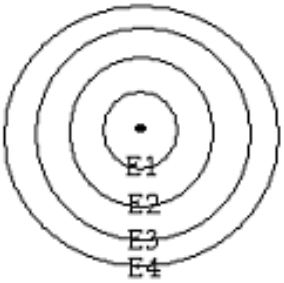
## Electrons, Energy, & the Electromagnetic Spectrum Notes

Simplified, 2-D Bohr Model:

Figure 1




orbits, paths, shells, rings = ENERGY LEVELS

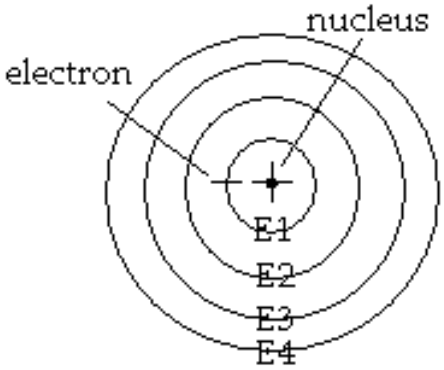
As the name "energy level" implies, there is a specific amount of energy associated with each energy level.

Electrons are lazy - they will occupy the location that requires the least amount of energy. This is called the AUFBAU principle.

lowest energy state = GROUND STATE

Figure 2

For hydrogen in the ground state...

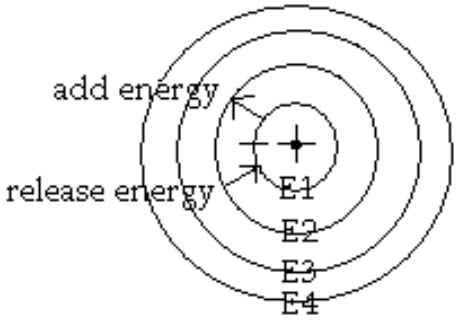



~ Electron is located in energy level 1 (E1) because E1 is closest to the nucleus. Nucleus is positively-charged & attracts negatively-charged electrons.

~ Therefore, low amount of energy needed to be in E1.

Figure 3

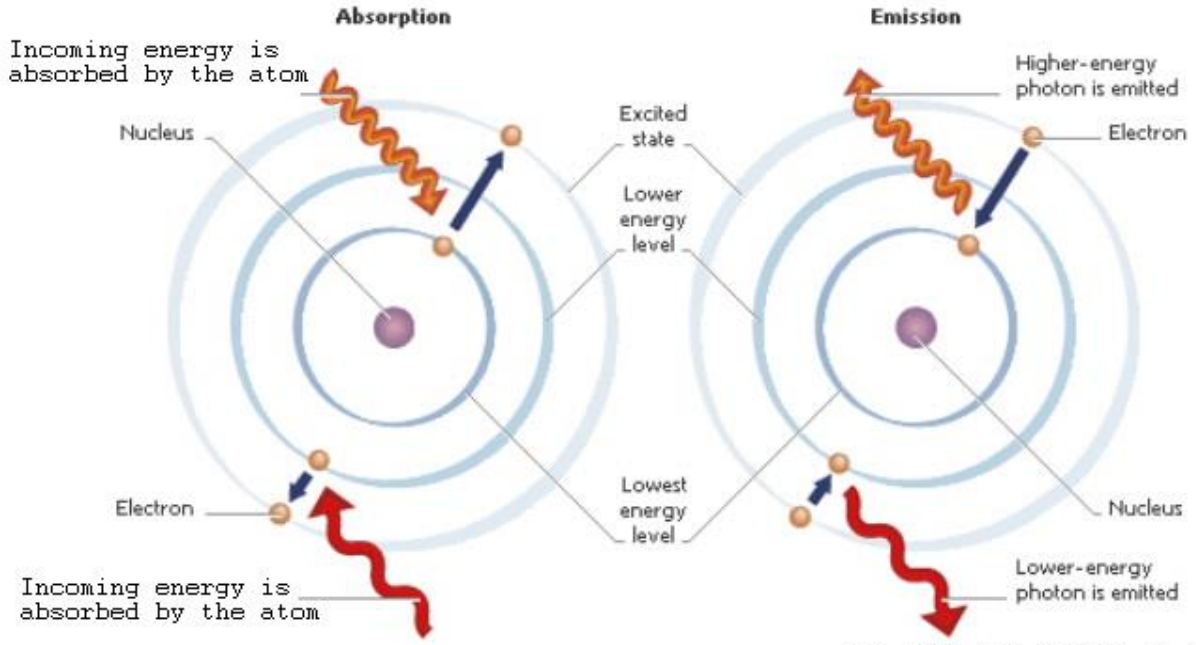
If energy (from an outside source) is added to the atom...




Electrons jump to a higher energy level because energy is absorbed. (Electron is now in the EXCITED STATE.)

As soon as the electron jumps to a higher level, it immediately falls back to a lower energy level. When the electron falls, energy is released.

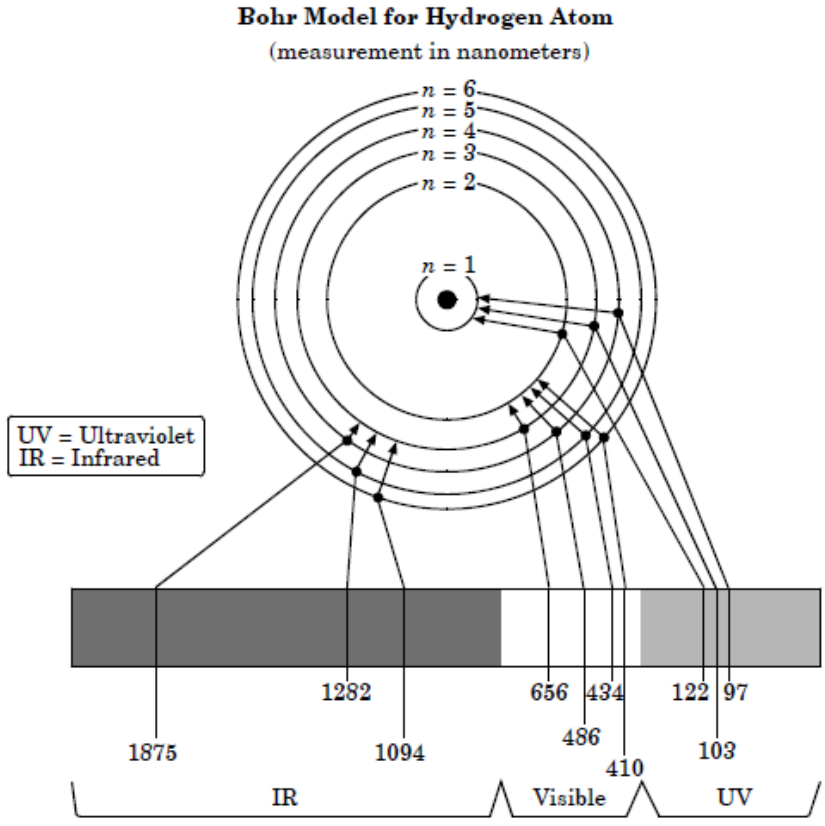
The energy is released as electromagnetic radiation. The type of electromagnetic radiation produced depends on the difference in energy between the energy levels.

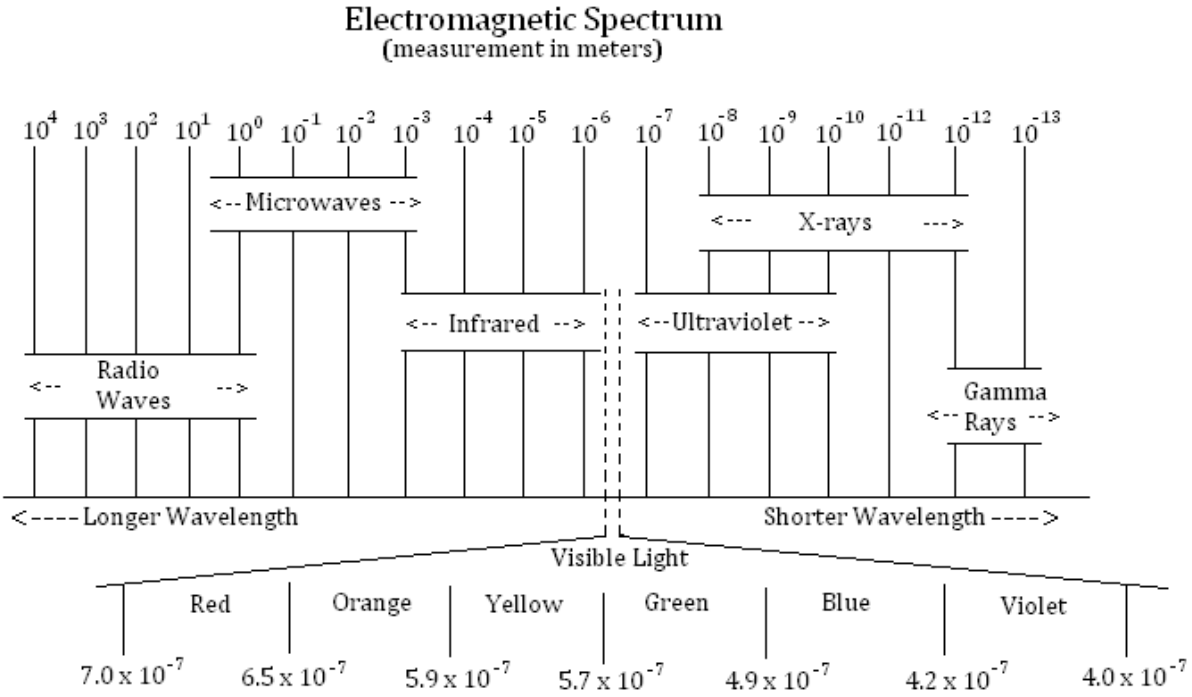



Why does the photon at the top (pictured in orange) have higher energy than the photon at the bottom (pictured in red)?

Bohr Model Diagram Interpretation

What form of EM radiation is released when an electron in a hydrogen atom falls from the 5th energy level to the 3rd energy level?






EM Spectrum Relationships Notes:
* Frequency and wavelength are _____ proportional
* Energy and frequency are _____ proportional

Light as a Particle Notes:
* Object emits energy in small, specific amounts (called _____)
* _____: particle of EM radiation carrying a quantum of energy
* Einstein suggested that light had properties of both waves and particles
  Referred to as the _____ of light

Quantum Theory Notes:
* When atom falls from excited state to ground state, _____

* Energy of photon = difference _____
_____

* Energy states of atoms are fixed

Bohr model of the hydrogen atom Notes:
* said that e- circled the nucleus in fixed paths
* when in path, has fixed amount of energy
* e- cannot exist in space between path
* drawback of Bohr's model =

Example Questions:
1. Which has a longer wavelength - microwaves or x-rays?
2. Which has higher frequency - radio waves or ultraviolet?
3. Which has more energy - gamma rays or visible light?

**PROPERTIES OF LIGHT WORKSHEET**

Part 1 - Select the best answer

1. Which has a longer wavelength, orange or violet light?
2. Which has a higher energy, x-rays or gamma rays?
3. Which has a lower frequency, radio waves or green light?
4. Which has the shortest wavelength, violet or ultraviolet light?
5. Which has lower energy, infrared light or x-rays?

Part 2 - Fill in the blanks

6. _____ formed a theory to explain the structure of an atom by revising physical theories.
7. As the energy level increases, the amount of energy an electron will possess _____.
8. Electrons give off energy in finite amounts called _____ when returning to the ground state.
9. When this energy is released in the form of light it is called a _____.
10. Wavelength and frequency are _____ proportional.
11. Energy and frequency are _____ proportional.
12. Bohr chose the element _____ to prove his theory.

Part 3 - True or False

13. Electrons may regularly occupy spaces between energy levels.
14. The varying wavelengths on the electromagnetic radiation spectrum travel at different speeds.
15. Atoms release energy when electrons jump to higher energy levels.

**ELECTRON ARRANGEMENT NOTES**

Heisenberg Uncertainty Principle:

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GENERAL LOCATION ---------- _____
|
V
_____
|
V
_____
|
V
SPECIFIC LOCATION ---------- _____

ENERGY LEVELS - divisions of the electron cloud
- numbered consecutively from closest to farthest away from nucleus

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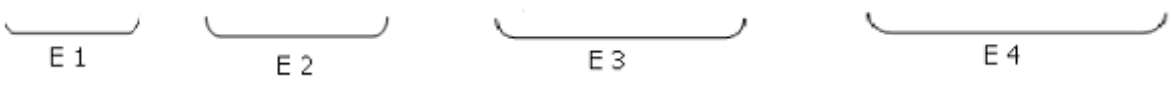
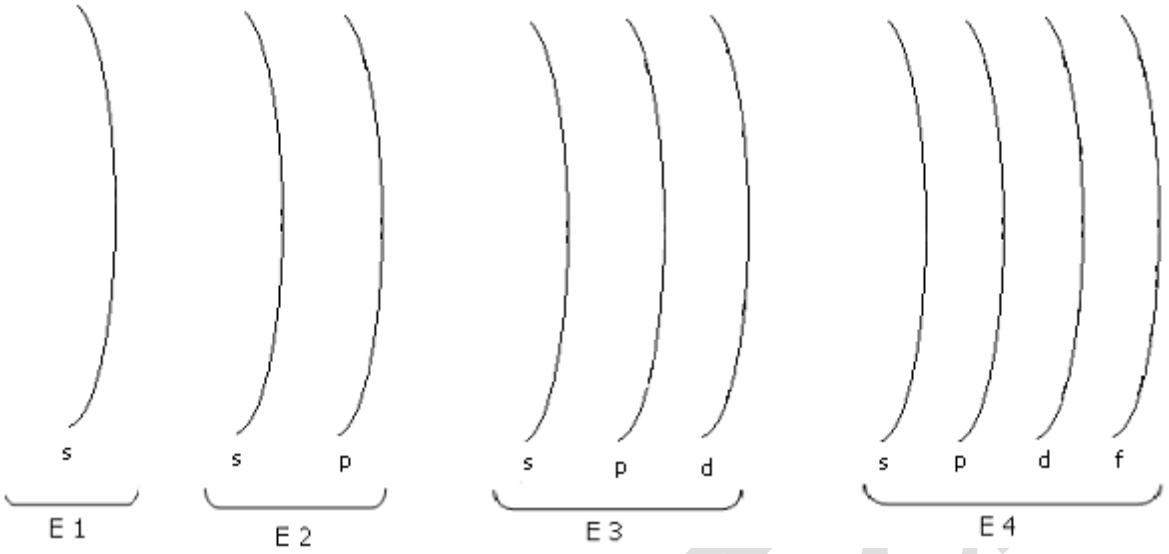



Electrons will occupy the location with the lowest amount of energy.

SUBLEVELS - divisions of energy levels
- designated by letters (s, p, d, f)
- number of sublevels in an energy level = # of the energy level

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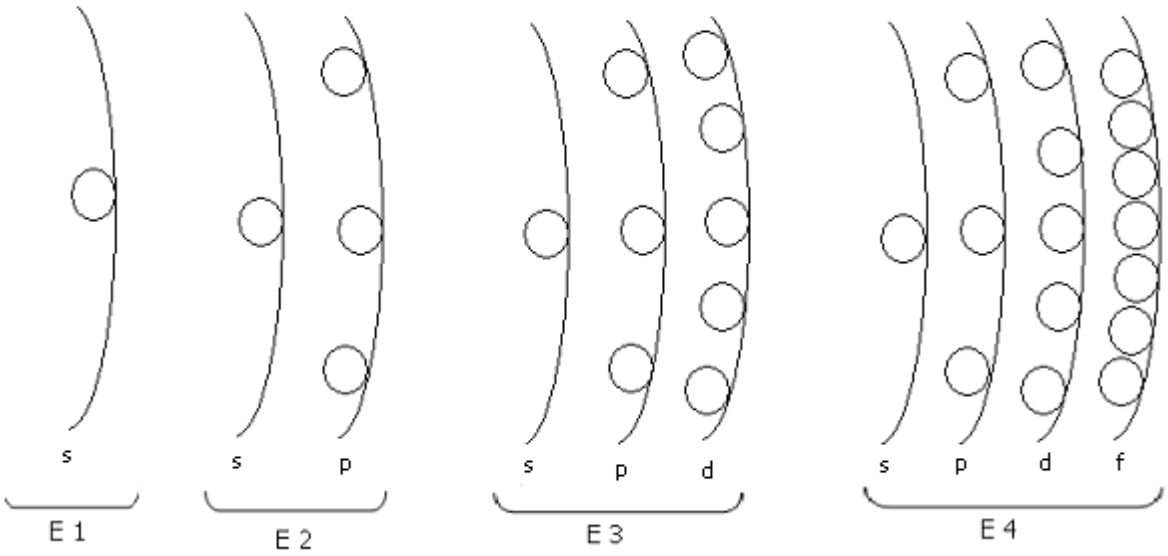
ORBITALS - divisions of sublevels
- number of orbitals in an energy level =
- "s" sublevel has 1 orbital; "p" sublevel has 3 orbitals; "d" sublevel has 5 orbitals; "f" sublevel has 7 orbitals

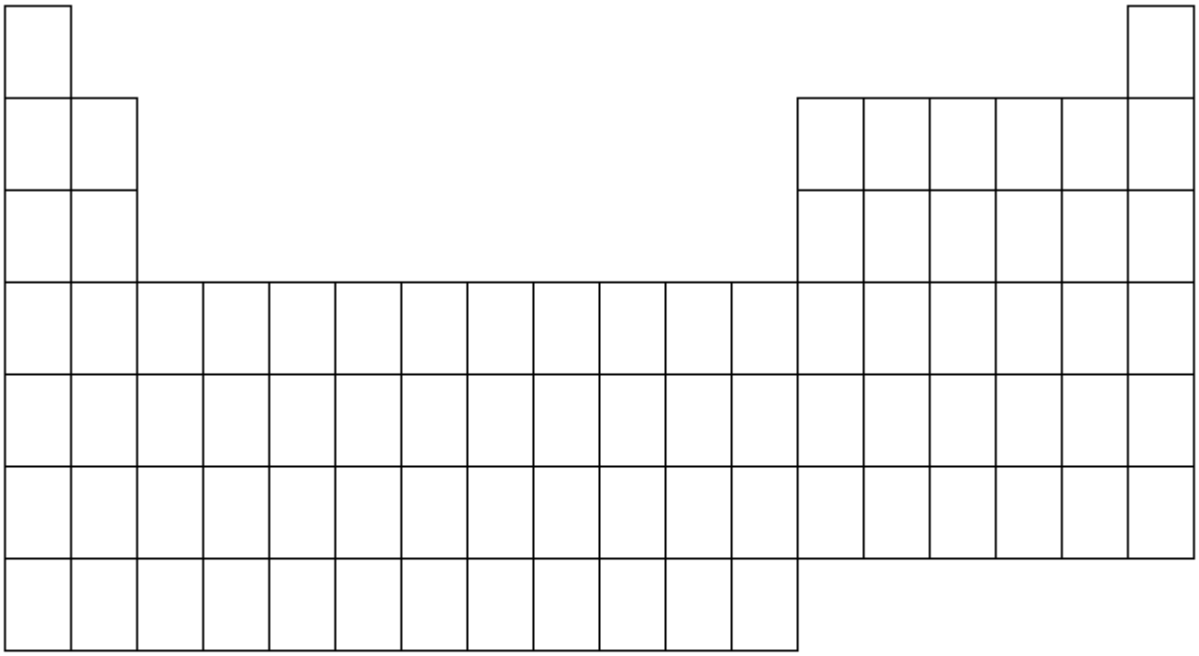


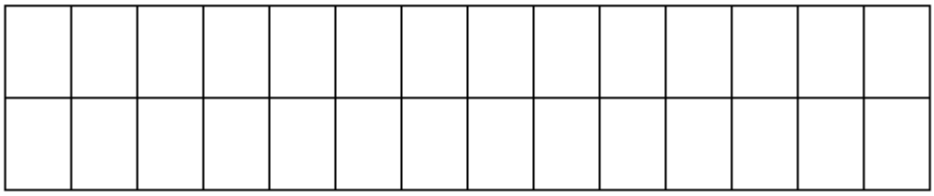

HOW MANY ELECTRONS CAN AN ORBITAL HOLD?

HOW MANY ELECTRONS CAN EACH SUBLEVEL HOLD?
"s" = ___ e- "p" = ___ e- "d" = ___ e- "f" = ___ e-

HOW MANY ELECTRONS CAN AN ENERGY LEVEL HOLD?

What is the order in which the sublevels fill with electrons? Use the PERIODIC TABLE.





ELECTRON ARRANGEMENT WORKSHEET

1. What is an electron cloud?
2. Name the three major divisions within an electron cloud with respect to the energy of an electron.
3. What letter represents the principal quantum number?
4. What does the principal quantum number tell about an electron?
5. What formula is used to determine the maximum number of electrons that can occupy any energy level?
6. What is the maximum number of electrons for each of the following?
   (A) 1st energy level (B) 4th energy level (C) n = 3 (D) n = 5
7. Energy levels are divided into _____.
8. How can we determine the possible number of sublevels in any energy level?
9. Name the four primary sublevels in order of increasing energy.
10. Circle the sublevel that represents the lowest energy in each pair.
    (A) 1s or 2s (B) 2s or 2p (C) 4f or 4d (D) 3d or 4s (E) 7s or 5d
    (F) 6s or 4s (G) 4p or 5p (H) 3s or 3d (I) 2p or 3s
11. Sublevels are divided into _____.
12. Each orbital can hold up to _____ electrons.
13. How many orbitals are in each sublevel?
    (A) s _____ (B) p _____ (C) d _____ (D) f _____

More Electron Arrangement NOTES

Examples:

Se $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^4$

Sn $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^2$

Hg $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^2\ 4f^{14}\ 5d^{10}$

HOEL (Highest Occupied Energy Level): energy level furthest from the nucleus that contains at least one electron

How to determine this using electron configuration?

~ largest non-exponent number

Se $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ \underline{4}s^2\ 3d^{10}\ \underline{4}p^4$ HOEL = 4

Sn $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ \underline{5}s^2\ 4d^{10}\ \underline{5}p^2$ HOEL = 5

Hg $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ \underline{6}s^2\ 4f^{14}\ 5d^{10}$ HOEL = 6

Valence Electrons: electrons in the HOEL

How to determine this using electron configuration?

~ add up exponents of terms in HOEL

Se $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ \underline{4}s^2\ 3d^{10}\ \underline{4}p^4$
HOEL = 4 Valence electrons = 2 + 4 = 6

Sn $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ \underline{5}s^2\ 4d^{10}\ \underline{5}p^2$
HOEL = 5 Valence electrons = 2 + 2 = 4

Hg $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ \underline{6}s^2\ 4f^{14}\ 5d^{10}$
HOEL = 6 Valence electrons = 2

Noble Gas Configuration: shortcut for electron configuration

How is it written?

~ [ symbol for noble gas closest to element with lower atomic # ]

~ [after brackets] write the rest of the configuration as if you had written the configuration for the noble gas

*NOTE: ending of electron configuration and noble gas configuration should be the same*

Se $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^4$
[Ar] $4s^2\ 3d^{10}\ 4p^4$
18 20 30 34

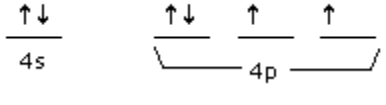
Sn $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^2$
[Kr] $5s^2\ 4d^{10}\ 5p^2$
36 38 48 50

Hg $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^2\ 4f^{14}\ 5d^{10}$
[Xe] $6s^2\ 4f^{14}\ 5d^{10}$
54 56 70 80

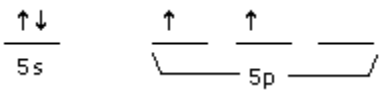
Orbital Notation: drawing of how electrons are arranged in orbitals; will only need to do this for the HOEL

*NOTE: ___ = orbital ↑ or ↓ = electrons

Se $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^4$




Sn $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^2$



Hg $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^2\ 4f^{14}\ 5d^{10}$ 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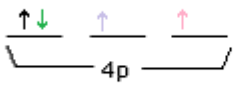
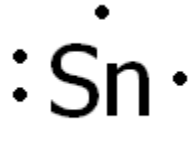
Dot Diagrams: symbol represents nucleus and non-valence ("inner-shell") electrons; dots around symbol represent valence electrons







Unit 4 Review Worksheet

Section I - Electromagnetic Spectrum

1. Label both ends of the spectrum with high/low frequency, high/low energy, and long/short wavelength

radio waves microwaves infrared light ROYGBIV ultraviolet light x-rays gamma rays

2. Which has a higher energy, gamma or x-rays?
3. Which has a shorter wavelength, radio or ultraviolet?
4. Which has a lower frequency, yellow or green light?
5. Energy and frequency are _____ proportional.
6. Wavelength and frequency are _____ proportional.
7. Electrons give off energy in the form of a _____ (packet of energy) when returning to the ground state.
8. Which scientist proposed the idea that electrons travel around the nucleus in fixed paths?
9. When an electron moves from the ground state to the excited state, energy is _____.
10. Bohr chose the element _____ to prove his theory.
11. The dual wave-particle nature of electrons describes how the electrons in atoms can behave as _____ and _____.

Section II - Electrons

12. What is the maximum number of electrons in any orbital?
13. The principal quantum number, n, indicates the _____.
14. The maximum number of electrons in an energy level can be determined by the equation _____
    That means the maximum number of electrons in the 3rd energy level is _____.
15. The number of sublevels in any energy level can be determined by _____.
16. The number of orbitals in an energy level can be determined by the equation _____.
    So, the 3rd energy level has ____ orbitals. (____ is/are "s" orbitals, ____ is/are "p" orbitals, and ____ is/are "d" orbitals)
17. List the four sublevels according to increasing energy.
18. The "s" sublevel has ____ orbitals.
19. A "p" sublevel has ____ orbitals.
20. The "d" sublevel has ____ orbitals and the "f" sublevel has ____ orbitals.

Section IV - Electron configuration, noble gas configuration, valence electrons, orbital notations

21. What is the electron configuration for phosphorus?
22. How many total electrons are in a neutral atom of phosphorus?
23. Write the noble gas configuration for phosphorus.

24. What is the highest occupied energy level for phosphorus?
25. What is the atomic number of phosphorus?
26. Draw the orbital notation for phosphorus.
27. How many electrons are in the highest occupied energy level of phosphorus?
28. How many inner-shell electrons does phosphorus have?
29. In which orbitals are the inner-shell electrons located?
30. Draw the electron dot diagram for phosphorus.