

It's in the Cards Discovering the Periodic Law

Introduction:

Dmitri Mendeleev's discovery of the Periodic Law ranks as one of the greatest achievements in the history of science. It has survived the test of time and stands to this day as the single most important tool to understand the chemistry of the elements. As we try to understand the essence of this great discovery, it is worthwhile to go back in time and look at how it was achieved. What did Mendeleev know and when did he know it?

Experiment Overview:

The purpose of this activity is to re-create Mendeleev's discovery of the classification of the elements and the periodic law using a special deck of element cards. The real properties of the elements, but not their names or symbols, are written on these cards. As the cards are arranged and rearranged based on logical trends in some of these properties, the nature of the periodic law should reveal itself.

Materials:

Special deck of 31 element cards

Procedure:

1. Form a research group with two or three other students. Obtain a deck of element cards and spread the cards out on the lab table.
2. Each card lists the properties of a single element (X), as shown below:

Ionization Energy	Atomic Radius
Atomic Mass	Formula of its oxide
Formula of its chloride	Melting Point
Density	Formula of its hydride
Electro-negativity	

3. Working in a collaborative manner, discuss the possibilities for arrangement of the element cards with all members of the group, and look for a logical arrangement of the cards. Consider the following questions:
 - a. What are the similarities and differences among the elements?
 - b. Are there any numerical or logical trends in their properties?
4. It is **NOT** within the rules of this game of chemical solitaire to look up information in a textbook or to use a modern periodic table as a guide!

5. One of the element cards is also missing in your deck of cards. Decide where the missing element belongs in the arrangement of the elements and rearrange the cards if necessary to accommodate the missing element.

Mendeleev's greatest insight in creating the periodic table was in recognizing there were some gaps when the elements were arranged in logical order. He had the courage not only to leave blanks in his table for the missing elements, but also predict their properties!

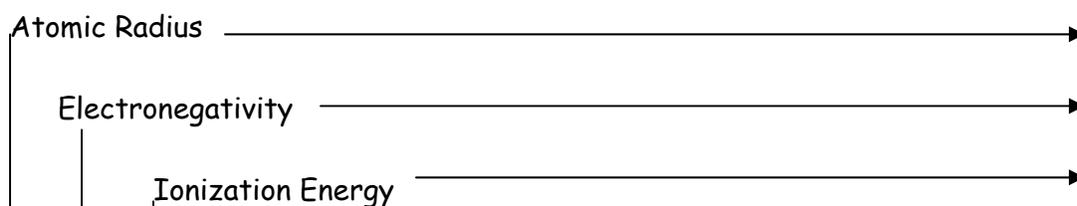
6. On the Data Sheet, fill in the Table of the Elements to illustrate the logical arrangement of the element cards. To do this, write down only the atomic mass of each element, as shown on its card. Leave a blank space for the missing element. *NOTE:* The table is 8x8 and contains 32 more squares than are needed - plenty of room to arrange the elements many different ways.

Data Sheet (Cut and Tape in lab notebook)

Questions:

1. Mendeleev's Periodic Law can be stated: "The physical and chemical properties of elements are periodic functions of their atomic masses". Looking at your arrangement of the element cards, describe in your own words what the terms "periodic function" means.
2. Some of the properties listed on each card are periodic properties, others are not. Name one property that is periodic and explain its periodicity. Name one that is not periodic and explain why it is not.

- The elements in the modern periodic table are arranged in order of increasing atomic number (instead of increasing atomic mass). Why didn't Mendeleev use atomic number to arrange the elements?
- From your instructor, obtain a handout showing one possible arrangement of the element cards. Identify each of the elements on the handout with its *atomic number* and *chemical symbol*.
- Predict the properties of the missing element by averaging the properties of its nearest neighbors (in any direction). Complete the card for the missing element by entering its predicted properties alongside the name of each property.
- There are certain trends in the properties of the elements, both within a column (from top to bottom) and across a row (from left to right) in the periodic table. On the arrow for each property, write the word increases or decreases to describe how that property changes. Cut and tape in lab notebook.



Periodic Table of the Elements

1 H 1.00794																	1 H 1.00794	2 He 4.002602
3 Li 6.941	4 Be 9.012182											5 B 10.811	6 C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797	
11 Na 22.989770	12 Mg 24.3050											13 Al 26.981538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948	
19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6934	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.904	36 Kr 83.80	
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc 101.07	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29	
55 Cs 132.90545	56 Ba 137.327	57 La 138.9055	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.96655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.98038	84 Po (209)	85 At (210)	86 Rn (222)	
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)			114 (289) (287)			116 (289)	118 (293)

58 Ce 140.116	59 Pr 140.90765	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.26	69 Tm 168.93421	70 Yb 173.04	71 Lu 174.967
90 Th 232.0381	91 Pa 231.03588	92 U 238.0289	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

7. On the periodic table shown below, locate the following: metals, nonmetals, and metalloids (or semi-metals). Color or shade each area of the periodic table to show their location. Cut and tape in lab notebook.

Periodic Table of the Elements

1 H 1.00794																	1 H 1.00794	2 He 4.002602			
3 Li 6.941	4 Be 9.012182															5 B 10.811	6 C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797
11 Na 22.989770	12 Mg 24.3050															13 Al 26.981538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938040	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6934	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.904	36 Kr 83.80				
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc 98	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29				
55 Cs 132.90545	56 Ba 137.327	57 La 138.9055	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.96655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.98038	84 Po (209)	85 At (210)	86 Rn (222)				
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)	114 (289)	116 (289)				118 (293)				

58 Ce 140.116	59 Pr 140.90765	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.26	69 Tm 168.93421	70 Yb 173.04	71 Lu 174.967
90 Th 232.0381	91 Pa 231.03588	92 U 238.0289	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

8. On the periodic table shown below, locate the following: Alkali metals, alkaline earth metals, halogens, noble gases, lanthanide series, actinide series, and the transition metals. Color or shade each area of the periodic table to show their location. Cut and tape in lab notebook.

Periodic Table of the Elements

1 H 1.00794																	1 H 1.00794	2 He 4.002602			
3 Li 6.941	4 Be 9.012182															5 B 10.811	6 C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797
11 Na 22.989770	12 Mg 24.3050															13 Al 26.981538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938040	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6934	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.904	36 Kr 83.80				
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc 98	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29				
55 Cs 132.90545	56 Ba 137.327	57 La 138.9055	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.96655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.98038	84 Po (209)	85 At (210)	86 Rn (222)				
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)	114 (289)	116 (289)				118 (293)				

58 Ce 140.116	59 Pr 140.90765	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.26	69 Tm 168.93421	70 Yb 173.04	71 Lu 174.967
90 Th 232.0381	91 Pa 231.03588	92 U 238.0289	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

"I wished to establish some sort of system of elements in which their distribution is not guided by chance... but by some definite and exact principle."
Dmitri Mendeleev