Division C: Chemistry Lab Answer Key
2019 SciOly Summer Study Session

- This exam contains two parts, one designed to test you on your knowledge of acids and bases and the other to test you on your knowledge of aqueous solutions.
- This exam can be split apart, but each page must have your team name and number if you decide to do this.
- You are not allowed to talk to other teams for help during this exam. If you have a question, ask one of the proctors instead so you don't get disqualified.

Names:_____

School:_____

Score:____/323

Place:___

Part One: Preliminary Knowledge (37 points)

1.Determine the molecular and net ionic equations for each of the following reactions.(4 points each)

a.Aqueous sodium sulfate reacts with aqueous calcium hydroxide.
Molecular: $Na_2SO_2(aq)+Ca(OH)_2(aq)\rightarrow 2NaOH(aq)+CaSO_2(s)$
Net Ionic:$SO_4^{2-}(aq)+Ca^{2+}(aq)\rightarrow CaSO_4(s)$

b.Phosphoric acid reacts with water.
Molecular: $H_3PO_4(aq)+H_2O(l)\rightarrow H_3O^+ + H_2PO_4^{2-}$
Net Ionic:Is the same.

c.Hypobromous acid reacts with ammonia
Molecular: $HBrO + NH_3 \rightarrow NH_4^+ + BrO^-$
Net Ionic: Is the same

d.Benzoic acid reacts with potassium acetate
Molecular: $HC_7H_5O_2(aq)+KC_2H_3O_2(aq)\rightarrow KC_7H_5O_2(aq)+HC_2H_3O_2(aq)$
Net Ionic:$HC_7H_5O_2(aq) + C_2H_3O_2^-(aq)\rightarrow C_7H_5O_2^-(aq) + HC_2H_3O_2(aq)$

e.Thiocyanic acid reacts with methylamine
Molecular: $HSCN(aq) + CH_3NH_2(aq)\rightarrow CH_3NH_3^+(aq) + SCN^-(aq)$
Net Ionic: Is the same as the molecular.

2. Balance the following chemical equations with the smallest whole number coefficients.(2 points each)

a. ___H_2SO_4 + __2_NaOH--->__2_H_2O + ___Na_2SO_4

b. __2_C_8H_{18} + __25__O_2---> ___16_CO_2 + __18__H_2O

c.__2_HIO_3 + ___FeI_2 + __4_HCl ---> ___$FeCl_3$ + _4__ICl + __3_H_2O

d._3__Cu + __8_HNO_3---> __3_$Cu(NO_3)_2$ + __2_NO + __4_H_2O

e._2__$KMnO_4$+__16_HCl--->__2_KCl+__2_$MnCl_2$+__8_H_2O+_5__Cl_2

3. Determine the amount of carbon dioxide produced from 1kg of C_8H_{18} reacting with a 90% yield according to the above equation in 2b.(7 points)(Round to 3 significant figures)

1000g of C_8H_{18} (1 mole of C_8H_{18}/114g)(8 moles of CO_2/ 1 mole of C_8H_{18})(44g/1 mol of CO_2) * .90 = 2780g of CO_2(+3 for correct answer, +4 for setup)

Part Two: Acids and Bases (143 points)

Multiple Choice:(2 points each)

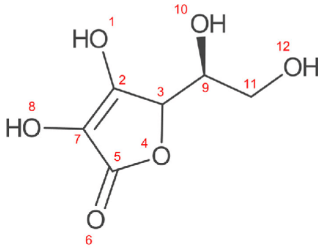
1.What is the pH of a 1M solution of HCl?
a) 3
b) 0
c) 1
d) -1

2.Which of the following acids are used to treat scurvy?
a) Ascorbic acid
b) Acetic acid
c) Propanoic acid
d) Phosphoric acid

3.Which of the following equations represents the K_a expression?
a)$H_3O^+ + C_2H_3O_2^- \rightarrow H_2O + HC_2H_3O_2$
b)$BCl_3 + F_2 \rightarrow BClF_2 + Cl_2$
c)$NaOH + H_2O \rightarrow OH^- + H_2O + Na^+$
d)$HCl + H_2O \rightarrow H_3O^+ + Cl^-$

4.Which of the following correctly pairs an acid with the correct conjugate base?
a)NH_4^+ & H^-
b)HCl & OH^-
c)$HC_2H_3O_2$ & $C_2H_3O_2^-$
d)KOH & OH^-

5.Which of the following is the most acidic -OH group in ascorbic acid?



Ascorbic acid

a)1
b)8
c)10
d)12

6.Fill in the blank: As a result of the leveling effect, the strongest form of an acid in solvent is the acidic form of _____?
a)Water
b)The Solvent
c)The Solute
d)None of the above

7. The K_a of acetic acid is $1.77*10^{-5}$. Calculate the pH of a 0.37M acetic acid solution.
a)2.53
b)2.49
c)2.69
d)2.59

8. Weak acids taste____
a)sour
b)bitter
c)sweet
d)no taste

9.Which of the following is always true?
a)pH=-log(pOH)
b)pH+pOH=14
c)K_w=1*10^-14
d)pH=pK_a-log([A^-]/[HA])

10.Which of the following is the strongest acid?
a)H_2CO_3(K_a=4.2*10^-7)
b)H_3PO_3(K_a=7.5*10^-3)
c)HN_3(K_a=1.8*10^-5)
d)HCN(K_a=4.0*10^-10)

11.Which of the following is a weak base?
a)NH_3
b)NaOH
c)H_2SO_4
d)KCl

12.Strong bases and strong acids are both:
a)gases at room temperature
b)compounds that have high boiling points
c)compounds that have high melting points
d)strong electrolytes

13.What compound below is used primarily in making fertilizers?
a)lye
b)ammonia
c)baking soda
d)glacial acetic acid

14.Which of the following is a lewis acid?
a)BF_3
b)CH_4
c)$Mg(OH)_2$
d)KOH

15.Which of the following is used in car batteries?
a)NaOH
b)HNO_3
c)H_2SO_4
d)HCl

16.What is the definition of a lewis base?
a)An electron pair donor
b)A proton acceptor
c)A proton donor
d)An electron pair acceptor

17.What is the name of the acid formed by the hypochlorite ion?
a)hydrochloric acid
b)chloric acid
c)hypochlorous acid
d)hydrogen hypochlorous acid
18.What is the pH of a 0.230M solution of carbonic acid?($K_{a1}=4.3*10^{-7}$,$K_{a2}=5.6*10^{-11}$)
a)3.50
b)3.13
c)3.64
d)4.17

19.Which of the following is the strongest acid?
a)H_2SO_4
b)HCl
c)HNO_3
d)HI

20.What is the conjugate base of H_3PO_4?
a)HPO_4^{2-}
b)$H_2PO_4^-$
c)PO_4^{3-}
d)None of the above

21.Which of the following can never be a base?
a)NH_4^+
b)SO_4^{2-}
c)F^-
d)NaOH

22.What is another name for hydrochloric acid when it is used in pools?
a)Chloric acid
b)Glacial acid
c)Muriatic acid
d)Lye

23.Titrating $HC_2H_3O_2$ with which of the following bases will yield an equivalence point that is NOT above 7?
a)$Ca(OH)_2$
b)NH_3
c)NaOH
d)$Mg(OH)_2$

24.At the half-equivalence point, which of the following is true?
a)pOH=10.5
b)pOH=pH
c)pH=3.5
d)$pH=pK_a$

25.Which of the following will decrease the pH of a solution when dissolved in it?(circle all that apply)
a)$Al(H_2O)_6^{3+}$
b)$Fe(H_2O)_6^{3+}$
c)$KC_2H_3O_2$
d)$MgCl_2$

Short Answer:

1.List all 7 strong acids and 8 strong bases when dissolved in water(1 point each).

Acids: HCl,H2SO4,HNO3,HI,HBr,HClO4,HClO3
Bases: NaOH,KOH, LiOH, Ca(OH)2,CsOH,Sr(OH)2,Ba(OH)2,RbOH

2. Determine the pH, pOH, percent dissociation and whether or not the solution is acidic or basic for each of the following situations: (4 points each)
a.0.15M of $HC_2H_3O_2$ ($K_a=1.8*10^{-5}$)
Acidic solution
pH=2.78
pOH=11.22
% dissociation:1.1%

b. 0.50M of H_2SO_4(K_{a1}=very large, $K_{a2}=1.2*10^{-2}$)
Acidic solution
pH=0.30(+/- .01)
pOH=13.70(+/- .01)
% dissociation=100%

c.0.30M of $H_2PO_4^-$($K_{a2}=6.2*10^{-8}$,$K_{a3}=3.6*10^{-13}$)
Acidic solution
pH=3.87
pOH=10.13
%dissociation:0.045%

d. 0.001M of HCl(K_{a1}=very large)
Acidic solution
pH=3
pOH=11
% dissociation=100%

e.0.75M of NH_3($K_b=1.8*10^{-5}$)
Basic solution
pH=11.57
pOH=2.43
% dissociation=0.49%

3. Determine if the following salts would produce an acidic, basic, or neutral solution in water. (1 point each)
a)NaOH(basic)
b)$MgSO_4$(basic)
c)$NaNO_3$(neutral)
d)KCl(neutral)
e)$LiC_2H_3O_2$(basic)
f)$NaHSO_4$(acidic)
g)NH_4Cl(acidic)
h)K_2S(basic)
i)$LiNO_2$(basic)
j)KI(neutral)
k)MgO(basic)

4.a) Determine the pH of 500mL of 0.0500M acetic acid. (12 points all together, 4 points for each part)
$K_a=[H^+][C_2H_3O_2^-]/[HC_2H_3O_2]$
$(1.78*10^{-5})=x^2/(0.0500M-x)$----> x is very small compared to 0.0500M, so it can be neglected
$x=9.433981132*10^{-4}M$
$pH=-\log[H^+]$
pH=3.025

b.) Determine the pH of the solution after the addition of 50g of $NaC_2H_3O_2$. Assume that the volume increase of the solution is negligible.What kind of solution is formed?
A buffer solution is formed.
50g/82g/mol=.6097560976 mols of conjugate base added
$pH=pK_a+\log([base]/[acid])$
$pH=-\log(1.78*10^{-5})$ + log(.6097560976 mols of conjugate base/0.0250 mols of acid)
pH=6.14

c.) Now that that kind of solution is formed, compute the pH of this solution after the addition of 50mL of 1M HCl. How does this compare to the pH of the solution if no $NaC_2H_3O_2$ was added earlier?
The pH of this solution is higher, or less acidic than the pH of the solution that has no conjugate base added.
50mL*1M=0.05mols of acid
.6097560976 mols of conjugate base-0.05 mols of acid=.5597560976 mols of base left

New volume of solution=550mL=.55L
$pH=pK_a+\log([base]/[acid])$
$pH=-\log(1.78*10^{-5})+\log(1.017738359/0.0454545455)$
pH=6.10(much higher than the solution without the conjugate base)

5. Explain the difference between the end point and equivalence point of a titration. (5 points)
Equivalence point = mols acid = mols base.
Endpoint = color change of the indicator

6. The following describes a titration of 50mL of 0.250M acetic acid($K_a=1.8*10^{-5}$) with 0.100M strontium hydroxide. Determine the pH at each step of the titration and identify the major species present in solution at each step.(5 points each)

a) 0mL of base added

Use the K_a expression and/or an ICE table to help you keep track of species.
$1.8*10^{-5}=x^2/(0.250M)$
$x=2.12*10^{-3}$
$pH=-\log([H^+])=-\log(2.12*10^{-3})=2.67$
Major species present are acetic acid as it only partially dissociates. The amount of H^+ and conjugate base are negligible compared to the amount of acid.

b) 40mL of base added

Find the moles of bases added:
Moles of base=2*.040L*0.100M=0.008 moles of base added
Moles of acid=.050L*0.250M=0.0125 moles of acid
Moles of acid remaining=0.0125-0.008=0.0045 moles of acid
New Volume of solution=50mL+40mL=90mL=0.090L
New Molarity of acid=0.0045mol/0.090L=0.05M
Use the K_a expression with the new molarity of the acid OR Henderson-Hasselbach after finding the new amount of conjugate base (0.008 moles as the acid fully reacts with the strontium hydroxide, forming 0.008 mols of conjugate base in the process)
$(1.8*10^{-5})=(x^2)/(0.05M)$
$x=9.48683*10^{-4}$
$pH=-\log[H^+]=-\log(9.48683*10^{-4})=3.02$
The major species present in solution is still acetic acid as while some of it reacted, the amount of it left dwarfs the amount of conjugate base produced as a result of reacting.

c) 100mL of base added

Find the moles of bases added:
Moles of base=2*0.10L*0.100M=0.02 moles of base added
Moles of acid=.050L*0.250M=0.0125 moles of acid
Moles of base remaining=0.02-0.0125=0.0075 moles of base
New Volume of solution=100mL+50mL=150mL=0.15L
Find pOH now as you have excess OH^- ions in solution

$[OH^-]$=0.0075mol/0.15L=0.05M
pOH=-log$[OH^-]$=-log(0.05M)=1.30
pH=14-pOH=14-1.30=12.70
The major species present at this are the acetate ion and the hydroxide ion as all of the acetic acid has reacted and there is excess hydroxide left over from the dissolution of strontium hydroxide.

d) At the equivalence point of the titration

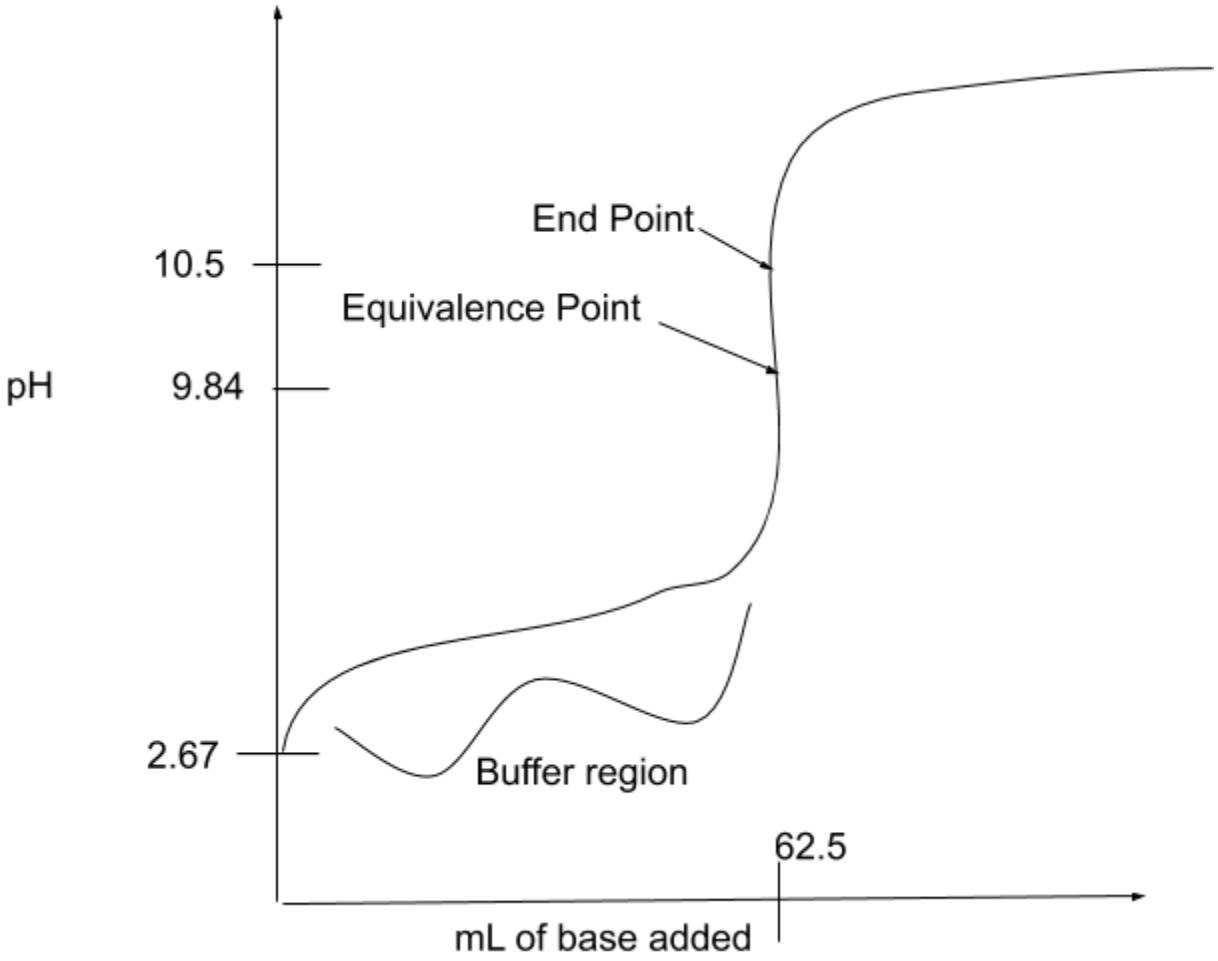
Use the titration equation: M_AV_A*(#of H^+ ions per acid molecule)=M_BV_B*(# of OH^- ions per molecule)
(0.250M)(50mL)(1H^+ per each molecule)=(0.100M)(2 OH^- ions per molecule) V_B
V_B=62.5mL
New Volume of solution=62.5mL+50mL=112.5mL=0.1125L
All of the acid molecules have now reacted with the OH^- ions, leaving only the conjugate base in the solution to react with water molecules to raise the pH. For every molecule of acetic acid which dissolves, one molecule of the acetate ion is produced as a result. Thus, as we already calculated there were 0.0125 mol of acid in the solution before the addition of OH^-, there must now be 0.00125 mol acetate ion in the solution now too. As this acts as a base, we need to reverse the K_a expression given to us to find K_b.
$K_b=1*10^{-14}/K_a=1*10^{-14}/1.8*10^{-5}=5.56*10^{-10}$
Now we have to find the molarity of the conjugate base in solution.
0.0125mol/0.1125L=0.111M
Now we can use the K_b expression.
$5.56*10^{-10}=x^2/0.111M$
$x=7.86*10^{-6}$(this is the moles of OH^- as we are dealing with the conjugate base)
Molarity of $OH^-=7.86*10^{-6}$mol/0.1125L=$6.99*10^{-5}$M
pOH=-log$[OH^-]$=-log($6.99*10^{-5}$M)=4.16
pH=14-pOH=14-4.16=9.84
The major species present here would just be the acetate ion as all of the strontium hydroxide has reacted and so has all of the acetic acid, producing an equivalent amount of conjugate base.

7. Out of the following indicators, which would be best for the titration described above?
(5 points) (Multiple indicators can be chosen)

Indicator	Low pH color	Transition pH range	High pH color
Gentian violet (Methyl violet 10B)	yellow	0.0–2.0	blue-violet
Leucomalachite green (first transition)	yellow	0.0–2.0	green
Leucomalachite green (second transition)	green	11.6–14	colorless
Thymol blue (first transition)	red	1.2–2.8	yellow
Thymol blue (second transition)	yellow	8.0–9.6	blue
Methyl yellow	red	2.9–4.0	yellow
Bromophenol blue	yellow	3.0–4.6	purple
Congo red	blue-violet	3.0–5.0	red
Methyl orange	red	3.1–4.4	yellow
Screened methyl orange (first transition)	red	0.0–3.2	grey
Screened methyl orange (second transition)	grey	3.2–4.2	green
Bromocresol green	yellow	3.8–5.4	blue
Methyl red	red	4.4–6.2	yellow
Azolitmin	red	4.5–8.3	blue
Bromocresol purple	yellow	5.2–6.8	purple
Bromothymol blue	yellow	6.0–7.6	blue
Phenol red	yellow	6.4–8.0	red
Neutral red	red	6.8–8.0	yellow
Naphtholphthalein	colorless to reddish	7.3–8.7	greenish to blue
Cresol Red	yellow	7.2–8.8	reddish-purple
Phenolphthalein	colorless	8.3–10.0	fuchsia
Thymolphthalein	colorless	9.3–10.5	blue
Alizarine Yellow R	yellow	10.2–12.0	red

Phenolphthalein and Thymolphthalein would be the best indicators as they both undergo a color change in the pH range of the equivalence point in the titration above.

8. Draw an example titration graph of the titration described above, labeling the equivalence point, end point and buffer regions of the graph.(Use thymolphthalein as the indicator)
One example:

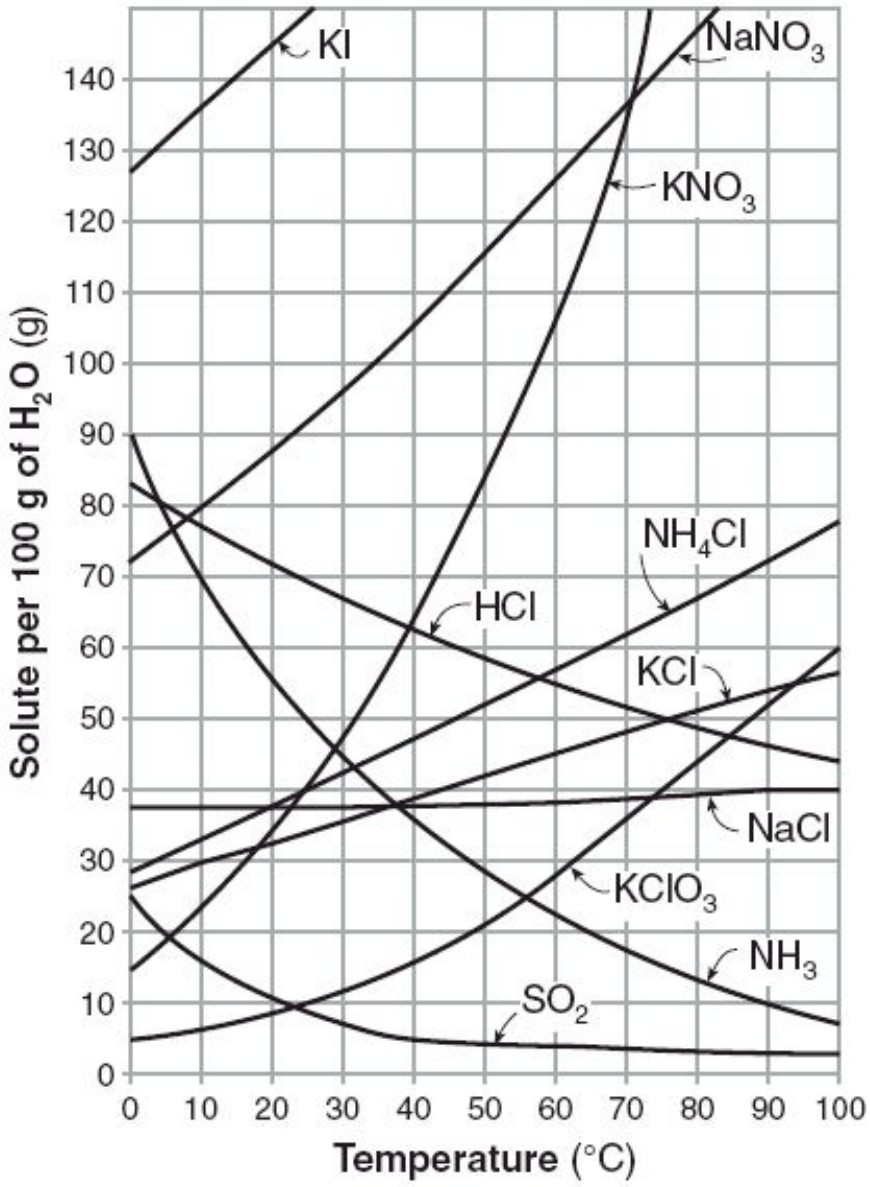


Part 3: Aqueous Solutions (143 points)

Multiple Choice (2 points each)

Use the following chart for questions 1-4.

Table G Solubility Curves



1. How manys grams of sodium nitrate must be added to 100 grams of water at 40℃ to form a saturated solution?
   A.100g
   B.75g
   C.105g
   D.115g

2. A solution of ammonia contains 30g of ammonia in 200g of water at 10℃. Which of the following amounts of ammonia would create a supersaturated solution if added to this solution?

A.40g
B.60g
C.80g
D.120g

3.Which of the following amounts of solute describes an unsaturated solution of sulfur dioxide at 60℃ in 100g of water?
A.2g
B.7g
C.10g
D.12g

4.Based on the chart, which of the following trends can be seen in the solubility of gaseous substances?
A.Solubility increases as temperature increases
B.Solubility increases as temperature decreases
C.Solubility decreases as temperature decreases
D.Solubility doesn't depend on temperature

5.What is the percent composition by mass of nitrogen in hydrazine? (N_2H_4)
A.88%
B.90%
C.100%
D.85%

6.What is the molarity of an HCl solution which contains 4 moles of HCl in 5 liters of water?
A.1M
B.0.80M
C.0.60M
D.0.85M

7.How many more moles should be added to 500mL of a .40M solution to achieve a new concentration of 0.50M?
A.0.05mols
B.0.20mols
C.0.25mols
D.0.10mols

8.What is the molality of a solution which contains 4 moles of solute in 4kg of solvent?
A.1m
B.3m
C.4m
D.2m

9.What is the ppm of a solution which contains 0.033g of solute in 500g of solution?
A.86ppm
B.76ppm
C.66ppm
D.56ppm

10.What is the ppb of the above solution?
A.56,000ppb
B.86,000ppb
C.76,000ppb
D.66,000ppb

11. How many moles of solute are contained in 50mL of solution that has a concentration of 5M?
A.0.25 moles
B.0.50 moles
C.250 moles
D.10 moles

12. How many kg of solvent are there in a solution with a molality of 6m and contains 2.0 moles of solute?
A.0.50kg
B.0.10kg
C.0.33kg
D.0.20kg

13. Which of the following is insoluble in water?
A.NaCl
B.AgCl
C.H_2SO_4
D.$MgCrO_4$

14. What happens to the boiling and freezing points of a solution as soluble solute is added?
A.Boiling point decreases and freezing point increases
B.They both increase
C.They both decrease
D.Boiling point increases and freezing point decreases

15.Which of the following are true of colligative properties?
A.The depend on the identity of the solute
B.The depend on the identity of the solvent
C.They depend on the number of particles in solution
D.None of the above

16.Which of the following compounds would lead to the highest change in boiling point of a solution?
A.$MgCl_2$
B.KOH
C.$NaNO_3$
D.$HC_2H_3O_2$

17.Which of the following isn't a colligative property?
A.Osmotic pressure
B.Vapor pressure lowering
C.Boiling point depression
D.Freezing point depression

18.1.5 mols of solute are dissolved in 200g of solution, which has a normal freezing point of 27℃. What is the new freezing point of this solution?(K_f=2.0℃/m)
A.15℃
B.12℃
C.20℃
D.30℃

19.What is the new boiling point of the above solution if the boiling point of pure solvent is 112℃?(K_b=1.75℃/m)
A.140℃
B.130℃
C.110℃
D.125℃

20. What is the percent by mass of carbon in octane?(C_8H_{18})
A.84.2%
B.80.5%
C.87%
D.88.3%

21. What is the equilibrium concentration of the chloride ion in a solution of silver chloride?($K_{sp}=1.77*10^{-10}$)
A.$5.56*10^{-5}$M
B.$1.33*10^{-5}$M
C.$2.14*10^{-6}$M
D.$9.45*10^{-4}$M

22.What will happen to the solubility of silver chloride as more chloride ions are added to the solution?
A.Only temperature can affect solubility
B.There will be no change.
C.It will increase
D.It will decrease

23. What is the equilibrium concentration of the hydroxide ion in a solution of magnesium hydroxide? ($K_{sp}=5.61*10^{-12}$)
A.$1.41*10^{-7}$M
B.$1.12*10^{-4}$M
C.$2.24*10^{-4}$M
D.$7.51*10^{-4}$M

24.Which of the following factors don't determine the solubility of a compound in water?
A.Molecular polarity
B.Temperature
C.The presence of radioactive elements
D.Whether the mixture is stirred or not

25.Which of the following is most likely to be insoluble in water?
A.Heptyne
B.Magnesium chloride
C.Potassium nitrate
D.Lithium hydroxide

Part Four: Short Answer

1.Write the reaction responsible for ocean acidification. What happens to the pH of the water as more gas is added?(10 points)

$CO_2(g) + H_2O(l) <---> H_2CO_3(aq)$
$H_2CO_3(aq) + H_2O(l) <---> H_3O^+(aq) + HCO_3(aq)$
The pH decreases as equilibrium shifts right for the first reaction, increasing the amount of carbonic acid that can react with water to produce the hydronium ion, which will lower the pH.

2.What forces must be overcome to form a solution? What is responsible for a solution being formed even if the process is endothermic?(11 points)

In order for a solution to be formed, solute-solute interactions must be broken to break apart the solute into individual particles and solvent-solvent interactions must be broken the make space for the solute particles. Then, solute-solvent interactions can take place, releasing energy in the process. However, if the released energy isn't greater then the energy required to overcome the first 2 forces, the solution is still formed because of the entropy increase associated with creating a solution.

3.Why must a soda can be pressurized and kept in cool temperatures in order for it not to explode?(11 points)
The solubility of a gas is inversely proportional to temperature and directly proportional to pressure. If the gas is kept under a high pressure and low temperature, it will be most soluble and remain in solution. However, if the temperature is increased or the pressure is decreased, the gas will escape, causing pressure to build up on the walls of the container, which will make it explode.

4.Identify each of the following as soluble or insoluble compounds in water. (1 point each)
a)$NaCl(s)$
b)$KNO_3(s)$
c)$Na_2S(s)$
d)$Mg_3(PO_4)_2(is)$
e)$NaHCO_3(s)$

f)$CaSO_4$(is)
g)$PbCl_2$(is)
h)$LiClO_3$(s)
i)$Mg(OH)_2$(is)
j)BaS(is)
k)$Mg(NO_3)_2$(s)

5. What is the change in vapor pressure of a solution where 30g of sodium chloride is dissolved in 200mL of water? The vapor pressure of pure water is 57.74torr at 39.8°C (20 points)

Use Raoult's Law:
$P_{solution}=x_{solvent}P_{solvent}$

$x_{solvent}$=moles of water/moles of solution=11.11/(11.11+0.514)=.956
Moles of water=200mL*(1g/mL)(1mol/18g)=11.11moles of water
Moles of solute=30g(1mol/58.4g)=0.514moles of solute
$P_{solution}$=(.956)(57.74torr)=55.19torr
Change in vapor pressure=$P_{solution}$-$P_{solvent}$=55.19torr-57.74torr=-2.552torr
The vapor pressure is lowered by 2.552torr.

6. What is the molar solubility of $Cu(OH)_2$ given that it's K_{sp} is $4.5*10^{-21}$?
The equation for the dissolution of $Cu(OH)_2$ is:
$Cu(OH)_2$<--->$Cu^{2+}+2OH^-$
$K_{sp}=[Cu^{2+}][OH^-]^2$
If the molar solubility is x, then $[Cu^{2+}]=x$ and $[OH^-]=2x$ as 2 moles of OH^- are formed from every mole of copper.
Thus, $K_{sp}=(x)(2x)^2$
$4.5*10^{-21}=(x)(4x^2)=4x^3$
$x=1.04*10^{-7}$

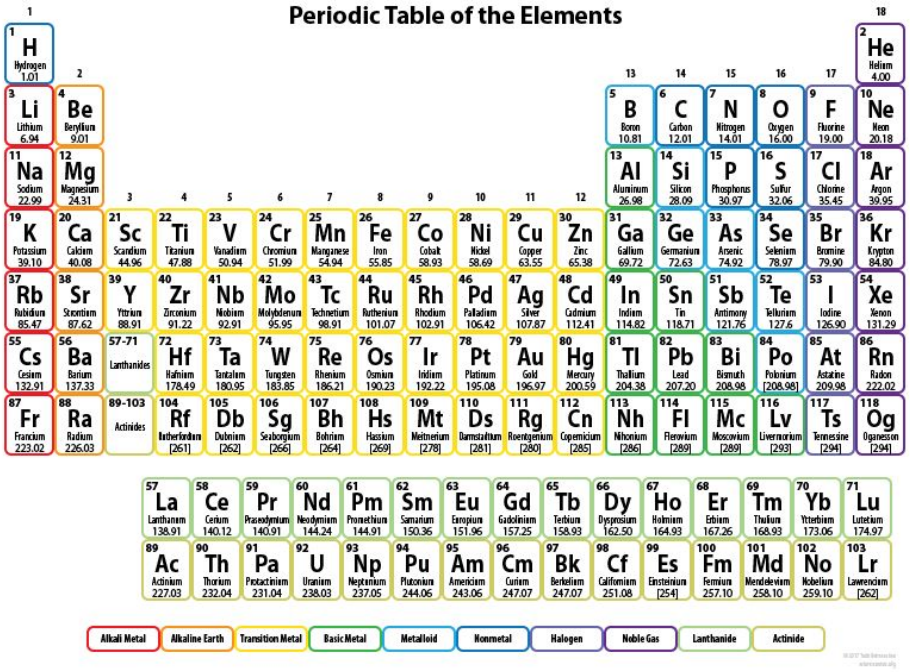
7. 50g of LiOH and 30g of K_3PO_4 are added to a 500mL beaker filled with water. What will be the first precipitate formed upon the addition of the Cu^{2+} ion?(The K_{sp} of $Cu(OH)_2$ is $4.5*10^{-21}$ and the K_{sp} of $Cu_3(PO_4)_2$ is $1.40*10^{-37}$)
To determine which one precipitates first, it must be determined which one needs the lowest amount of copper to cause the creation of a precipitate as when the copper exceeds the molar concentration of itself in a saturated solution, a precipitate is created. First, we must find out the molar concentrations of the ions that the copper bonds with.
Moles of OH^-=50g(1mol LiOH/24g)(1molOH^-/1molLiOH)=2.0833333 moles of OH^-
Moles of PO_4^{3-}=30g(1molK_3PO_4/212g)(1molPO_4^{3-}/1molK_3PO_4)=0.141509434 moles of PO_4^{3-}
$[OH^-]$=2.0833333mol/0.500L=4.1667M
$[PO_4^{3-}]$=0.28302M

As both of the K_{sp} are very small, we can assume that the molar concentration of both the hydroxide ion and the phosphate ion will remain the same compared to how much dissolves. This allows us to plug in both values for the K_{sp} expressions for both precipitates to determine which needs the smallest amount of copper to precipitate first.
For OH^-:
$4.5*10^{-21}=[Cu^{2+}](4.1667)^2$
$[Cu^{2+}]=2.5920*10^{-22}M$
Mols of Cu^{2+} needed$=2.5920*10^{-22}M*0.500L=1.30*10^{-22}$ mols

For PO_4^{3-}:
$(1.40*10^{-37})=[Cu^{2+}]^3(0.28302)^2$
$[Cu^{2+}]=1.2*10^{-12}M$
Moles of $Cu^{2+}=(1.2*10^{-12}M)(0.500L)=6.023*10^{-13}$mols
Thus, the $Cu(OH)_2$ will precipitate first as it requires the least amount of moles of copper to precipitate.

8.A solution of potassium acetate has a concentration of 0.534M. It's density is 1.0745g/mL. What is the molality and ppm of the solution?
Molality:
1.Assume you have 1L of the solution. Thus, you will have 1L(1000mL/1L)(1.0745g/mL)=1,074.5g of solution
2. Now, you need to find the grams of solute:0.534M(1L)(82g/mol)=43.79grams of solute
3. Mass of solvent=1,074.5g-43.97g=1.03053kg of solvent
4.molality=moles of solute/kg of solvent=0.534moles/1.03053kg=0.518m
PPM:
1.As a result of the calculations above, you already have the mass of the solute and solution. All you need to do now is plug those numbers into the ppm formula.
ppm=mass of solute/mass of solution*1000000=43.79g/1074.5g*1000000=40,753.84ppm

9.Calculate the osmotic pressure of 0.89m sodium chloride dissolved in 1kg water at 25℃.(Assume that the addition of the NaCl doesn't change the volume of the solution)
The first step is to convert the molality into molarity and then use the osmotic pressure formula.As the solvent is water, we can assume that we have 1kg of it to make our calculations easier.
0.89m(1kg)=0.89moles of sodium chloride
1kg(1mL/1g)(1000g/1kg)=1000mL=1L of water.
Molarity=0.89moles/1L of solution=0.89M
25℃=298K
Osmotic Pressure=(0.89M)((0.08206 L atm mol-1 K-1)(298K)=21.76atm


Periodic Table of the Elements
1 H Hydrogen 1.01
2 He Helium 4.00
3 Li Lithium 6.94
4 Be Beryllium 9.01
5 B Boron 10.81
6 C Carbon 12.01
7 N Nitrogen 14.01
8 O Oxygen 16.00
9 F Fluorine 19.00
10 Ne Neon 20.18
11 Na Sodium 22.99
12 Mg Magnesium 24.31
13 Al Aluminum 26.98
14 Si Silicon 28.09
15 P Phosphorus 30.97
16 S Sulfur 32.06
17 Cl Chlorine 35.45
18 Ar Argon 39.95
19 K Potassium 39.10
20 Ca Calcium 40.08
21 Sc Scandium 44.96
22 Ti Titanium 47.88
23 V Vanadium 50.94
24 Cr Chromium 51.99
25 Mn Manganese 54.94
26 Fe Iron 55.85
27 Co Cobalt 58.93
28 Ni Nickel 58.69
29 Cu Copper 63.55
30 Zn Zinc 65.38
31 Ga Gallium 69.72
32 Ge Germanium 72.63
33 As Arsenic 74.92
34 Se Selenium 78.97
35 Br Bromine 79.90
36 Kr Krypton 84.80
37 Rb Rubidium 85.47
38 Sr Strontium 87.62
39 Y Yttrium 88.91
40 Zr Zirconium 91.22
41 Nb Niobium 92.91
42 Mo Molybdenum 95.95
43 Tc Technetium 98.91
44 Ru Ruthenium 101.07
45 Rh Rhodium 102.91
46 Pd Palladium 106.42
47 Ag Silver 107.87
48 Cd Cadmium 112.41
49 In Indium 114.82
50 Sn Tin 118.71
51 Sb Antimony 121.76
52 Te Tellurium 127.6
53 I Iodine 126.90
54 Xe Xenon 131.29
55 Cs Cesium 132.91
56 Ba Barium 137.33
57-71 Lanthanides
72 Hf Hafnium 178.49
73 Ta Tantalum 180.95
74 W Tungsten 183.85
75 Re Rhenium 186.21
76 Os Osmium 190.23
77 Ir Iridium 192.22
78 Pt Platinum 195.08
79 Au Gold 196.97
80 Hg Mercury 200.59
81 Tl Thallium 204.38
82 Pb Lead 207.20
83 Bi Bismuth 208.98
84 Po Polonium [208.98]
85 At Astatine 209.98
86 Rn Radon 222.02
87 Fr Francium 223.02
88 Ra Radium 226.03
89-103 Actinides
104 Rf Rutherfordium [261]
105 Db Dubnium [262]
106 Sg Seaborgium [266]
107 Bh Bohrium [264]
108 Hs Hassium [269]
109 Mt Meitnerium [278]
110 Ds Darmstadtium [281]
111 Rg Roentgenium [280]
112 Cn Copernicium [285]
113 Nh Nihonium [286]
114 Fl Flerovium [289]
115 Mc Moscovium [289]
116 Lv Livermorium [293]
117 Ts Tennessine [294]
118 Og Oganesson [294]
57 La Lanthanum 138.91
58 Ce Cerium 140.12
59 Pr Praseodymium 140.91
60 Nd Neodymium 144.24
61 Pm Promethium 144.91
62 Sm Samarium 150.36
63 Eu Europium 151.96
64 Gd Gadolinium 157.25
65 Tb Terbium 158.93
66 Dy Dysprosium 162.50
67 Ho Holmium 164.93
68 Er Erbium 167.26
69 Tm Thulium 168.93
70 Yb Ytterbium 173.06
71 Lu Lutetium 174.97
89 Ac Actinium 227.03
90 Th Thorium 232.04
91 Pa Protactinium 231.04
92 U Uranium 238.03
93 Np Neptunium 237.05
94 Pu Plutonium 244.06
95 Am Americium 243.06
96 Cm Curium 247.07
97 Bk Berkelium 247.07
98 Cf Californium 251.08
99 Es Einsteinium [254]
100 Fm Fermium 257.10
101 Md Mendelevium 258.10
102 No Nobelium 259.10
103 Lr Lawrencium [262]
Alkali Metal
Alkaline Earth
Transition Metal
Basic Metal
Metalloid
Nonmetal
Halogen
Noble Gas
Lanthanide
Actinide