

Ap Chem Summer Assignment #2

Shaurya Singh

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1 What is the charge on the following:

- (a) The cation in CsCl has a charge of 1+, with Cs being the cation.
- (b) The sulfate ion (SO_4^{2-}) has a charge of 2-
- (c) The barium ion (Ba^{2+}) has a charge of 2+
- (d) The nitrate ion (NO_3^-) has a charge of 1-

2 How many protons, neutrons, and electrons are in:

- (a) Uranium-235 has **92 protons**, since it has an atomic number of 92. It also has **143 neutrons**, since $235 - 92 = 143$. Lastly, it has **92 electrons**, since it has no charge so the number of protons must equal the number of electrons.
- (b) Uranium-238 has **92 protons**, since it has an atomic number of 92. It also has **146 neutrons**, since $238 - 92 = 146$. Lastly, it has **92 electrons**, since it has no charge so the number of protons must equal the number of electrons.

3 Elements in the same vertical column in the periodic table have similar what?

Elements in the same vertical column in the periodic table will be in the same group. Therefore, they will have the **same number of valence electrons**. This means that they will have similar properties and reactivity

- 4 An element “E” is present as 10 E with a mass value of 10.01 amu, and as 11 E with a mass value of 11.01 amu. The natural abundances of 10 E and 11 E are 19.78% and 80.22% respectively. What is the average atomic mass of the element? What is the element?

In order to calculate the average atomic mass of the element, we must take the weighted average of the two isotopes against their percentage abundance. For this we have the following equation

$$(x_1 * w_1) + (x_2 * w_2)$$

Where the variables are as following:

$$\begin{aligned}x_1 &= 10.01 \\w_1 &= 0.1978 \\x_2 &= 11.01 \\w_2 &= 0.8022\end{aligned}$$

Multiplying that out, we get

$$x = (10.01 * 0.1978) + (11.01 * 0.8022)$$

Where x is the average atomic mass. Solving for x we get

$$x = 10.8122$$

Since we must round to 5 significant figures, the correct answer is

$$x \approx 10.812$$

Therefore, the element has an average atomic mass of **10.81 amu**. Looking at the periodic table, the element with an average atomic mass of 10.812 is **Boron**.

5 Naturally occurring sulfur consists of four isotopes, 32 S (95.0%), 33 S (0.76%), 34 S(4.22%), and 36 S(0.014%). Using this data, calculate the atomic weight of naturally occurring sulfur. The masses of the isotopes are given in the table below.

In order to calculate the atomic weight of Sulfur, we must take the weighted average of the 4 isotopes against their percentage abundance. The equation for this is

$$(x_1 * w_1) + (x_2 * w_2) + (x_3 * w_3) + (x_4 * w_4)$$

Where the variables are the following:

$$\begin{aligned} x_1 &= 31.97 \\ w_1 &= 0.950 \\ x_2 &= 32.97 \\ w_2 &= 0.0076 \\ x_3 &= 33.97 \\ w_3 &= 0.0422 \\ x_4 &= 35.97 \\ w_4 &= 0.00014 \end{aligned}$$

Multiplying that out, we get

$$x = (31.97 * 0.950) + (32.97 * 0.0076) + (33.97 * 0.0422) + (35.97 * 0.00014)$$

Where x is the atomic weight. Solving for x we get

$$\begin{aligned} x &= 30.373 + 0.251 + 1.433 + 0.005 \\ &= 30.7357392814 \end{aligned}$$

Since we must round to 4 significant figures, the correct answer is

$$x \approx 32.06$$

Therefore, the element has an atomic weight of **32.06 amu**.

6 Explain each of the following:

- (a) Alpha radiation penetrates a much shorter distance into a piece of material than does beta radiation of the same energy.

- **Answer:** Alpha particles have a greater mass than beta particles, which means they travel slower, and therefore have less penetrating potential.

- (b) Define the word isotope. Distinguish between isotope and isomer. Describe the differences between alpha, beta, and gamma particles.

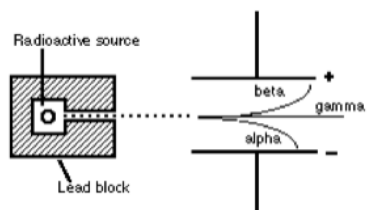
- **Define the word isotope:** An isotope in chemistry is two or more forms of the same element that contain equal numbers of protons but different numbers of neutrons in their nuclei. They differ in atomic mass, but share similar chemical properties
- **Distinguish between isotope and isomer:** An isomer is two or more compounds with the same formula but a different arrangement of atoms in the molecules. Unlike isotopes, isomers have different properties.
- **Describe the difference between alpha, beta, and gamma particles:** Alpha particles are fully ionized helium nuclei, ejected by the decay of a radioactive isotope atom. Beta Particles are highly energetic electrons or positrons ejected by the decay of a neutron or proton in a radioactive isotope atom. Gamma radiation comprises of highly energetic photons above the x-ray energy range that may arise in nuclear decay. Each particle has a different charge and mass.

- (c) Nuclear fusion requires large amounts of energy and to get started, whereas nuclear fission can occur spontaneously, although both processes release energy.

- **Answer:** Large amounts of energy are needed to initiate fusion reactions, since they need to overcome the repulsive forces between the positively charged nuclei. On the other hand, large amounts of energy are not required in order to cause a large unstable nuclei to split apart (fission)

- (d) Describe how α , β , and γ rays each behave when they pass through an electric field. Use the diagram below to illustrate your answer.

- **Answer:** α particles are positively charged, β are negatively charged, γ particles are electrically neutral. Therefore, α rays will be attracted to the negative plate and β rays will be attracted to the positive plate. The electric field will have no effect on γ rays, as they are electrically neutral



(e) Why is it not possible to eliminate the hazard of nuclear waste by the process of incineration (burning)?

- **Answer:** Incineration does not decrease radioactivity. Burning nuclear waste will contaminate the surrounding air

7 How many moles are in a sample of 300 atoms of Nitrogen (N)? How many grams?

We have 3 variables

$$x = \text{number of atoms} = 300$$

$$a = \text{Avogadro's number} = 6.022 * 10^{23}$$

$$n = \text{mol}$$

One mole contains $6.022 * 10^{23}$ atoms, or Avogadro's number. As a result, we get the following equation

$$n = x/a$$

Therefore 300 atoms of nitrogen contain:

$$\begin{aligned} n &= 300 \text{ atoms} \\ &= \frac{300}{6.022 * 10^{23}} \frac{\text{atoms}}{\text{mol}} \\ &= 5 * 10^{-22} \text{ mol} \end{aligned}$$

There are $5 * 10^{-22}$ mol in 300 atoms of Nitrogen.

To calculate for mass, we multiply the molar mass by the number we calculated earlier:

$$\begin{aligned}m &= \text{molar mass} = 14.007 \\n &= \text{mol} = \frac{g}{\text{mol}} \times 5 * 10^{-22} \\x &= \text{mass(g)}\end{aligned}$$

We have the following equation

$$mn = x$$

Plugging in our variables, we get $14.007 \frac{g}{\text{mol}} \times 5 * 10^{-22} \text{ mol} = 7 * 10^{-21}$
Therefore, 300 atoms of nitrogen contain $7 * 10^{-21}g$ of nitrogen.

8 A sample of sulfur (S) has a mass of 5.37 g. How many moles are in the sample? How many atoms?

Sulfur has a molar mass of 32amu. Therefore, it has a molar mass of $32 \frac{g}{\text{mol}}$
We have the following variables

$$\begin{aligned}m &= \text{mass} = 5.37g \\a &= \text{molar mass} = 32 \text{ g/mol}\end{aligned}$$

To calculate for mol, we can use the following equation

$$\frac{m}{a} = \text{mol}$$

Once we plug in our variables, we get the following

$$\frac{5.37g}{32g/\text{mol}} = 0.167\text{mol}$$

To convert that to atoms, we can use Avogadro's number ($6.022 * 10^{23}$).

$$\begin{aligned}x &= \text{Avogadro's number} * \text{mol} \\&= (6.022 * 10^{23}) * (0.167) \\&= 1.02374 * 10^{23} \\&\approx 1.01 * 10^{23}\end{aligned}$$

Therefore there are 0.17mol and 1.01×10^{23} atoms in the sample of sulfur

9 How many grams of zinc are in 1.16×10^{22} atoms of zinc (Zn)?

Zinc atoms have a mass of 65.4g . Using Avogadro's number, we know that there are 6.022×10^{23} atoms per mole of zinc. We also know Zinc has a molar mass of $65.4 \frac{\text{g}}{\text{mol}}$. From that we can get the following formula

$$\begin{aligned}x &= \frac{\text{atoms}}{\text{Avogadro's number}} \times \text{molar mass} \\&= \frac{1.16 \times 10^{22}}{6.022 \times 10^{23}} \times 65.4 \frac{\text{g}}{\text{mol}} \\&= 0.0192\text{mol} \times 65.4 \frac{\text{g}}{\text{mol}} \\&= 1.25568\text{g} \\&\approx 1.26\text{g}\end{aligned}$$

Therefore, there are 1.26 grams of zinc in 1.16×10^{22} atoms of zinc

10 Calculate the number of grams per mole (gfm) for each of the following:

(a) What is the gfm of CuSO_4

To find the molar mass of CuSO_4 , we must take the molar mass of each element in the molecule, and add it together.

Cu (Copper) has a molar mass of 63.546 g/mol .

S (Sulfur) has a molar mass of 32.065 g/mol .

O (Oxygen) has a molar mass of 16 g/mol . Since we have 4 oxygen atoms, the actual molar mass would be $16 \times 4 = 64 \text{ g/mol}$

Combining the molar mass of the 3 elements, we get

$$63.546 + 64 + 32.065 = 159.611 \text{ g/mol}$$

(b) What is the gfm of NH_4OH

To find the molar mass of NH_4OH we must take the molar mass of each element in the molecule, and add it together.

N (Nitrogen) has a molar mass of 14.0067 g/mol.

O (Oxygen) has a molar mass of 15.9994 g/mol.

H (Hydrogen) has a molar mass of 1.00794 g/mol. Since we have 5 Hydrogen molecules, that means the molar mass for this element will be $1.0088 * 5 = 5.0397 \text{ g/mol}$.

Combining the molar mass of the 4 elements, we get

$$14.0067 + 15.9994 + 1.00794 = 35.04580 \text{ g/mol}$$

(c) What is the gfm of $\text{Zr}(\text{SeO}_3)_2$

To find the molar mass of $\text{Zr}(\text{SeO}_3)_2$ we must take the molar mass of each element in the molecule, and add it together.

Zr (Zirconium) has a molar mass of 91.224 g/mol.

O (Oxygen) has a molar mass of 15.9994 g/mol. Since we have 6 Oxygen molecules, that means the molar mass for this element will be $15.9994 * 6 = 95.9964 \text{ g/mol}$.

Se (Selenium) has a molar mass of 78.971 g/mol. Since we have 2 Selenium molecules, that means the molar mass for this element will be $78.971 * 2 = 157.92 \text{ g/mol}$.

Combining the molar mass of the 3 elements, we get

$$91.224 + 157.92 + 95.9964 = 345.16 \text{ g/mol}$$

(d) What is the gfm of $\text{Ca}_2\text{Fe}(\text{CN})_6 \cdot 12\text{H}_2\text{O}$

To find the molar mass of $\text{Ca}_2\text{Fe}(\text{CN})_6 \cdot 12\text{H}_2\text{O}$ we must take the molar mass of each element in each molecule, and add it together.

Ca (Calcium) has a molar mass of 40.087 g/mol. Since there are two Ca atoms, we multiply that by two to get 80.174 g/mol

Fe (Iron) has a molar mass of 55.845 g/mol.

C (Carbon) has a molar mass of 12.0107 g/mol. Since we have 6 Carbon molecules, that means the molar mass for this element will be $12.0107 * 6 = 72.0642 \text{ g/mol}$.

N (Nitrogen) has a molar mass of 14.0067 g/mol. Since we have 6 Nitrogen molecules, that means the molar mass for this element will be $14.0067 * 6 = 84.0402 \text{ g/mol}$.

H (Hydrogen) has a molar mass of 1.00794 g/mol. Since we have 24 Hydrogen molecules, that means the molar mass for this element will be $1.00794 * 24 = 24.19056 \text{ g/mol}$.

O (Oxygen) has a molar mass of 15.9994 g/mol. Since we have 12 Oxygen molecules, that means the molar mass for this element will be $15.9994 * 12 = 191.9928 \text{ g/mol}$.

Combining the molar mass of the 2 molecules, we get

$$80.174 + 55.845 + 72.0642 + 84.0402 + 24.19056 + 191.9928 = 508.307 \text{ g/mol}$$

11 How many moles of cadmium bromide (CdBr_2) are in a 39.25 g sample?

For this we can use Avogadro's number. One mole contains $6.022 * 10^{23}$ particles. From that we get the following

$$N = \text{molar mass}$$

$$N_o = 272.219$$

$$n = \text{moles}$$

$$n = \frac{N}{N_o}$$

Therefore, we can get

$$\begin{aligned} n &= \frac{39.25}{272.219} \\ &= 0.144185380153 \\ &\approx 0.1442 \end{aligned}$$

Rounding to 4 significant figures, there will be $1.442 * 10^{-1}$ moles of cadmium bromide in a 39.25 g sample

12 $\text{CH}_3\text{CH}_2\text{OH}$ boils at 78°C and CH_3OCH_3 boils at -24°C , although both compounds have the same composition. This difference in boiling points may be attributed to a difference in

The answer is **D**. Hydrogen bonding. The extra hydrogen bonds of $\text{CH}_3\text{CH}_2\text{OH}$ make it harder to separate molecules, as more heat and energy is required, resulting in a higher boiling point compared to CH_3OCH_3

13 Which of the following elements has the smallest ionization energy? Explain.

Ionization energy decreases down a group, and increases from left to right across a period. Therefore, Potassium has the smallest ionization energy, which is **D**.

14 Which of the following represents the ground state electron configuration for the Mn $3+$ ion? (Atomic number Mn = 25) (Hint: first write the e - config of Mn atom, then try the Mn $3+$ ion.)

The electron configuration for Mn is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$. The $3+$ ion will have 3 fewer electrons, since a positive charge indicates more protons than electrons. Therefore, the electron configuration of Mn^{3+} is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4$, and the correct option is **B**

15 Which of the following represents an excited state?

Option **A**, $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4 4s^2$ is in an excited state, as it skips the final electron in the 3d orbital.

16 The table above shows the first three ionization energies for atoms of four elements from the third period of the periodic table. Answer the following questions.

(a) What is the chemical symbol for element 3, explain your reasoning.

- **Answer:** The third element is Mg, or Magnesium. It has low first and second ionization energies relative to the third, which means it has two valence electrons. Magnesium is the element with two valence electrons in the third period of the periodic table

(b) Write the complete electron configuration of element 3.

- **Answer:** Mg has an atomic number of 12, therefore the electron configuration of Magnesium is $1s^2 2s^2 2p^6 3s^2$
- (c) What is the chemical symbol for element 2 and what is the expected ion charge for its most common ion?
- **Answer:** The symbol for element 2 is Na, and the expected ion charge for its most common ion is $1+$.
- (d) A neutral atom of which of the four elements above has the smallest radius? Write the symbol for this element and explain this using the first ionization values given.
- **Answer:** Element 1 Cl, Atomic radius has a trend from right to left across a period, while ionization energy has a trend from left to right across a period. Since element 1 has the highest ionization energy, it would have the smallest atomic radius
- (e) Which would have a higher electronegativity, element 1 or 4? Briefly explain.
- **Answer:** Element 1 would have a higher electronegativity. Both electronegativity and ionization energy follow the same trend, this means that the element with the higher ionization energy will have a higher electronegativity. In this case, that is element 1.
- (f) Identify the elements: Element 1: Cl, Element 2: Na, Element 3: Mg, Element 4: S

17 Calculate the mass percent of Cl in each of the following compounds

- (a) Cl has a Mass Percent of %65.110 in ClF
- (b) Cl has a Mass Percent of %51.787 in HClO_2
- (c) Cl has a Mass Percent of %52.737 in CuCl_2

18 Calculate the mass percent of each element in $\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$, or barium hydroxide octahydrate

- Ba has a Mass Percent of %43.532 in $\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$,

- H has a Mass Percent of %5.751 in $\text{Ba}(\text{OH})_2 \cdot 8 \text{H}_2\text{O}$,
- O has a Mass Percent of %50.717 in $\text{Ba}(\text{OH})_2 \cdot 8 \text{H}_2\text{O}$,

19 A compound is found, by mass spectral analysis, to contain the following percentages of elements by mass, C = 49.67%, Cl = 48.92%, H = 1.39%, The molar mass of the compound is 289.9 g/mole. Determine the empirical and molecular formulas of the compound.

First we must calculate the quantity of each element

$$C : \frac{49.67g}{1} \times \frac{1molC}{12.01g} = 4.135mol$$

$$Cl : \frac{48.92g}{1} \times \frac{1molCl}{35.453g} = 1.380mol$$

$$H : \frac{1.39g}{1} \times \frac{1molH}{1.008g} = 1.380mol$$

$$E.F.M. = (3)12.011g + 35.453g + 1.008g = 72.494g$$

From that we can calculate the following ratios:

$$\frac{4.135mol}{1.380mol} = 3$$

$$\frac{1.380mol}{1.380mol} = 1$$

$$\frac{1.380mol}{1.380mol} = 1$$

Since C, Cl, and H have a ratio of 3 : 1 : 1, the molecular formula will be $(\text{C}_3\text{ClH})_n$ To calculate the empirical formula we solve for n

$$n = \frac{289.9g}{72.494g}$$

$$= 4$$

Therefore, we can substitute 4 for n.

$$(\text{C}_3\text{ClH})_n = (\text{C}_3\text{ClH})_4$$

$$= \text{C}_{12}\text{Cl}_4\text{H}_4$$

20 Determine the empirical formula of a compound that contains the following percentages of elements by mass: Mo = 43.95%, O = 7.33%, Cl = 48.72%.

First we must calculate the quantity of each element

$$\begin{aligned} Mo : \frac{43.95g}{1} \times \frac{1molMo}{95.95g} &= 0.458mol \\ Cl : \frac{48.72g}{1} \times \frac{1molCl}{35.45g} &= 1.374mol \\ O : \frac{7.33g}{1} \times \frac{1molO}{15.99g} &= 0.458mol \end{aligned}$$

From that we can calculate the following ratios:

$$\begin{aligned} \frac{0.458mol}{0.458mol} &= 1 \\ \frac{1.374mol}{0.458mol} &= 3 \\ \frac{0.458mol}{0.458mol} &= 1 \end{aligned}$$

Since Cl, Mo, and O have a ratio of 3 : 1 : 1, the empirical formula will be Cl_3MoO

21 Aspartame is an artificial sweetener used in food and beverages that is 160 times sweeter than sucrose.

(a) Using the molecular structure, determine the molecular formula of aspartame, using this format $C_WH_XN_YO_Z$

- **Answer:** There are 18 hydrogen atoms, 14 Carbon atoms, 2 Nitrogen atoms, and 5 Oxygen atoms. Therefore, the solution is $C_{14}H_{18}N_2O_5$

(b) How many molecules are present in 10.0 mg of aspartame? How many hydrogen atoms? O atoms?

- **Answer:** First we must calculate the molar mass of aspartame
 $14 \times 6 + 18 \times 1 + 2 \times 7 + 5 \times 8 = 283 \frac{g}{mol}$ Now, we have the following values

$$m = mol$$

$$x = grams = 0.01g$$

$$y = molar\ mass = 283 \frac{g}{mol}$$

We can plug that into the following equation to calculate for m

$$m = \frac{x}{y}$$

Using that we get

$$mol = \frac{g}{g/mol}$$

$$mol = \frac{0.01g}{283g/mol}$$

$$mol = 3.533568905 * 10^{-5}$$

$$mol \approx 4.0 * 10^{-5}$$

Therefore, there are $4.0 * 10^{-5} mol$ of aspartame in 10 milligrams
 Multiplied by Avogadro's number, that's $2.05 * 10^{18}$ molecules.

- (c) What is the mass in grams of 1.0×10^9 molecules of aspartame? Mass of one molecule of aspartame?

- **Answer:** There are $4.9 * 10^{-22}g$ in $1.0 * 10^9$ molecules of aspartame.
 There are $4.9 * 10^{-22}g$ in 1 molecule of aspartame

22 Watch the following video on making a solution and how to calculate molarity and answer the following questions:

- (a) Describe how you would make 100.0 mL of a 1.0 M solution of lithium chloride.

We have a $1.0M$ solution, which translates to a $1.0mol/L$ We need to find the value for $100ml$, or $0.1L$ $y = 100mL = 0.1L$ We can plug that into this equation, and solve for x

$$\begin{aligned}
 x &= M * y(mol/L) * LiCl \frac{g}{mol} \\
 &1.0 * 0.1(mol/L) * 42.394 \frac{g}{mol} \\
 &0.1mol * 42.394 \frac{g}{mol} \\
 &4.2g
 \end{aligned}$$

Therefore, in order to get $100mL$ of lithium chloride, we must need $4.2g$ of lithium chloride

- 1 First we must get our lithium chloride.
 - 2 Afterwards, using our electronic balance, lab scoop, and weighing paper we can measure out $4.2g$ of $LiCl$.
 - 3 Once we calculate that out, we can use a $100.0mL$ volumetric flask to measure it.
 - 4 Since the molarity is $1.0mol/L$, 100% of the solution is $LiCl$, and no water is required.
- (b) Design an experiment to collect data that supports the claim that your 100.0 mL , 1.0 M $LiCl$ solution is a homogeneous mixture.
- 1 First we transfer the solution to a $100mL$ beaker
 - 2 Now, we will heat this solution until it boils and water starts evaporating. We will place a cold surface above the steam coming out from the boiling solution.
 - 3 What we will observe is that when all the water evaporates, we can see white precipitate of $NaCl$ in the bottom of the container. We will also see that water has condensed on the sides of the container
 - 4 We used physical methods to restore the components of the solution separately. Based on these observations, we prove that $NaCl$ is a homogenous solution

23 The structures of a water molecule and a crystal of LiCl(s) are represented above. A student prepares a 0.10 M solution by dissolving LiCl(s) in enough water to make 100.0 mL of solution.

(a) How much LiCl(s) was dissolved to make the 0.10 M solution? Justify with a calculation.

- **Answer:** We have a 0.10M solution, which translates to a $0.10\text{mol}/L$
 We need to find the value for 100ml, or $0.1L$ $y = 100\text{mL} = 0.1L$
 We can plug that into this equation, and solve for x

$$\begin{aligned} x &= M * y(\text{mol}/L) * LiCl \frac{g}{mol} \\ 0.10 * 0.1(\text{mol}/L) &* 42.394 \frac{g}{mol} \\ 0.01\text{mol} * 42.394 \frac{g}{mol} \\ 0.42394g \end{aligned}$$

Therefore, 0.42394g of LiCl was dissolved to make the solution

(b) Show the interactions of the components of LiCl(aq) by making a drawing.

