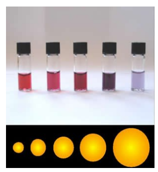
Nanotechnology: What's All the Buzz About

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.

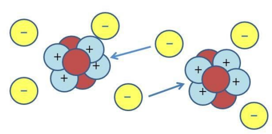
Examples of How Properties Change at the Nanoscale

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

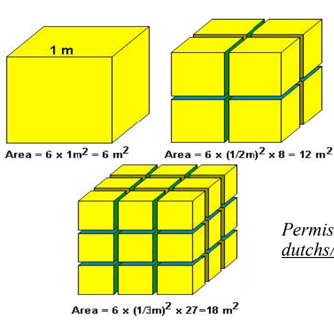


Douma, M., curator. (2008). Gold. In Cause of Color. Retrieved 1/30/2012, http://www.webexhibits.org/causesofcolor/3.html.

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

National Nanotechnology Coordinated Infrastructure

Allotropes of Carbon

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

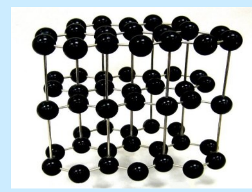


Image courtesy of R.Weller/ Cochise College

Diamond – hardest naturally occurring substance

Image courtesy of R.Weller/Cochise College

Buckminsterfullerene C_{60} – nicknamed "bucky ball"

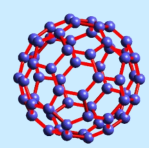
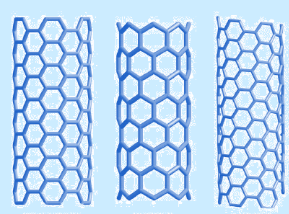


Image at US DOE: http://www.osti.gov/accomplishments/smalley.html

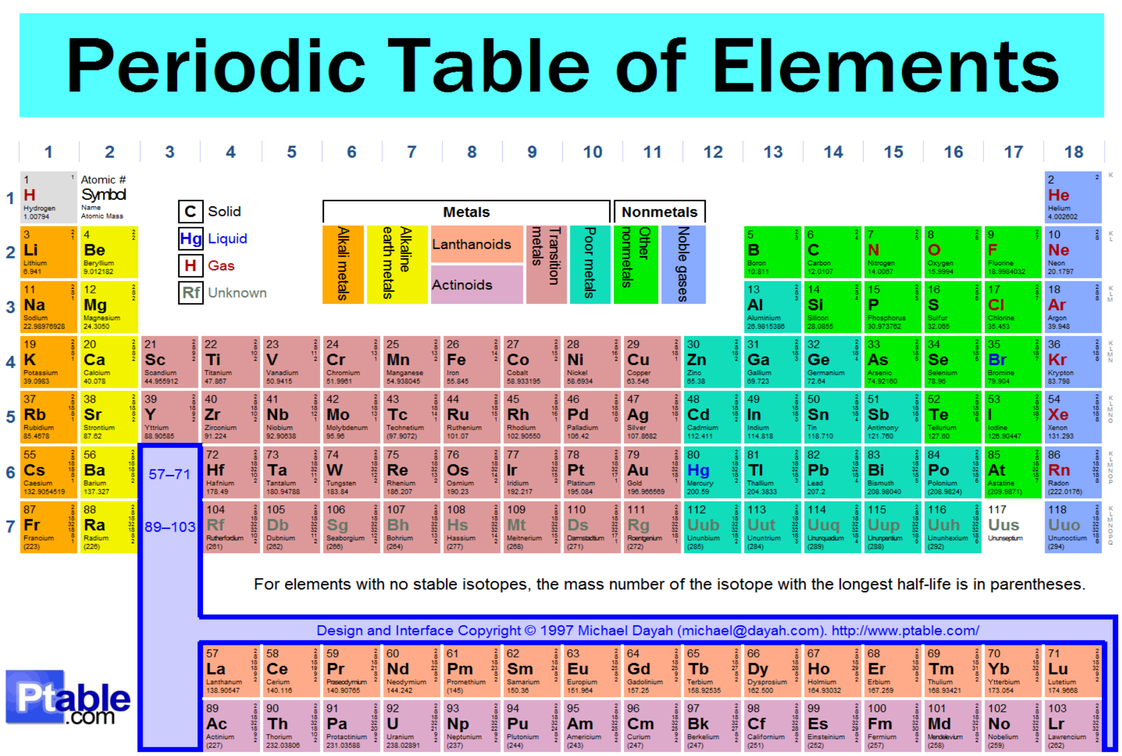
Carbon nanotubes – 100 times stronger than steel



Formulas

Density = $\frac{\text{mass}}{\text{volume}}$	$D = \frac{m}{V}$
Equilibrium constant for aA + bB $\rightleftharpoons$ cC + dD	$K_{eq} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$
Ionization constant of water = (hydrogen ion concentration)(hydroxide ion concentration)	$K_w = [H^+][OH^-]$
pH = –logarithm (hydrogen ion concentration)	$pH = -\log[H^+]$
Molarity = $\frac{\text{moles of solute}}{\text{liter of solution}}$	$M = \frac{\text{mol}}{\text{L}}$
Molality = $\frac{\text{moles of solute}}{\text{kilogram of solvent}}$	$m = \frac{\text{mol}}{\text{kg}}$
Boiling point elevation = (molal boiling point constant)(molality)	$\Delta T_b = K_b m$
Freezing point depression = (molal freezing point constant)(molality)	$\Delta T_f = K_f m$
(Volume of solution a)(molarity of solution a) = (volume of solution b)(molarity of solution b)	$V_a M_a = V_b M_b$
(Pressure)(volume) = (moles)(ideal gas constant)(temperature)	$PV = nRT$
$\frac{\text{(Initial pressure)(initial volume)}}{\text{(Initial moles)(initial temperature)}} = \frac{\text{(final pressure)(final volume)}}{\text{(final moles)(final temperature)}}$	$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$
Total pressure of a gas = (sum of the partial pressures of the component gases)	$P_T = P_1 + P_2 + P_3 + \ldots$
Heat gained or lost = (mass)(specific heat)(change in temperature)	$Q = mc_p\Delta T$
Final mass = (initial mass)$\left(\frac{1}{2}\right)^{\text{(number of half-lives)}}$	$m_f = m_i\left(\frac{1}{2}\right)^n$
Enthalpy of reaction = (enthalpy of products) – (enthalpy of reactants)	$\Delta H = \Delta H_f^\circ(\text{products}) - \Delta H_f^\circ(\text{reactants})$
Percent error = $\left(\frac{\text{accepted value – experimental value}}{\text{accepted value}}\right)(100)$	
Percent yield = $\left(\frac{\text{actual yield}}{\text{theoretical yield}}\right)(100)$	

10^n	Prefix	Symbol	Decimal
10^{24}	yotta-	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



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