

STUDY GUIDE - Ch.2.2 - An element's properties depend on the structure of its atoms.

NAME: _____

- Please **PHYSICALLY PRINT OUT** these pages and **HANDWRITE** the answers directly on the printouts. *Typed work or digitally-produced answers will not be accepted.*
- **Importantly, guided readings are NOT GROUP PROJECTS!!!** You, and you alone, are to answer the questions as you read. You are ***not*** to share them with another students or work together on filling it out. You are ***not*** to copy any answers from any other source including the internet. Please report any dishonest behavior to your instructor to be dealt with accordingly.
- **Get in the habit of writing legibly, neatly, and in a NORMAL, MEDIUM-SIZED FONT.** AP essay readers and I will skip grading anything that cannot be easily and quickly read so start perfect your handwriting.
- Please **SCAN** documents properly and upload them to Archie. Avoid taking photographs of or uploading dark, washed out, side ways, or upside down homework. Please use the scanner in the school's media lab if one is not at your disposal and keep completed guides organized in your binder to use as study and review tools.
- **READ FOR UNDERSTANDING** and not merely to complete an assignment. Though all the answers are in your textbook, you should try to put answers in your own words, maintaining accuracy and the proper use of terminology, rather than blindly copying the textbook whenever possible.

1. What is an **atom**?

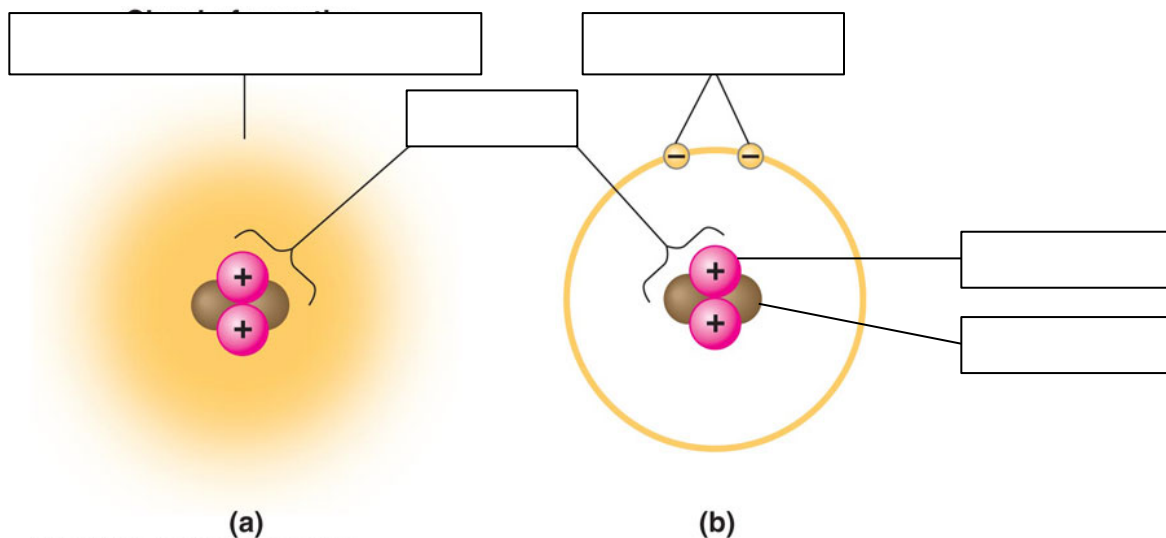
2. a. Three subatomic particles of an atom include the neutron, proton, and electron. How do these differ in terms of **electrical charge**?

1. **Neutron** =

2. **Proton** =

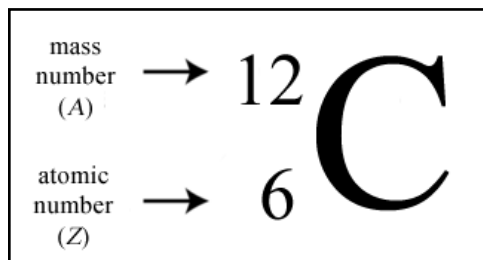
3. **Electron** =

b. Label the model of a helium atom (He) below, indicating the location of its neutrons, protons, and electrons.



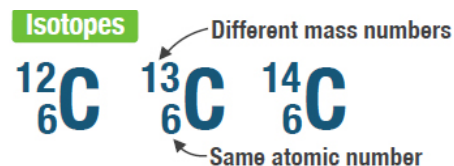
3. All atoms of the same element share the same number of _____ (even if the number of neutrons and electrons may vary).
4. What is an atom's **atomic number**?
5. **If an atom is neutral in overall net charge** (the charges of the atom cancel each other out when you add up all the positive and negative charges, i.e. the total number of protons and electrons), then what do you know about the number of electrons that exist in that atom's electron cloud?

6. What is an individual atom's **mass number**?



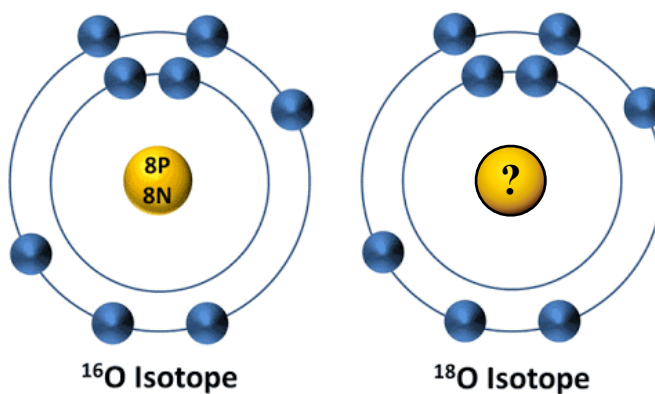
7. If you know an atom's atomic number and mass number, what other information can you determine about this atom?

8. Atoms of an element may come in different forms. What exactly is an **isotope**?



9. a. As you learn from your text, the element carbon is composed of atoms of carbon that, though they all have an atomic number of 6 (6 *protons*), exist in one of three isotopic forms: C-12, C-13, and C-14. Isotopes of oxygen also exist.

Oxygen Isotopes



Based on the information provided in the figure above regarding the contents of the electron cloud and the nucleus of isotope O-16, how is the composition of the electron cloud the same or different in the isotope O-18?

- b. Compared to the isotope O-16, how is the composition of the nucleus of an O-18 atom 1. the same and 2. different?

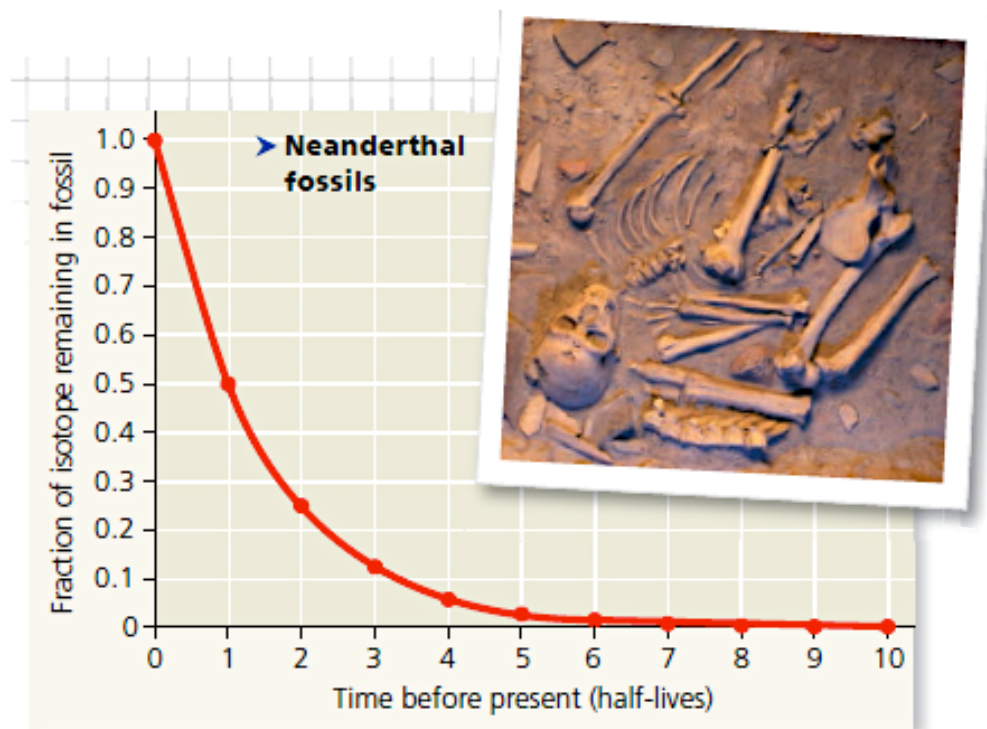
10. **FYI:** While the mass number is a count of the total number of protons and neutrons in one atom's nucleus, an element's atomic mass or atomic weight is the weighted average mass of an atom of that element based on the relative natural abundance of that element's possible isotopes. For example, the atom carbon-12 has a mass number of 12 daltons or amu (due to it having 6 protons and 6 neutrons, each weighing 1 dalton or 1 amu, electrons having a negligible mass 1/2000 that of a proton or a neutron). Carbon-12 is not the only atom that makes up the element carbon, however. While 98.93% of all carbon atoms are carbon-12, 1.07% of carbon atoms are carbon-13 (with a mass of 13 daltons). An even smaller fraction of carbons are carbon-14. Hence, the atomic mass or atomic weight of the element carbon is actually 12.011 daltons. This value is an average value of the element's mass taking into account the masses and relative abundance of the three carbon isotopes in nature.
11. What is a radioactive isotope?
12. Because it is unstable, what happens to the nucleus of carbon-14 over time?
13. Though the type and amount of radiation (*the amount of energy & types of particles*) emitted by radioactive atoms of certain elements can damage biological molecules like DNA, radioactive elements, in low doses, are useful tools in medicine. Explain why they are effective as tracers that can be used to track chemical processes in the body.
14. We can use the fact that radioactive isotopes' nuclei decay over time to determine the actual age of rocks surrounding fossils or of fossils themselves found in layers of sedimentary rock. For various types of radioactive isotopes of different elements, scientists have calculated the fixed rate at which this "parent" isotope decays into its "daughter" isotope. This fixed rate of decay is referred to as the isotope's half life. Define this term.
15. What do scientists do when they engage in radiometric dating using radioactive isotopes of elements?
16. Read the SCIENTIFIC SKILLS EXERCISE: Calibrating a Standard Radioactive Isotope Decay Curve & Interpreting Data.
- a. What is the half life of radioactive carbon-14 or ^{14}C ?
- b. Why does the ratio of ^{12}C to ^{14}C not change over time in living organisms even though some carbon-14 is always decaying into nitrogen?
- c. What happens to the ^{12}C and to the ^{14}C isotope concentrations after the organism dies?

d. Using an understanding of the half life of ^{14}C and the proportion of carbon isotopes in nature, how can scientists use radiometric dating (*which in this case is also sometimes called **carbon dating***) to calculate the age of a carbon-based fossil?

e. In this skills exercise, a Neanderthal fossil was found that only had a fraction of the ^{14}C in it compared to the original amount of ^{14}C found in the atmosphere and thus the original amount of ^{14}C assumed to have been present in the Neanderthal when it was alive. The graph below is a generic graph that can be used to represent any radioactive isotope's decay over time.

1. On the graph, the x-axis represents the time before present day, with present day being at position 0. For each radioactive isotope, one half life represents a certain amount of time of decay. Recall how many years make up one half life of carbon-14 decay (the answer you gave above in question 15.a). Let's add to the x-axis of this graph the amount of time in years that has passed after each half-life of carbon-14 has been reached.

- Under "1," write how many years have passed when 1 half-life of ^{14}C has passed.
- Under "2," write how many years have now passed since time 0 (the present) when 2 half-lives of ^{14}C have passed.
- Under "3," write how many years have now passed since time 0 (the present) when 3 half-lives of ^{14}C have passed.
- Under "4," write how many years have now passed since time 0 (the present) when 4 half-lives of ^{14}C have passed.



2. Reachers found that the fossil had 0.0078 as much ^{14}C in it as would have been originally present in the atmosphere and, thus, Neanderthal when alive. Approximate where 0.0078 falls on your y-axis and, on the graph above, draw a horizontal line from that position on the y-axis that intersects with the graphed curve (in red). At this point of intersection, now draw a vertical line that runs from your graphed curve down and intersects with your x-axis in order to approximate the number of half-lives that have passed since the Neanderthal died and started losing ^{14}C due to decay.
3. Based on your estimation, how many half-lives have passed since the Neanderthal died?
4. Based on your estimation and your knowledge of the length of a ^{14}C half-life, calculate the age of this fossil in years (*rounded off to the nearest thousand*). **Show your work.**

f. Carbon dating can only be used to date fossils that are up to 75,000 years old, but not older. Why?

17. Of the three subatomic particles discussed above, electrons, protons, neutrons, which are directly involved in chemical reactions between atoms?

18. a. Define **Energy**.

b. What is **Potential Energy**?

19. True or false, matter prefers being in the state of lowest possible potential energy.

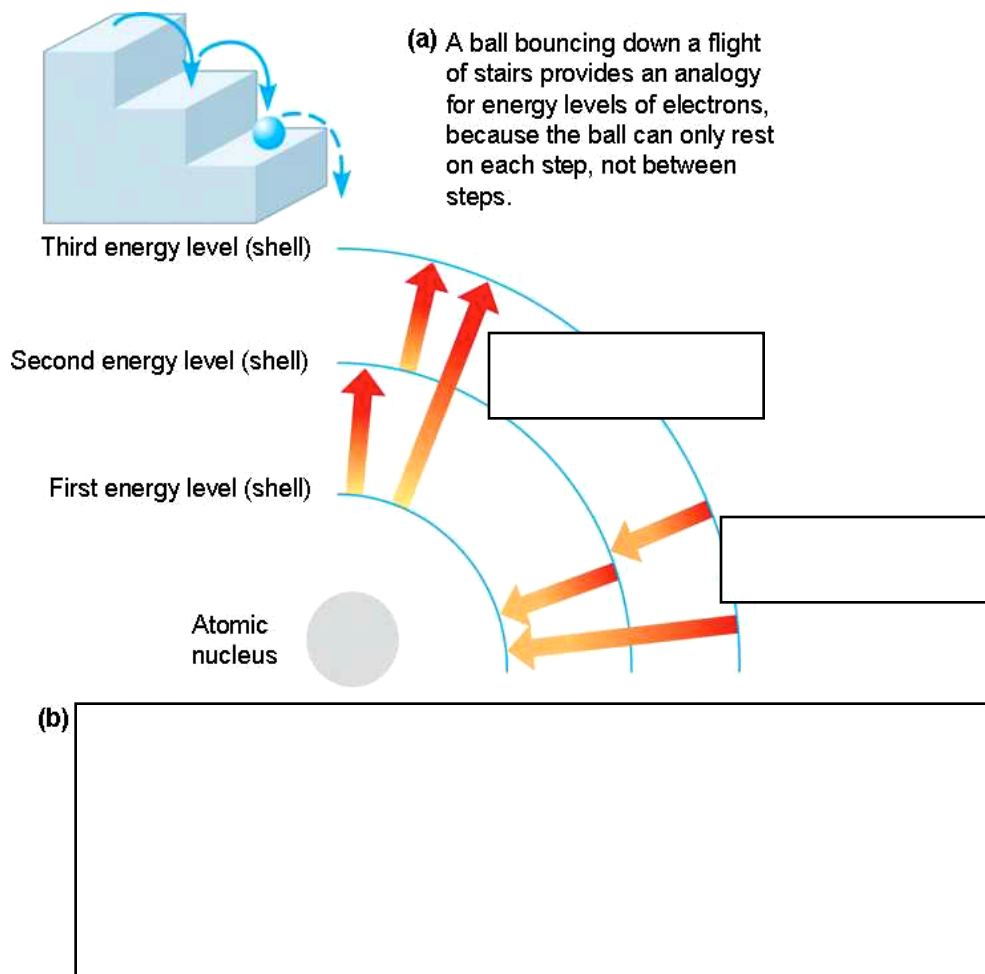
20. Why do electrons have potential energy?

21. a. Electrons are found in different _____ in the atom's electron cloud, each with a characteristic average distance and energy level.

b. Electrons in which shell have the lowest amount of potential energy?

c. How does an electron move from a lower energy shell to a higher shell and from a higher shell to a lower one?









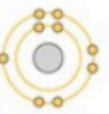
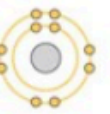

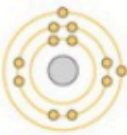

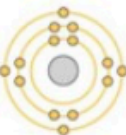
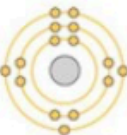


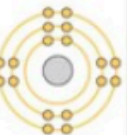
22. Fill in the diagram below, highlighting the **movement of electrons among different energy shells** as it relates to the concept of **potential energy**.



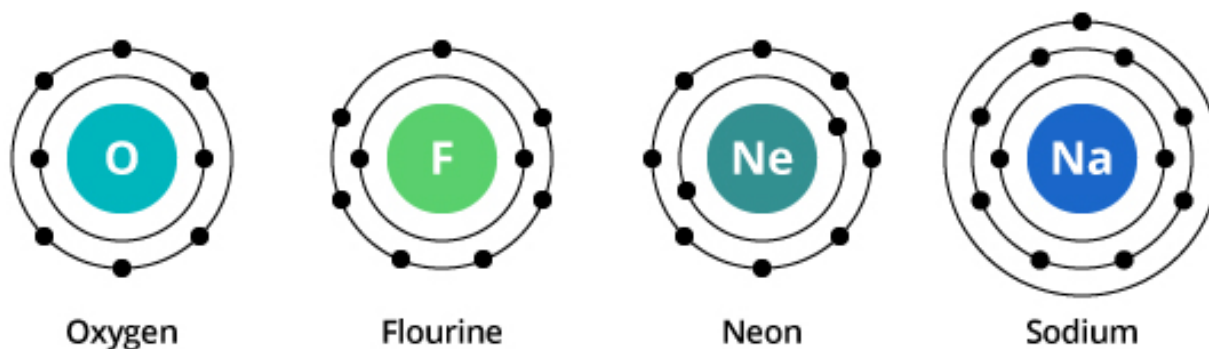
23. Electrons tend to occupy the lowest available state of potential energy in the electron cloud. This means, they occupy the first energy shell first. How many electrons can the first energy shell of an atom hold?
25. As the number of protons increase in a neutral atom, so do the number of electrons in the electron cloud. How many electrons can occupy the second energy shell?
26. a. Which electrons in the electron cloud determine the **chemical behavior** of an atom?
- b. What do we call these electrons?
- c. What do we call the electron shell these electrons occupy?
27. What is different about an atom with a fully filled valence shell?

28. a. As you analyze the portion of the Periodic Table of Elements shown below, what do all atoms of the different elements have in common as you move across a row, or across the period.

b. What do all atoms of the different elements have in common as you move down a column, or down a group.

Hydrogen ${}^1_1\text{H}$ 	<div> <div>2</div> <div>He</div> <div>4.003</div> </div> <div> <div>Atomic number</div> <div>Element symbol</div> <div>Atomic mass</div> </div> <div> <div>Electron distribution diagram</div> </div>						Helium ${}^2_2\text{He}$ 
Lithium ${}^3_3\text{Li}$ 	Beryllium ${}^4_4\text{Be}$ 	Boron ${}^5_5\text{B}$ 	Carbon ${}^6_6\text{C}$ 	Nitrogen ${}^7_7\text{N}$ 	Oxygen ${}^8_8\text{O}$ 	Fluorine ${}^9_9\text{F}$ 	Neon ${}^{10}_{10}\text{Ne}$ 
Sodium ${}^{11}_{11}\text{Na}$ 	Magnesium ${}^{12}_{12}\text{Mg}$ 	Aluminum ${}^{13}_{13}\text{Al}$ 	Silicon ${}^{14}_{14}\text{Si}$ 	Phosphorus ${}^{15}_{15}\text{P}$ 	Sulfur ${}^{16}_{16}\text{S}$ 	Chlorine ${}^{17}_{17}\text{Cl}$ 	Argon ${}^{18}_{18}\text{Ar}$ 

29. Here are some electron distribution diagrams for various atom. Let's focus on the neutral atom of sodium below.



a. How many total electrons does it have?

b. How many protons does it have?

c. How many valence electrons does it have?

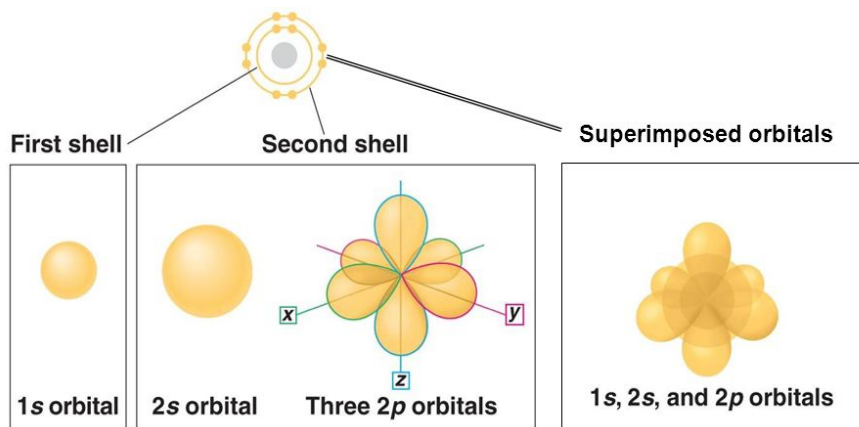
d. Circle the valence electrons in the diagram.

30. Electron shells are usually represented as concentric circles around the nucleus, the circles representing the average distance between electrons in that shell and the nucleus. In reality, however, the electrons occupy various orbitals of distinct shapes and orientations. What is an **orbital**?

31. a. What is the **total number of electrons that can be found within any one orbital**?

b. Which type of **orbital occupies the first electron shell**?

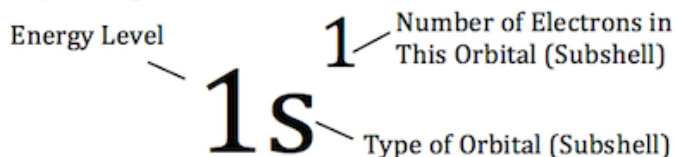
c. Which types of **orbitals occupy the second electron shell**?



d. Remember, **the reactivity of an atom, the ability of that atom to react with another atom, comes about because of the presence of unpaired electrons in one or more orbitals of the atom's outermost valence shell. An atom with a filled outer valence shell is inert or nonreactive, while one that does not have all outermost orbitals filled will react with other atoms.**

- In atoms with only one energy shell (ex: Hydrogen and Helium), the one valence *s* orbital (1*s*) can hold up to two electrons maximum. No other orbitals exist in the first energy shell. Once the 1*s* orbital has two electrons, the atom is considered inert, or a noble gas, as is the case with Helium. Hydrogen, however, which has one electron in the 1*s* orbital and so will react with other atoms.

Electron Configuration of Hydrogen



- In atoms with two energy shells (ex: Carbon and Oxygen), the outermost energy shell can hold up to 8 valence electrons in total. The inner *s* orbital (1*s*) holds two electrons, the outermost *s* orbital (2*s*) holds up to two electrons, and three *p* orbitals (2*p_x*, 2*p_y*, and 2*p_z*) hold up to 6 valence electrons, two per each type of 2*p* orbital. Carbon, for example, has a total of 6 electrons in its electron cloud, 2 in the first energy level's 1*s* orbital and 4 in the second energy level. Of these 4 outermost valence shell electrons, 2 are found in the 2*s* orbital, 1 is located in one 2*p* orbital, and another 1 is found in another 2*p* orbital, for a total of 2 electrons held in 2*p* orbitals. Carbon will thus react with other atoms because its valence shell's 3 *p* orbitals are not filled yet with two electrons each.

