CHAPTER E

- **Temperature Conversion:**
  - Degrees F = degrees C(9/5) + 32
  - K = degrees C + 273.15
- **SI prefix multipliers:**
  - Kilo (k) = 1000 = 10^3
  - Deci (d) = 0.1 = 10^-1
  - Centi (c) = 0.01 = 10^-2
  - Milli (m) = 0.001 = 10^-3
  - Micro (u) = 10^-6
  - Nano (n) = 10^-9
  - Pico(p) = 10^-12
- **Accuracy vs. precision**
  - Accuracy: how close the measure value is to the actual value
    - Systematic error: always affects measurements the same amount or by the same proportion; predictable
      - Caused by observational error, imperfect instrument calibration, or environmental interference
      - EX: Forgetting to tare a balance will always produce measurements that are off by the same amount
  - Precision: how close a set of measurements are to one another
    - Random error: causes one measurement to differ slightly from the next
      - Typically affects the last sig fig
      - Caused by limitations of instruments, environmental factors, or slight variations in procedure
      - EX: When reading the volume from a flask, you read it from a different angle each time.
- **Density**
  - = m/V
  - 1 mL = 1 cm^3
- **Intensive vs. extensive properties**
  - Intensive: independent of the amount of the substance
  - Extensive: depends on the amount of the substance
- **Energy**
  - The capacity to do work
    - Work: the action of a force through a distance

i) Constructive interference: building up; happens when waves align with overlapping crests
   (1) Diagram p. 80
ii) Destructive interference: cancelling out; happens when waves align with opposite orientations (crest from one overlaps with the trough from the other)
   (1) Diagram p. 80

10) Explain the wave behavior known as diffraction. Draw the diffraction pattern that occurs when light travels through two slits comparable in size and separation to the light's wavelength.

a) Diffraction: a characteristic behavior of waves in which they bend (or diffract) around an obstacle (or a slit that is comparable in size to its wavelength) when they encounter it
b) Diffraction of light through 2 slits → an interference pattern
   i) Each slit acts as a new wave source and the 2 new waves interfere with each other
   ii) Result is a pattern of bright and dark lines that can be seen on a screen
c) Diagram p. 81

11) Describe the photoelectric effect. How did experimental observations of this phenomenon differ from the predictions of classical electromagnetic theory?

a) Classical model of atom said that any wavelength or frequency of light that was shone on a metal would be sufficient (provide enough energy) to eject electrons off the surface
   i) Thought it depended on the amplitude
b) Photoelectric effect: the observation that many metals emit electrons when light shines upon them
   i) Proved the particle nature of light
   ii) Proved that ejection of electrons from a metal's surface was not dependent on amplitude (intensity)
   iii) Threshold frequency: line below which light will not have sufficient energy to eject an electron
      (1) Threshold frequency condition: hv = binding energy of emitted e- (symbol)
      (2) KE of ejected e- = hv - binding energy
         (a) As frequency of light increases over threshold frequency, e- is ejected with greater speed

   a. The rows get progressively longer because sublevels are added as *n* increases

19. **Explain the relationship between a main-group element's lettered group number (the number of the element's column) and its valence electrons.**
    a. The number of the column of main-group elements equals the number of valence electrons in the elements of that column
20. **Explain the relationship between an element's row number in the periodic table and the highest principal quantum number in the element's electron configuration. How does this relationship differ for main-group elements, transition elements, and inner transition elements?**
    a. For main-group elements, an element's row number equals its principal quantum number
    b. For transition elements, an element's principal quantum number is equal to its row number minus 1
    c. For inner transition elements, an element's principal quantum number is equal to its row number minus 2
21. **Which of the transition elements in the first transition series have anomalous electron configurations?**
    a. Cr: $4s^1 3d^5$
    b. Cu: $4s^1 3d^{10}$
22. **Metals, nonmetals, and metalloids**
    a. <u>Metals:</u>
        i. Good conductors of heat and electricity
        ii. Can be pounded into flat sheets (malleable)
        iii. Can be drawn into wires (ductile)
        iv. Often shiny
        v. Tend to lose e- in chemical reactions
    b. <u>Nonmetals:</u>
        i. Can be solids, liquids, or gases
        ii. Poor conductors of heat and electricity
        iii. Tend to gain e- in chemical reactions
    c. <u>Metalloids:</u>
        i. <u>Semiconductors:</u> intermediate and temperature-dependent electrical conductivity
23. **Explain the relationship between the properties of an element and the number of valence electrons that it contains.**
    a. The chemical properties of elements are largely determined by the number of valence electrons they contain.

   b. % ionic character = (measured dipole moment of bond / dipole moment if e- were completely transferred) x 100%
      i. EX: use dipole moment formula to calculate that separating a p+ and e- by 130 pm results in dipole moment = 6.2 D
      ii. A certain molecule has a bond length of 130 pm w/ a dipole moment = 3.5 D
      iii. % ionic character = 3.5 D / 6.2 D x 100% = 56%
   c. As electronegativity difference increases, % ionic character increases
   d. Bonds w/ greater than 50% ionic character are referred to as ionic bonds
   e. No bond is 100% ionic

4. What is a dipole moment?
   a. Polarity of a bond is quantified by the size of its dipole moment
   b. <u>Dipole moment (u):</u> occurs anytime there is a separation of positive and negative charge
      i. Separation of two particles of equal but opposite charges
   c. U = qr
      i. Q = magnitude of charges
      ii. R = distance
   d. Measured in debye (D)
      i. 1 D = 3.34 x 10^-30 C x m

5. What is the basic procedure for writing a covalent Lewis structure?
   a. Step 1: write correct skeletal structure
      i. H atoms always terminal
      ii. Least electronegative atom in central position
   b. Step 2: calculate # of electrons by summing the # of valence electrons of the elements
      i. For ions:
         1. Add 1 electron for each - charge
         2. Subtract 1 electron for each + charge
   c. Step 3: distribute electrons among atoms to give octets to as many atoms as possible, then add lone pairs where needed

6. How do you determine the number of electrons that go into the Lewis structure of a molecule? A polyatomic ion?
   a. The number of valence electrons of all the elements in the chemical formula

7. What are resonance structures? What is a resonance hybrid?
   a. <u>Resonance structures:</u> when 2 or more valid Lewis structures can be drawn for the same compound

        i. The value of a change in a state function is always the difference between its final and initial values

8. **What is internal energy? Is internal energy a state function?**
    a. Internal energy (E): the sum of the kinetic and potential energies of all of the particles that compose the system
    b. It is a state function
9. **If energy flows out of a chemical system and into the surroundings, what is the sign of ΔE_{system}?**
    a. Negative
10. **If the internal energy of the products of a reaction is higher than the internal energy of the reactants, what is the sign of ΔE for the reaction? In which direction does energy flow?**
    a. $\Delta E = E_{products} - E_{reactants}$
        i. So, if E of products is higher than E of reactants, ΔE is positive & E flows into the system
11. **What is heat? Explain the difference between heat and temperature.**
    a. Heat(q): the flow of energy caused by a temperature difference; the transfer of thermal energy
    b. Temperature: a measure of the thermal energy within a sample of matter
        i. Thermal equilibrium: when there is no additional transfer of heat between 2 things
        ii. $\Delta T = T_{final} - T_{initial}$
12. **How is the change in internal energy of a system related to heat and work?**
    a. $\Delta E = q + w$
        i. For q (heat):
            1. If positive, system GAINS thermal energy
            2. If negative, system LOSES thermal energy
        ii. For w (work):
            1. If positive, work is done ON the system
            2. If negative, work is done BY the system
        iii. For ΔE (change in internal E):
            1. If positive, E flows INTO the system
            2. If negative, E flows OUT of the system
13. **What is heat capacity? Explain the difference between heat capacity and specific heat capacity.**
    a. Heat capacity: the quantity of heat required to change a system's temperature by 1 degree Celsius
        i. The constant of proportionality between q & ΔT

    ii. Heavier molecules diffuse more slowly than lighter ones
  b. <u>Effusion:</u> the process by which a gas escapes from a container into a vacuum through a small hole
    i. Root mean square velocity influences rate of diffusion
    ii. Heavier molecules diffuse more slowly than lighter ones
    iii. Rate of effusion is inversely proportional to the square root of the molar mass of the gas
  c. <u>Graham's law of effusion:</u> says that the rate of effusion of 2 different gases equals...
    i. $rate_A/rate_B$ = sq rt (M_B/M_A)

16. If a reaction occurs in the gas phase at STP, the mass of a product can be determined from the volumes of reactants. Explain.

  a. Use ideal gas equation to calculate # of moles of reactants and then use balanced chemical equation to find # of moles of product and then molar mass to determine mass

17. Deviations from the ideal gas law are often observed at high pressure and low temperature. Explain this in light of kinetic molecular theory.

  a. Gases behave ideally when:
    i. The volume of the gas particles is small compared to the space between them AND...
    ii. The forces between the gas particles are not significant
  b. At STP, these assumptions are valid for most common gases
  c. However, these assumptions break down at HIGHER PRESSURES AND/OR LOWER TEMPERATURES
  d. The size of gas particles becomes important at high pressure because the volume of the particles occupies a significant portion of the total gas volume
    i. Molar volume will be greater at higher pressure?
  e. Intermolecular forces are typically small in gases
  f. At lower temperatures, collisions between particles occur with less kinetic energy and even weak intermolecular forces can affect the collisions
    i. Causes a decrease in the number of collisions and a corresponding decrease in pressure compared to that of an ideal gas
  g. <u>Van der Waals equation:</u> for gases under nonideal conditions
    i. $[P + a(n/V)^2] \times [V - nb] = nRT$
      1. First brackets is the correction for intermolecular forces
      2. Second brackets is the correction for particle volume
      3. Units of a: $(L^2 \text{ x atm})/(mol^2)$

b. Doped semiconductors contain small amounts of impurities that result in either additional electrons in the conduction band or electron “holes” in the valence band
    i. When electrons are added, the additional electrons are then mobile and can conduct electrical current
        1. This is called an n-type semiconductor because the charge carriers are Negatively charged electrons in the conduction band
    ii. Electron holes (empty molecular orbitals) are created by adding another element which traps some of the electrons in the valence band
        1. Electrons can move between holes → conducts electricity
            a. Called a p-type semiconductor because each hole acts as a Positive charge
c. p-n junction: a tiny spot that is p-type on one side and n-type on the other
    i. Can act as diodes (circuit elements that allow the flow of electrical current in only one direction) or amplifiers (elements that amplify a small electrical current into a larger one)

9. What is the trend in the size of the band gap as you move down the column of the group 4A elements?

a. Band gap decreases