AP Chemistry 2024-2025 Summer Review

Welcome to AP Chemistry. Summer review work is meant to get us off to a running start when fall arrives. You should already know most of the material in this packet from your first-year chemistry class. Nonetheless, START NOW to make your way leisurely through this review. Do not think you should wait until the very end of the summer, so it is "fresh in your mind." The LONGER it is in your mind, the better it will stick. Email me with any questions or concerns. I will try to respond ASAP. My email is dying@cherrycreekschools.org

This packet contains topics on

1.) **Nomenclature** – (naming and writing formula) with the memorization of common polyatomics and elements. Memorization of names, symbols (chemical formula) and charge is a must.
2.) **PEN Tables** – protons, neutrons, electrons, mass number and atomic mass.
3.) **Electron configuration** – long and abbreviated. Configuration of ions.
4.) **Chemical composition** – Percent composition, empirical and molecular formula.
5.) **Stoichiometry** – Stoichiometry, limiting and percent yield.
6.) **Solution** – Molarity, dilutions, millimoles.
7.) **Gases** – Simple gas laws, ideal gas law. Dalton's law of partial pressure.
8.) **Chemical reactions** – writing out a chemical reaction and net ionic equations.

Nomenclature

You will be more successful in AP chemistry if you can name chemicals from their formulas, and if you can write chemical formulas from the name of the chemical. You don't need to know all polyatomic ions – just a short list will be helpful. You should be able to do this with only the assistance of a periodic table, after *memorizing* the polyatomic ions in the charts below.

Polyatomic Ions -

Memorize the shaded ions (and learn the pattern so you can easily memorize their companions). Or just memorize all of them.

By learning the four shaded "-ate" ions in the table to the right **and** knowing that one less oxygen (same charge) turns the name to –*ite*, **and** two less oxygens (when possible) turns the name to *hypo*–xxx–ite **and** one more oxygen (when possible) turns the name to *per*–xxx–ate will make learning all eighteen ions in the chart below as easy as learning just four.

Memorize the six extra polyatomic ions in the second table below, and don't forget ammonium in the table by itself.

Polyatomic Ions to Memorize *(Use the pattern to help)*

hypo- (2 less O)	**-ite (1 less O)**	**-ate**	**per- (1 more O)**
	nitrite NO_2^-	nitrate NO_3^-	
	sulfite SO_3^{2-}	sulfate SO_4^{2-}	
	phosphite PO_3^{3-}	phosphate PO_4^{3-}	
hypochlorite ClO^-	chlorite ClO_2^-	chlorate ClO_3^-	perchlorate ClO_4^-
hypobromite BrO^-	bromite BrO_2^-	bromate BrO_3^-	perbromate BrO_4^-
hypoiodite IO^-	iodite IO_2^-	iodate IO_3^-	periodate IO_4^-

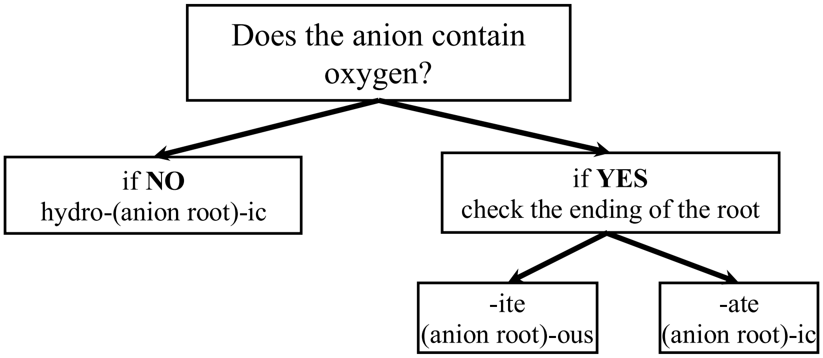
Odd Companions or No Companion

hydroxide OH^-	
cyanide CN^-	
acetate $C_2H_3O_2^-$	
carbonate CO_3^{2-}	bicarbonate HCO_3^-
permanganate MnO_4^- *purple color*	ammonium NH_4^+

Acids and Bases

You will need to be able to name acids. Knowing your polyatomic ions is critical in naming the acids. Use the chart below to review the pattern and method of naming.

Demystifying the Naming of Acids



Summer Review:

DO NOT DETACH FROM BOOK.

PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.008																	2 **He** 4.00
3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.30											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.63	33 **As** 74.92	34 **Se** 78.97	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.95	43 **Tc**	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57–71 *	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po**	85 **At**	86 **Rn**
87 **Fr**	88 **Ra**	89–103 †	104 **Rf**	105 **Db**	106 **Sg**	107 **Bh**	108 **Hs**	109 **Mt**	110 **Ds**	111 **Rg**	112 **Cn**	113 **Nh**	114 **Fl**	115 **Mc**	116 **Lv**	117 **Ts**	118 **Og**

*Lanthanoids	57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm**	62 **Sm** 150.36	63 **Eu** 151.97	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
†Actinoids	89 **Ac**	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np**	94 **Pu**	95 **Am**	96 **Cm**	97 **Bk**	98 **Cf**	99 **Es**	100 **Fm**	101 **Md**	102 **No**	103 **Lr**

Summer Review: Nomenclature Practice

You should learn your polyatomic ions well enough to write these names and formulas without looking at the polyatomic ion chart. Use only the periodic table in this packet. (ANSWERS are on the following page)

Write chemical formulas for the following names.

1. sodium sulfite ______________________________
2. copper(II) nitrate ___________________________
3. hydrochloric acid ___________________________
4. sodium hydroxide ___________________________
5. acetic acid _________________________________
6. aluminum perchorate ________________________
7. silver sulfide _______________________________
8. carbonic acid _______________________________
9. ammonium phosphate ________________________
10. potassium permanganate _____________________
11. lead(II) cyanide ____________________________
12. calcium acetate ____________________________
13. nitrous acid _______________________________
14. hydroiodic acid ____________________________
15. sodium bicarbonate _________________________
16. nickel(III) iodate ___________________________
17. chloric acid _______________________________
18. aluminum sulfite ___________________________
19. phosphorous acid __________________________
20. barium hydroxide __________________________

Write names for the following formulas.

21. $Sr(CN)_2$ ___________________________________
22. H_3PO_4 ___________________________________
23. $ZnSO_4$ ____________________________________
24. $Cu(SO_3)_2$ _________________________________
25. H_2SO_4 ___________________________________
26. AuOH ______________________________________
27. K_2CO_3 ___________________________________
28. $NaHCO_3$ _________________________________
29. $HClO_2$ ___________________________________
30. $AgNO_2$ ___________________________________
31. HBrO ______________________________________
32. KOH _______________________________________
33. $HC_2H_3O_2$ ________________________________
34. $Ni(BrO_2)_3$ ________________________________
35. HBr _______________________________________
36. $NaMnO_4$ __________________________________
37. $HBrO_2$ ___________________________________
38. H_3PO_4 ___________________________________
39. $(NH_4)_2SO_4$ _______________________________
40. $Ni(OH)_2$ __________________________________

Summer Review: Nomenclature Practice

1. sodium sulfite	**Na_2SO_3**
2. copper(II) nitrate	**$Cu(NO_3)_2$**
3. hydrochloric acid	**HCl**
4. sodium hydroxide	**$NaOH$**
5. acetic acid	**$HC_2H_3O_2$**
6. aluminum perchorate	**$Al(ClO_4)_3$**
7. silver sulfide	**Ag_2S**
8. carbonic acid	**H_2CO_3**
9. ammonium phosphate	**$(NH_4)_3PO_4$**
10. potassium permanganate	**$KMnO_4$**
11. lead(II) cyanide	**$Pb(CN)_2$**
12. calcium acetate	**$Ca(C_2H_3O_2)_2$**
13. nitrous acid	**HNO_2**
14. hydroiodic acid	**HI**
15. sodium bicarbonate	**$NaHCO_3$**
16. nickel(III) iodate	**$Ni(IO_3)_3$**
17. chloric acid	**$HClO_3$**
18. aluminum sulfite	**$Al_2(SO_3)_3$**
19. phosphorous acid	**H_3PO_3**
20. barium hydroxide	**$Ba(OH)_2$**
21. $Sr(CN)_2$	**strontium cyanide**
22. H_3PO_4	**phosphoric acid**
23. $ZnSO_4$	**zinc sulfate**
24. $Cu(SO_3)_2$	**copper(IV) sulfite**
25. H_2SO_4	**sulfuric acid**
26. $AuOH$	**gold(I) hydroxide**
27. K_2CO_3	**potassium carbonate**
28. $NaHCO_3$	**sodium bicarbonate**
29. $HClO_2$	**chlorous acid**
30. $AgNO_2$	**silver nitrite**
31. $HBrO$	**hypobromous acid**
32. KOH	**potassium hydroxide**
33. $HC_2H_3O_2$	**acetic acid**
34. $Ni(BrO_2)_3$	**nickel(III) bromite**
35. HBr	**hydrobromic acid**
36. $NaMnO_4$	**sodium permanganate**
37. $HBrO_2$	**bromous acid**
38. H_3PO_4	**phosphoric acid**
39. $(NH_4)_2SO_4$	**ammonium sulfate**
40. $Ni(OH)_2$	**nickel(II) hydroxide**

Summer Review: Atomic and Chemical Composition

Percent Composition

Laboratory experiments can give the masses of the various elements contained in the total mass of the compound. This common practice is called elemental analysis or mass percent composition or more simply percent composition. Example, H_2O: 2 (1.01 g/mole) + 16.00 g/mole = 18.02 g/mole total (these numbers are the molar masses from the periodic chart.)

$$H\colon \frac{2.02\,g}{10.02}\;x\;100 = 11.02\% \qquad O\colon \frac{16.00g}{18.02}\;x\;100 = 89.88\%$$

Thus water is 11 % hydrogen and 89 % oxygen

Empirical and Molecular Formulas

As you know, the chemical formulas for molecular compounds are not always written in the lowest whole number ratios. We have often used formaldehyde CH_2O and sugar $C_6H_{12}O_6$ as an example. Because of this, the elemental analysis to determine empirical formulas would not allow a chemist to distinguish between sugar and formaldehyde. Another analysis tool, mass spectroscopy would be needed to give one more piece of information: the molar mass of the particular compound being analyzed. So the first 4 steps below will help determine the empirical formula, steps 5-6 must be added to determine the molecular formula.

1. Divide each mass or mass percentage by the molar mass of the element, which will give the number of moles of each element.
2. Divide the results from step 1 by whichever number of moles is the smallest. This maintains the mole ratios from step 1 but bases them on the least abundant element being 1.
3. If some results are far from being whole numbers, multiply all the moles through by a common factor that will convert all the mole amounts to whole numbers or near whole numbers.
4. Round each mole amount to the nearest whole number.
5. If a molar mass is given for the compound, calculate the molar mass for the empirical formula just established from step 4. If the molar mass of the empirical formula is the same as the molar mass of the compound given in the problem, then the empirical formula and the molecular formula are one and the same.
6. If the molar mass of the empirical formula is smaller than the molar mass of the compound, divide the two to determine the whole number factor that the empirical formula must be multiplied by to determine the molecular formula.

Sample Problem

Determine the empirical formula for some compound that was analyzed to be 1.33 g of carbon,0.22 g of hydrogen, and 1.78 g of oxygen. Determine the molecular formula for this compound if the molar mass was measured and found to be 180 g/mole.

- First do step 1 as outlined above.

$$C\colon 1.33\,g\;x\;\frac{1\,mol}{12.01\,g} = 0.111\,mol \qquad H\colon 0.22\,g\;x\;\frac{1\,mol}{1.01\,g} = 0.219\,mol \quad O\colon 1.78\,g\;x\;\frac{1\,mol}{16.00\,g} = 0.111\,mol$$

- ○ Proceed to step 2.

$$C\colon \frac{0.111\,mol}{0.111\,mol} = 1 \quad H\colon \frac{0.219\,mol}{0.111\,mol} = 2 \quad O\colon \frac{0.111mol}{0.111mol} = 1$$

Voilà. The empirical formula is CH_2O

- ○ Since steps 3 and 4 are not necessary, proceed to step 5
  - ○ For CH_2O molar mass = 30 g/mole which is of course not the same as 180 g/mole
- ○ Proceed to step 6
- ○ $\frac{180}{30} = 6$
- ○ Therefore when the factor of 6 is distributed through the empirical formula CH_2O
- ○ Voilà. The empirical formula converts to $C_6H_{12}O_6$

Summer Review: Atomic and Chemical Composition *(Answers on the next page.)*

1. Complete the following table to demonstrate your knowledge of sub-atomic particles

symbol	**# of protons**	**# of neutrons**	**# of electrons**	**atomic #**	**mass #**	**charge**
		24	21			0
			18	15	31	
$^{13}_{6}C$					13	
	17				35	1−
			23	26	58	

2. Write complete electron configurations for the following particles.
   a. S
   b. Zr
   c. P^{3-}
   d. Cr^{2+}

3. Write condensed electron configurations for the following particles.
   a. Ge
   b. Pb

4. Bismuth subsalicylate, is the active ingredient in Pepto-Bismol which is used to treat upset stomachs. This chemical has the formula $C_7H_5BiO_4$.
   a. Calculate the percent composition of bismuth subsalicylate.

   b. If each tablet of the medication contains 262 milligrams of $C_7H_5BiO_4$ calculate the mass of bismuth in 2 tablets.

5. Determine the empirical and molecular formula of benzene which contains only carbon and hydrogen and is 7.74% hydrogen by mass. The molar mass of benzene is 78.1 g/mol.

6. 6.394 g of compound used as a drying agent is analyzed and determined to be 2.788 g phosphorus and 3.606 g oxygen. The molar mass is approximately 284 g/mol. Determine the empirical and molecular formulas of this compound. What is the name of this compound?

Summer Review: Atomic and Chemical Composition *ANSWERS*

1. Complete the following table to demonstrate your knowledge of subatomic particles

symbol	**# of protons**	**# of neutrons**	**# of electrons**	**atomic #**	**mass #**	**charge**
Sc	21	24	21	21	45	0
P^{3-}	15	16	18	15	31	3−
$^{13}{}_{6}C$	6	7	6	6	13	0
Cl^{-}	17	18	18	17	35	1−
$^{58}{}_{26}Fe^{3+}$	26	32	23	26	58	3+

2. Write complete electron configurations for the following particles.

   a. S $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

   b. Zr $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^2$

   c. P^{3-} $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

   d. Cr^{2+} $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4\ 3d^4$ (Cr atom will lose its valence "s" electrons because they are further from the nucleus.)

3. Write condensed electron configurations for the following particles.

   a. Ge [Ar] $4s^2\ 3d^{10}\ 4p^2$

   b. Pb [Xe] $6s^2\ 4f^{14}\ 5d^{10}\ 6p^2$

4. Bismuth subsalicylate, is the active ingredient in Pepto-Bismol which is used to treat upset stomachs. This chemical has the formula $C_7H_5BiO_4$.

   a. $C_7H_5BiO_4\ \ 7(12.01g) + 5(1.008g) + (208.98g) + 4(16g) = 362.09\ g$

$$C\ \frac{84.07}{362.09}\ x\ 100 = 23.22\% \qquad H\ \frac{5.04}{362.09}\ x\ 100 = 1.39\ \%$$

$$Bi\ \frac{208.98}{362.09}\ x\ 100 = 57.71\% \qquad H\ \frac{64}{362.09}\ x\ 100 = 17.68\ \%$$

   b. $2\ x\ 262 = 524\ g\ C_7H_5BiO_4 \quad 524\ g\ C_7H_5BiO_4\ x\ 0.5771 = 302.4\ g\ Bi$

5. Empirical formula: CH and molecular formula: C_6H_6

$$100\%\ total - 7.74\%H = 92.26\%C$$

$$C\ \ 92.26\ g\ x\ \frac{1\ mol}{12.01g} = 7.68\ mol.\ Thus\ CH\ 12.01 + 1.008 = 13.018$$

$$H\ \ 7.74\ g\ x\ \frac{1\ mol}{1.08g} = 7.68\ mol.\ \ \frac{78.1}{13.018} = 6\ \ Thus\ C_6H_6$$

6. Empirical formula: P_2O_5 and molecular formula: P_4O_{10}

$$P\ \ 2.788\ g\ x\ \frac{1\ mol}{30.97g} = 0.090\ mol.\ \frac{0.090}{0.090} = 1\ x\ 2 = 2$$

$$O\ \ 3.606\ g\ x\ \frac{1\ mol}{16g} = 0.225\ mol.\ \frac{0.225}{0.090} = 2.5\ x\ 2 = 5\ \ Thus\ P_2O_5$$

$$2(30.97) + 5(16) = 142, \qquad \frac{284}{142} = 2. Thus\ P_5O_{10}\ \ tetraphosphorus\ decoxide$$

Summer Review: Stoichiometry

A Typical Plan for Solving Stoichiometry Problems

There is a basic pattern to all stoichiometry problems, with variations depending on what information is given and what questions must be answered. You are using dimensional analysis so be sure to set up you calculations with the starting units on top and bottom so it will cancel out and with the desired substance on the top.

A. You must start with a balanced equation.

B. Convert the units of any starting substances into moles. (USE Molar Mass (g/mol) complete this calculation) Since the stoichiometric LINK or RATIO – coefficients from the balanced equation – is in moles, you must work the problem in moles.

C. Reread the problem to determine the information that you need to calculate. Use the stoichiometric LINK to convert from a known substance to a desired substance that you need to answer the question. Note that the LINK is set up with the known substance on the bottom (so it will cancel out) and with the desired substance on the top.

D. If necessary, convert any answers back into grams.

If your problems only involve only moles, then you can skip steps B and E

Sample Problem

Lithium hydroxide is used in space vehicles to remove exhaled carbon dioxide from the living environment by forming solid lithium carbonate and liquid water. What mass of gaseous carbon dioxide can be absorbed by 1.00. kg of lithium hydroxide?

STEP A. balanced equation: $2\ LiOH + CO_2 \rightarrow Li_2CO_3 + H_2O$

Notice that the starting info is given in kilograms, so 1.00 kg should be converted to grams.

$$1.00\ x\ 10^3\ gLiOH\ x\ \frac{1\ mol}{23.99g}\ x\ \frac{1\ mol\ CO_2}{2\ mol\ LiOH}\ x\ \frac{44.01\ g\ CO_2}{1\ mol\ CO_2} = 917\ g\ CO_2$$

Steps in the dimensional analysis: B. C. D.

STEP B. Change to moles using the molar mass of LiOH

STEP C. Change from moles of LiOH to moles of CO_2 using the coefficients from the balanced equation.

STEP D. Change from moles of CO_2 back to grams of CO_2 using the molar mass of CO_2.

Problem Solving Plan - Limiting Reactant and Percent Yield

For limiting reactant problems, the problem will give you information about two reactants as opposed to information given for only reactant and an assumption that the other reactant is present in excess.

A. You must always start with a balanced equation.

B. If it is a limiting reactant problem.... Determine which reactant LIMITS

C. First you *must* change your mass values to moles. NOTE: The mathematical trick to determine which reactant limits is to divide the moles of each reactant by the coefficient (from the balanced equation) associated with that reactant. The number that comes out the smallest indicates which reactant is the limiting one. The limiting reactant is the one that you must base all your other calculations on because it is the substance that limits how much of everything else can be made or is needed.

D. Solve the problem using the same steps for Stoichiometry problems above based on the LR.

E. Of course, the other reactant (if there's only two) will be the excess reactant, and some of it will be left over. (Knowing which reactant limits and which is excess, use the limiting reactant to set up a stoichiometric LINK to determine the mass of the excess reactant that is actually needed to do the reaction. Then, subtract the mass of reactant that you just calculated was needed from the amount of excess reactant started with to determine the mass of excess reactant that is left over.

F. Determining Percent Yield- After determining the LR, use the link to calculate the theoretical amount of the product for which you need a yield.

G. The experimental amount actually produced will be given in the problem. Use it to set up the equation below and determine the percent yield:

$$\boldsymbol{\frac{Experimental}{Theoretical}\ x\ 100\% = Percent\ Yield}$$

Summer Review: Solutions and Gases

In doing mathematical problems in Chemistry, it is highly recommended to write the formula that you use. There are a lot of topics in Chemistry and a lot of formula. To start a problem, it is best to write the equation that you use to justify answer. If a problem isn't justified well enough no credit will be given. Not only during the course but also on the AP exam.

Molarity (M):

This is the most common method of reporting concentration used in AP chemistry.

Molarity is the number of moles of solute per liter of solution. $\boldsymbol{Molairty} = \frac{\boldsymbol{Moles\ of\ solute}}{\boldsymbol{Litere\ of\ Solution}}$

When a more concentrated solution is diluted, the moles of the solute will be the same before and after the dilution. This gives rise to the dilution equation, which is just a variation of the molarity equation. $\mathbf{M_1V_1 = M_2V_2}$

Sample Problems

1. What is the molarity of a solution that contains 6.57 g of magnesium chloride in 250. mL of solution?

2. Given 25.0 mL of a 0.05 M of aluminum sulfate solution.

   (a) How many millimoles of aluminum sulfate does this solution contain?

   (b) How many millimoles of sulfate does this solution contain?

3. If 38.0 mL of a 6.0 M HCl solution are diluted to a final volume of 250 mL, what is the final concentration?

Gases:

There are 4 properties that affect gases; pressure, volume, temperature and moles.
Pressure and volume are inversely related while pressure and temperature are directly related. You should know the relationship between these 4 properties and if they are directly or indirectly related. The easiest way to tell is using the ideal gas law.

The ideal gas law is the most common gas law used in AP Chemistry. The equation is **PV= nRT**. This equation uses all 4 properties of a gas with the universal gas constant. The value of the universal gas constant can change depending on what units it has. Most of the time is it **0.08206 L atom mol^{-1} K^{-1}** but it can be **8.314 J mol^{-1} K^{-1}** and **62.36 L torr mol^{-1} K^{-1}**.

Standard temperature and pressure (**STP**) is also used in AP Chemistry which represent temperature at **273.15K** and **1.0 atm**. The volume of 1 mole at STP is **22.4 L mol^{-1}**.

4. How many moles are in a 49.5 L vessel at 298K and a pressure of 1.15 atm?

5. What is the temperature in degree Celsius of 5.15 grams of H2 in a 115 mL container at 78.6 kPa

Summer Review: Solutions and Gases

ANSWER

1. What is the molarity of a solution that contains 6.57 g of magnesium chloride in 250. mL of solution?

- *First you need to be able to write out the chemical formula for magnesium chloride, and calculate the molar mass.*
  - $MgCl_2$ 24.31 + 2 × 35.45 = 95.21 g/mol
- *Next, convert the mass of magnesium chloride to moles.* $6.57\ g\ MgCl_2\ x\frac{1\ mol\ MgCl_2}{95.21\ g\ MgCl_2} = 0.0690\ mol\ MgCl_2$
- *Next apply the molarity equation.* $\frac{\mathbf{0.069\ mol}}{\mathbf{0.25\ L}} = \mathbf{0.276M}$

Hey look! Molarity which is moles per liter, is also millimoles per milliliter!!

$$\frac{5\ mol}{1L} = \frac{1000\ millimol}{1\ mol}\ x\ \frac{1\ L}{1000\ mL}\ x\ \frac{5\ millimol}{1\ mL}$$

2. Given 25.0 mL of a 0.05 M of aluminum sulfate solution

a. How many millimoles of aluminum sulfate does this solution contain?

M x V = moles 0.05*M* x 25mL = 1.25 millimol

b. How many millimoles of sulfate does this solution contain?

To answer part (b) you need to write out the chemical formula for aluminum sulfate. $Al_2(SO_4)_3$

Thus you can see there are three sulfate ions per aluminum sulfate.

$$1.25\ mmol\ \ Al_2(SO_4)_3\ x\frac{3\ mol\ SO_4^{2-}\ ions}{1\ mol\ Al_2(SO_4)_3} = \mathbf{3.75\ mmol\ SO_4^{2-}\ ions}$$

3. If 38.0 mL of a 6.0 M HCl solution are diluted to a final volume of 250 mL, what is the final concentration?

To answer simply apply the dilution equation $M_1V_1 = M_2V_2$

$M_1V_1 = M_2V_2$, $M_2 = \frac{6M\ x\ 38mL}{250\ mL}$, $\mathbf{M_2 = 0.91M}$

4. How many moles of oxygen are in a 49.5 L vessel at 298K and a pressure of 1.15 atm?

To answer this you will use the ideal gas law. PV=nRT

P = 1.15 atm *PV = nRT*

V = 49.5 L $n = \frac{PV}{RT} = \frac{(1.15\ atm)(49.5\ L)}{(0.08206\ L\ atm\ mol^{-1}\ K^{-1})(298K)} = 2.33\ mol$

T = 298K

5. What is the temperature in degree Celsius of 1.15 grams of O_2 in a 315 mL container at 78.6 kPa

To answer this you will use the ideal gas law again but you need to convert to the correct units before plugging into the equation. . PV=nRT

$P = 78.6\ kPa\ x\ \frac{1\ atm}{101.325\ kPa} = 0.776\ atm$ $V = 315\ mL\ x\ \frac{1\ L}{1000\ mL} = 0.315\ L$

$1.15\ grams\ O_2 = \frac{1\ mol\ O_2}{32\ grams\ O_2} = 0.0360\ mol\ H_2$

$$T = \frac{PV}{nR} = \frac{(0.776\ atm)(0.315\ L)}{(0.0360\ mol)(0.08206\ L\ atm\ mol^{-1}\ K^{-1})} = 82.9K$$

$T_{oC} = T_K + 273.15$

$T_{oC} = 82.9 + 273.15 = \mathbf{356.0^oC}$

Summer Review: Writing Chemical Reactions

Solution	Concentration (Molarity)	Volume (Liters)
$Na_2S_2O_3$	0.500	250.
NOCl	2.00	150.
NaOH	0.600	175

6. Solutions of nickel(II) chloride and potassium phosphate will react to produce a light green precipitate .
   - a. Write a balanced overall chemical equation to represent this reaction.
   - b. What mass of potassium phosphate in solution would be required to react completely with 0.875 g of nickel(II) chloride in solution?
   - c. Calculate the theoretical mass of nickel(II) phosphate that could be produced.
   - d. Convert the overall equation to the net ionic equation.

7. Gallium metal reacts with perchloric acid. *Assume that at room conditions, 24.0 L is the volume of 1.00 mole of gas.*
   - a. Write both overall and net ionic balanced equations to represent this reaction.
   - b. If 2.25 L of hydrogen gas were collected, what mass of gallium metal was dropped into the acid solution?

8. Aluminum will cause copper to reduce from a solution of copper(II) chloride.
   - a. Write a balanced net ionic chemical equation to represent this reaction.
   - b. Is 5.00 g of aluminum enough aluminum to reduce all of the copper(II) ions from 750. ml of a 0.500 M solution?
   - c. If 5.00 g of aluminum is more than enough, what mass would be left over? OR if 5.00 g of aluminum is not enough, what is the additional mass of aluminum that would be needed to remove all of the copper(II) ions from solution?

9. Hydrochloric acid reacts with solid magnesium hydroxide.
   - a. Write a balanced overall chemical equation to represent this reaction.
   - b. What volume, in milliliters, of 0.25 M hydrochloric acid solution would be required to completely react with 4.56 g of magnesium hydroxide?
   - c. Convert the balanced overall equation to a net ionic equation.

10. 1.65 g of zinc is dropped into 150. ml of 0.250 M of hydrobromic acid.
    - a. Write both overall and net ionic balanced chemical equations to represent this reaction.
    - b. Which reactant is the limiting reactant in this chemical reaction?
    - c. Calculate the theoretical mass of solid zinc bromide that should be produced.
    - d. If Consuela and Pete were able to produce 3.67 g of the zinc bromide, what is their percent yield?

11. Eldon and Sally were preparing a sulfuric acid solution for a lab and they needed 500. ml of 0.045 M
    - a. Calculate the volume of 3.0 M solution that Eldon and Sally should measure out into the 500. ml volumetric flask.
    - b. What is the molarity of H^+ ions for the solution that Eldon and Sally prepared?
    - c. What are the number of millimole of H^+ ions that are in Eldon and Sally's 500. ml of 0.045 M sulfuric acid solution?

12. Nitric acid will react with a sodium carbonate solution.
    - a. Write a balanced overall equation to represent this reaction. (Hint: one of the products is a phantom, and will turn into two products. Refer to page 5 of this packet for more information.)
    - b. What volume of 0.25 M nitric acid would be required to react completely with 245 ml of 0.38 M of the sodium carbonate solution.

$$Na_2S_2O_{3(aq)} + 4\,NaOCl_{(aq)} + 2\,NaOH_{(aq)} \rightarrow 2Na_2SO_{4(aq)} + 4\,NaCl_{(aq)} + H_2O_{(L)}$$

13. Answer the following questions about the balanced redox equation shown above.
    - a. The student combines the solutions shown in the table to the right. Determine the limiting reactant.
    - b. How many moles of water would be produced during this reaction?
    - c. Convert the overall equation shown above into a net ionic equation.

Summer Review: Stoichiometry *ANSWERS*

6. Solutions of nickel(II) chloride and potassium phosphate will react to produce a light green precipitate .

   a. $3\ NiCl_{2(aq)} + 2\ K_3PO_{4(aq)} \rightarrow 6\ KCl_{(aq)} + Ni_3(PO_4)_{2(s)}$

   b. $0.875\ g\ NiCl_2\ x\ \frac{1\ mol}{129.59\ g}\ x\ \frac{2\ mol\ K_3PO_4}{3\ mol\ NiCl_2}\ x\ \frac{212.27\ g}{1\ mol} = 0.956\ g\ K_3PO_4$

   c. $0.875\ g\ NiCl_2\ x\ \frac{1\ mol}{129.59\ g}\ x\ \frac{1\ mol\ Ni_3(PO_4)_2}{3\ mol\ NiCl_2}\ x\ \frac{366,01\ g}{1\ mol} = 0.824\ g\ Ni_3(PO_4)_2$

   d. $3Ni^{2+} + 2\ PO_4^{3-} \rightarrow Ni_3(PO_4)_2$

Solution	Concentration (Molarity)	Volume (Liters)
$Na_2S_2O_3$	0.500	250.
NOCl	2.00	150.
NaOH	0.600	175

7. Gallium metal reacts with an aqueous perchloric acid solution. *At room conditions, 24.0 L is the volume of 1.00 mole of gas.*

   a. Overall: $2\ Ga_{(s)} + 6HClO_{4(aq)} \rightarrow 2\ Ga(ClO_4)_{3(aq)} + 3\ H_{2(g)}$ Net: $2Ga_{(s)} + 6H^+_{(aq)} \rightarrow 2Ga^{3+}_{(aq)} + 3H_{2(g)}$

   b. $2.25\ L\ H_2\ x\ \frac{1\ mol}{24.0\ L}\ x\ \frac{2\ mol\ Ga}{3\ mol\ H_2}\ x\ \frac{69.72\ g}{1\ mol} = 4.36\ g\ Ga$

8. Aluminum will cause copper to reduce from a solution of copper(II) chloride.

   a. $2\ Al_{(s)} + 3Cu^{2+}_{(aq)} \rightarrow 2Al^{3+}_{(aq)} + 3Cu_{(s)}$

   b. $0.5M\ x\ 0.75\ L\ x\ \frac{2\ mol}{3\ mol\ Cu^{2+}}\ x\ \frac{26.98\ g}{1\ mol} = 6.745\ g\ Al\ needed$, thus 5.00 g of aluminum would NOT be enough.

   c. 6.745g needed − 5.00g provided = 1.74 g (or 1.75 g) more aluminum would be needed

9. Hydrochloric acid reacts with solid magnesium hydroxide.

   a. $2HCl_{(aq)} + Mg(OH)_{2(s)} \rightarrow 2H_2O_{(l)} + MgCl_{2(aq)}$

   b. $4.56\ g\ Mg(OH)_2\ x\ \frac{1\ mol}{58.33\ g}\ x\ \frac{2\ mol\ HCl}{3\ mol\ Mg(OH)_2}\ x\ \frac{1\ L}{0.25\ mol} = 0.625\ L\ HCl$

   c. This is 625 ml of hydrochloric acid
   (Remember that molarity means moles/Liter, thus it is used in the dimensional analysis upside down.)

   d. $2H^+_{(aq)} + Mg(OH)_{2(s)} \rightarrow 2H_2O_{(l)} + Mg^{2+}_{(aq)}$

10. 0.165 g of zinc is dropped into 150. ml of 0.250 M of hydrobromic acid.

    a. Overall: $2HBr_{(aq)} + Zn_{(s)} \rightarrow 2H_{2(g)} + ZnBr_{2(aq)}$ Net: $2H^+_{(aq)} + Zn_{(s)} \rightarrow 2H_{2(g)} + Zn^{2+}_{(aq)}$

    b. $0.165g\ x\ \frac{1\ mol\ Zn}{65.41\ g} = \frac{0.0252\ mol}{1\ mol\ Zn} > 0.25\ M\ x\ 0.15\ L = \frac{0.0375\ mol\ HBr}{2\ mol\ HBr}$ Thus the HBr acid solution limits.

    c. $0.0.375\ molHBr\ x\ \frac{1\ mol\ ZnBr}{2\ mol\ HBr}\ x\ \frac{225.21\ g}{1\ mol\ ZnBr} = 4.22\ g\ ZnBr_2$

    d. $\frac{Experimental}{Theoretical} = \frac{3.67\ g\ ZnBr_2}{4.22\ g\ ZnBr_2}\ x\ 100 = 87.0\%$

11. Eldon and Sally were preparing a sulfuric acid solution for a lab and they needed 500. ml of 0.045 M

    a. $M_1V_1 = M_2V_2$, $3M\ x\ V_2 = 0.045M\ x\ 500mL$, $V_2 = 7.5\ mL$

    b. $0.045\ M\ H_2SO_4\ x\ \frac{2\ mol\ H^+}{1\ mol\ H_2SO_4} = 0.090\ M\ H^+$

    c. 0.090 M H+ x 500 mL = 45 millimol

12. Nitric acid will react with a sodium carbonate solution.

    a. $2\ HNO_{3(aq)} + Na_2CO_{3(aq)} \rightarrow 2NaNO_{3(aq)} + (H_2CO_3$ *decomposes to* $\Rightarrow)\ H_2O^{(l)} + CO_{2(g)}$

    b. $0.38\ \frac{mol}{L}(M)\ x\ 0.245L\ Na_2CO_3\ x\ \frac{2\ mol\ HNO_3}{1\ mol\ Na_2CO_3}\ x\ \frac{1\ L}{0.25mol} = 0.775\ L\ HNO_3$

    c. *Some of you may look at this and be confused by the single string of dimensional analysis. Perhaps you would prefer to think about solving the problem in three parts as shown below:*

    d. $0.38\ \frac{mol}{L}(M)\ x\ 0.245L\ Na_2CO_3 = 0.0931\ mol\ Na_2CO_3$ $0.0931\ mol\ Na_2CO_3\ x\ \frac{2\ mol\ HNO_3}{1\ mol\ Na_2CO_3} = 1.862\ mol\ Na_2CO_3$

e. $Molairty = \frac{moles}{liter}$ $0.25\ M = \frac{0.1862\ mol}{x}$, $x = 0.775\ L\ HNO_3$

$$Na_2S_2O_{3(aq)} + 4\ NaOCl_{(aq)} + 2\ NaOH_{(aq)} \rightarrow 2Na_2SO_{4(aq)} + 4\ NaCl_{(aq)} + H_2O_{(L)}$$

13. Answer the following questions about the balanced redox equation shown above.

a. $0.500M\ x\ 0.250\ L = 0.125\ mol\ Na_2S_2O_3$ $\frac{0.125\ mol\ Na_2S_2O_3}{1} = 0.125$

$2.00M\ x\ 0.150\ L = 0.300\ mol\ NOCl$ $\frac{0.300\ mol\ NOCl}{4} = 0.075$

$0.60M\ x\ 0.175\ L = 0.105\ mol\ NaOH$ $\frac{0.105\ mol\ NaOHO}{2} = 0.0525$ Thus NaOH is limiting

b. 0.105 mol NaOH x $\frac{1\ mol\ H_2O}{2\ mol\ NaOH}$ = 0.210 mol H_2O

c. $S_2O_3^{2-}{}_{(aq)} + 4OCl^-{}_{(aq)} + 2OH^-{}_{(aq)} \rightarrow 2SO_4^{2-}{}_{(aq)} + 4Cl^-{}_{(aq)} + H_2O_{(L)}$

Note that the sodium spectator ions drop out of the overall equation.