

## Grade 11 Chemistry Exam Review Answers

1. Fill in the following chart with the number of electrons, protons, neutrons, atomic number, mass number, and the element notations

Atom	Atomic Number	Mass Number	# of Protons	# of neutrons	# of electrons
<b>K<sup>+</sup></b>	19	39.0983	19	20	18
<b>Es</b>	99	252	99	153	99
<b>Mo</b>	42	95.94	42	54	42
<b>P<sup>3-</sup></b>	15	30.97376	15	16	18
Al	<b>13</b>	26.98154	<b>13</b>	<b>14</b>	13
As	33	<b>75</b>	33	<b>42</b>	33
Pt	78	195.08	78	<b>117</b>	<b>78</b>
W	74	<b>184</b>	<b>74</b>	110	74
Es	<b>99</b>	<b>252</b>	99	153	99
Lr	103	<b>260</b>	103	<b>157</b>	103

2. Draw Bohr diagrams and Lewis dot diagrams for the following elements: Li, Ca, Al, C, P, O, F, K

3. Draw Bohr diagrams of the following **IONS**: Na<sup>+</sup>, Mg<sup>2+</sup>, B<sup>3+</sup>, Si<sup>4+</sup>, N<sup>3-</sup>, S<sup>2-</sup>, Cl<sup>-</sup>.

4. Find the average atomic mass of P when the atomic mass with 15 neutrons is 30 is in 77% abundance and the atomic mass with 17 neutrons is 32 is in 23% abundance.  

$$\text{AAM} = (30 \times 0.77) + (32 \times 0.23) = 30.46 \text{ amu}$$
5. Find the Average atomic mass of Ca when the element which has 20 neutrons is in 12% abundance and the element which has 21 neutrons is in 88% abundance.  

$$\text{AAM} = (40 \times 0.12) + (41 \times 0.88) = 40.88 \text{ amu}$$
6. Find the average atomic mass of Cr if the atomic number is 24 and the two isotopes are; 18 neutrons at 97% abundance, and 19 neutrons at 3% abundance.  

$$\text{AAM} = (42 \times 0.97) + (43 \times 0.03) = 42.03 \text{ amu}$$

7. What is ionization energy, electron affinity, and electronegativity?  
 Ionization Energy • The energy required to remove an electron from a gaseous atom  
 Electron Affinity • The energy that accompanies the addition of an electron to a gaseous atom  
 Electronegativity • The tendency of an atom to attract electrons to itself when it is chemically combined with another element.
8. For the following elements decide which one has a larger atomic radius, electronegativity, ionization energy, and reactivity.

		Largest Atomic Radius	Largest Electronegativity	Largest Ionization Energy	Greatest Reactivity
O	Po	Po	O	O	O
B	N	B	N	N	N
Ni	Pt	Pt	Ni	Ni	Pt
Mg	Ra	Ra	Mg	Mg	Ra
K	Fe	K	Fe	Fe	K
Ag	Rb	Rb	Ag	Ag	Rb
Au	Cu	Au	Cu	Cu	Au
Hg	Zn	Hg	Zn	Zn	Hg
I	Cl	I	Cl	Cl	Cl
As	N	As	N	N	N

9. Describe how the atomic radius gets smaller as we add more electrons in a row.  
 As you move to the right on the periodic table, you get more protons in the nucleus which will have a greater pulling force for the electrons, bringing them closer to the nucleus, therefore making a smaller atomic radius to the right.
10. Describe how the reactivity is linked to ionization energy for the metals and electron affinity for the non-metals. The lower the ionization energy, the more an atom wants to get rid of its electron, therefore the faster it will react making a greater reaction. Therefore the Lower the ionization energy, the greater the reactivity.
11. Which family of elements do the following elements belong?

Element	Family
He	Noble Gases
Ca	Alkaline Earth Metals
Pm	Lanthanides
Yb	Lanthanides
Np	Actinides
Fr	Alkali Metals

Element	Family
Cl	Halogens
Cs	Alkali Metals
Es	Actinides
I	Halogens
Sr	Alkaline Earth Metals
Xe	Noble Gases

12. What is the octet rule and what does it mean for any element that has its octet full.  
 • All atoms are striving for a full outer orbital of electrons. Therefore, atoms will lose or gain electrons to get a full outer orbital of electrons
13. What is the bonding capacity of the following elements: P, S, Cl, K, B, N, O, F, Br, Si  
 $P \rightarrow 3, S \rightarrow 2, Cl \rightarrow 1, B \rightarrow 3, N \rightarrow 3, O \rightarrow 2, F \rightarrow 1, Br \rightarrow 1, Si \rightarrow 4$
14. Define the following terms: alloy, metalloid, solution, hydrate  
 Alloy: solid solution of metals  
 Metalloid: Semi-metals – “staircase” line from the top of Group 13 to the bottom of Group 16  
 Solution: a homogeneous mixture of a solvent and one or more solutes  
 Hydrate: a compound that has a specific number of water molecules bonded to each formula unit
15. How is matter classified:

All matter is classified in two groups: mixtures and pure substances. Mixtures can be heterogeneous (all components are visible) and homogeneous (solutions). Pure substances are classified into elements and compounds.

16. Describe the difference between ionic bonds and covalent bonds. Be sure to include which type of elements are joined together for each type of bond, how strong the bond is, if the electrons are either transferred or shared.

<b>Ionic Bonds</b>	<b>Covalent Bonds</b>
Between a Metal (or $\text{NH}_4^+$ ) and a Non-Metal	Between 2 Non-Metals
Bond	Bond
Transfer of Electrons	Shares Electrons

17. Indicate whether the following are ionic or covalent bonds and draw the Lewis structures.

a)  $\text{LiF} \rightarrow$  Ionic Bond      b)  $\text{F}_2 \rightarrow$  Covalent      c)  $\text{MgS} \rightarrow$  Ionic Bond      d)  $\text{O}_2 \rightarrow$  Covalent

e)  $\text{AlF}_3 \rightarrow$  Ionic Bond      f)  $\text{CO}_2 \rightarrow$  Covalent      g)  $\text{H}_2\text{O} \rightarrow$  Covalent      h)  $\text{Mg}_3\text{N}_2 \rightarrow$  Ionic

18. Describe polar covalent, non-polar covalent, pure covalent, and ionic bond with respect to electronegativities.

Pure covalent  $\Delta=0$ , non-polar covalent  $0 < \Delta < 0.4$ , polar covalent  $0.4 < \Delta < 1.7$ , ionic bond  $\Delta > 1.7$

19. Discuss polar vs non-polar substances and their ability to dissolve in different solvents.

Polar dissolves in polar, Non-Polar dissolves in Non-Polar. Polar molecules have an overall difference in the charge while a non-polar molecule will not have a difference in charge.

20. Name the following compounds

NaF	Sodium Fluoride
CaF <sub>2</sub>	Calcium Fluoride
CoO	Cobalt (II) Oxide
Mg <sub>3</sub> N <sub>2</sub>	Magnesium Nitride
ZnBr <sub>2</sub>	Zinc Bromide
CO <sub>2</sub>	Carbon Dioxide
SnCl <sub>2</sub>	Tin (II) Chloride
CrF <sub>2</sub>	Chromium (II) Fluoride
MnO <sub>2</sub>	Manganese (IV) Oxide
MnS <sub>2</sub>	Manganese (IV) Sulfide
Cu <sub>3</sub> N <sub>2</sub>	Copper (II) Nitride
SO <sub>2</sub>	Sulfur Dioxide
AsBr <sub>3</sub>	Arsenic Tribromide
CuO	Copper (II) Oxide
AlBr <sub>3</sub>	Aluminum Bromide
Hg <sub>2</sub> O	Mercury (I) Oxide
Br <sub>2</sub> O	Dibromine Monoxide
FrH	Francium Hydride
SnS <sub>2</sub>	Tin (IV) Sulfide
MnCl <sub>2</sub>	Manganese (II) Chloride
Li <sub>2</sub> O <sub>2</sub>	Lithium Peroxide
CaO	Calcium Oxide
AlN	Aluminum Nitride
KH	Potassium Hydride
BeBr <sub>2</sub>	Beryllium Bromide
SnS	Tin (II) Sulfide

LiBr	Lithium Bromide
SnCl <sub>4</sub>	Tin (IV) Chloride
MgH <sub>2</sub>	Magnesium Hydride
CO	Carbon Monoxide
SbBr <sub>5</sub>	Antimony Pentabromide
Cu <sub>2</sub> O	Copper (I) Oxide
Li <sub>2</sub> O	Lithium Oxide
MnS <sub>2</sub>	Manganese (IV) Sulfide
MnCl <sub>4</sub>	Manganese (IV) Chloride
SrO	Strontium Oxide
HgO	Mercury (II) Oxide
CCl <sub>4</sub>	Carbon Tetrachloride
Cu <sub>3</sub> N	Copper (I) Nitride
CS <sub>2</sub>	Carbon Disulfide
NaBrO <sub>2</sub>	Sodium Bromite
Ca(NO <sub>3</sub> ) <sub>2</sub>	Calcium Nitrate
Fe(ClO) <sub>2</sub>	Iron (II) Hypochlorite
HBrO <sub>2</sub>	Bromous acid
HgCO <sub>3</sub>	Mercury (II) Carbonate
Ba(ClO <sub>4</sub> ) <sub>2</sub>	Barium Perchlorate
Li <sub>3</sub> PO <sub>3</sub>	Lithium Phosphite
CuS	Copper (II) Sulfide
PbF <sub>4</sub>	Lead (IV) Fluoride
MgCO <sub>3</sub>	Magnesium Carbonate
Al <sub>2</sub> (SO <sub>3</sub> ) <sub>3</sub>	Aluminum Sulfite
Ca <sub>3</sub> (PO <sub>3</sub> ) <sub>2</sub>	Calcium Phosphite

21. Write the chemical formula for the following

Sodium Bromide	NaBr	Copper (II) Nitrite	Cu(NO <sub>2</sub> ) <sub>2</sub>
Ferric Hydroxide	Fe(OH) <sub>3</sub>	Magnesium Carbonate	MgCO <sub>3</sub>
Iron (II) Sulfide	FeS	Potassium Sulfite	K <sub>2</sub> SO <sub>3</sub>
Barium Carbonate	BaCO <sub>3</sub>	Lead (IV) Phosphate	Pb <sub>3</sub> (PO <sub>4</sub> ) <sub>4</sub>
Sodium Perchlorate	NaClO <sub>4</sub>	Hypobromous Acid	HbrO
DiHydrogen Monoxide	H <sub>2</sub> O	Bismuth (V) Sulfide	Bi <sub>2</sub> S <sub>5</sub>
Tin (IV) Fluoride	SnF <sub>4</sub>	Manganese (IV) Oxide	MnO <sub>2</sub>
Cesium Sulfite	Cs <sub>2</sub> SO <sub>3</sub>	Silver Iodite	AgIO <sub>2</sub>
Sulfur Trioxide	SO <sub>3</sub>	Calcium Chloride	CaCl <sub>2</sub>
Aluminum hypobromite	Al(BrO) <sub>3</sub>	Calcium Phosphate	Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>
Sodium Oxide	Na <sub>2</sub> O	Lithium Phosphite	Li <sub>3</sub> PO <sub>3</sub>
Silver Perchlorate	AgClO <sub>4</sub>	Zinc Chlorite	Zn(ClO <sub>2</sub> ) <sub>2</sub>
Lithium Sulfate	Li <sub>2</sub> SO <sub>4</sub>	Carbon Tetrachloride	CCl <sub>4</sub>
Cobalt (III) Hydroxide	Co(OH) <sub>3</sub>	Calcium Hypobromite	Ca(BrO) <sub>2</sub>
Magnesium Iodate	Mg(IO <sub>3</sub> ) <sub>2</sub>	Potassium Sulfate	K <sub>2</sub> SO <sub>4</sub>
Nickel (II) Sulfate	NiSO <sub>4</sub>	Antimony (V) Perbromate	Sb(BrO <sub>4</sub> ) <sub>5</sub>
Calcium Phosphite	Ca <sub>3</sub> (PO <sub>3</sub> ) <sub>4</sub>	Silver Nitrate	AgNO <sub>3</sub>

22. Balance the following equations.

- $2 \text{Na} + 2 \text{H}_2\text{O} \rightarrow 2 \text{NaOH} + \text{H}_2$
- $\text{CaCO}_3 + 2 \text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$
- $\text{Mg} + 2 \text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$
- $2 \text{KClO}_3 \rightarrow 2 \text{KCl} + 3 \text{O}_2$
- $\text{C}_3\text{H}_8 + 5 \text{O}_2 \rightarrow 3 \text{CO}_2 + 4 \text{H}_2\text{O}$
- $2 \text{Al} + 3 \text{H}_2\text{SO}_4 \rightarrow \text{Al}_2(\text{SO}_4)_3 + 3 \text{H}_2$
- $2 \text{Fe}_2\text{O}_3 + 3 \text{C} \rightarrow 4 \text{Fe} + 3 \text{CO}_2$

- h)  $4 \text{NH}_3 + 5 \text{O}_2 \rightarrow 4 \text{NO} + 6 \text{H}_2\text{O}$   
 i)  $2 \text{Fe}(\text{OH})_3 + 3 \text{H}_2\text{SO}_4 \rightarrow \text{Fe}_2(\text{SO}_4)_3 + 6 \text{H}_2\text{O}$   
 j)  $\text{CaC}_2 + 2 \text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2 + \text{C}_2\text{H}_2$   
 k)  $\text{CH}_3\text{OH} + \text{O}_2 \rightarrow \text{CO} + 2 \text{H}_2\text{O}$   
 l)  $5 \text{FeCl}_2 + \text{KMnO}_4 + 8 \text{HCl} \rightarrow 5 \text{FeCl}_3 + \text{KCl} + \text{MnCl}_2 + 4 \text{H}_2\text{O}$   
 m)  $3 \text{Cu} + 8 \text{HNO}_3 \rightarrow 3 \text{Cu}(\text{NO}_3)_2 + 2 \text{NO} + 4 \text{H}_2\text{O}$

23. Define the law of conservation of mass → In any physical or chemical reaction, matter is not created nor destroyed, it is conserved.

24. Define the law of definite proportions → In any chemical compound, the elements are always combined in the same proportion by mass.

25. Define the law of constant composition → The percent by mass of an element in a compound is always a constant.

26. What type of reaction are the following unbalance equations. Balance them

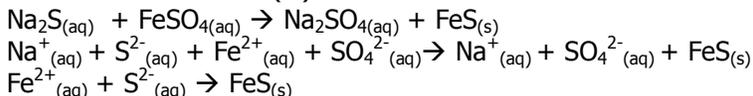
- |   |                     |
|---|---------------------|
| a) $2 \text{Na} + 2 \text{H}_2\text{O} \rightarrow 2 \text{NaOH} + \text{H}_2$  | Single Displacement |
| b) $\text{Mg} + 2 \text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$  | Single Displacement |
| c) $2 \text{KClO}_3 \rightarrow 2 \text{KCl} + 3 \text{O}_2$  | Decomposition       |
| d) $\text{C}_3\text{H}_8 + 5 \text{O}_2 \rightarrow 3 \text{CO}_2 + 4 \text{H}_2\text{O}$                             | Combustion          |
| e) $2 \text{Al} + 3 \text{H}_2\text{SO}_4 \rightarrow \text{Al}_2(\text{SO}_4)_3 + 3 \text{H}_2$                      | Single Displacement |
| f) $2 \text{Fe}_2\text{O}_3 + 3 \text{C} \rightarrow 4 \text{Fe} + 3 \text{CO}_2$                                     | Single Displacement |
| g) $2 \text{Fe}(\text{OH})_3 + 3 \text{H}_2\text{SO}_4 \rightarrow \text{Fe}_2(\text{SO}_4)_3 + 6 \text{H}_2\text{O}$ | Neutralization      |
| h) $3 \text{H}_2 + \text{N}_2 \rightarrow 2 \text{NH}_3$  | Synthesis           |
| i) $\text{CH}_3\text{OH} + \text{O}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O}$                                 | Combustion          |
| j) $\text{BaSO}_4 + 2 \text{NaCl} \rightarrow \text{BaCl}_2 + \text{Na}_2\text{SO}_4$                                 | Double Displacement |
| k) $2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O}$   | Synthesis           |

27. Complete the following reactions. Remember to balance them.

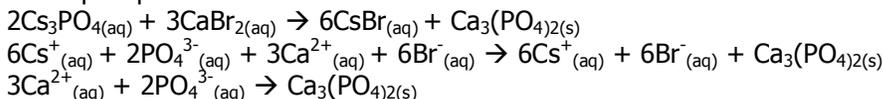
- a)  $\text{Fe} + \text{CuSO}_4 \rightarrow \text{FeSO}_4 + \text{Cu}$   
 b)  $\text{Cu} + \text{AgNO}_3 \rightarrow \text{CuNO}_3 + \text{Ag}$   
 c)  $\text{Mg} + 2 \text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$   
 d)  $2 \text{Li} + 2 \text{H}_2\text{O} \rightarrow 2 \text{LiOH} + \text{H}_2$   
 e)  $\text{Na}_2\text{CO}_3 + \text{CuSO}_4 \rightarrow \text{CuCO}_3 + 2 \text{Na}^+ + \text{SO}_4^{2-}$   
 f)  $(\text{NH}_4)_2\text{SO}_4 + \text{CaCl}_2 \rightarrow \text{CaSO}_4 + 2 \text{NH}_4^+ + 2 \text{Cl}^-$   
 g)  $\text{KOH} + \text{Co}(\text{NO}_3)_2 \rightarrow \text{Co}(\text{OH})_2 + 2 \text{K}^+ + 2 \text{NO}_3^-$   
 h)  $\text{Na}_2\text{S} + \text{Pb}(\text{NO}_3)_2 \rightarrow \text{PbS} + 2 \text{Na}^+ + 2 \text{NO}_3^-$   
 i)  $\text{Zn} + \text{Pb}(\text{NO}_3)_2 \rightarrow \text{Zn}(\text{NO}_3)_2 + \text{Pb}$   
 j)  $\text{Ag} + \text{CuSO}_4 \rightarrow \text{No Reaction}$   
 k)  $2 \text{Al} + 3 \text{NiCl}_2 \rightarrow 2 \text{AlCl}_3 + 3 \text{Ni}$   
 l)  $\text{Mg} + \text{H}_2\text{SO}_4 \rightarrow \text{MgSO}_4 + \text{H}_2$   
 m)  $\text{MgS} + \text{Cu}(\text{ClO}_4)_2 \rightarrow \text{CuS} + \text{Mg}^{2+} + 2 \text{ClO}_4^-$   
 n)  $\text{Ba}(\text{OH})_2 + \text{ZnSO}_4 \rightarrow \text{BaSO}_4 + \text{Zn}(\text{OH})_2$   
 o)  $\text{KBr} + \text{AgOH} \rightarrow \text{AgBr} + \text{K}^+ + \text{OH}^-$   
 p)  $3 \text{CaS} + \text{Ni}_2(\text{SO}_4)_3 \rightarrow 3 \text{CaSO}_4 + \text{Ni}_2\text{S}_3$

28. For the following pairs of aqueous solutions write the balanced chemical equation, total ionic equation and net ionic equation.

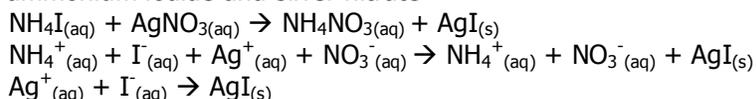
a) sodium sulfide and iron (II) sulfate



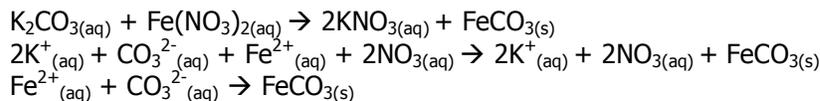
b) cesium phosphate and calcium bromide



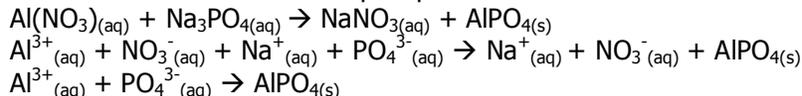
c) ammonium iodide and silver nitrate



d) potassium carbonate and iron (II) nitrate



e) aluminum nitrate and sodium phosphate



29. What is the molar mass of the following.

a) $\text{NH}_3$	= 14 + 3(1)	= 17 g/mol
b) $\text{AgNO}_3$	= 107.868 + 14 + 3(16)	= 170 g/mol
c) $\text{H}_2\text{O}$	= 2(1) + 16	= 18 g/mol
d) $\text{C}_6\text{H}_{12}\text{O}_6$	= 6(12) + 12(1) + 6(16)	= 180 g/mol
e) $\text{AlCl}_3$	= 27 + 3(35.45)	= 133.35 g/mol
f) $\text{Mg}(\text{BrO}_4)_2$	= 24.3 + 2(79.9) + 8(16)	= 312.1 g/mol
g) $\text{Fe}_2(\text{CO}_3)_3$	= 2(55.845) + 3(12) + 9(16)	= 291.69 g/mol
h) $\text{CO}_2$	= 12 + 2(16)	= 44 g/mol

30. How many moles of  $\text{AlBr}_3$  are there if there is:

a) 4.6 grams	$n=m/M$	$n=4.6/266.7$	$n=0.0172$ mol
b) 3.9 grams	$n=m/M$	$n=3.9/266.7$	$n=0.0146$ mol
c) $2.3 \times 10^6$ g	$n=m/M$	$n=2.3 \times 10^6/266.7$	$n=8625$ mol

31. How many grams of  $\text{B}_2\text{S}_3$  is there if there is:

a) 3.8 moles	$m=nM$	$n=3.8 \times 117.6$	$m=447$ g
b) 2.9 moles	$m=nM$	$n=2.9 \times 177.6$	$m=341$ g
c) $7.3 \times 10^4$	$m=nM$	$n=7.3 \times 10^4 \times 177.6$	$m=8.59 \times 10^6$ g

32. How many atoms of He are there if there are:

a) 4.7 moles	$=4.7 \times 6.022 \times 10^{23}$	$=2.83 \times 10^{24}$ atoms
b) 2.9 moles	$=2.9 \times 6.022 \times 10^{23}$	$=1.75 \times 10^{24}$ atoms
c) 8.6 moles	$=8.6 \times 6.022 \times 10^{23}$	$=5.18 \times 10^{24}$ atoms

33. How many atoms of O is there in:

a) 7.8 moles of $\text{AgNO}_3$	$=7.8 \times 6.022 \times 10^{23} \times 3$	$=1.4 \times 10^{25}$ atoms
b) 9.2 moles of $\text{CO}_2$	$=9.2 \times 6.022 \times 10^{23} \times 2$	$=1.1 \times 10^{25}$ atoms
c) 3.3 moles of $\text{O}_2$	$=3.3 \times 6.022 \times 10^{23} \times 2$	$=4.0 \times 10^{24}$ atoms

34. Calculate the percentage by mass of each element in the following compounds.

a) $\text{CH}_4$	$\%C=1(12)/(1(12)+4(1)) \times 100\%$	$=75\%$
	$\%H=4(1)/(1(12)+4(1)) \times 100\%$	$=25\%$
b) $\text{C}_3\text{H}_8$	$\%C=3(12)/(3(12)+8(1)) \times 100\%$	$=81\%$
	$\%H=8(1)/(3(12)+8(1)) \times 100\%$	$=19\%$
c) $\text{NaHCO}_3$	$\%Na=23/(23+1+12+3(16)) \times 100\%$	$=27.4\%$
	$\%H=1/(23+1+12+3(16)) \times 100\%$	$=1.2\%$
	$\%C=12/(23+1+12+3(16)) \times 100\%$	$=14.3\%$
	$\%O=3(16)/(23+1+12+3(16)) \times 100\%$	$=57.1\%$

35. Iron and oxygen combine to form two different compounds. The formulas of the compounds are  $\text{FeO}$  and  $\text{Fe}_2\text{O}_3$ . Calculate the percentage by mass of iron and oxygen in each compound.

$\text{FeO}$	$\%Fe=55.845/55.845+16 \times 100\%$	$=77.7\%$
	$\%O=16/55.845+16 \times 100\%$	$=22.3\%$
$\text{Fe}_2\text{O}_3$	$\%Fe=2(55.845)/(2(55.845)+(3)16 \times 100\%$	$=70\%$
	$\%O=3(16)/(2(55.845)+(3)16 \times 100\%$	$=30\%$

36. Ammonium nitrate,  $\text{NH}_4\text{NO}_3$ , and ammonium sulphate,  $(\text{NH}_4)_2\text{SO}_4$ , are both used as fertilizers. Show by calculation which compound has the greater percentage by mass of nitrogen.

$\text{NH}_4\text{NO}_3$	$\%N=2(14)/(14+4(1)+14+3(16)) \times 100\%$	$=35\%$
$(\text{NH}_4)_2\text{SO}_4$	$\%N=2(14)/(2(14)+8(1)+32+4(16)) \times 100\%$	$=21.2\%$

37. Determine the empirical formula of each of the following compounds. The percentage composition by mass is given.

a) 85.7% carbon, 14.3% hydrogen				
Assume 100g	C	$n=m/M$	$=85.7/12$	$=7.14$
	H	$n=m/M$	$=14.3/1$	$=14.3$
	Divide both by 7.14		$\text{CH}_2$	
b) 52.9% aluminum, 47.1% oxygen				

Assume 100g	Al	n=m/M	=52.9/27	=1.96
	O	n=m/M	=47.1/16	=2.94

Divide by 1.96 and multiply by 2  $Al_2O_3$

c) 62.6% lead, 8.4% nitrogen, 29.0% oxygen

Assume 100g	Pb	n=m/M	=62.6/207.2	=0.302
	N	n=m/M	=8.4/14	=0.6
	O	n=m/M	=29/16	=1.81

Divide by 0.3  $PbN_2O_6$

38. A compound of carbon, hydrogen, and chlorine consists of 49.0%, 2.75% hydrogen, and 48.3% chlorine by mass. What is the empirical formula of the compound?

Assume 100g	C	n=m/M	=49/12	=4.08
	H	n=m/M	=2.75/1	=2.75
	Cl	n=m/M	=48.3/35.45	=1.36

Divide by 1.36  $C_3H_2Cl$

39. Chemical analysis of rubbing alcohol show that it consists of 59.97% carbon, 13.35% hydrogen, and 26.68% oxygen by mass. What is the empirical formula of rubbing alcohol?

Assume 100g	C	n=m/M	=59.97/12	=5
	H	n=m/M	=13.35/1	=13.35
	O	n=m/M	=26.68/16	=1.67

Divide by 1.67  $C_3H_8O$

40. Chemical analysis of one of the constituents of gasoline showed that it consists of 92.29% C and 7.71% H by mass. If the molecular mass of the compound is 78 g/mol, determine its molecular formula.

Assume 100g	C	n=m/M	=92.29/12	=7.7
	H	n=m/M	=7.71/1	=7.71

Divide by 7.7  $CH$

$$78 = X(12 + 1) \quad X = 6 \quad C_6H_6$$

41. A compound of silicon and fluorine was analyzed and found to consist of 33.0% silicon and 67.0% fluorine by mass. The molecular mass of the compound was determined by experiment to be 170 g/mol. What is the molecular formula of the compound?

Assume 100g	Si	n=m/M	=33/28	=1.18
	F	n=m/M	=67/19	=3.5

Divide by 1.18  $SiF_3$

$$170 = X(28+3(19)) \quad X = 2 \quad Si_2F_6$$

42. Glucose is an important source of energy for organisms. Analysis of a sample of glucose shows that it consists of 39.95% carbon, 6.71% hydrogen, and the remainder oxygen. In a separate experiment, the molar mass of glucose is found to be 180 g/mol. Determine the molecular formula of glucose.

Assume 100g	C	n=m/M	=39.95/12	=3.33
	H	n=m/M	=6.71/1	=6.71
	O	n=m/M	=53.34/16	=3.33

Divide all by 3.33  $CH_2O$

$$180 = X(12+2(1)+16) \quad X=6 \quad C_6H_{12}O_6$$

43.  $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

a) What mass of oxygen is required to react with 1200 g of ethanol

$$C_2H_5OH \quad n=m/M \quad =1200/2(12)+6(1)+16 \quad =26.09 \text{ mol of } C_2H_5OH$$

$$n \text{ of } C_2H_5OH/n \text{ of } C_2H_5OH = n \text{ of } O_2/n \text{ of } O_2 \quad 26.09/1=X/3 \quad n \text{ of } O_2=78.3 \text{ mol}$$

$$O_2 \quad m = n \times M \quad =78.3 \times 2(16) \quad =2504 \text{ g of } O_2$$

b) If 655 g of water is produced, what mass of ethanol is burned?

$$H_2O \quad n=m/M \quad =655/2(1)+16 \quad =36.39 \text{ mol}$$

$$n \text{ of } H_2O/n \text{ of } H_2O = n \text{ of } C_2H_5OH/n \text{ of } C_2H_5OH \quad 36.39/3=X/1 \quad n \text{ of } C_2H_5OH=12.13 \text{ mol}$$

$$C_2H_5OH \quad m = n \times M \quad =12.13 \times (2(12)+6(1)+16) \quad =558 \text{ g}$$

44. Sodium Hydroxide, when mixed with hydrochloric acid, will produce Sodium Chloride and Water.

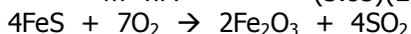
a) Write the balanced equation for the reaction.



$$NaCl \quad n=m/M \quad =225/23+35.45 \quad =3.85 \text{ mol}$$

$$nNaCl/nNaCl = nNaOH/nNaOH \quad 3.85/1=x/1 \quad =3.85 \text{ mol of NaOH}$$

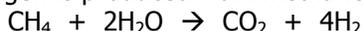
$$NaOH \quad m=nM \quad =(3.85)(23+1+16) \quad =154 \text{ g of NaOH}$$



45. The sulphur dioxide produced in this reaction, and in other reactions similar in it, is responsible for much of the acid rain that falls on North America. What mass of iron(III) oxide can be obtained by the roasting of 774 g of the sulphide ore? What mass of sulphur dioxide is produced?

$$\begin{array}{llll} \text{FeS} & n=m/M & =774/55.845+32 & =8.81 \text{ mol of FeS} \\ n \text{ of FeS}/n \text{ of FeS} = n \text{ of Fe}_2\text{O}_3/n \text{ of Fe}_2\text{O}_3 & & 8.81/4 = X/2 & n \text{ of Fe}_2\text{O}_3=4.4 \text{ mol} \\ \text{Fe}_2\text{O}_3 & m=nXM & =4.4 \times (2(55.845)+3(16)) & =703.5 \text{ g} \\ n \text{ of FeS}/n \text{ of FeS} = n \text{ of SO}_2/n \text{ of SO}_2 & & 8.81/4 = X/4 & n \text{ of SO}_2 = 8.81 \text{ mol} \\ \text{SO}_2 & m=nXM & =8.81 \times (32+2(16)) & =563.8 \text{ g} \end{array}$$

46. Solid carbon dioxide (dry ice) may be used for refrigeration. Some of this carbon dioxide is obtained as a by-product when hydrogen is produced from methane in the following reaction.



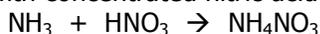
a) What mass of carbon dioxide should be obtained from the complete reaction of 1250 g of methane?

$$\begin{array}{llll} \text{CH}_4 & n=m/M & =1250/(12+4(1)) & =78.125 \text{ mol} \\ n \text{ of CH}_4/n \text{ of CH}_4 = n \text{ of CO}_2/n \text{ of CO}_2 & & 78.125/1=X/1 & n \text{ of CO}_2=78.125 \text{ mol} \\ \text{CO}_2 & m=nXM & =78.125 \times (12+2(16)) & =3437.5 \text{ g} \end{array}$$

b) If the actual yield obtained is 3000 g, what is the percentage yield?

$$\% \text{yield} = \text{Experimental/Theoretical} \times 100\% = 3000/3437.5 \times 100\% = 87.3\%$$

47. Ammonium nitrate is an important compound used both as a fertilizer and as an explosive. It is produced by reacting ammonia with concentrated nitric acid.



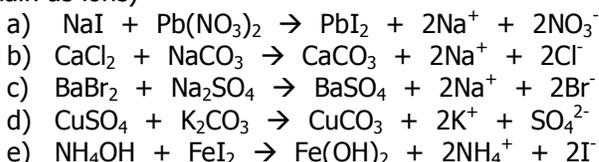
a) What mass of ammonium nitrate can theoretically be produced from the reaction of 375.0 g of ammonia with excess nitric acid?

$$\begin{array}{llll} \text{NH}_3 & n=m/M & =375/(14+3(1)) & =22.06 \text{ mol} \\ n \text{ of NH}_3/n \text{ of NH}_3 = n \text{ of NH}_4\text{NO}_3/n \text{ of NH}_4\text{NO}_3 & & 22.06/1=X/1 & n \text{ of NH}_4\text{NO}_3=22.06 \text{ mol} \\ \text{NH}_4\text{NO}_3 & m=nXM & =22.06 \times (2(14)+4(1)+3(16)) & =1764.7 \text{ g} \end{array}$$

b) If the percentage yield is 88.5%, what mass of ammonium nitrate is actually obtained?

$$\% \text{yield} = \text{Experimental/Theoretical} \times 100\% \quad 0.885 = \text{Experimental}/1764.7 \quad =1561.8 \text{ g}$$

48. Finish the following equations taking into account the solubility rules. Circle all spectator ions(the ones that remain as ions)



49. What is the difference between an Arrhenius acid/base and a Bronsted-Lowry acid/base.

Arrhenius Acid • Any substance that increases the hydronium ion concentration in neutral water

Arrhenius Base • Any substance that increases the hydroxide ion concentration in neutral water

Bronsted-Lowry Acid • Any substance that acts as a proton donor

Bronsted-Lowry Base • Any substance that acts as a proton acceptor

50. What is the concentration of a solution of 3.7 moles of CH<sub>4</sub>

- 1L  $c=n/V = 3.7/1 = 3.7 \text{ mol/L}$
- 7L  $c=n/V = 3.7/7 = 0.529 \text{ mol/L}$
- 450 mL  $c=n/V = 3.7/0.45 = 8.22 \text{ mol/L}$

51. What is the volume of 5.8 moles of a solution of NaCl

- 4.5 moles/L  $V=n/c = 5.8/4.5 = 1.29 \text{ L}$
- 2.9 moles/L  $V=n/c = 5.8/2.9 = 2 \text{ L}$

52. What is the concentration of a solution of 8L of 4.7 moles/L, if it is diluted to 200L.

$$c_1V_1=c_2V_2 \quad (4.7)(8) = (200)c_2 \quad =0.188 \text{ mol/L}$$

53. What is the concentration of a solution of 200 mL of 3.2 mol/L, if it is diluted to 1L.

$$c_1V_1=c_2V_2 \quad (0.2)(3.2) = (1)c_2 \quad =0.64 \text{ mol/L}$$

54. What is the concentration of sulfate ions in the solution that has 4.0 g of ammonium sulfate dissolved in 350 mL of water?



$$\text{moles of ammonium sulfate: } n=m/M \quad n= 4.0\text{g}/ 132\text{g/mol} \quad n = 0.0303 \text{ mol}$$

$$\text{moles of ammonium sulfate} = \text{moles of sulfate}$$

$$c = n/V \quad c = 0.0303 \text{ mol}/ 0.350 \text{ L} \quad c = 0.0866 \text{ mol/L}$$

55. If you perform an acid base titration and place 50 mL of 0.25 mol/L acetic acid into an Erlenmyer and read the burette initially at 3.5 mL and at the endpoint at 25.2 ml, what is the concentration of the base?

$$c_A V_A = c_B V_B \quad (50)(0.25) = (25.2-3.5)c_2 \quad =0.576 \text{ mol/L}$$

56. If the hydronium ion concentration of a solution is  $2.5 \times 10^{-6}$ , what is the hydroxide ion concentration, the pH, and the pOH.  
 $[H^+][OH^-] = 1 \times 10^{-14}$        $[OH^-] = 4 \times 10^{-9} \text{ mol/L}$   
 $pH = -\log[H^+]$        $pH = 5.6$        $pOH = -\log[OH^-]$        $pOH = 8.4$
57. If the hydroxide ion concentration of a solution is  $4.7 \times 10^{-4}$ , what is the hydronium ion concentration, the pH, and the pOH.  
 $[H^+][OH^-] = 1 \times 10^{-14}$        $[H^+] = 2.13 \times 10^{-11} \text{ mol/L}$   
 $pH = -\log[H^+]$        $pH = 10.67$        $pOH = -\log[OH^-]$        $pOH = 3.33$
58. If the pH of a solution is 3.4, what is the pOH, the hydroxide concentration, and the hydronium ion concentration.  
 $pH + pOH = 14$        $pOH = 10.6$   
 $[H^+] = 10^{-pH}$        $[H^+] = 3.98 \times 10^{-4} \text{ mol/L}$        $[OH^-] = 10^{-pOH}$        $[OH^-] = 2.5 \times 10^{-11} \text{ mol/L}$
59. If the pOH of a solution is 8.4, what is the pH, the hydroxide concentration, and the hydronium ion concentration?  
 $pH + pOH = 14$        $pH = 5.6$   
 $[H^+] = 10^{-pH}$        $[H^+] = 2.5 \times 10^{-6} \text{ mol/L}$        $[OH^-] = 10^{-pOH}$        $[OH^-] = 3.98 \times 10^{-9} \text{ mol/L}$
60. Describe Boyle's Law, Charles's Law, and the Pressure-Temperature Law.  
 Boyle's Law • Pressure is inversely proportional to Volume •  $P_1V_1 = P_2V_2$   
 Charles's Law • Volume is directly proportional to Temperature •  $V_1/T_1 = V_2/T_2$   
 Pressure-Temperature Law • Pressure is directly proportional to Temperature •  $P_1/T_1 = P_2/T_2$
61. What is the difference between STP and SATP?  
 STP • Standard Temperature and Pressure     $P = 101.3 \text{ kPa}$ ,  $T = 0^\circ\text{C}$   
 SATP • Standard Ambient Temperature and Pressure     $P = 100 \text{ kPa}$ ,  $T = 25^\circ\text{C}$
62. What is the volume of 1 mol of a gas at STP (Molar Volume)      22.4 L
63. What is the pressure of He if it begins at  $78^\circ\text{C}$  with a pressure of 56 kPa and then gets changed to a temperature of  $109^\circ\text{C}$ .  
 $P_1/T_1 = P_2/T_2$        $P_1/109+273.15 = 56/78+273.15$        $P_1 = 60.5 \text{ kPa}$
64. What is the Temperature of  $\text{O}_2$  gas if it starts at  $45^\circ\text{C}$  and a volume of 7L and ends at a volume of 30L?  
 $V_1/T_1 = V_2/T_2$        $7/45+273.15 = 30/T_2$        $T_2 = 1363.5 \text{ K}$
65. What would be the new temperature of a gas that begins at  $56^\circ\text{C}$  with a pressure of 90 kPa and changes to a pressure of 207 kPa.  
 $P_1/T_1 = P_2/T_2$        $90/56+273.15 = 207/T_2$        $T_2 = 757 \text{ K}$
66. What would be the volume of He if it begins at  $4^\circ\text{C}$  at of volume of 8L and the temperature then increases by  $7^\circ\text{C}$ .  
 $V_1/T_1 = V_2/T_2$        $8/4+273.15 = V_2/7+273.15$        $V_2 = 8.09 \text{ L}$
67. What would be the pressure of  $\text{F}_2$  gas if the initial pressure was 67 kPa and the volume increased from 4L to 9L.  
 $P_1V_1 = P_2V_2$        $(67)(4) = P_2(9)$        $P_2 = 29.8 \text{ kPa}$
68. What is the initial volume of  $\text{Cl}_2$  if it ends with a volume of 6L. The initial pressure is 145 kPa with a temperature of  $70^\circ\text{C}$  and ends with a pressure of 200 kPa with a temperature of  $45^\circ\text{C}$ .  
 $P_1V_1/T_1 = P_2V_2/T_2$        $(145)V_1/70+273.15 = (200)(6)/45+273.15$        $V_1 = 8.93 \text{ L}$
69.  $2\text{KClO}_3 \rightarrow 2\text{KCl} + 3\text{O}_2$   
 Balance the following equation before starting the question.  
 During the formation of 35 g of potassium chloride, what volume of oxygen gas was produced when measured at  $10^\circ\text{C}$  and 100 kPa.  
 KCl       $n = m/M = 35/(39.1+35.45)$        $n = 0.469 \text{ mol of KCl}$   
 $n \text{ of KCl} / n \text{ of KCl} = n \text{ of O}_2 / n \text{ of O}_2$        $0.469/2 = x/3$        $x = 0.704 \text{ mol of O}_2$   
 $\text{O}_2$        $PV = nRT$        $(100)V = (0.704)(8.314)(10+273.15)$        $V = 16.6 \text{ L}$
70. What is the pressure of  $\text{F}_2$  gas if it starts at a volume of 4L and ends at a volume that is increased by 8L and a pressure of 78Kpa.  
 $P_1V_1 = P_2V_2$        $P_1(4) = (78)(12)$        $P_1 = 234 \text{ kPa}$
71. A sample of gas has a volume of 150mL at 260K and 92.3 kPa. What will the new volume be at 376K and 123 kPa?  
 $P_1V_1/T_1 = P_2V_2/T_2$        $(92.3)(0.150)/260 = (123)(V_2)/376$        $V_2 = 163\text{mL}$
72. In a large syringe, 48 mL of ammonia gas at STP is compressed to 24 mL and 110 kPa. What must the new temperature of the gas be?  
 $P_1V_1/T_1 = P_2V_2/T_2$        $(101.3)(0.048)/(273) = (110)(0.024)/T_2$        $T_2 = 148$
73. What is the pressure of Ne if it begins at 100kPa, 8L, and  $33^\circ\text{C}$  that changes to 2L at  $56^\circ\text{C}$ .  
 $P_1V_1/T_1 = P_2V_2/T_2$        $(100)(8)/(33+273.15) = P(2)/(56+273.15)$        $P = 430 \text{ kPa}$
74. What is the temperature of Ar if there is 3.6 g, 560 kPa, and 7.4L. Remember  $R = 8.31 \text{ kPa L/mol K}$

$$n = m/M \quad n = 3.6/39.95 \quad n = 0.0901 \text{ mol}$$

$$PV = nRT \quad (560)(7.4) = (0.0901)(8.314)T \quad T = 5532 \text{ K}$$

75. A balloon contains 2.0 L of He gas at STP. How many moles of He are present?

$$PV = nRT \quad n = PV/RT \quad n = (101.3)(2.0)/(8.314)(273) \quad n = 0.089$$

76.  $N_2 + 3H_2 \rightarrow 2NH_3$

How many moles of the following are required to manufacture 5.0 mol of ammonia?

a) Nitrogen

$$nNH_3/nN_2 = nN_2/nN_2 \quad 5/2 = nN_2/1 \quad nN_2 = 2.5 \text{ mol}$$

b) Hydrogen

$$nNH_3/nH_2 = nH_2/nH_2 \quad 5/2 = nH_2/3 \quad nH_2 = 7.5 \text{ mol}$$

77.  $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

How many moles of oxygen are required to react with

a) 3.0 mol of propane

$$nC_3H_8/nO_2 = nO_2/nO_2 \quad 3/1 = nO_2/5 \quad nO_2 = 15 \text{ mol}$$

b) 20.0 mol of propane

$$nC_3H_8/nO_2 = nO_2/nO_2 \quad 20/1 = nO_2/5 \quad nO_2 = 100 \text{ mol}$$

c) 0.2 mol of propane

$$nC_3H_8/nO_2 = nO_2/nO_2 \quad 0.2/1 = nO_2/5 \quad nO_2 = 1 \text{ mol}$$

78.  $4FeS + 5O_2 \rightarrow 2Fe_2O_3 + 4SO_2$

If I have 4.15 g of Iron Sulfide, how many grams of Iron (III) Oxide will be made?

$$FeS \quad n = m/M \quad = 4.15/55.845 + 32 \quad = 0.0472 \text{ mol}$$

$$nFeS/nFe_2O_3 = nFe_2O_3/nFe_2O_3 \quad 0.0472/4 = x/2 \quad = 0.0236 \text{ mol of } Fe_2O_3$$

$$Fe_2O_3 \quad m = nxM \quad = (0.0236)(2(55.845) + 3(16)) \quad = 3.77 \text{ g}$$

79.  $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

If I have 3.8 g of oxygen, how much water will be made?

$$O_2 \quad n = m/M \quad = 3.8/2(16) \quad = 0.119 \text{ mol}$$

$$nO_2/nO_2 = nH_2O/nH_2O \quad 0.119/3 = x/3 \quad = 0.119 \text{ mol of } H_2O$$

$$H_2O \quad m = nxM \quad = (0.119)(2(1) + 16) \quad = 2.14 \text{ g}$$

80.  $2Na + Cl_2 \rightarrow 2NaCl$

If I have 4.5 g of sodium and 6.4 grams of chlorine, which is the limiting reactant and which is in excess?

$$Na \quad n = m/M \quad = 4.5/23 \quad = 0.196 \text{ mol}$$

$$nNa/nCl_2 = nCl_2/nCl_2 \quad 0.196/2 = x/1 \quad = 0.098 \text{ mol of } Cl_2$$

$$Cl_2 \quad m = nxM \quad = (0.098)(35.45)(2) \quad = 6.95 \text{ g}$$

Since we have 6.4 g of  $Cl_2$  which is lower than 6.95g,  $Cl_2$  is the limiting reactant and Na is in excess

81.  $2Al + 3Br_2 \rightarrow 2AlBr_3$

If I have 3.2 g of aluminum and 5.4 g of bromine, which is the limiting reactant and which is in excess?

$$Al \quad n = m/M \quad = 3.2/26.98 \quad = 0.119 \text{ mol}$$

$$nAl/nAl = nBr_2/nBr_2 \quad 0.119/2 = x/3 \quad = 0.178 \text{ mol of } Br_2$$

$$Br_2 \quad m = nxM \quad = (0.178)(2(79.9)) \quad = 28.42 \text{ g of } Br_2$$

Since we have 5.4 g of  $Br_2$  which is less than 28.42 g,  $Br_2$  is the limiting reactant and Al is in excess

82.  $CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$

What mass of carbon dioxide should be obtained from the complete reaction of 1250 g of methane and 2000 g of water?

$$CH_4 \quad n = m/M \quad = 1250/12 + 4(1) \quad = 78.125 \text{ mol}$$

$$nCH_4/nCH_4 = nH_2O/nH_2O \quad 78.125/1 = x/2 \quad = 156.25 \text{ mol of } H_2O$$

$$H_2O \quad m = nM \quad = (156.25)(2(1) + 16) \quad = 2812.5 \text{ g of } H_2O$$

Since we have 2000g of water which is less than 2812.5,  $H_2O$  is the limiting reactant

$$H_2O \quad n = m/M \quad = 2000/2(1) + 16 \quad = 111.1 \text{ mol}$$

$$nH_2O/nH_2O = nCO_2/nCO_2 \quad 111.1/2 = x/1 \quad = 55.6 \text{ mol of } CO_2$$

$$CO_2 \quad m = nM \quad = (55.6)(12 + 2(16)) \quad = 2444 \text{ g of } CO_2$$

83.  $2N_2H_4 + 7O_2 \rightarrow 4HNO_3 + 2H_2O$

If I have 4.3 g of  $N_2H_4$  and 6.8 g of  $O_2$ , what will the percent yield be if in a

Reaction, I get 4.9 g of  $HNO_3$  produced?

$$N_2H_4 \quad n = m/M \quad = 4.3/(2(14) + 4(1)) \quad = 0.134 \text{ mol}$$

$$nN_2H_4/nN_2H_4 = nO_2/nO_2 \quad 0.134/2 = x/7 \quad = 0.470 \text{ mol of } O_2$$

$$O_2 \quad m = nM \quad = (0.47)(2(16)) \quad = 15.05 \text{ g}$$

Since we have 6.8 g of  $O_2$  which is less than 15.05g  $O_2$  is the limiting reagent

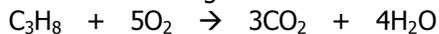
$$O_2 \quad n = m/M \quad = 6.8/2(16) \quad = 0.2125 \text{ mol}$$

$$nO_2/nO_2 = nHNO_3/nHNO_3 \quad 0.2125/7 = x/4 \quad = 0.121 \text{ mol of } HNO_3$$

$$\text{HNO}_3 \quad m=nM \quad = (0.121)(1+14+3(16)) \quad = 7.65 \text{ g of HNO}_2$$

$$\% \text{yield} = \text{Experimental/Theoretical} \times 100\% \quad \% \text{yield} = 4.9/7.65 \times 100\% \quad = 64\%$$

84. Consider the following reaction:



- a) If 1.5 L of propane gas are burned in a barbecue what volume of carbon dioxide is produced and what volume of oxygen is consumed? (Assume all gases are at STP)
- b) If 35 g of propane gas is burned in a barbecue what volume of water vapor is produced assuming SATP?
- c) If 35 g of propane gas is burned in a barbecue what volume of oxygen gas is consumed at SATP?

a) volume to volume = mass to mass

$$1 \text{ mol C}_3\text{H}_8 / 3 \text{ mol CO}_2 = 1.5 \text{ L} / x \quad x = 4.5 \text{ L of carbon dioxide}$$

$$1 \text{ mol C}_3\text{H}_8 / 5 \text{ mol O}_2 = 1.5 \text{ L} / x \quad x = 7.5 \text{ L of oxygen}$$

b)  $n = m/M \quad n = 35\text{g} / 44\text{g/mol} \quad n = 0.795 \text{ mol}$

$$1 \text{ mol C}_3\text{H}_8 / 4 \text{ mol H}_2\text{O} = 0.795 \text{ mol} / x \quad x = 3.18 \text{ mol}$$

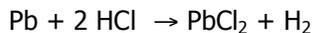
$$PV = nRT \quad V = nRT/P \quad V = 78.8 \text{ L}$$

c)  $n = m/M \quad n = 35\text{g} / 44\text{g/mol} \quad n = 0.795 \text{ mol}$

$$1 \text{ mol C}_3\text{H}_8 / 5 \text{ mol O}_2 = 0.795 \text{ mol} / x \quad x = 3.95 \text{ mol}$$

$$PV = nRT \quad V = nRT/P \quad V = 97.9 \text{ L}$$

85. Excess Pb(II) reacts with 25 mL of 1.5 M hydrofluoric acid to produce hydrogen gas at 22°C and 88.5 kPa. How many liters of dry hydrogen gas are collected?



$$\text{Moles of HCl: } n = cV \quad n = 1.5 \text{ mol/L} \times 0.025\text{L} \quad n = 0.0375 \text{ mol}$$

$$2 \text{ mol HCl} / 1 \text{ mol H}_2 = 0.0375 \text{ mol} / x \quad n = 0.01875 \text{ mol}$$

$$PV = nRT \quad V = nRT/P \quad V = 519.6 \text{ L}$$