Chapter 9 Study Questions

1. How are wavelength and frequency related? How are energy and frequency related?

2. What was the revolutionary new idea in Bohr's model of the hydrogen atom? What was the most significant difference between the quantum mechanical atom and the Bohr hydrogen atom? Briefly explain the relationship between electronic transitions and atomic spectra.

3. Explain, in terms of their electron configurations, why the most reactive metals are in Group 1A, the most reactive nonmetals are in Group 7A, and the noble gases are chemically inert.

4. What is the electron capacity of
   a) any Principal shell? b) each type of subshell? c) each orbital?

5. Which of the following subshells do not exist? List the ones that do exist in order of increasing energy.
   a) 1*s* b) 2*s* c) 4*s* d) 1*p* e) 2*p* f) 3*p*

6. Which subshell is in the process of being filled in the following regions of the periodic table?
   a) Groups 1A and 2A b) Transition metals
   c) Group 5A d) Inner transitional metals

7. What is the valence shell electron configuration of the following groups?
   a) alkali metals b) halogens c) noble gases

8. Classify each of the following electron configurations as ground state, excited state or impossible:
   a) $1s^2 2s^2 2p^1$ b) $1s^2 1p^6 2s^2$ c) $1s^2 2s^2 2p^4 3s^1$ d) $1s^2 2s^2 2p^6 3p^1$

9. Give the complete electron configuration of
   a) sulfur b) the element with atomic number 19

10. Give the noble gas core notation for phosphorus.

11. Give the valence shell electron configuration of the following
    a) Strontium b) Bismuth

12. Give the symbol of the element which (in the ground state)
    a) has the valence shell electron configuration $6s^2$
    b) is in Group 8A but has no *p* electrons
    c) has three unpaired 4*p* electrons
    d) has four valence electrons in the second shell.
    e) is in Period 3 and has the same valence shell configuration as F.

13. Sketch the shape of *s* and *p* orbitals. How do orbitals change as *n* increases?

14. Draw a complete box diagram for
    a) oxygen b) titanium ($Z = 22$)

15. Which is a better predictor of chemical properties: Period number or Group number?

16. a) Which element has a greater ionization energy? Cl or Ar? Na or K?
    b) Which element has a larger atomic size? Mg or Ca? S or Cl?

Summary of Chapter 9: Modern Atomic Theory

wavelength (λ), frequency (ν)
atomic spectra
Bohr model of the hydrogen atom
ground state, excited states
quantum mechanics
orbitals
principle shells (n)
subshells (s, p, d, f): electron capacity and relative energies
complete electron configuration of atoms
noble gas electron configurations
valence shell electron configurations
valence electrons
orbital diagrams
ionization energy
atomic size
metallic character
electron configuration & the Periodic Table
alkali metals, alkaline earth metals and halogens:
    valence shell electron configurations and ion charges

Answers to Chapter 9 Study Questions

1. Wavelength and frequency are inversely related. Energy and frequency are related directly.

2. The new idea in Bohr's model was that electrons can only exist in specific energy states. Bohr's model included an electron orbiting the nucleus as a planet does the sun; according to the quantum mechanical model, we can only define the probability of finding an electron at a given location. When electrons drop from higher energy levels to lower ones, they give off energy in the form of light. The color of light emitted depends on the energy difference between the levels. The greater the energy difference, the shorter the wavelength of light, the more violet the color.

3. The electron configurations of all Group 1A metals end with a single *s* electron. When these metals lose this *s* electron, they acquire noble gas electron configurations which end in completed subshells. They have a strong tendency, therefore, to lose their final single *s* electrons. This makes them extremely reactive and the metals with the greatest tendency to lose electrons. Group 7A elements need only one *p* electron to complete their outermost subshell. They have a strong tendency to gain an electron and thus are the most reactive nonmetals. The subshells of noble gases are all full so these elements have no need to gain or lose electrons and therefore don't react with anything.

4. a) $2n^2$, where n = Principal subshell
   b) s = 2 e-, p = 6 e-, (d = 10 e-, f = 14 e-)
   c) 2 e-

5. Does not exist: d) 1*p*; Increasing energy: $1s < 2s < 2p < 3p < 4s$

6. a) *s* b) *d* c) *p* d) *f*

7. a) ns^1 b) ns^2np^5 c) ns^2np^6

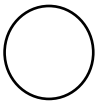
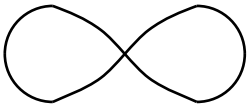
8. a) ground state b) impossible c) excited d) excited

9. a) $1s^22s^22p^63s^23p^4$ b) $1s^22s^22p^63s^23p^64s^1$

10. a) $[_{10}\text{Ne}]\ 3s^2\ 3p^3$

11. a) $5s^2$ (Period 5, Group 2A) b) $6s^2\ 6p^3$ (Period 6, Group 5A)

12. a) Ba (Period 6, Group 2)
    b) He ($1s^2$)
    c) As ($4s^24p^3$ = Period 4, Group 5A)
    d) C ($2s^22p^2$ = Period 2, Group 4A)
    e) Cl (Period 3, Group 7A)

13. *s*:  *p*: 

As *n* increases, the size of an orbital increases since the probability of finding an electron farther from the nucleus increases.

14. a) O: (↑↓) (↑↓) (↑↓)(↑)(↑)
1*s* 2*s* 2*p*

b) Ti: (↑↓) (↑↓) (↑↓)(↑↓)(↑↓) (↑↓) (↑↓)(↑↓)(↑↓) (↑↓) (↑)(↑)( )( )( )
1*s* 2*s* 2*p* 3*s* 3*p* 4*s* 3*d*

15. Chemical properties are shared within a Group but not within a Period. Group number is a good predictor of chemical properties; Period number is not.

16. a) Ar; Na b) Ca; S