Week 1 covers sections 1-5 of chapter 13 in the textbook. Topics include

- temperature and measurement scales
- measurements of amount and density
- the ideal gas law
- kinetic theory of gas

1. The Celsius temperature scale is based on the *triple point* of water, but it is more common to think of it as being 0 °C when water freezes and 100 °C when water boils at 1 atm of pressure. But the Fahrenheit scale is more well known to us so lets do some conversion of common Fahrenheit temperatures. 105 °F, 98.6 °F, 72 °F, 32 °F, 0 °F. Keep going down in Fahrenheit, and see if you can find a Fahrenheit temperature that gives you the same number in Celsius. Make sure you can go backwards and convert some Celsius temperatures back to Fahrenheit.

$$T_F = \frac{9}{5} T_C + 32$$

$$\frac{9}{5} T_C = T_F - 32$$

$$T_C = \frac{5}{9}\left(T_F - 32\right)$$

T_F	T_C
105°F	40.6°C
98.6	37
72	22
32	0
0	-18

$$T = \frac{9}{5} T + 32$$

$$-\frac{9}{5}T \qquad -\frac{9}{5}T$$

$$-\frac{4}{5}T = 32$$

$$T = -40$$

2. If I only tell you a *change* in Fahrenheit temperature of a substance but not the actual temperature, then you can figure out the corresponding change in Celsius, but still not the actual temp. A change in temperature measured in Fahrenheit is 1.8 times bigger than the change measured in Celsius. So if the temperature increased by 30 °F, then by how much does the temperature change in Celsius? What does this mean about the "size" of a Celsius degree vs. the "size" of a Fahrenheit degree? Which one represents a larger change in temperature?

$$\Delta T_F = \frac{9}{5} \Delta T_C$$

$$T_{F,2} - T_{F,1}$$

3. The kelvin temperature scale is designed as an *absolute* temperature scale, meaning the lowest temperature any object could theoretically be is set to 0 K. The size of a Kelvin degree is the same as the size of a Celsius degree, so that a 20 °C change in temperature is the same as a 20 K temperature change. Absolute zero in the Kelvin Scale is set to −273.15 °C. So, what is 0 °C in Kelvin? What is 20 °C in Kelvin. What is 70 K in Celsius? What is normal human body temperature in K?

$T_K = T_C + 273.15$

$T_C = T_K - 273.15$

T_C	T_K
−273.15°C	0 K
0°C	273.15 K
20°C	293.15 K
−203.15°C	70 K
37°C	310 K

$\Delta T_C = \Delta T_K$

4. What is absolute zero in the Fahrenheit temperature scale? Find this by using $T_C = -273.15$ first if you want, but then try using a substitution for T_C that will give you an expression for finding any Fahrenheit temperature given a Kelvin one.

5. What is the ~~molecular~~ ~~weight~~ of Carbon-12? Find a periodic table to help. How many protons are in Carbon-12? How many neutrons? What about the number of protons in Carbon-14? What about the number of neutrons in Carbon-14?

atomic mass → 12 g/mol

6p

6n = 12 − 6p

6p

8n

atomic mass − # of proton = # of neutrons

6. How many atoms are in a mole of Helium? How many atoms are in a mole of Carbon-12? What is the mass of a mole of Helium? What is the mass of a mole of Carbon-12?

$M_{He} = 4g$ $\quad 6.022 \cdot 10^{23}$ atoms = 1 mol of He

$M_C = 12g$

7. What is the mass of a single CO_2 molecule? What is the mass of a mole of CO_2?

$12g + 2(16g) = 44g$

$$\frac{44g/mol}{6.022 \cdot 10^{23} \text{ molecules/mol}} = 7.3 \cdot 10^{-23} \frac{\text{grams}}{\text{molecule}} \cdot \frac{1\,kg}{1000g} = 7.3 \cdot 10^{-26}\,kg$$

10^3

8. What is the mass of a mole of dry air which is 78% N_2, 21% O_2, and 1% Ar?

$28g \cdot 0.78 =$ ____

$32g \cdot 0.21 =$ ____

$40g \cdot 0.01 =$ ____

29 g/mol

9. A balloon is filled with 0.4 mol of helium so that its volume is 0.010 m^3.

   - Find the number of atoms.

- Find the number density.

- Find the mass density.

- Estimate the average distance between atoms. To do this, fine the *volume per particle*, and then treat that volume like a cube and find the side length of the cube. Draw a picture of this model and use that to justify your approximation.

10. You have a pound of feathers and a pound of lead.

    - Which one weighs more?
    - Which one has more mass?
    - Which one has the greater volume?
    - Which one contains a larger number of moles?
    - Which one contains a larger number of atoms?
    - Which one contains a larger number of protons and neutrons?

11. You check your car tire pressure and see that the pressure is $25\,\mathrm{lb/in^2}$. What is this in Pascal? (You'll need to look up a conversion factor). This is a gauge pressure, so what is the absolute pressure in the tire?

12. You check you car tire pressure when it is $15\,^\circ\mathrm{C}$ and it is $25\,\mathrm{lb/in^2}$. By what factor do you increase the number of particles in the tire so that the pressure becomes that $30\,\mathrm{lb/in^2}$? (*Hint: The volume and temperature do not change.*)

13. The gas pressure inside of a 1 liter sealed container at room temperature is $1\,\mathrm{atm}$. How many molecules are inside? How many moles of molecules?

14. If the pressure inside a tank is 1 atm when the temperature is 100 K, then what is the pressure when the temperature rises to 200 K?

15. If the pressure inside a tank is 1 atm when the temperature is 100 °C, then what is the pressure when the temperature rises to 200 °C? *CAREFUL!*

16. A gas is in a sealed container. By what factor does the pressure change if

    - the volume is doubled?

    - the temperature is tripled?

    - the volume is double and the temperature is tripled?

- the volume is halved?

17. You are standing in a room at atmospheric pressure and room temperature. You estimate the room to be 10 m wide by 15 m long by 2 m high. How many moles of gas are in the room?