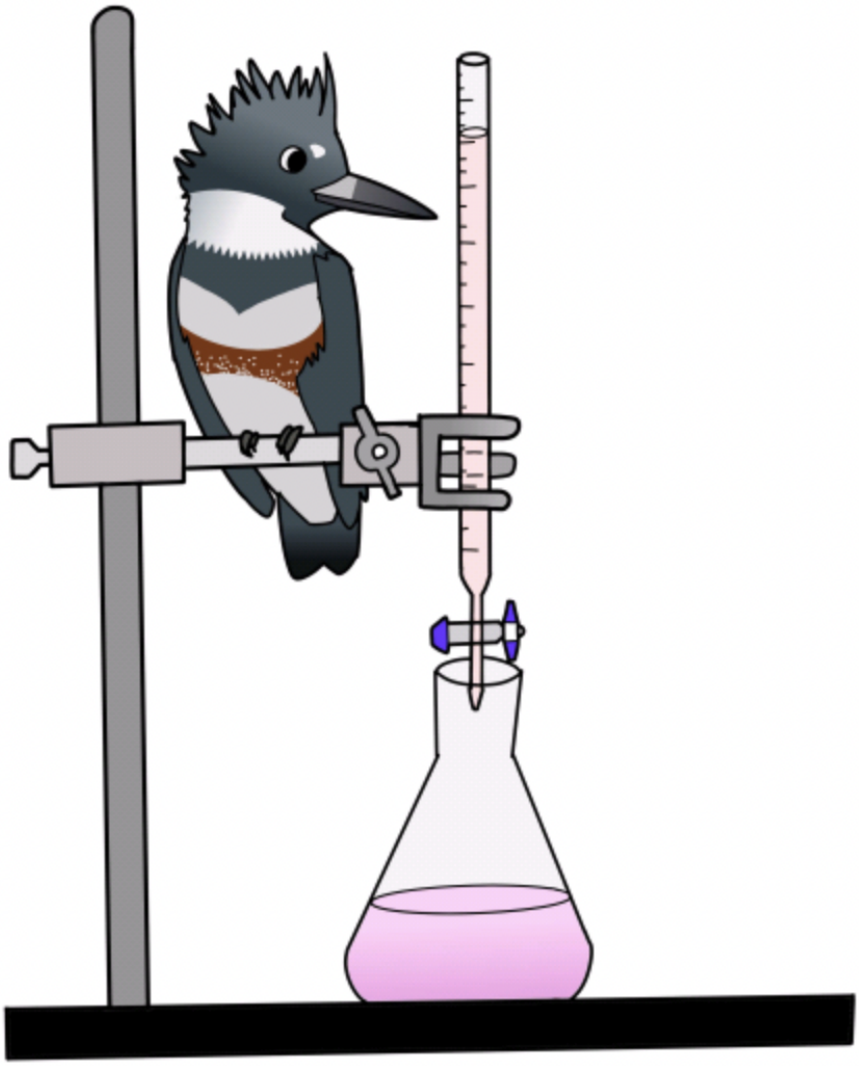

BirdSO Mini Invitational 12/11/2021

Chemistry Lab C

Event Supervisors: Daniel Ye and Dave Jiang

ANSWER KEY

Welcome to Chem Lab!

We are Daniel and Dave, and we are excited to be your supervisors for this event!

Some key reminders:

1. This is a 50 minute exam
2. Your reference sheets must be printed out. Your time spent out of browser WILL be recorded.
3. You may call your teammate through a phone call/Zoom/Discord etc. Make sure you don't accidentally click on that application/tab.
4. Make sure you have a working stand-alone calculator
5. Please read all instructions before starting the test!
6. This exam may test chemical principles beyond Solutions and Electrochem. It's impossible to be good at one area of general chemistry without knowledge of other areas (ex: Electrochem and equilibrium, acids/bases and solutions). Therefore, do expect a somewhat "comprehensive" treatment of general chemistry.
7. There is no wet-lab component to this exam
8. There are 120 questions
9. Good luck!

Part I - Redox Titration Experiment [15]

1. 0.737 V
2. $MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$
3. 8.2×10^{-4} moles
4. 4.1×10^{-3} moles
5. 0.23 g
6. 1.44%
7. The endpoint was overreached and additional MnO_4^- was added.
8. To complex Iron, lowering concentration of Fe^{3+}, easier visualization of endpoint
9. Mn^{2+} served as the color indicator. MnO_4^- is pinkish, Mn^{2+} is pale

Part II - Nitrogen Compounds [18]

10. Rate = $k[N_2O_2][O_2]$
11. $k_2k'[NO]^2[O_2]$ or $k_1k_2/k_{-1}\ [NO]^2[O_2]$ or $k[NO]^2[O_2]$
12. 0.66 M
13. 0.00665 M
14. $Cu \rightarrow Cu^{2+} + 2e^-$
15. $NO_3^- + 3e^- + 4H^+ \rightarrow NO + 2H_2O$
16. 0.95 V
17. -353 kJ/mol, change in entropy is positive
18. $Ag^+ + 2NH_3 \rightarrow [Ag(NH_3)_2^+]$
    i. *Note: Typo on Scilympiad so we accepted $Ag^{2+} + NH_3$ -> $[Ag(NH_3)^{2+}]$ or $Ag^+ + NH_3$ -> $[Ag(NH_3)^+]$ and other reasonable balanced alternatives.
19. 4.9×10^{-3} M

Part III - Gasoline [14]

20. $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$
21. 466 K
22. 8.75 moles
23. Warmer, negative deviation, exothermic (since Pmeasured<Pcalculated)
24. 1.6×10^{-4} M

Part IV - Vapor Pressure and Colligative Properties [32]

25. -0.987 Celsius
26. 5.57% by mass
27. 2.786 kPa

28. 400 K
29. 114.31 g/mol
30. 293 K
31. 26.47 g/mol
32. 422 grams
33. 11.29 grams
34. It raises the boiling point of solution, but also lowers the specific heat/heat capacity. It takes less energy to increase the temperature, but the temperature required for boiling is increased. Both of these changes are negligible since the amount of salt usually added during cooking is like nothing compared to the amount of other stuff.
35. 1.8×10^{-5}
36. Positive

Part V - Acids and Bases [18]

37. 1.633
38. 0.0257 M
39. 6
40. Endothermic - as T increases, K increases
41. 2.411
42. 1.057×10^{-5}
43. 19.76 mL
44. 9.21

Part VI - Transition Metal Complexes [11]

45. 1.25×10^{-4}
46. Low spin because CN^- is strong field ligand
47. A, C, D
48. 161.7 kJ/mol

Part VII - General Solutions Problems [27]

49. 6.30 M
50. 2.82 M
51. 8×10^{-14}
52. 2.7×10^{-5} M
53. Shifts to the right
54. 10.35

55. $BaSO_4$, 1.33 x 10^{-4} M needed
56. 4.5 x 10^{-5}
57. Any value from 680 to 700
58. 9.375 x 10^{-6} M
59. 132000
60. 1.6 x 10^{-11}
61. 4.61 x 10^{-42}

Part VIII - General Electrochemistry Problems [55]

62. 0.8871 V
63. -342.3 kJ
64. 0.8753 V
65. 2.5 grams
66. 1.44 V
67. 1.21 V
68. Phase boundary
69. 2.74E-16
70. 6.02 x 10^{7}
71. 336 g/mol
72. $2F^- \rightarrow F_2 + 2e^-$
73. YF_4
74. $Y^{4+} + 4F^- \rightarrow Y + 2F_2$
75. 0.57 L or 0.54 L
76. 14.1 A
77. 4.6 x 10^{22}
78. 1.617 g
79. 0.70 L
80. $AuCl_4^-$ ion itself is negative, and since like charges repel, stirring is needed to get the anions to the cathode
81. 2.59 x 10^{-5}
82. $Pb + 2Co(en)_3^{3+} \rightleftharpoons Pb^{2+} + 2Co(en)_3^{2+}$
83. 0.0154
84. -0.18 V
85. 1.39 V
86. 0.653 V
87. 0.82 V

88. E- + Co3+ → Co2+ has E of 1.82, which is enough to oxidize water

Part IX - General Chemistry Problems [32]

89. 0.75 M
90. 0.625 M
91. 0.25 M
92. 0.00116 M
93. $HOClO_3$ - conjugate base is more stable as more electronegative groups are attached, the negative charge is more distributed
94. 75 mL
95. 2
96. -404.9 kJ/mol
97. -106.8 J/mol K
98. 0<T<3791 K
99. $[Ar]4s^2 3d^{10}$
100. 18
101. 9
102. 30
103. [HA]=0.36, $[A^-]$=0.64 (accept +/- 0.02 or something)
104. 89
105. C
106. Cyclohexene

Part X - Haber Process & Ostwald Process [29]

107. 0.446 moles
108. 6.415 M
109. 4.3875 M
110. 0.305 moles
111. 0.21383 moles
112. 0.0951 moles
113. ~107.9 mmHg
114. 6.34 M
115. -23.5 kJ
116. Less because less temperature = less kinetic energy in the gaseous molecules (Kinetic Molecular Theory). Less kinetic energy = less frequent collisions = lowers the rate of reaction = less HNO_3 will be produced (Collision Theory).

117. Rate = $k[NH_3]^4[O_2]^5$

118. Increase by a factor of 2592.

Part XI - End Questions [2]

119. :)

120. :)

Test out of 253 points