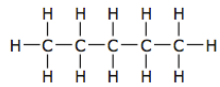
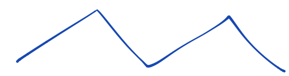
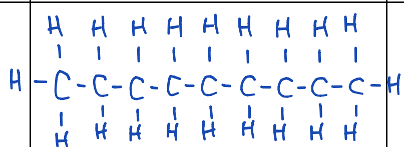
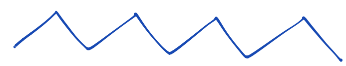
Chemistry 11

Final Exam Review

Name: Key
Date:
Block:

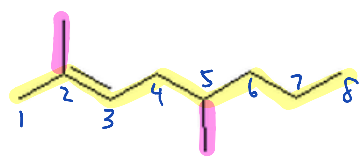
Unit 1: Organic Chemistry

Organic Chemistry I

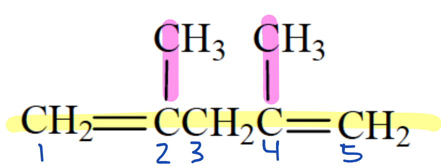
Alkane & Formula	Structural Formula	Condensed Structural Formula	Carbon Skeleton Formula
Pentane C_5H_{12}		$CH_3CH_2CH_2CH_2CH_3$	
Nonane C_9H_{20}		$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	

Organic Chemistry II

Name the following hydrocarbons:



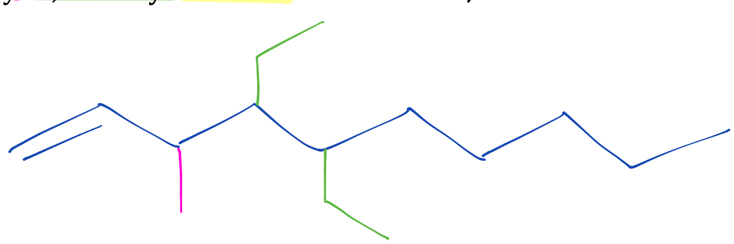
2,5-dimethyl-2-octene



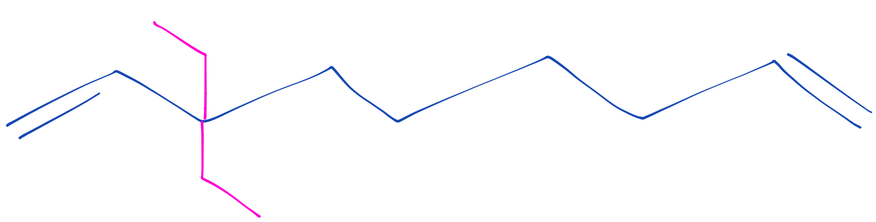
2,4-dimethyl-1,4-pentadiene

Draw the following hydrocarbons:

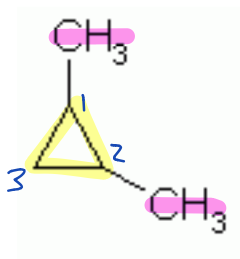
3-methyl-4,5-diethyl-1-decene ⟶ 4,5-diethyl-3-methyl-1-decene

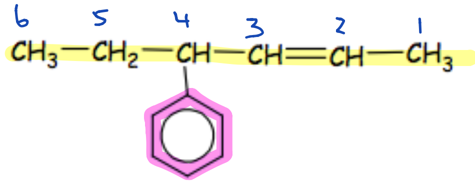


3,3-diethyl-1,8-nonadiene



Organic Chemistry III



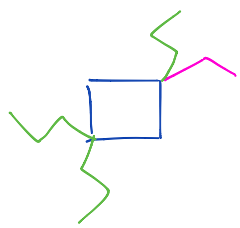


1,2-dimethylcyclopropane

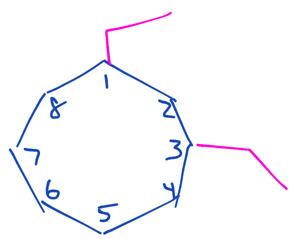
4-phenyl-2-hexene

Draw the following hydrocarbon:

1-ethyl-1,3,3-tripropylcyclobutane

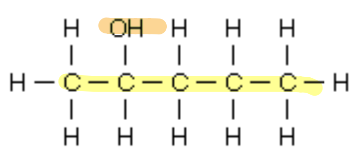


1,3-diethylcyclooctane

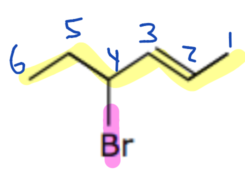


Organic Chemistry IV

Name the following hydrocarbon:



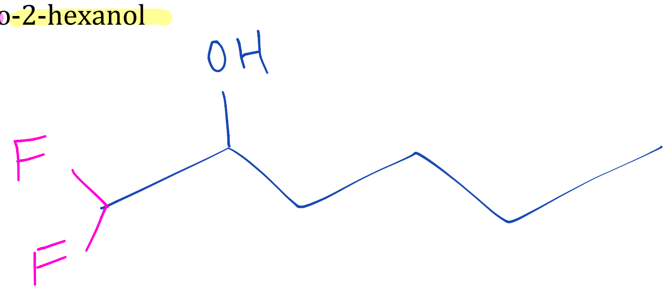
2-pentanol



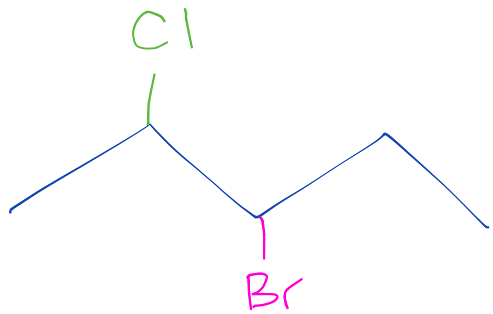
4-bromo-2-hexene

Draw the following hydrocarbon:

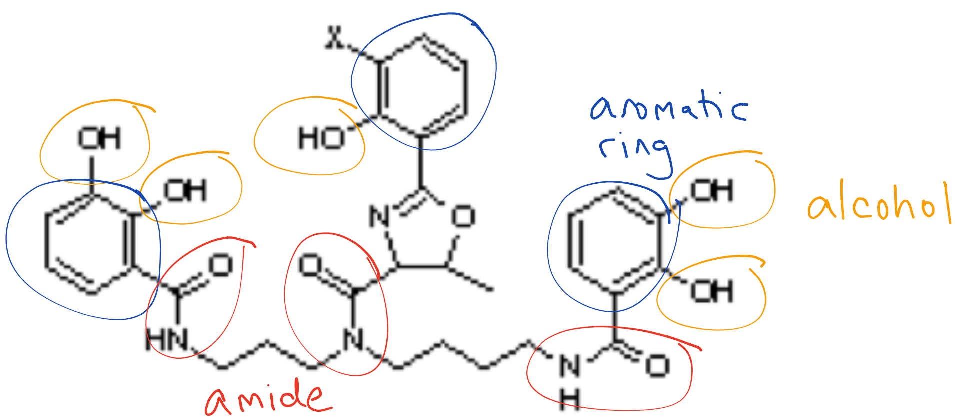
1,1-difluoro-2-hexanol



3-bromo, 2-chloropentane

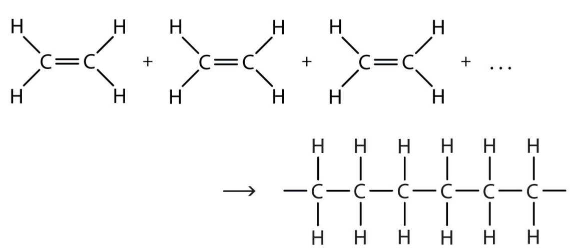


Circle and identify at least 3 different functional groups in the following molecules:

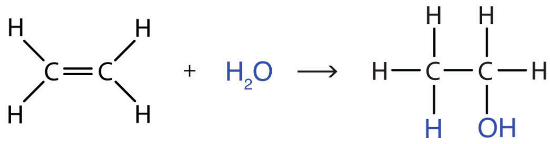


<u>Organic Chemistry V</u>

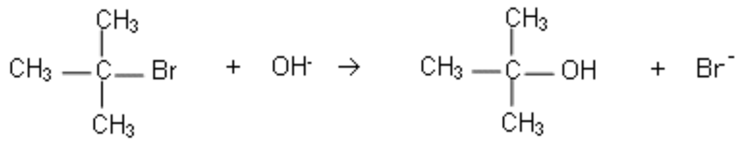
Classify the following type of reactions as combustion, substitution, addition, elimination or polymerization:



polymerization



addition



substitution

Unit 2: Atomic Theory

Atomic Theory I

Element Symbol	Element Name	Atomic Number	Mass Number	Number of protons	Number of neutrons	Number of electrons
Ti^{4+}	Titanium	22	48	22	26	18
Cd	Cadmium	48	112	48	64	48

Calculate the average atomic mass of silver if 13 out of 25 atoms are silver-107 and 12 out of 25 atoms are silver-109.

$\text{Silver}_{107} : 13/25 = 0.52$

$\text{Silver}_{109} = 12/25 = 0.48$

$(0.52 \times 107) + (0.48 \times 109)$

$= \boxed{107.96\,\text{amu}}$

Atomic Theory II-III

Element: **Oxygen**

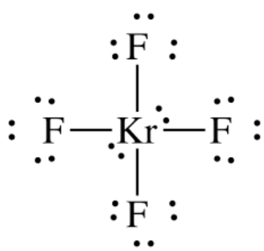
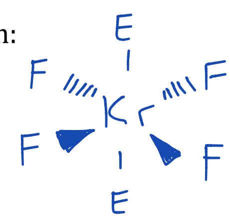
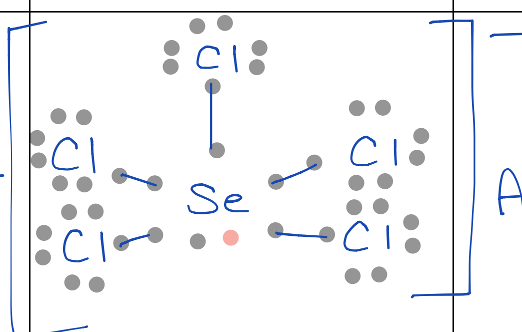
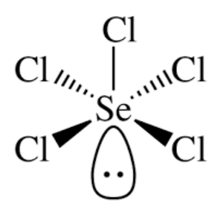
Full Electron Configuration	Core Notation Orbital Diagram
$1s^2 2s^2 2p^4$	[He] ↑↓ (2s) ↑↓ ↑ ↑ (2p)
Core Notation	**Core Notation Orbital Diagram for O^{2-}**
$[He] 2s^2 2p^4$	[He] ↑↓ (2s) ↑↓ ↑↓ ↑↓ (2p)

Element: **Iron**

Full Electron Configuration	Core Notation Orbital Diagram
$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$	$[Ar]\ \underset{4s}{\uparrow\downarrow}\ \ \underset{3d}{\uparrow\downarrow\ \uparrow\ \uparrow\ \uparrow\ \uparrow}$
Core Notation	**Core Notation Orbital Diagram for Fe^{3+}**
$[Ar]4s^2 3d^6$	$[Ar]\ \underset{4s}{\_\_}\ \ \underset{3d}{\uparrow\ \uparrow\ \uparrow\ \uparrow\ \uparrow}$

Atomic Theory IV

Fill in the blanks for the following table:

Molecule	Lewis Diagram	Notation	Shape
KrF_4		AX_4E_2	Name: Square planar Diagram: 
$SeCl_5^-$		AX_5E	Name: Square pyramidal Diagram: 

Atomic Theory V

Arrange the following from largest atomic radius to smallest atomic radius:

a) Ca, Ba, Mg, Sr

largest ... smallest

Ba > Sr > Ca > Mg

b) Explain how you arranged the above

Atomic radius increases as you move down a group because more energy shells are added

Arrange the following from highest ionization energy to lowest ionization energy:

a) Zr, Ag, Mo, Lu

highest → lowest

Ag > Mo > Zr > Lu

b) Explain how you arranged the above

As you move across a period, atomic radius ↓ and ionization energy ↑ because it will take more energy to remove an outer electron if the atom is small (outer electrons closer to the positive nucleus)

Arrange the following from most electronegative to least electronegative:

a) Ca, Mg, B, Be

most → least

B > Be > Mg > Ca

b) Explain how you arranged the above

As you move down a group, atomic radius ↑ and electronegativity ↓ because the ability to attract a bonded electron becomes weaker when the size is larger

Use the following particles to answer the questions below:

Chemical Name:	**Magnesium atom**	**Phosphorus ion**	**Fluorine atom**	**Calcium atom**	**Potassium ion**
Chemical Formula:	Mg 3rd	P^{-3} 3rd	F 2nd	Ca 4th	K^{+} 3rd

a) Rank the particles in atomic size from smallest to biggest (you must use **chemical formulas** and *not* the chemical name):

F → K^{+} → P^{-3} → Mg → Ca

b) Which of the particles would have the greatest electronegativity? F

c) Which of the particles would have the greatest ionization energy? F

Determine the type of bond that forms between the following atoms

a) Na and Cl $3.0 - 0.9 = 2.1$ ionic

b) H and O $3.5 - 2.1 = 1.4$ polar covalent

c) Br and Br $2.8 - 2.8 = 0$ nonpolar covalent

Unit 3: The Mole

Mole I-III

How many moles are in 7.50×10^{24} atoms of lithium?

$$7.50\times10^{24}\,\cancel{\text{atoms}}_{Li} \times \frac{1\ \text{mol}_{Li}}{6.022\times10^{23}\,\cancel{\text{atoms}}_{Li}} = \boxed{12.5\ \text{mol}_{Li}}$$

How many molecules are in 0.23 mol of KCl?

$$0.23\ \cancel{\text{mol}}_{KCl} \times \frac{6.022\times10^{23}\ \text{molecules}_{KCl}}{1\ \cancel{\text{mol}}_{KCl}} = \boxed{1.4\times10^{23}\ \text{molecules}_{KCl}}$$

What does 2.65 mol of sodium chloride weigh?

$$2.65\ \cancel{\text{mol}}_{NaCl} \times \frac{58.44\ g_{NaCl}}{1\ \cancel{\text{mol}}_{NaCl}} = \boxed{155\ g_{NaCl}}$$

How many carbon atoms are in 72.6 g of propane (C_3H_8)?

$$72.6\ \cancel{g}_{C_3H_8} \times \frac{1\ \cancel{\text{mol}}_{C_3H_8}}{44.11\ \cancel{g}_{C_3H_8}} \times \frac{6.022\times10^{23}\ \cancel{\text{molecules}}_{C_3H_8}}{1\ \cancel{\text{mol}}_{C_3H_8}} \times \frac{3\ \text{atoms}_C}{1\ \cancel{\text{molecule}}_{C_3H_8}} = \boxed{2.97\times10^{24}\ \text{atoms}_C}$$

Mole IV

How many mol are in 0.72 L of 2.5 M NaOH?

$$0.72\ \cancel{L}_{NaOH} \times \frac{2.5\ \text{mol}_{NaOH}}{1\ \cancel{L}} = \boxed{1.8\ \text{mol}_{NaOH}}$$

What would be the resulting molar concentration if 1.0 g KCl was dissolved in 2.0 L of water?

$$\frac{1.0\ \cancel{g}_{KCl}}{2.0\ L} \times \frac{1\ \text{mol}_{KCl}}{74.55\ \cancel{g}_{KCl}} = \boxed{\frac{0.0067\ \text{mol}_{KCl}}{1\ L} = 6.7\times10^{-3}\ M_{KCl}}$$

What mass of sodium hydroxide would you need to prepare 2.0 L with a concentration of 0.010 M?

$$2.0\ \cancel{L}_{NaOH} \times \frac{0.010\ \cancel{\text{mol}}_{NaOH}}{1\ \cancel{L}} \times \frac{40.00\ g_{NaOH}}{1\ \cancel{\text{mol}}_{NaOH}} = \boxed{0.80\ g_{NaOH}}$$

Mole V

A sample of caffeine is analyzed and found to contain 1.4844 g C, 0.1545 g H, 0.4947 g O and 0.8661 g N. It was determined that the molar mass is 194.19 g/mol. What is the molecular formula of caffeine?

$$C: \ 1.4844\,g \times \frac{1\,mol}{12.01\,g} = \frac{0.1236\,mol_C}{0.03092\,mol} = 4\,mol_C$$

$$H: \ 0.1545\,g \times \frac{1\,mol}{1.01\,g} = \frac{0.1530\,mol_H}{0.03092\,mol} = 5\,mol_H$$

$$O: \ 0.4947\,g \times \frac{1\,mol}{16.00\,g} = 0.03092\,mol_O \rightarrow 1\,mol_O$$

$$N: \ 0.8661\,g \times \frac{1\,mol}{14.01\,g} = \frac{0.06182\,mol_N}{0.03092\,mol} = 2\,mol_N$$

empirical formula $\rightarrow C_4H_5ON_2 = (4\times12.01) + (5\times1.01) + (1\times16.00) + (2\times14.01)$

molar mass $= 97.11\,g/mol$

$$\frac{194.19\,g/mol}{97.11\,g/mol} = 2 \times (C_4H_5ON_2)$$

$$= \boxed{C_8H_{10}O_2N_4}$$

Find the percent composition of each element by mass of ammonium phosphate.

$$(NH_4)_3PO_4 = (3\times14.01) + (12\times1.01) + (30.97) + (4\times16.00)$$

$$= 149.12\,g/mol$$

$$N: \ \frac{(3\times14.01)}{149.12} \times 100\% = \boxed{28.19\%\ N}$$

$$H: \ \frac{(12\times1.01)}{149.12} \times 100\% = \boxed{8.13\%\ H}$$

$$P: \ \frac{30.97}{149.12} \times 100\% = \boxed{20.77\%\ P}$$

$$O: \ \frac{(4\times16.00)}{149.12} \times 100\% = \boxed{42.92\%\ O}$$

Unit 4: Stoichiometry

Stoichiometry I-II

Write out a complete balanced chemical formula:

a) Magnesium oxide reacts with chlorine gas to form magnesium chloride and oxygen gas.

$$2\,MgO + 2\,Cl_2 \longrightarrow 2\,MgCl_2 + O_2$$

b) Water decomposes into its elements.

$$2\,H_2O \longrightarrow 2\,H_2 + O_2$$

Lithium metal reacts violently with water $2Li + H_2O \longrightarrow H_2 + Li_2O$

a) If 4.37 moles of hydrogen gas are produced, how many moles of lithium metal reacted?

$$4.37\ \cancel{mol\ H_2} \times \frac{2\ mol\ Li}{1\ \cancel{mol\ H_2}} = \boxed{8.74\ mol\ Li}$$

b) How many grams of lithium is this?

$$8.74\ \cancel{mol\ Li} \times \frac{6.94\ g\ Li}{1\ \cancel{mol\ Li}} = \boxed{60.7\ g\ Li}$$

Stoichiometry III

Sodium metal reacts with the oxygen in the air to produce sodium oxide

a) Write out the balanced equation below:

$$4\ Na + O_2 \longrightarrow 2\ Na_2O$$

b) If 9.11 mol of sodium reacted at STP, how many liters of oxygen reacted?

$$9.11\ \cancel{mol\ Na} \times \frac{1\ \cancel{mol\ O_2}}{4\ \cancel{mol\ Na}} \times \frac{22.4\ L\ O_2}{1\ \cancel{mol\ O_2}} = \boxed{51.0\ L\ O_2}$$

c) If 2.3L of 0.45M sodium reacted, how many grams of sodium oxide were produced?

$$2.3\ \cancel{L\ Na} \times \frac{0.45\ \cancel{mol\ Na}}{1\ \cancel{L\ Na}} \times \frac{2\ \cancel{mol\ Na_2O}}{4\ \cancel{mol\ Na}} \times \frac{61.98\ g\ Na_2O}{1\ \cancel{mol\ Na_2O}} = \boxed{32\ g\ Na_2O}$$

The formula for benzoic acid is $C_7H_6O_2$

a) What is the balanced combustion reaction?

$$2\ C_7H_6O_2 + 15\ O_2 \longrightarrow 14\ CO_2 + 6\ H_2O$$

b) What volume of 3.8g of 1.72M $C_7H_6O_2$ is required for this reaction?

$$3.8\ \cancel{g\ C_7H_6O_2} \times \frac{1\ \cancel{mol\ C_7H_6O_2}}{122.13\ \cancel{g\ C_7H_6O_2}} \times \frac{1\ L\ C_7H_6O_2}{1.72\ \cancel{mol\ C_7H_6O_2}} = \boxed{0.018\ L\ C_7H_6O_2}$$

Stoichiometry IV

Given the balanced reaction:

$$4\ FeS + 7\ O_2 \rightarrow 2\ Fe_2O_3 + 4\ SO_2$$

A 439.5 g sample of FeS is mixed with 256.0 g of O_2.

a) Identify the limiting reactant.

$$439.5\ \cancel{g\ FeS} \times \frac{1\ \cancel{mol\ FeS}}{87.92\ \cancel{g\ FeS}} \times \frac{2\ mol\ Fe_2O_3}{4\ \cancel{mol\ FeS}} = 2.499\ mol\ Fe_2O_3$$

$$256.0\ \cancel{g\ O_2} \times \frac{1\ \cancel{mol\ O_2}}{32.00\ \cancel{g\ O_2}} \times \frac{2\ mol\ Fe_2O_3}{7\ \cancel{mol\ O_2}} = 2.286\ mol\ Fe_2O_3$$

$\therefore$ $\boxed{O_2 \text{ is the limiting reactant}}$

b) Calculate the mass of each product that is produced.

$$2.286\ \cancel{mol\ Fe_2O_3} \times \frac{159.70\ g\ Fe_2O_3}{1\ \cancel{mol\ Fe_2O_3}} = \boxed{365.1\ g\ Fe_2O_3}$$

$$256.0\ \cancel{g\ O_2} \times \frac{1\ \cancel{mol\ O_2}}{32.00\ \cancel{g\ O_2}} \times \frac{4\ \cancel{mol\ SO_2}}{7\ \cancel{mol\ O_2}} \times \frac{64.07\ g\ SO_2}{1\ \cancel{mol\ SO_2}} = \boxed{292.9\ g\ SO_2}$$

c) Calculate the mass of the excess reactant left over.

$$256.0\ \cancel{g\ O_2} \times \frac{1\ \cancel{mol\ O_2}}{32.00\ \cancel{g\ O_2}} \times \frac{4\ \cancel{mol\ FeS}}{7\ \cancel{mol\ O_2}} \times \frac{87.92\ g\ FeS}{1\ \cancel{mol\ FeS}} = 401.9\ g\ FeS$$

$$439.5\ g - 401.9\ g = \boxed{37.6\ g\ FeS}$$

Stoichiometry V

Consider the reaction:

$$\underline{4}\ Al + \underline{3}\ O_2 \rightarrow \underline{2}\ Al_2O_3$$

theoretical actual

a) A 20.0 g sample of Al reacts to produce 32.7g of Al_2O_3. What is the percentage yield of the reaction?

$$20.0\,\cancel{g\,Al} \times \frac{1\,\cancel{mol\,Al}}{26.98\,\cancel{g\,Al}} \times \frac{2\,\cancel{mol\,Al_2O_3}}{4\,\cancel{mol\,Al}} \times \frac{101.96\,g\,Al_2O_3}{1\,\cancel{mol\,Al_2O_3}} = 37.8\,g\,Al_2O_3$$

$$\%\ yield = \frac{actual}{theoretical} \times 100\% = \frac{32.7g}{37.8g} \times 100\% = \boxed{86.5\%}$$

actual theoretical

b) If this reaction has a percentage yield of 74.2%, what mass of Al_2O_3 can be produced with 50.0g of Al?

$$50.0\,\cancel{g\,Al} \times \frac{1\,\cancel{mol\,Al}}{26.98\,\cancel{g\,Al}} \times \frac{2\,\cancel{mol}\,Al_2O_3}{4\,\cancel{mol\,Al}} \times \frac{101.96\,g\,Al_2O_3}{1\,\cancel{mol\,Al_2O_3}} = 94.5\,g\,Al_2O_3$$

theoretical

$$74.2\% = \frac{x}{94.5g} \times 100\%$$

$$x = 0.742 \times 94.5g = \boxed{70.1\,g\,Al_2O_3}$$

actual

Consider the reaction:

$$\underline{4}\ KO_2 + \underline{2}\ CO_2 \rightarrow \underline{2}\ K_2CO_3 + \underline{3}\ O_2$$

a) A 30.0g sample of KO_2 is 59.3% pure. What mass of K_2CO_3 can the sample produce?

$$59.3\% = \frac{x}{30.0g} \times 100\%$$

$$0.593 \times 30.0g = x$$

$$x = 17.8g\ pure\ KO_2$$

$$17.8\,\cancel{g\,KO_2} \times \frac{1\,\cancel{mol\,KO_2}}{71.10\,\cancel{g\,KO_2}} \times \frac{2\,\cancel{mol\,K_2CO_3}}{4\,\cancel{mol\,KO_2}} \times \frac{138.21\,g\,K_2CO_3}{1\,\cancel{mol\,K_2CO_3}} = \boxed{17.3g\,K_2CO_3}$$

b) Another sample of KO_2 with a mass of 150.0g is reacted so as to produce 89.7g of K_2CO_3. What is the percentage purity of KO_2?

$$89.7\,\cancel{g\,K_2CO_3} \times \frac{1\,\cancel{mol\,K_2CO_3}}{138.21\,\cancel{g\,K_2CO_3}} \times \frac{4\,\cancel{mol\,KO_2}}{2\,\cancel{mol\,K_2CO_3}} \times \frac{71.10\,g\,KO_2}{1\,\cancel{mol\,KO_2}} = 92.3\,g\,KO_2$$

$$\%\ purity = \frac{92.3\,g\,KO_2}{150.0\,g\,KO_2} \times 100\%$$

$$= \boxed{61.5\%\ KO_2}$$

Unit 5: Solution Chemistry

Solution I

Consider a 500. mL solution made by dissolving 6.7 g of $CuSO_4$ in water.

a) What is the molarity of this solution?

$$\frac{6.7\,\cancel{g\,CuSO_4}}{0.500\,L} \times \frac{1\,mol\,CuSO_4}{159.62\,\cancel{g\,CuSO_4}} = \boxed{0.084\,M\,CuSO_4}$$

b) If this solution (from the above question) was then diluted by adding 250 mL of water, what is the final concentration?

$$C_1V_1 = C_2V_2$$

$$(0.084\,M)(500.\,mL) = (C_2)(750.\,mL)$$

$$C_2 = \boxed{0.056\,M\,CuSO_4}$$

or

$$\frac{6.7\,g\,CuSO_4}{0.750\,L} \times \frac{1\,mol\,CuSO_4}{159.62\,g\,CuSO_4} = \boxed{0.056\,M\,CuSO_4}$$

When 350.0 mL of 0.250 M $MgCl_2$ is boiled down to a final volume of 275.0 mL, what is the molarity of the $MgCl_2$ in the resulting solution?

$$C_1V_1 = C_2V_2$$

$$(0.250\,M)(350.0\,mL) = (C_2)(275.0\,mL)$$

$$C_2 = \boxed{0.318\,M\,MgCl_2}$$

Solution II

Write the balanced ionization equation for the following solutes in water:

a) Na_3PO_4

$$Na_3PO_{4\,(aq)} \longrightarrow 3\,Na^+_{(aq)} + PO_4^{3-}{}_{(aq)}$$

b) BaF_2

$$BaF_{2\,(aq)} \longrightarrow Ba^{2+}_{(aq)} + 2\,F^-_{(aq)}$$

250.0 mL of 0.60 M HCl is added to 300.0 mL of 1.0 M HBr. What is the final concentration of each ion in solution?

[HCl]

$C_1V_1 = C_2V_2$

$(0.60M)(250.0mL) = C_2 (550.0mL)$

$C_2 = 0.27M = [HCl]$

[HBr]

$C_1V_1 = C_2V_2$

$(1.0M)(300.0mL) = C_2 (550.0mL)$

$C_2 = 0.55M = [HBr]$

$HCl \longrightarrow H^+ + Cl^-$

0.27M   0.27M   0.27M

$HBr \longrightarrow H^+ + Br^-$

0.55M   0.55M   0.55M

$$\boxed{\begin{array}{l} [H^+] = 0.27M + 0.55M = 0.82M \\ [Cl^-] = 0.27M \\ [Br^-] = 0.55M \end{array}}$$

Write a formula equation, complete ionic equation and net ionic equation for the following reactions:

F   C   N

a. Potassium phosphate and copper (II) chloride

F $2K_3PO_{4(aq)} + 3CuCl_{2(aq)} \longrightarrow 6KCl_{(aq)} + Cu_3(PO_4)_{2(s)}$

C $\cancel{6K^+_{(aq)}} + 2PO_4^{-3}{}_{(aq)} + 3Cu^{2+}{}_{(aq)} + \cancel{6Cl^-_{(aq)}} \longrightarrow \cancel{6K^+_{(aq)}} + \cancel{6Cl^-_{(aq)}} + Cu_3(PO_4)_{2(s)}$

N $3Cu^{2+}{}_{(aq)} + 2PO_4^{-3}{}_{(aq)} \longrightarrow Cu_3(PO_4)_{2(s)}$

b. Silver nitrate and sodium phosphate

F $3AgNO_{3(aq)} + Na_3PO_{4(aq)} \longrightarrow Ag_3PO_{4(s)} + 3NaNO_{3(aq)}$

C $3Ag^+_{(aq)} + \cancel{3NO_3^-{}_{(aq)}} + \cancel{3Na^+_{(aq)}} + PO_4^{-3}{}_{(aq)} \longrightarrow Ag_3PO_{4(s)} + \cancel{3Na^+_{(aq)}} + \cancel{3NO_3^-{}_{(aq)}}$

N $3Ag^+_{(aq)} + PO_4^{-3}{}_{(aq)} \longrightarrow Ag_3PO_{4(s)}$

2. A solution contains the following ions. Using a flow chart, show what compounds could be added and in what order to separate these ions.

★ other answers possible!

OH^-, S^{2-}, SO_4^{2-}

① Add $Mg(NO_3)_{2(aq)}$ → $Mg(OH)_{2(s)}$ ppt

S^{2-}, SO_4^{2-}

② Add $Ca(NO_3)_{2(aq)}$ → $CaSO_{4(s)}$ ppt

S^{2-}

③ Add $Al(NO_3)_{3(aq)}$ → $Al_2S_{3(s)}$ ppt

Solution III

Consider the following results from a titration lab.

3.00 g of NaOH was dissolved to make a 100. mL solution
Below is the volume of the NaOH solution needed to neutralize 10.0 mL H_3PO_4.

	Trial #1	**Trial #2**	**Trial #3**
Initial reading of burette (mL)	0.00	12.45	24.94
Final reading of burette (mL)	12.45	24.94	37.36

NaOH used (mL) 12.45 12.49 12.42

What is the concentration of the standardized solution of NaOH?

$$\frac{3.0\text{g NaOH}}{0.100\text{L}} \times \frac{1\text{ mol NaOH}}{40.00\text{g}} = \boxed{0.750\text{ M}_{\text{NaOH}}}$$

What was the average volume of NaOH was needed?

$$\frac{12.45\text{mL} + 12.49\text{mL} + 12.42\text{mL}}{3} = \boxed{12.45\text{mL}_{\text{NaOH}}}$$

What is the concentration of the acid?

$$3\,NaOH + H_3PO_4 \longrightarrow 3\,H_2O + Na_3PO_4$$

$$0.01245\text{L}_{\cancel{\text{NaOH}}} \times \frac{0.750\text{ mol}_{\text{NaOH}}}{1\,\cancel{\text{L}}_{\text{NaOH}}} \times \frac{1\text{ mol }H_3PO_4}{3\text{ mol}_{\cancel{\text{NaOH}}}} \times \frac{1}{0.0100\text{L}_{H_3PO_4}} = \boxed{0.311\text{ M}_{H_3PO_4}}$$