Chapter 4

Summary of Terms

Atomic Mass The total mass of an atom. The atomic mass of each element presented in the periodic table is the *average* atomic mass of the various isotopes of that element occurring in nature.

Atomic Nucleus The dense, positively charged center of every atom.

Atomic Number The number of protons in the atomic nucleus of each atom of a given element.

Atomic Spectrum The pattern of frequencies of electromagnetic radiation emitted by the atoms of an element, considered to be an element's "fingerprint."

Conceptual Model A representation of a system that helps us predict how the system behaves.

Effective Nuclear Charge The nuclear charge experienced by outer-shell electrons, diminished by the shielding effect of inner-shell electrons and also by the distance from the nucleus.

Electromagnetic Spectrum The complete range of waves, from radio waves to gamma rays.

Electron An extremely small, negatively charged subatomic particle found outside the atomic nucleus.

Electron Configuration The arrangement of an atom's electrons within orbitals.

Energy-level diagram A schematic drawing used to arrange atomic orbitals in order of increasing energy levels.

Inner-Shell Shielding The tendency of inner-shell electrons to partially shield outer-shell electrons from the attractive pull exerted by the positively charged nucleus.

Ionization Energy The amount of energy needed to pull an electron away from an atom.

Isotope Any member of a set of atoms of the same element whose nuclei contain the same number of protons but different numbers of neutrons.

Mass Number The number of nucleons (protons plus neutrons) in the atomic nucleus. Used primarily to identify isotopes.

Neutron An electrically neutral subatomic particle found in atomic nuclei.

Nucleon Any subatomic particle found in an atomic nucleus. Another name for either proton or neutron.

Physical Model A representation of an object on some convenient scale.

Proton A positively charged subatomic particle in atomic nuclei.

Quantum A small, discrete packet of energy.

Quantum Number An integer that specifies the quantized energy level within an atom.

Shell A graphic representation of a collection of orbitals of comparable energy in a multielectron atom. A shell can also be viewed as a region of space about the atomic nucleus within which electrons may reside.

Spectroscope A device that uses a prism or diffraction grating to separate light into its color components and measure their frequencies.

Review Questions

4.1 Physical and Conceptual Models

1. If a baseball were the size of the Earth, about how large would its atoms be?

2. What is the difference between a physical model and a conceptual model?

4.2 Discovering of the Electron

3.Why is a cathode ray deflected by a nearby electric charge or magnet?

4. What did Thomson discover about the electron?

5. What did Millikan discover about the electron?

4.3 Discovering the Atomic Nucleus

6. What did Rutherford discover about the atom?

7. To Rutherford's surprise, what was the fate of a tiny fraction of alpha particles in the gold-foil experiment?

8. What kind of force prevents atoms from squishing into one another?

4.4 Protons and Neutrons

9. What role does atomic number play in the periodic table?

10. Distinguish between atomic number and mass number.

11. Distinguish between mass number and atomic mass.

4.5 Light Is a Form of Energy

12. Does visible light constitute a large or small portion of the electromagnetic spectrum?

13. What does a spectroscope do to the light coming from an atom?

4.6 Atomic Spectra and the Quantum

14. What causes an atom to emit light?

15. Why do we say atomic spectra are like fingerprints of the elements?

16. What was Planck's quantum hypothesis?

17. Did Bohr think of his planetary model as an accurate representation of what an atom looks like?

4.7 Electrons Exhibit Wave Properties

18. Who first proposed that electrons exhibit the properties of a wave?

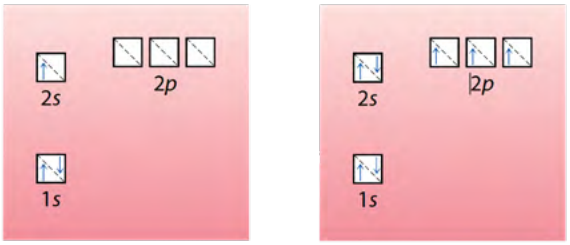
19. About how fast does an electron travel around the atomic nucleus?

20. How does the speed of an electron change its fundamental nature?

4.8 Orbitals and Energy-Level Diagrams

21.How many electrons can reside in a single atomic orbital?

22. What two elements are represented by these two energy-level diagrams?



23. What element has the electron configuration: $1s^2 2s^2 2p^3$?

24. What atomic orbitals comprise the third shell?

4.9 The Shell Model and Periodic Table

25. Which electrons are most responsible for the properties of an atom?

26. What is the relationship between the number of electrons each shell can hold and the number of elements in each period of the periodic table?

27. What is effective nuclear charge?

28. How would you know from the periodic table that oxygen, O (number 8), molecules are smaller than nitrogen, N (number 7), molecules?

29. What happens to the strength of the electric force with increasing distance?

4.10 Quantum Phenomena

30. What is uncertain in the uncertainty principle?

31. What is a fundamental limit of the transistor?

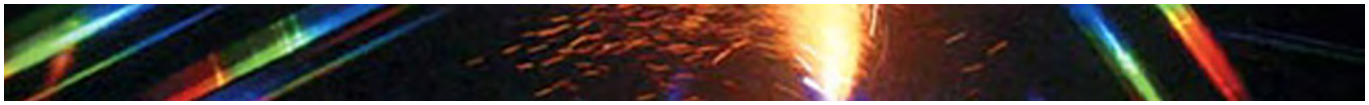
Quantitative Questions

32. A class of 20 students takes an exam and every student scores 80 percent. What is the class average? Would the class average be slightly less, the same for slightly more if one of the students instead scored 100 percent? How is this similar to how we derived the atomic masses of elements?

33. The isotope lithium-7 has a mass of 7.0160 atomic mass units, and the isotope lithium-6 has a mass of 6.0151 atomic mass units. Given the information that 92.58 percent of all lithium atoms found in nature are lithium-7 and 7.42 percent are lithium-6, show that the atomic mass of lithium, Li (atomic number 3) is 6.941 amu

34. The element bromine, Br (atomic number 35), has two major isotopes of similar abundance, both around 50 percent. The atomic mass of bromine is reported in the periodic table as 79.904 atomic mass units. Choose the most likely set of mass numbers for these two bromine isotopes:

(a) ^{80}Br, ^{81}Br (b) ^{79}Br, ^{80}Br (c) ^{79}Br, ^{81}Br.



Solutions (Odd-Numbered)

1. The atoms in the baseball would be the size of ping pong balls if the baseball were the size of Earth.

3.The ray itself is negatively charged since it is a stream of electrons.

5. Millikan discovered the fundamental increment of all electrical charge to be 1.60×10^{-19} Coulombs.

7. Rutherford found that a few of the alpha particles were scattered backwards.

9. Elements are listed in the periodic table in order of increasing atomic number.

11. Mass number is the count of the number of nucleons in an isotope. Atomic mass is a measure of the total mass of an atom.

13. A spectroscope separates the light into color components whose frequencies can then be measured.

15. The atoms of each element emit only select frequencies of light. The pattern of these frequencies is unique to that element.

17. No, Bohr's model merely illustrated the different energy levels of an electron in an atom.

19. An electron moves around the nucleus at around 2 million meters per second.

21. Two.

23. Nitrogen

25. The electrons in the outer most shell of an atom are the ones most responsible for the properties of an atom.

27. Inner-shell electrons diminish the attraction outer-shell electrons have for the nucleus. The strength of the nuclear charge is also diminished for outer-shell electrons because they are farther away from the nucleus. This diminished nuclear charge experienced by outer-shell electrons is called the effective nuclear charge.

29. The electric force weakens with increasing distance.

31. A limiting factor for a transistor is the heat it generates.

33.

	Mass (amu)		Fraction of Abundance		
Li-6	6.0151	×	0.0742	=	0.446
Li-7	7.0160	×			

Solutions to Calculation Corner

Calculating Atomic Mass

Atomic mass of chlorine

	Contributing Mass of ^{35}Cl	Contributing Mass of ^{37}Cl
Fraction of Abundance	0.7553	0.2447
Mass (amu)	× 34.97	× 36.95
	26.41	9.04

atomic mass = 26.41 + 0.94 = 35.48

Mass of hydrogen atom in grams

(1.0079 ~~amu~~)(1.661 × 10^{-24} g / 1 ~~amu~~) = 1.674 × 10^{-24} g

Mass of water molecule in grams

Two hydrogen atoms: $\frac{0.9258}{6.941 \text{ amu}} = \frac{6.495}{\text{amu}}$ 3.348 × 10^{-24} g

One oxygen atom: 2.657 × 10^{-23} g

One water molecule: 2.992 × 10^{-23} g

Number of water molecules in 1 gram

(1.000 ~~g~~ H_2O)(1 molecule H_2O / 2.992 × 10^{-23} ~~g~~) = 3.342 × 10^{22}