5) "MAKE FIVE" A game about mineral recipes

This game is recommended for older students, or those who are very enthusiastic about rocks and minerals. If "Symbol Jars" was enough, you can skip this game. You could also wait and play this game after the next chapter.

By definition, a mineral has a definite chemical composition (a recipe). In this game you will be introduced to the recipes for some common minerals. It's also an opportunity to keep on learning all those letter abreviations (symbols).

You will need: copies of the pattern pages copied onto card stock, scissors, and white glue (if you are assembling the paper dice) If you are using wooden cubes for the dice, you'll also need one or more markers.
(In a pinch for time, just take a fine point marker (red?) and write on real dice. Everyone can ignore the dots.)

NOTE: If you can get three wooden cubes, this is the best option. Most craft stores sell wooden cubes by the "each" or in small units and fairly inexpensively. If you want this game sturdy enough to survive future uses, consider using wooden cubes.

Preparation:

1) Cut out the dice patterns (copied onto heavy card stock) and make into cubes, using small dabs of white glue on the tabs. (Or, write the symbols on wooden dice or even regular dice.)

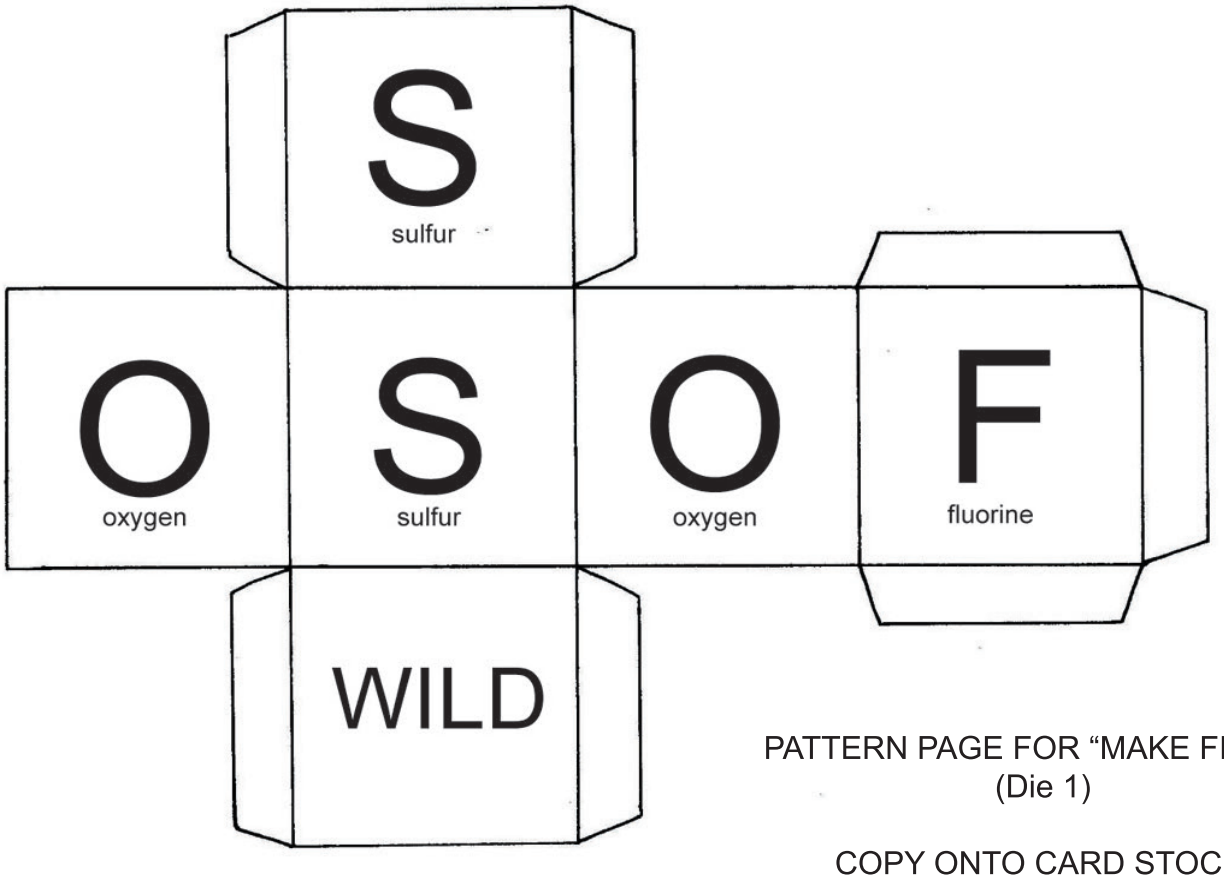
2) Cut apart the 16 mineral cards.

How to play:

Place the mineral cards on the table, face up, so they form a 4 x 4 square. Each player will have a turn rolling all three dice at once. The goal is to roll the ingredients to form a mineral. (One roll of the three dice per player per turn.) For example, if the first player rolls: Cu, Fe, and S, he should notice that those are the ingredients of chalcopyrite. Therefore, that player picks up the chalcopyrite card. If the next player rolls Ca, C, and WILD, he could make the wild card into O, and be eligible to pick up calcite.

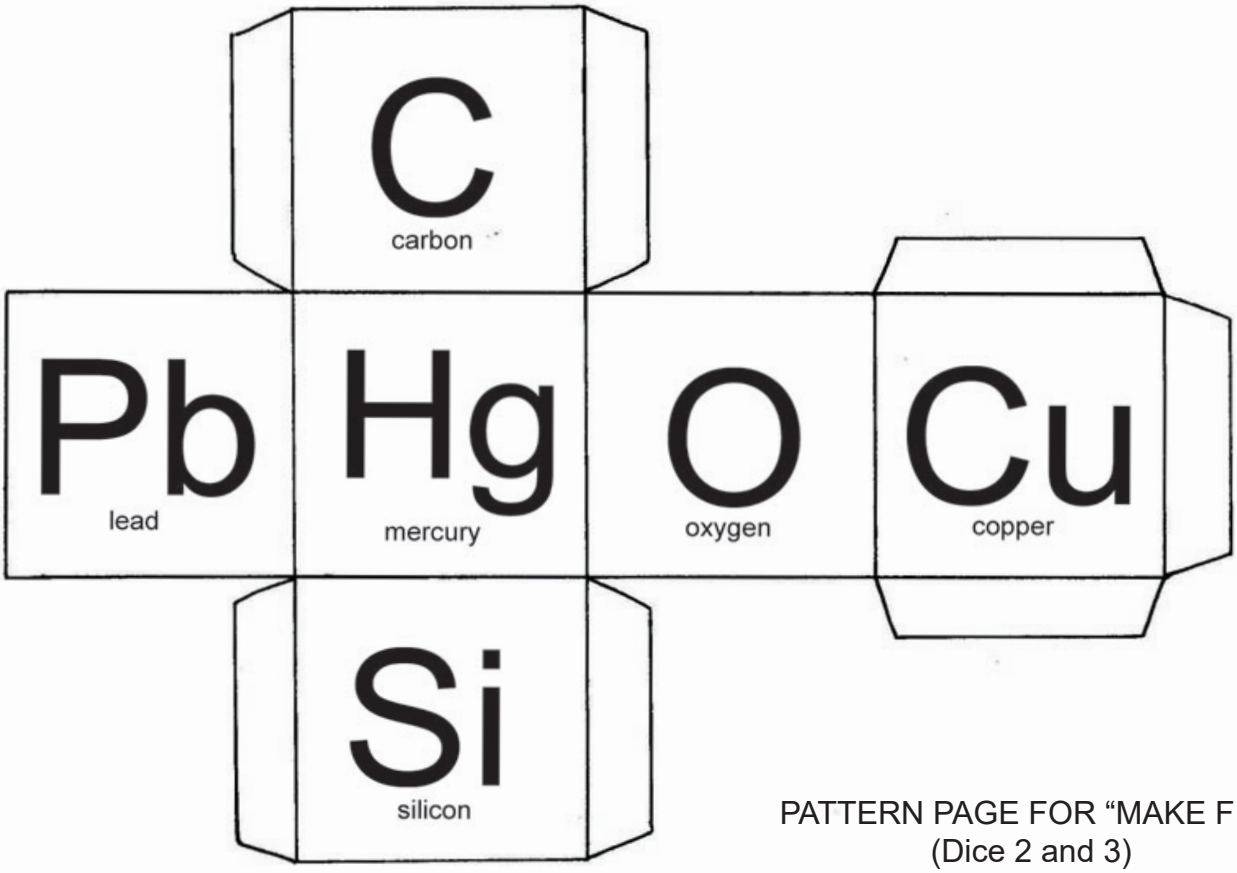
The first player to collect five cards wins the game.

NOTE: If you are working from a paperback copy of this book, not a digital download, and you would like a digital file so that you can print these patterns using your computer's printer, go to www.ellenjmchenry.com, click on FREE DOWNLOADS, then on CHEMISTRY, and then you will see a link for "Printable pages for The Elements curriculum."



PATTERN PAGE FOR "MAKE FIVE"
(Die 1)

COPY ONTO CARD STOCK



PATTERN PAGE FOR “MAKE FIVE”
(Dice 2 and 3)

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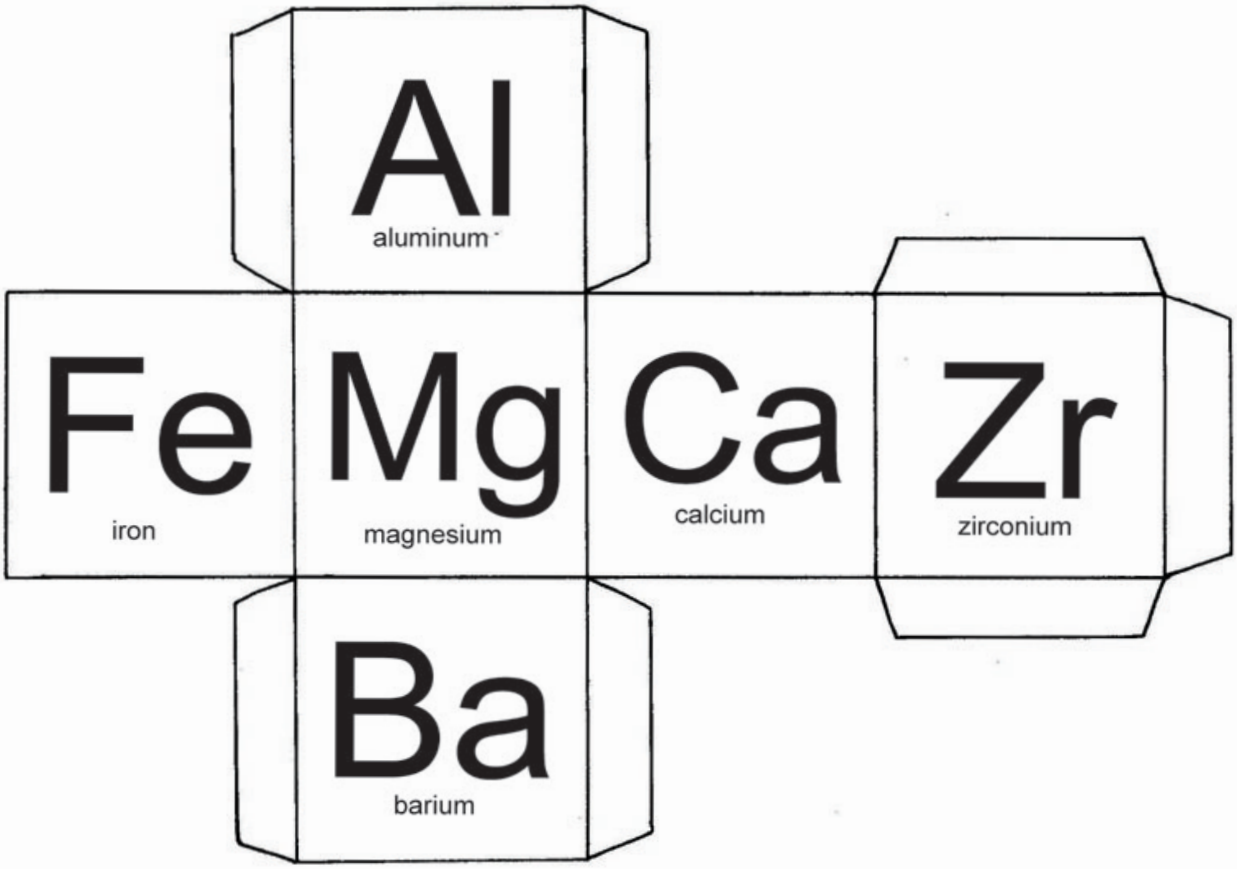


barite

$BaSO_4$

Often found in limestone or hot spring areas. Usually white or light brown. Sometimes crystalizes into rose shapes, which are popular with collectors.

zircon

$ZrSiO_4$

Found in nearly all igneous rocks, although in very small amounts. Because it is so hard, it is often used as a gemstone in jewelry.

hematite

Fe_2O_3

Hematite is a major ore (source) of iron. The name "hematite" comes from its blood-red color ("hema" means blood).

cinnabar

HgS

Cinnabar has a reddish color and is very dense (heavy) because of the mercury (Hg). Pure mercury is a liquid at room temperature, but it is a solid when bound to sulfur.

cuprite

Cu_2O

Cuprite forms cubic crystals. It is sometimes called "ruby copper" because of its color. When exposed to air it changes to CuO.

fluorite

CaF_2

Fluorite is used in the production of steel. It has a glassy luster and can look similar to a quartz crystal, except for its tetragonal (4-sided) shape.

quartz

SiO_2

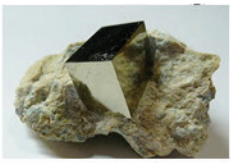
Quartz is used in electronics, as a gemstone, and in the manufacturing of glass (where it is the main component). Sand is made of very tiny pieces of quartz.

galena

PbS

Galena is very dense (heavy) because of the lead in it. During the era of musket rifles, galena was used as the source of lead to make musket balls.

pyrite



FeS_2

This mineral is often called "fool's gold" because of its golden color and shiny luster. It has no actual gold in it. It leaves a black streak, not gold.

FIRST PATTERN PAGE FOR "MAKE FIVE"

COPY ONTO CARD STOCK

corundum

Al_2O_3

Corundum is very hard. It is so hard that it is used in industry as an abrasive (like sand paper). Blue corundum is called a sapphire and red is a ruby.

talc

$Mg_3Si_4O_{10}$

Talc is extremely soft. In fact, you can scratch it with your fingernail! Talc is the main ingredient in talcum powder (used to dry off after a shower).

calcite

$CaCO_3$

Calcite is the main ingredient in limestone. It is one of the most common minerals in the world. Caves are made of limestone.

gypsum

$CaSO_4$

Gypsum is a soft mineral. It is one of the main ingredients in plaster and plasterboard. One type of gypsum is called alabaster and was carved by ancient peoples.

chalcopyrite

$CuFeS_2$

Chalcopyrite is pinkish-purple with flecks of gold. It is found wherever copper is mined. The copper can be taken out of it by using chemical processes.

epsom salt

$MgSO_4$

This mineral dissolves into water very easily. It is often used in medical treatment of wounds on hands and feet. It helps in the healing process.

diamond/graphite

C

Strangely enough, both priceless diamonds and the stuff in your pencil are made of the same thing: pure carbon. The difference is how the atoms are bonded together.

SECOND PATTERN PAGE FOR “MAKE FIVE”

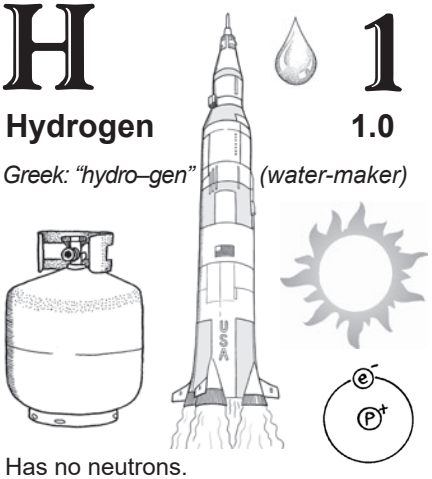
COPY ONTO CARD STOCK

PATTERN PAGE FOR “SYMBOL JARS” COPY ONTO CARD STOCK

H 1

Hydrogen **1.0**

Greek: "hydro–gen" (water-maker)

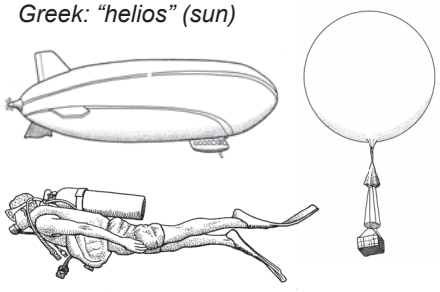


- Has no neutrons.
- Is the fuel for stars (including our sun)
- Used in rocket fuel and fuel cells
- Combines with O to make water.
- Combines with C to make natural gas.

He 2

Helium **4.0**

Greek: "helios" (sun)



- Used in balloons, blimps and scubing diving tanks.
- Discovered in the sun in 1895 using a spectrometer.

Li 3

Lithium **6.9**

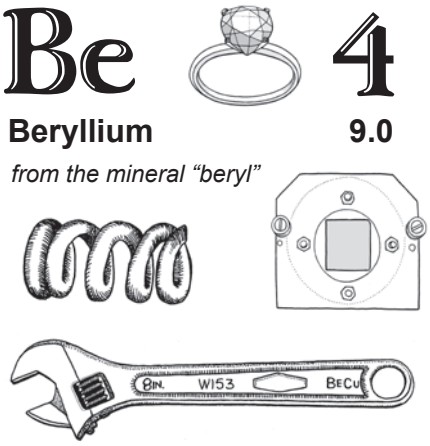
Greek: "lithos" (stone)

- Used in batteries, lubricants, medicines, red fireworks, and nuclear bombs.
- Is never found by itself in nature (it's always in a compound).

Be 4

Beryllium **9.0**

from the mineral "beryl"



- Found in emeralds.
- Is mixed with copper to make "beryllium bronze," for making tools and parts that won't create sparks.
- Used for "windows" that let x-rays pass.

B 5

Boron **10.8**

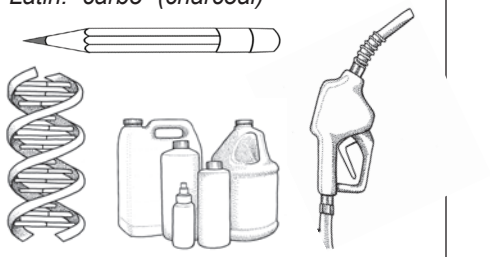
from the compound "borax"

- Used to make heat-resistant glass.
- Used in boric acid antiseptic eye wash.
- Is a main ingredient in Borax® washing powder
- Used in nuclear power plants.
- Combines with white glue to make "slime"

C 6

Carbon **12.0**

Latin: "carbo" (charcoal)



- Diamonds, graphite (pencil "lead") and coal are all made of carbon.
- Carbon makes long chains (polymers) that are the basis of fossil fuels and plastics.
- Carbon is necessary for organic molecules found in living organisms.

N 7

Nitrogen **14.0**

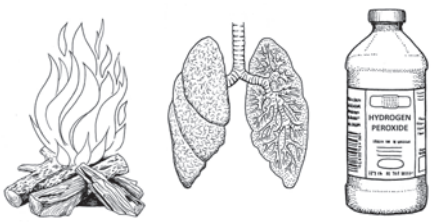
Greek: "nitron" (the mineral saltpetre)

- Most of the air we breathe is nitrogen.
- Used in air bags in cars.
- Combines with H to make ammonia (found in some cleaning products)
- Plants need N to stay green.
- Found in gun powder.

O 8

Oxygen **15.9**

Greek: "oxy-gen" (acid-maker)

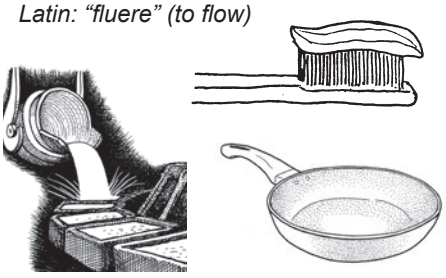


- Combines with silicon to make sand
- Necessary for respiration and combustion.
- H_2O is water.
- H_2O_2 is hydrogen peroxide.

F 9

Fluorine **18.9**

Latin: "fluere" (to flow)



- Combines with Ca to make fluorite.
- Is put into toothpaste to fight cavities.
- Combines with C to make Teflon.®
- Used as flux in steel making (makes hot metal flow better).

Ne 10

Néon **20.1**

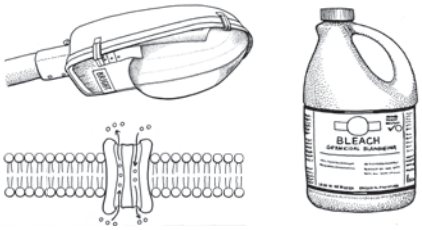
Greek: "neo" (new)

- Used in neon lights and lasers.
- Neon doesn't bond to other elements.

Na 11

Sodium **22.9**

from soda ash



- Combines with Cl to make table salt.
- Used in street lights.
- Found in bleach, NaClO.
- Found in sodium/potassium pumps in cell membranes.

Mg 12

Magnesium **24.3**

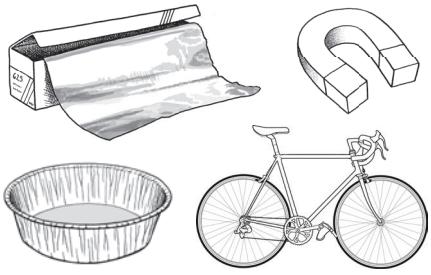
from Magnesia, in Greece

- Used in white sparklers.
- Found in Epsom salt, $MgSO_4$.
- Is the central atom in chlorophyll (the green molecule in leaves).
- Used to make fire starters.

Al 13

Aluminum **26.9**

from the compound "alumina"

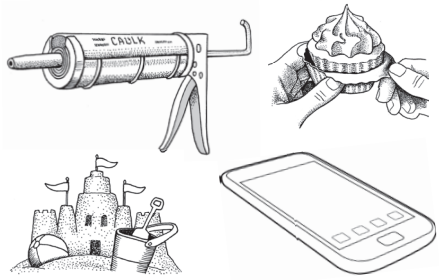


- Used to build bicycles and airplanes
- Al_2O_3 is the mineral (gem) corundum.
- Used for foil, and for beverage cans.
- Used in AlNiCo magnets.

Si 14

Silicon **28.0**

Latin: "silex" (hard stone, boulder)



- SiO_2 is quartz (which can form sand).
- Used to make microchips.
- Used to make silicon rubber products like caulk and flexible baking dishes.

P 15

Phosphorus **30.9**

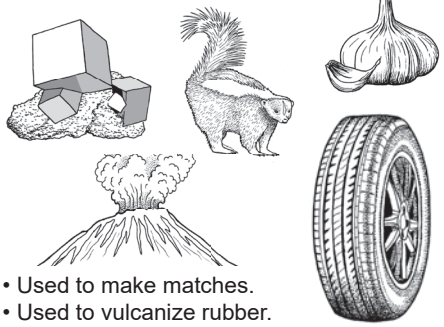
Greek: "phosphoros" (bringer of light)

- Found in matches and some cleaners.
- Necessary for strong bones and teeth
- Phosphoric acid is often in fizzy drinks.
- Is an ingredient in many plant fertilizers.

S 16

Sulfur **32.0**

Latin: "sulfur" (stone that burns)

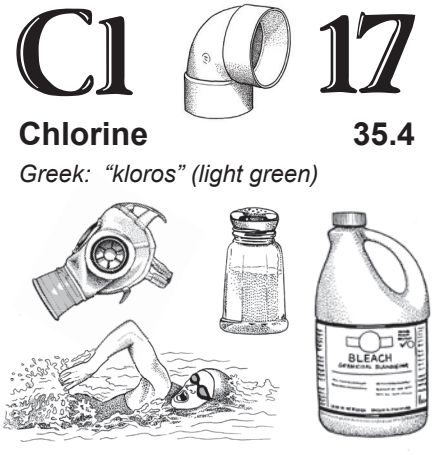


- Used to make matches.
- Used to vulcanize rubber.
- Volcanoes produce gases containing sulfur.
- Makes skunks and garlic stinky.
- Combines with Fe to make the mineral pyrite.

Cl 17

Chlorine **35.4**

Greek: "kloros" (light green)

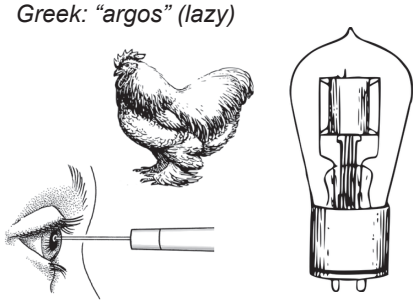


- Bonds with Na to make table salt.
- Used to disinfect swimming pools.
- Is an ingredient in PVC plastics.
- Found in bleach, NaClO
- In pure form is a poisonous green gas.

Ar 18

Argon **39.9**

Greek: "argos" (lazy)

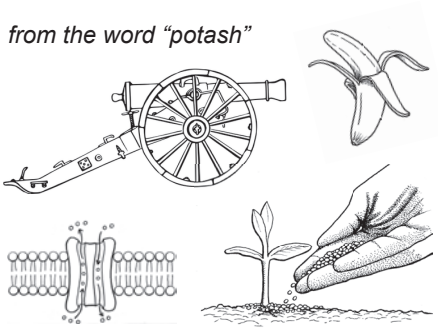


- Replaces air in lightbulbs.
- Used to make lasers for eye surgery.
- Used to butcher chickens.
- Doesn't form any molecules.

K 19

Potassium **39.0**

from the word “potash”

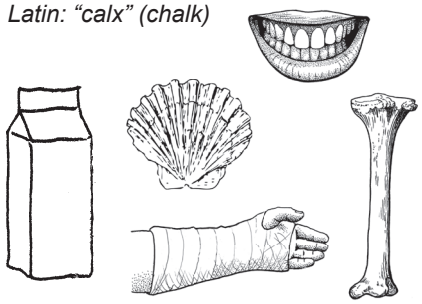


- Used in fertilizers.
- Is an ingredient in gun powder.
- Bananas contain a lot of potassium.
- Is found in mineral orthoclase feldspar.

Ca 20

Calcium **40.0**

Latin: “calx” (chalk)

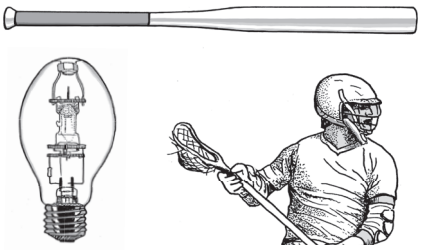


- Found in chalk, limestone and plaster.
- Needed for strong bones and teeth.
- Milk and broccoli have lots of calcium.
- Seashells are made with $CaCO_3$.

Sc 21

Scandium **44.9**

named after Scandinavia

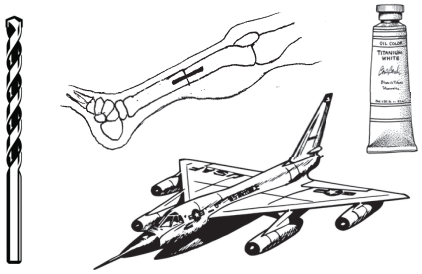


- Used in high intensity light bulbs.
- Used in large television screens.
- Alloys containing Sc are used to make sports equipment.

Ti 22

Titanium **47.9**

named after the Greek Titan gods

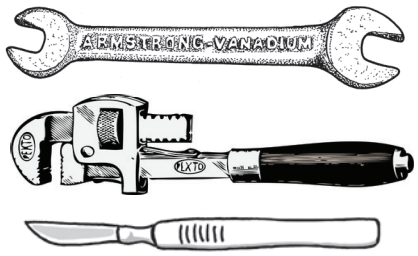


- Used to repair bones.
- Used to make white pigment for paint.
- Alloys are used to make airplane engines, drill bits and tools.

V 23

Vanadium **50.9**

after the Scandinavian goddess Vanadis

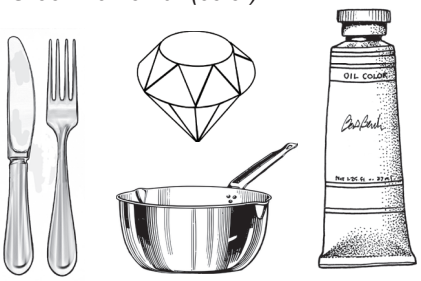


- Added to steel to make very durable and corrosion-resistant tools, springs and engine parts

Cr 24

Chromium **51.9**

Greek: “chroma” (color)

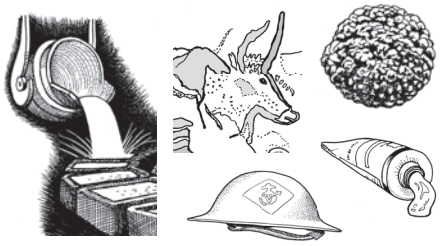


- Gives rubies their red color.
- Used to make red, green and yellow paint.
- Used as a shiny coating for metals.
- Added to steel to make it “stainless.”

Mn 25

Manganese **54.9**

Latin: “magnes” (magnetic)

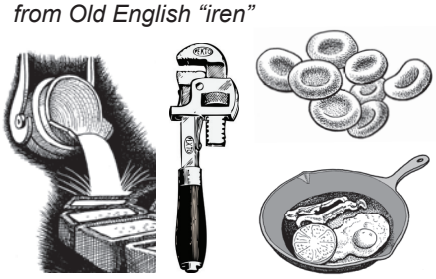


- Used to remove impurities from steel.
- Manganese nodules are on ocean floor.
- Found in vitamin B1.
- Is the "Mn" in YInMn blue pigment.
- Found in pigments in cave paintings.

Fe 26

Iron **55.8**

from Old English “iren”



- Discovered in ancient times.
- Used in steel and in magnets.
- Found in red blood cells and in rust.
- Used to make cast iron cooking pans.
- Red blood cells are red due to iron.

Co 27

Cobalt **58.9**

German “kobald” (evil gnomes)

- Used in AlNiCo magnets.
- Used in making drill bits and razors.
- Can be used to color glass deep blue. or to make blue glaze/paint for pottery.

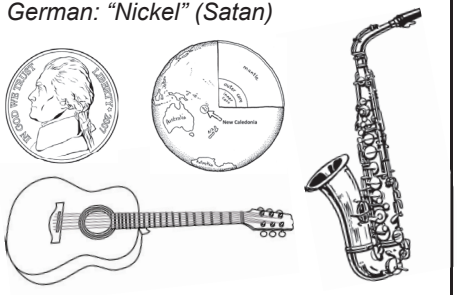
“Quick Six” pattern page 3

Copy onto white card stock

Ni 28

Nickel **58.7**

German: "Nickel" (Satan)



- Core of earth likely made of Ni and Fe.
- Used to make coins and utensils.
- Used as coating for keys of musical
- Used to make AlNiCo magnets.
- Guitar strings made of nickel and steel.

Cu 29

Copper **63.5**

Latin: "Cuprum" (from Cyprus)

- Used for coins, wires and pipes.
- The Statue of Liberty is made of copper.
- Copper mixed with zinc makes brass.
- Copper mixed with tin makes bronze.

Zn 30

Zinc **65.4**

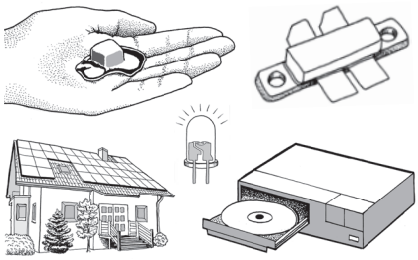
Greek: "zink"

- Used for galvanizing (protecting)
- Was used to make voltaic pile battery.
- Zinc sulfide glows in the dark.
- Zinc and copper make brass.
- Sunscreens can contain Zn compounds

Ga 31

Gallium **69.7**

Latin: "Gallia" (France)

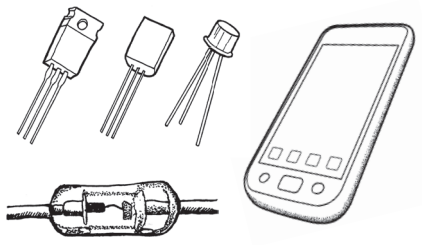


- Gallium arsenide is used in LEDs, lasers, and in Blu-ray players.
- Used in electronic devices.
- Gallium arsenide is in solar panels.

Ge 32

Germanium **72.6**

Latin: "Germania" (Germany)

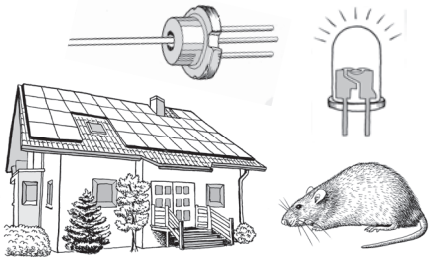


- Is a semi-conductor and therefore is used in transitors and diodes.
- Used in photographic lenses.
- Used in infrared-sensing devices.

As 33

Arsenic **74.9**

Latin: "arsenicum" (a pigment)

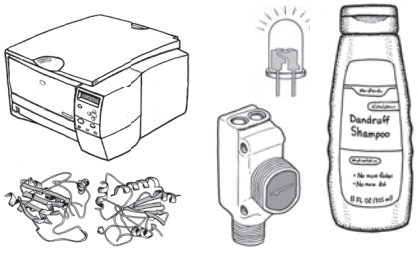


- Famous for its use as a poison.
- Gallium arsenide is in solar panels.
- Used in lasers and LED's.
- In the past, was used for green pigment.

Se 34

Selenium **78.9**

Greek: "selene" (moon)

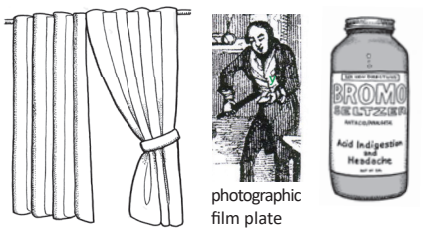


- Used in photocopiers because it conducts electricity in the presence of light.
- Used in solar panels and in light meters.
- Selenium used as an anti-oxidant in our bodies, protecting us from cellular damage.
- A key ingredient in anti-dandruff shampoo.

Br 35

Bromine **79.9**

Greek: "bromos" (stench)



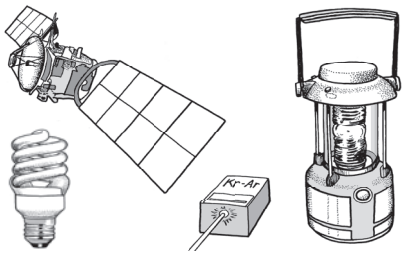
photographic film plate

- Bromine is in the purple ink taken out of murex mollusks (royal purple)
- Used to make fire-resistant fabrics.
- Was used in photographic film.
- Was key ingredient in Bromo-Seltzer.®

Kr 36

Krypton **83.8**

Greek: "kryptos" (hidden)

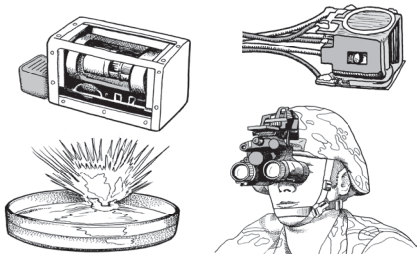


- Used in fluorescent bulbs, and for bulbs that need to be extremely bright.
- Used in UV lasers and in atomic clocks.
- Was used as propellant in satellites.

Rb 37

Rubidium **85.5**

Latin: “rubidus” (deep red)

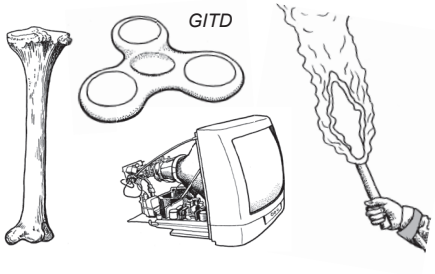


- Will burn in water (red flames).
- Used as a “scavenger” in vacuum tubes.
- Used in magnetometers and night vision goggles.
- Used in small atomic clocks.

Sr 38

Strontium **87.6**

after the Scottish village of Strontia

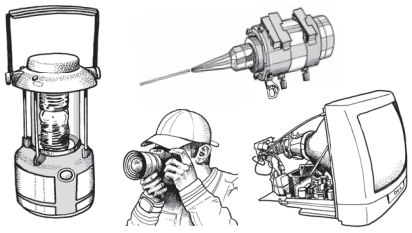


- Used in fireworks and flares.
- Sr in old bones is used by archaeologists.
- Was used in CRT television screens.
- Strontium aluminate glows in the dark.

Y 39

Yttrium **88.9**

after the Swedish town of Ytterby

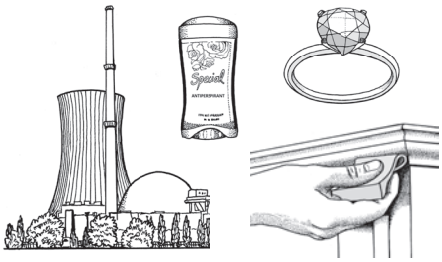


- Used in mantles for gas lanterns.
- Used in YAG (yttrium garnet) lasers.
- Made red color in CRT televisions.
- Is the "Y" in YInMn blue p
- Used in glass for specialty lenses.

Zr 40

Zirconium **91.2**

Arabic: “zargun” (gold color)

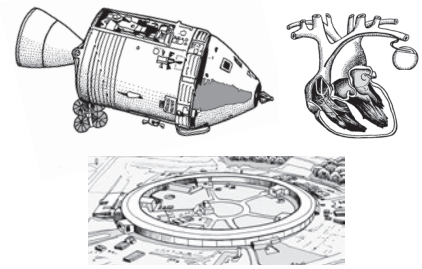


- Made into gemstones.
- Found in antiperspirants (along with Al)
- Used for tubes in nuclear power plants •
- Used to make abrasives (sand paper)

Nb 41

Niobium **92.9**

named after the Greek goddess Niobe

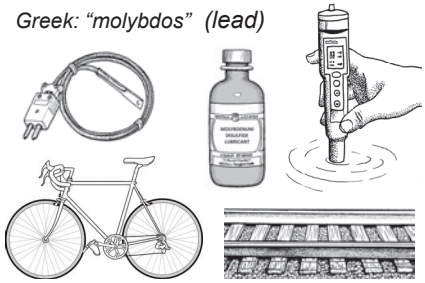


- Used in welding rods and cutting tools.
- Used in alloys for rocket engines.
- Niobium jewelry is iridescent.
- Nb wired used in particle accelerators.

Mo 42

Molybdenum **95.9**

Greek: “molybdos” (lead)

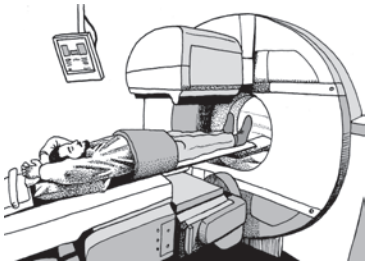


- Used for filaments in heaters.
- Added to steel (“Chromoly” steel) used for things that must be durable.
- Used in water quality gauges.
- MoS_2 is used as a dry lubricant.

Tc 43

Technitium **99.0**

Greek: “teknetos” (artificial)

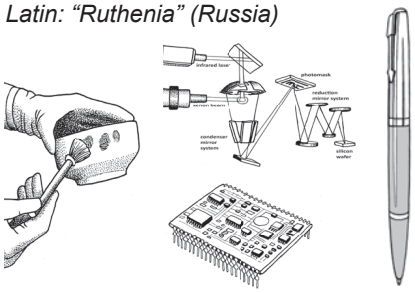


- Is radioactive.
- Not found in nature. Must be made in a nucluear laboratory.
- Used in medical procedures.

Ru 44

Ruthenium **101.1**

Latin: “Ruthenia” (Russia)

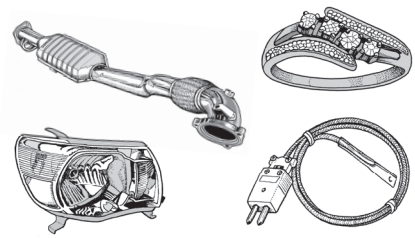


- Used to make resistor chips for electronic devices
- Was used to make tips for fountain pens.
- Used for lifting fingerprints.

Rh 45

Rhodium **102.9**

Greek: “rhodon” (rose)

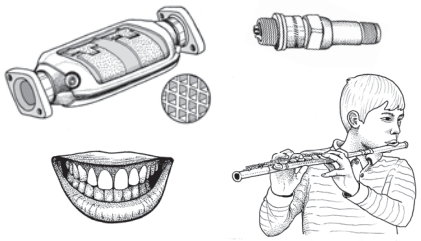


- Used in catalytic converters in cars.
- Used in headlight reflectors.
- Makes jewelry look extra shiny.
- Combined with **Pt** and **Pd** to make spark plugs and electrodes.

Pd 46

Palladium **106.4**

named after the asteroid Pallas

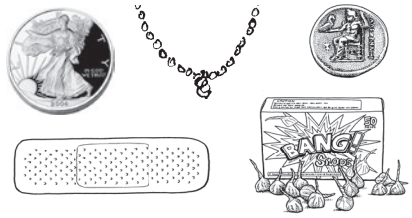


- Used in catalytic converters in cars.
- Found in airplane spark plugs.
- Used to make high quality flutes.
- Used in jewelry and dentistry.
- Used with silver for capacitors.

Ag 47

Silver **107.8**

Anglo-Saxon: "soilful" (silver)
Symbol from Latin "argentum"

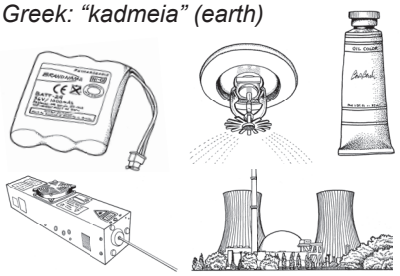


- Used to make coins, jewelry, mirrors, silverware, photographic film.
- Used to make anti-bacterial bandages.
- Bang snaps use silver fulminate.
- Found, with silver, in capacitors.

Cd 48

Cadmium **112.4**

Greek: "kadmeia" (earth)

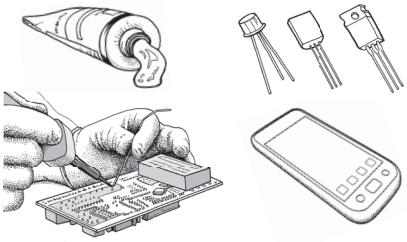


- Used in rechargeable batteries.
- Used in some lasers.
- Makes yellow and red pigments.
- Used (with Bi) for sprinkler fuses.
- Absorbs neutrons in nuclear reactors.

In 49

Indium **114.8**

Latin: "indicum" (indigo blue)



- Used in transistors and solar cells.
- Used in soldering.
- Indium-tin-oxide, ITO, is used as a conductive surface for touch screens.
- Is the "In" in YInMn blue pigment.

Sn 50

Tin **118.7**

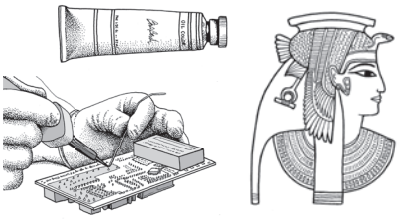
Latin: "stannum" (tin)

- Is an ingredient of pewter.
- Is mixed with copper to make bronze.
- Indium-tin-oxide, ITO, is used as a conductive surface for touch screens.
- Metal toys used to be make of tin.

Sb 51

Antimony **121.7**

Greek: "anti-monos" (not alone)
Symbol comes from "stibnium"

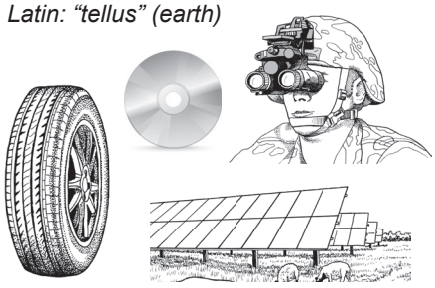


- Used in solder.
- Key ingredient in Naples yellow paint.
- Found in safety matches, and is added to fabrics to make the fire-resistant.
- Ancients used it in eye-liner cosmetics.

Te 52

Tellurium **127.6**

Latin: "tellus" (earth)

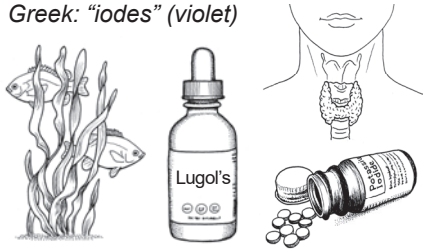


- Can replace sulfur in vulcanization process.
- HgCdTe is used to sense infrared, used in military night-vision equipment
- CdTe is used in solar panels.
- Used to make Blu-ray discs.

I 53

Iodine **126.9**

Greek: "iodes" (violet)

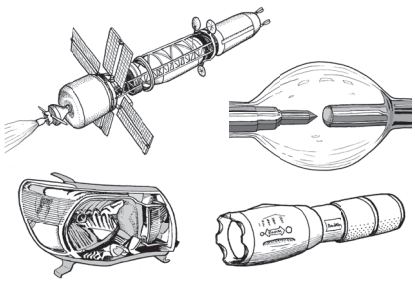


- Used as a disinfectant.
- Used in halogen lamps, ink pigments and photographic film.
- Our thyroid glands need iodine.
- Silver iodide is used to make clouds rain.
- Found naturally in seaweed.

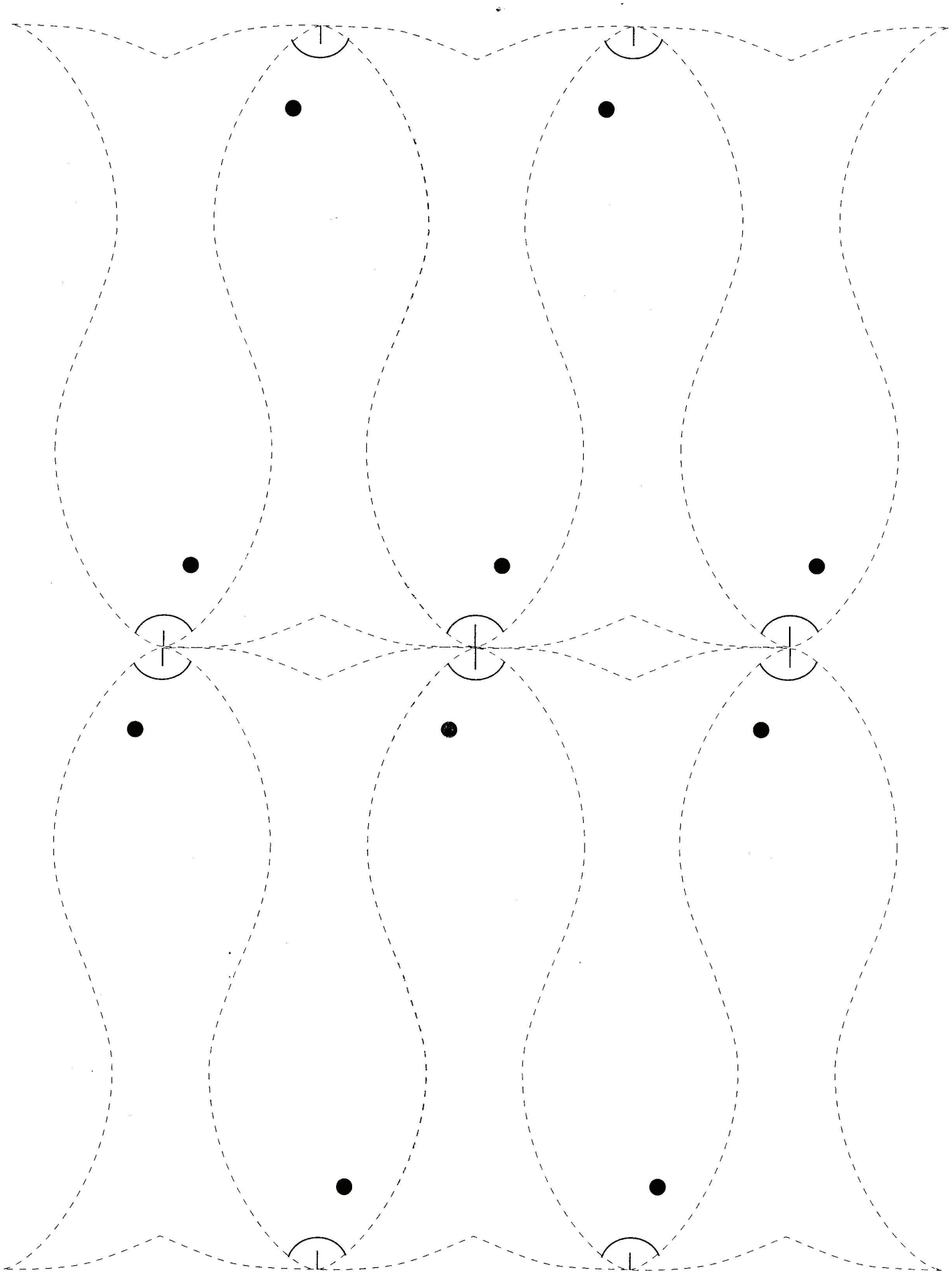
Xe 54

Xenon **131.3**

Greek: "xenos" (strange)



- Used in camera flash bulbs, strobe lights, and other high intensity bulbs.
- Was used as propellant for satellites.



Start

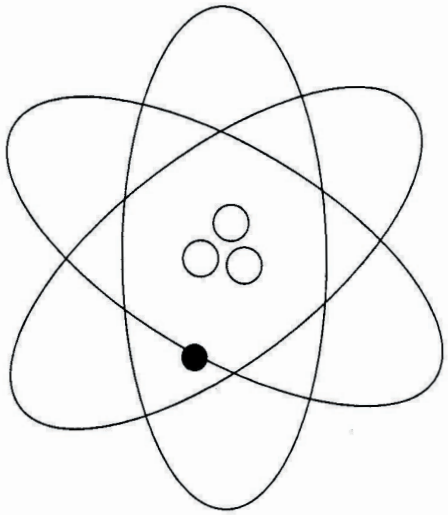
THE Periodic Table Game

Liquid or Gas at Room Temperature > **Roll Again**

Radioactive > **Put up Shields on Either Side** 

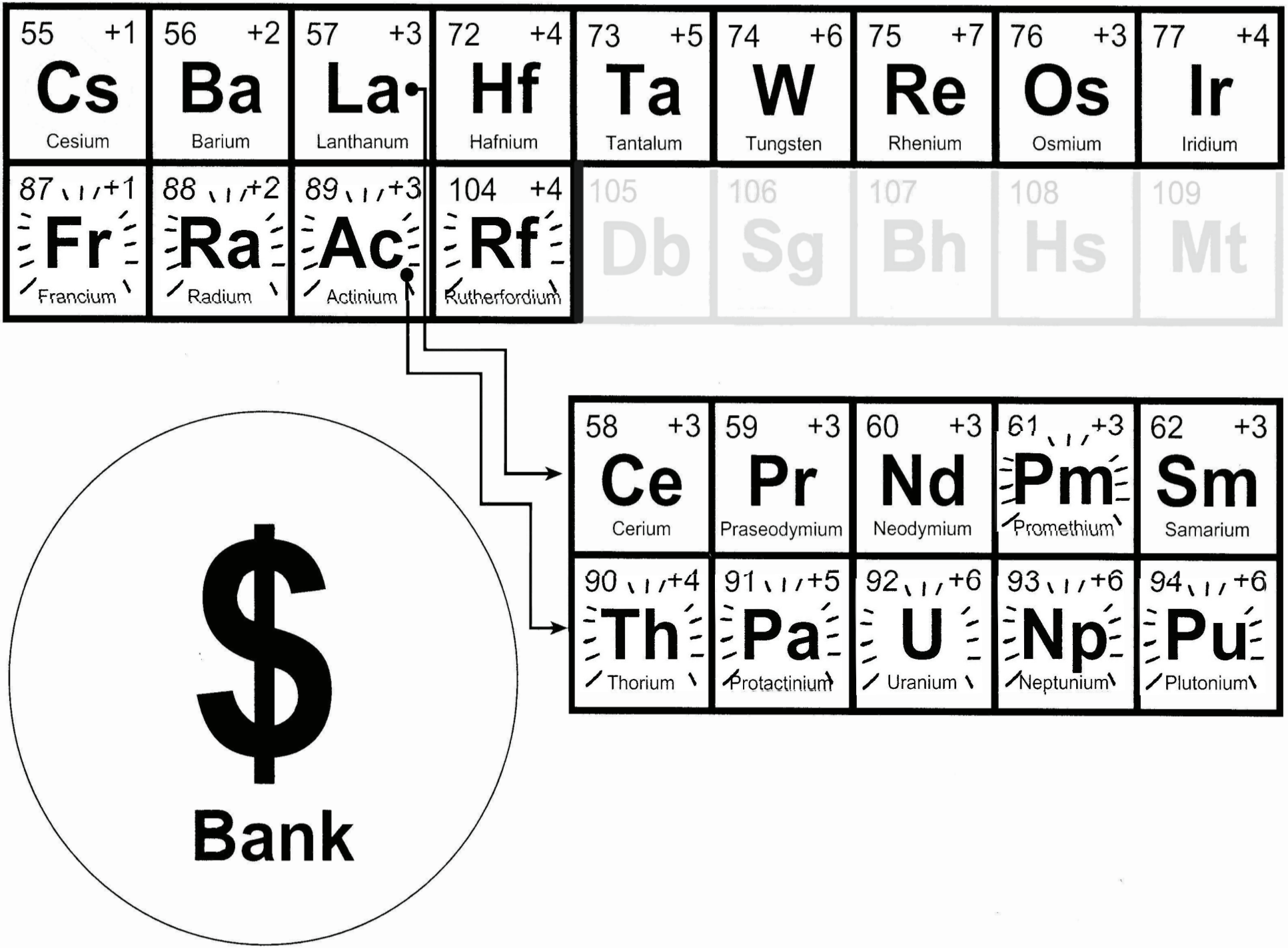
Named After Person or Place > **3 Extra Pennies if You Name It!**

1 +1 **H** Hydrogen								
3 +1 **Li** Lithium	4 +2 **Be** Beryllium							
11 +1 **Na** Sodium	12 +2 **Mg** Magnesium							
19 +1 **K** Potassium	20 +2 **Ca** Calcium	21 +3 **Sc** Scandium	22 +4 **Ti** Titanium	23 +5 **V** Vanadium	24 +6 **Cr** Chromium	25 +7 **Mn** Manganese	26 +3 **Fe** Iron	27 +3 **Co** Cobalt
37 +1 **Rb** Rubidium	38 +2 **Sr** Strontium	39 +3 **Y** Yttrium	40 +4 **Zr** Zirconium	41 +5 **Nb** Niobium	42 +6 **Mo** Molybdenum	43 +7 **Tc** Technetium	44 +3 **Ru** Ruthenium	45 +3 **Rh** Rhodium



Radioactive Shields

						2 0 **He** Helium
		5 +3 **B** Boron	6 +4 **C** Carbon	7 -3 **N** Nitrogen	8 -2 **O** Oxygen	9 -1 **F** Fluorine	10 0 **Ne** Neon
		13 +3 **Al** Aluminum	14 +4 **Si** Silicon	15 -3 **P** Phosphorus	16 -2 **S** Sulfur	17 -1 **Cl** Chlorine	18 0 **Ar** Argon
28 +3 **Ni** Nickel	29 +2 **Cu** Copper	30 +2 **Zn** Zinc	31 +3 **Ga** Gallium	32 +4 **Ge** Germanium	33 -3 **As** Arsenic	34 -2 **Se** Selenium	35 -1 **Br** Bromine	36 0 **Kr** Krypton
46 +4 **Pd** Palladium	47 +1 **Ag** Silver	48 +2 **Cd** Cadmium	49 +3 **In** Indium	50 +4 **Sn** Tin	51 -3 **Sb** Antimony	52 -2 **Te** Tellurium	53 -1 **I** Iodine	54 0 **Xe** Xenon


55 +1 Cs Cesium
56 +2 Ba Barium
57 +3 La Lanthanum
72 +4 Hf Hafnium
73 +5 Ta Tantalum
74 +6 W Tungsten
75 +7 Re Rhenium
76 +3 Os Osmium
77 +4 Ir Iridium
87 +1 Fr Francium
88 +2 Ra Radium
89 +3 Ac Actinium
104 +4 Rf Rutherfordium
105 Db
106 Sg
107 Bh
108 Hs
109 Mt
58 +3 Ce Cerium
59 +3 Pr Praseodymium
60 +3 Nd Neodymium
61 +3 Pm Promethium
62 +3 Sm Samarium
90 +4 Th Thorium
91 +5 Pa Protactinium
92 +6 U Uranium
93 +6 Np Neptunium
94 +6 Pu Plutonium
$
Bank

78 +4	79 +3	80 +2	81 +3	82 +4	83 -3	84 -2	85 -1	86 0
Pt Platinum	**Au** Gold	**Hg** Mercury	**Tl** Thallium	**Pb** Lead	**Bi** Bismuth	**Po** Polonium	**At** Astatine	**Rn** Radon
110 **Ds**	111 **Rg**	112 **Cn**	113 **Nh**	114 **Fl**	115 **Mc**	116 **Lv**	117 **Ts**	118 **Og**

Go to 72 Hf

63 +3	64 +3	65 +3	66 +3	67 +3	68 +3	69 +3	70 +3	71 +3
Eu Europium	**Gd** Gadolinium	**Tb** Terbium	**Dy** Dysprosium	**Ho** Holmium	**Er** Erbium	**Tm** Thulium	**Yb** Ytterbium	**Lu** Lutetium
95 +6 **Am** Americium	96 +4 **Cm** Curium	97 +4 **Bk** Berkelium	98 +4 **Cf** Californium	99 +3 **Es** Einsteinium	100 +3 **Fm** Fermium	101 +3 **Md** Mendelevium	102 +3 **No** Nobelium	103 +3 **Lr** Lawrencium

Go to 104 Rf

Start

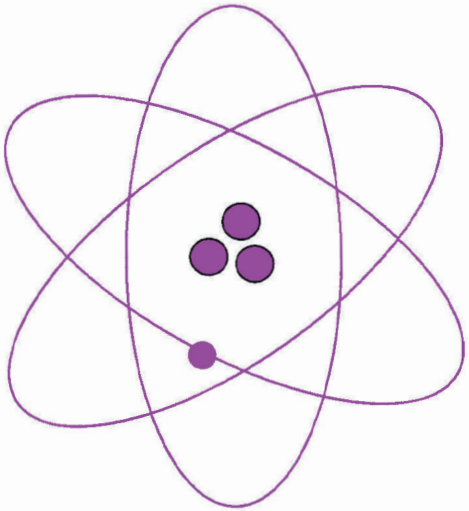
THE Periodic Table Game

Liquid or Gas at Room Temperature > **Roll Again**

Radioactive > **Put up Shields on Either Side** 

Named After Person or Place > **3 Extra Pennies if You Name It!**

1 +1 H Hydrogen									
3 +1 Li Lithium	4 +2 Be Beryllium								
11 +1 Na Sodium	12 +2 Mg Magnesium								
19 +1 K Potassium	20 +2 Ca Calcium	21 +3 Sc Scandium	22 +4 Ti Titanium	23 +5 V Vanadium	24 +6 Cr Chromium	25 +7 Mn Manganese	26 +3 Fe Iron	27 +3 Co Cobalt	
37 +1 Rb Rubidium	38 +2 Sr Strontium	39 +3 Y Yttrium	40 +4 Zr Zirconium	41 +5 Nb Niobium	42 +6 Mo Molybdenum	43 +7 Tc Technetium	44 +3 Ru Ruthenium	45 +3 Rh Rhodium	



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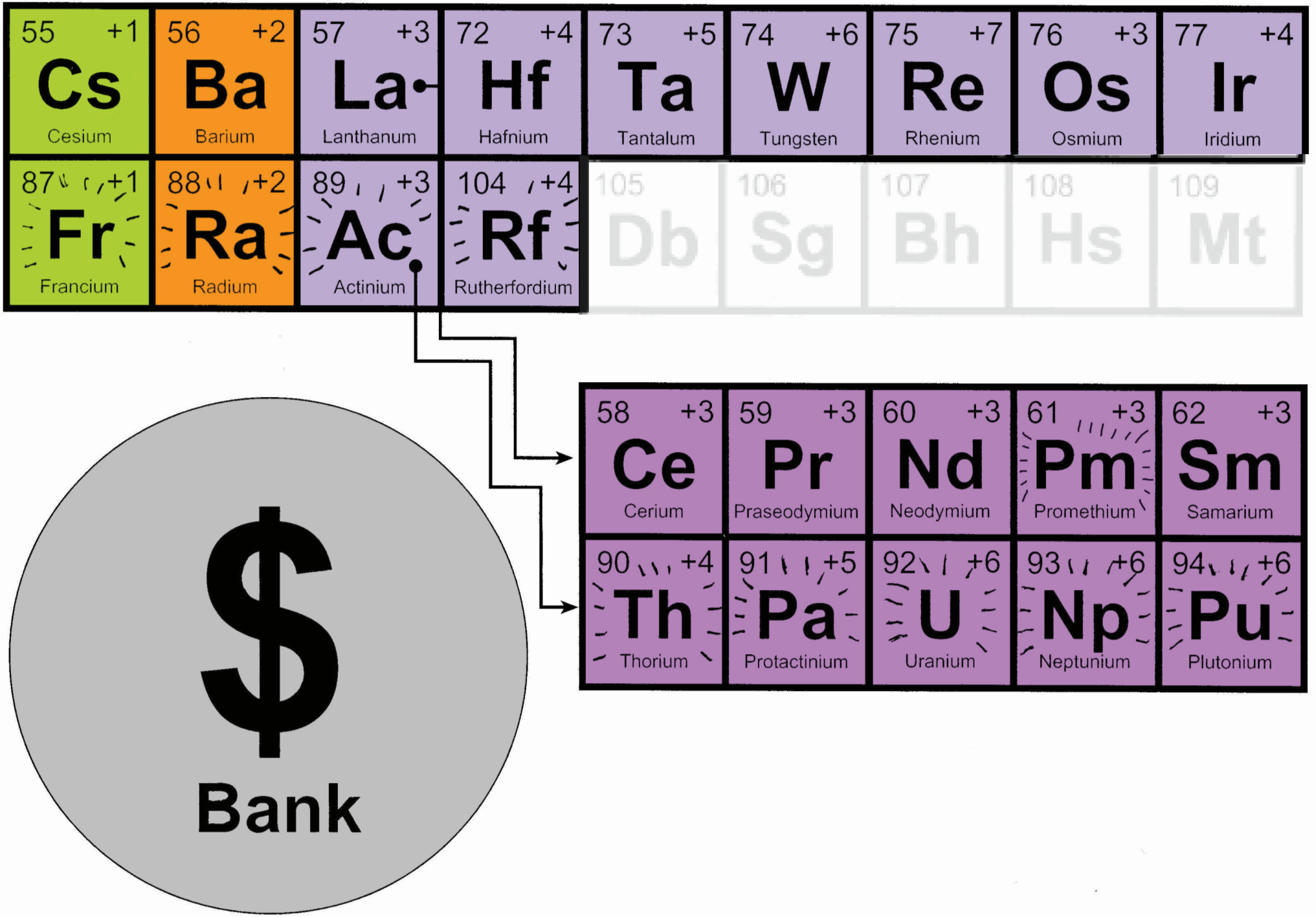
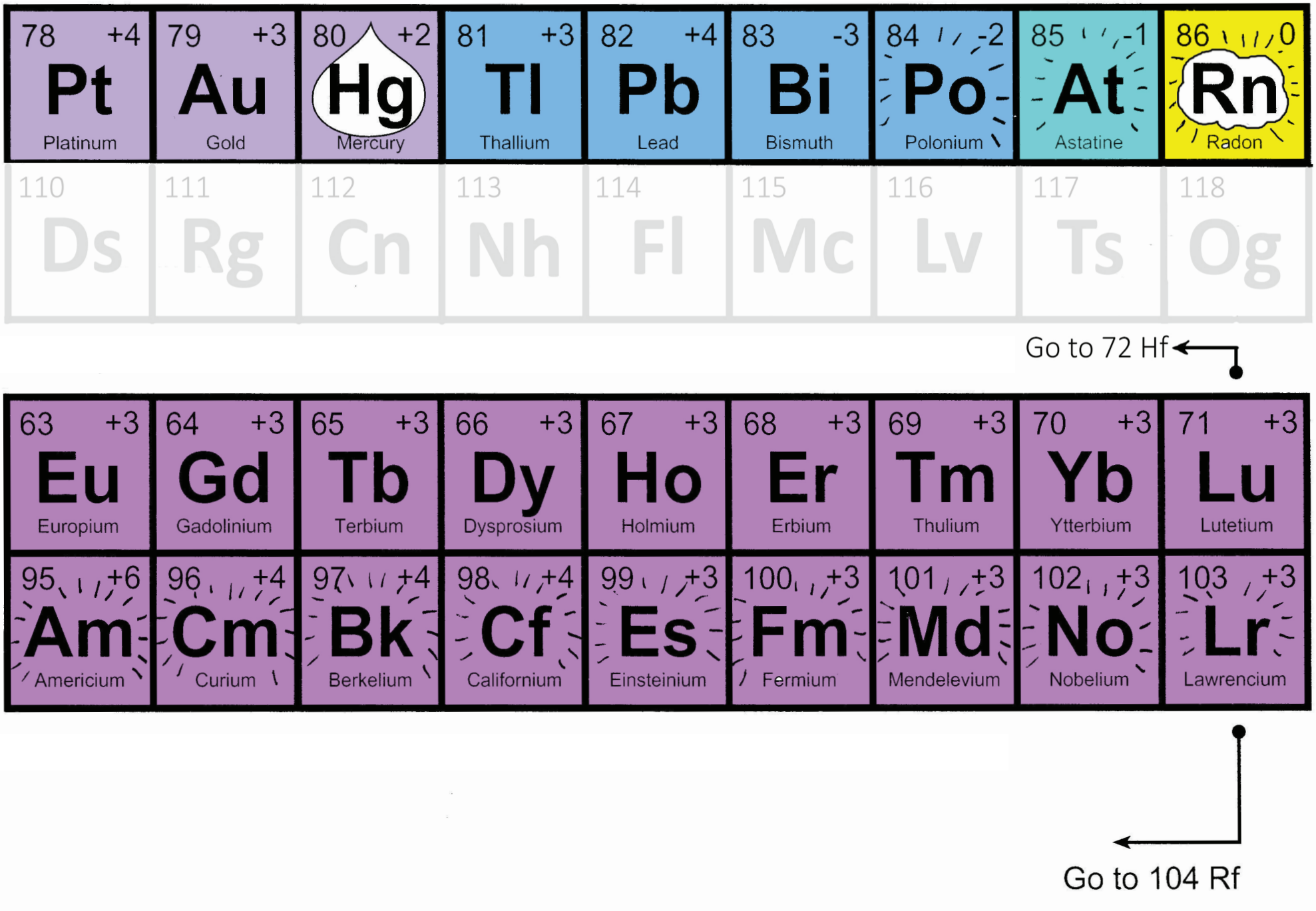
		13 +3 **Al** Aluminum	14 +4 **Si** Silicon	15 -3 **P** Phosphorus	16 -2 **S** Sulfur	17 -1 **Cl** Chlorine	18 0 **Ar** Argon
28 +3 **Ni** Nickel	29 +2 **Cu** Copper	30 +2 **Zn** Zinc	31 +3 **Ga** Gallium	32 +4 **Ge** Germanium	33 -3 **As** Arsenic	34 -2 **Se** Selenium	35 -1 **Br** Bromine	36 0 **Kr** Krypton
46 +4 **Pd** Palladium	47 +1 **Ag** Silver	48 +2 **Cd** Cadmium	49 +3 **In** Indium	50 +4 **Sn** Tin	51 -3 **Sb** Antimony	52 -2 **Te** Tellurium	53 -1 **I** Iodine	54 0 **Xe** Xenon


55 +1
Cs
Cesium
56 +2
Ba
Barium
57 +3
La
Lanthanum
72 +4
Hf
Hafnium
73 +5
Ta
Tantalum
74 +6
W
Tungsten
75 +7
Re
Rhenium
76 +3
Os
Osmium
77 +4
Ir
Iridium
87 +1
Fr
Francium
88 +2
Ra
Radium
89 +3
Ac
Actinium
104 +4
Rf
Rutherfordium
105
Db
106
Sg
107
Bh
108
Hs
109
Mt
58 +3
Ce
Cerium
59 +3
Pr
Praseodymium
60 +3
Nd
Neodymium
61 +3
Pm
Promethium
62 +3
Sm
Samarium
90 +4
Th
Thorium
91 +5
Pa
Protactinium
92 +6
U
Uranium
93 +6
Np
Neptunium
94 +6
Pu
Plutonium
$
Bank


78 +4 Pt Platinum
79 +3 Au Gold
80 +2 Hg Mercury
81 +3 Tl Thallium
82 +4 Pb Lead
83 -3 Bi Bismuth
84 -2 Po Polonium
85 -1 At Astatine
86 0 Rn Radon
110 Ds
111 Rg
112 Cn
113 Nh
114 Fl
115 Mc
116 Lv
117 Ts
118 Og
Go to 72 Hf
63 +3 Eu Europium
64 +3 Gd Gadolinium
65 +3 Tb Terbium
66 +3 Dy Dysprosium
67 +3 Ho Holmium
68 +3 Er Erbium
69 +3 Tm Thulium
70 +3 Yb Ytterbium
71 +3 Lu Lutetium
95 +6 Am Americium
96 +4 Cm Curium
97 +4 Bk Berkelium
98 +4 Cf Californium
99 +3 Es Einsteinium
100 +3 Fm Fermium
101 +3 Md Mendelevium
102 +3 No Nobelium
103 +3 Lr Lawrencium
Go to 104 Rf

2) CRAFT: Make a Periodic Table pillowcase

You will need: copies of the following pattern pages, clear tape, a blank pillowcase (white or a very light pastel color is best), fabric markers, glow-in-the-dark paint (if possible), and some pins to hold the pattern in place (and an iron if the instructions on your fabric markers say to use one)

What to do:

1) Copy the pattern pages onto regular paper (no need for card stock). Tape the four pages together so that they form a blank Periodic Table. Put this inside the pillowcase. You should be able to see the black lines right through the fabric. Adjust the pattern so that it is placed in the middle of the pillowcase, and pin it in place.

NOTE: A few key numbers are given as a guide, to prevent major mistakes such as forgetting to jump down to the lanthanide and actinide series down below, or going top to bottom instead of left to right.

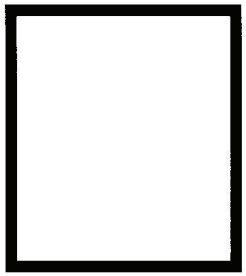
2) Use the fabric markers to trace over the squares. Color code the families. You don't have to use the color code shown here. You can decide what color to make each family. (If you want to add more elements, after 109, you are welcome to add them. These are what I call the "extremely silly elements" because they really don't exist. A few atoms blink in and out of existence for a millionth of a second. But you are welcome to add them to that bottom row if you want to.)

3) Write in the symbol for each element and its atomic number.

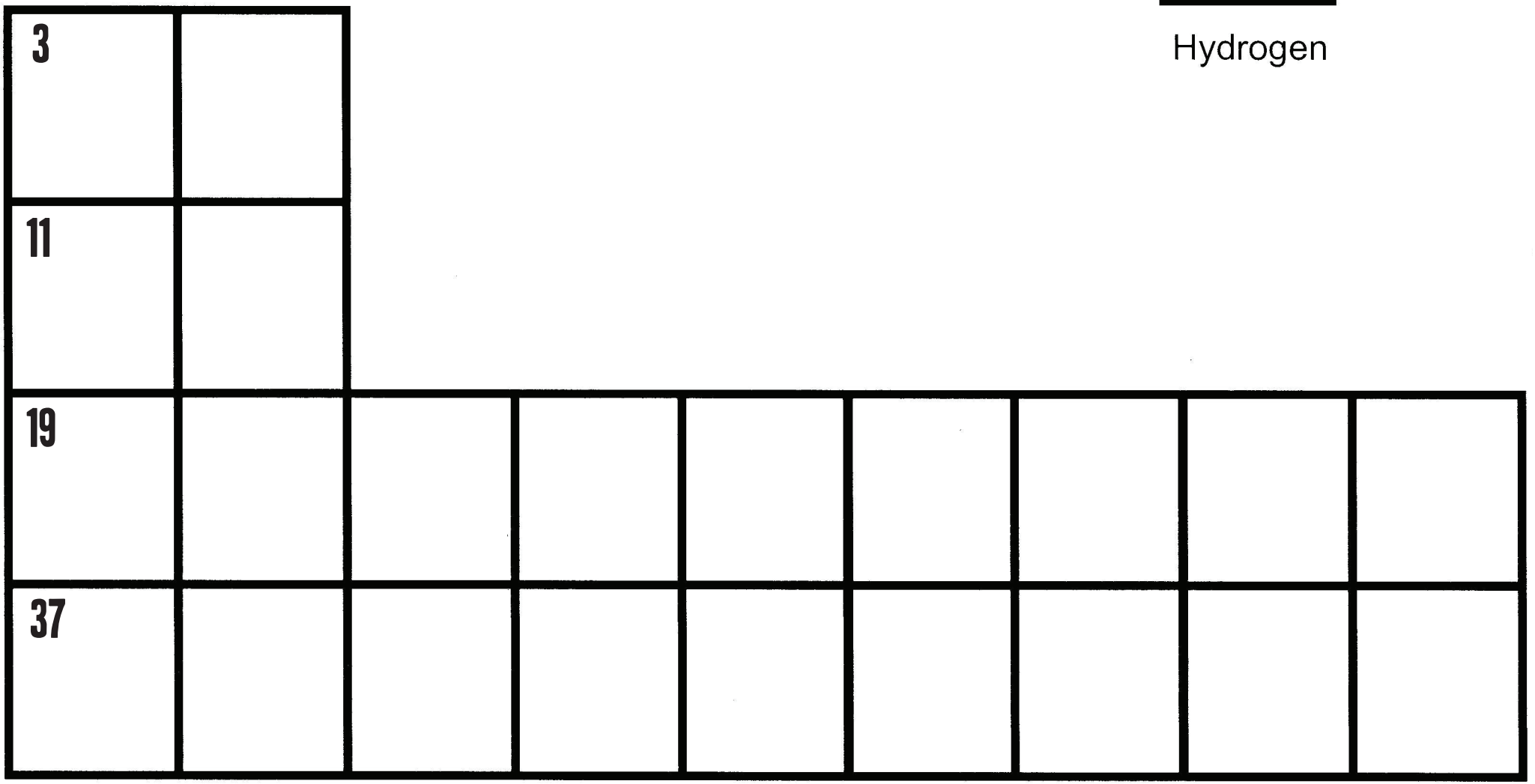
4) FUN EXTRA FEATURE: You could put glow-in-the-dark paint on the radioactive elements. GITD paint is easily obtained from any craft store and is not expensive. Look at your Periodic Table game (or find a Periodic Table on the Internet) to see which elements are radioactive. (Don't forget Technetium!)

5) Follow any ironing or washing instructions that come with your fabric markers.

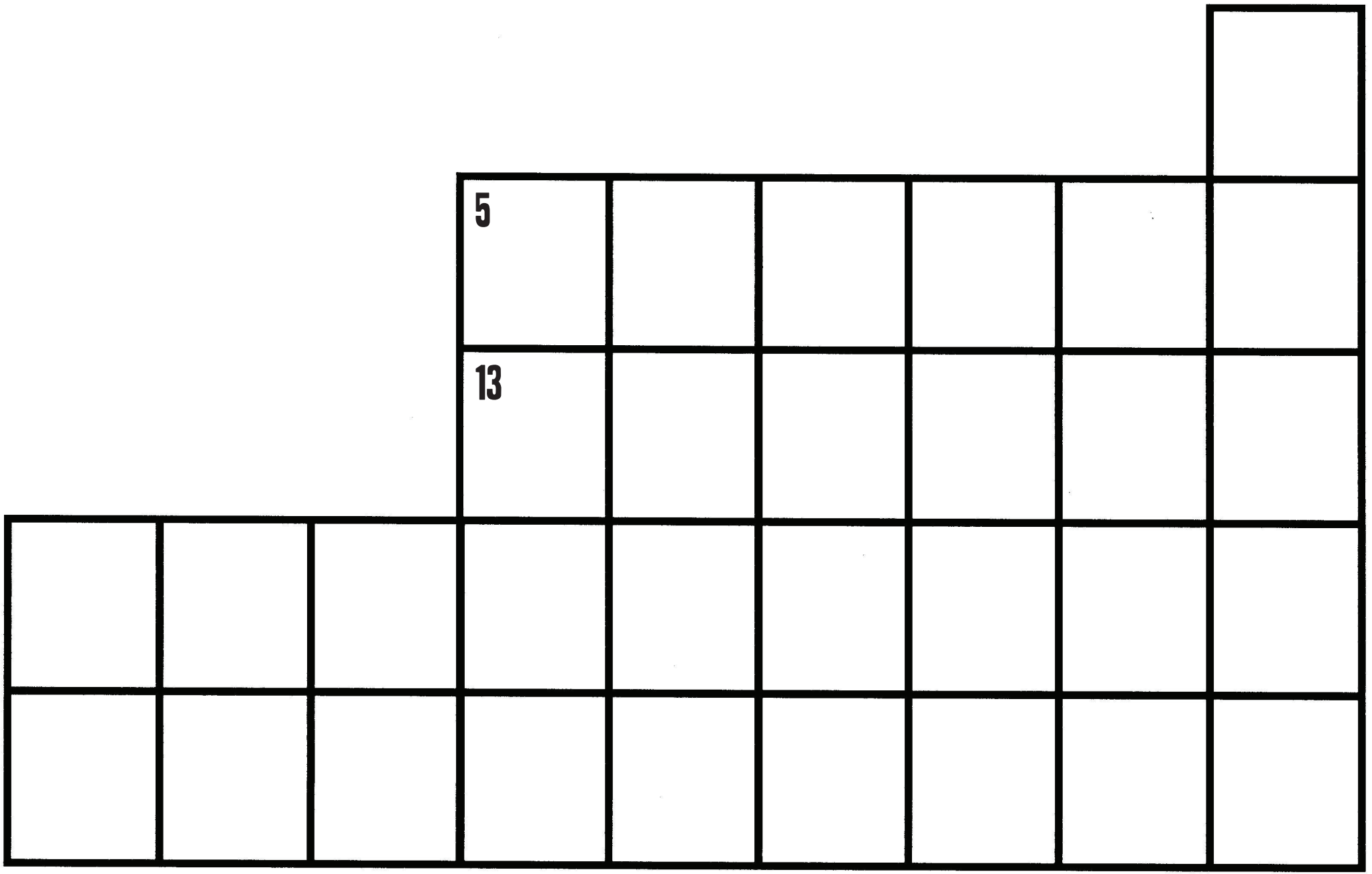
Upper Left

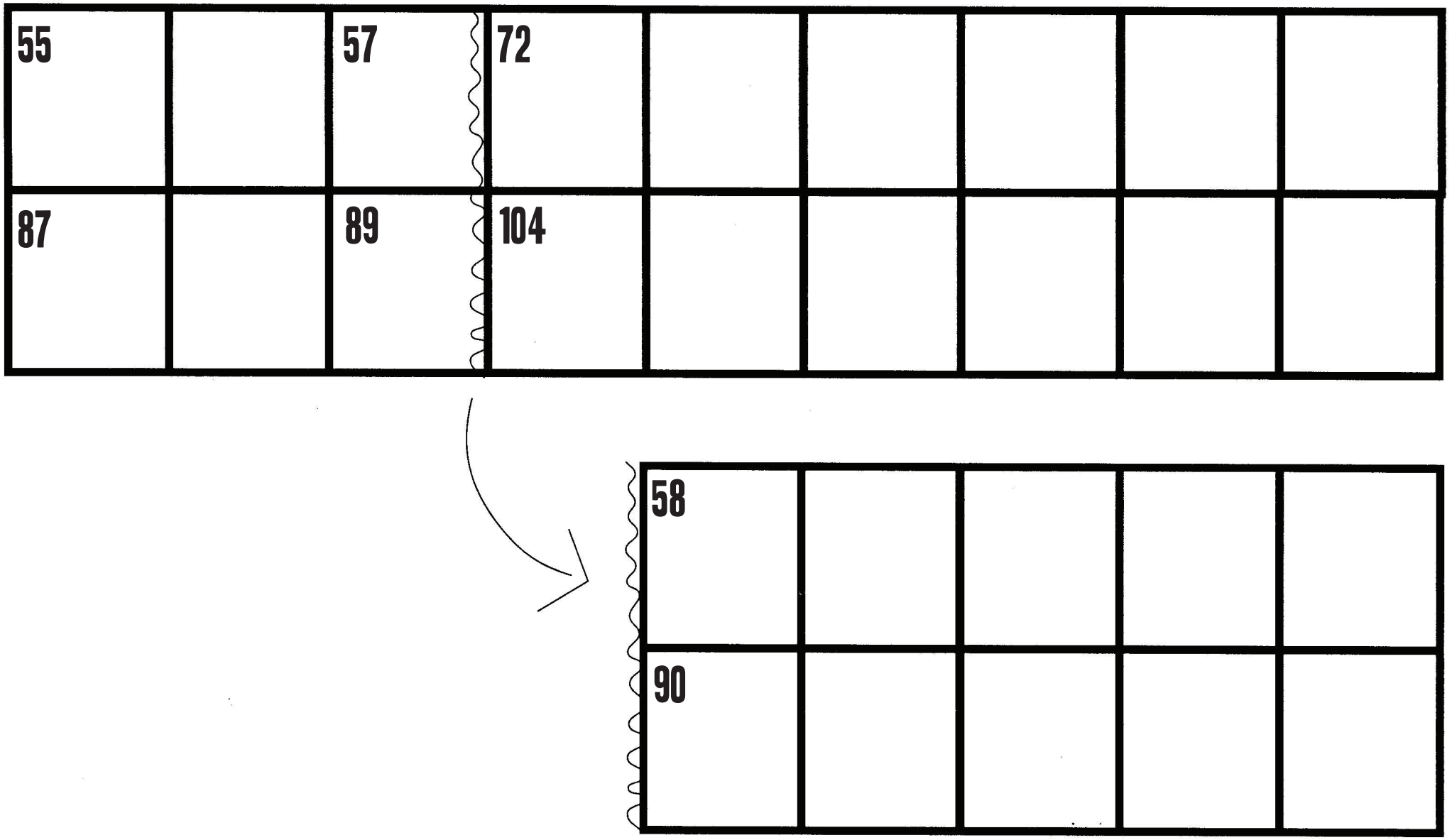


Hydrogen



Upper Right



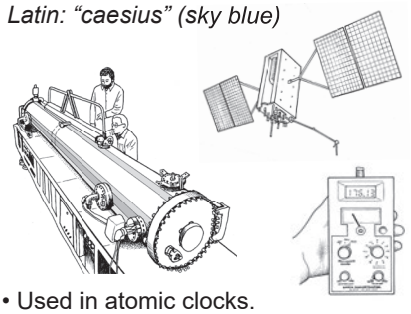


Lower Left

Cs 55

Cesium **132.9**

Latin: "caesius" (sky blue)

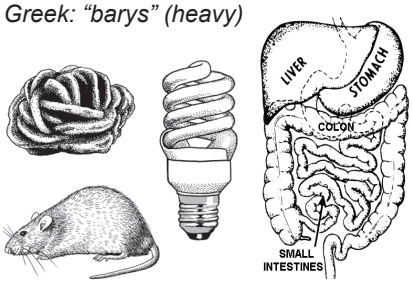


- Used in atomic clocks.
- GPS satellite use these atomic clocks.
- Used as a "scavenger" (collector) inside vacuum tubes.
- Found in some magnetometers.

Ba 56

Barium **137.3**

Greek: "barys" (heavy)



- Used for X-rays of digestive systems.
- Used in fireworks (green color).
- Found in mineral barite (desert rose).
- BaO is in electrodes in fluorescent lights.
- Barium carbonate was used to kill rats.

La 57

Lanthanum **138.9**

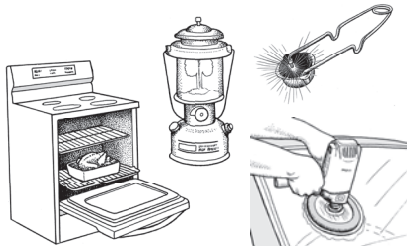
Greek: "lanthanein" (to lie hidden)

- Used in telescope and camera lenses.
- Used for electrodes in high intensity lights and in mantles for gas lanterns
- Used in spark-making devices
- Found in some algae-killing solutions.

Ce 58

Cerium **140.1**

named after the asteroid Ceres

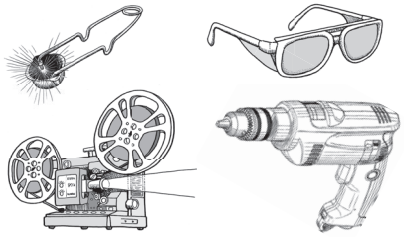


- Used in mantles for gas lanterns.
- Used in self-cleaning ovens.
- Used in sparking devices.
- Cerium oxide is used to polish glass.
- Extracted from monazite sand.

Pr 59

Praseodymium **140.9**

Greek: "prasios-didymos" (green twin)

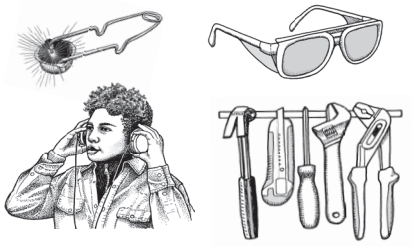


- Used in dymium glasses for welders.
- Used in bulbs for movie projectors.
- Used in magnets in electric tools.
- Sometimes found in sparking devices.
- Extracted from monazite sand.

Nd 60

Neodymium **144.2**

Greek: "neos-didymos" (new twin)

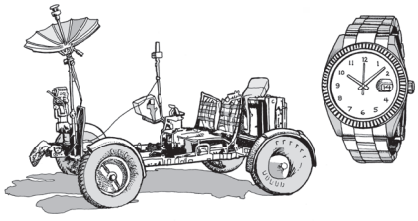


- Used in dymium glasses for welders.
- Used to make strong magnets found in headphones and other electronic devices.
- Used to color glass (blue, green, purple).
- Extracted from monazite sand.

Pm 61

Promethium **147.0**

named after Greek god Prometheus

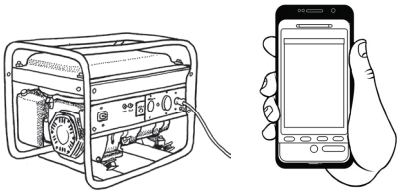


- Is a synthetic element made in nuclear reactors or cyclotrons.
- Was used to make glow-in-the-dark paint for the Apollo lunar rover.
- Replaced radium to make glowing paint for watches and clocks.

Sm 62

Samarium **150.3**

named after the mineral "samarskite" which was named for Col. Samarski, a Russian army engineer

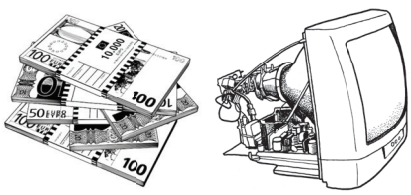


- Used in magnets for MRI machines, computers and cell phones.
- Samarium-cobalt magnets found in heavy-duty generators.
- Extracted from monazite sand.

Eu 63

Europium **151.9**

named after Europe

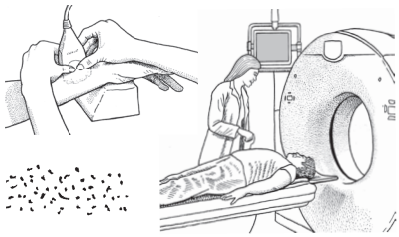


- Used to make red color in old CRT televsions.
- Used in fluorescent bulbs.
- Used to make fluorescent marks on Euros to prevent counterfeiting.
- Extracted from monazite sand.

Gd 64

Gadolinium **157.2**

named for chemist Johann Gadolin

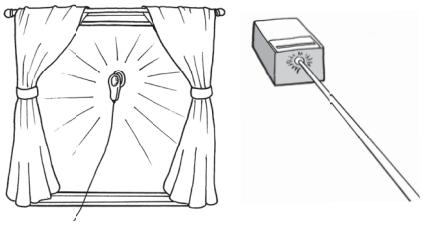


- Used in fluorescent bulbs (green light).
- Radioactive isotopes used in bone scans.
- Used as tracer in MRI scans.
- Extracted from monazite sand.

Tb 65

Terbium **158.9**

named after Swedish village of Ytterby

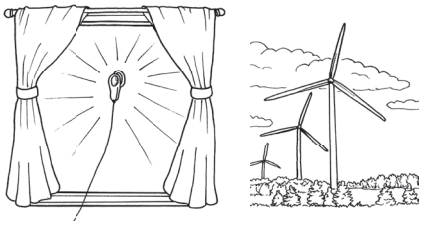


- Used to make Terfenol-D, which can turn any surface into a speaker.
- Used in fluorescent bulbs (glows green).
- Used in some green lasers.
- Extracted from monazite sand.

Dy 66

Dysprosium **162.5**

Greek: "dysprositos" (difficult to obtain)

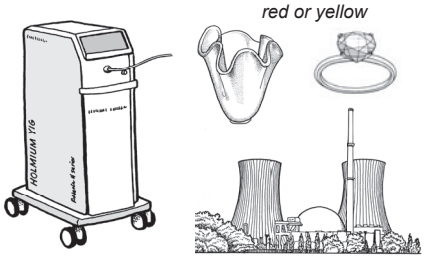


- Used to make Terfenol-D, which can turn any surface into a speaker.
- Used in wind generator magnets.
- Found in high intensity light bulbs.
- Extracted from monazite sand.

Ho 67

Holmium **164.9**

named for Stockholm, Sweden

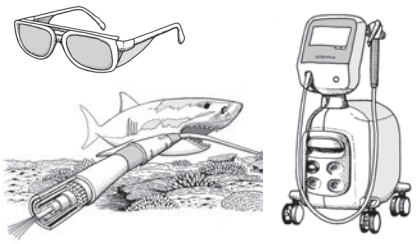


- Used in eye-safe medical lasers.
- Used to color glass red or yellow.
- Absorbs neutrons in nuclear reactors.
- Extracted from monazite sand.

Er 68

Erbium **167.3**

named after Sweidish village of Ytterby

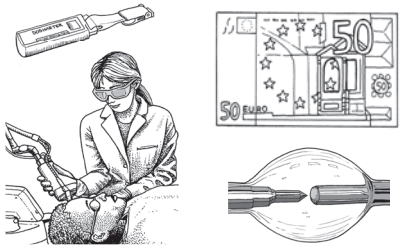


- Erbium glasses protect a patient's eyes during laser surgery.
- Used for coloring glass pink.
- Used to make medical lasers.
- Used to make relays in fiberoptic cables.

Tm 69

Thulium **168.9**

Thule is the ancient name for Scandinavia

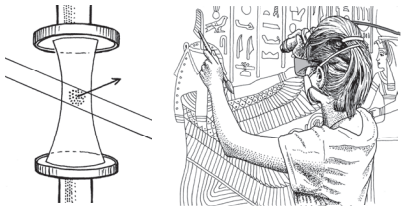


- Used in medical lasers.
- Makes fluorescent blue strip in Euro notes.
- Used in some radiation dosimeters.
- Used in some arc light bulbs.
- Extracted from monazite sand.

Yb 70

Ytterbium **173.0**

named after Swedish village of Ytterby

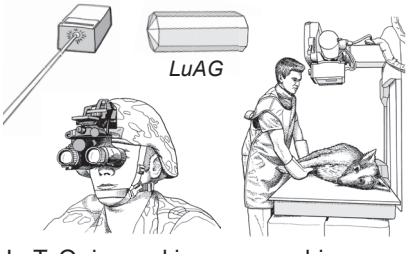


- Used in precision lasers that can clean ancient artifacts and famous paintings.
- Is added to steel to improve strength.
- Yb fluoride can be used in dental fillings
- Yb atomic clocks use suspended atoms.
- Extracted from monazite sand.

Lu 71

Lutetium **174.9**

Lutetia is the ancient name for Paris

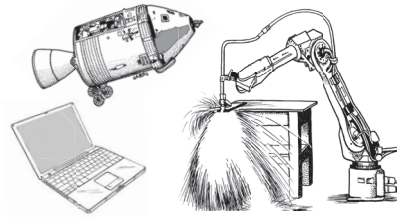


- $LaTaO_4$ is used in x-ray machines.
- Alloys of Lu are used to refine petroleum.
- Is the "Lu" in LuAG crystal lasers.
- Used in infrared sensing night-vision.
- Extracted from monazite sand.

Hf 72

Hafnium **178.5**

Hafnia is the ancient name for Copenhagen

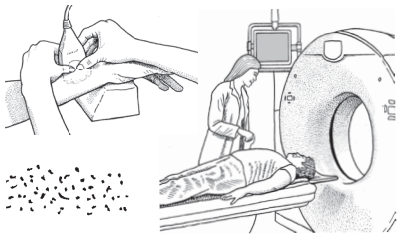


- Usually found with zirconium.
- Hf alloys were used to make nozzles of Apollo lunar module.
- Used for metal tips on plasma cutters.
- Enabled a critical step in learning to make smaller computer chips.

Gd 64

Gadolinium **157.2**

named for chemist Johann Gadolin



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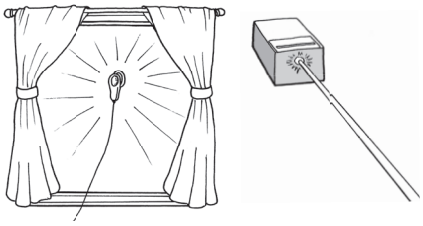

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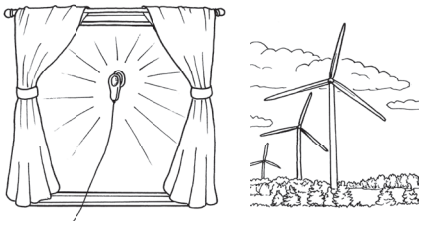

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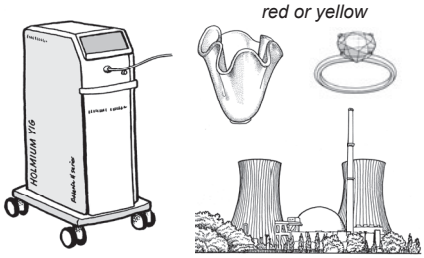

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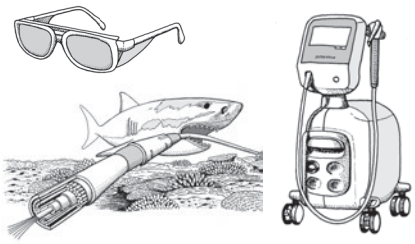

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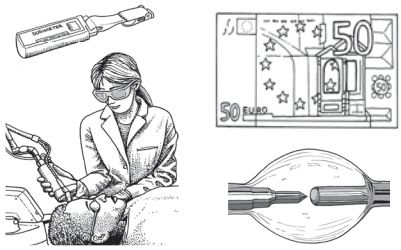

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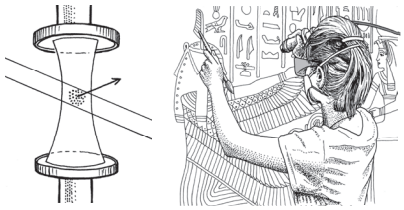

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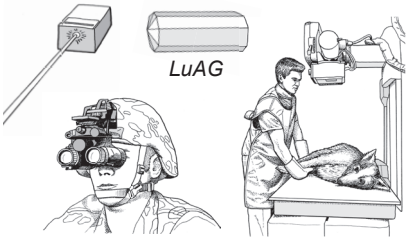

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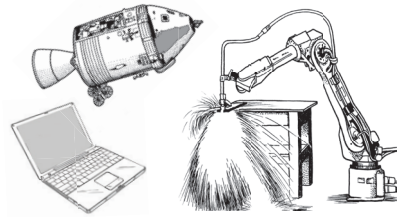

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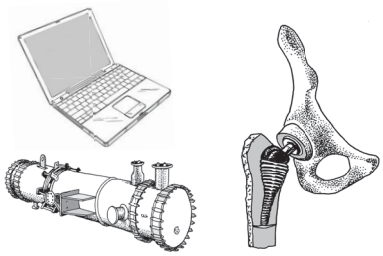
Ta 73

Tantalum **180.9**

named after the Greek god Tantalus

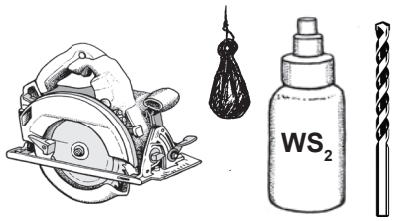


- Used in some artificial joints.
- Used to make pipes for heat exchangers (such as the large one shown here).
- Used for capacitors in electronics.

W 74

Tungsten **183.8**

Swedish: "Tung stem" (heavy stone)
Used to be called Wolframite

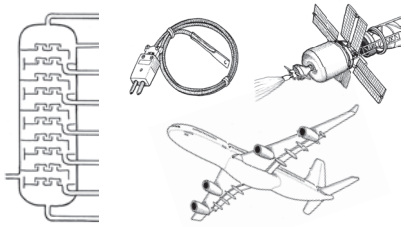


- Used for filaments in incandescent bulbs.
- Used to make drill bits and saw blades.
- Highest melting point of all the metals.
- Tungsten sulfide used as dry lubricant.
- Used as lead (Pb) substitute.

Re 75

Rhenium **186.2**

Latin: "Rhenus" (Rhine River)

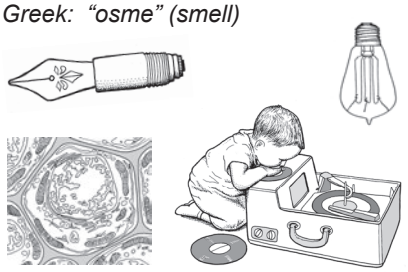


- Used in electrical switches.
- Used for thermocouples, high-temp thermometers, and oven filaments.
- Used in petroleum refining process.
- Re-W alloys used for jet engines.

Os 76

Osmium **190.2**

Greek: "osme" (smell)

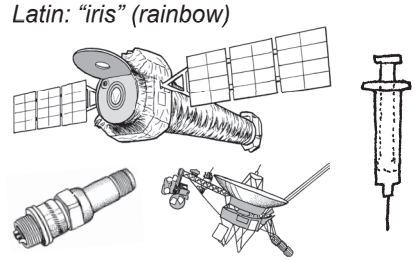


- Was used to make fountain pen points.
- Used for the first phonograph needles.
- Used for staining microscopic samples.
- Is the most dense element.
- Was used in early light bulbs.

Ir 77

Iridium **192.2**

Latin: "iris" (rainbow)

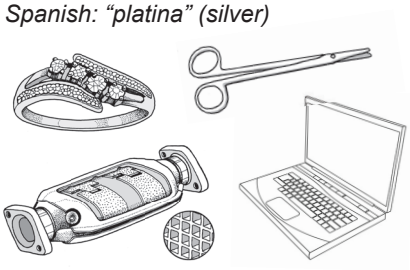


- Used to make the mirrors for Chandra X-ray observatory
- Used in airplane/helicopter spark plugs.
- Used to make hypodermic needles.
- Satellites can be powered by plutonium that is housed in iridium containers.

Pt 78

Platinum **195.1**

Spanish: "platina" (silver)



- Used in jewelry and dentistry.
- Used in computers and other devices.
- Used in catalytic converters for cars.
- Pt alloys are used to make corrosion-resistant tools.

Au 79

Gold **196.9**

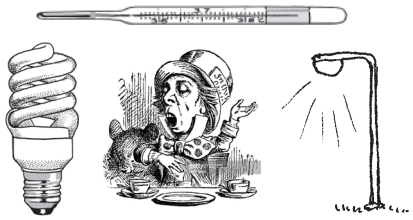
Old English: "gold"
"Au" comes from Latin: "aurum"

- Used for coins and jewelry.
- Used to make electrical circuits.
- Ancient artifacts often contain gold.
- Used as a reflective coating on the outside of large glass windows.

Hg 80

Mercury **200.6**

named after the Roman god Mercury

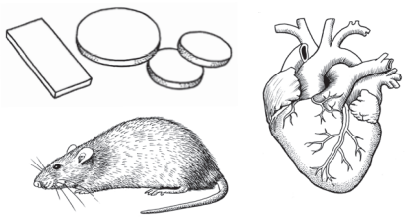


- The symbol **Hg** comes from the Latin "hydragyrum" meaning "liquid silver."
- Used in thermometers, barometers, street lights, and fluorescent bulbs.
- Was used by hat-makers in the 1800s.

Tl 81

Thallium **204.4**

Greek: "thallos" (green twig)

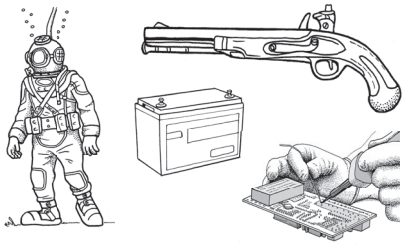


- Looks like lead and is poisonous.
- Was once used to kill pests.
- Used to diagnose heart disease.
- Used in some automatic outdoor lights.
- Used in specialty lenses.

Pb 82

Lead **207.2**

Ancient Anglo-Saxon: "lead"
"Pb" comes from Latin: "Plumbum"

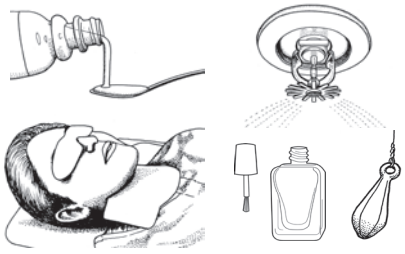


- Was used for fishing/diving weights.
- Was used to make "shot" (bullets).
- Still used in batteries for cars and boats.
- Has been used in soldering.

Bi 83

Bismuth **208.9**

German" "weisse masse" (white mass)

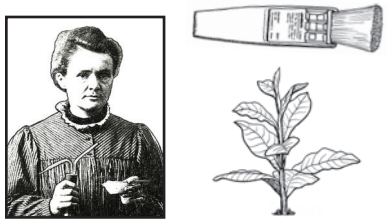


- Used in pink, liquid stomach medicines.
- Used in indoor sprinkler systems.
- Used as lead replacement for sinkers.
- Used in shields protecting from x-rays.
- Found in iridescent nail polish.

Po 84

Polonium **210**

named after Poland

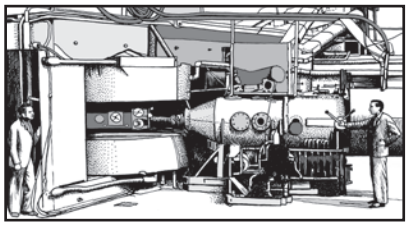


- Discovered by Marie Curie.
- Used in anti-static brushes.
- Radon from ground sticks to tobacco leaves, then decays into polonium, helping to make tobacco a carcinogen.

At 85

Astatine **210**

Greek: "astatos" (instable)



- Created in 1940 in the cyclotron at what is now Berkeley National Lab. They threw alpha particles (two protons and two neutrons) at bimuth atoms.
- No commerical applications.

Rn 86

Radon **222**

named after the element radium

- Is the heaviest gaseous element.
- Comes up out of the ground,
- Decays into polonium.
- Probably the result of uranium decay.

Fr 87

Francium **223**

named after France

uranite

- Discovered in France by Marguerite Perey, a student of Marie Curie.
- Comes from the decay of U and Th (in minerals pitchblende and uranite).
- Is too unstable to be used for anything.

Ra 88

Radium **226.0**

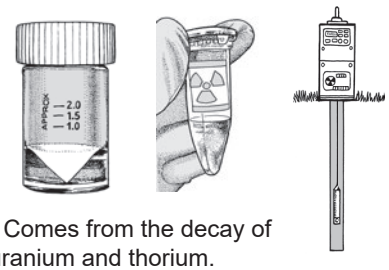
Latin: "radius" (ray)

- Discovered by Marie Curie.
- Was once used to make glowing clocks.
- Used widely before it was discovered to be terribly dangerous.
- Now used to treat bone cancer because it will go to bones like calcium does.

Ac 89

Actinium **227**

Greek: "actinos" (ray or beam)

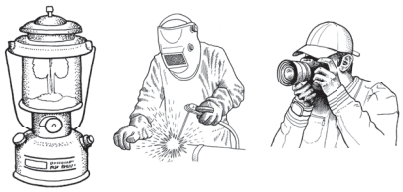


- Comes from the decay of uranium and thorium.
- One particular isotope is very useful in treating certain types of cancer.
- Shipped in V-shaped vials. Ac atoms collect at point of V.

Th 90

Thorium **232**

after the ancient Scandinavian god Thor, god of lightning and thunder



- Was used to make mantles for gas lanterns until its radioactivity was found.
- Also used to be used in welding electrodes and specialty lenses.
- One isotope is relatively stable.

"Quick Six" pattern page 11

Copy onto white card stock

Pa 91

Protactinium **231**

Greek: "protos" (first), plus "actinium"

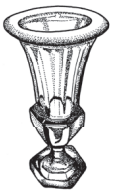
Pa ⇨ Ac

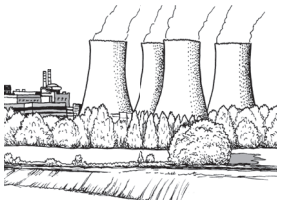
• Was given this name because it always decays into actinium. (Protactinium "comes first.")
• Found in nuclear waste.
• Levels of Pa and Th are studied in ocean sediments in order to learn about their history.

U 92

Uranium **238**

named after the planet Uranus



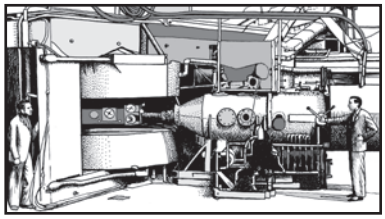


• Used as fuel in nuclear reactors.
• Depleted uranium (which is much less radioactive) is used to color glass yellow and to make metals for military vehicles.
• Primary ores: pitchblende, uranite.

Np 93

Neptunium **237**

named after the planet Neptune

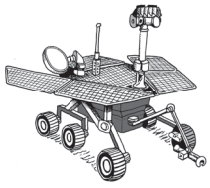


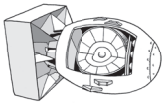
• Was manufactured in 1940 at what is now Berkeley National Lab.
• Is found in nuclear waste.
• Formation of Np from U is a step in the process of making weapons-grade Pu.

Pu 94

Plutonium **242**

named after Pluto





• Is made from uranium inside "breeder" nuclear reactors.
• Used in nuclear weapons.
• Was used to power the lunar modules. Now powers satellites and Mars rovers.
• Was used to power heart pacemakers.

Am 95

Americium **243**

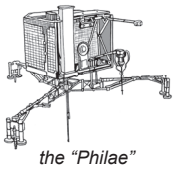
named after America

• Used in smoke detectors.
• Used in crystal research.
• Used as a source of neutrons in density gauges that search for underground water.
• Manufactured at Berkeley Lab in 1944.

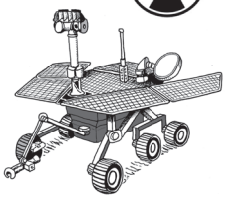
Cm 96

Curium **247**

named after Marie Curie



the "Philae"



Mars rover

• Is used in devices that detect x-rays, and therefore can be found in the x-ray spectrometers on satellites and rovers. These devices can determine what elements are present in rocks and dirt.

Bk 97

Berkelium **247**

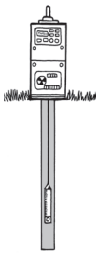
named after Berkeley, California

• Was made at Berkeley Lab in 1949.
• Only practical use is as a starting point for making even heavier elements.
• Like many super-heavy elements, it was discovered using a spectrometer.

Cf 98

Californium **251**

named after California

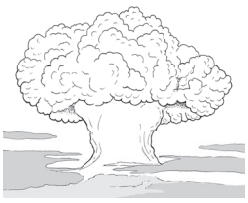


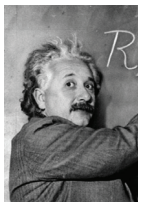
• Can be used as a portable source of neutrons in gauges that look for flaws in metal structures.
• Also used in devices that sense sources of underground water.

Es 99

Einsteinium **252**

named after Albert Einstein





• Discovered during the investigation of debris from the first atomic bomb.
• Einstein is famous for his equation that shows the relationship of matter to energy ($E=mc^2$).

"Quick Six" pattern page 12

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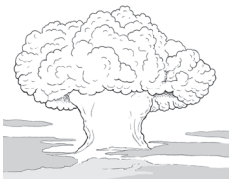
Fm 100

Fermium **257**

named after Enrico Fermi

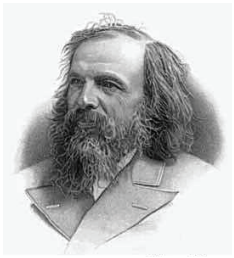


- Discovered during investigation of the debris from the first atomic bomb.
- No commerical use.
- Fermi was a physicist who studied atomic structure and radioactivity.

Md 101

Mendelevium **256**

named after Dmitri Mendeleyev



- Made in nuclear reactors.
- No commerical use.
- Mendeleyev invented the Periodic Table.

No 102

Nobelium **259**

named after Alfred Nobel

- Joint Institute of Nuclear Research in Dubna, Russia, given credit for discovery.
- No commerical use.
- Alfred Nobel established the Nobel Prizes using money from his invention: TNT

Lr 103

Lawrencium **262**

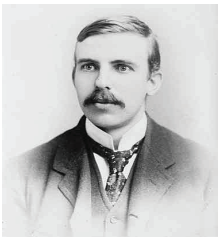
named after Ernest O. Lawrence

- Lawrence was the inventor of the cyclotron machine that was used to discover elements heavier than uranium.
- No commercial use.

Rf 104

Rutherfordium **261**

named after Ernest Rutherford



- Rutherford figured out the structure of the atom. His “gold foil” experiment showed that atoms are mostly empty space.
- No commerical use.

Db 105

Dubnium **262**

named after Dubna, Russia

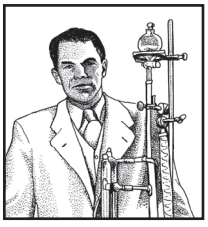
J.I.N.R.

- Was made in 1968 at the Joint Institute for Nuclear Research in Dubna, Russia.
- Also made in 1978 at the Berkeley Lab.
- Russia and US share credit for discovery.
- No commercial use.

Sg 106

Seaborgium **263**

named after Glenn T. Seaborg

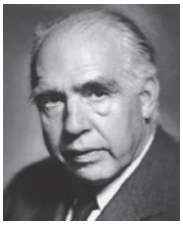


- Seaborg and his team at Berkeley Lab discovered Pu, Am, Cm, Bk, Cf, Es, Fm, Md and No.
- Is one of the few super-heavy elements that has been observed to form a molecule with other elements.

Bh 107

Bohrium **262**

named after Niels Bohr



- Niels Bohr discovered electron energy levels (orbital and shells).
- The longest half-life is 40 seconds.
- No commercial use.

Hs 108

Hassium **265**

named after German state of Hesse

- Named after the German state where the GIS Helmholtz Institute is located.
- Longest-lived isotope is 110 seconds.
- No commercial use.

Mt 109

Meitnerium **268**

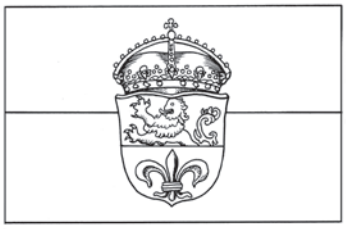
named after Lise Meitner

• Meitner worked with Otto Hahn (1930-40) to discover the process of fission in uranium atoms.
• No commercial use.

Ds 110

Darmstadtium **269**

named after Darmstadtium, Germany



• Discovered in 1994 at the GSI Helmholtz Institute in Darmstadt.
• No commerical use.

Rg 111

Roentgenium **272**

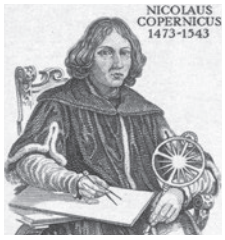
named after Wilhelm Roentgen

• Roentgen discovered x-rays.
• Is the heaviest member of the group (column) that contains copper, silver, gold.

Cn 112

Copernicium **277**

named after Ernest O. Lawrence



• Only element named after a scientist who was not a chemist or physicist.
• Copernicus discovered that the earth goes around the sun.
• No commercial use.

Nh 113

Nihonium **284**

named after Japan (Nihon)

• Several labs made this element but RIKEN lab in Japan given official credit.
• No commerical use.

Fl 114

Flervorium **289**

named after Georgy Flyorov

J.I.N.R.

• Geory Flyorov was director of JINR Lab in Dubna for a number of years.
• Only 58 atoms have ever been made.
• No commercial use.

Mc 115

Moscovium **288**

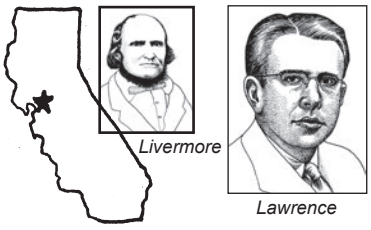
named after Moscow, Russia

• Was first manufactured in 2004 at the JINR, which is in the state of Moscow.
• Longest-lived isotope is 1/2 second.
• No commercial use.

Lv 116

Livermorium **292**

named after Livermore, CA



• Livermore, CA, got its name from its founder, Robert Livermore, a rancher.
• Lv was collaborative effort of JINR and Lawrence Livermore National Lab.
• No commercial use.

Ts 117

Tennessine **294**

named after state of Tennessee

• Manufacturing of Ts was a collaboration between JINR (Russia) and Lawrence Livermore National Lab (US).
• Made from Bk atoms that were made at Oak Ridge National Lab in Tennessee.
• No commercial use.