Sacramento City College
CHEM 309: General, Organic and Biochemistry
Prof. Dianne Bennett

Agenda (Fall) • Agenda (Spring) • Homework Problems

1. Chapter 2: The Classical Wave Equation
2. 2.1: The One-Dimensional Wave Equation
3. 2.2: The Method of Separation of Variables
4. 2.3: Oscillatory Solutions to Differential Equations
5. 2.4: The General Solution is a Superposition of Normal Modes
6. 2.5: A Vibrating Membrane
7. 2.E: The Classical Wave Equation (Exercises)

• Homework Solutions

1. Chapter 11: Computational Quantum Chemistry
2. 11.1: Gaussian Basis Sets
3. 11.2: Extended Basis Sets
4. 11.3: Orbital Polarization Terms in Basis Sets
5. 11.4: The Ground-State Energy of H2H2
6. 11.5: Quantum Calculations
7. 11.E: Computational Quantum Chemistry (Exercises)

• Chapters

1. Chapter 12: Group Theory: The Exploitation of Symmetry
2. 12.1: The Exploitation of Symmetry
3. 12.2: Symmetry Elements
4. 12.3: Symmetry Operations Define Groups
5. 12.4: Symmetry Operations as Matrices
6. 12.5: The C3VC3V Point Group
7. 12.6: Character Tables
8. 12.7: Characters of Irreducible Representations
9. 12.8: Using Symmetry to Solve Secular Determinants
10. 12.9: Generating Operators
11. 12.E: Group Theory: The Exploitation of Symmetry (Exercises)

• Video Tutorials

1. Chapter 13: Molecular Spectroscopy
2. 13.1: The Electromagnetic Spectrum
3. **13.2: Rotations Accompany Vibrational Transitions**
4. **13.3: Unequal Spacings in Vibration-Rotation Spectra**
5. **13.4: Unequal Spacings in Pure Rotational Spectra**
6. **13.5: Vibrational Overtones**
7. **13.6: Electronic Spectra Contain Electronic, Vibrational, and Rotational Information**
8. **13.7: The Franck-Condon Principle**
9. **13.8: Rotational Spectra of Polyatomic Molecules**
10. **13.9: Normal Modes in Polyatomic Molecules**
11. **13.10: Irreducible Representation of Point Groups**
12. **13.11: Time-Dependent Perturbation Theory**
15. **13.14: Group Theory Determines Infrared Activity**

- **Basic Knowledge Practice Quizzes**

There are select answers to these problems [here](#).

ALL questions listed must be answered to earn credit for completing the text homework. Yes, even the Additional Exercises.

**Elements and Atomic Structure**

1. Of the three subatomic particles, which is the least massive? Which of the subatomic particles are located inside the nucleus of the atom?

2. Neon has 10 electrons, and Argon has 18 electrons. Of the two Noble gases, which would you expect to have the greater atomic radius? Justify your answer.

3. Using the periodic table, identify the atomic symbols and names of the elements that correspond to the following atomic numbers:
   
   a. 8  
   b. 27  
   c. 33  
   d. 59  
   e. 90

4. How many electrons do each of the following elements contain? Hint: These are not ions, but neutral elements.
a. Fluorine
b. Magnesium
c. Iodine
d. Copper
e. Silicon

(5) Which elements contain the following numbers of protons and electrons?

a. 15 protons and 15 electrons
b. 77 protons and 77 electrons
c. 42 protons and 42 electrons
d. 4 protons and 4 electrons
e. 99 protons and 99 electrons

(6) Between elements in the same column, would you expect elements that are higher up in the column to have a larger atomic radius, or ones that are lower in the column? Justify your answer.

(7) Of the three subatomic particles that make up an element, which one can always be used to identify the element? Why can the others not be used in this way? Explain.

(8) Define the mass number of an element. Is this different from the atomic number? Explain.

(9) What is an isotope? How does one isotope differ from another within the same element?

(10) In a sample of different isotopes of Carbon-11, Carbon-12, Carbon-13 and Carbon-14, fill in the blanks for the atomic number, how many protons, neutrons, electrons and the mass number of each isotope.

(11) What do all isotopes of nitrogen have in common? Is this true for isotopes of all elements?

(12) How would you determine which isotope in a group is the smallest? The largest?

(13) Two of the most well-known isotopes of carbon are carbon-12 and carbon-14. Answer the following:

a. What is the atomic mass of each isotope?
b. What is the atomic number of each isotope?
c. What is the difference between the two isotopes?
d. Based on the atomic mass listed on your periodic table, which of the two is more abundant in nature, carbon-12 or carbon-14? The mass of carbon on the periodic table is 12.01.

(14) Starting with polonium, atomic number 84, there are no stable, non-radioactive isotopes of any subsequent elements on the periodic table. Using the atomic symbol and the mass and atomic numbers, express the isotope of polonium-84.
Periodic Table of Elements

(15) One of the main groups on the periodic table is the Metals. How many different subgroups of metals are there on the periodic table? Name each of them. Where in the periodic table can each subgroup be located? Be specific.

(16) Apart from Metals, there are Metalloids and Non-Metals as groups on the periodic table. Name at least two subgroups within the Non-Metals. Where on the periodic table are these subgroups located? Be specific.

(17) How do the transition metals differ from the alkali and alkaline earth metals?

(18) Determine if the following descriptions are examples of a physical or chemical property.

a. Iron nails rust when left out in the rain
b. Glass is transparent and rigid
c. Table salt creates an electrical current when dissolved in water
d. Diamond is virtually unbreakable
e. Metallic sodium explodes when exposed to water

(19) Of the following elements, which of the three categories, metal, non-metal and metalloid, do they each belong to?

a. Manganese
b. Bromine
c. Silicon
d. Uranium
e. Phosphorus

(20) Using the given clues, determine the identity of the following elements:

a. A transition metal in period 4 with 3 valence electrons
b. A noble gas with atomic number less than 10
c. A metalloid from period 2
d. Group 7A element that does NOT exist as a diatomic molecule
e. Group 5A element directly adjacent to a metalloid

(21) For periods 1-6, how many electrons are in each energy level? How many valence electrons do the following elements from levels 2 and 3 have?

a. Fluorine
b. Aluminum
c. Nitrogen
d. Magnesium
e. Silicon

(22) Which family of elements has the least number of valence electrons? Which has the most?
Additional Exercises

(23) If the atomic radius of sodium atoms is $1.86 \times 10^{-10}$ m, how many sodium atoms are needed to make a line that is 1.00 cm in length?

(24) If the atomic radius of osmium atoms is $1.34 \times 10^{-10}$ m, how many osmium atoms are needed to make a line that is 5.85 m in length?

(25) The compound that sodium makes with chlorine has sodium and chlorine atoms in a 1:1 ratio. Name two other elements that should make a compound having a 1:1 ratio of atoms with sodium.

(26) The compound that magnesium makes with oxygen has magnesium to oxygen atoms in a 1:1 ratio. Name two other elements that should make a compound having a 1:1 ratio of atoms with magnesium.