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.

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

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

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

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

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

$T = -40$

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?

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

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

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?

$T_K = T_C + 273.15°C$

$T_C = T_K - 273.15°C$

$\Delta T_C = \Delta T_K$

T_C	T_K
0°C	273.15 K
20°C	293.15 K
−203°C	70 K
37°C	310 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.

$T_{F,\text{abs zero}} = \frac{9}{5}(-273.15°C) + 32$

$= -459°F$

$T_F = \frac{9}{5}T_C + 32$ $\quad T_C = T_K - 273.15$

$T_F = \frac{9}{5}(T_K - 273.15) + 32$

$T_F = \frac{9}{5}T_K - 459$

5. What is the ~~molecular~~ atomic ~~weight~~ mass 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?

12 grams/mole

6 p

6 p

6 n

8 n

atomic mass − # of protons = # of neutrons

12 − 6 = 6

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?

1 mole of things = $6.022 \cdot 10^{23}$ things

4 g

12 g

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

$12g + 2(16g) = 44\ g/mol$

mass of one thing × number of things = total mass of a collection of things

$$M_{CO_2} = \frac{44\ g}{6.022 \cdot 10^{23}\ molecules} = 7.1 \cdot 10^{-23}\ g/molecule = 7.1 \cdot 10^{-26}\ kg/molecule$$

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

$N_2 \rightarrow 28\ g/mol \times 0.78 =$ ____

$O_2 \rightarrow 32\ g/mol \times 0.21 =$ ____

$Ar \rightarrow 40\ g/mol \times 0.01 =$ ____

$29\ g/mol$

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 °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 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?