STATION 11

THE 11 ELEMENT ID CHALLENGE.

IN THE PERIODIC TABLE ON THE WALL, YOU WILL NOTICE THAT 11 OF THE ELEMENTS ARE HIGHLIGHTED WITH THE APPROXIMATE COLOR OF THE ELEMENT. YOUR GOAL FOR THIS STATION WILL BE TO DETERMINE THE IDENTITY OF EACH OF THE 11 ELEMENTS USING RELATIVE DENSITY, ELECTRICAL CONDUCTIVITY PROPERTIES, MAGNETIC PROPERTIES, COLOR AND LUSTER.

1. Density - Each of the cased in scales has one of the 11 elements on it. The reading gives you the mass of the sample. Since all of the samples are the same volume, the mass readings are proportional to the density and provide a ranking of the densities of the elements. Rank the masses (relative density) and use the densities in the periodic table or a list of density rankings to determine the identity of as many of the 11 elements (A- K) as possible.

2. Electrical conductivity- Use the electrical conductivity device to determine if the 11 elements (A - K) conduct electricity. Use the selector switch to choose the element. There are two indications of conductivity. If the LED light is not on, the element is a conductor. The ohmmeter indicates the resistance of the element up to a maximum of 10 ohms. Values of about 0.00 to 0.15 ohms should be considered conductors. Values between 0.15 and 10 ohms should be considered weak conductors. A non-reading indicates a non-conductor.

3. Magnetic properties - Use the magnetic probe to determine which masses of the objects are significantly affected by the magnet. Only ferromagnetic materials have strong enough magnetic properties to be affected. This test should provide useful id information.

4. The colors of the elements should provide more useful id information.

5. Examine the sample of each element on the balance and determine if the element is lustrous. This observation should provide useful id information.

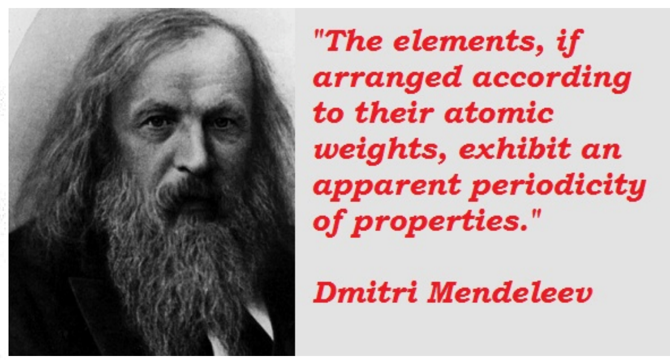
Using your combined observations, assign identities to each of the 11 elements.

Concepts and Answers

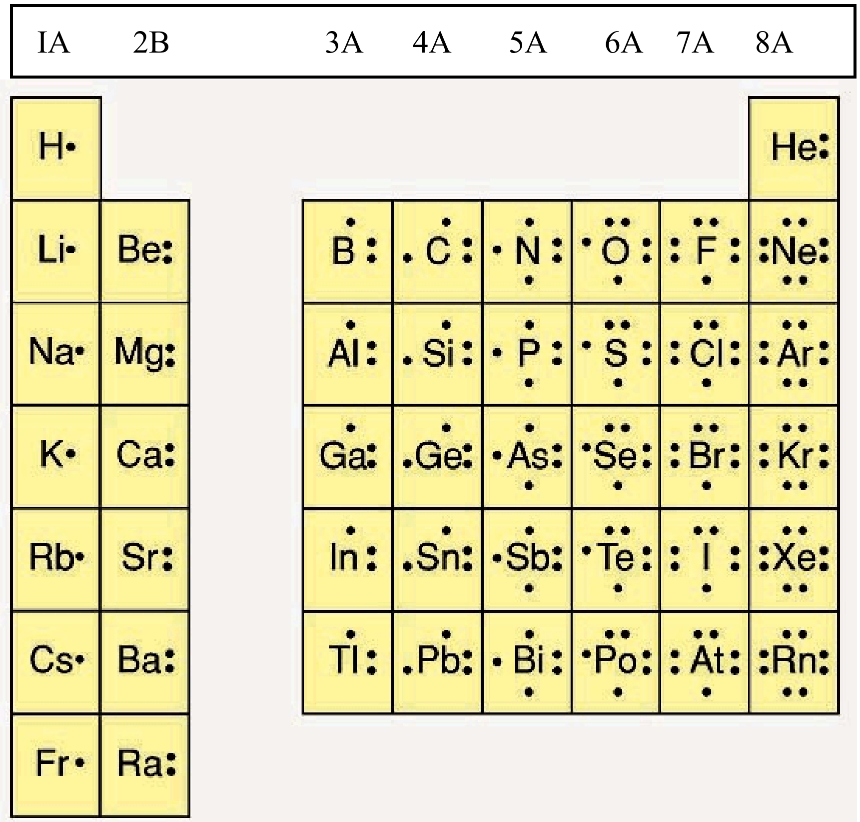
THE PERIODIC TABLE

We have noticed that there are two kinds of substances, elements and compounds. Elements cannot be broken down into simpler substances using chemical means. Therefore, elements are the building blocks of all the materials in our life including ourselves. The concept of the atom was formally presented by Dalton in the early 19th century but an understanding of the atom required many new ideas and experiments. While continuing to evolve, our current model for the atom has only really been around for about 100 years. Despite a lack of a model for the atom, Dimitri Mendeleev in 1869, based on experimental results and properties, was able to organize the elements into a draft of one of the most valuable and important scientific achievements of all time called the Periodic Table.

			Ti = 50	Zr = 90	? = 180
			V = 51	Nb = 94	Ta = 182
			Cr = 52	Mo = 96	W = 186
			Mn = 55	Rh = 104,4	Pt = 197,4
			Fe = 56	Ru = 104,4	Ir = 198
			Ni = Co = 59	Pd = 106,6	Os = 199
H = 1			Cu = 63,4	Ag = 108	Hg = 200
	Be = 9,4	Mg = 24	Zn = 65,2	Cd = 112	
	B = 11	Al = 27,4	? = 68	Ur = 116	Au = 197?
	C = 12	Si = 28	? = 70	Sn = 118	
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210?
	O = 16	S = 32	Se = 79,4	Te = 128?	
	F = 19	Cl = 35,5	Br = 80	J = 127	
Li = 7	Na = 23	K = 39	Rb = 85,4	Cs = 133	Tl = 204
		Ca = 40	Sr = 87,6	Ba = 137	Pb = 207
		? = 45	Ce = 92		
		?Er = 56	La = 94		
		?Yt = 60	Di = 95		
		?In = 75,6	Th = 118?		

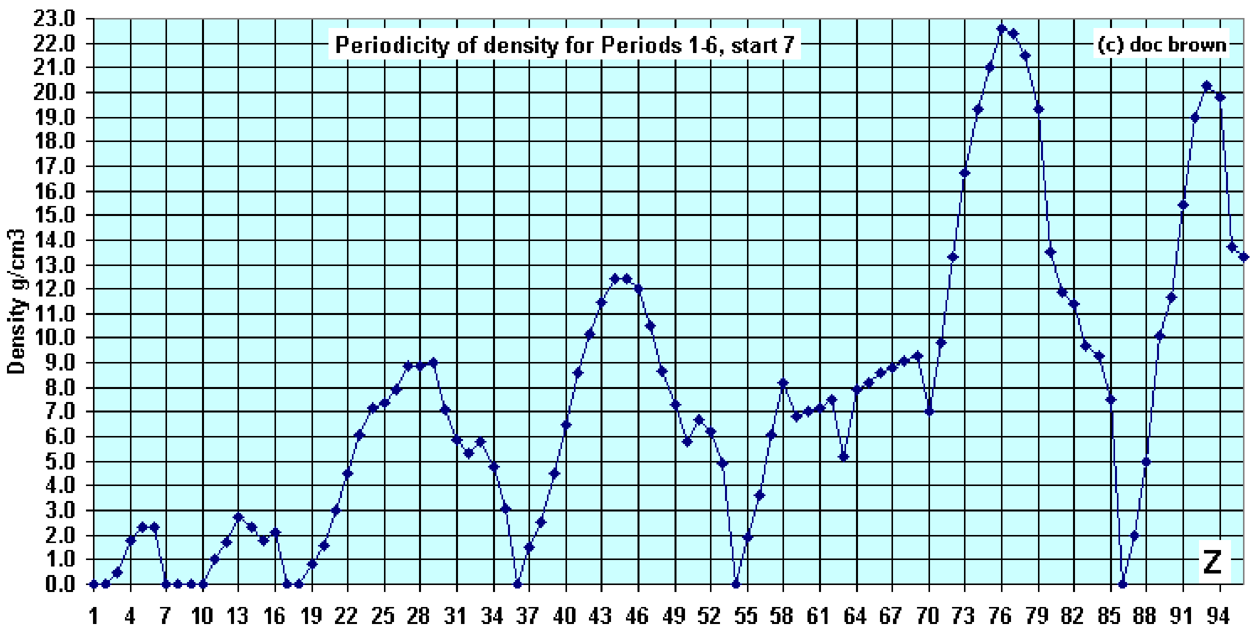


Mendeleev arranged the elements according increasing to atomic mass (there is a very high correlation between atomic mass and the correct parameter atomic number or the number of protons in the nucleus). He folded over rows or periods so that chemical properties of the elements lined up in groups or families. As an example, Mendeleev recognized that the chemical behavior of sodium is similar to that of lithium so he put sodium under lithium. Upon reaching potassium he realized potassium needed to be below sodium so he started a new row. This turned out to be very insightful as the remaining elements in each period also fell below an element of similar reactivity. For example, fluorine, chlorine, bromine and iodine all have similar properties and appropriately end up in the same group.



It is important to recognize that chemical properties and reactions are the result of donation, accepting or sharing of electrons and electrons only. Since only the outer electrons of an atom are available for changes, a look at the outer electrons of some of the elements reveals why the arrangement of Mendeleev worked. The chart to the right shows the outer (called valence) electrons for 8 groups of elements. As you can observe, the elements in each group have the same valence electron configuration. For this reason, lithium, sodium, potassium, rubidium and cesium each having one valence electron behave similarly in chemical reactions (1A elements react by giving up one electron). The halogens (7A) on the other hand have 7 valence electrons and generally react by acquiring one more electron.

Many of the properties of the elements tend to be periodic. For example, a graph of density vs atomic number yields the following:



The relative densities of 12 of the elements will be used in Station 11 as one of the properties that can be used to distinguish among the 12 elements (C, Mg, Al, S, Ti, Fe, Ni, Cu, Zn, Se, W and Pb) with colored squares on the periodic table on a later page. In addition to density, electrical conductivity, magnetic properties and appearance will be used to assign element names to each of the elements (designated A, B C, D, E, F, G, H, I, J, K, L by a random selection process).

The goal for the centerpiece of this exhibit (station 11) is to identify 11 (C, Mg, Al, S, Ti, Fe, Ni, Cu, Zn, Se, W and Pb designated A, B C, D, E, F, G, H, I, J and K by a random selection process) of the elements using four easily observable properties of the elements. Several of the previous stations have involved observations of properties related to density.

Since **density** is the mass of an object divided by its volume, measurements of both the mass and volume are needed to calculate the density. On exception is the use of a calibrated measuring device like the hydrometer used to determine the density of water directly in Station 9. 11 cylinders of the same size for each of the 11 elements have been placed on electronic scales on the 2 ft x 4ft platform in front of you. Because the volume of the cylinders in all cases is the same, a reading of the mass gives a relative density reading (or given that the volume of each cylinder is 3.22 g/cm^3, the density can be calculated) and allows you to rank the elements from lowest density (1) to highest density (11). This measurement alone should enable you to distinguish all but perhaps a couple of the elements. To distinguish between the remaining elements and to provide additional evidence to assign element identities, you will also determine three more properties.

You should notice a staircase that has a line on the left side of boron and proceeds down and to the right. Very roughly, this staircase divides the elements into two categories, **metals and non-metals**. The transition from metal to non-metal is not abrupt and the elements touching the staircase usually have properties intermediate between metals and non-metals. For this reason, you might recognize some of them as semi-conductors. Metals can be distinguished from non-metals according to the following table:

	Metal	***Non-metal***
state of matter	solid (except Hg)	solids, liquids, gases
electrical conductivity	good	poor or non-conductor
magnetic properties	mixed but some ferro	mixed
luster	shiny	dull
malleable	yes	no
ductile	yes	no

You will notice in the periodic table below that each of the 11 elements is described by one of three classifications; conductor, semiconductor or non-electrical conductor. Using **an electrical conductor test apparatus**, you will be able to classify each of the elements adding to your ability to distinguish among the 11 elements. With a more sophisticated apparatus, it could be possible to measure actual conductances. Since even the metals have different conductances, this would provide information that would distinguish among the metals. However, this type of measurement is beyond the scope of this exhibit and is not needed to distinguish between the 11 elements.

The **magnetic properties** of the elements depend on the electronic structure of the element and the ability to hold electronic alignments. The properties can be divided into three categories summarized in the table below.

Magnetic characteristic	electronic structure	observation
diamagnetism	all paired electrons	extremely weak repulsion by magnetic field
paramagnetism	at least one unpaired e^-	weak attraction to a magnetic field
ferromagnetism	at least one unpaired e^- + ability to hold magnetic alignment	strong permanent attraction to magnetic field

Of the properties above, only ferromagnetism is easily observed. You will hold a magnet over each of the 12 elements on the balances and determine if the mass of the object changes. Since diamagnetism and paramagnetism are weak, the mass reading on the scale will not be significantly affected for elements in these categories. However, two of the eleven elements are ferromagnetic as indicated in the Periodic Table and it should be easy to determine by mass changes when the magnet is near the sample that the sample is ferromagnetic.

All 11 elements at this station are solids at room temperature but appearance alone provides important information. Metals are lustrous and non-metals are not lustrous. This should enable you to distinguish carbon, sulfur and selenium from the other nine elements. In addition, the color of each element is given in the periodic table and should provide additional useful information.

At this point, using relative densities (or given that the volume of each cylinder is 3.22 g/cm^3, actual densities can be calculated), electrical conductance, magnetic properties and appearance, it should be possible to assign element identities to A - K.

Element symbol	Name	Density Lit. Val. (g/cm^3)	GVM density (g/cm^3)	GVM density Rank	Color	Elect. Cond.	Magnetic Prop.
Mg	**magnesium**	1.74	**1.70**	**1**	**silver**	**C**	**NF**
C	**carbon**	2.27	**1.76**	**2**	**black**	**WC**	**NF**
S	**sulfur**	2.07	**1.89**	**3**	**yellow**	**NC**	**NF**
Al	**aluminum**	2.70	**2.71**	**4**	**silver**	**C**	**NF**
Se	**selenium**	4.79	**4.20**	**5**	**gray**	**NC**	**NF**
Ti	**titanium**	4.51	**4.48**	**6**	**silver**	**C**	**NF**
Fe	**iron**	7.87	**8.04**	**7**	**gray**	**C**	**F**
Cu	**copper**	8.92	**8.92**	**8**	**copper**	**C**	**NF**
Ni	**nickel**	8.91	**9.04**	**9**	**gray**	**C**	**F**
Pb	**lead**	11.34	**11.39**	**10**	**slate gray**	**C**	**NF**
W	**tungsten**	19.3	**19.27**	**11**	**gray**	**C**	**NF**

Unk. letter	Mass (grams)	Rank (1-11) (rel. density)	Elect. Cond.	Magnetic (ferro or not)	Color	Luster	Element Name
A	**14.42**	**6**	**C**	**NF**	**silver**	**yes**	**titanium**
B	**6.08**	**3**	**NC**	**NF**	**yellow**	**no**	**sulfur**
C	**28.73**	**8**	**C**	**NF**	**copper**	**yes**	**copper**
D	**8.74**	**4**	**C**	**NF**	**silver**	**yes**	**aluminum**
E	**29.10**	**9**	**C**	**F**	**grey**	**yes**	**nickel**
F	**36.69**	**10**	**C**	**NF**	**slate gray**	**yes**	**lead**
G	**5.48**	**1**	**C**	**NF**	**silver**	**yes**	**magnesium**
H	**25.89**	**7**	**C**	**F**	**gray**	**yes**	**iron**
I	**5.68**	**2**	**WC**	**NF**	**black**	**no**	**carbon**
J	**62.04**	**11**	**C**	**NF**	**gray**	**yes**	**tungsten**
K	**13.53**	**5**	**NC**	**NF**	**gray**	**no**	**selenium**
For station 12							
X	**23.51**		**C**	**NF**	**silver**	**yes**	**tin**

Density for X = mass/3.22 = **7.30** g/cm^3

C = conductor
WC = semiconductor
NC = non-conductor
F = ferromagnetic
NF = not ferromagnetic

PERIODIC TABLE OF THE ELEMENTS

s | d | p

The 11 Element ID Challenge

KEYS

C = electrical conductor
WC = weak conductor
NC = non-electrical cond.
F = ferromagnetic
NF = not ferromagnetic

Atomic #	elect. cond.
Element Symbol	
Density	mag. prop.

Density (g/cm^3)
metals left of staircase - lustrous
non-metals right of staircase - non-lustrous
touching staircase - metalloids

1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 NC *H* NF																	2 NC *He* NF
3 C Li 0.53 NF	4 Be 1.85 NF											5 NC B 2.34 NF	6 WC C 2.27 NF	7 NC *N* NF	8 NC *O* NF	9 NC *F* NF	10 NC *Ne* NF
11 C Na 0.97 NF	12 C Mg 1.74 NF											13 C Al 2.70 NF	14 NC Si 2.33 NF	15 NC P 1.82 NF	16 NC S 2.07 NF	17 NC *Cl* NF	18 NC *Ar* NF
19 C K 0.86 NF	20 C Ca 1.55 NF	21 C Sc 2.99 NF	22 C Ti 4.51 NF	23 C V 6.11 NF	24 C Cr 7.19 NF	25 C Mn 7.43 NF	26 C Fe 7.87 F	27 C Co 8.86 F	28 C Ni 8.91 F	29 C Cu 8.92 NF	30 C Zn 7.13 NF	31 C Ga 5.91 NF	32 WC Ge 5.32 NF	33 C As 5.72 NF	34 NC Se 4.79 NF	35 NC Br 3.1 2 NF	36 NC *Kr* NF
37 C Rb 1.63 NF	38 C Sr 2.54 NF	39 C Y 4.47 NF	40 C Zr 6.51 NF	41 C Nb 8.57 NF	42 Mo 10.22 NF	43 C Tc 11.5 NF	44 C Ru 12.37 NF	45 C Rh 12.41 NF	46 C Pd 12.02 NF	47 C Ag 10.5 NF	48 C Cd 8.65 NF	49 C In 7.31 NF	50 C Sn 7.31 NF	51 C Sb 6.68 NF	52 WC Te 6.24 NF	53 NC I 4.93 NF	54 NC *Xe* NF
55 C Cs 1.87 NF	56 C Ba 3.59 NF	57 C La 6.15 NF	72 C Hf 13.31 NF	73 Ta 16.65 NF	74 C W 19.3 NF	75 C Re 21.04 NF	76 C Os 22.6 NF	77 C Ir 22.4 NF	78 C Pt 21.45 NF	79 C Au 19.32 NF	80 C Hg 13.55 NF	81 C Tl 11.85 NF	82 C Pb 11.3 NF	83 C Bi 9.75 NF	84 C Po 9.32 NF	85 At 7 NF	86 *Rn* NF
87 C Fr 1.87 NF	88 Ra 5.5 NF	89 Ac 10.07 NF	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

f

58 C Ce 6.77 NF	59 C Pr 6.77 NF	60 C Nd 7.01 F	61 C Pm 7.26 NF	62 C Sm 7.52 NF	63 C Eu 5.24 NF	64 C Gd 7.9 F	65 C Tb 8.2 3 NF	66 C Dy 8.55 F	67 C Ho 8.8 NF	68 C Er 9.07 M	69 C Tm 9.32 NF	70 C Yb 6.96 NF	71 C Lu 9.84 NF
90 C Th 11.72 NF	91 C Pa 15.4 NF	92 C U 18.95 NF	93 C Np 20.2 NF	94 C Pu 19.84 NF	95 Am 13.67 NF	96 Cm 13.5 NF	97 Bk 14.78 NF	98 Cf 15.1 NF	99 Es	100 Fm 8.84	101 Md	102 No	103 Lr

Colors of 11 Elements*
black - C
silver - Mg, Al, Ti
gray - Fe, Se, W, Ni
yellow - S
copper - Cu
slate gray - Pb
*Station 11 elements

key: italics - gas, shadow - liquid, bold or normal - solid, normal print - all known isotopes are radioactive.
Colored elements are the unknowns for this experiment. Distinguish using color, luster, relative density, electrical conductivity and magnetic attraction.

Materials and Images.

For scales, see Station 8. For elements, visit: http://www.elementsales.com/

To construct the case for the scales, a 2 ft x 4 ft x 0.5 inch piece of plywood was used. Side and back walls were made from 2 in. x 4 in. topped by a 1 in. x 2 in. board to make the top the right height. The front board was cut from a 1 in. by 5 in. board trimmed to the correct height. The case was topped with a 2 ft. by 4 ft. by 0.25 inch piece of Plexiglas. A 12 plug multiple strip was installed in the back o f the case along with the 12 scales. For each scale one of the legs was removed and replaced with a bolt from the bottom of the plywood.