TF's name:_____Discussion Day & Time: _____ Student name_____

Things you should know when you leave Discussion today:

- Isotopes; Mahaffy, 2e, 2.8
- Relative atomic mass (A_r), atomic weight, molar mass (M); Mahaffy, 2e, 2.9-10
- Amount of substance and its units Mahaffy, 2e, 2.11
    a. Mole, Atomic mass unit (u), Avogadro's Number
- Naming Ionic Compounds ; Mahaffy, 2e, 3.4
- **Useful information**: $N_A = 6.022140857 \times 10^{23}$ mol^{-1}, $c = 2.99792458 \times 10^8$ m/s

1. What are the units of the following? Explain the differences between them
   Relative atomic mass (A_r):
   Atomic weight:
   Molar mass:

2. What is a connection between the following:
   a. Atomic weight and Relative atomic mass (A_r)
       i.   What is similar?
       ii. What is different?
       iii. How would you convert from one to another?

   b. Atomic weight and molar mass:
       i.   What is similar?
       ii. What is different?
       iii. How would you convert from one to another?

   c. Mass of a single atom (or molecule) in grams and in Atomic mass unit (u)
       i.   What is similar?
       ii. What is different?
       iii. How would you convert from one to another?

3. Calculate and then put the following in order of increasing mass.

   a) 0.500 mol Cl_2

   b) 4.00 N_A molecules of H_2

   c) Amount of Ca containing 4.0×10^{24} electrons

   d) 7.0×10^{14} u of Ba

(lightest) ____ < ____ < ____ < ____ (heaviest)

4. On the scale for which one C-12 atom has mass exactly 12 u, one Mg-25 atom has mass 24.3111 u. If instead we chose the different scale for which one Mg-25 atom has a mass of exactly 25 u*, what would be the mass in grams of the atomic mass unit u*? Express your answer to five significant figures. (Hint: you need to find the new Avogadro number first).

5. How many grams of water contain the same number of hydrogen atoms as are in 92 g of dimethyl ether (CH_3OCH_3)?

6. Ruthenium (Ru) has 7 stable isotopes. Please answer the questions below using the table provided. A ruthenium atom has 60 neutrons. How many moles of ^{104}Ru neutrons are in 10.1 mL of naturally found Ru (density $= 12.5$ g/mL)?
   Hint: not all Ruthenium neutrons are ^{104}Ru neutrons.

Isotope	Abundance (%)
^{96}Ru	3
^{98}Ru	2
^{99}Ru	13
^{100}Ru	12
^{101}Ru	17
^{102}Ru	33
^{104}Ru	20.

7. A McDonald's cheeseburger has about 8.0×10^2 mg of salt (sodium chloride).

   a. How many protons that belong to a positive ion of the ionic compound are in two McDonald's cheeseburgers?

   b. What is a chemical formula for the salt?

   c. Which ion is positive which ion is negative?

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8. If we took all the salt in twenty cheeseburgers and made a cube from it, what would the density (in g/ml) of this salt cube be if the sides of the cube are 0.02m? ($1 \text{ cm}^3 = 1 \text{ mL}$).

9. I like to have something sweet after something salty. A McDonald's apple pie has 34.2 grams of carbohydrates. Let's guess that 10.% by mass of those come from sucrose ($C_{12}H_{22}O_{11}$). How many sucrose carbon atoms (that is, how many carbon atoms *that come from sucrose*) are in each apple pie.

10. An atom X has three known isotopes, with average mass m_{avg}. The first isotope has mass m_1 and fractional abundance f_1. The second isotope has a mass m_2 and fractional abundance f_2. Write an expression for the fractional abundance f_3 of the third isotope of mass m_3 in terms of $m_1, m_2, m_3, m_{avg}, f_1$, and f_2.

11. In a parallel universe element X has the three stable isotopes two of them are shown in the table below. The average mass of this element is 25.5 u.

    a. What is the mass of the third isotope in grams?
    b. What is the molar mass of the third isotope?

Isotope	Mass	Abundance
^{20}X	20.u	0.30
^{30}X	30. u	0.40

12. How many protons of calcium are in 286 grams of calcium hypochlorite?

13. Calculate the mass of the zinc that has the same number of atoms as 7.22 grams of copper.

14. How many protons of manganese are in 362 grams of magnesium permanganate?

15. In terms of the molar mass, M, of ammonium phosphate and the Avogadro constant, N_A, write the symbolic expression for the **number of ions** in solution when G grams of ammonium phosphate dissolves in water and completely ionizes.

16. An atom Y has three known isotopes, with an average mass of m_{avg}. The first isotope has a mass of m_1 and a fractional abundance f_1. The second isotope has a mass of m_2 and a fractional abundance f_2. Write an expression for the mass, m_3, of the third isotope in terms of m_1, m_2, m_{avg}, f_1, and f_2.

17. Assume that the atom in a solid are cubes with edges of length L. Derive an expression to evaluate L in terms of molecular weight, M; density, ρ; and Avogadro constant, N_A. Assume there is no space between the atoms.

18. Lithium has two stable isotopes: ^6Li (7.5%) and ^7Li. Write an expression for the atomic weight of lithium in terms of the relative atomic weights, A_r, of the isotopes.

19. Imagine that you decide to start your own meth lab, like in "Breaking Bad." However, because you are only in CH101, part of your product explodes at a crucial step. What explodes is 124 mL of ethylene glycol, $C_2H_4(OH)_2$. If the density of ethylene glycol is 1.5 g/mL, and it takes 1.5×10^{18} atoms of C to release exactly 1 J of energy, calculate the total amount of energy released in the resultant explosion, in kJ $= 10^3$ J and to the correct number of significant figures.

20. A compound has a composition by mass of 24.1% carbon, 5.9% hydrogen, and 70.0% chlorine. What is the empirical formula of the compound?

21. Of ^{39}K, ^{40}K and ^{41}K, ^{40}K has very low abundance. Using the periodic table, which isotope (^{39}K or ^{41}K) is more abundant? Use that ^{39}K $A_r = 38.964$ and ^{41}K $A_r = 40.962$ and that K atomic weight $= 39.083$.

22. What is relative atomic mass, atomic weight and molar mass of ^{16}O?

23. What is relative atomic mass of ^{12}C, mass of a single ^{12}C atom (in u), mass of a single ^{12}C atom (in g), atomic weight of C (in u), molar mass of ^{12}C, and molar mass of C?

24. What is the chemical name of NH_4CH_3COO is _____

25. What is the chemical formula of sodium perchlorate _____

26. If 3.0 mol of sodium phosphate is dissolved in water and ionize completely, what is the number of moles of ions in the solution?

Numerical Answers

3. d < b < c < a
4. 1.61478×10^{-24} g
5. 110 g H_2O
6. 15 mol of ^{104}Ru neutrons
7.
   a. 1.8×10^{23} protons
   b. NaCl
   c. Na (+); Cl (-)
8. 2 g/mL
9. 7.2×10^{22} carbon atoms
10. $f_3 = \dfrac{m_{avg} - (m_1 f_1) - (m_2 f_2)}{m_3}$
11.
    a. 4.2×10^{-23} g
    b. 25 g/mol
12. 2.4×10^{25} protons
13. 7.43 g
14. 4.12×10^{25} protons
15. $4\dfrac{G N_A}{M}$
16. $m_3 = \dfrac{m_{avg} - (m_1 f_1) - (m_2 f_2)}{1 - f1 - f2}$
17. $L = \sqrt[3]{\dfrac{M}{N_A} \dfrac{1}{\rho}}$
18. $(0.075\, m_6) + (0.925\, m_7) = 6.94$
19. 2.4×10^3 kJ
20. CH_3Cl
21. ^{39}K

22. 12.0000, 12.0000 u, 1.9927×10^{-23} g, 12.011 u, 12.0000 g, 12.011 g
23. Ammonium acetate
24. $NaClO_4$
25. 12 mol

At-home Activity 1: Traveling Waves

You will first need to download Wolfram CDF Player on your computer. To do so, select the "Student" option in the roll down menu and follow the directions on the website: http://www.wolfram.com/cdf-player/ Once this is complete, please go to the following website: http://quantum.bu.edu/CDF/101/01-TravelingWaves.cdf

When loaded, you will see a graph with a travelling wave moving along the x-axis. You can start this simulation by pressing the play button at the top ▶ . The simulation can be paused ▐▐ , sped up, or slowed down ⏫⏬ using the buttons at the top. The sliders below allow you to change the frequency and the wavelength of the traveling wave. You will notice that both wavelength and velocity are given with the unit nm (1 nm = 10^{-9} m). This is because you will be working with light during this semester, and light has such a small wavelength that nm is more commonly used. Once the animation starts, the velocity of the wave and the time will be presented on the graph. Please use this simulation to answer the following questions.

Wavelength and Frequency

Waveform: The frequency of an oscillation (ν) is the number of waveforms that pass through one point on the x-axis in one second. The unit for frequency is Hertz (Hz), 1 Hz = 1/s. The wavelength (λ) is the length of one complete waveform. The unit for wavelength is meters (m).

1. Using the online simulation, set the wavelength equal to one of the values in the table below. Change the frequency of the wave until the velocity reads 1 nm/s. Record this frequency in the table below. Repeat this process for each of the wavelengths given in the table.

λ (nm)	ν (Hz = s^{-1})
1.0	
1.5	
2.0	
2.5	
3.0	
3.5	
4.0	
4.5	
5.0	
5.5	

2. You will now repeat this process for a velocity of 2 nm/s. Record this frequencies corresponding to each wavelength in the table below.

λ (nm)	ν (Hz = s^{-1})
1.0	
1.5	
2.0	
2.5	
3.0	
3.5	
4.0	
4.5	
5.0	
5.5	

3. On a piece of graph paper (or neatly in your notebook), please graph frequency as a function of wavelength for the two different velocity tables above. (You will be plotting two lines on the same set of axes.) Make sure to label which line corresponds to which velocity.

4. **Relationships**: From the tables and graphs you created above, determine the appropriate relationships between each of the following variables. Example: "A" is directly proportional to "B", "A" is inversely proportional to "B", etc.
    a. Frequency and Wavelength
    b. Velocity and Wavelength
    c. Velocity and Frequency
    d. From these relationships, see if you can come up with an equation for the speed of a wave:

At-home Activity 2: Wavenumbers

In chemistry, an additional variable is used when talking about light: The wavenumber. While wavelengths (λ) have a unit of m or nm, wavenumbers ($\tilde{v}$) have a unit of cm^{-1}.
    1. Using the units given for wavenumbers above, see if you can determine the wavenumber for a wave with a wavelength of 0.1 m (10 cm).

    2. Given this information, what is the relationship between wavenumber and wavelength?

    3. Complete the following table by first converting wavenumbers to wavelengths, and then calculating frequency using the equation for the speed of a light wave.

$$c = \lambda\, v$$
$$c = 2.9979 \times 10^8 \text{ m/s}$$

$\tilde{v}$ (cm^{-1})	λ (m)	v (Hz)
100		
200		
500		
1000		
2000		
5000		

4. Given this information, what is the relationship between wavenumber and frequency?

5. If a graph is plotting increasing wavenumber from left to right, how is the wavelength changing from left to right? What about the frequency?