

Key for Test1

Overall results for the class 58 ± 18 . The highest is 89.5 points/100.

A rough breakdown of letter grades is given by the following points:

A ≥ 80 pts, B ≥ 72 pts, C ≥ 50 pts.

							X	X		
						X	X	X		
						X	X	X		
						X	X	X		
						X	X	X		
				X	X	X	X	X	X	
		X	X	X	X	X	X	X	X	
	X	X	X	X	X	X	X	X	X	
	X	X	X	X	X	X	X	X	X	
	X	X	X	X	X	X	X	X	X	
X	X	X	X	X	X	X	X	X	X	
9	19	29	39	49	59	69	79	89	99	

1) a) $m = \text{moles solute/kg solvent}$; first, MW of $\text{Mg}(\text{NO}_3)_2 = 148.33$ MW of $\text{Mg}(\text{NO}_3)_2$
 $m = (21.52 \text{ g } \text{Mg}(\text{NO}_3)_2 / 148.33 \text{ moles } \text{Mg}(\text{NO}_3)_2) / 0.0500 \text{ kg}$ $\frac{24.31}{148.33}$
 $= 2.90_{1638} = 2.90_2$ or **2.90 molal** $2(14.01) = 28.02$
 $\frac{6(16.00) = 96.00}{148.33}$

b) ionic strength:

$\mu = 1/2 \sum c_i z_i^2$; but here we need to express c_i in terms of molarity. So, first, we have to solve for the molarity, M:

$$M = \text{moles solute/L sol'n}; M = (21.52 \text{ g } \text{Mg}(\text{NO}_3)_2 / 148.33 \text{ moles } \text{Mg}(\text{NO}_3)_2) / 0.0653 \text{ L} = 2.22_2 \text{ M}$$

$$\text{so now, } \mu = 1/2 \sum c_i z_i^2 = (1/2)\{(2.22_2 \text{ M})(+2)^2 + (2(2.22_2 \text{ M})(-1)^2)\} = \mathbf{6.66_6 \text{ M}}$$

c) density of the solution:

$$\text{density, } d = m/V = (21.52 + 50.0 \text{ g}) / 65.3 \text{ mL} = 1.09_5 \text{ or } 1.10 \text{ g/mL}$$

$$\%e_d = \{\%e_m^2 + \%e_v^2\}^{1/2} = \{(1\%)^2 + (1.7\%)^2\}^{1/2} = 2\%; \text{ so } e_d \times 100\% / 1.09_5 = 2\%$$

$$\text{of } e_d = 2\%(1.09_5) / 100\% = 0.0219 = .02$$

thus, $d = \mathbf{1.10 \pm .02}$ (note that the error is in the 2nd decimal place and so the last significant figure of d is also in the 2nd decimal place.)

d) weight % $\text{Mg}(\text{NO}_3)_2 = \text{g solute} \times 100\% / \text{g solution} = 21.52 \times 100\% / (21.52+50.0)\text{g} = 2152/71.52$
 $= 30.089\% = 30.0\%$ or **30.1%**

2) Essentially, this is a problem comparing replicate measurements. But first, let's determine whether to eliminate any measurement from method #2 (spectrophotometric):

Rearranging the data from smallest to largest: 1.11, 1.15, 1.17, 1.19, 1.20, 1.33.

$Q_{\text{calc}} = \text{gap}/\text{range} = (1.33-1.20)/(1.33-1.11) = .59$; Since $Q_{\text{calc}} = .59 > Q_{\text{table}} = 0.56$ for $n=6$ @ 90% confidence. We **drop 1.33**.

Solve for mean \pm std deviation: $\bar{x}_2 = 1.16$, $s_2 = .04$. Since the standard sample is the same, we can use comparison of replicate measurements:

$$s_{\text{pooled}} = \sqrt{\{(.02^2(5-1) + .04^2(5-1))/(5+5-2)\}} = 0.03$$

$$\text{and } t_{\text{calc}} = \{(1.16-1.11)/.03\}(5(5)/(5+5))^{1/2} = 2.635.$$

Since $t_{\text{calc}} > t_{\text{table}}$ at either the 90% or 95% confidence, we can say that **YES** the two methods are significantly different at 90% or 95% confidence. Note that we have assumed the Q test will also eliminate 1.33 @ 95% confidence.

3) a) the reagents used are: ammonia (or ammonium) and phosphate. The precipitated form of magnesium is $\text{Mg}(\text{NH}_4)\text{PO}_4$. This was given during the lecture on gravimetry – with a note that students are accountable to know about this.

b) This is a problem of 2 unknowns. We can initially write:

$$\text{grams MgCl}_2 + \text{grams Mn}(\text{CN})_2 = 4.200 \text{ g}$$

$$\text{grams Mg}_2\text{P}_2\text{O}_7 + \text{grams Mn}_2\text{P}_2\text{O}_7 = 5.320 \text{ g}$$

we can proceed by letting $x = \text{grams MgCl}_2$ and $y = \text{grams Mn}(\text{CN})_2$

$$\text{Equation (1) becomes: (1) } x + y = 4.200 ; \text{ This gives us: } y = 4.200 - x$$

Equation (2) can be written in terms of x and y using the appropriate gravimetric factors (the MW's are given in the test):

$$(2) \quad \left\{ \frac{222.558 \text{ g Mg}_2\text{P}_2\text{O}_7}{(2)(95.211)} \right\} x + \left\{ \frac{283.824 \text{ g Mn}_2\text{P}_2\text{O}_7}{(2)(106.958)} \right\} y = 5.320$$

Substituting for y from (1) and simplifying the coefficients in (2), Eqn (2) becomes:

$$1.1688 x + 1.32680 (4.200 - x) = 5.320$$

solving for y we get:

$$1.1688 x + 5.57256 - 1.32680 x = 5.320$$

$$0.15800 x = 0.25256$$

or, $x = 1.5985$ grams of MgCl_2 and $y = 4.200 - x = 4.200 - 1.5985 = 2.6015$ grams $\text{Mn}(\text{CN})_2$

$$\text{so, } \% \text{ Mg} = \frac{1.5985 (24.305 \text{ g Mg} / 95.211 \text{ g MgCl}_2)(100\%)}{4.200 \text{ g ore}} = 9.71\% = \mathbf{9.72\% \text{ Mg}}$$

$$\text{and also, } \% \text{ Mn} = \frac{2.6015 (54.938 \text{ g Mn} / 106.958 \text{ g Mn}(\text{CN})_2)(100\%)}{4.200 \text{ g ore}} = \mathbf{31.8\% \text{ Mn}}$$

Note that we can also let $x =$ grams $\text{Mg}_2\text{P}_2\text{O}_7$ etc and solve for this. Or, we can also let $x =$ moles MgCl_2 etc... We will get the same answer as long as we are doing the math correctly.

4) This is a K_{sp} equilibrium. Designed to see if you understand how to use it and solve for solubility. Also to see how you calculate ppm:

the chemical equilibrium equation is: $\text{PbCl}_2 (\text{s}) \rightleftharpoons \underset{x}{\text{Pb}^{2+}(\text{aq})} + \underset{2x}{2 \text{Cl}^{-}(\text{aq})}$ $K_{sp} = 1.66 \times 10^{-6}$

OK, the expression for K_{sp} in this case is: $K_{sp} = [\text{Pb}^{2+}][\text{Cl}^{-}]^2 = x(2x)^2 = 4x^3 = 1.66 \times 10^{-6}$

Solving for x we get $x = (1.66 \times 10^{-6} / 4)^{1/3} = \mathbf{0.00746 \text{ M}}$ and that is the molar solubility.

As of the ppm of Cl^{-} we get:

$$[\text{Cl}^{-}] = 2x = 2(0.00746 \text{ M}) = (0.01492 \text{ mol/L}) (35.453 \text{ g/mol}) (1000 \text{ mg/g}) = \mathbf{529 \text{ ppm Cl}^{-}}$$

(5) a) Charge Balance equation:

OK, we line up all the cations (i.e. the “+ ions”) on the left side of the “equal sign” and all the anions on the right side:

$$2 [\text{Fe}^{2+}] + [\text{Na}^{+}] = 3[\text{PO}_4^{3-}]_{\text{F}} + [\text{F}^{-}]_{\text{F}} \quad \text{Note that } \text{PO}_4^{3-} \text{ and } \text{F}^{-} \text{ have various forms as it reacts with water}$$

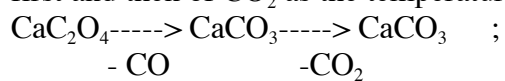
to form the conjugate acids. OH^{-} is formed as it picks up H^{+} from H_2O molecules..., so the final

$$\text{equation should be: } \mathbf{2 [\text{Fe}^{2+}] + [\text{Na}^{+}] = 3[\text{PO}_4^{3-}] + 2[\text{HPO}_4^{2-}] + [\text{H}_2\text{PO}_4^{-}] + [\text{OH}^{-}] + [\text{F}^{-}]}$$

b) Mass Balance Equation:

$$\text{Here we write: } 2 [\text{Fe}^{2+}] = 3[\text{PO}_4^{3-}]_{\text{F}} = 3 \{ [\text{PO}_4^{3-}] + [\text{HPO}_4^{2-}] + [\text{H}_2\text{PO}_4^{-}] + [\text{H}_3\text{PO}_4] \}$$

(6) We note that when we heat up CaC_2O_4 , we obtain CaCO_3 first then CaO with the removal of CO first and then of CO_2 as the temperature reaches the appropriate high temperature:



where we can show: $\text{FW}(\text{CaC}_2\text{O}_4) = 128.098$; $\text{FW}(\text{CaCO}_3) = 100.088$; $\text{FW}(\text{CaO}) = 56.078$

$$\# \text{ moles CaO} = \text{moles CaC}_2\text{O}_4 + \text{moles CaCO}_3 = (0.1450/128.098) + (0.2250/100.088) = 0.003380 \text{ moles}$$

$$\text{g CaO} = 0.003380 \text{ moles} (56.078 \text{g/mol}) = \mathbf{0.1895 \text{ g CaO}}$$