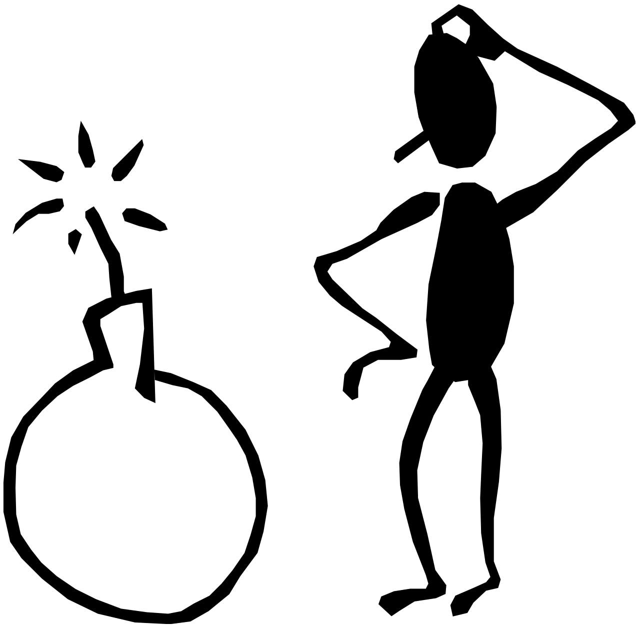
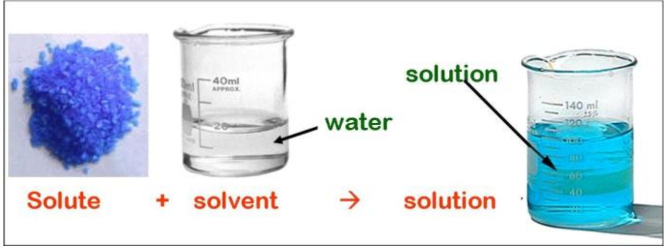
Name: KEY

Chemistry 20 Solutions Worksheets

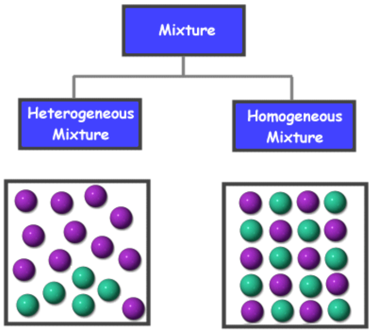


Worksheet 4.1 – Solution Terminology and Theory

1. Illustrate (with a drawing) the difference between:
   a) solute vs. solvent



   b) homogenous mixture vs. heterogenous mixture



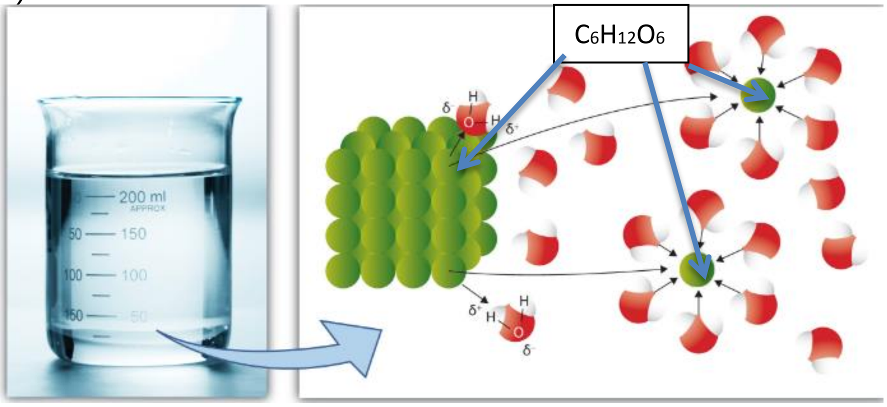
   c) electrolyte vs. non-electrolyte

2. Illustrate two factors that affect the rate of solubility.

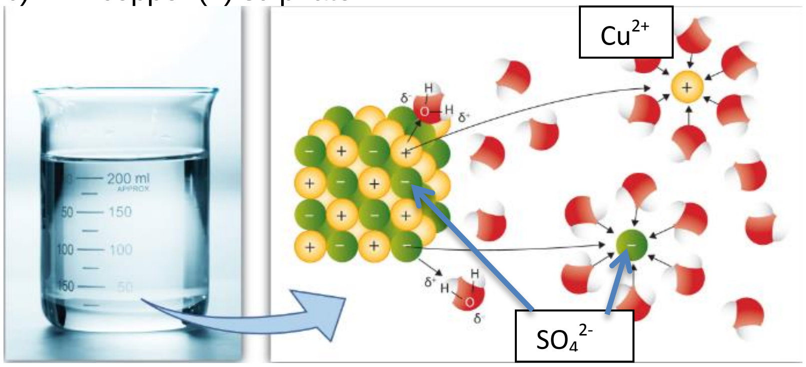
1) Agitation
2) Temperature
3) Surface area

3. Illustrate how the following solids dissolve in water

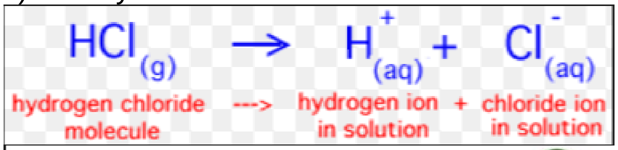
a) Glucose



b) copper (II) sulphate

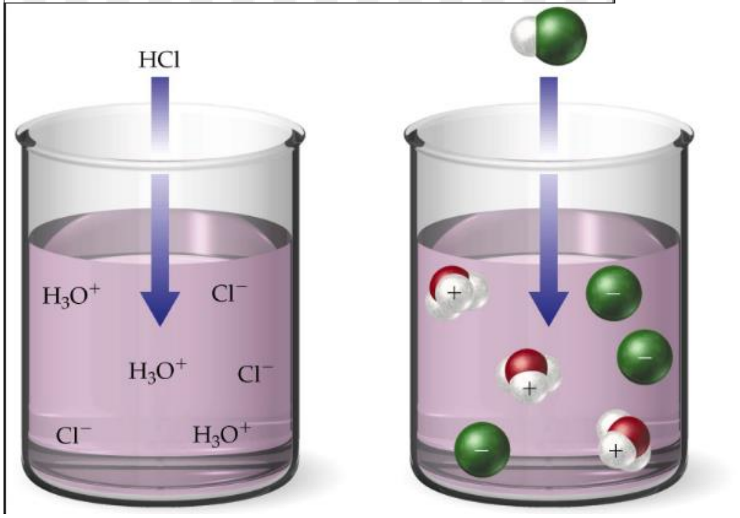


c) hydrochloric acid



$HCl_{(g)} \rightarrow H^{+}_{(aq)} + Cl^{-}_{(aq)}$

hydrogen chloride molecule ---> hydrogen ion in solution + chloride ion in solution



4. Many reactions only occur when the reactants are dissolved in water. Why?

Water allows ions to come into contact with each other.

Worksheet 4.2: Concentration Problems

1. What is the molar concentration of an electroplating solution in which 1.50 mol of copper (II) sulphate are dissolved in 2.00 L of water?

$C=\frac{n}{V}$; $C=\frac{1.50mol}{2.00L}$

C=0.750 mol/L

2. What is the molar concentration of a solution in which 0.240 mol of washing soda, sodium carbonate decahydrate, is dissolved in 480 mL of water to make soft water solution?

C=n/V; C=0.240 mol/0.480 L; C=0.500 mol/L

3. What is the molar concentration of 500 mL of a solution that contains 12.7 g of swimming pool chlorinator, $Ca(OCl)_2$?

1) n=m/M; n=12.7/142.98g/mol; n=0.0888…mol

Ca = 40.08
Ox2 = 32.00
Clx2 =70.90
142.98g/mol

2) C=n/V; C=0.0888…mol / 0.500L; C=0.178 mol/L

4. A given sample of household ammonia contains 156 g of ammonia dissolved in water to form a 2.00L solution. What is the molar concentration of the ammonia solution?

1) n=m/M; n=156g/17.04 g/mol; n=9.154…mol

N = 14.01
Hx3=3.03
17.04 g/mol

2) **C=n/V; C=9.154…mol /2.00L; C=4.58 mol/L**

5. Find the number of moles of sodium phosphate in 2.00L of a 0.100 mol/L sodium phosphate cleaning solution.

n=CV; n=0.100mol/L x 2.00 L; n=0.200mol

6. How many moles of potassium sulphate are there in 500 mL of a 0.242 M solution used to remove rust stains?

n=CV; n=0.242mol/L x 0.500L; n=0.121 mol

7. What mass of sodium bicarbonate must be added to a 2.50 L bowl to obtain a necessary 0.150 mol/L solution?

1) n=CV; n=0.150mol/L x 2.50L; n=0.375 mol
2) m=nM; m=0.375..mol x 84.01g/mol=31.5 g

Na = 22.99
H = 1.01
C = 12.01
Ox3=48.00
84.01 g/mol

8. What volume of a 0.075 mol/L solution would contain the necessary 1.10 mol of sodium phosphate used to remove radiator scales?

V=n/C; V=1.10mol/0.075 mol/L; V=15 L

9. What mass of sodium silicate is necessary to prepare 10.0 L of a 0.00500 mol/L water softening solution?

6.10g

10. How many litres of 0.800 mol/L solution would contain 119.2 g of NaOCl?

1) n=m/M; n=119.2g/74.44g/mol; n=1.60…mol

2) V=n/C; v=1.60…mol/0.800mol/L; v=2.00 L

Na=22.99
O=16.00
Cl=35.45
74.44g/mol

Worksheet 4.3: Making solutions and dilutions

1. A scientist has a container with solid sodium hydroxide and a container of 5.00 mol/L sodium hydroxide.

   a) What are the two ways that the scientists can use to make a solution with a specific volume and concentration?

   Make a solution by mixing a solute of specific mass with a specific volume of solvent (water) OR make a dilution by adding water to a solution that is already made.

   b) What are two ways that the scientist can dilute the 5.00 mol/L solution?

   Evaporate the solvent and then remove some solute and add the solvent back OR add more solvent to a small portion of the solution.

2. Describe the steps you would take to make 100 mL of a 0.200 mol/L sodium chloride solution from salt crystals. Include the equipment and calculations you would make. Remember this is not a reaction.

   1) Calculate moles – n=CV; n=0.200 mol/L x 0.100 L; n=0.0200 mol Na=22.99
   2) Calculate mass – m=nM; m=0.0200mol x 58.44g/mol; m=1.17g Cl=35.45
   3) Weight with a scale; Mix in beaker with 50 mL of water. 58.44 g/mol
   4) Place solution in a 100 mL volumetric flask and fill to the meniscus/calibration line
   5) **Cap and mix**

3. Describe the steps you would take to make 250 mL of a 0.453 mol/L solution of copper (II) sulphate from solid copper (II) sulphate pentahydrate. Include equipment and calculations.

   1) Calculate the moles – n= CV; n=0.453 mol/L x 0.250 L; n=0.113…mol Cu=63.55
   2) Calculate the mass – m=nM; m=0.113…mol x 249.71g/mol; m=28.3g
   3) Wieght it; mix in beaker with about 125 mL
   4) Place in a 250 mL volumetric flask and fill to the meniscus/calibration line
   5) **Cap and mix**
   Equipment: Calculator, weight scale, 250 mL volumetric flask, 125 mL beaker, eye dropper, cap

4. Describe the steps you would take to make 100 mL**(V2)** of a 0.50 mol/L **(C2)** sucrose solution from a container of 2.10 mol/L**(C1)** sucrose solution. Include equipment and calculations.

   1) Calculate volume that needs to be removed. $V_1=C_2V2/C1$;
   V1=0.50mol/Lx0.100L/2.10mol/L
   V1=0.0238; V1=24mL
   2) Remove 24 mL with a graduated pipet
   3) Place in a 100 mL volumetric flask;
   4) fill to calibration line; cap and mix

5. Describe the steps you would take to make 500 mL**(V2)** of a 0.900 mol/L**(C2)** sulphuric acid from a 1.50 L**(V1)** container of 6.00 mol/L**(C2)** sulphuric acid solution. Include equipment and calculations.

   1) Calculate volume; V1=C2V2/C1; V1=0.900mol/L x 0.500L/6.00mol/L =0.0750L or 75.0 mL
   2) Remove 75 mL with a volumetric pipet.
   3) Place in a 500 mL volumetric flask;
   4) fill with 425ml of water to calibration line and cap and mix

6. What is the final concentration of a cleaner if 10 L(**V1)** of concentrated sodium hydroxide (19.1 mol/L)**C1)** is diluted to 400 L(**V2)**?

$C_2 = C_1V_1/V_2$; 19.1mol/L x 10 L / 400L = 0.48 mol/L

7. What is the mass of baking soda (sodium hydrogen carbonate) needed to make 2.5 L of a 1.00mol/L solution?

1) n=CV; 1.00 mol/L x 2.5 L; n=2.5 mol
2) m=nM; 2.5mol x 84.01 g/mol; m=2.1 x 10^2 g or 0.21 kg

8. If 2.0 L of water is added to 1.0 L of a 0.250 mol/L solution of potassium hydroxide what is the final concentration. (Be Careful)

$C_2=C_1V_1/V_2$; C_2=0.250mol/L x 1.0L /3.0 L ; C_2 = 0.083 mol/L

9. CHALLENGE: If 1.50 L of a 12.4 mol/L solution of hydrochloric acid was mixed with 300 mL of a 6.10 mol/L solution of hydrochloric acid, then what would be the final concentration.

$C_{new}=n_{total}/V_{total}$; C_{new} = (1.50Lx12.4mol/L) + (6.10 mol/L x 0.300L)/ (1.50L + 0.300L)
C_{new}=(18.6 mol + 1.83 mol)/1.8 L; C_{new} = 11.4 mol/L

10. CHALLENGE: How much water is added to 50.0 mL**(V1)** of a 0.500 mol/L**(C1)** solution to make a 0.100 mol/L**(C2)** solution?

$V_2=C_1V_1/C_2$; V_2=0.500mol/L x 0.050L/0.100mol/L; V2 = 250 mL
$V_{water} = V_2-V_1$; Vwater = 250 ml – 50 mL; V_{water} = 200 mL

Worksheet 4.4: Dissociation and ionization reactions

1. What type of compounds dissociate? What type of compounds ionize?

   Ionic compounds dissociate **Acids & gases w/hydrogen ionize**

2. Write dissociation or ionization reactions for the following chemicals after they are mixed with water. Show the physical states of all species involved. Use modified ionization reactions when necessary.

   a) Aqueous hydrochloric acid (ionizes)

   OLD: $HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$

   MODIFIED: $HCl_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$

   b) Solid strontium hydroxide (ionic compounds dissociate)

   $Sr(OH)_{2(s)} \rightarrow Sr^{2+}_{(aq)} + 2OH^-_{(aq)}$

   c) Solid copper (II) sulphate pentahydrate

   $CuSO_4\ 5H_2O_{(s)} \rightarrow Cu^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}\ (+\ 5H_2O_{(l)})$

   d) Solid sodium bicarbonate (hydrogen carbonate

   $NaHCO_{3(s)} \rightarrow Na^+_{(aq)} + HCO_3^-{}_{(aq)}$

   e) ammonia gas (acid and bases)

   $NH_{3(g)} + H_2O_{(l)} \rightarrow NH_4^+{}_{(aq)} + OH^-_{(aq)}$

3. For each of the following write dissociation or ionization equations and find the concentration of each ion.

   a) 0.90 mol/L solution of sodium phosphate

   G **R1** **R2**

   $Na_3PO_{4(aq)} \rightarrow 3\ Na^+_{(aq)} + 1\ PO_4^{3-}{}_{(aq)}$

   R1) $$\frac{0.90\,mol}{L(same)} \times \frac{3\,mol\ of\ Na^+}{1\ mol\ of\ Na_3PO_4} = 2.7\,mol/L$$

   R2) $$\frac{0.90\,mol}{L(same)} \times \frac{1\ mol\ of\ PO_4^{3-}}{1\ mol\ of\ Na_3PO_4} = 0.90\,mol/L$$

   b) 0.143 mol/L solution of nitric acid

   G **R1** **R2**

   $1\ HNO_{3(aq)} + H_2O_{(l)} \rightarrow 1\ H_3O^+{}_{(aq)} + 1\ NO_3^-{}_{(aq)}$

   0.143mol/L **0.143 mol/L** **0.143 mol/L**

   c) 0.0135 mol/L solution of calcium hydroxide

   $Ca(OH)_{2(s)} \rightarrow Ca^{2+}_{(aq)} + 2OH^-_{(aq)}$

   0.0135mol/L **x1mol/1mol** **x1mol/2mol**

   =0.0135 mol/L **=0.0270mol/L**

   d) 0.150 mol of hydrogen fluoride gas bubbled into 1.00 L of water

   $HF_{(g)} + H_2O_{(g)} \rightarrow H_3O^+_{(aq)} + F^-_{(aq)}$

   0.150mol **0.150mol/L** **0.150mol/L**

4. What is the concentration of chloride ions in a solution prepared by dissolving 800 g of zinc chloride in 4.50 L of water?

1) n=m/M; n=800/136.28g/mol; n=5.87…mol

2) $ZnCl_{2(s)} \rightarrow Zn^{2+}_{(aq)} + 2Cl^-_{(aq)}$

5.87 mol 11.74…mol

C=n/V; C=2.61mol/L

5. What is the mass of calcium chloride required to prepare 2.000 L of 0.120 mol/L chloride ions?

1) n=CV; 0.120mol/L x 2.00L = 0.240mol

2)$CaCl_{2(s)} \rightarrow Ca2+_{(aq)} + 2Cl-_{(aq)}$

3) X/1mol = 0.240mol/2mol

X=0.120mol

4)m=nM; m=0.120mol x 110.98g/mol; m=13.3 g

6. What is the final concentration if 2.0 L of ***water*** is added to 4.50 L of a 0.89 mol/L solution of sodium chloride?

$C_2=C_1V_1/V_2$; C_2=0.89mol/L x 4.50L/6.50L; C_2=0.62mol/L

Worksheet 4.5: Net Ionic Equations

For the following reactions, write the nonionic equation, the total ionic equation and the net ionic equation.

1. Aqueous solutions of sodium sulphate and barium bromide are mixed.

NON IONIC: $Na_2SO_{4(aq)} + Ba(Br)_{2(aq)} \rightarrow BaSO_{4(s)} + 2NaBr_{(aq)}$

TOTAL IONIC: $\cancel{2Na^+_{(aq)}} + SO_4^{2-}{}_{(aq)} + Ba^{2+}_{(aq)} \cancel{2Br^-_{(aq)}} \rightarrow BaSO_{4(s)} + \cancel{2Na^+_{(aq)}} + \cancel{2Br^-_{(aq)}}$

NET IONIC: $SO_4^{2-}{}_{(aq)} + Ba^{2+}_{(aq)} \rightarrow BaSO_{4(s)}$

Spectator Ions: $Na^+_{(aq)}$; $Br^-_{(aq)}$

2. A lead (II) nitrate solution reacts with sodium sulphide solution

NON IONIC: $Pb(NO_3)_2{}_{(aq)} + Na_2S_{(aq)} \rightarrow 2\ NaNO_{3(aq)} + PbS_{(s)}$

Total IONIC: $Pb^{2+}_{(aq)} + \cancel{2NO_3^-{}_{(aq)}} + \cancel{2Na^+_{(aq)}} + S^{2-}_{(aq)} \rightarrow \cancel{2Na^+_{(aq)}} + \cancel{2NO_3^-{}_{(aq)}} + PbS_{(s)}$

NET IONIC: $Pb^{2+}_{(aq)} + S^{2-}_{(aq)} \rightarrow PbS_{(s)}$

3. Sulphuric acid is neutralized by a potassium hydroxide solution

NON IONIC: $H_2SO_{4(aq)} + 2KOH_{(aq)} \rightarrow K_2SO_{4(aq)} + 2HOH_{(l)}$

TOTAL IONIC: $2H^+_{(aq)} + \cancel{SO_4^{2-}{}_{(aq)}} + \cancel{2K^+_{(aq)}} + 2OH^-_{(aq)} \rightarrow \cancel{2K^+_{(aq)}} + \cancel{SO_4^{2-}{}_{(aq)}} + 2HOH_{(l)}$

NET IONIC: $2H^+_{(aq)} + 2OH^-_{(aq)} \rightarrow 2HOH_{(l)}$

$H^+_{(aq)} + OH^-_{(aq)} \rightarrow HOH_{(l)}$

4. Hydrochloric acid is added to a solution of barium hydroxide

NON IONIC: $2HCl_{(aq)} + Ba(OH)_{2(aq)} \rightarrow BaCl_2{}_{(aq)} + 2HOH_{(l)}$

TOTAL IONIC: $2H^+_{(aq)} + \cancel{2Cl^-_{(aq)}} + \cancel{Ba^{2+}_{(aq)}} + 2OH^-_{(aq)} \rightarrow \cancel{Ba^+_{(aq)}} + \cancel{2Cl^-_{(aq)}} + 2HOH_{(l)}$

NET IONIC: $2H^+_{(aq)} + 2OH^-_{(aq)} \rightarrow 2HOH_{(l)}$

$H^+_{(aq)} + OH^-_{(aq)} \rightarrow HOH_{(l)}$

5. Magnesium metal is added to an aqueous solution of hydrogen bromide

NON IONIC: $Mg_{(s)} + 2HBr_{(aq)} \rightarrow H_{2(g)} + MgBr_{2(aq)}$

TOTAL IONIC: $Mg_{(s)} + 2H^+_{(aq)} \cancel{+ 2Br^-_{(aq)}} \rightarrow H_{2(g)} + Mg^{2+}_{(aq)} \cancel{+ 2Br^-_{(aq)}}$

NET IONIC: $Mg_{(s)} + 2H^+_{(aq)} \rightarrow H_{2(g)} + Mg^{2+}_{(aq)}$

6. Zinc reacts with copper (II) sulphate solution

NON IONIC: $Zn_{(s)} + CuSO_{4(aq)} \rightarrow Cu_{(s)} + ZnSO_{4(aq)}$

TOTAL IONIC: $Zn_{(s)} + Cu^{2+}_{(aq)} + \cancel{SO_4^{2-}{}_{(aq)}} \rightarrow Cu_{(s)} + Zn^{2+}_{(aq)} + \cancel{SO_4^{2-}{}_{(aq)}}$

NET IONIC: $Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Cu_{(s)} + Zn^{2+}_{(aq)}$

7. Zinc reacts with acetic acid (vinegar)

NON IONIC: $Zn_{(s)} + 2CH_3COO\underline{H}_{(aq)} \rightarrow H_{2(g)} + Zn(CH_3COO)_{2(aq)}$

TOTAL IONIC: $Zn_{(s)} + \cancel{2CH_3COO^-_{(aq)}} + 2H^+_{(aq)} \rightarrow H_{2(g)} + Zn^{2+}_{(aq)} + \cancel{2CH_3COO^-_{(aq)}}$

NET IONIC: : $Zn_{(s)} + 2H^+_{(aq)} \rightarrow H_{2(g)} + Zn^{2+}_{(aq)}$

8. Bromine is added to a magnesium iodide solution

NON IONIC: $Br_{2(l)} + MgI_{2(aq)} \rightarrow I_{2(s)} + MgBr_{2(aq)}$

TOTAL IONIC: $Br_{2(l)} + Mg^{2+}_{(aq)} + 2I^-_{(aq)} \rightarrow I_{2(s)} + Mg^{2+}_{(aq)} + 2Br^-_{(aq)}$

NET IONIC: $Br_{2(l)} + 2I^-_{(aq)} \rightarrow I_{2(s)} + 2Br^-_{(aq)}$

Worksheet 4.6: Solution Stoichiometry

1. A 200 mL solution of potassium phosphate reacts with 100 mL of 0.150 mol/L iron (III) sulphate solution. What is the concentration of the potassium phosphate solution?

R G

1) $2\ K_3(PO_4)_{(aq)}$ + $Fe_2(SO_4)_{3(aq)}$ → $3\ K_2(SO_4)_{(aq)}$ + $2\ Fe(PO_4)_{(aq)}$

V =0.200 L V= 0.100L

C= ? C=0.150 mol/L

2) n=CV; n=0.150 mol/Lx0.100L = 0.0150 mol

3) x 2 mol of $K_3(PO_4)_{(aq)}$/ 1 mol of $Fe_2(SO_4)_{3(aq)}$ = 0.0300 mol

4) C = n/V = 0.0300mol/0.200 L

C = 0.150 mol/L

UNIT ANALYSIS METHOD:

$$\frac{0.150\text{ mol } Fe_2(SO_4)_{3(aq)}}{L} \times 0.100\text{ L} \times \frac{2\text{ mol of } 2\ K_3(PO_4)_{(aq)}}{1\text{ mol of } Fe_2(SO_4)_{3(aq)}} \times \frac{1}{0.200\text{ L}} = 0.150\text{ mol/L}$$

2. If 230 mL of a 1.00 mol/L solution of aluminium chlorate is reacted with sufficient lithium hydroxide solution, what mass of precipitate is formed?

R

1) $Al(ClO_3)_{3\ (aq)}$ + $3LiOH_{(aq)}$ → $3LiClO_{3(aq)}$ + $Al(OH)_{3(s)}$

0.230L = V

1.00 mol/L = C

2) n=CV; n=1.00mol/Lx0.230L = 0.230 mol

2) 0.230mol of $Al(ClO_3)_{3\ (aq)}$ x 1mol of $Al(OH)_{3(s)}$ /1mol of $Al(ClO_3)_{3\ (aq)}$ =0.230mol of $Al(OH)_{3(s)}$

m=nM; m=0.230mol x 78.01g/mol

m=17.9 g

UNIT ANALYSIS METHOD:

$$\frac{1.00\text{ mol } Al(ClO_3)_{3\ (aq)}}{L} \times 0.230\text{ L} \times \frac{1\text{ mol of } Al(OH)_{3(s)}}{1\text{ mol of } Al(ClO_3)_{3\ (aq)}} \times \frac{78.01\text{ g}}{1\text{mol}} = 17.9\text{g}$$

3. Predict the mass of magnesium metal that will be required to react with 44.0 ml of 0.200 mol/L hydrochloric acid.

R G

$Mg_{(s)}$ + $2HCl_{(aq)}$ → $H_{2(g)}$ + $MgCl_{2(s)}$

$$\frac{0.200\text{mol of HCl}}{1\text{ L}} \times 0.044\text{L} \times \frac{1\text{ mol Mg}}{2\text{ mol HCl}} \times \frac{24.31\text{g of Mg}}{1\text{ mol of Mg}} = 0.10696\ldots = 0.107\text{ g}$$

4. What volume of 1.00 mol/L $HNO_{3(aq)}$ is required to react completely with 1.20g of $LiOH_{(aq)}$?

R G

1) $HNO_{3(aq)}$ + $LiOH_{(aq)}$ → $LiNO_{3(aq)}$ + $HOH_{(l)}$

2) V=? n=1.20g/23.95g/mol

V n=0.050104mol

3) = 0.050104…mol x 1mol/1mol

=0.050104…mol of $HNO_{3(aq)}$

4) V=n/C; V=0.050104…mol/1.00mol/L

V=0.0501L or 50.1 mL

UNIT ANALYSIS METHOD:

$$\frac{1.20\text{ g } LiOH_{(aq)}}{23.95\text{g/mol } LiOH_{(aq)}} \times \frac{1\text{ mol of } HNO_{3(aq)}}{1\text{ mol of } LiOH_{(aq)}} \times \frac{1\text{ L}}{1.00\text{mol } HNO_{3(aq)}} = 0.0501\text{L or } 50.1\text{ mL of } HNO_{3(aq)}$$

5. A 100 ml sample of sodium sulphide solution is completely reacted with 50.0 ml of 0.250 mol/L lead (II) nitrate solution. Predict the concentration of the $Na_2S_{(aq)}$?

R		G				
$Na_2S_{(aq)}$	+	$Pb(NO_3)_{2\ (aq)}$	+ →	2 $NaNO_{3(aq)}$	+	$PbS_{(s)}$

$$\frac{0.250\ mol\ Pb(NO_3)_{2\ (aq)}}{L} \times 0.050L \times \frac{1\ mol\ of\ Na_2S_{(aq)}}{1\ mol\ of\ Pb(NO_3)_{2\ (aq)}} \times \frac{1}{0.100L\ Na_2S_{(aq)}} = 0.125\ mol/L$$

6. 500 ml of 0.150 mol/L cobalt (II) nitrate solution is reacted with 500 ml of 0.250 mol/L of sodium hydroxide solution producing 4.77 g of precipitate. Find the % yield for this reaction.

G1		G2				R
$Co(NO_3)_{2(aq)}$	+	$2NaOH_{(aq)}$	→	$2NaNO_{3(aq)}$	+	$Co(OH)_{2(s)}$
n=CV		n=CV				n=m/M
n=0.150mol/Lx0.500L		n=0.250mol/Lx0.500L				n=4.77g/92.95g/mol
n=0.075mol		n=0.125mol				n=0.0513…mol (AY)
x 1mol/1mol		x 1mol/2mol				
= 0.075mol (EXCESS)		= 0.0625 mol LIMITING(x 92.95 g/mol = 5.809..g)				
% yield = A/T x 100%;		% yield = 0.0513…mol/0.0625 mol x 100%;				% yield = 82.1%

7. CHALLENGE: Predict the final mass of a 500 g bar of lead that is allowed to react completely with 2.00 L of 2.00 mol/L HCl.

R		G				
$Pb_{(s)}$	+	$2HCl_{(aq)}$	→	$H_{2(g)}$	+	$PbCl_{2(s)}$
500g		n=CV				
		n=2.00mol/L x 2.00L				
		n=4.00mol				

4.00 mol x 1mol of Pb /2 mol of HCl = 2.00 mol of Pb was used

m=nM; m=2.00mol x 207.2g/mol; m=414.40 g

m_{final} = original – used

m_{final} = 500 – 414.40 = 85.6 g left over

8. A 75.0 mL sample of 0.25 mol/L silver chlorate solution reacts with 19.0 mL of 0.50 mol/L copper (II) sulphate solution. What is the concentration of the solution produced? (NOTE: Find out what the **total** volume of the solution produced.)

G1		G2		R
1) 2 $AgClO_{3(aq)}$	+	1 $CuSO_{4(aq)}$	→	$Cu(ClO_3)_{2(aq)}$ + $Ag_2SO_{4(s)}$
2) n=CV		n=CV		C=?
n=0.25mol/Lx0.075L		n=0.50mol/Lx0.019L		
n=0.01875 mol		n=0.0095 mol		
x1mol/2mol		x1mol/1mol		
=0.009375…mol		=0.0095 mol		
LIMITING		EXCESS		

$C=n/V_{total}$; C=0.009375mol/0.094L

C=0.0997; C=0.10 mol/L

Worksheet 4.7: Review of Solutions

1. Answer the following questions
    a) How do solutions differ from heterogeneous mixtures?

    Solutions are uniform and appear as one substance – heterogenous do not.

    b) How do the number of molecules of $C_{12}H_{22}O_{11}$ in 250 mL of a 1.5 mol/L solution of $C_{12}H_{22}O_{11}$ compare to the number of molecules of $C_6H_{12}O_6$ in 250 mL of a 1.5 mol/L $C_6H_{12}O_6$?

    The number of molecules is the same (n=CV; p=nP); However the mass is different

    c) What is the term used to describe two liquids which will **NOT** mix with each other?

    immiscible

    d) What are two factors that affect the amount of solute that dissolves and two factors that affect the rate of dissolving? **Amount: temperature, pressure Rate: temperature, surface area, agitation**

2. Write the equation for each of the following dissolving in water. Use modified Arhenius theory.
    a) Hydrogen chloride gas

    $HCl_{(g)} + H_2O_{(g)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$*IONIZE*

    b) Solid aluminum nitrate

    $Al(NO_3)_{3(s)} \rightarrow Al^{3+}_{(aq)} + 3NO_3^-{}_{(aq)}$ DISSOCIATE

    c) Solid sucrose

    $C_{12}H_{22}O_{11(s)} \rightarrow C_{12}H_{22}O_{11(aq)}$ DISSOLVE

    d) Aqueous nitric acid

    $HNO_{3(aq)} + H_2O_{(g)} \rightarrow H_3O^+_{(aq)} + NO_3^-{}_{(aq)}$*IONIZE*

3. Determine the concentration of each of the following solutes in the solution described.
    a) 0.725 mol of cobalt (II) nitrate in 1.35 L of solution.

    C=n/V; C=0.725mol/1.35L; C=0.537 mol/L

    b) 15.0 g of barium sulphate in 125 mL of solution.

    n=m/M; n=15.0g/233,39g/mol; n=0.0642…mol
    C=n/V; C=0.065…mol/0.125L; C=0.514mol/L

    Ba=137.33
    S=32.06
    Ox4=64.00/233.39g/mol

    c) 1.85×10^{22} molecules of ammonia gas in 400 mL of solution.

    n=p/P; $n=1.85 \times 10^{22} / 6.02 \times 10^{23}$; n=0.0307..mol
    C=n/V; C=0.0307…mol/0.400L; C=0.0768 mol/L

4. Write the dissociation equation and calculate the concentration of each of the ions produced in 1.25 mol/L solution of barium chloride.

$BaCl_{2(s)}$	$\rightarrow$	**$Ba^{2+}_{(aq)}$**	+	**$2Cl^-_{(aq)}$**
1.25mol/L/		**x1mol/1mol**		**2mol/1mol**
		=1.25 mol/L		**=2.50 mol/L**

5. Write the dissociation equation and determine the concentration of the solution if 1.26 mol/L of [Na^+] is found in a sodium phosphate solution.

    $Na_3PO_{4(s)} \rightarrow 3Na^+_{(aq)} + PO_4^{3-}{}_{(aq)}$
    1.26 mol/L x 1 mol/3mol
    =0.420mol/L

6. CHALLENGE: What is the [Cl^-] in a solution made by mixing 200 mL of 0.300 mol/L sodium chloride solution with 350 mL of 0.250 mol/L calcium chloride solution?

$NaCl_{(s)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)}$	**$CaCl_{2(s)} \rightarrow Ca^{2+}_{(aq)} + 2Cl^-_{(aq)}$**	**$C_{final}=n_{total}/V_{total}$**
n=CV; n=0.300mol/Lx0.200L	**n=CV;n=0.250mol/Lx0.350L**	**C=(0.600+0.175)/(0.2 +0.35)**
n=0.0600molx1mol/1mol	**n=0.0875molx2mol/1mol**	**C=0.235mol/0.550L**
n_{Cl}=0.0600mol	**n_{Cl}=0.175 mol**	**C=0.427 mol/L**

Write net ionic equations for the following reactions. (3 marks)

a) lead nitrate solution is mixed with sodium hydroxide

$Pb(NO_3)_{2(aq)} + 2NaOH_{(aq)} \rightarrow 2NaNO_{3(aq)} + Pb(OH)_{2(s)}$

$Pb^{2+}_{(aq)} + \cancel{2NO_3^{-}{}_{(aq)}} + \cancel{2Na^{+}_{(aq)}} + 2OH^{-}_{(aq)} \rightarrow \cancel{2Na^{+}_{(aq)}\ 2NO_3^{-}{}_{(aq)}} + Pb(OH)_{2(s}$

$Pb^{2+}_{(aq)} + 2OH^{-}_{(aq)} \rightarrow Pb(OH)_{2(s)}$

b) barium nitrate reacts with potassium sulphide

$Ba(NO_3)_{2(aq)} + K_2S_{(aq)} \rightarrow 2KNO_{3(aq)} + BaS_{(aq)}$

$\cancel{Ba^{2+}_{(aq)} + 2NO_3^{-}{}_{(aq)} + 2K^{+}_{(aq)} + S^{2-}_{(aq)}} \rightarrow \cancel{2K^{+}_{(aq)} + 2NO_3^{-}{}_{(aq)} + Ba^{2+}_{(aq)} + S^{2-}_{(aq)}}$

NO NET IONIC EQUATION (all ions are spectator ions)

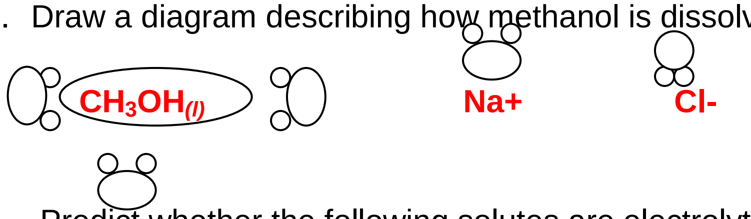
c) nitric acid reacts with barium hydroxide

$2HNO_{3(aq)} + Ba(OH)_{2(aq)} \rightarrow Ba(NO_3)_{2(aq)} + 2HOH_{(l)}$

$2H^{+}_{(aq)} + 2NO_3^{-}{}_{(aq)} + Ba^{2+}_{(aq)} + 2OH^{-}_{(aq)} \rightarrow Ba^{2+}_{(aq)} + 2NO_3^{-}{}_{(aq)} + 2HOH_{(l)}$

$H_{(aq)} + OH_{(aq)} \rightarrow HOH_{(l)}$ **(Don't forget to reduce)**

7. Draw a diagram describing how methanol is dissolved in water. (1 mark)



8. Predict whether the following solutes are electrolytes or nonelectrolytes:
   a) nitrogen monoxide – **nonelectrolyte (molecular)**
   b) hydrofluoric acid – **electrolyte (acid)**
   c) magnesium hydroxide – **nonelectrolyte (ionic BUT not aqueous)**
   d) potassium hydrogen carbonate – **electrolyte (ionic & aqueous)**

9. A scientists wants to make 100 mL of a 0.150 mol/L sodium hydroxide solution. He has 100 g of solid sodium hydroxide and he has 1.00 L of a 2.25 mol/L sodium hydroxide solution. Describe step by step the two ways that he could make his 0.150 mol/L solution. Include the sample calculations and equipment.

Method I - from solid	**Method II - dilution**
1) Find moles; n=CV; 0.150x0.100=0.0150mol	**1) Find volume; $V_1=C_2V_2/C_1$=0.150x0.100/2.25=6.67ml**
2) Find mass: m=nM; 0.0150x40.00=0.600g	**2) Remove 6.67mL with a graduated pipet**
3) Weigh on a scale	**3) Place in a 100 mL volumetric flask and fill to line**
4) Mix 0.600g in 50 ml of water	**4) Cap and mix**
5) Place in 100 mL volumetric flask and fill to calibration line. Cap and mix	

10. A 20.0 g sample of lead (II) nitrate is mixed in 1.00 L of water. The lead (II) nitrate solution then reacts with a 1.00 L of a 0.100 mol/L solution of rubidium iodide. If 20.0 g of precipitate forms, what is the percent yield?

$Pb(NO_3)_{2(aq)} + 2NaOH_{(aq)} \rightarrow 2NaNO_{3(aq)} + Pb(OH)_{2(s)}$

Worksheet 2.8: Introduction to Acids & Bases

1. Safety is very important when working with acids. Describe what the student should do in the following situations.
   a) A student drops a 100 mL beaker with 50 mL of hydrochloric acid and spills the acid onto the floor.
      Report the accident to a teacher. Place baking soda until it stops bubbling. (If you have no baking soda, dilute the acid with water.)

   b) A student drips a couple of drops of sodium hydroxide solution onto his hand.
      Report the incident to a teacher. Wash the sodium hydroxide off with cold water. Add vinegar to the spill.

   c) A beaker with $Ba(OH)_2$ tips over onto the lab bench.
      Report the incident to a teacher. Place vinegar (acetic/ethanoic acid) onto the base. (If you have no vinegar, dilute the base with water.)

   d) A student would like to dilute an acid and would like to know if he should add the acid to the water or the water to the acid
      Always add acid to water (A to W).

2. WHMIS symbols help communicate dangers.
   a) WHMIS stands for **Workplace Hazardous Materials Information System**
   b) The symbol that would be associated with a beaker of base that corrodes metal is

Corrosive

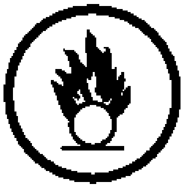
Causes severe Skin Burns & Eye Damage.
Is corrosive to metal.

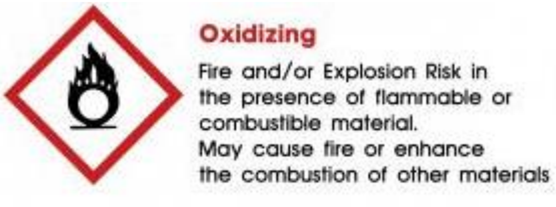
   c) Acids and bases can cause immediate and serious damage to a person's skin. The WHMIS symbol related to this is

Harmful or Fatal

Acute Toxicity.
Potentially fatal poisonous substance if inhaled, swallowed, or through skin contact, even in small amounts.

   d) Some acids react with oxygen. The WHMIS symbol found on a bottle of this acid would be





Oxidizing

Fire and/or Explosion Risk in the presence of flammable or combustible material.
May cause fire or enhance the combustion of other materials

3. A person would like to make 100 mL 1.00 mol/L solution of NaOH. Describe the steps the student would use. Include the calculations.

1) Calculate the moles: n=CV; n=1.00mol/L x 0.100L; n=0.100mol

2) Calculate mass: m=nM; m=0.100mol x 40.00g/mol; m=4.00g

3) Weigh with scale; mix in beaker with 50 mL of water.

4) Place in 100 mL volumetric flask, fill to calibration line, cap & mix.

4. A person would like to dilute a 12.1 mol/L solution of HCl and make a 250 mL 3.00 mol/L solution. Describe the steps the student would use. Include the calculations.

1) Find the volume; v1=C2V2/C1; V1=3.00mol/Lx 0.250L/12.1mol/L: V=62.4mL

2) Remove it with graduated pipet.

3) Place in 250 mL volumetric flask; fil to calibration line; cap & mix

5. Indicators change color to indicate whether you have an acid or base. Litmus paper and bromothymol blue are two common indicators. Complete the following table for these indicators.

PH	**Litmus Paper color**	**Bromothymol Blue color**
3	**Red**	**yellow**
7	**No change**	**Green**
10	**Blue**	**Blue**

6. What is one property that is similar between acids and bases?

Both electrolytes, both dissolve in water (aqueous)

7. What is one property that is different between acids and bases?

pH, taste, touch, reactions

8. Complete the following acid or base reactions.

a) sulphuric acid is neutralized by potassium hydroxide. Identify the "salt" in the reaction.

$H_2SO_{4(aq)} + 2KOH_{(aq)} \rightarrow \underset{\text{Salt}}{K_2SO_{4(aq)}} + 2HOH_{(l)}$

b) hydrochloric acid reacts with magnesium

$2HCl_{(aq)} + Mg_{(s)} \rightarrow \underset{\text{salt}}{MgCl_{2(aq)}} + H_{2(g)}$

c) self ionization of water

$H_2O_{(l)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + OH^-_{(aq)}$ OR $H_2O_{(g)} \rightarrow H^+_{(aq)} + OH^-_{(aq)}$

No salt

Worksheet 2.9: Acid & Base Calculations

1. A 1.00 L solution of 1.50 mol/L perchloric acid is dilluted by adding 500 mL *of water*. What is the hydronium concentration of the dilluted solution? $V_2 = V_1 + V_{water} = 1.00L + 0.500L$

   $HClO_{4(aq)} + H_2O_{(g)} \rightarrow H_3O^+_{(aq)} + {ClO_4}^-_{(aq)}$

   $C_2=C_1V_1/V_2$

   $C_2=1.50mol/Lx1.00L/1.50L$

   $C_2=1.00mol/L$ **1.00mol/L/1mol = X/1mol**

   X=1.00mol/L

2. A 250mL solution of 3.56 mol/L barium hydroxide is sitting on the counter in the lab. Help a chemistry 20 student determine the hydronium concentration of the solution.

   $Ba(OH)_{2(s)} \rightarrow Ba^{2+}_{(aq)} + 2OH\text{-}_{(aq)}$

   n=CV; n=3.56 x 0.250 = 0.89 mol

   X 2mol/1mol =1.78mol

   C = n/V; C = 1.78mol/0.250L = 7.12mol/L

   $H_3O^+_{(aq)} = Kw/[OH^-_{(aq)}]$; $H_3O^+_{(aq)} = 1E\text{-}14/7.12$

   = 1.40E-15 mol/L

3. A 1.00 mol/L solution of nitric acid ionizes. What is the hydroxide ion concentration?

   $HNO_{3(aq)} + H_2O_{(g)} \rightarrow H_3O^+_{(aq)} + {NO_3}^-_{(aq)}$

   1.00 mol/L X1/1mol; X=1.00 mol/L

   $[OH^-_{(aq)}] = kw/[\,H_3O^+_{(aq)}]$

   $= 1.00 \times 10^{-14}(mol/L)^2/1.00mol/L$; $[OH^-_{(aq)}] = 1.00 \times 10^{-14} mol/L$

4. A student takes 11.6 grams of strontium hydroxide and adds it to 3.00 litres of water. What is the hydronium concentration?

5. A solution contains 1.67 x 10 $^{-14}$ mol/L of hydronium ions. Determine the mass of barium hydroxide that was added to 1.00 L of water to make this solution.

   $Ba(OH)_{2(s)} \rightarrow Ba^{2+}_{(aq)} + 2OH^-_{(aq)}$ $[OH^-] = kw/[\,H_3O^+_{(aq)}]$

   $= 1.00 \times 10^{-14}(mol/L)^2/1.67 \times 10^{-14}mol/L$

   X1mol/2mol 0.5988…mol/L

   X=0.2994…mol/L

   n=CV; n=0.2994 x 1L=0.2994…mol

   m=nM; m= 0.2994…mol x 171.35 g/mol

   m=51.3 g

6. What is the concentration of hydroxide ions found in a 1.00 L solution of 2.00 mol/L potassium hydroxide?

7. What is the hydroxide concentration of a 1.00 L solution of 2.50 mol/L hydrobromic acid?

$HBr_{(aq)}$ + $H_2O_{(g)}$ → $H_3O^+_{(aq)}$ + $Br^-_{(aq)}$

2.50 mol/L x 1mol/1mol

X=2.50 mol/L

$[OH^-_{(aq)}]$ = kw/[$H_3O^+_{(aq)}$]

= 1.00 x 10^{-14}(mol/L)^2/2.50mol/L

$[OH^-_{(aq)}]$ = 4.00 x 10^{-15}mol/L

8. What is the hydronium concentration when 1.00 mol/L of barium hydroxide dissociates

9. 6.02 x 10^{22} particles of sulphuric acid ionize into hydrogen sulphate ions in 1.00 L of water. What is the hydroxide concentration of the solution?

$H_2SO_{4(aq)}$ + $H_2O_{(g)}$ → $H_3O^+_{(aq)}$ + $HSO_4^-{}_{(aq)}$

n=p/P

n=6.02 x 10^{22}ions/6.02 x 10^{23}ions/mol

n=0.1…mol

C=n/V = 0.1…mol/1.00L

0.100mol/L x 1mol/1mol; X=0.100 mol/L

$[OH^-_{(aq)}]$ = kw/[$H_3O^+_{(aq)}$]

= 1.00 x 10^{-14}(mol/L)^2/0.100mol/L;

$[OH^-_{(aq)}]$ = 1.00 x 10^{-13}mol/L

10. A solution contains 3.45 x 10^{-12} mol/L of hydroxide ions. What is the concentration of the hydrochloric acid solution that contains these hydroxide ions?

Worksheet 2.10: Acid & Base Review

1. The concentration of hydroiodic acid is 1.73 x 10^{-3} mol/L. What is the pH and the pOH?

   $HI_{(aq)} + H_2O_{(g)} \rightarrow H_3O^+_{(aq)} + I^-_{(aq)}$

   1.73 x 10-3 mol/L/1mol = X/1mol

   X=1.73 x 10-3 mol/L

   PH = -log (1.73 x 10-3 mol/L)

   PH = 2.76195…. (2.762)

   POH = 14-pH = 11.238

2. What is the hydronium concentration and hydroxide concentration of a 2.47 x 10 $^{-2}$ mol/L solution of strontium hydroxide?

3. Complete the following table (Significant digits are important):

pH	$[H^+]$ or $[H_3O+]$	$[OH^-]$	pOH	A/B/N
14 -4.56 **OR** **-log(3.6E-10)** **= 9.44**	**1E-14/2.8E-5** **=3.6E-10mol/L** **OR** **10 $^{-9.44}$**	**=$10^{-4.56}$ = 2.8E-5mol/L** **OR** **1E-14/3.6E-5**	4.56	**B**
2) 14-4.910 =9.090	**8.13 x10^{-10}mol/L**	1.23 X 10^{-5}	**-log (1.23E-5) =4.910**	**B**
3) 7.449	3.56 x 10^{-8}	**2.81 x 10^{-7}mol/L**	**6.551**	**B**
4) 12.8	**2 x 10^{-13}mol/L**	**6. x 10^{-2}mol/L**	**1.2**	**B**
5) 3.52	**3.0 x 10^{-4}mol/L**	**3.3 x 10^{-11}mol/L**	**10.48**	**A**
6) 13.759	**1.74 x 10^{-14}**	5.74 X 10^{-1}	**0.241**	**B**
7) 6.55	**2.8 x 10^{-7}**	**3.5 x 10^{-8}**	7.45	**A**
8) 2.399	3.99 X 10^{-3}	**2.51 x 10^{-12}**	**11.601**	**A**
9) 12.77	**1.7 x 10^{-13}**	**5.9 x 10^{-2}**	1.23	**B**
10) 5.95	**1.1 x 10^{-6}**	8.9 X 10^{-9}	**8.05**	**A**

4. What color would the indicator be given the following data:

	ORANGE IV	METHLY RED	PHENOL RED	METHYL ORANGE	INDIGO CARMINE
pOH=9.00 **pH = 5.00**	**yellow**	**Red + Yellow = orange**	**yellow**	**yellow**	**blue**
pH=8.3	**Yellow**	**Yellow**	**Red**	**Yellow**	**Blue**
[H+]=9.5 x 10^{-4} **pH = 3.02**	**Yellow**	**Red**	**Yellow**	**Red**	**Blue**
[OH-]=5.6 x 10^{-3} **pOH = 2.25; pH = 11.75**	**Yellow**	**yellow**	**Red**	**Yellow**	**Blue + yellow = green**
[H_3O+] =1.0 x 10^{-7}	**Yellow**	**Yellow**	**Yellow to red = orange**	**Yellow**	**Blue**