

2018 MAARS Summer Workshop

Middle School Teachers

Jackson State University

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www.terrificscience.org



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CHEMISTRY with CHARISMA

24 Lessons That Capture & Keep Attention in the Classroom

> Terrific Science Press, with funding from the National Science Foundation, Ohio Board of Regents, and National Center for Research Resources, National Institutes of Health

volume 2 CHEMISTRY with CHARISMA

MORE 28 Lessons That Capture & Keep Attention in the Classroom

> Terrific Science Press, with funding from the National Science Foundation, Ohio Board of Regents, and National Center for Research Resources. National Institutes of Health

Play is learning without punishment!

If I were to present myself before you with an offer to teach you some new game— If I were to tell you an improved plan of throwing a ball,

of flying a kite, or of playing leapfrog

Oh, with what **actention** you would listen to me!

Well, I am going to teach you many new games. I intend to instruct you in a science full of

interest, wonder, and beauty

a science that will afford you amusement in your youth, and riches in your more mature years.

In short, I am going to teach you the science of **CHEMISTRY**

— Dr. Scoffern, Devonshire, England, *Chemistry No Mystery*, 1848



The old shell game.

How keen are your powers of observation?

"Super Slurper" (Sodium Polyacrylate)







Students do it ALL

- *do* an activity or observe a demonstration
- form testable questions
- *devise* an experiment to answer their testable question
- *make* observations and collect data
- *interpret* data to provide evidence
- *develop* a claim about the system they are investigating
- *use* evidence to substantiate their claims



so Your Challenge is to:

make observations formulate testable questions design an experiment collect evidence formulate a claim













Hot Stuff: Investigating Reusable Heat Packs



supersaturated sodium acetate solution







Additional research & literature reveals



^{06/03/03 08:40} SCANecified X: 4 scans, 4.0cm-1, apod weak Fourier Transform Infra Red Spectrometer (FTIR)



the fish is made of



Cellulose

Wrapper for Fortune Telling Fish





06/03/03 08:52 SCANecified X: 4 scans, 4.0cm-1 Fourier Transform Infra Red Spectrometer (FTIR)



the wrapper is made of



Polyethylene





Testing if the type of hanger affects the results





Testing if the length of the string affects the results



Sound System honger

interaction the hanger mit a sound and the hanger Vibrated in My ear.

Grade 2 student's claim with substantiating evidence

evidonce

If the hanger vibrate I neard the hanger make Sound" I felt the hanger vibrate in my ear.



LIOSIES GOES TO A CONCERT

ISBN 0-374-35067-1







Qualitative Observations Quantitative Observations



Discrepant events are only possible if **prior experience** would tell you otherwise

"Expect the unexpected"

Chinese proverb









no chemical reactions



no leather or rubber



no paint or coatings



no metals or polymers



No fabrics





No you!



Reunite the FUN and **MENTAL** aspects of scientific play !

 By combining the fun/hands-on and mental/minds-on aspects of science teaching and learning, we have found that **BOTH** increased motivation and understanding result.
Some M&M Science

RESERVEN

1 WT 42.0 02 (2 LB 10.0 02)

1007

S.

Students do the science

- using observational skills
- forming testable questions
- designing experiments
- collecting data
- analyzing data to provide evidence for a claim that can be defended

Teachers set the perimeters

• Is there something you observed about your system that led you to ask this question?

FT WT 42.0 02 (2 LB 10.0 02

EVICO

- What data will you need to gather in order to answer your question?
- What tools, materials, & methods will you use to do your experiment & collect this data?

Student-generated Testable Questions

- Do all the colors act similarly?
- Does the temperature of the water affect the dissolving rate?
- If more than one M&M are in the same bowl, will the colors mix?
- Will the results be the same if I use oil instead of water?
- What will happen if I stack M&M's in a test tube instead of a bowl? Will the order of stacking make a difference?
- Are the results different if I pour the water over the M&M's as opposed to dropping them into water?
- Do different types of M&M's (peanut, pretzel) or other types of hardshelled candy (Skittles, Reese's Pieces) act similarly?
- Is the color that dissolves in a sphere completely surrounding the candy?
- Would a colored sugar solution dropped in water act similarly?



A Grow Beast Challenge: How? Why?

Any testable questions to help solve the challenge???

estimate growth•Weighing it•Tracing & counting squares



ISB<u>N</u> 0-06-444186-5

Gro-Dinos



Exploring solids, liquids, & gases in a syringe





- Trap air inside a syringe. Observe as you increase and decrease the pressure.
- Put a small, tied-off balloon into the syringe. Close the system. What happens if you decrease the pressure in the syringe?
- Repeat the experiment with a marshmallow.
 What happens?



HS Student's Visualization & Storyboarding





What do whoopee cushions, potato guns, and exploding straws have in common?





Straws: Science Tools



Figure 3: After (a) grasping the straw with both hands, (b) twist one hand over another until about two inches of unrolled straw are left in the middle.

Home-made potato shooter





Figure 4: Push the plug 5–6 cm (about 2 inches) into the tube with the dowel.

Charles Law meets the bubble film

Simple... yet surprising & they are doing it!

Placement in your curriculum •gas laws (V α T)





Crushing bottles reversibly













Density Bottle



Household Density Column





What's happening here?





Cartesian Divers





Beral Pipet

(b)

Folded straw

How Much Sugar in Your Soda?



Figure 1: A pencil hydrometer



Collecting evident to understand the system



The System



Procedure:

- •Light the candle
- •Invert jar or other container
- •Quickly lower it over the candle & into the water

Students observe:

•A few bubbles at the very beginning (~40% of the time)

•Water rises into the jar

•The flame goes out

•Water continues to rise even after flame is out





What *testable* questions can you ask?

What variable would you change that could allow you to collect information to answer your question?

Group 1

Does increasing the amount of heat affect the results ?





Group 2: testable question

Does the height of the candle change the results?





Group 3

Does a larger bottle affect the results ?





Group 4

Note the sides of the container





other views



Another group tries a similar test


Pooling results... The Sum is Greater than the Parts

- As groups share their claims and evidence with the class, the knowledge base of the class increases.
- As a class, they negotiate meaning from the various studies that were undertaken.
- Formulate more advanced claims as the discussion progresses.



Resource search reveals

Charles' Law: $V \propto T$

accounts in part for •the bubbles observed initially $T \uparrow V \uparrow$ •water moves into jar $T \downarrow V \downarrow$

BUT wait.. There is MORE to search...



Resource search reveals

Gay-Lussac's Law: $P \propto T$

accounts in part for •the bubbles observed initially $T\uparrow P\uparrow$ •water moves into jar $T\downarrow P\downarrow$

BUT wait.. There is MORE to search...



Resource search reveals

Avogadro's Law: $V \propto n$

But is "n" changing?



Combustion of wax

$C_{17}H_{36}(g) + 26 O_{2}(g) \rightarrow 17 CO_{2}(g) + 18 H_{2}O(g)$

Moles of gas as the reaction is in process: $1 (g) + 26(g) \rightarrow 17(g) + 18(g)$ 27 moles (g) reactants 35 moles (g) products

When the system cools: $18 H_2O(g) \rightarrow 18H_2O(l)$

Moles of gas once cooled:

- $1 (g) + 26(g) \rightarrow 17(g) + 18(!)$ 27 moles (g) reactants 17 moles (g) products



n↓V↓



Let's look at the details....

 $C_{17}H_{36}(g) + 26 O_{2}(g) \rightarrow 17 CO_{2}(g) + 18 H_{2}O(g)$ Moles of gas as the reaction is in process: $1 (g) + 26(g) \rightarrow 17(g) + 18(g)$ 27 moles (g) reactants 35 moles (g) products When the system cools: $18 H_2O(g) \rightarrow 18H_2O(l)$ Moles of gas once cooled: $1 (g) + 26(g) \rightarrow 17(g) + \frac{18 (l)}{18 (l)}$ 27 moles (g) reactants 17 moles (g) products

Phases changes make a difference

1 gram of H₂O(g) occupies about

1300 times

the volume of the same mass of $H_2O(I)$!!!!



What's happening to the water?



What temperature does water boil at?

Vapor Pressures of Diethyl Ether, Ethanol, and Water at Various Temperatures





Hand boiler (love meter)



How does it work?

Is this boiling?

base chamber→

Useful, engaging, & fun chemistry tools!

Hand boiler (love meter)



Challenge students to figure out

the engineering/design of the toythe science of the system

Placement in your curriculum

- •how gases make pressure
- •gas laws (P α T)
- •what is boiling & what isn't



carefully invert ...

keeping ALL of the colored liquid in the base chamber..





What does the chamber feel like?

Ice-salt bath

Shrinky Dinks®

Adapted from Polymers All Around You, 2nd edition, published by Terrific Science Press, www.terrificscience.org



Commercial Toy: Shrinky Dinks Shrinkable Plastic

Other Stuff: ►conventional or toaster oven (not a microwave) ►permanent markers ►aluminum foil ►cookie sheet or toaster oven tray ►oven mitt ►spatula ►(optional) clear container made from polystyrene plastic (recycle code #6)

What to Do:

- Use permanent markers to create a design on a piece of Shrinky Dinks or polystyrene plastic. Place it on a cookie sheet or toaster oven tray lined with aluminum foil.
- Heat the plastic in a preheated 325°F oven until it stops shrinking. It typically takes about 30 seconds and will curl and then reflatten in the process.
- Use an oven mitt to remove the cookie sheet or tray from the oven. Use the spatula to remove the plastic from the foil and set it aside to cool.

How It Works:

Shrinky Dinks and containers with recycle code #6 are made of polystyrene, a common polymer that shrinks when heated because of how it is made. When the plastic is manufactured, it is heated, stretched, and then quickly cooled. The sudden cooling "freezes" the molecules of the polymer into their stretched-out position. When they are heated again, the polymer molecules return to their original positions, resulting in the observed shrinkage.

More Fun?

Terrific Science Press (<u>www.terrificscience.org/bookstore</u>) offers the following books that include activities with shrinking plastic:

Teaching Physical Science through Children's Literature
Polymers All Around You, 2nd Edition

Want to buy Shrinky Dinks? Visit the Terrific TOY Store at www.terrificscience.org/toystore.



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Shrinking Plastic









Jake

ISBN 0-064-43129-0

Fluorescence & Phosphorescence









Whiter than white?

absorbs energy in the UV portion of the spectrum and re-emits it in the blue portion of the visible spectrum



Fluorescence Models that involve role-playing



UV light provides energy to "kick" electrons up to an excited state. When they return to ground state, energy is given off as light.



Phosphorescence



An intermediate level is available for excited electrons to land before returning to the ground state. Light continues to be given off even after energy source is removed.

phosphorescent vinyl another use

ZnS doped with Cu: emission occurs at 520 nm

Wavelengths of the LED light:

- **RED** $\lambda = 630 \text{ nm}$
- **GREEN** $\lambda = 525 \text{ nm}$
- **BLUE** $\lambda = 470 \text{ nm}$

a common craft toy

Make observations





Generate testable questions

1	Periodic Table of the Elements														18		
H Hydrogen 1.008	2			Kev	1							13	14	15	16	17	Helum 4.003
3 Li Lithium 6.941	4 Be Beryllum 9.012		11- Na - Sodium -	Atomi Eleme Eleme	c number nt symbol nt name							5 Boron 10.811	6 Carbon 12.011	7 Nitrogen 14.007	8 Oxygen 15.999	9 F Fluorine 18.998	10 Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305	3	4	Averag	ge atomic n 6	nass* 7	8	9	10	11	12	13 Al Aluminum 26.982	14 Silcon 28.096	15 P Phasphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Argon 39,948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.967	23 Vanadium 50.942	24 Cr Chromlum 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 Gallum 69.723	32 Ge Germanium 72.631	33 Arsenic 74,922	34 Se Selentum 78.971	35 Br Bromine 79,904	36 Kr Krypton 94.798
37 Rb Rubidium 84.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Noblum 92.906	42 Mo Molibdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112,414	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 Iodine 126.904	54 Xenon 131,249
55 Cs Cestum 132.905	56 Ba Barium 137.328	57-71 Lanthanides	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenlum 196.207	76 Os Osmlum 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.085	79 Au Gold 196,967	80 Hg Mercury 200.592	81 TI Thailium 204,383	82 Pb Lead 207.2	83 Bismuth 208,990	84 Po Polonium [208.982]	85 At Astatine 209,987	86 Rn ^{Radon} 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103 Actinides	104 Rf Rathenfordiam [261]	105 Db Dubnium [262]	106 Sg Seaborglum [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	I I 0 Ds Darmatadium [269]	III Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium unknown	4 Fl Flerovium [289]	115 Ununpentium unknown	116 Lv Livermorium [298]	117 Uus Ununseptium unknown	I 18 Uuo Ununoctium unknown

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Lanthanum	Certum	Presendentium	Neodymium	Promethium	Samarium	Europlum	Gadolinium	Terblum	Dysprosium	Holmium	Erbium	Thultum	Ytterblum	Lutetium
138.905	140.116	140.908	144.243	144.913	150.36	151.964	157.25	158.925	162.500	164.930	167.259	168.934	173.055	174.967
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac	Th	Pa	υ	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
Actinium	Thorium	Protactinium	Uranium	Neptunium	Plutonium	Americium	Curlum	Berkeltum	Californium	Einsteinium	Fermium	Mendelevium	Nobelium	Lawrencium
227.028	232.038	231.036	238.029	237.048	244 064	243.061	247 070	247 070	251.080	[254]	257.095	2581	259 101	12621

Periodic Table of the Elements																	18 8A	
1	1 H Hydrogen	2					ĸ	ev					13	14	15	16	17	2 He Helium
2	3 Li Lithium 6.94	4 Be Beryllium 9.01				Na Sodiur	5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18						
3	11 Na Sodium 22.99	12 Mg Magnesium 24.31	3 3B	4 4B	5 5B	6 6B	7 7 7B	erage atom 8	ic mass* 	10	11 1B	12 2B	13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.07	17 Cl Chlorine 35.45	18 Ar Argon 39.95
4	19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.87	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.39	31 Ga Gallium 69.72	32 Ge Germanium 72.61	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80
5	37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	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 lodine 126.90	54 Xe Xenon 131.29
6	55 Cs Cesium 132.91	56 Ba Barium 137.33	57 La Lanthanum 138.91	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 TI 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 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (269)	109 Mt Meitoerium (268)							s		
*	If this numb t refers to th nost stable i	er is in parer e atomic ma sotope.	ntheses, the iss of the		58 Ce Cerium 140.12 90 Th Thorium	59 Pr Paseodymium 140.91 91 Pa Protactinium	60 Nd Neodymium 144.24 92 U Uranium 230.02	61 Pm Promethium (145) 93 Np Neptunium (1320)	62 Sm ^{Samarium} 150.36 94 Plutonium (344)	63 Eu Europium 151.96 95 Am Americium	64 Gd Gadolinium 157.25 96 Cm Curlum	65 Tb Terbium 158.93 97 Bk Berkelium	66 Dy Dysprosium 162.50 98 Cf Californium	67 HO Holmium 164.93 99 Es Einsteinium	68 Er Erbium 167.26 100 Fm Fermium	69 Tm Thulium 168.93 101 Mendelextum	70 Yb Ytterbium 173.04 102 Nobelium (150)	71 Lu Lutetium 174.97 103 Lr Lawrencium

Iron for breakfast

Gregory, the Terrible Eater

by Mitchell Sharmat by Nitchell Sharmat illustrated by Jose Aruego and Ariane Dewey

ISBN 0-590-43350-4



Formula writing

NaCl

sodium chloride





magnesium chloride

MgCl₂





aluminum oxide

Al⁺³ O⁻²

 Al_2O_3



Radicals

hydroxide OH⁻¹

sulfate SO₄⁻²

nitrate

NO₃⁻¹



calcium hydroxide

Ca ⁺² OH⁻¹

Ca(OH)₂



aluminum sulfate

Al⁺³ SO4⁻²

$Al_2(SO4)_3$


Pop beads or Legos: Science Tools ?? Element, Compound, or Mixture ??



pure substance

Sample B





mixture of two different elements

Y [monoatomic element] (X-X) [diatomic molecule]



Mixture of 2 compounds compound (X-Y-X-Y) and *isomers* compound (X-X-Y-Y)



Share and Share Alike?





Tug of War



pure covalent





University students demonstrate a pure covalent bond.



Tug of War



polar covalent



Tug of War



ionic



Anti-gravity bottle

Testable questions ?

Other materials?

How big can the hole be?

~1.3 cm in diameter



Models as teaching tools...















ionic solid









Nonpolar substance

Drops on a coin

How many drops of water can you place on a coin before the water spills off?





Red drop---Green drop



Materials:

- •Waxed paper
- Toothpick
- •Red liquid
- •Green liquid

Examine a drop of each on waxed paper.

Try drops on a penny with each.

Which liquid is *colored* water?

What type of chemical was added to the other liquid?

We used a surfactant.

How do they do this?



Can you do this?







Magic sand





WATER

- The "universal non-solvent"
- Hydrophobic effect















water



















Adding water









"Holeyness of matter" $H_2O + H_2O = ?$

- ½ fill tube with colored water
- COMPLETELY fill with colorless water IMMEDIATELY cover with your thumb... do NOT remove your thumb
- SLOWLY Invert 4 times while observing (feel & look)
- Move close to ear and remove thumb
- Quiet EVERYONE & listen carefully !!!

"Holeyness of matter" $H_2O + alcohol = ?$

- 1/2 fill tube with colored water
- COMPLETELY fill with alcohol & IMMEDIATELY cover with your thumb... do NOT remove your thumb
- SLOWLY Invert 4 times while observing (feel & look)
- Move close to ear and remove thumb
- Quiet EVERYONE & listen carefully !!!

$$50 \text{ mL } \text{H}_2\text{O} + 50 \text{ mL } \text{H}_2\text{O} = 100 \text{ mL } \text{H}_2\text{O}$$



50 mL H₂O + 50 mL *alcohol*≠ 100 mL solution

Modeling to explain



Modeling to explain








Mixture Separation



Chromatography Garden





Radial Chromatography









Colorful Gala





carefully invert ...

keeping ALL of the colored liquid in the base chamber..





What does the chamber feel like?

Ice-salt bath

Distillation



Separating a mixture

shake





Volume estimate

Student explorations



pressure changes temperature changes methyl red indicator (if colorless soda)



Visualizing a Chemical Reaction



reactants

products







Visualizing a Chemical Reaction



decomposition reaction



Visualizing a Chemical Reaction



single replacement reaction



Figure 1: Small bag inside larger one









Figure 1: Assemble the pencil electrolysis apparatus.











$4H_2O(I) + 4e^- \rightarrow 2H_2(g) + 4OH^-(aq)$ $2H_2O(I) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

$\text{\emph{BH}}_2\text{O}(\text{l}) \rightarrow 2\text{H}_2(g) + \text{O}_2(g) + 4\text{H}_2\text{O}(\text{l})$









Chemiluminescence





A scientist is someone whose curiosity survives education's assault on it.

— Sir Herman Bondi



A scientist is someone whose curiosity is nurtured by education's impact on it.



- A good teacher is...
 - 1/3 heart
 - 1/3 head
 - 1/3 ham



