

Nanotechnology: What's All the Buzz About

Nanotechnology is the science and technology of small things – in particular things that are less than 100nm in size. One nanometer is 10^{-9} or one billionth of a meter. Scientists have discovered that materials at small dimensions-small particles, thin films, etc., can have significantly different properties than the same materials at larger scale. There are endless possibilities for improved devices, structures, and materials if we can understand these differences, and learn how to control materials and structures at the nanoscale. There are different views of what is included in nanotechnology but most agree that three things are important: 1) Small size – 1 to 100 nanometers or less, 2) Unique properties because of the small size, and 3) Ability to control the structure and composition in order to control these properties.

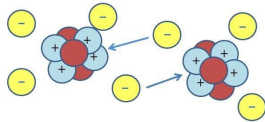
Examples of How Properties Change at the Nanoscale

Optical Properties: Bulk gold appears yellow in color- Nanosized gold appears as different colors depending on particle size. Many other materials behave similarly. The ability to change the optical properties of materials is a powerful tool in the development of nanotechnology products

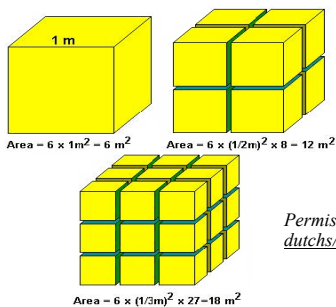


Douma, M., curator. (2008). Gold. In Cause of Color. Retrieved 1/30/2012, <http://www.webexhibits.org/causesofcolor/3.html>.

Forces: gravitational forces become negligible and electromagnetic forces dominate.



Surface Area to Volume Ratio: For smaller particles, a greater proportion of material is exposed on the surface. This becomes even more important in the nanoscale, where a large fraction of the atoms become "surface atoms" where they are more accessible to chemical reactions



Permission granted by S. Dutch; <http://www.uwgb.edu/dutchs/EarthSC202Notes/ROCKCYCL.HTM>

More Nanotechnology Resources
www.nnin.org/education-training
Learn more about Nanotechnology
www.nanooze.org

Allotropes of Carbon

Graphite – atomic planes slide easily over each other making it a natural lubricant.

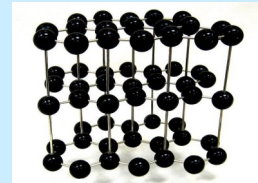


Image courtesy
Cochise College

of R.Weller/

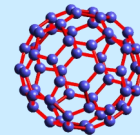
Diamond –
rally occur-
stance



hardest natu-
ring sub-

Image courtesy of R.Weller/Cochise College

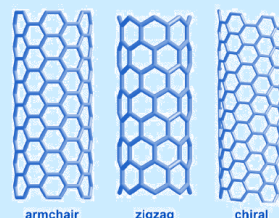
**Buckminster-
nicknamed
"bucky ball"**



fullerene C₆₀ –

Image at US DOE: <http://www.osti.gov/accomplishments/smalley.html>

**Carbon
100
er
than steel**



**nanotubes –
times strong-**

Reference ♦ PHYSICAL SCIENCE ♦ Information

Acceleration = $\frac{\text{final velocity} - \text{initial velocity}}{\text{time}}$ ($a = \frac{v_f - v_i}{t}$)

Speed = $\frac{\text{distance}}{\text{time}}$ ($v = \frac{d}{t}$)

Density = $\frac{\text{mass}}{\text{volume}}$ ($D = \frac{m}{V}$)

Force = mass x acceleration ($F = ma$)

Power = $\frac{\text{work}}{\text{time}}$ ($P = \frac{W}{t}$)

Work = force x distance ($W = Fd$)

Mechanical advantage = $\frac{\text{effort distance}}{\text{resistance distance}}$ ($MA = \frac{d_e}{d_r}$)

Efficiency = $\frac{\text{work out}}{\text{work in}}$ ($e = \frac{W_o}{W_i}$)

Kelvin = °Celsius + 273 ($K = °C + 273$)

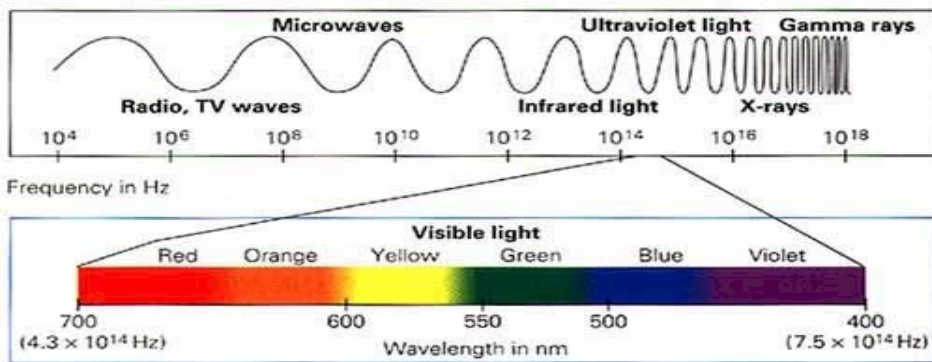
Voltage = current x resistance ($V = IR$)

Weight = mass x acceleration of gravity ($w = mg$)

Acceleration of gravity = $g \approx 10 \frac{m}{sec^2}$

Volume of a rectangular solid = length x width x height ($V = lwh$)

$F_{\text{gravity}} = \frac{km_1m_2}{d^2}$



<http://web.princeton.edu/sites/ehs/laserguide/spectrum.jpg>

10 ⁿ	Prefix	Symbol	Decimal
10 ²⁴	votta-	Y	1 000 000 000 000 000 000 000 000
10 ²¹	zetta-	Z	1 000 000 000 000 000 000 000
10 ¹⁸	exa-	E	1 000 000 000 000 000 000
10 ¹⁵	peta-	P	1 000 000 000 000 000
10 ¹²	tera-	T	1 000 000 000 000
10 ⁹	giga-	G	1 000 000 000
10 ⁶	mega-	M	1 000 000
10 ³	kilo-	k	1 000
10 ²	hecto-	h	100
10 ¹	deca-	da	10
10 ⁰	(none)	(none)	1
10 ⁻¹	deci-	d	0.1
10 ⁻²	centi-	c	0.01
10 ⁻³	milli-	m	0.001
10 ⁻⁶	micro-	μ	0.000 001
10 ⁻⁹	nano-	n	0.000 000 001
10 ⁻¹²	pico-	p	0.000 000 000 001
10 ⁻¹⁵	femto-	f	0.000 000 000 000 001
10 ⁻¹⁸	atto-	a	0.000 000 000 000 000 001
10 ⁻²¹	zepto-	z	0.000 000 000 000 000 000 001
10 ⁻²⁴	yocto-	y	0.000 000 000 000 000 000 000 001

Periodic Table of Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.00794	2 He Helium 4.002602																
3 Li Lithium 6.941	4 Be Beryllium 9.012182																
5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.007	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797												
11 Na Sodium 22.98976928	12 Mg Magnesium 24.3050																
13 Al Aluminum 26.9815386	14 Si Silicon 28.0855	15 P Phosphorus 30.973762	16 S Sulfur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.948												
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955912	22 Ti Titanium 47.887	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.933195	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.786
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.96	43 Tc Technetium (97.9072)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.293
55 Cs Cesium 132.9054519	56 Ba Barium 137.327	57-71 Lanthanoids	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94788	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 196.966569	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98040	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222.0176)
87 Fr Francium (223)	88 Ra Radium (226)	89-103 Actinoids	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 Uub Ununbium (285)	113 Uut Ununtrium (284)	114 Uuq Ununquadium (289)	115 Uup Ununpentium (288)	116 Uuh Ununhexium (289)	117 Uus Ununseptium	118 Uuo Ununoctium (294)

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

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57 La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92535	66 Dy Dysprosium 162.500	67 Ho Holmium 164.93032	68 Er Erbium 167.259	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.054	71 Lu Lutetium 174.9668
89 Ac Actinium (227)	90 Th Thorium 232.03806	91 Pa Protactinium 231.03688	92 U Uranium 238.02891	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)

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