

Chemistry 362 Spring 2019
Professor Kim Dunbar
Goals for FINAL EXAM Chapters 8, 9, 10, 11, 14, 16, 18

The Periodic Table and the Chemistry of the Elements

1. Know the classifications for the structures of the elements: monoatomic, diatomic, polyatomic and extended structures.
2. Know that elemental C has 3 allotropes, graphite, diamond and buckminsterfullerene a.k.a. bucky balls.
3. Know that Si and Ge exhibit the diamond structure but that Sn exists in an equilibrium between the gray (diamond) and the white (distorted ccp) structures.
4. Realize that most of the elements in the periodic table are metals and that they have distinct properties: High reflectivity, high electrical conductance, high thermal conductance, mechanical properties of strength and ductility.
5. Know the three main structural types of metals – ccp, hcp, and bcc – and the most important differences between these types of packing.
6. Understand the basics of the bonding in metals. The orbitals of atoms overlap the same as in a molecule, but because the energy levels are so similar, they lead to bonding orbitals that are so close together that they form a continuum of bands. Different bands are created by the overlap of different types of atomic orbitals; for example, Na with one electron in a 3s orbital will have a half-filled 3s band and an empty 3p band. The proximity (or even overlap) of the filled or partially filled bands (HOMO's or valence band) to the empty band (LUMO or conduction band) determines the conductivity of the material. *The bigger the gap between the two types of bands, the poorer the conductivity.* Metal versus semi-conductor is determined by these issues.
7. Know the issues that the book raises (and those that were raised in the notes) about the “Survey of the Elements” of the first two short rows of the periodic table.
8. Know the first ionization energy trend for Li → Ne and how to explain it.
9. Know that the first short row of elements, Li → Ne are not representative of the rest of the groups that they head. The second short row is much more representative. Know the five reasons that were put forth in your book as to why this is so.
10. Know the aspects of the chemistry of the rest of the non-transition elements in the brief manner in which chapter 8 treats them.

11. Know that the strict definition of the transition elements is “elements with partially filled d or f sub-shells”. Actually, most people usually reserve this term for the d sub-shell elements only including the so-called “coinage metals” (Cu, Ag and Au). Although the elements themselves are d^{10} , and therefore not partially filled, in their compounds they have lost electrons and thus qualify as having a partially filled d sub-shell). Know the main characteristics of transition metals on page 266.
12. The f block elements are sometimes called the “rare earth elements” and they consist of two periods: the lanthanides and the actinides. Know that the high effective nuclear charge experienced by the f electrons of the lanthanides causes the elements from La to Lu to shrink significantly because of the poor shielding ability of the f orbitals along with increasing effective nuclear charge. The lanthanide contraction causes the second and third rows of the d-block transition metals to be of approximately the same size.

Hard and Soft Acid-Base Theory

13. Know the characteristics that determine hard acid, soft acid, hard base, soft base.
14. Be able to use HSAB to predict the outcome of a reaction. Remember that hard acids prefer to bind hard bases and soft acids prefer soft bases.

Hydrogen

15. Know the various methods of producing hydrogen as discussed in class. For example, electrolysis, the reaction of methane and water and the reaction of carbon monoxide and water.
16. Know the general reactions of hydrogen and its compounds. For example, the reduction of metal oxides to metals, reactions with metals to form hydrides, reactions of hydrides with water and the Haber-Bosch process.
17. Understand the various types of bonding that hydrogen can undergo – ionic bonding as both a cation or anion, covalent bonding with main group elements and 3-center-2-electron bonding (i.e. B_2H_6).
18. Be able to describe hydrogen-bonds and when they occur.
19. Know what a clathrate is.
20. Understand the three properties of water that are crucial to life and be able to explain why each one is important. The three properties are water’s high boiling point, the low density of ice and the ability to form hydrogen bond networks.

The Group I Elements

1. Know the properties of the alkali metals. Know that they are easily ionized to M^+ cations but not to the M^{2+} cations. Know that the metals themselves are relatively soft. Be able to explain these properties.
2. Know and be able to explain why lithium is different from all the other alkali metals.
3. Know how the alkali metals react with water, nitrogen (in the case of Li) and oxygen. Know which metals form oxides, peroxides and superoxides.
4. Understand what occurs when alkali metals are dissolved in liquid ammonia.
5. Know the basic reactivity patterns of the oxides of the alkali metals as discussed in class. Know that the oxides are basic when dissolved in water and why.
6. Understand the differences in the hydration spheres of the alkali metal cations.
7. Understand how crown ethers and cryptates are used to facilitate the formation of solutions of alkali metal cations.
8. Review the reactivity patterns of the alkali metals as shown on pages 301 and 302 of the text.

The Group II Elements

1. Understand the key differences in the properties of the alkaline earth metals as compared to the alkali metals and why they occur.
2. Know that Be exhibits a high degree of covalency, as compared to the other group II metals, in its compounds and be able to explain why this is so.
3. Be able to describe the polymerization of beryllium halides in the condensed phase.
4. Be familiar with the oxides of the alkaline earth metals and their properties. Are they basic or acidic?
5. Understand the differences between the chemistry of Be, Mg and the rest of the alkaline earth metals.

Carbon

1. Be able to describe the bonding in the three allotropes of carbon: graphite, diamond and fullerenes.
2. Know the preparations for carbon dioxide and carbon monoxide.
3. Know that carbon monoxide and cyanide are both toxic in the human body. CO attacks the iron heme in the blood and CN^- attacks the copper heme in the mitochondria.
4. Be familiar with some of the uses of carbon dioxide in industry.
5. Understand that in water: $\text{CO}_{2(\text{aq})} + \text{H}_2\text{O} \leftrightarrow \text{H}_2\text{CO}_{3(\text{aq})}$.
6. Understand that cyanide is a weak base.

Nitrogen

1. Know the Haber-Bosch process for nitrogen fixation and the importance it has played in our world.
2. Be familiar with the formation of amides and ammonium ions from ammonia.
3. Know what nitride is.
4. What is nitric acid? Know the Ostwald process for making it. Be able to describe important applications of nitric acid.

Oxygen

1. Know the two allotropes of oxygen.
2. Know how oxygen is produced and used in nature. Understand why it's important to maintain a certain level of oxygen in the atmosphere.
3. Be familiar with major industrial uses of O_2 .
4. Be familiar with the properties of O_3 as discussed in the lectures.
5. Know the difference between acidic, basic and amphoteric oxides. Be able to give examples of each case.
6. Be able to predict if a transition metal oxide is basic, acidic or amphoteric.
7. Know the properties of peroxides.