Water absorption [%]	Volume specific resistivity [Ω m]	Surface specific resistivity [Ω]	Relative dielectric constant	Dielectric loss factor, tan δ [5] @50 Hz	Breakthrough voltage @50 Hz [kV/cm]
Air ($N_2$78-$O_2$21-Ar1-CO_2-Ne-He-CH_4-Kr)	-213	0.00129				0.00025	0.9969	ca 1200	1.5 2.7@30°C			1.000594	$4 \cdot 10^{-6}$	**28.6** two spheres
Aluminium oxide ≥99.5 % (Al_2O_3)	2050	3.9.. 4.0	172.. 267	350.. 416	..1725	0.28.. 0.33	0.725.. 0.785	4.6.. 8.4	0.0	10^{13}.. 10^{15}		9.5.. 10.1	0.2	320 @ 0,25 mm
Beryllium oxide 99.5 % (BeO)	2530	2.9	170.. 275	300.. 355	..1850	1.15.. 2.80	1.1	2.4.. 6.5		10^{11}.. 10^{14}		6.4.. 6.7		100.. 315
Epoxy (EP)		0.70.. 2.3	16.. 80	30	-(70..20).. (80..265)	0.001.. 0.014	1.6.. 2.1	6.. 70	0.003.. 0.7	10^{11}.. $5 \cdot 10^{14}$		3.0.. 6.4	0.01.. 0.05	120.. 180
Epoxy-glass FR4, FR5		1.8.. 1.9	220.. 250	7.. 17	..120	0.0016.. 0.017	0.9.. 1.1	10..20 xy 40..300 z	0.1	10^{10}.. 10^{12}	10^{12}.. 10^{13}	4.2.. 4.9	<0.035	
Ferrite (Fe_2O_3-Ni-Zn, ...Mn-Zn, ...Li-Zn)		3.8.. 5.1	ca 20	ca 150	..(70.. 950)	0.033.. 0.063	ca 1	5.. 12		0.05.. 10^8				
Glass		2.2.. 3.0	15..90		..(110.. 500)	0.0039.. 0.015	0.9	0.55.. 12.4		>10^6.. <10^{16}		2.. 17	0.003.. 0.09	>100
Glass, borosilicate	ca 1200	2.22.. 2.5		57.. 88	..500	0.009.. 0.015 @ 0..400 °C	0.85	2.2.. 10 @ 0..300 °C		10^{12} >10^8 @ 0..300 °C	10^{14}	4.. 6.3	0.003.. 0.01	140.. 450
Mica	1260.. 1290	2.6.. 3.2	250.. 400		..(500.. 1000)	0.0035.. 0.0071	0.5.. 0.84	8.5.. 48.6		10^9.. 10^{15}		5.. 7.5	0.0002.. 0.020	250.. >800
Paper		0.2..1.2			..110	0.0014	1.4		3..9 content	>10^{13}		1.5..2.6	0.0001	60..90
Polymethyl methacrylate (PMMA, Acrylic)	>200	1.18.. 1.19	56.. 70	1.2.. 3.3	-50.. 100	0.0014.. 0.00195	1.2.. 1.7	50.. 100	0.1.. 2	10^{10}.. $1.1 \cdot 10^{13}$	10^{12}.. 10^{14}	3.6 @ 50 Hz 2.6 @ 1 MHz	0.06 <0.02 @ 1 MHz	150.. 250
Polyamide (PA, Nylon)	175.. 265	1.0.. 1.5	17.. 100	0.29.. 5.5	-40.. (100..110)	0.0020.. 0.0030	1.2.. 2.6	80.. 450	0.4.. 9.5	>10^{10}.. 10^{12}	10^{10}.. $6 \cdot 10^{12}$	3.0..6 @ 1 MHz	0.014.. 0.05@1MHz	200.. 500
Polycarbonate (PC)	280.. 345	1.2.. 1.5	55.. 75	1.6.. 2.4	-135.. (95..154)	0.0021	1.2.. 1.7	12.. 100	0.1.. 0.5	$8.2 \cdot 10^{14}$	10^{14}	3.2	0.0075 @ 1 MHz	150.. 420
Polyethylene terephthalate (PETE, Polyester, PET)	250.. 265	1.1.. 1.7	57.. 75	2.5.. 3.1	-70.. (63..150)	0.0015.. 0.0024	1.0.. 2.3	60	0.2.. 0.5	10^9.. 10^{14}	10^{14}	3.1.. 4	0.002	>420.. >5000

[5] For capacitor equivalent circuit with paralel R and C: $\tan \delta = |I_R| / |I_C|$.

Material	Melting point [°C]	Density [g/cm^3]	Tensile strength [MPa]	Young's modulus [3] [GPa]	Broadest temperature range continous duty [°C]	Thermal conductivity [W/(K cm)]	Specific heat [J/(g K)]	Linear thermal expansion [10^{-6} K^{-1}]	Water absorption [%]	Volume specific resistivity [Ω m]	Surface specific resistivity [Ω]	Relative dielectric constant	Dielectric loss factor, tan δ [5] @50 Hz	Breakthrough voltage @50 Hz [kV/cm]
Polyethylene HD (PE-HD)	125..137	0.94..0.97	10..50	0.18..1.6	-60..90	0.0036..0.0050	1.8..2.3	140..400	<0.02	10^{14}..10^{15}	>10^{13}..10^{18}	2.1..2.4 @ 100 kHz	0.0004 @ 1 MHz	>200..1000
Polyethylene LD (PE-LD)	108	0.91..0.93	7..25	0.15..0.35	-60..70	0.003..0.004	2.2..2.3	190..600	<0.004	10^{14}..10^{15}	10^{14}..>10^{15}	2.2..2.3 @ 800 Hz	0.0003 @ 1 MHz	>200..750
Polyimide (PI)		1.4..1.6	72..90	1.3..4.0	-190..(280..360)	0.0035	1.0..1.5	13..45	0.24..1.0	10^{14}..10^{15}	>10^{15}	3.4..3.6		220..1500
Polypropilene (PP)	175..200	0.90..0.93	25..33	1.2..1.5	-30..(90..100)	0.0018..0.0023	1.7..2.2	100..400	0.01..0.1	10^{15}..10^{17}	>10^{13}	2.2..2.4 @ 100 kHz	>0.0003 @ 1 MHz	300..900
Polystirene (PS)	>180	1.0..1.2	19..50	1.8..3.5	-70..(55..85)	0.0013..0.0016	1.2..1.7	50..150	0.03..0.5	10^{13}..>10^{15}		2.4..2.5	<0.0004	250..1000
Polytetra-fluoroethylene (PTFE, Teflon)	327 amorphous gel	0.8..2.2	17..27	0.70..8.4	-260..260	0.0023..0.0047	0.97	4..190 13000 @ 19 °C	<0.01..0.029	10^{15}..>10^{18}	5·10^{14}..10^{17}	2.1..3.4 @ 50 Hz..1 MHz	<0.006 @ 50 Hz..1 MHz	>200..800
Polyurethane (PUR)	185	1.2	30		-(50..40)..(90..165)	0.002	1.1	65..450	0.5..0.65	2 · 10^{12}		3.2..6.2	0.005..0.05	>170..200
Polyvinil chloride (PVC)	>170	1.1..1.5	28..58	2.5..3.0	-(50..10)..(50..70)	0.0012..0.0017	2.1..2.6	60..150	<0.1..0.6	10^{10}..5 · 10^{13}		3.5..4.5	0.01..0.02 0.047@1MHz	100..750
Porcelain		2.3..2.5	30..50			ca 0.014	0.9	ca 3		10^{9}..10^{12}		4.5..7.0	0.0018..0.03	300..400
Quartz (SiO_2)	1710..1750	2.2 vitre. 2.65 cristal	80..110	69..72.5	..800	0.001 0.08 ⊥.. c 0.15 ∥.. c	0.728 vitreous	0.57 vitre. 7.1..8.0 ∥ 13.2..14.4 ⊥		10^{16}		3.8..4.7	0.0020..0.0050 @ 1 MHz	200..4400
Rosin	120..135	1.0..1.1			..80		1.2			>10^{13}		2.5..3	0.002..0.008	100..150
Rubber		1.2			..(80..250)	ca 0.002	1.42	ca 20		..>10^{13}		3..7	<0.1	100..500
Silicone oil	-93..-22	0.85..1.1			..(40..300)	ca 0.002	ca 1.5	ca 300		10^{12}.. 10^{14}		2.2..2.8	<0.0003	100..250
Water, deionized	**0.010** TP (ITS-90)	**0.998272 0.997113** @ 25 °C				0.00597	4.182 (2.0 ice)	70		**238500** (UPW).. ca 33000		81.07 (2.0..3.0 ice)	18.59.. ca 133	
Wood		0.13..1.3	8..20			0.00050..0.0012	1.7..3	3..10 ∥ ca 60 ⊥	..65	10^{5}..10^{12}	10^{8}..10^{15}	1.4..6.5	0.02..0.5	10..70

5 Electrochemical Voltages Between Metals

Magnesium, magnesium alloys	Zinc, zinc alloys	Sn80-Zn20 on steel, Zn on iron or steel	Aluminium	Cd on steel	Al-Mg alloy	Mild steel	Duralumin	Lead	Cr on steel, soft solder	Cr on Ni on steel, Sn on steel, Cr12 stainless steel	High Cr stainless steel	Copper, copper alloys	Silver solder, austenitic stainless steel	Ni on steel	Silver	Rh on Ag on Cu, Ag–Au alloys	Carbon	Gold, platinum	
0.00	0.05	0.55	0.70	0.80	0.85	0.90	1.00	1.05	1.10	1.15	1.25	1.35	1.40	1.45	1.60	1.65	1.70	1.75	Magnesium, magnesium alloys
	0.00	0.05	0.20	0.30	0.35	0.40	0.50	0.55	0.60	0.65	0.75	0.85	0.90	0.95	1.10	1.15	1.20	1.25	Zinc, zinc alloys
		0.00	0.15	0.25	0.30	0.35	0.45	0.50	0.55	0.60	0.70	0.80	0.85	0.90	1.05	1.10	1.15	1.20	Sn80-Zn20 on steel, Zn on iron or steel
			0.00	0.10	0.15	0.20	0.30	0.35	0.40	0.45	0.55	0.65	0.70	0.75	0.90	0.95	1.00	1.05	Aluminium
				0.00	0.05	0.10	0.20	0.25	0.30	0.35	0.45	0.55	0.60	0.65	0.80	0.85	0.90	0.95	Cd on steel
					0.00	0.05	0.15	0.20	0.25	0.30	0.40	0.50	0.55	0.60	0.75	0.80	0.85	0.90	Al-Mg alloy
						0.00	0.10	0.15	0.20	0.25	0.35	0.45	0.50	0.55	0.70	0.75	0.80	0.85	Mild steel
							0.00	0.05	0.10	0.15	0.25	0.35	0.40	0.45	0.60	0.65	0.70	0.75	Duralumin
								0.00	0.05	0.10	0.20	0.30	0.35	0.40	0.55	0.60	0.66	0.70	Lead
									0.00	0.05	0.15	0.25	0.30	0.35	0.50	0.55	0.60	0.65	Cr on steel, soft solder
										0.00	0.10	0.20	0.25	0.30	0.45	0.50	0.55	0.60	Cr on Ni on steel, Sn on steel, Cr12 stainless steel
											0.00	0.10	0.15	0.20	0.35	0.40	0.45	0.50	High Cr stainless steel
												0.00	0.05	0.10	0.25	0.30	0.35	0.40	Copper, copper alloys
													0.00	0.05	0.20	0.25	0.30	0.35	Silver solder, austenitic stainless steel
														0.00	0.15	0.20	0.25	0.30	Ni on steel
															0.00	0.05	0.10	0.15	Silver
																0.00	0.05	0.10	Rh on Ag on Cu, Ag–Au alloys
																	0.00	0.05	Carbon
																		0.00	Gold, platinum

Corrosion due to electrochemical action between dissimilar metals which are in contact, is minimised if the combined electrochemical voltage is below about 0.6 V. In above table the combined electrochemical voltages are listed for a pairs of metals in common use. Shaded pairs should be avoided.

6 Thermoelectric Voltage of Various Materials

in Junction With Platinum (Pt) Near 20 ºC

For junctions made of two arbitrary metals A and B, the thermoelectric voltage is: $U_{A-B} = U_{A-Pt} - U_{B-Pt}$.

Material	Potential [µV/°C]
WO_3	-740
FeO	-500
FeS_2	-200
PbS	-160
SnO	-140
Bismuth	-64..-72
Constantan (Cu55-Ni45)	**-34.0**
Nickel	-15.2
Cobalt	-15.2
Alumel (Ni95-Al2-Mn-Si)	**-12.0**
Potassium	-9.2
Rhodium	-6.4
CuS	-3
Palladium	**-2.8**
Sodium	-2

Material	Potential [µV/°C]
Platinum	**0.00**
Mercury	0.0..0.6
Carbon	3
Aluminum	3..4
Tin	4.2
Lead	4.4
Tantalum	4.5
thermocouple Pt-Rh	**6.5**
Gold	**6.77**
Manganin	6.9
Silver	7.2
Solder Cd60-Sn40	ca 7.5
Zinc	7.5
Copper	**7.5**
Tungsten	7.7

Material	Potential [µV/°C]
Cadmium	ca 8
Solder Sn-Pb	8.5..10.5
Molybdenum	12
Iron	**18.8**
Nichrome (Ni80-Cr20)	**20.0**
Chromel (Ni90-Cr10)	**29.5**
FeS	30
Antimony	47
Kovar	48
NiO	244
Germanium	307
Silicon	412
Tellurium	500
Selenium	1000
Cu_2O	1200

7 Costs of Some Materials

Metal	Price per kg May 2005		Density [g/cm^3]	Price per cm^3 May 2005	
	[$]	Normalized (Pb: 1)		[$]	Normalized (Pb: 1)
Aluminium, primary	1.75	1.84	2.70	0.00473	0.438
Copper	3.10	3.26	8.92	0.0277	2.57
Glass	ca 1.4	ca 1.5	2.5	ca 0.0036	ca 0.33
Gold	13550.	14263.	19.32	262.	24282.
Iron	ca 0.13	ca 0.14	7.9	ca 0.00105	ca 0.097
Lead	0.95	1.00	11.36	0.01079	1.000
Nickel	16.13	16.98	8.90	0.1436	13.31
Platinum	30620.	32232.	21.45	657.	60890.
Polypropilene	0.92	0.97	0.91	0.00084	0.0776
Silver	ca 428.	ca 450.	10.5	ca 4.5	ca 417.
Steel, stainless	ca 2.9	ca 3.1	7.9	ca 0.023	ca 2.13
Tin	8.05	8.47	7.31	0.0588	5.45
Zinc	1.25	1.31	7.14	0.00893	0.828

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