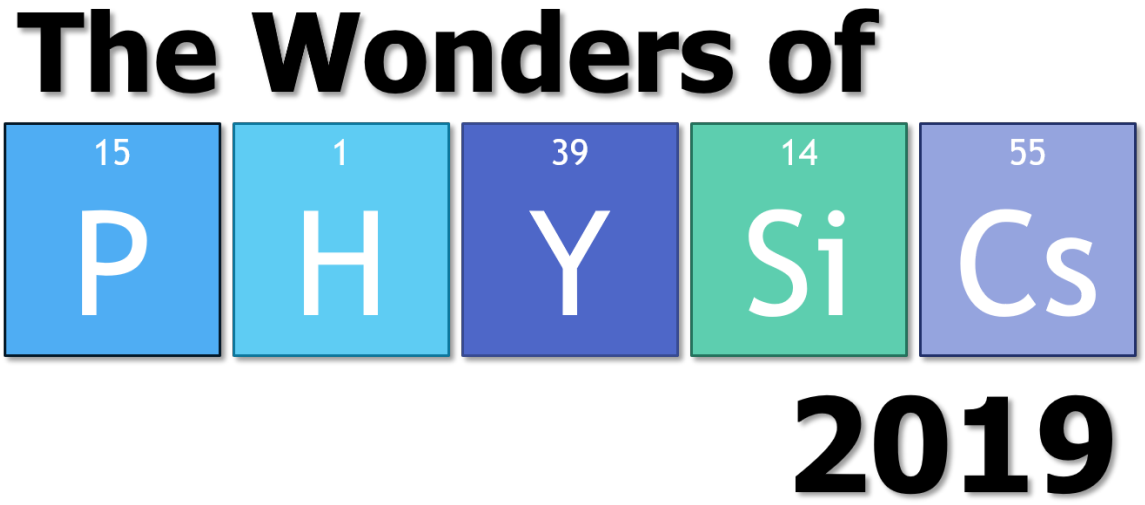
The Wonders of Physics 2019



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Characters:

Cast	Characters (and relatives)

Clint Sprott	**Himself**
Pete Weix	**Mendeleev's great grandson**
Michael Winokur	**Nitrogen (Oxygen…)**
Terry Craney	**T. L. Copper (Aluminum…)**
Mike Randall	**Iron Man (Nickel…)**
Akire Trestrail	**Carbon**
Emily Ehlerding	**Dr. H. (Hydrogen)**
Kimberly Palladino	**Silicon, the Semi-Conductor**
Shimon Kolkowitz	**Duke Nobellington (Noble gases…)**

Premise

Because of budget cuts, our funding agency has demanded that we eliminate some of the elements in the Periodic Table. Peter is tasked with delivering the news, and he has a vested interest in this because he happens to be the great grandson of Mendeleev and wants to improve on the Periodic Table by coming up with a Version 2.0. Sprott enlists his team of scientists to show why this is a bad idea, eventually winning Peter over and establishing the Element Protection Agency (EPA).

Demo List

{This is the list Steve will use, and so please keep it updated!}

Emily (H)
- Hydrogen Rockets ***- { Loud with upto 60sec delay }***
- Electrolysis ***- { Start !} -- { Camera # 6 }***

Shimon (He)
- Breathing Helium
- Exploding Balloons
- Electrolysis - Ignite the Hydrogen ***- { End ! } - { Camera # 6 }***
- Cloud Chamber ***- { Camera T3V1 }***

Akire (C)
- Fire Tornado ***- { Camera # 6 }***
- *CO2 trough (?)* ***- { Camera # 6 }***
- *Graphite diamagnetic response (?)* ***- { Camera T2V1 }***

Michael (N)
- Atmosphere of pure oxygen ***- { Camera # 6 }***
- Ping Pong ball bazooka ***- { Camera # 6 }***
- Radioactive decay of Ba137 ***- { Computer 1 Table 1 }***
- Brownian Motion ***- { Camera T1V1 }***
- Liquid Nitrogen Cannon

Terry (Cu, Al, etc.)
- Induction -- Coil & Magnet
- Induction -- Flash Bulb
- Heat Conduction with Marbles
- Copper Tube Race
- Eddy Currents -- 2 Large Copper Plates
- Can Launcher

Mike (Fe)
- Hoberman sphere W/smaller ball (Supernova)
- Ferrocell
- Iron in cereal

Kimberly (Si, Ge)
- Sand Pendulum Lissajous Figures (may need to build, should be easy)
- Chladni Plate (sand on speaker wave patterns)
- Fiber optics
- Solar cell
- IR
- Silly Putty
- Silicone (adhesive, caulk, lubricant, insulator)
- Transistor, diode, etc

Spectra

- Fe in a Flame - Mike
- Si in a Flame - Kimberly
- Cu in a Flame - Terry
- N Spectra - Michael
- C Arc lamp & Co2 Spectra - Akire
- He Spectra - Shimon
- H Spectra - Emily

The Wonders of Physics 2019

"Physics of the Periodic Table"

Opening **(Peter [Mic #2], Sprott [Mic #1])**

Lights: ***Main Lights only***

Audio: Science Songs
(ON A&C) - Cameras 5 & 6: {Crowd Shots on A & C }

(ON B) - ***RGB {T1 Computer 1}: PPT intro (Can Emily prepare this?)***
https://docs.google.com/presentation/d/1MSOYBDfYJjkfHT4U-ETpaVGiWwsbVDu2PlpTpkj_LLc/edit?usp=sharing
Lights: ***Change to Stage & Floods***

Peter: Welcome to the (308, 309, 310, 311, 312, 313, 314, 315, 316, 317) presentation of *The Wonders of Physics*... Before the show begins, I want to assure you we make all our demonstrations as safe as possible provided you remain in your seats. ***(Last day only: You will also notice that we are videorecording the show. If you don't want to appear on the video or want your children to appear, don't volunteer for any of the demonstrations.)***

(ON B) - ***{Lectern Computer 1 - PPT Slide #2}: Dmitri Mendeleev***

Peter: The United Nations has proclaimed 2019 the International Year of the Periodic Table of the Elements. It was 150 years ago that my great grandfather ***Dmitri Mendeleev*** produced the Periodic Table that we still use today. However, because of budget cuts, our funding agency has demanded that we eliminate some of the elements. It's my duty to deliver this news to Professor Sprott.

Peter: And so let's give a welcome to that Expert Engineer of the Elements, that Adept Authority on the Atom, that Intrepid Investigator of Isotopes, that Wonder of Physics, Professor Cliiiiint Sprott...

{Theme music - Sprott rides in on the Rocketcycle.}
Audio: ***WOP Theme*** (short)

Sprott: Welcome to ***The Wonders of Physics*****!** This is the International Year of the Periodic

Table of the Elements upon which much of physics and chemistry are based. But Mr. Weix, what's this I hear about changing the Periodic Table?

Peter: Yes, our funding agency has demanded that we eliminate some of the elements to save costs. The Periodic Table is now 150 years old, and we need an updated and simpler Version 2.0. It was my great grandfather who devised the one we've used all these years, and I think we can do better!

Sprott: That's ridiculous! You can't change the Periodic Table, and every element is essential. Let's start with the simplest element of hydrogen with our first witness, Doctor H...

Hydrogen **(Emily [Mic #3])**

Audio: We are the Champions
(ON B) - ***{Lectern Computer 1 - PPT Slide #4}: H***

{Emily comes on stage with a #1 finger...}

Emily: Any way you slice it, hydrogen is #1 of the elements. Without H, none of us would be here. In fact, none of any of this would be here. You see, it's the building block for all the elements. Without H, there is no you. Fusion in stars can take a bunch of H-s and turn it into a bunch of the other elements.

Emily: As if that's not enough, it's also really important for the most important part of physics… blowing stuff up. ***{ Loud - Cover your ears }***
We can fill this rocket with some fuel. Now this fuel is pure hydrogen, really powerful stuff. So now that that's full, we can light it. This may take a while, but you'll know when it goes off. You may want to cover your ears, because this demonstration of the element of surprise is really loud. I'll give you the signal when it's time...

Demo: { Hydrogen Rocket } - {30 to 60 sec} Emily
Audio: TaDa

Emily: Well, it's not all rocket science when it comes to hydrogen. It's also ⅔ of a really important, and really powerful, molecule here on earth. Let's see if you can guess it… If you consume too much of this molecule, it can cause excessive sweating. Accidental inhalation of this molecule can kill you. This molecule is so powerful, that if enough of it falls from the sky, it can even knock down bridges and pick up cars. Any ideas? If you guessed dihydrogen monoxide, you're correct! But for those of us who are familiar with this molecule, we can just use its nickname… water.
Water is all around us, and without it, we couldn't survive. And since H is ⅔ of water… you all can't survive without *it*!

Emily: Now we saw earlier that hydrogen usually exists in a gaseous state. But as we all know, most of the water around us is a liquid. So it might be hard to believe that combining two gases can give us a liquid. I've got a contraption here to prove that water is, indeed, made up of two of H and one of oxygen, by separating the liquid water into the two types of gas. This is called electrolysis. By sending electricity through this colored water, we are able to overcome those forces inside the molecules that hold the hydrogen and oxygen together, and separate liquid water into its two gaseous parts.

(ON A & C) -- Camera 6.1
Start Demo: Electrolysis of Water - Start {Needs to sit for a while}

Emily: Well, while that is doing its thing, I suppose I'll let someone else make their case, and I'll just go into my resting state over here…

Helium **(Shimon [Mic #4])**

Peter: Well, what about all these elements in the rightmost column? It says they're the "inert" gases, so it doesn't sound like they do much at all. Surely we can at least get rid of them?

Sprott: No, of course not! The inert, or Noble, gases are very important, precisely because they're inert and don't interact with the other elements. My good friend ***Duke Nobellington***, will explain.

Audio: Nobleman
(ON B) - {Lectern Computer 1 - PPT Slide #6}: He

Demo: { Inhaling Helium }
{Shimon enters, dressed as nobility and holding a helium party balloon, and having just inhaled helium. He speaks in a regal manner, but with an artificially high voice}
Shimon: Ah, Professor Sprott, my good man! Now then, now then, what's all this nonsense I hear about removing my fellow nobility from the Periodic table? Outrageous, I say! The inert gases are the noblest of elements, and have many important properties and uses.

Sprott: Uh, Duke, what's wrong with your voice?

Shimon: Well, I just took a big breath of Helium, the second element on the periodic table, and the first Noble gas. Now, kids, please don't try this at home! The helium you buy for party balloons isn't as pure as the helium I have here, and there can be contaminants that will cause real harm. This is ultrapure research grade helium, and because it's a Noble, or inert, gas I know it won't poison me. But why did it make my voice so funny? Helium is much less dense than air, and the speed of sound in helium is twice as high. This shifts the resonance frequencies of my vocal tract, and makes my voice sound higher than usual. Now what do you think will happen if I breathe in a gas that is denser than air, like the sulfur hexaflouride I happen to have in a balloon over here?
{Shimon inhales sulfur hexafluoride}

Shimon: Hmmm, that's odd, no effect at all! Must be the wrong balloon. But if it was sulfur hexaflouride it would have made my voice sound deeper. In fact, just to be safe, since sulfur hexafluoride is denser than air I need to bend down in order to completely expel it from my lungs. Excuse me for a moment while I take a bow...
Audio: TaDa

Demo: { Exploding balloons - He & H } - Shimon & Emily
{transition into Exploding balloons demo with Emily}
Fly the Big Fish --??

Shimon: Of course, because helium is lighter than air, we also use it to make *party balloons and blimps float.*

Emily: But you could use hydrogen instead! It's also lighter than air!

(ON B) - {Lectern Computer 1 - PPT Slide #8}: Hindenburg

Shimon: That's true, and people have tried it before, and it hasn't always *gone very well*... That's because Hydrogen isn't a Noble gas, and it's very reactive. In fact, let's give it a try! We've got two party balloons here, one filled with pure helium, and one filled with pure hydrogen. First, I'll try to light this helium balloon on fire with a match.
{Shimon lights match, and applies it to the helium balloon, it pops.}

Shimon: The balloon popped, but that was just the rubber giving way under the heat of the match. Now why don't you try it with your hydrogen balloon?

Emily: OK! Kids, you might want to cover your ears if you don't like loud bangs...
{Emily lights match and applies it to the hydrogen balloon, it explodes.}
Audio: TaDa

Shimon: See, which of those would you rather have at your next birthday party… Actually, never mind, don't answer that! Helium also has lots of other important uses. We use it to cool things down just a few degrees above absolute zero, or -450 Farenheit! This is really important for medical imaging, and for physics research.

Peter: OK, fine, we'll keep Helium, but what about some of these other inert gases? Haven't I heard bad things about ***Radon***?

(ON B) - {Lectern Computer 1 - PPT Slide #10}: Rn

Shimon: Yes, well, ***Radon*** is sort of the black sheep of the Noble gas family, and lives down in the basement. But even radioactive elements like radon are important. Come over here and I'll show you.

(On A & C) -- Camera: Table 3 Video 1
Demo: { Cloud chamber } - { Table 3: Camera 1 }

Shimon: This is a cloud chamber. It uses supersaturated alcohol vapor to allow us to see single atomic nuclei! Each of those little trails is created by what's called an alpha particle, which is really just a fancy word for a helium nucleus. They're being emitted by this ***{fill in the blank here}***, which is a source of alpha particles. You're seeing the tracks made by single atoms in real-time!
Audio: TaDa

Shimon: As you can see, this radioactive source is emitting helium particles all the time. In fact, we get all our helium on Earth from the radioactive decay of elements like radon! And as you'll hear about later in the show, radioactive elements are important for medical imaging too! I hope I've convinced you that all the Noble gases are far too important to dethrone! Now if you'll excuse me, I'm due to have afternoon tea with the Earl of the Alkalis.

{Shimon exits stage left, pursued by a barium.}

Peter: Alright, alright, fine, we'll keep the rest of the Noble gases. But what about that middle row on the periodic table? Surely if we gave carbon the boot then global warming would be gone.

Sprott: Don't call me Shirley. Peter, you're not thinking this through. If it weren't for carbon none of us would be here.

Carbon **(Emily [Mic #3], Akire [Mic xxx])**

(ON B) - {Lectern Computer 1 - PPT Slide #12}: C

Emily: You got that right! *Carbon* is pretty important. So important, in fact, that he couldn't make it today. Something about being critical to all life on earth or something like that. Anyways, he said I could make his case for him.

Emily: Carbon and hydrogen hang out a lot. They even have a couple's name… hydrocarbon. They're no Brangelina, but when carbon and hydrogen get together, things can get really fired up. Let me explain.

Emily: Hydrocarbons, or organic molecules, are the building blocks for all life-forms here on earth - we people are made up of carbon and hydrogen (and other things, but they're not around as much), your dog is made up of C and H, and trees are made up of C and H. Things that are made from trees, like say this paper here, are also made up of C and H.

Emily: When things like trees or paper that are made up of hydrocarbons are given a spark of energy, they can catch fire! Let me show you. Here I have some paper, and I'll add a little lighter fluid (can you guess what elements make up lighter fluid?) to really get this going. If I give this a little spark with my lighter, we get a flame! That little flame isn't that exciting. But we can do some cool things with it. Let's add this screen here. If I give that a spin, we get the coolest campfire I've ever seen!

(On A & C) - Camera 6 - Zoom in
Demo: { Fire Tornado }
Audio: Mary-go-round { ? Akire with marshmallow on stick? }

Akire arrives! ***{ Aha! I finally made it. Well I see that I haven't missed anything, … }***

(ON B) - {Lectern Computer 1 - PPT Slide #14}: Fire Tornados

Akire: Oh I'm so sorry I'm late. This carbon dating lifestyle is demanding let me tell you!!

Emily: Oh look who finally found the time to show up!! It's Dr. Carbide

Akire: You call that a fire? I'll show you a fire!! Because fire takes air to survive, if I rotate the air I can get the fire to rotate as well! This is called a ***fire tornado***. Well how can I get the air to spin? Aha, I can utilize this screen and as I spin the screen, the air entering from the sides is forced to spin as well and when the fire consumes the spinning air, it causes the fire to rotate!! Physics tells us that when things spin, they have angular momentum. The

higher the angular momentum, the closer to the center of rotation the fire gets and speeds up which forces the fire to grow taller. Oh for those of you from the southern hemisphere, let's see what happens if we spin the screen in the other direction. The fire still rotates and so fire tornados can exist in both the northern and southern hemispheres!!

(ON B) - {Lectern Computer 1 - PPT Slide #?}: slide of CO2 molecule

Akire: Okay, well air isn't the only gas we deal with though. Other gases can have different properties than air. ***{CO2 molecule slide}*** For instance, carbon dioxide might be a gas you've heard of. CO2 sure isn't a replacement for air, but it does have some interesting properties. Who here has a birthday this month? I've got some candles here, so let's celebrate all the February birthdays!!

(On A & C) - Camera 6.2

Demo: { CO2 trough }

Audio: Happy Birthday

Akire: I'll light all the birthday candles, but we're not gonna blow out the candles in the traditional way!! Oh no!! Instead, we'll take this container and pour it at the top of this trough. Well look at that - all the flames go out!! This is how we here in physics blow out our candles!!

Audio: TaDa

(ON B) - {Lectern Computer 1 - PPT Slide #?}: CO2 fire extinguisher

Akire: So, what happened, Why did the candles go out? ***{CO2 fire extinguisher slide}*** Turns out that container had CO2 in it and CO2 is heavier than air! So when I pour this heavy gas out at the top of the tray, it pushes all the "***Air"*** out of the way. Without air, more specifically the oxygen in the air, the candles can no longer burn and the flames go out!! That's why some fire extinguishers use CO2!!

(ON B) - {Lectern Computer 1 - PPT Slide #?}: Large diamond in front face

Akire: Finally, I want to share with you another pretty cool property of carbon. Carbon does not always need to be combined with other elements like oxygen and hydrogen. ***{diamond slide}*** Although I do love hanging out with Dr H sometimes, I mean I am a girl's best friend, at other times I like hanging out by myself!! Did you know that diamonds are pure carbon?!

Emily: Err Dr Carbide, what's this cool property of yours that you don't need me for?

Akire: Oh right right, my cool property!! Has anyone ever tried to get a magnet to hover above

another magnet? Well let's try it. You can see these two magnets are attracted to each other right now, which means each end is the opposite pole to the other. So if I flip them around, you'd expect one to float over the other right? Well turns out it doesn't. Magnets have a tendency to push off on the sides preventing them from hovering over each other!! Well that's what makes me carbon super cool!! I come in a form called ***Pyrolytic Graphite*** which can **levitate** over any magnet!!

(On A & C) - Camera: Table 2 Video 1
Demo: { Pyrolytic Graphite } magnetic response

Akire: If I take this form of carbon and place it above this row of magnets, and use my magic powers you'll notice…***"Levioso" !!*** …. It Floats! Thus, showing that Carbon can have magnetic properties which can levitate with more stability than permanent magnets!!

Audio: TaDa

Emily: Oh! I almost forgot! It's time to prove that hydrogen is the most important part of water…
{ Ignite Hydrogen with candle }

(On A & C) - Camera 6.1 via move
Demo: { Electrolysis of Water } -- finish up
Demo: { Ignite the Hydrogen }
Audio: TaDa

Akire: Well okay Mr Weix, I hope you can "C" that carbon is certainly extremely important and definitely should remain as an element on the periodic table!

Akire: Oh Dr H, I think we've made our point. There's some folks freezing in northern Wisconsin that need us to keep them warm. We should get up there and help them out!!

Nitrogen **(Michael [Mic #5])**

Peter: Hmmm, okay I guess. But what about the next row? It may be just a wild "gas" but surely nitrogen could be purged from the periodic table. We already have two elements ending in "gen" and, if you want my opinion, we just don't need a third.

(ON B) - {Lectern Computer 1 - PPT Slide #16}: N

Sprott: Peter...I'm a"ghast" at that thought. Without nitrogen it would be the N'd of the world, and to explain, I've N'listed Professor Air N. Barr well known for his gaseous emissions.

{{ Someone needs to pull back the curtains }} ***{ Michael rides in on a bike with training wheels… but the tires are flat, and so he must struggle with pedaling. Could be fun to have an air horn...it's a blast. }***

? Audio: Some Intro sound bit

Michael: Professor Sprott made it look so easy. Some other clown got carried away when I asked them to "Just get the oxygen out of my tires" . But the good news, at least they're only flat on the bottom...

Peter: Yes but we could inflate those tires with any one of the other gases so far, hydrogen, helium or even oxygen.

Michael: Think about it ….hydrogen is flammable, helium is super rare and don't get me started with oxygen. Did you know that air is 80% nitrogen and it's a good thing too. It may be chemistry but nitrogen doesn't react like oxygen, and that is really important. Nitrogen gas "blankets" are used to keep food like vegetables and fruits fresh longer.

(On A & C) - Camera 6.2 via move
Demo: { Atmosphere of pure oxygen } ….if nitrogen were eliminated.

Michael: Can you imagine how unfun the world would be without nitrogen??? Just look at this candle. Let's light it up for a little experiment. (Light the candle). Oh, I forget...notice this divider, it is really important because it sets up a convection current. Fresh air goes down on one side and hot air up the other. But now I'll just bleed in pure oxygen through this tube….watch closely. ***{Candle really flames up.}*** OOOhhhh, it really flames up. Hey Pete, let's see its effect on you?

Audio: TaDa

Peter: Thank you but I think I'll pass….

Michael: But this is mostly chemistry and we need to emphasize the physics….the wonders of physics. For example, the force of gravity on atmospheric nitrogen can also be put to good use. My good friends, here we have a device we call the `ping pong ball bazooka'.

(On A & C) - Camera 6.3
Demo: { Ping Pong ball bazooka }

Michael: Our goal … tip over this brass block over…. but with….this little ping pong ball. You may laugh but the N'end is Nigh. Notice the sealing tape on both ends of this long tube and so, with a vacuum pump, we can remove the air inside. This means there is one 'barr' (or one atmosphere) of pressure of the air on the outside and almost none inside. When the tape is ruptured the air, mostly nitrogen, rushes in and pushes on just one side of the ping pong ball.. Shall we try? II could some help, a countdown starting at three….it could be loud…..3.2.1... ***{ A countdown and then a little poke. }***
Audio: TaDa

(ON B) - {Lectern Computer 1 - PPT Slide #18}: Schroedinger's cat
(ON B) - {Lectern Computer 1 - PPT Slide #19}: PET Scanner

Michael: See, the forecast was for snow. That was fun. We can use nitrogen in other ways. Did you hear about my PET? No, not a dog or even ***Schroedinger's cat*** but in medical physics, P-E-T, positron emission tomography. A radioactive isotope of nitrogen, N-13, is used in ***PET scanners***. The N-13 atom decays by emitting a sub-atomic particle called a positron. N-13 has a half life of about 10 minutes. Unfortunately to make N-13 we need a cyclotron and sadly the closest one is across the street. But I can show what this half-life means using radioactive Ba-137 which has a half-life of about 3 minutes.

(ON B) - {Lectern Computer 1 - PPT Slide #21}: Ba & Cs
Demo: { Radioactive decay of Ba137 using Cs137 generators }

***** GET INCENSE LIT***

Michael: This special container produces Ba-137 from radioactive Cs-137 (think Fukashima...). A saturated salt solution will just wash out the barium. We can then observe the decay of the excited Ba atoms usingthis gamma-ray detector (its sort of like a Geiger counter).
(ON A) - {Computer: Table 3 Computer 1 }: -- Pasco Computer

Michael: See the curve that is going down? It shows the number of Ba atoms that decay every 4 seconds from an earlier test. Let's see if we can reproduce that result. ***{ Elution followed by decay}*** The curve is dropping and, after 3 minutes, there will only be half as many decays.

Michael: Now..dropping nitrogen atoms….does anyone know what vegetable you get when you drop a nitrogen atom? Not a carrot or a cucumber but an ***"N"-dive***…***{ picture of an endive would help, I will draw it up }***

Audio: Crickets

Demo: { Brownian Motion }
(ON B) - {Lectern Computer 1 - PPT Slide #23}: Brownian Motion
(On A & C) - Camera: Table 1 Camera 1

Michael: Nitrogen in the air is also important for moving things around. At room temperature nitrogen molecules are moving all the time. The effect on small particles is ***Brownian motion*** (after the botanist Robert Brown) and was explained by none other that Albert Einstein. You can see it in this special microscope.

Audio: TaDa

Michael: You know nitrogen has a useful boiling temperature, a cool minus 196 celsius or minus 320 fahrenheit. Liquid nitrogen is important for long term cold storage and when is goes from liquid to gas it expands by about 700 times. We can put that to use in another way. Imagine I'm a Knight in shiny armor and I happen to have a little cannon….just like this one.. All I need to do is pour in this liquid nitrogen, pound in the stopper, and close this valve…. That was a blast. Surely nitrogen can stay….even though I am out of gas.

Demo: {Nitrogen Cannon}
Audio: TaDa

Peter: Okay….well maybe nitrogen should stay but surely there must be something we can cut. I hear that silicon is nearly worthless.

Sprott: Not so Mr. Weix! Silicon is the basis for most of the electronics industry as Professor Sandy Glass will explain...

Silicon **(Kimberly [Mic #6])**

Kimberly: Indeed Professor Sprott, Silicon has many important electronic properties due to its nature as a semiconductor, as my outfit points out. They won't let me be a full conductor since I can't keep the beat.

Audio: classical music clip

Kimberly: Silicon is different from the other elements we've mentioned today, because we encounter it as a solid, not as a gas or liquid. In fact, silicon makes up over 25% of the earth's crust, mostly in silicate minerals. And often those minerals get ground into sand, which is very useful in physics demonstrations. Here we can use sand to help us see sound waves. When we vibrate a plate at a particular frequency, the sand on the plate will pile up in areas where the plate does not vibrate. These regions are called nodes and can make very beautiful patterns.

Demo: { Chladni Plate } -- { Camera 2 }

Kimberly: Silicon is also very light. I'll draw on this plate with a dry erase marker, which has ink made of silicon, other chemicals, and alcohol, and let the alcohol evaporate. While I do that, let me get a volunteer from the audience. Now we can add some water to this plate, and we see our image float away. It can even transfer to our volunteer's hand.

Demo: {floating image}

Kimberly: And of course, when sand was melted down, people learned to make glass which has a number of very useful properties. We can use shaped pieces of glass to correct our vision, or magnify things.

Demo: { converging lens and lightbulb }

Kimberly: When glass is stretched into long fibers, we make cables that can carry laser signals long distances. The light cannot exit the sides of the fiber as it undergoes total internal reflection to stay in the fiber.

Demo: { fiber optics }
Audio: TaDa

Kimberly: Glass can reflect some wavelengths of light too. Here is an infrared camera, which allows us to see light with wavelengths longer than visible light. We can see visible light through this glass plane, but when we look through the glass with the IR camera instead, we see our audience reflected instead!

Demo: {IR camera with pane of glass }

Peter: Well, glass is nice, but modern plastics can do these things too. Can silicon do anything else?

Kimberly: Finally, we come to the useful electric properties of our semiconductor. A solar panel can free electrons in in a silicon wafer, creating electricity. Electricity that can turn a motor!

Demo: {Solar panel}
Audio: TaDa

Kimberly: Now I know silicon can be quite abrasive, silicon is in sandpaper and some toothpaste too, but it also has a softer side. Silicon can be made into polymers like silicone caulk or lubricants, it even put the silly in silly putty. Without silicon we wouldn't have computers, cell phones or video games. Now that would be a bummer.

Audio: Game over video game sound or similar
https://www.youtube.com/watch?v=5Wc3kwv0Ddw

Copper **(Terry [Mic #7])**

Peter: Well Professor Sprott, let's get rid of some of the common metals like copper, zinc or nickel? I'll pick one. How about copper? We don't need copper, many of its properties are not that useful and are duplicated by other elements.

(ON B) - {Lectern Computer 1 - PPT Slide #25}: Cu
(ON B) - {Lectern Computer 1 - PPT Slide #26}: Sn

Sprott: Not so Mr. Weix! Copper is important not only in physics but also in the arts. Copper mixed with tin (atomic number 50, Sn) makes bronze, which is used in statues like this ***badger*** outside the Governor's office

(ON B) - {Lectern Computer 1 - PPT Slide #27}: - Badger
(ON B) - {Lectern Computer 1 - PPT Slide #28}: Zn

Sprott: Or when mixed with zinc (atomic number 30, Zn) makes brass used in this sculpture of the ***"Fonz"*** from the "Happy Days" TV show.

(ON B) - {Lectern Computer 1 - PPT Slide #29}: - Fonz

Sprott: We have with us today Professor T. L. Copper, the famous metallurgist who works with the minds of young students, or maybe he "just works in the mines"?

TLC: Thank you Professor Sprott, I think? Maybe you should just "mind" your own business. Yes, I am T.L. Copper, and I am here to discuss and demonstrate the unique and marvelous physical properties of copper (atomic number 29 - Cu), a wonderful metal and my namesake. By the way, did you know that copper atoms have mass, *pause,* but only the Catholic ones. Well, I was going to make more puns about copper, but I can ***C U (see you)*** don't like them.

Audio: Crickets
(ON B) - {Lectern Computer 1 - PPT Slide #31}: "C" "u"

Demo: { Induction -- Coil & Magnet }
(On A & C) - Camera 5.1 - On the Meter

TLC: So let's start with this coil of copper wire. One of the properties of copper is that it's an excellent conductor of electricity -- the ability to move electrons from one atom to another without much resistance. One way of producing electricity, and the major way most household electricity that we use is produced, is by moving a magnet through a conducting coil of wire. According to ***Faraday's law***, whenever a conductor is moved

near by a magnetic, a current, or a flow of electricity, is produced in the conductor. We can see that electrical current with this galvanometer. When I push the magnet in the current goes one direction and when pulled out goes the opposite direction- a simple alternating current. Notice the the magnet must be moving to produce a current.

(ON B) - {Lectern Computer 1 - PPT Slide #33} - Faraday's Law

(ON B) - {Lectern Computer 1 - PPT Slide #34}: Nd

TLC: So, if we take an even stronger magnet like this one made of Neodymium in the shape of a hockey puck (*atomic number 60, Nd*) and move it quickly through this copper coil, we can produce enough electrons moving, or a strong enough electrical current to light this old-time flash bulb. This will be bright so I will put this tinted shield over the bulb and you may want to look off to the side. Countdown 3… 2…1. Wow, we produced enough current to ignite the gases in the bulb and make it flash. ***{ Warning! Bright Flash }***

Demo: { Induction -- Flash Bulb }

Audio: TaDa

(On A & C) - Camera 5.2 - Marbles

TLC: Copper, besides being a great electrical conductor, is also one of the better heat conductors. Copper can transfer heat energy through itself quite readily. Here are two metal bars, one of copper and one of iron, with marbles attached to each with beeswax. ***(Start marble demo by lighting burner)*** Watch what happen-- this may take a couple of minutes, so keep one eye on it as I go on. …. (After a few balls drop) Let's stop this before I lose all of my marbles. As you can see the copper rod moved the heat outward much quicker than the steel rod. This is why often on the bottom of your better cookware and fry pans, a copper coating is added to distribute the heat faster and more evenly, compared to cast iron fry pans which take a long time to heat up and have hot spots.

Demo: { Heat Conduction with Marbles } - "Start"

(ON B) - {Lectern Computer 1 - PPT Slide #36} - Lenz's Law

TLC: So now, I need a young volunteer from the audience to help me in a copper race. What is your name? I have two identical copper tubes. Look down the tubes to make sure there is nothing in them. Now take this ball and I will take the other ball, and when I say "1, 2, 3, go" drop the ball down the tube and I will drop mine also. "Go". Wow, you won the race-- way to go. For winning I will give you this copper penny. Let's give him/her a hand. Thank you. How was the volunteer able to win the race? Both tubes were the same. But the difference was that my ball was magnetic while theirs was not. Another principle in electricity and magnetism is called ***Lenz's Law***. It says that whenever a current is produced in a conductor by a magnet like we did earlier, that current produces its own ***magnetic effect*** in the conductor. This new magnet creates a force that opposes the motion of the original magnet, like two magnets opposing one another.

(ON B) - {Lectern Computer 1 - PPT Slide #37} - Magnetic Field Lines

{ Get Audience Guest } -- {Show demo of copper tube and ball magnet.}

Demo: { Copper Tube Race }
(On A) - Camera 6
Audio: TaDa

TLC: We can also demonstrate this principle with our Neodymium magnet and this large copper plate. When I hold the the magnet a few inches about the plate and drop it, watch what happens. It slowly floats down to the copper. When place on the side it slowly tips. I can magnify the effect by using a better conductor of electricity. By cooling an identical plate with liquid nitrogen down to -320 F, it makes the copper a better conductor by a factor of five to ten times. I can drop the magnet higher up and tip it even more slowly. Again, the neodymium magnet, as it falls, makes a current in the copper plate which makes the plate magnetic which then opposes the original magnet. ***{show both Cu plates}***

Demo: { Eddy Currents -- 2 Large Copper Plates }
(On A & C) - Camera 5.3 - Plates
Audio: TaDa

(ON B) - {Lectern Computer 1 - PPT Slide #39}: Al

TLC: For my final demonstration I will be using this apparatus, a large capacitor. A capacitor is simply a device which can hold a large electrical charge and release it in the form of a large current. That current will flow through this copper coil which has an ***aluminum*** (my sister metal) soda can in it. Before the show I asked an assistant in the audience to help me. So let's see what happens. Start charging the capacitor. Wow, good catch. How does the can feel? Warm! So what happened? The current in the coil created a current in the can which heated it up. That current in the can, in turn, created a magnetic field which opposed the coil magnet and ejected the can. Thank assistant and give him/her a copper penny.

(On A & C) - Camera 6 - Can Launcher
Demo: { Can Launcher }
Audio: Ball Game
Audio: TaDa

TLC: So Mr. Weix, you can see how useful and important copper and the other related metals are-- we can't get rid of them. Copper makes perfect cents (sense) and has to stay! ***{hold up copper penny.}***

(ON B) - {Lectern Computer 1 - PPT Slide #41}: Penny

…

Audio: Black Sabbath "Iron Man"

Iron (Mike [Mic #8])

{ Mike comes on stage carrying a steam iron…

Audio: Black Sabbath "Iron Man"

Peter: Who are you?
(ON B) - {Lectern Computer 1 - PPT Slide #43}: Fe

Mike: I'm Iron Man.

Sprott: Uh...you're not quite what we expected.

Mike: What do you mean?

(ON B) - {Lectern Computer 1 - PPT Slide #44}: Tony Stark

Sprott: I thought you'd be someone like ***Tony Stark***, from the Iron Man comics.

Mike: Oh, don't get me started on Tony Stark! I used to WORK for Tony Stark.

Peter: Really? What did you do?

Mike: I use to iron his suits! Worst. Job. Ever.

Peter: Oh, so you'd be in FAVOR of taking Iron off the periodic table?

Mike: Whoa whoa whoa! THAT would be a REALLY bad idea! For a LOT OF reasons!
None of you would be here if it weren't for iron and other elements like it. We'll get to that.
But let's start off with something easy.

(ON B) - {Lectern Computer 1 - PPT Slide #46}: - Big Red Barn

Mike: Hey, that's a nice barn. Who knows why they ***paint barns red***?

Mike: They paint barns red because red paint is ***CHEAP!***

(ON B) - {Lectern Computer 1 - PPT Slide #47}:- Why Barns are red

Mike: The red ochre pigment in red paint is RUST - iron oxide. And rust is ***CHEAP*** - because there's ***LOTS of it around!***

(ON B) - {Lectern Computer 1 - PPT Slide #48}: - Bulk Earth Abundance

Mike: Iron, or as the chemists likes to call it, “Feh”, is the most abundant element on Earth, by weight. There is a catch: only about 6 percent is in the Earth's crust, where we can get at it easily. That’s still a lot! Most of Earth's iron is in the middle - Earth's core. The core is over 80 percent iron!

Mike: So why do we have so much iron? Because of ***exploding stars***!

(ON B) - {Lectern Computer 1 - PPT Slide #50}: - Crab Nebula

Demo: Hoberman Sphere w/ Smaller Ball -- Analogy - Type II Supernovas

Mike: Let’s pretend this little ball here is our Sun. And this thing is a big star ***{pointing to the Hoberman sphere}***. This star is about 8 to 50 times bigger than the Sun. BIG star! But it’s going to get even bigger!

Mike: Does everyone remember from earlier in the show what makes stars tick? ***{Audience interaction}***

Mike: Right, ***fusion***. You take some little hydrogen atoms ***{Emily cheers}***, you squeeze them together, and bang! You've got helium ***{Shimon cheers}*** and lots of energy. Makes things pretty HOT in there! All those little atoms are zipping around really fast. So why don’t they zip away? Gravity! That’s where stuff pulls on other stuff. And there's a LOT of stuff in there! So it balances out...

Mike: ...UNTIL you start running out of hydrogen. Then what? The star starts crunching down. Ooooh, but when it does that, the pressure and temperature starts going way up! Pretty soon those little HELIUM atoms get so hot and squished, THEY start fusing! And making other elements further up the chart, like lithium, carbon, and so on. Things get even HOTTER, and the star gets even BIGGER! ***{expand the Hoberman sphere gradually}***

Mike: When’s it gonna end? Right here - with iron! ***{pointing to counterweight}***

Mike: You see, when you fuse lighter atoms, they GIVE off energy. BUT, it TAKES energy to fuse IRON, or heavier elements! Now that's bad news for our big star. No more fusion energy, no more balance. Gravity wins, and the whole thing come crashing down! ***{shrink the Hoberman sphere rapidly}***

Mike: This happens REALLY FAST - over 150 million miles an hour! In a few seconds, the whole thing crunches down on the core. WHAM! The middle gets SUPER SUPER HOT -

around a hundred BILLION degrees! Under these extreme conditions, Iron and other elements can fuse, creating many of the heavier elements on the periodic table.

Mike: But wait! There's MORE! When all that stuff crashes down on the core, it BOUNCES! ***{expand the Hoberman sphere rapidly}*** creating an outward explosion called a ***Supernova***. The energy released in a few SECONDS is more than our Sun will EVER give off in its whole LIFE.

Mike: All those elements, including a LOT of iron, get blasted out into space! That's how iron - and many of the heavier elements - got here. ***And THAT'S why barns are RED.***

Audio: TaDa

(On A & C) - Camera 6 - front table

Mike: Do you know what else is red? Your blood! And that's ALSO because of iron. There's a very important molecule in our red blood cells called hemoglobin. It's job it to transport oxygen from our lungs to other body tissue. So how does the iron get inside you? You EAT IT! ***{Pretend to eat a big nail}***. Mmmmm…. I know. Nail biting is a bad habit.

Mike: Don't eat nails! We get iron from the food we eat. Iron-rich foods include clams, oysters, liver, tofu, and spinach.

(ON B) - {Lectern Computer 1 - PPT Slide #?}: - Iron Foods
https://drive.google.com/file/d/1GHRX3t9bgGmpTtHi9cWbQwkIDfsPrrOL/view?usp=sharing

Mike: Ew. You know, this nail is starting to look pretty good. OR, we could eat foods that have iron ***added*** to them! Many cereals are ***fortified*** with iron. I'll show you!

Demo: Iron in our bodies

Mike: I'll tell you later how you can try this at home, with an adult's help. Hey! I need a helper! Hi! What's your name? <Name>, this is a magnet. Look it over closely. What color is it? Yes, it's covered in white plastic. This is a magnetic stirring rod. Put that in this glass beaker. Earlier, I put a serving of iron-fortified cereal and some water into this blender. Push this big button. ***{Blender pulverizes cereal}***. Mmmm...doesn't that look yummy? Let's pour this glop into the beaker with the magnetic stirring rod. Now turn that switch on ***{Activates magnetic stirrer}***. You can see how our spinning magnet is stirring up our cereal glop.

Mike: OK <Name>, turn off the motor. Let's take a look at our stirring rod magnet. ***{Retrieve magnet with steel screwdriver}***. <Name>, do you notice anything different? Let's put

the magnet under a camera, so everyone else can see. There's some black stuff on the ends of the magnet!

Audio: TaDa

Mike: That's the iron from the cereal! Iron is attracted to magnets, so as the magnet spun in the cereal glop, the iron stuck to it. Let's give <Name> a big round of applause!

Mike: If you want to try this at home, you don't need all this fancy equipment. Just some fortified cereal, water, a zip-top bag, and a strong magnet. Put the cereal and water in the bag, and let it soak until it's soggy (about 20 to 30 minutes). Munge up the sealed bag with your hands, then put the magnet on the outside of the bag and shake it around. You'll see the iron collect on the inside of the bag near the magnet.

Peter: Well, I can now see it would be iron-ic to eliminate iron and related elements from the periodic table. ***{Peter laughs at his own pun}***

Mike: Hey, Mr. Weix. You might want to lay off those iron jokes. That last one was a little ***rusty***…

? Audio: rim shot

Peter: Whatever. Hey, I have a question. How do we KNOW that all those elements are found in exploding stars? Stars are a LONG way from us.

Spectra **(Cast)**

{Everyone comes out and shows off their element -- in reverse order}

{Lectern Computer 1 - PPT Slide #51 - ?? }:

Mike: That's a great question! It turns out that every element has a unique "fingerprint" - its light spectra. As you heat up an element, it gives off a unique combination of colors. So we can tell what's in a star by looking at the colors coming from it...even if it's on the other side of the universe! Do you want to see what that looks like? Great! Let me invite all my elemental colleagues back into the room. Everyone, either look at the overhead screens, OR put your special diffraction glasses on, like this! After the show, you can leave your glasses in front of you for people in the next show, OR take them with you and talk with our greeters out front about how you can take them home. Now, let's turn down the room lights.

Mike: Now, for the elements that usually exist as a gas, we can send electricity through the gas and see the spectra. Let's start with hydrogen.
(Hydrogen spectra)

Mike: Now Helium!
(Helium spectra)

Mike: Let's see what Nitrogen looks like!
(Nitrogen spectra)

Mike: Now Carbon, as carbon dioxide!
(CO2 spectra)

Mike: We're going to do something a little different for the other elements. When we heat an element with a flame, you'll see some different colors in the flame. Let's try silicon first.

Kimberly: For silicon, I have Professor Copper's thumb drive…

Terry: **NOT THAT!** ***{grabbing the thumb drive from Kimberly }*** I have an important report on that drive!

Mike: Uh, why don't we skip silicon. Let's try iron next.
(Spray FeCl into flame)

Mike: So that's iron! Mr. Copper, you're up!
(Spray Cu Cl into flame)

Mike: And that's how we know what stars are made of!

{ Split into two groups - Stand on either side- keeping the center open for "Closing" }

Closing **(Sprott, Cast)**

Sprott: So you see, Peter, we can't just arbitrarily change the Periodic Table. The elements are what nature has given us, and they are all good and useful. Maybe we should propose a new government agency. We could call it the "Element Protection Agency" (the EPA).

Peter: I'll see if I can convince our funding agency to abandon this crazy idea.

{Sprott turns to address the audience:}

Sprott: Of course our funding agency has not really made such a ridiculous demand. But our politicians do sometimes misunderstand the role of science and its importance. Science is about facts and not opinions. We laugh that 120 years ago, the legislature of Indiana considered a bill that redefines pi to be 3.2, but they realized that you can't change the facts. Sometimes we hear talk about "alternate facts," and mentions of climate change are being removed from government websites. Let's hope that our present legislature will be at least as wise as the one in Indiana. Not everyone should be a scientist, but everyone should understand what science is, how it works, and why it is important. I hope you will all join in the effort to make that happen.

Sprott: (the usual ending) And now I'd like to end the show as we do every year by making for you a cloud using a liquid form of the element nitrogen...

(ON B) - RGB {Lec Computer 1}: PPT SLIDE # 48 - Clouds / Thank You
(ON B) - DVD Video: Theme music video
Audio: WOP Theme-long-3m22s.wav

Theme music video plays.

{Cast all bow in unison.}

Resources:

- 2018 PowerPoint Slide Show
- Physics Lecture Demonstrations
  - An old Physics 103 Demo List
  - An old Physics 104 Demo List
  - WoP Demos from Previous Years
  - 85 Video Clips from Physics Demonstrations Book
- WOP sound library
- 2018 WOP script
- 2017 WOP script
- 2016 WOP script
- 2015 WOP script
- 2014 WOP script
- 2013 WOP script
- 2012 WOP script
- 2011 WOP script
- Free Sound Effects Archive
- Nova “Hunting the Elements” video
- Tom Lehrer’s Elements song
- The elemental abundances (with uncertainties) of the most Earth-like planet
  Estimates (with uncertainties) of the elemental abundances of the bulk Earth

Demo: Iron in our bodies

Materials

- Cereal such as Total® (must be high in iron)
- Magnetic stirring rod
- Water
- Blender
- Beaker
- Magnetic stirring apparatus
- White paper towels or napkins
- Big nails (5 or 6)

Instructions

- http://www.physicscentral.com/experiment/physicsathome/iron.cfm
- Magnet Man: How Magnets Work
- Dietary Supplement Fact Sheet: Iron
- All About Anemia
- Iron in Cereal
- Magnetic Cereal

NOTES:

Helium walks into a bar. The bartender says, "We don't serve noble gases here." Helium doesn't react.

“How can you tell the difference between a chemist and a plumber?”
“Ask them to pronounce ‘unionized’.”

What don't you understand about copper? It makes perfect CENTS!

A wrestler holding down an opponent may have a NEON him.

What is the element's favorite carnival ride? The Ferrous Wheel, of course!

What does a metal miner write home in a letter to his girlfriend? I am zincing of you all the time!

Guys, stop it with the puns. We've all sulfured enough.

Silicon jokes: Q: Is silicon the same in Spanish? | A: Si

If "Fe" is Iron, then does that mean that a Female is Iron Man?

What will happen if you get into water and can't zwim? Zinc!

My wealthy old aunt passed away and all I got was the antimony!

What's the name of the element that comes after nine? -- Tin

No, I'm not trying to poison you...now finish your Pb and J sandwich.

My date was boron me today so tonight Iodine alone.

I'm not out of element puns yet, I still got a copper more.

What kind of fish is comprised of a pair of sodium atoms?....Two Na

Why are my pants so wrinkled, iron deficiency

The mountains here look so beautiful....yes indeed the views arsenic.

Not politically correct... Q. What was that druggie looking for? A: He needed eur opium.

James Cagney said "you'll never take me alive copper" in the movie Public Enemy

Studying the elements is a really serious bismuth.

Do you know the scariest element in the periodic table, Ah!_112, the element of surprise.

Dear departed Dynium, we gather here not to Praseodymium but to Barium.

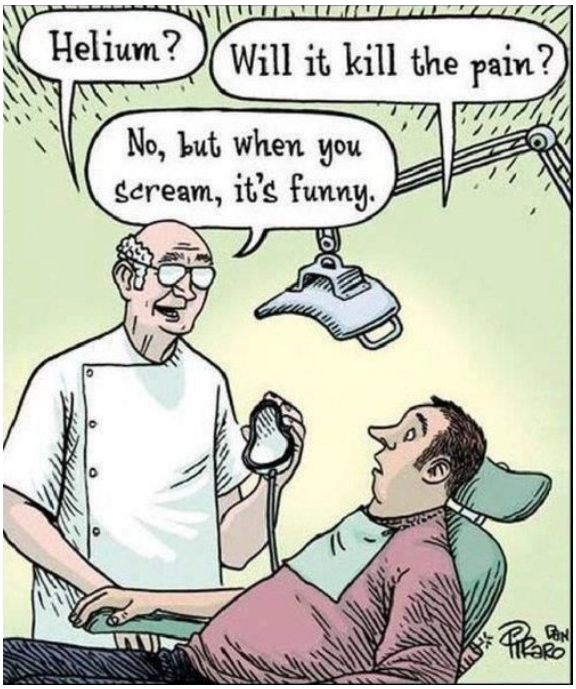
I was going to tell a chemistry joke, but lost the element of surprise. So I doubt I will get a reaction. All the good jokes Argon, anyways.

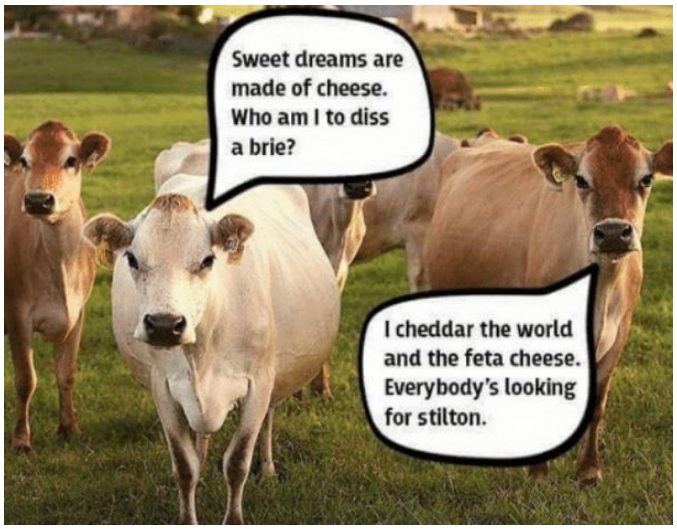
Did you hear the joke about the pair of atoms making up the superfluid state of He-3? No, but I remember the punch line....He-He (hee-hee)....

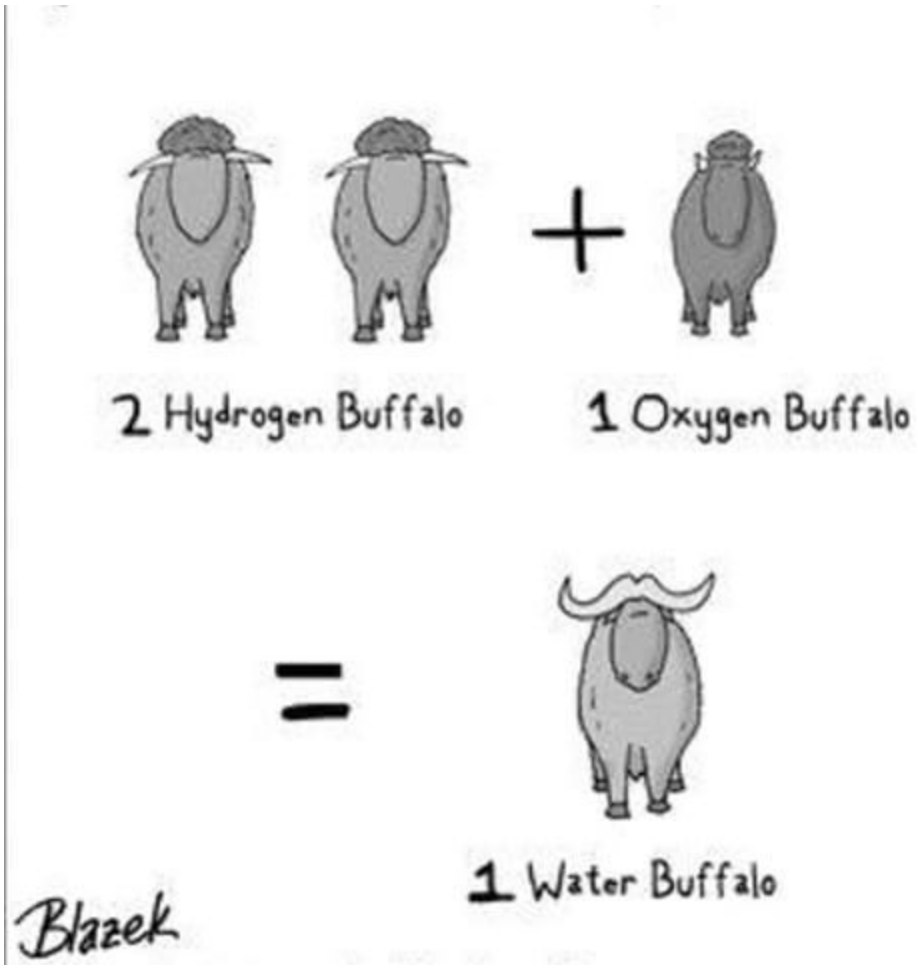
So this dude's like, "What are you going to do with all that element 83?". And I was I "It's none of your bismuth..."

I just heard that oxygen and magnesium were like dating and I said "OMg"....

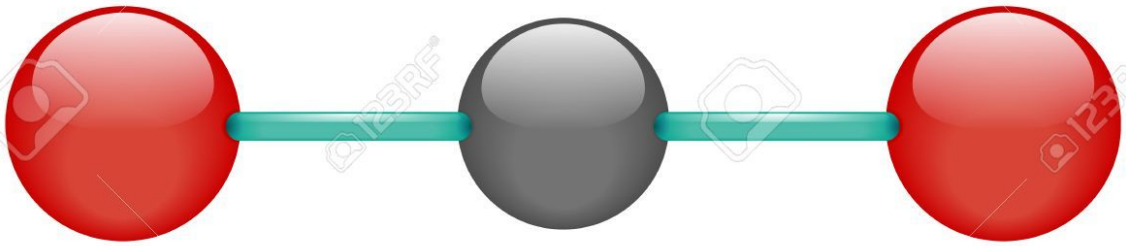
What do you call the king's flatulence? A noble gas.






2 Hydrogen Buffalo
1 Oxygen Buffalo
=
1 Water Buffalo
Blazek

CO_2 O=C=O



carbon dioxide

Carbon Checklist

Lighter for candles

Dry ice to blow out candles

Two magnets to contrast levitation

Silicon Checklist

Sand available for Chladni plates, and randomly distributed

Plate, warm water and pen for floating images

Lens

Batteries in laser pointer, Lightguide on stand

IR camera battery charged

Lightsource, motor and solar panel