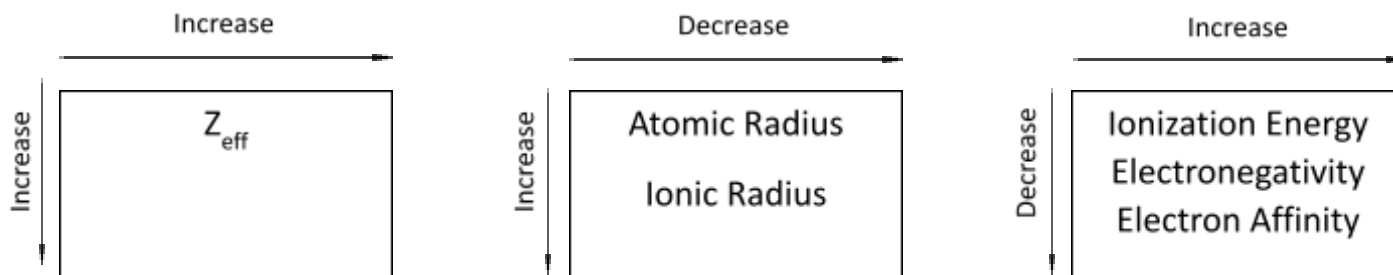


Unit 1 Study Guide

*Reminders:

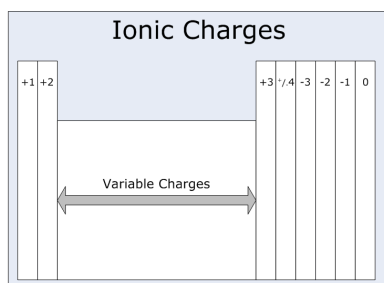
1. Make sure you know your periodic trends.



2. Periodic trends do not change as much across the d and f sublevels.
3. F is the most electronegative element on the periodic table.
4. Do not use a trend to explain a trend (unless you have to). Always focus on nuclear charge and distance of valence electrons from the nucleus.
5. Make sure you know the sublevels on the periodic table.

1s ¹																	1s ²
2s ¹ 2s ²																	2p ¹ 2p ² 2p ³ 2p ⁴ 2p ⁵ 2p ⁶
3s ¹ 3s ²																	3p ¹ 3p ² 3p ³ 3p ⁴ 3p ⁵ 3p ⁶
4s ¹ 4s ²	3d ¹	3d ²	3d ³	3d ⁴	3d ⁵	3d ⁶	3d ⁷	3d ⁸	3d ⁹	3d ¹⁰	4p ¹	4p ²	4p ³	4p ⁴	4p ⁵	4p ⁶	
5s ¹ 5s ²	4d ¹	4d ²	4d ³	4d ⁴	4d ⁵	4d ⁶	4d ⁷	4d ⁸	4d ⁹	4d ¹⁰	5p ¹	5p ²	5p ³	5p ⁴	5p ⁵	5p ⁶	
6s ¹ 6s ²	5d ¹	5d ²	5d ³	5d ⁴	5d ⁵	5d ⁶	5d ⁷	5d ⁸	5d ⁹	5d ¹⁰	6p ¹	6p ²	6p ³	6p ⁴	6p ⁵	6p ⁶	
7s ¹ 7s ²	6d ¹	6d ²	6d ³	6d ⁴	6d ⁵	6d ⁶	6d ⁷	6d ⁸	6d ⁹	6d ¹⁰	7p ¹	7p ²	7p ³	7p ⁴	7p ⁵	7p ⁶	
	5d ¹	4f ¹	4f ²	4f ³	4f ⁴	4f ⁵	4f ⁶	4f ⁷	4f ⁸	4f ⁹	4f ¹⁰	4f ¹¹	4f ¹²	4f ¹³	4f ¹⁴		
	6d ¹	6d ²	5f ¹	5f ²	5f ³	5f ⁴	5f ⁵	5f ⁶	5f ⁷	5f ⁸	5f ⁹	5f ¹⁰	5f ¹¹	5f ¹²	5f ¹³	5f ¹⁴	

6. Most of the time, they will not rearrange standard electron configuration on the AP exam. That is ok, but you must remember to rearrange if you need to write the electron configuration for a cation, so just always rearrange.
7. The energy levels are represented by the number and the sublevels are represented by the letter. (Ex. 2s and 2p make up the 2nd principle energy level, but 2s and 2p are different sublevels.) The s and p sublevels contain the valence electrons.
8. Make sure you know the charges and valence electrons of each element.

[illegible]

9. Isotopes have the same atomic number (p^+) but different mass numbers (p^+ and n^0).

***Sample Problems:**

Questions 1-5 refer to the following diagram of the periodic table.

1. Highest first ionization energy
 2. Highest electronegativity
 3. Largest atomic radius
 4. Most metallic character
5. Correct explanations for the increases and decreases in ionization energies between elements between atomic numbers 2 and 10 (and 11 and 18) include:
- I. There is repulsion of paired electrons in the p^4 configuration.
 - II. The electrons in a filled s orbital are more effective at shielding the electrons in the p orbitals of the same n than each other.
 - III. Filled orbitals and subshells are more stable than unfilled orbitals and subshells.
- a. I only
 - b. II only
 - c. III only
 - d. I and II only
 - e. I, II, and III
6. Which of the following electrons configurations represents an atom in an excited state?

- a. $1s^2 2s^2 2p^5$
- b. $1s^2 2s^2 2p^5 3s^2$
- c. $1s^2 2s^2 2p^6 3s^1$
- d. $1s^2 2s^2 2p^6 3s^2 3p^5$
- e. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

7. If metal Z forms an ionic chloride with the formula ZCl_2 , which of the following is most likely the formula for the stable phosphide of Z?

- a. ZP_2
- b. Z_2P_3
- c. Z_3P_2
- d. $Z_2(PO_4)_3$
- e. $Z_3(PO_4)_2$

Questions 8-11 refer to the following:

8. Highest first ionization energy

9. An atom in the excited state

10. Has exactly 5 valence electrons

11. A chemically unreactive atom

12. Which of the following shows the correct number of protons, neutrons, and electrons in a neutral cadmium-112 atom?

	Protons	Neutrons	Electrons
a.	48	48	48
b.	48	64	48
c.	48	64	64
d.	64	48	64
e.	112	48	112

13. Based on the ionization energies for element X listed in the table below, which of the following elements is X most likely to be?

Ionization Energies for Element X ($\text{kJ} \cdot \text{mol}^{-1}$)				
First	Second	Third	Fourth	Fifth
786	1,577	3,228	4,354	16,100

- a. Li
- b. Be
- c. Al
- d. Si
- e. As

14. Which of the following chemical species is correctly ordered from smallest to largest radius?
- a. $P < S < Cl$
 - b. $Ne < Kr < Ar$
 - c. $F < O < O^{2-}$
 - d. $K < K^+ < Rb$
 - e. $Na^+ < Mg^{2+} < Na$

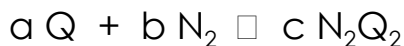
Questions 15-17 refer to the ground state atoms of the following elements:

- a. Ga b. Cl c. C d. S e. N

15. This atom contains exactly one unpaired electrons.
16. This atom contains exactly two unpaired electrons.
17. This atom contains exactly two electrons in the highest occupied energy sublevel.
18. Which of the following compounds has the greatest ionic character?
- a. SiO_2 b. ClO_2 c. CH_4 d. AlF_3 e. SO_2
19. Use the principles of atomic structure and/or chemical bonding to explain each of the following. In each part, your answers must include references to **both** elements.
- a. The atomic radius of Li is larger than that of Be.
 - b. The second ionization energy of K is greater than the second ionization energy of Ca.
20. Cl_2 reacts with the element Sr to form an ionic compound. Based on periodic properties, identify a molecule, X_2 , that is likely to react with Sr in a way similar to how Cl_2 reacts with Sr. Justify your choice.
21. Using the principles of atomic structure, explain why the first ionization energy of Po is less than that of Se.

22. Using principles of atomic structure, explain why the atomic radius of Kr is less than the ionic radius of Se^{2-} .
23. Photoelectron spectroscopy data for the 1s sublevel of Te and the 1s sublevel of O are represented below. In terms of Coulomb's law and atomic structure, explain why the peak for O is positioned so far to the right of the peak for Te.
24. A new element with atomic number 116 was discovered in 2000. In 2012 it was named livermorium, Lv. Although Lv is radioactive and short-lived, its chemical properties should follow periodic trends.
- Write the electron configuration for the valence electrons of Lv in the ground state.
 - According to periodic properties, what would the most likely formula for the product obtained when Lv reacts with $\text{H}_{2(g)}$?
25. a. Write the electron configuration for a Zn atom in the ground state.
b. From which sublevel are electrons removed when a Zn atom in the ground state is oxidized?
26. The first ionization energy of magnesium samples found on Earth is experimentally determined to be 736 kJ/mol. If a similar experiment is conducted to determine the first ionization energy of magnesium in a rock sample from another planet (different percent abundances of isotopes), will it be greater than, less than, or equal to the first ionization energy of magnesium found on Earth? Explain your reasoning.

27. A scientist heats a sample of a pure nonmetal, Q, in a closed container containing pure nitrogen gas, N₂. The reaction proceeds to completion. The unbalanced chemical equation for the reaction appears below.



a. Give the correct value of each stoichiometric coefficient for the reaction.

a =

b =

c =

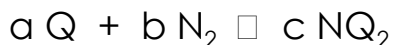
A particulate representation from before and after the reaction is shown below. The contents of the container before the reaction are represented in the box on the left, and the contents of the container after the reaction are shown in the box on the right.

b. A student claims that N₂ is the limiting reactant. Do you agree or disagree? Justify your answer.

In a different reaction, N₂ reacts with a pure metal X to form the compound X₃N.

c. Which of the following complete photoelectron spectra could be that of metal X? Justify your choice.

28. A scientist heats a sample of a pure nonmetal, Q, in a closed container containing pure nitrogen gas, N₂. The reaction proceeds to completion. The unbalanced chemical equation for the reaction appears below.



a. Give the correct value of each stoichiometric coefficient for the reaction.

a =

b =

c =

A particulate representation from before and after the reaction is shown below. The contents of the container before the reaction are represented in the box on the left, and the contents of the container after the reaction are shown in the box on the right.

b. A student claims that N_2 is the excess reactant. Do you agree or disagree? Justify your answer.

In a different reaction, N_2 reacts with a pure metal X to form the compound XN .

c. Which of the following complete photoelectron spectra could be that of metal X? Justify your choice.

29. Consider the two chemical species S and S^{2-} .

a. Write the electron configuration (e.g., $1s^2 2s^2 \dots$) of each species.

b. Explain why the radius of S^{2-} ion is larger than the radius of the S atom.

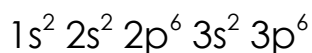
c. Which of the following species would be attracted into a magnetic field? Explain.

30. Using the principles of atomic structure, explain why the first ionization energy of Ge is lower than that of Si.

31. A partial photoelectron spectrum of pure Si is shown below. On the spectrum, draw the missing peak that corresponds to the electrons in the 3p sublevel.
32. The photoelectron spectrum for an unknown element is shown below.
- Based on the photoelectron spectrum, identify the unknown element and write its electron configuration.
 - Consider the element in the periodic table that is directly to the right of the element identified in part (a). Would the 1s peak of this element appear to the left of, the right of, or in the same position as the 1s peak of the element in part (a)? Explain your reasoning.
33. The complete photoelectron spectrum of an element in its ground state is represented below.

- a. Based on the spectrum, write the ground-state electron configuration of the element, and
 - b. identify the element.
34. The complete photoelectron spectrum for an element is shown below. Which of the following observations would provide evidence that the spectrum is consistent with the atomic model of the element?
- a. A neutral atom of the element contains exactly two electrons.
 - b. The element does not react with other elements to form compounds.
 - c. In its compounds, the element tends to form ions with a charge of +1.
 - d. In its compounds, the element tends to form ions with a charge of +3.
35. The complete photoelectron spectra of neutral atoms of two unknown elements, X and Y, are shown below. Which of the following can be inferred from the data?
- a. Element X has a greater electronegativity than element Y does.
 - b. Element X has a greater ionization energy than element Y does.
 - c. Element Y has a greater nuclear charge than element X does.

- d. The isotopes of element Y are approximately equal in abundance, but those of element X are not.
36. Which of the following properties generally decreases across the periodic table from sodium to chlorine?
- a. first ionization energy
 - b. atomic mass
 - c. electronegativity
 - d. maximum value of oxidation number
 - e. atomic radius
37. Which of the following elements has the largest first ionization energy?
- a. Li b. Be c. B d. C e. N
38. The complete photoelectron spectrum of an unknown element is given below.
- a. Draw an X above the peak that corresponds to the orbital with electrons that are, on average, closest to the nucleus. Justify your answer in terms of Coulomb's law.
- b. Based on the spectrum, write the complete electron configuration of the element.
- c. On the graph, draw the peak(s) corresponding to the valence electrons of the element that has one more proton in its nucleus than the unknown element has.
39. Which of the following species has the electron configuration shown below?



a. O

b. Ne

c. K^+

d. Cl^+

40. The complete photoelectron spectrum for the element chlorine is represented below. Peak X in the spectrum corresponds to the binding energy of electrons in a certain orbital of chlorine atoms. The electrons in this orbital of chlorine have a binding energy of 273 MJ/mol, while the electrons in the same orbital of sulfur atoms have a binding energy of 239 mJ/mol.
- Identify the orbital and explain the difference between the binding energies in terms of Coulombic force.
 - Peak Y corresponds to the electrons in certain orbitals of chlorine atoms. On the spectrum, carefully draw the peak that would correspond to the electrons in the same orbitals of sulfur atoms.