CH 221 Fall 2025:
Problem Set #3
Instructions

Step One:

• **Learn the material** for Problem Set #1 by **reading Chapter 3** of the textbook and/or by watching the videos found on the website (https://mhchem.org/221video)

• **Try the problems** for Problem Set #3 found on the next pages on your own first. Write your answers in the space provided or write your answers on separate paper (your choice.) Include your name on your problem set!

Step Two:

Watch the recitation video for Problem Set #3:

http://mhchem.org/1/3

Self correct *all* of the problems while viewing the video. Mark correct problems with a star (or other similar mark), and correct all incorrect problems (show the correct answer and the steps required to achieve it.)

Step Three:

Turn the Problem Set in at the beginning of recitation to the instructor on **Monday, October 13 (section L1), Tuesday, October 14 (section L2) Wednesday, October 15 (section L3)** *or* **Friday, October 17 (section L4)** The graded problem set will be returned to you the following week during recitation.

Do *not* include this page to avoid a point penalty; your front page should be page II-2-3.

If you have any questions regarding this assignment, please email (mike.russell@mhcc.edu) the instructor! Good luck on this assignment!

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CH 221 Problem Set #3

Name:

Complete the problem set on your own first using these sheets for your work or separate paper (your choice.) **Self correct your work *(all problems!)*** using the recitation video for this problem set, found here: **http://mhchem.org/1/3**

***** *Covering:* **Chapter Three** *and* **Chapter Guide Three**

***** *Important Tables and/or Constants:* periodic table (http://mhchem.org/pertab)**, $c = 2.998 \times 10^{8}$ m/s, $h = 6.626 \times 10^{-34}$ J s**, the **Electromagnetic Spectrum** *and* **Subshell Filling Order diagrams** *at the end of this problem set*. ***Memorize c and h!***

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1. Consider the electromagnetic spectrum:
   a. What color of light has photons of greater energy, yellow or blue?

   b. Which color of light has the greater frequency, blue or green?

   c. Place the following types of radiation in order of increasing energy per photon.
      i. **radar** signals (RADAR = RAdio Detection And Recognition)
      ii. radiation within a **microwave** oven
      iii. **gamma rays** from a nuclear reaction
      iv. **red (visible) light** from a neon sign
      v. **ultraviolet** radiation from a sun lamp

2. The most prominent line in the spectrum of magnesium is 285.2 nm; other lines are found at 383.8 and 518.4 nm.
   a. In which **regions** of the electromagnetic spectrum are these three lines found?

   b. Which is the most energetic ("highest energy") line?

   c. What is the frequency and energy (in both Joules per photon and kJ per mol) of the wavelength of the most energetic line?

3. Consider only transitions involving the $n = 1$ through $n = 4$ energy levels for the hydrogen atom:
    a. How many emission lines are possible? Draw a sketch showing the emission lines.

    b. Photons of the lowest energy are emitted in a transition from the level with $n =$ ___ to a level with $n =$ ___.

    c. The emission line having the shortest wavelength corresponds to a transition from the level with $n =$ ___ to the level with $n =$ ___.

4. A beam of electrons ($m = 9.11 \times 10^{-31}$ kg/electron) has an average speed of 1.3×10^{8} m s^{-1}. What is the de Broglie wavelength of electrons having this average speed? *(Note to physics fans: no relativity in this problem!)*

5. The quantum numbers:
    a. When $n = 4$, $\ell = 2$ and $m_l = -1$, to what orbital type does this refer? (Use the subshell label (*nl* notation), such as 1*s* for your answer.)

    b. Explain briefly why each of the following is not a possible set of quantum numbers for an electron in an atom. In each case, change the incorrect value(s) to make the set valid.
        i. $n = 2, \ell = 2, m_l = 0, m_s = +1/2$
        ii. $n = 2, \ell = 1, m_l = -1, m_s = 0$
        iii. $n = 3, \ell = 1, m_l = +2, m_s = +1/2$

    c. What is the maximum number of orbitals that can be identified by each of the following sets of quantum numbers?
        i. $n = 4, \ell = 3$
        ii. $n = 4$
        iii. $n = 2, \ell = 2$
        iv. $n = 3, \ell = 1, m_l = -1$

d. State which of the following are incorrect designations for orbitals according to the quantum theory: $3p$, $4s$, $2f$, and $1p$. Briefly explain your answers.

e. How many nodal surfaces (planar *and* spherical) are associated with each of the following atomic orbitals?
   i. $4f$
   ii. $2p$
   iii. $6s$

6. Electron configurations:
   a. Write the electron configuration for neutral Mg and Ar using both *spdf* notation and orbital box diagrams.

   b. Using *spdf* and noble gas notations, write electron configurations for neutral atoms of the following elements:
      i. Strontium, Sr. This element is named for a town in Scotland.

      ii. Tin, Sn. The metal was used in the ancient world. Alloys of tin (solder, bronze, pewter) are important.

   c. Using orbital box diagrams, depict an electron configuration for each of the following ions:
      i. Na^{+}
      ii. Al^{3+}
      iii. F^{-}

7. Explain each answer briefly:
    a. Arrange the following elements in order of increasing size: Ca, Rb, P, Ge, Sr

    b. Which has the largest first ionization energy: O, S, or Se?

    c. Which has the most negative electron affinity: Se, Cl or Br?

    d. Which has the largest radius: O^{2-}, F^{1-} or F?

    e. Which is most paramagnetic: Fe^{3+} or Cr^{3+}? Explain.

8. Give the formula and charge for the following ions:
    a. selenide ion (from selenium)
    b. potassium ion
    c. iron ion *(trick!)*
    d. permanganate ion
    e. nitrite ion
    f. phosphate ion
    g. dihydrogen phosphate ion
    h. ammonium ion
    i. sulfite ion

9. Give the name or formula for the following:

Formula	**Name**	**Formula**	**Name**
KBr			aluminum iodide
$CuCl_2$			cobalt(II) oxide
$Cu(NO_3)_2$			chromium(III) chlorate
$Ti(SO_4)_2$			uranium(IV) sulfate
NO_2			phosphorus triiodide
N_2O			dihydrogen monoxide

10. Give the name or formula for the following:

Formula	**Name**	**Formula**	**Name**
HCl			hydrobromic acid
HNO_3			perchloric acid
NaOH			potassium hydroxide
$CoI_2 \cdot 2\ H_2O$			ammonia

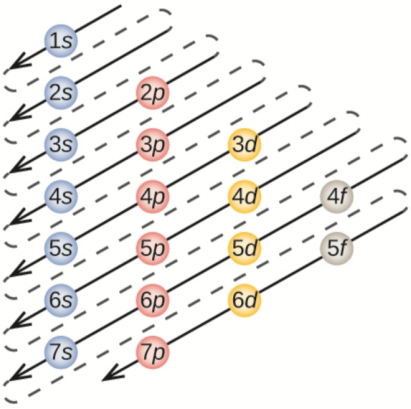

Figure 6.27 The arrow leads through each subshell in the appropriate filling order for electron configurations. This chart is straightforward to construct. Simply make a column for all the *s* orbitals with each *n* shell on a separate row. Repeat for *p*, *d*, and *f*. Be sure to only include orbitals allowed by the quantum numbers (no 1*p* or 2*d*, and so forth). Finally, draw diagonal lines from top to bottom as shown.

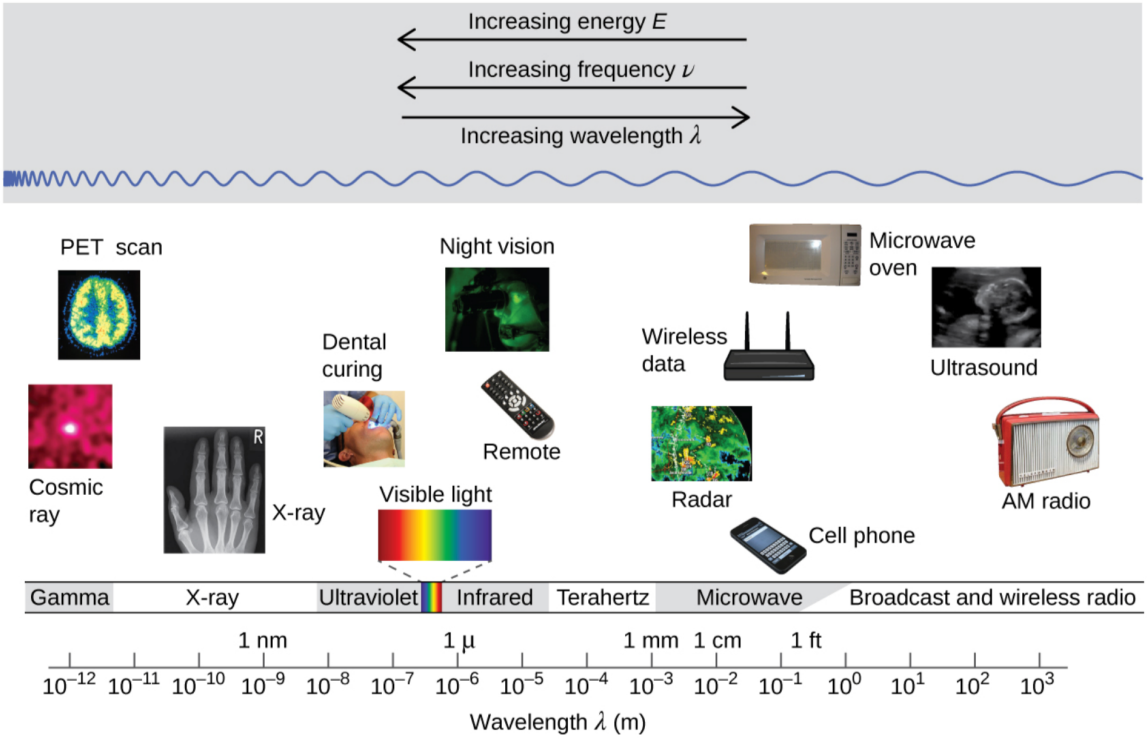

Figure 6.3 Portions of the electromagnetic spectrum are shown in order of decreasing frequency and increasing wavelength. Examples of some applications for various wavelengths include positron emission tomography (PET) scans, X-ray imaging, remote controls, wireless Internet, cellular telephones, and radios. (credit "Cosmic ray": modification of work by NASA; credit "PET scan": modification of work by the National Institute of Health; credit "X-ray": modification of work by Dr. Jochen Lengerke; credit "Dental curing": modification of work by the Department of the Navy; credit "Night vision": modification of work by the Department of the Army; credit "Remote": modification of work by Emilian Robert Vicol; credit "Cell phone": modification of work by Brett Jordan; credit "Microwave oven": modification of work by Billy Mabray; credit "Ultrasound": modification of work by Jane Whitney; credit "AM radio": modification of work by Dave Clausen)

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