Teacher Professional Development during the NNIN: Lessons learned and resources now at NNCI

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SDNI-NNCI Annual Educational Symposium 2020

Program Development - 2005

- Two key questions –
  - What Nanoscale Science & Engineering (NSE) concepts should be included and how do these concepts relate to K-12 science content?
  - Do the approaches lead to correct understanding of key concepts?

- Where to begin???
  - Ask the teachers

Where to begin?

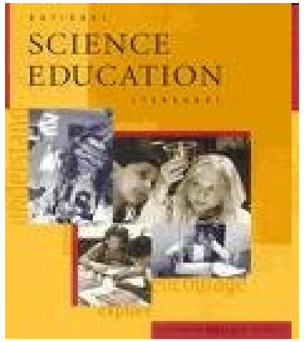
- **Hire a teacher!**
  - Former RET at Georgia Tech
  - 30 years of classroom experience in STEM
  - Provided not only teacher perspective but also credibility when working with educators
- **Use literature on best practices for teacher PD**
  - Example: 80 contact hours with follow-up
- NSTA 2005 - Dallas
  - Talked to teachers
  - Surveyed attendees

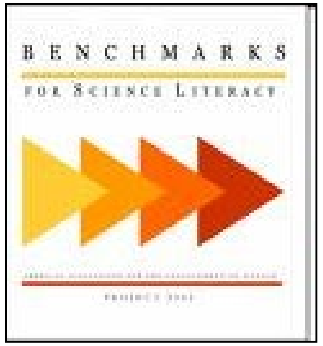
Determining Teacher Needs
Surveys 2005-2006

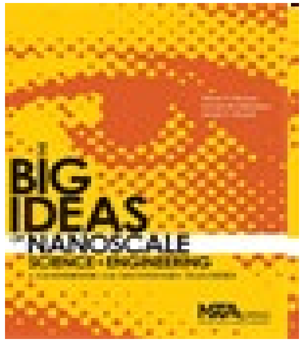
Question	Choices and responses				
1. NSE Knowledge	None	A little	Some	A lot	**Little or nothing**
	15%	50%	31%	4%	**65%**
NSTA 2018	9%	26%	34%	31%	35%
2. Source of NSE knowledge	News media/ publications	Colleagues	Internet	Workshop	Students/ other
	49%	14%	7%	14%	16%
3. Type of materials needed	Add-on unit (enrichment)	Short activity tied to required concept (1 class)	Special topic linked to NSE (2-3 weeks)	Required concept and NSE (2-3 weeks)	Other
	15%	46%	12%	25%	2%
4. Support needed to include in classroom	Textbook/printed materials	On-line units	Videos	Workshops	Online assistance
	8%	30%	14%	30%	18%

Professional Development Workshops for Teachers

- Georgia Tech NNIN site
  - Development of workshops
    - ½ day to 1 week
  - Elementary, Middle and High School teachers
    - Physical science, physics, chemistry, and biology
  - How to fit NSE into standards-based science curriculum
    - Currently taught topics
  - Guided by “Big Ideas” Stevens et al 2009
  - Requirement: cheap cheap cheap and easy easy easy



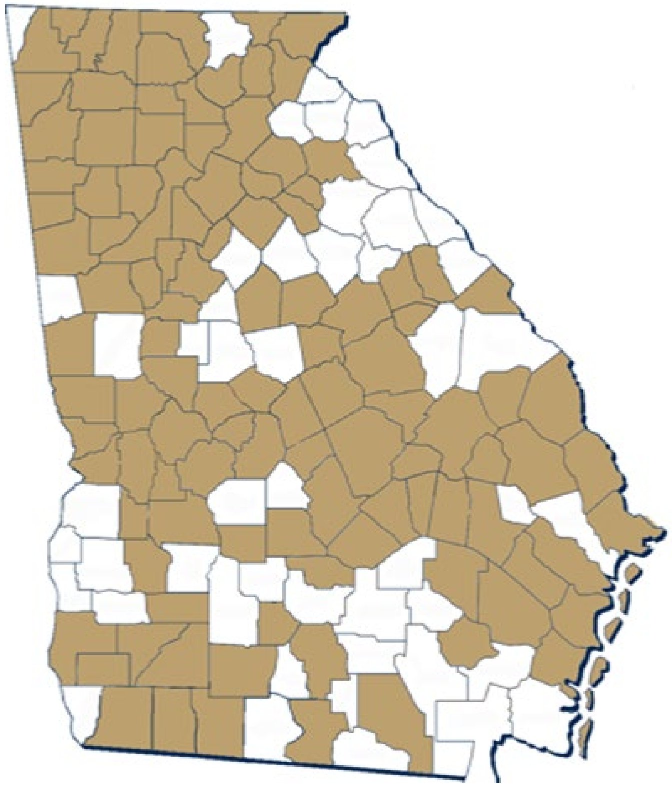


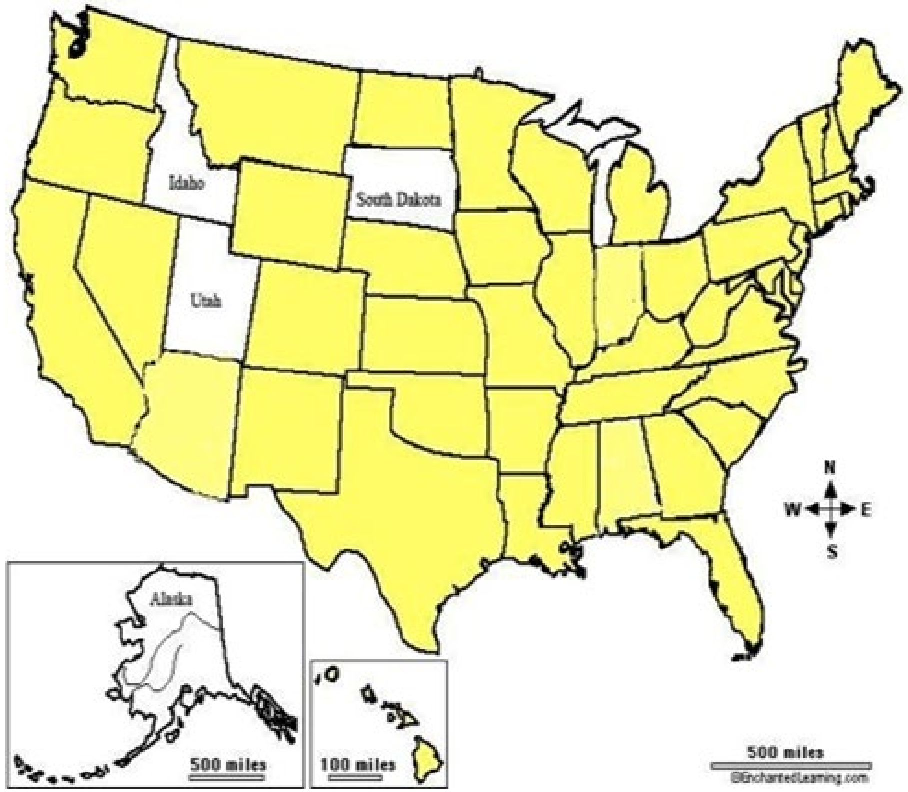


NEXT GENERATION SCIENCE STANDARDS

Reached teachers in 46 of 50 states (including PR) and >2/3rd of Georgia’s 159 counties

Teacher Workshops – reach of NNIN





Initial Workshops

- Assessed 40-50 lessons available on web
  - Good content; alignment with science content; simple & inexpensive materials; and short duration
- Concepts addressed:
  - Size & scale
  - Self assembly
  - Hydrophilic/hydrophobic properties
  - Consumer products/workforce issues
- Crosswalked each lesson to science standards & *Big Ideas* of Stevens et al, 2009

Pre & Post Survey Results – workshops 2006-2010

1. Size of a nanometer ($1x10^{-9}$) (n=85)	Pre-survey	Post-survey
Correct	89%	99%
Incorrect	11%	1%
2. Sorting of nano & microscale objects		
Correct	64%	69%
Incorrect	36%	31%

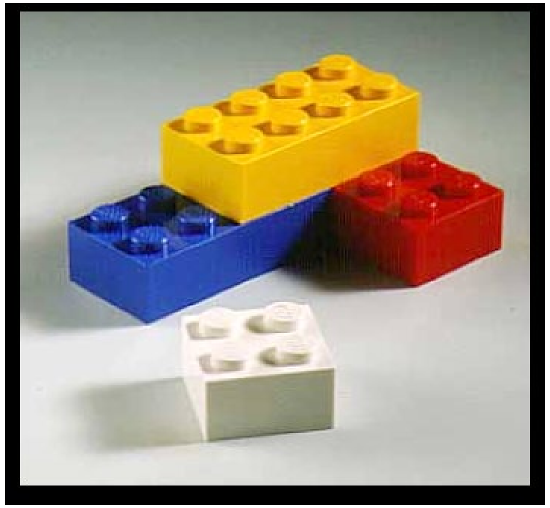
Pre and Post Survey Results

Question	**Pre-survey**	**Post-survey**
Self assembly is how to fabricate nanoscale objects (**2007-2009**)		
Correct	37%	33%
Incorrect	63%	67%
Self assembly is how to fabricate nanoscale objects (**2009-2010**)		
Correct	54%	70%
Incorrect	46%	30%

Fabrication

Bottom-up
manufacturing

VS



Top-down
manufacturing

Pre and Post Survey Results 2009-2010

5. Nanoscale objects below range of visible light & cannot be seen by optical scopes	**Pre-survey**	**Post-survey**
Correct	72%	86%
Incorrect	28%	14%
6. Ferrofluids -what is attracted to a magnet		
Correct	43%	53%
Incorrect	57%	47%
7. Colloids have particles that are in the range of……? (list of choices)		
Correct	31%	69%
Incorrect	69%	31%

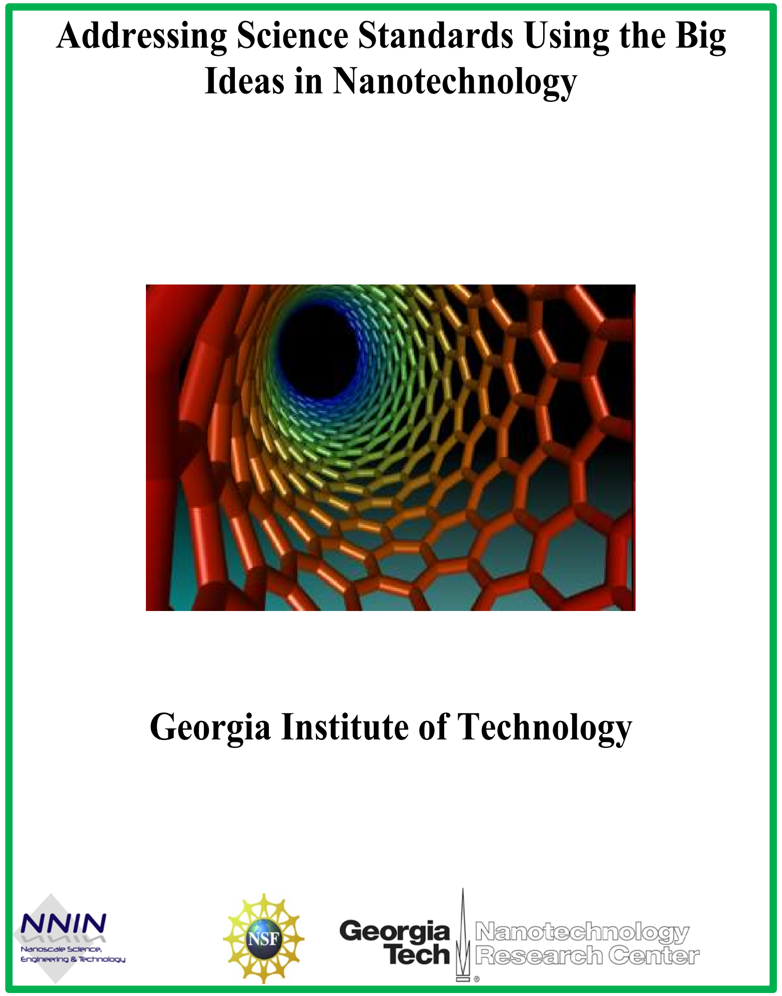
Follow-up 2010 workshop (n=36)

Question about use of workshop materials	Response
I used a lesson from the workshop	42%
I used more than one lesson from the workshop	42%
I used a lesson from another source	5%
I did not use any nano-lessons in my teaching	11%
I used the lesson as part of a **standard based lesson** (required concept) – **short activity**	61%
I used the lesson as a special nano topic (not a required concept) – **short activity**	33%
I used the lesson as a special topic – longer activity	11%

86%

Example of week-long PD workshop

- One week workshop
  - Teachers in rural south Georgia
  - Middle and high school teachers
  - Required to do a summer camp at high school
    - Enactment of what they learned before returning to the classroom
- Goals:
  - Increase teacher content/nano knowledge
  - Increase teacher confidence
  - Increase student interest and understanding of STEM concepts.
- Evaluation
  - Survey included more content-based questions
    - 25 questions



Sample daily agendas

- **Day 1 Size and Scale**
- Time Activity
- 8:00 Welcome & Pre-survey
- 8:30 Nanotechnology Fact or Fiction
- 9:00 Intro to Nanotechnology PowerPoint
- 9:30 NanoSense Size Matters: Lesson 2 Size Sorting
- 10:00 Sizing up the NanoWorld (Exploratorium)
- 10:30 Conceptualizing Nanoscale – Dime Walk
- 11:00 Investigating Surface Area and Volume using cells
- 12:00 Lunch
- 1:00 Computer Time with Size and Scale
- 1:30 The Size of a Molecule - Oleic Acid activity
- 2:30 Prepare Gecko Tape
- 3:00 **Wrap-up and Applications to Curriculum**
- 3:30 **Plans for Implementation**

- **Day 3 Forces and Interactions**
- Time Activity
- 8:00 Reading Assignment Spin of the Wheel
- 8:30 What does Nanotechnology have to do with Magnetism?
- 9:00 Lab-on-a Slab
- 10:00 DNA Nanotechnology
- 11:00 Computer Time with Forces and Structure of Matter
- 12:00 Lunch
- 1:00 Carbon Allotropes
- 1:30 Connecting Acids and Bases with Encapsulation
- 2:30 Part 1 Can We Absorb Nanoparticle Pollutants
- 3:00 **Wrap-up and discussion of applications to curriculum**
- 3:30 **Implementation Plan**

External Evaluation

- Participants increased their knowledge of:
  - Potential to address standards-based curriculum through NSE topics
  - Connection of NSE topics to state/national standards
  - Availability of NSE materials and resources for teaching
  -

n <12	50 Items Multiple Choice & True/False Items	23 Items Multiple Choice
Mean Pre-test score	60.0%	60.2%
Mean Post-test score	72.0%	73.9%
Change	12.0%	13.7%
(Actual/Potential) Gain	30.0%	34.4%

How knowledgeable with respect to the science behind nanotechnology?

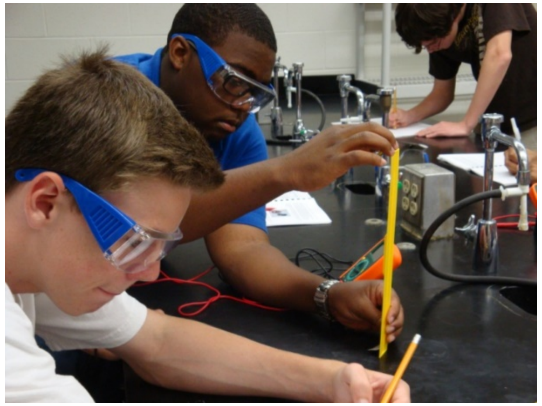
Potential Impact of Nanotechnology	Before		After			Change	Actual/ Potential
	Mean	SD	Mean	SD			
- On science & engineering	2.57	0.98	4.57	0.53		2.00	82.3%
- On the economy	2.00	1.00	4.57	0.53		2.57	85.7%
- On society	2.29	1.11	4.57	0.53		2.29	84.1%
- Career opportunities	2.14	1.21	4.29	0.76		2.14	75.2%
- Ethical issues	2.29	1.11	4.57	0.79		2.29	84.1%
- Address GA standards (process)	1.86	0.90	4.29	0.95		2.43	77.4%
- Address GA standards (content)	1.86	0.90	4.43	0.79		2.57	81.8%
Average	2.14		4.47			2.33	81.6%

Student learning (n=30)

Domain	# of Items	Mean score		Change Pre - Post	% Actual/Potential
		Pre	Post		
Nanometer scale	12	39.5	62.0	22.5	37.2
Science content	13	37.9	84.4	46.4	74.8
All	25	38.7	73.6	34.9	57.0

Student learning conclusions

- Were engaged in learning activities
- Were interested in learning more
- Understood the impact and importance of NSE
- Developed new science knowledge but remained unsure about nanometer scale



Lessons Learned for Teacher PD

- *Big Ideas* - great foundation for NSE workshop topics/organization
- Teachers have gains in:
  - NSE content knowledge
  - Understanding impact of nano
  - Connections to standards & STEM curriculum
- Misconceptions may be tied to too many topics in a short time frame
  - Longer workshops provide greater depth of training
    - For shorter workshops limit the number of topics and/or lessons presented
- Must be VERY clear on presenting NSE topics that are outside the realm of common knowledge
- **Make time for sense making!**

NanoTeach*

- An R&D project funded by NSF
  - Test the viability of a PD model designed to support the integration of NSE content into high schools (physical science).
  - Pilot 2010-2011
  - Field test 2011-2012
  - NSE content and *Designing Effective Science Instruction* (pedagogy)
- Partners:
  - Mid-continent Research for Education and Learning (lead)
  - Stanford
  - Georgia Tech
  - NNIN
  - Aspen Associates
  - High school teachers as advisors
- http://www2.mcrel.org/NanoTeach/index.asp

* Funded by NSF Discovery Research K12

NanoTeach

Fully Facilitated Model

- 80 hours
- Face-to-face & online training
- Peer groups
- Participant manual
- Online virtual classroom (synchronous)

Team Study Model

- 80 hours
- Self-paced team study
- Peer groups
- Participant manual (step-by step)

NanoTeach Evaluation

Teachers in both models:

- were equally prepared to teach NSE
- were similar in emphasizing learning basic science concepts, investigation skills, and furthering science learning
- engaged in a variety to inquiry-based practices
- reported high levels of engagement & interest in learning science & nano
- Demonstrated statistically significant moderate to large gains in NSE knowledge (pre and post tests)

- NanoTeach team concluded – one year was not sufficient to show significant improvements in teacher practice

NanoTeach – digging deeper

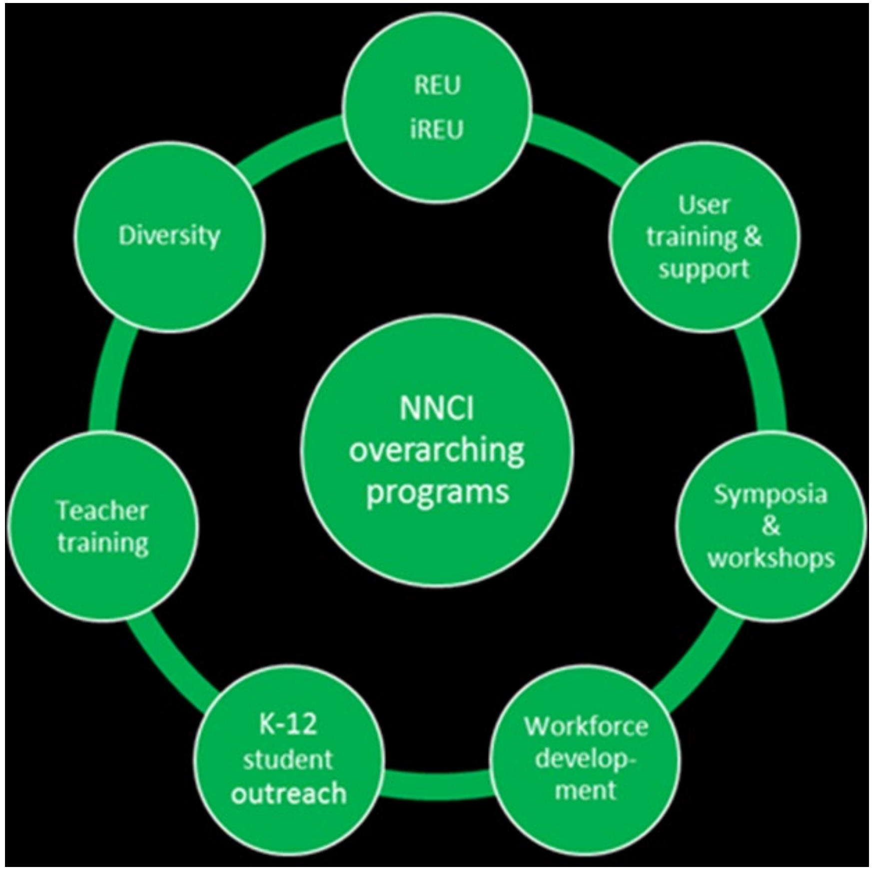
- All PD should begin with size and scale
- Recruitment should include formal presentations at school districts
- Provide greater depth of NSE content rather than pedagogy
- **Allow adequate time for sense making**; be aware of needs of groups; consolidate daily learning at end of day wrap up
- If asking them to create lesson plans – provide examples
- Manual should be hardcopy & online
- Provide a website with additional resources
- Build redundancy be referring back to the PD's storyline, learning goals & manual
- Final report: http://www2.mcrel.org/NanoTeach/pdfs/NanoTeach_Final_Report.pdf

Review of NNIN Education Portal Resources - now continued with NNCI

- ***Royal Society of Chemistry:*** *"The site also contains teaching resources and it has done a great job of organizing these so it is as easy as possible to slot them into existing modules. Their guide system is designed around the US curriculum, but it's still fairly easy to see how each resource could fit into UK lessons. The resources themselves are top notch, with detailed instructions and assessment for learning built-in. Overall this is a great website to know about."*

www.nnci.net/learn

NNCI Education portal (nnci.net)



- Learn
  - Education & Outreach
    - Site Education & Outreach
    - Resources for Educators
    - *Nanooze*
    - Other Educational Resources

Resources for Educators K-16 Curriculum Materials -- >100 lessons
Majority written by teachers for teachers

K-16 Curriculum Materials (Searchable Listing)

Lesson Name	Subject Area	Grade Level
Achoo! Pollen Makes US More than Sneeze	General Science; Physical Science; Biology	Middle
An Easy (Bake) Approach to an Edible NanoLab	General Science; Physical Science	Middle
Big vs. Little – Micro to Nano	General Science	Elementary
Bigger is not always better: Size, Scale, Function, and Measurement Systems	General Science; Physical Science; Chemistry	High
Catalytic converters and Nanocatalysts	Chemistry; Environmental Science	High
CDs and DVDs as Diffraction Gratings	Physical Science; Physics	High
Changing Conductive Properties by Diffusion	Physical Science; Chemistry	Middle and High
Coffee Break with Nanoscience: Film Formation and "Coffee Rings"	Chemistry; Physical Science	High and Undergraduate
Demonstrations for the Materials Science Classroom	Chemistry; Physics; Engineering; Materials Science	High and Undergraduate
Design Challenge: Incorporating Shape Memory Alloys into Rube	General Science; Physical Science	Middle and High

Resources for Educators

- NNCI Demonstration Guide
  - 17 activities
- K-12 Reference Sheets
  - Chemistry
  - Biology
  - Physical Science
  - Physics
  - Genetics & Cell Division
- Additional Resources
  - Teacher Resource Brochure
  - Size & Scale Poster
  - Other external resources
    - Articles, podcasts, websites, and online course materials.

Reference ♦ CHEMISTRY ♦ Information

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 = $\frac{\text{moles of solute}}{\text{liter of solution}}$	$M = \frac{mol}{L}$
Molality = $\frac{\text{moles of solute}}{\text{kilogram of solvent}}$	$m = \frac{mol}{kg}$
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	

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

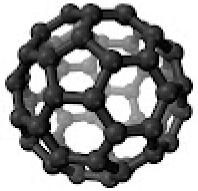
Nanooze (*https://www.nnci.net/nanooze*)

- Science magazine and website (Cornell)
  - Grades 5-8
  - **FREE** for classrooms
- Physical science topics
- 15 issues
  - 5 in Spanish (online only)
  - Online and in print
- *Nanooze* and Teaching Middle School STEM
  - NGSS links and compendium of lessons for each issue
  - Link found on Nanooze and K-16 curriculum materials pages

NNCI Resources for Virtual Classrooms, Kitchens, Backyards, and Beyond

http://myscope-explore.org.au/

- Includes:
  - videos
  - online magazines
  - podcasts
  - activities that can be done from home using common items
- Suitable for K-grey
- Resource example:



NanoTube - The National Nanotechnology Initiative

Thank you for your attention!

NNCI--Developed or developing modules??? Please have them posted on NNCI.net!!!!

Questions??

Visit https://www.nnci.net/learn

Support: NSF ECCS 0335765, ECCS 1626153; ECCS 1542174