Investigation: Chemical Periodicity

In this activity, you will examine trends in the physical properties of the first 54 elements of the periodic table.
Using the data below (use reference materials to fill in the missing data) construct a graph for each pair of quantities:

a) atomic radius versus atomic number
b) ionization energy versus atomic number
c) melting point versus atomic number
d) density versus atomic number
e) electronegativity versus atomic number

Atomic Number	Symbol	Atomic Radius (nm)	Ionization Energy (kJ/mol)	Melting Point (°C)	Density (kg/m^3)	Electronegativity
1	H	0.032	1312			
2	He	0.031	2372			
3	Li	0.123	520			
4	Be	0.090	899			
5	B	0.082	801			
6	C	0.077	1086			
7	N	0.075	1402			
8	O	0.073	1310			
9	F	0.072	1681			
10	Ne	0.071	2081			
11	Na	0.154	496			
12	Mg	0.136	738			
13	Al	0.118	578			
14	Si	0.111	786			
15	P	0.106	1012			
16	S	0.102	1000			
17	Cl	0.099	1251			
18	Ar	0.098	1521			
19	K	0.203	419			
20	Ca	0.174	590			
21	Sc	0.144	630			
22	Ti	0.132	660			
23	V	0.122	650			
24	Cr	0.118	650			
25	Mn	0.117	720			
26	Fe	0.117	759			
27	Co	0.116	758			
28	Ni	0.115	737			
29	Cu	0.117	745			
30	Zn	0.125	906			
31	Ga	0.126	579			
32	Ge	0.122	762			
33	As	0.120	947			
34	Se	0.117	941			
35	Br	0.114	1140			
36	Kr	0.122	1351			
37	Rb	0.216	403			
38	Sr	0.191	550			
39	Y	0.162	616			
40	Zr	0.145	660			
41	Nb	0.134	664			
42	Mo	0.130	685			
43	Tc	0.127	702			
44	Ru	0.125	711			
45	Rh	0.125	720			
46	Pd	0.128	805			
47	Ag	0.134	731			
48	Cd	0.148	868			
49	In	0.144	558			
50	Sn	0.140	709			
51	Sb	0.140	832			
52	Te	0.136	869			
53	I	0.133	1008			
54	Xe	0.131	1170			

Questions:

A. Atomic radius versus atomic number

A number of physical and chemical properties are related to the sizes of the atoms, but atomic size is somewhat difficult to define. There is no precise outer boundary of an atom. The radius is one half the distance between the centers of two adjacent atoms. The radius of an atom depends on the environment in which it is found. For *bonded* atoms, we customarily speak of a covalent radius, ionic radius, and, in the case of metals, a metallic radius. For atoms that are not bonded together, the radius is known as the van der Waals radius. For comparison, all radii in the above table are covalent.

1. Which is the largest of the first 54 elements?
2. Describe how the atomic radius varies within a period and within a family.
3. Use your graph to predict the atomic radius of the following elements:
   (a) cesium (b) tungsten (c) thallium (d) radon
4. Which group of the main group elements contains the largest elements?

B. Ionization energy versus atomic number

1. How would you explain *ionization energy* to your partner?
   (a) How does the ionization energy vary within a period and within a family?
   (b) Which element on your graph has the strongest hold of its valence electrons?
2. (a) Write the electron configuration for chlorine.
   (b) Which electron is lost when 1251 kJ/mol of energy are applied to a sample of chlorine atoms?
2. Compare the ionization energies of metals to nonmetals.

C. Melting point versus atomic number

1. Describe the trend of melting points within a period
2. Which group of elements tends to have the highest melting points
3. Tungsten is used in incandescent light bulbs because it has an extremely high melting point. Which element on your chart could be a reasonable replacement for tungsten? Why?

D. Density versus atomic number

1. Describe how density varies within a period.
2. Compare the densities of the elements in the second period with the elements in the third period.
3. Assume that the transition metals given in the table are representative of the other members of this group. How do the densities of the transition metals compare with those of the elements in the main group?
4. Explain why aluminum and magnesium are more suitable than iron for use in some airplane parts.

E. Electronegativity versus atomic number

1. Describe how electronegativity varies within a period.
2. Describe how electronegativity varies within a family.

References:

Kimball, D., E. Kuzub and M. Sanader (1993), *Chemistry Laboratory Manual 1*, Student's Edition, Don Mills: Addison-Wesley Publishers Limited

Petrucci, R.H. (1982), *General Chemistry, Principles and Modern Applications*, 3rd ed. New York: Macmillan Publishing Co., Inc.

Whitman, R.L., E.E. Zinck and R.A. Nalepa (1988), *Chemistry Today 1*, 3rd ed. Scarborough: Prentice-Hall Canada Inc.

Whitman, R.L., E.E. Zinck and R.A. Nalepa (1982), *Chemistry Today Laboratory Manual,* 2nd ed. Scarborough: Prentice-Hall Canada Inc.