Name _____ Date _____ Class _____

5–1 Apply

Mendeleev's Periodic Table

The periodic table shown below is one of many versions that Mendeleev designed in 1869. Although Mendeleev's periodic table looks quite different from the periodic table in use today, the arrangement of elements is actually very similar. Compare Mendeleev's table to the periodic table on pages 166 and 167 in your textbook. Then answer the following questions on a separate sheet of paper.

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

1. What do the numbers on Mendeleev's periodic table represent?
2. The current periodic table arranges elements in horizontal rows in order of increasing atomic number. Describe Mendeleev's scheme for organizing elements by number.
3. Describe the way in which Mendeleev arranged elements with similar properties.
4. Name the chemical family of elements that is absent from Mendeleev's table. Why do you think these elements are not represented in the table?
5. Calcium (Ca) seems out of place on Mendeleev's table. Discuss what Mendeleev's reasons might have been for placing calcium where he did. Where would you have placed this element in his table to be consistent with the current periodic table?
6. Use the periodic table in the textbook to identify the four elements marked with question marks on Mendeleev's table.

atomic number

atomic mass

family

Name _____ Date _____ Class _____

5–2 Apply

Using the Periodic Table

Deepa was asked to identify nine unknown elements that were sealed in separate glass containers. Additional information about each element was attached to its container. Deepa recorded the properties of the nine elements in the following table.

Element	Appearance	Additional Information
1	pale yellow gas	poisonous, reactive element; found in a compound used in toothpaste
2	silvery solid	very malleable; easily cut with a knife; catches fire spontaneously in water
3	silvery solid	very malleable; easily cut with a knife; reacts violently with water; found in table salt, saltpeter, and baking soda
4	colorless gas	inert; used in incandescent light bulbs
5	silvery solid	fairly hard; found in upset stomach remedies ; burns with a bright light in air
6	colorless gas	inert gas; one of the heaviest gases; used in stroboscopic lamps
7	silvery solid	rather hard; compounds found in bones and hard water
8	colorless gas	inert gas; used to fill balloons
9	greenish gas	poisonous; found in bleach

1. List the elements in the table that are metals.
2. List the elements that belong to the
   a. halogen group.
   b. noble gases.
3. Would you expect elements 1 and 8 to belong in the same group? Why or why not?
4. Use what you know about the properties of elements 3, 6, 7, and 9 to place them in their correct locations on the periodic table below. What are the names of these elements?

H	
Li	Be
	Mg
K	
Rb	Sr
Cs	Ba

					He
B	C	N	O	F	Ne
Al	Si	P	S		Ar
Ga	Ge	As	Se	Br	Kr
In	Sn	Sb	Te	I	
Tl	Pb	Bi	Po	At	Rn

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5 Laboratory Investigation

DESIGNING an EXPERIMENT

Determining Trends in a Group

Problem

How does the density change going down a group in the periodic table? Use densities to determine the density of carbon

Suggested Materials (per group)

balance
10-mL graduated cylinder
plastic weighing dishes
lead shot (Pb)
silicon pieces (Si)
tin pieces (Sn)
graph paper
metric ruler

Suggested Procedure

1. Devise an experiment to determine the density of three or more elements within the same group of the periodic table. Silicon (Si), tin (Sn), and lead (Pb) are suggested. ~~and Carbon~~
2. Write down the steps of your experimental procedure on a separate sheet of paper.
3. Prepare a table, such as the one shown, to record your data.
4. Conduct your experiment after having your teacher approve your procedure and data table.
5. From your data, calculate the densities of the elements you used in your experiment.

Observations/Data

Measurement	Lead (Pb)	Silicon (Si)	Tin (Sn)

Data Analysis

1. On a sheet of graph paper, prepare a graph of density vs. period number for lead, silicon, and tin. (this is a calibration curve) add the density of Be ~~[illegible]~~ 5.46 g/mL
2. Identify the density of C on graph

Conclusion

1. Define periodic trends
2. State the trend in densities for Gr. 14
3. Define calibration curve
4. Ideal [illegible] density of carbon

→ over

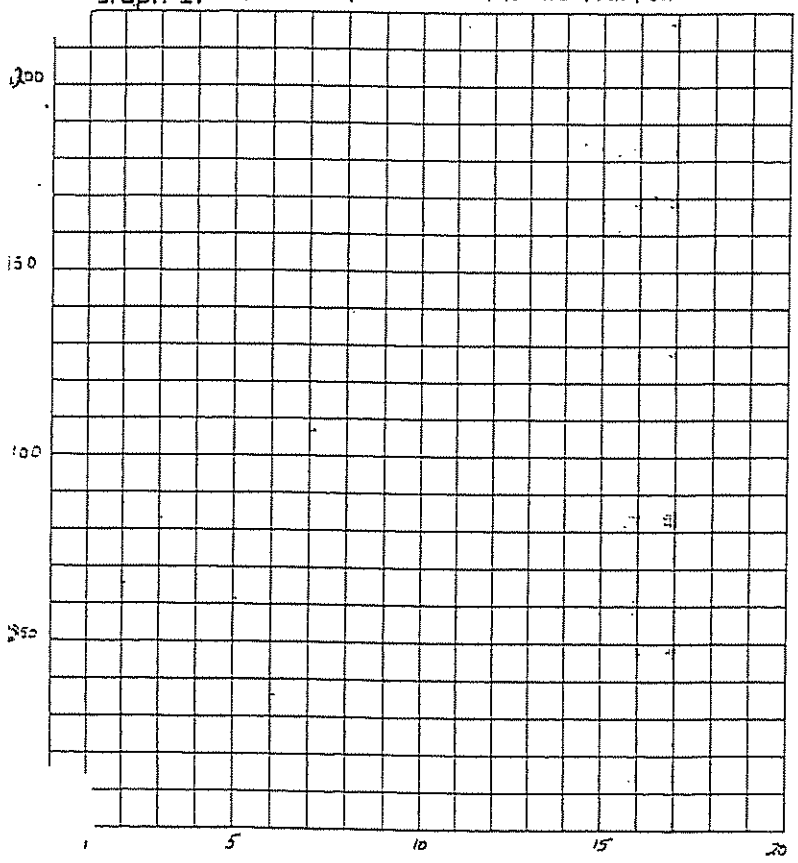
Periodic Properties 2

Set 2

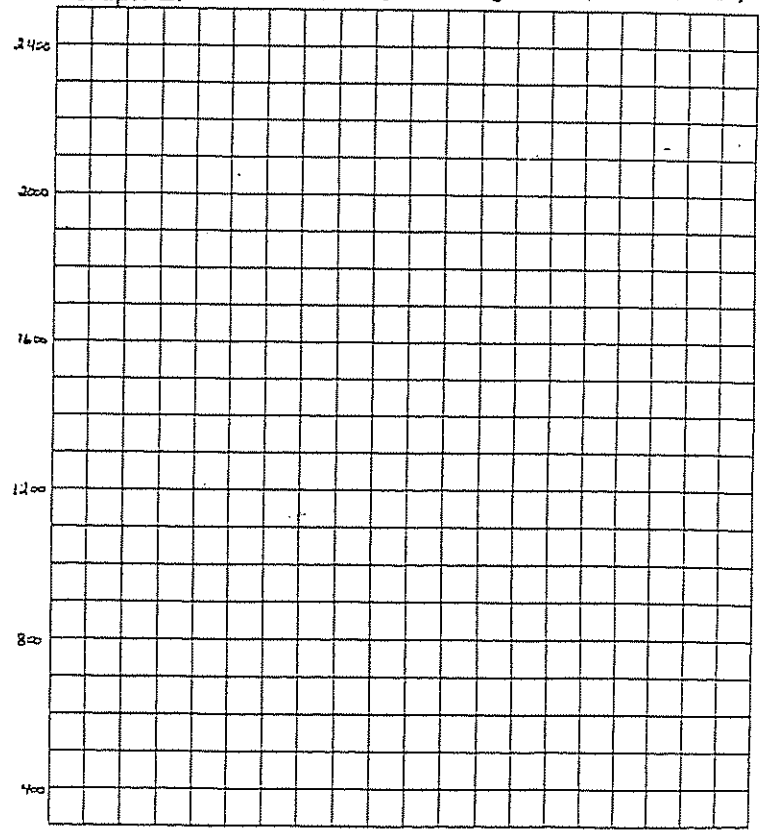
Table 1

Element Symbol	Atomic Number	Atomic Radius (nm)	First Ionization Energy (kJ/mol)
H	1	0.037	1312
He	2	0.054	2372
Li	3	0.152	519
Be	4	0.111	900
B	5	0.088	799
C	6	0.077	1088
N	7	0.070	1406
O	8	0.066	1314
F	9	0.064	1682
Ne	10	0.070	2080
Na	11	0.186	498
Mg	12	0.160	736
Al	13	0.143	577
Si	14	0.117	787
P	15	0.110	1063
S	16	0.104	1000
Cl	17	0.099	1255
Ar	18	0.094	1519
K	19	0.231	418
Ca	20	0.197	590

Graph 1: Atomic Radius vs Atomic Number



Graph 2: First Ionization Energy vs Atomic Number



Trend:

Trend:

atomic radius →

Trend:

ionization energy →

Trend:

GROUPING THE ELEMENTS

You will be given a set of 20 element data cards. Each card lists some properties of one of the first 20 elements.

1. Arrange the cards in order of increasing atomic mass.
2. Next, place the cards in a number of different groups. Each group should include elements with similar properties. For example, you might put all elements with boiling points below 0 °C in one group, and in another all elements with boiling points above 0 °C. Or you might examine the formulas of chlorine-containing compounds, and group the elements by the number of chlorine atoms in these formulas.
3. Examine the cards within each group for any patterns. Arrange cards within each group in some logical sequence.
4. Observe how particular properties vary from group to group.
5. Arrange all the card groups into some logical sequence.
6. Decide on the most reasonable and useful patterns within and among card groups. Then tape the cards onto a sheet of paper to preserve your pattern for classroom discussion.

Mendeleev's Periodic Table

Atomic mass	1	Atomic mass	19	Atomic mass	36	Atomic mass	18
Melting point (°C)	-259	Melting point (°C)	-218	Melting point (°C)	-101	Melting point (°C)	-219
Boiling point (°C)	-252	Boiling point (°C)	-188	Boiling point (°C)	-34	Boiling point (°C)	-183
O in oxide	0.5	O in oxide	0.5	O in oxide	0.5	O in oxide	–
Cl in chloride	1	Cl in chloride	1	Cl in chloride	1	Cl in chloride	2
Atomic mass	9	Atomic mass	20	Atomic mass	27	Atomic mass	40
Melting point (°C)	1287	Melting point (°C)	-248	Melting point (°C)	659	Melting point (°C)	-189
Boiling point (°C)	2507	Boiling point (°C)	-246	Boiling point (°C)	2327	Boiling point (°C)	-186
O in oxide	1	O in oxide	–	O in oxide	1.5	O in oxide	–
Cl in chloride	2	Cl in chloride	–	Cl in chloride	3	Cl in chloride	–
Atomic mass	7	Atomic mass	32	Atomic mass	23	Atomic mass	10
Melting point (°C)	179	Melting point (°C)	119	Melting point (°C)	97	Melting point (°C)	2037
Boiling point (°C)	1327	Boiling point (°C)	445	Boiling point (°C)	889	Boiling point (°C)	2527
O in oxide	0.5	O in oxide	3	O in oxide	0.5	O in oxide	1.5
Cl in chloride	1	Cl in chloride	2	Cl in chloride	1	Cl in chloride	3
Atomic mass	39	Atomic mass	12	Atomic mass	4	Atomic mass	28
Melting point (°C)	64	Melting point (°C)	3470	Melting point (°C)	-272	Melting point (°C)	1407
Boiling point (°C)	757	Boiling point (°C)	4347	Boiling point (°C)	-269	Boiling point (°C)	2677
O in oxide	0.5	O in oxide	2	O in oxide	–	O in oxide	2
Cl in chloride	1	Cl in chloride	4	Cl in chloride	–	Cl in chloride	1
Atomic mass	40	Atomic mass	31	Atomic mass	14	Atomic mass	24
Melting point (°C)	851	Melting point (°C)	44	Melting point (°C)	-210	Melting point (°C)	650
Boiling point (°C)	1487	Boiling point (°C)	280	Boiling point (°C)	-196	Boiling point (°C)	1117
O in oxide	1	O in oxide	2.5	O in oxide	2.5	O in oxide	1
Cl in chloride	2	Cl in chloride	3	Cl in chloride	3	Cl in chloride	2

Periodic Variation in Properties

Your teacher will give you the atomic numbers of the 20 elements you arranged in Section B.5. Use these atomic numbers and information on the element cards to prepare the two graphs described below. It will be helpful to label each plotted point with the symbol of the element involved.

Periodic Properties

Set 1

1. Label the *x* axis of Graph 1 with atomic numbers from 1 to 20.
2. Select either the formulas for oxide or chloride compounds. Label the *y* axis for the number of chlorine or oxygen atoms as follows:
   a. To prepare to plot chloride data, label the *y* axis 0 for formation of no chloride, 1 for ECl compounds (1 chlorine atom for each E atom), 2 for ECl_2, 3 for ECl_3, and 4 for ECl_4.
   b. To prepare to plot oxide data, label the *y* axis 0 for formation of no oxide, 0.5 for E_2O (0.5 oxygen atom for each E atom, 1 oxygen atom for 2 E atoms), 1 for EO, 1.5 for E_2O_3 (do you see why?), 2 for EO_2, and 2.5 for E_2O_5.
3. Plot the oxide or chloride data from the element cards.
4. Label the *x* axis of Graph 2 with the atomic numbers from 1 to 20.
5. Select either melting point or boiling point data; label the *y* axis as shown in the accompanying figure. Use as much of the space on your graph paper as possible.
6. Plot the data from the element cards. Do not include data for the element with atomic number 6 (carbon)—the *y*-axis value for this element will be quite far off the graph.
7. On each graph, connect adjacent points with straight lines.

Questions

1. a. Does either graph reveal a repeating or cyclic pattern? (*Hint:* Focus on elements in the peaks or valleys.)
   b. Are these graphs consistent with your earlier grouping of the elements? Why or why not?
2. Based on these graphs, why is the chemist's organization of elements called a *periodic* table?