Chemistry Lab: Division C
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.
- A periodic table is provided on the last page for reference and to help answer some questions.

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)

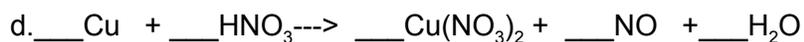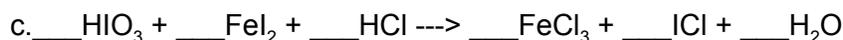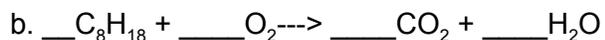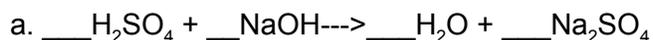a.Aqueous sodium sulfate reacts with aqueous calcium hydroxide.

b.Phosphoric acid reacts with water.

c.Hypobromous acid reacts with ammonia

d.Benzoic acid reacts with potassium acetate

e.Thiocyanic acid reacts with methylamine

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

a. ___H_2SO_4 + __NaOH--->___H_2O + ___Na_2SO_4

b. __C_8H_{18} + _____O_2---> ____CO_2 + ____H_2O

c.___HIO_3 + ___FeI_2 + ___HCl ---> ___$FeCl_3$ + ___ICl + ___H_2O

d.___Cu + ___HNO_3---> ___$Cu(NO_3)_2$ + ___NO +___H_2O

e.___$KMnO_4$+___HCl--->___KCl+___$MnCl_2$+___H_2O+___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)

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)$H_3O^+ + C_2H_3O_2^- \text{---}> H_2O + HC_2H_3O_2$
b)$BCl_3 + F_2 \text{---}> BClF_2 + Cl_2$
c)$NaOH + H_2O \text{---}> OH^- + H_2O + Na^+$
d)$HCl + H_2O \text{---}> H_3O^+ + Cl^-$

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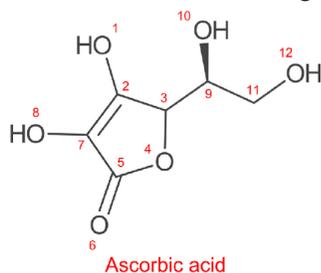
a)1
b)8
c)10
d)12

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).

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 $HC_2H_3O_2$ ($K_a=1.8*10^{-5}$)

b. 0.50M of H_2SO_4(K_{a1}=very large, $K_{a2}=1.2*10^{-2}$)

c. 0.30M of $H_2PO_4^-$($K_{a2}=6.2*10^{-8}$,$K_{a3}=3.6*10^{-13}$)

d. 0.001M of HCl(K_{a1}=very large)

e. 0.75M of NH_3($K_b=1.8*10^{-5}$)

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

k)MgO

4.a) Determine the pH of 500mL of 0.0500M acetic acid.(12 points all together, 4 points for each part)

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?

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?

5. Explain the difference between the end point and equivalence point of a titration. (5 points)

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

b)40mL of base added

c)100mL of base added

d) At the equivalence point of the titration

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

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

8. Draw an example titration graph of the titration described above, labeling the equivalence point, end point and buffer regions of the graph.(5 points)

Part 3: Aqueous Solutions(143 points)

Multiple Choice(2 points each)

Use the following chart for questions 1-4.

Table G   Solubility Curves
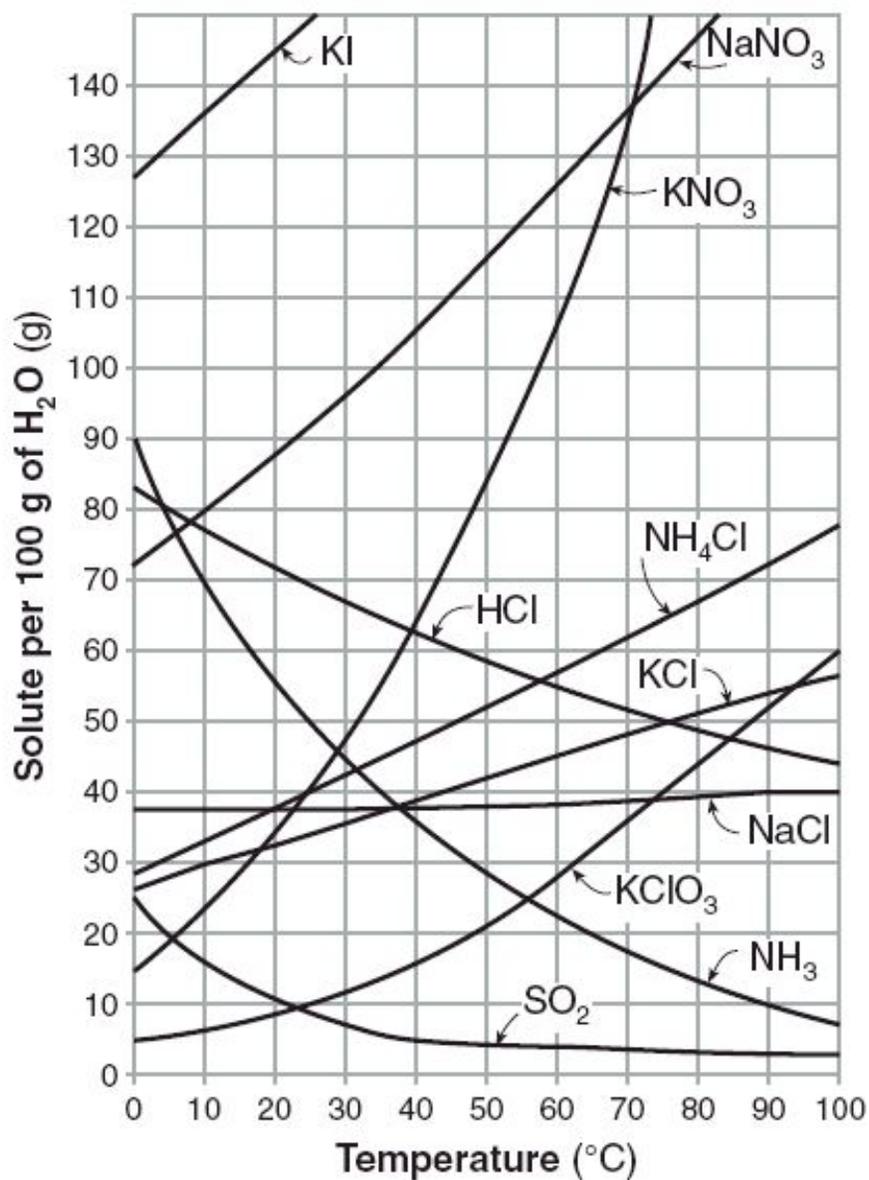
1.How manys grams of sodium nitrate must be added to 100 grams of water at 40°C to form a saturated solution?

A.100g
B.75g
C.105g
D.115g

2. A solution of ammonia contains 30g of ammonia in 200g of water at 10°C. 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°C 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°C. What is the new freezing point of this solution?(K_f=2.0°C/m)

A.15°C

B.12°C

C.20°C

D.30°C

19.What is the new boiling point of the above solution if the boiling point of pure solvent is 112°C?(K_b=1.75°C/m)

A.140°C

B.130°C

C.110°C

D.125°C

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

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)

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)

3.Why must a soda can be pressurized and kept in cool temperatures in order for it not to explode?(11 points)

4.Identify each of the following as soluble or insoluble compounds in water.(1 point each)
a)NaCl
b)KNO_3
c)Na_2S
d)$Mg_3(PO_4)_2$
e)$NaHCO_3$
f)$CaSO_4$
g)$PbCl_2$
h)$LiClO_3$
i)$Mg(OH)_2$
j)BaS
k)$Mg(NO_3)_2$

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(10 points)

6. What is the molar solubility of $Cu(OH)_2$ given that it's K_{sp} is $4.5*10^{-21}$?(10 points)

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 $1.40*10^{-37}$)(10 points)

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?(10 points)

9.Calculate the osmotic pressure of 0.89m sodium chloride dissolved in water at 25°C.(Assume that the addition of the NaCl doesn't change the volume of the solution)(10 points)

Periodic Table:

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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]

Legend: Alkali Metal · Alkaline Earth · Transition Metal · Basic Metal · Metalloid · Nonmetal · Halogen · Noble Gas · Lanthanide · Actinide