First-Year HL & SL Chemistry

4. Periodicity: Physical and Chemical properties

Read: Zumdahl[2] Chapter 7: Sections 12-13; Chapter 8: Section 2 (pp. 352-353), 4 (pp 360-361); Chapter 19: Section 2; Chapter 20: Section 7 (pp. 967-970).

Presumed knowledge (from GCSE)

- period, group, metals, alkali metals, alkaline earth metals, transition metals, nonmetals, halogen, noble gas
- reactivity, reactivity of alkali metals, reactivity of halogens

Concepts to be mastered:

To master a concept, you must be able to do three things:

1. define the concept
2. explain the concept, and
3. give an example of the concept.

Physical properties

- atomic radius, ionization energy, electron affinity, ionic radius, cationic radius, anionic radius, melting point, electronegativity

Chemical properties

- reaction, reactivity, acid anhydride, base anhydride, hydration, hydrolysis, acidic, basic, metallic, nonmetallic

Skills to be mastered:

To master a skill, you must be able to

1. recognize when the skill is needed,
2. recognize what information is needed to execute the skill,
3. execute the skill, and
4. assess whether the skill has been executed correctly.

Physical properties

	Zumdahl[2] problems	Further problems
• Describe the trends in atomic radius, electronegativity, ionization energy, electron affinity, cationic radius, anionic radius, ionic radius and melting point	**7**.85-90, 94-102 **8**.1, 3, 21-22, 33-36	5, 6, 7, 8
• Explain the periodic trends in atomic radius, ionization energy, electron affinity, cationic radius, anionic radius, ionic radius and melting pint using your knowledge of atomic structure and electrical force	**7**.93-102, **8**.95	5, 6, 7, 8, 9, 10,11, 12, 13
• Account for the existence of sub-levels (sub shells) using evidence from first ionization energies [**ONLY HL**]		4, 5

Chemical properties

- Describe and explain the trends in chemical properties of elements in the same group
  a) Li, Na, K reactions with water and with Cl_2 and Br_2
  b) Cl_2, Br_2, I_2 reactions with water and with halide ions [lab based]
  c) Cl^-, Br^-, I^- reactions with silver ions (Ag^+) [lab based]
- Explain the trends in chemical properties

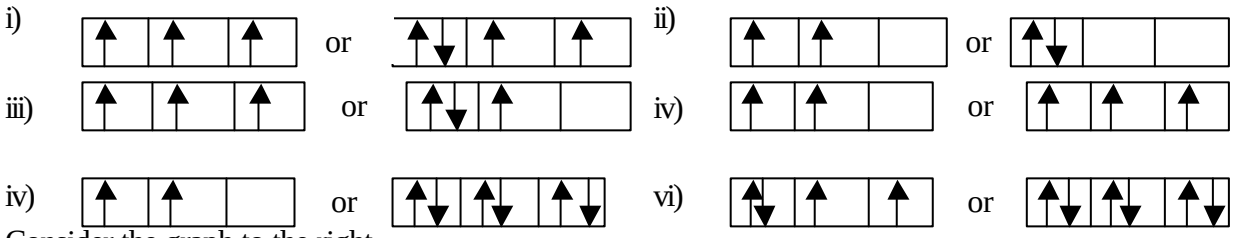
14, 15,

- Describe the change from metallic to non-metallic nature of the elements across period 3: **19**.17, 18 — 16
  a) acidic or basic character of oxides [lab based]
  b) reactions of period 3 halides with water [lab based]
  c) reaction of chlorides with water [lab based] [**Not relevant to SL**]

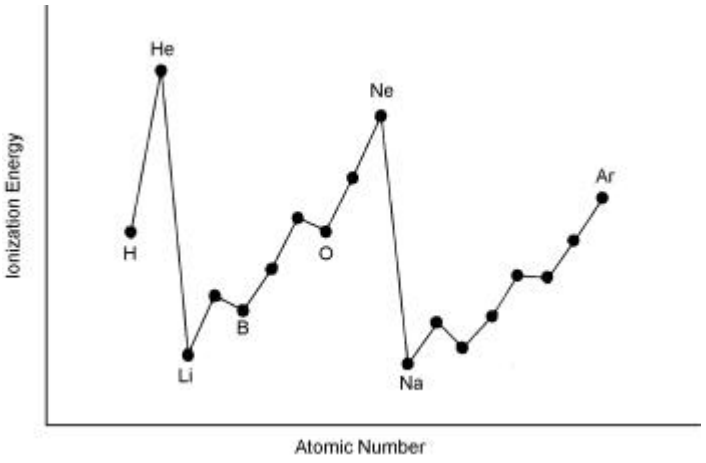
Additional Problems:
7.6, 7, 10-14, 27, 28, 29, 30, 103-110, 121.

Further problems:

1. Referring to the periodic table in your textbook,
   (a) what group 2 element is in period 4?
   (b) What period 5 element is a halogen?
2. Identify each of the following:
   (a) the element in period 3 with three electrons in its outermost shell
   (b) an element in period 2 with the same number of electrons in its outermost shell as the element with 20 protons in its nucleus.
   (c) the group to which an element with seven electrons in its outermost shell belongs
   (d) the number of electrons in the outermost shell of element number 14.
3. Use only the position in the periodic table (<u>not</u> the atomic number) to write the outermost electron configuration (beyond the rare gas core) of (a) Cs, (b) Pb, (c) I, (d) Au [**Only HL.**]
4. State and where possible explain which of the pair of *p* subshell configurations is more stable



5. Consider the graph to the right.



   i) Why is there a general increase in ionization energy on passing from Li to Ne?
   ii) What accounts for the unusual behavior of oxygen? [HL only]
   iii) Explain why He has the largest ionization energy of all the noble gases.
6. Write equations corresponding to (a) the first ionization energy of sodium (b) the second ionization energy of lead.
7. List the elements Be, N and Mg in order of increasing ionization energy and explain the order.
8. Choose the species with the larger ionization energy:
   (a) Li or Be, (b) C or N, (c) Ne or Na, (d) Na^+ or Mg^+
9. Consider the following successive ionization energies (kJ/mol) of element X.

1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}	6^{th}
737	1450	7732	10540	13360	17995

   a) What is the most likely formula of X's chloride?
   b) Why is the value for the 2^{nd} ionization energy greater than the 1^{st}?
   c) Why is the value for the 3^{rd} ionization energy so much greater than the 2^{nd}?

10. Explain why atomic radius increases down a group and decreases across a period.
11. For each pair state which one is bigger in size and why.

    i) Na and Al; ii) C and Si; iii) Ne and Na; iv) Mg and Mg^{2+}; v) F^- and F; vi) Cl^- and Ar; vii) Be^{2+} and F^-; viii) S^{2-} and Cl^-; ix) K^+ and Ca^{2+}; x) Rb^+ and Kr
12. Choose the larger species in each pair and state why it is larger:

    (a) S or Se, (b) C or N, (c) Fe^{2+} or Fe^{3+}, (d) O^+ or O^-, (e) S or S^{2-}
13. Arrange the following species in order of increasing size: Ar, K^+, Ca^{2+}, S^{2-}, Cl^-. Explain your order.
14. Write a balanced chemical equation for each of the following reactions:

    (a) $Li + H_2O$, (b) $Na + Br_2$, (c) $Cl_2 + H_2O$, (d) $Br_2 + I^-$, (e) $Cl^- + Ag^+$
15. Indicate whether or not each of the following reactions can occur:

    (a) $I_2 + H_2O$, (b) $Cl_2 + Br^-$, (c) $I^- + Ag^+$, (d) $Br_2 + Cl^-$, (e) $Br_2 + Cl_2$, (f) $Br^- + H_2O$
16. Indicate whether or not each of the following reactions could occur. Where a reaction could occur, write a balanced equation for the reaction.

    (a) $Na_2O + H_2O$
    (b) $SO_2 + H_2O$
    (c) $MgO + NaOH$
    (d) $MgO + HCl$
    (e) $MgCl_2 + H_2O$
    (f) $PCl_3 + H_2O$