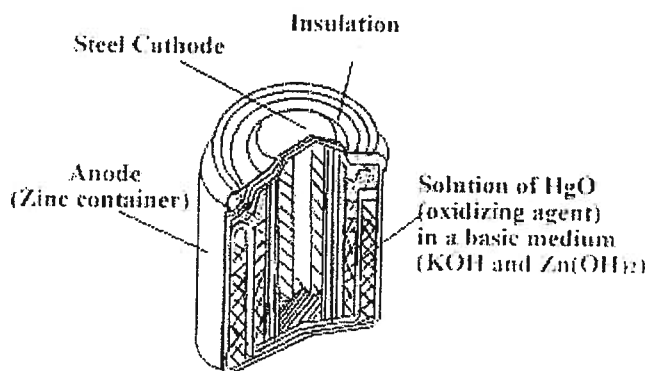


CHEMISTRY LAB

Kenston Science Olympiad Invitational

January 15, 2011



Mercury Dry Cell Battery

School Name: _____ Team # _____

Participant Names:

1. _____

2. _____

RAW SCORE: Redox _____/50

Aq. Solutions _____/50

TOTAL SCORE _____/100

Rank _____

CHEMISTRY LAB—Redox Answer Sheet

Kenston Science Olympiad Invitational

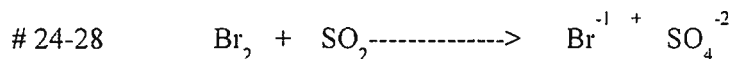
January 15, 2011

ONLY THESE TWO PAGES WILL BE GRADED IN THIS SECTION

School _____

Team # _____

- | | | | |
|----------|----------|-----------|-----------------|
| 1. _____ | 7 _____ | 13. _____ | 19. _____ |
| 2. _____ | 8 _____ | 14. _____ | 20. _____ |
| 3 _____ | 9 _____ | 15. _____ | 21 _____ |
| 4 _____ | 10 _____ | 16. _____ | 22 _____ (TB#1) |
| 5 _____ | 11 _____ | 17. _____ | 23 _____ |
| 6 _____ | 12 _____ | 18. _____ | |



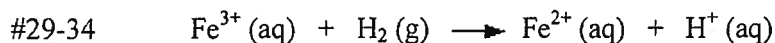
24. oxidation reaction:

25. reduction reaction:

26. overall reaction

27. oxidizing agent:

28. reducing agent:



29. What is the anode?

30. What is the cathode?

31. What is the overall reaction in acidic solution.

32. What does the vertical line represent in the line notation for a cell such as that in problem #20..(TB#2)

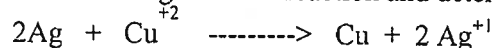
33-34. Write the correct line notation for this reaction.(2pts)

OXIDATION REDUCTION –PART I –50 points

- 1-6 What is the oxidation number for the underlined element in these compounds and ions?
1. $\underline{As}O_4^{-3}$ 2. \underline{C}_4H_8O 3. $K\underline{O}_2$ 4. $\underline{Cr}_2O_7^{-2}$ 5. \underline{Br}_2 6. \underline{OH}^{-1}
7. The sum of the oxidation numbers of all the atoms in the tetrathionate ion, $S_4O_6^{-2}$ is
- a. -2 b. +2 c. +2.5 d. +4 e. +5
8. Calculate the oxidation number of phosphorus in sodium dihydrogen phosphate.
- a. +1 b. -3 c. +3 d. +7 e. +5

9. Which of the following has an oxidation number of +6?
- a. chlorine in ClF_3 d. platinum in $PtCl_6^{2-}$
 b. gold in $KAuCl_4$ e. all of the above
 c. tungsten in WO_4^{2-}

10. Calculate the cell voltage for this reaction and determine if it is spontaneous or not.

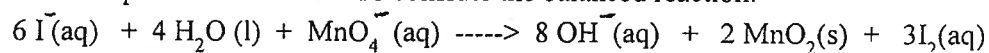


- a. -0.46v yes f. +1.14v no k. -1.26v yes
 b. -0.46v no g. -1.14v yes l. +1.26v no
 c. +0.46 yes h. -1.14v no
 d. +0.46 no i. +0.64v yes
 e. +1.14v yes j. -0.64 v no

11. In which of the following is reduction occurring?

- a. $SO_3 \longrightarrow SO_4^{-2}$ c. $H_2O_2 \longrightarrow OH^{-}$ e. $Mn^{+2} \longrightarrow Mn_2O_3$
 b. $KO_2 \longrightarrow O_2$ d. $SO_2 \longrightarrow HSO_3^{-}$

- #12-13 For the questions #10 and # 11 consider the balanced reaction:



12. The product in the **reduction half reaction** is:

- a. I^{-} b. MnO_4^{-} c. OH^{-} d. I_2 e. MnO_2

13. The reducing agent is

- a. I^{-} b. MnO_4^{-} c. H_2O d. K^{+} e. MnO_2

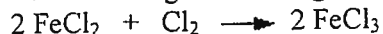
14. Balance the following half-reaction, in acid solution, using smallest whole number coefficients.



What is the coefficient of H^{+} in the balanced equation?

- a. 1 b. 2 c. 3 d. 4 e. 8

15. Iron (II) chloride reacts with chlorine gas according to the following equation:



- FeCl_2 is reduced, and Cl_2 is oxidized.
- FeCl_2 is the reducing agent, and Cl_2 is the oxidizing agent.
- Cl_2 is the reducing agent, and FeCl_2 is the oxidizing agent
- Cl_2 is both the reducing agent and the oxidizing agent.
- This is not a redox reaction

16. Sodium metal reacts with water to evolve hydrogen gas:



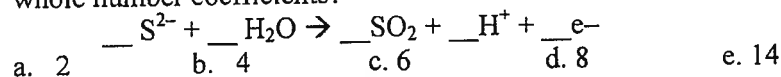
Which of the following is correct?

- Na is oxidized, and O is reduced.
- H is oxidized, and Na is reduced
- H is oxidized, and O is reduced
- O is oxidized, and H is reduced
- Na is oxidized, and H is reduced

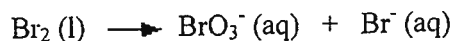
17. Which change represents an oxidation?

- $\text{NO}^{2-} \rightarrow \text{N}_2$ (C) $\text{ClO}^- \rightarrow \text{Cl}^-$
- $\text{VO}^{2+} \rightarrow \text{VO}^{3+}$ (D) $\text{CrO}_4^{2-} \rightarrow \text{Cr}_2\text{O}_7^{2-}$

18. What is the coefficient for H^+ when the half equation is balanced with the smallest whole number coefficients?

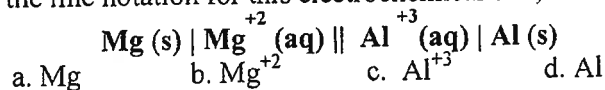


19. Write a balanced ionic equation for the following redox reaction in *basic* solution:

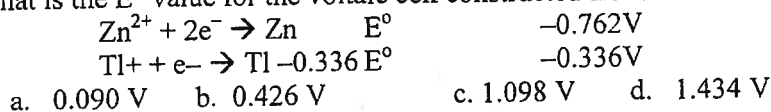


- $12 \text{OH}^- + 6 \text{Br}_2 \rightarrow 2 \text{BrO}_3^- + 6 \text{H}_2\text{O} + 10 \text{Br}^-$
- $6 \text{H}_2\text{O} + 6 \text{Br}_2 \rightarrow 2 \text{BrO}_3^- + 12 \text{H}^+ + 10 \text{Br}^-$
- $3 \text{H}_2\text{O} + \text{Br}_2 \rightarrow \text{BrO}_3^- + 6 \text{H}^+ + \text{Br}^-$
- $6 \text{OH}^- + \text{Br}_2 \rightarrow \text{BrO}_3^- + 3 \text{H}_2\text{O} + \text{Br}^-$
- none of the above

20. In the line notation for this electrochemical cell, what is the cathode?



21. What is the E° value for the voltaic cell constructed from the half-cells?



22. A solution of aqueous CuSO₄ is electrolyzed with a 1.50 ampere current for 30.0 minutes. What mass of copper metal is deposited? (TB #1)

- a. 0.889 g b. 1.19 g c. 1.78 g d. 3.56 g

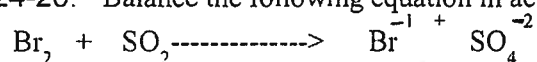
23. During the electrolysis of a dilute solution of sulfuric acid, what substance is produced at the anode?

- a. hydrogen b. hydrogen sulfide c. oxygen d. sulfur dioxide

FOR THE FOLLOWING QUESTIONS

WRITE ANSWERS ON ANSWER SHEET--SPACE HERE IS FOR YOUR CONVENIENCE AND WILL NOT BE GRADED.

#24-28. Balance the following equation in acidic solution:



24. oxidation reaction:

25. reduction reaction:

26. overall reaction

27. oxidizing agent: _____

28. reducing agent: _____

#29-34 Consider the following spontaneous redox reaction:



Assume the half reactions are separated into two compartments. Platinum electrodes are immersed in an iron solution and in an acid solution. Which of the following is correct?

29. What is the anode?

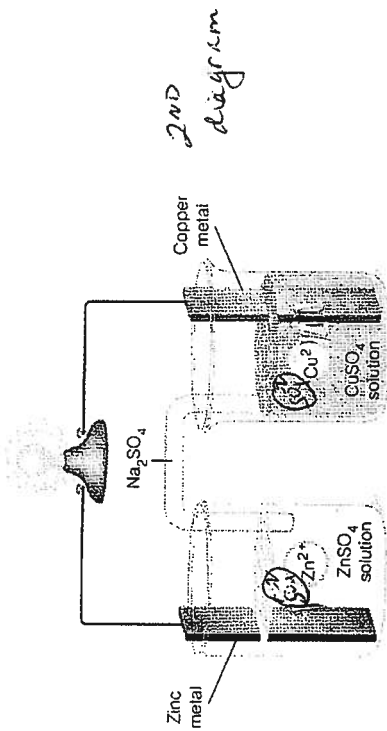
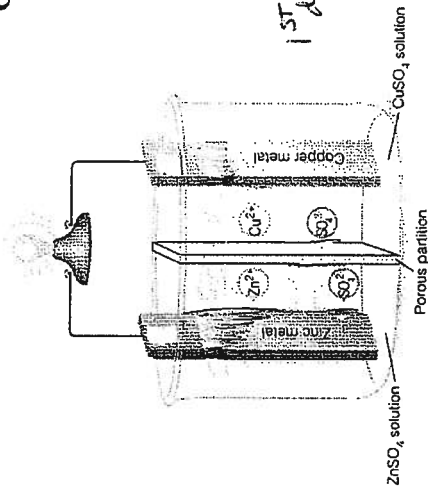
30. What is the cathode?

31. What is the overall reaction in acidic solution.

32. What does the vertical line represent in the line notation for a cell such as that in problem #20..(TB#2)

33-34. Write the correct line notation for this reaction.(2pts)

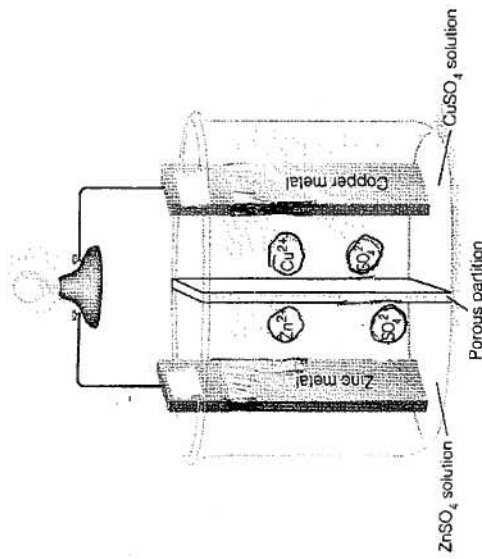
FOR THE FOLLOWING QUESTIONS
WRITE ANSWERS ON ANSWER SHEET--SPACE HERE IS FOR YOUR
CONVENIENCE AND WILL NOT BE GRADED.



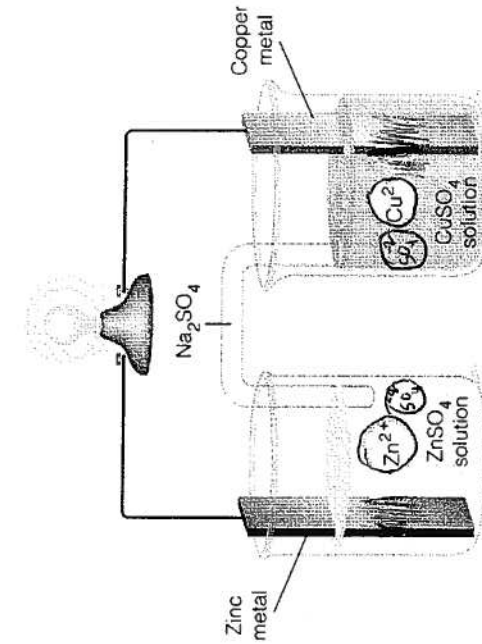
- #35-50 These are typical electrochemical cells.
- 35-37. What are three other names commonly used for electrochemical cells. (3pts)
 35 _____
 36 _____
 37 _____
38. Which metal is the anode? _____ 39. Which metal is the cathode? _____
40. What process occurs at the anode? (oxidation or reduction) _____
41. What process occurs at the cathode? (oxidation or reduction) _____
42. What is the voltage for these cells assuming 1M concentrations of ionic solutions? _____
43. Write the oxidation half-reaction: _____
44. Write the reduction half reaction: _____
45. Write the overall reaction _____
46. Indicate directly on the first image which is the + electrode and which is the - electrode.
47. Indicate directly on the second image which beaker contains the anode and which contains the cathode.
48. What is the name of the inverted "U" shaped tube in the second image?
49. Show the direction of flow of the ions across the porous partition in the first diagram.
50. Show the direction of flow of the electrons in the wiring on the second diagram.

Redox Answer Sheet

1st Diagram



2nd Diagram



#35-50 These are typical electrochemical cells.

35-37. What are three other names commonly used for electrochemical cells. (3pts) 36

38. Which metal is the anode? 37

39. Which metal is the cathode?

40. What process occurs at the anode? (oxidation or reduction)

41. What process occurs at the cathode? (oxidation or reduction)

42. What is the voltage for these cells assuming 1M concentrations of ionic solutions?

43. Write the oxidation half-reaction:

44. Write the reduction half reaction:

45. Write the overall reaction

46. Indicate directly on the first image which is the + electrode and which is the - electrode.

47. Indicate directly on the second image which beaker contains the anode and which contains the cathode.

48. What is the name of the inverted "U" shaped tube in the second image?

49. Show the direction of flow of the ions across the porous partition in the first diagram.

50. Show the direction of flow of the electrons in the wiring on the This is a typical electrochemical cell

Periodic Table of the Elements

<http://chemistry.about.com>
 ©2010 Todd Helmenstine
 About Chemistry

1A	1 H 1.00794 Hydrogen	2A	4 Be 9.012182 Beryllium	3A	5 B 10.811 Boron	4A	6 C 12.0107 Carbon	5A	7 N 14.0067 Nitrogen	6A	8 O 15.9994 Oxygen	7A	9 F 18.9984032 Fluorine	8A	2 He 4.002602 Helium
	3 Li 6.941 Lithium		12 Mg 24.3050 Magnesium		13 Al 26.9815386 Aluminum		14 Si 28.0855 Silicon		15 P 30.973762 Phosphorus		16 S 32.065 Sulfur		17 Cl 35.453 Chlorine		10 Ne 20.1797 Neon
	11 Na 22.989769 Sodium		20 K 39.0983 Potassium		31 Ga 69.723 Gallium		32 Ge 72.64 Germanium		33 As 74.92160 Arsenic		34 Se 78.96 Selenium		35 Br 79.904 Bromine		18 Ar 39.948 Argon
	19 K 39.0983 Potassium		37 Rb 85.4678 Rubidium		49 In 114.818 Indium		50 Sn 118.710 Tin		51 Sb 121.760 Antimony		52 Te 127.60 Tellurium		53 I 126.90447 Iodine		36 Kr 83.798 Krypton
	55 Cs 132.9054519 Cesium		56 Ba 137.327 Barium		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		85 At [210] Astatine		54 Xe 131.293 Xenon
	87 Fr [223] Francium		88 Ra [226] Radium		113 In [284] Ununtrium		114 Uuq [289] Ununquadium		115 Uup [288] Ununpentium		116 Uuh [293] Ununhexium		117 Uus [294] Ununseptium		55 La 138.90547 Lanthanum
	39 Y 88.90585 Yttrium		57-71 Sc [89-103] Lanthanides		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		56 Ce 140.116 Cerium
	38 Sr 87.62 Strontium		39 Y 88.90585 Yttrium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		57 La 138.90547 Lanthanum
	20 Ca 40.078 Calcium		21 Sc 44.955912 Scandium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		58 Ce 140.116 Cerium
	38 Sr 87.62 Strontium		39 Y 88.90585 Yttrium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		59 Pr 140.90765 Praseodymium
	56 Ba 137.327 Barium		57-71 Sc [89-103] Lanthanides		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		60 Nd 144.242 Neodymium
	88 Ra [226] Radium		89-103 Ac [89-103] Actinides		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		61 Pm [145] Promethium
	55 La 138.90547 Lanthanum		56 Ce 140.116 Cerium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		62 Sm 150.36 Samarium
	87 Fr [223] Francium		88 Ra [226] Radium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		63 Eu 151.964 Europium
	57 La 138.90547 Lanthanum		58 Ce 140.116 Cerium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		64 Gd 157.25 Gadolinium
	89 Ac [227] Actinium		90 Th 232.03806 Thorium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		65 Tb 158.92535 Terbium
	57 La 138.90547 Lanthanum		58 Ce 140.116 Cerium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		66 Dy 162.500 Dysprosium
	89 Ac [227] Actinium		90 Th 232.03806 Thorium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		67 Ho 164.93032 Holmium
	57 La 138.90547 Lanthanum		58 Ce 140.116 Cerium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		68 Er 167.255 Erbium
	89 Ac [227] Actinium		90 Th 232.03806 Thorium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		69 Tm 168.93421 Thulium
	57 La 138.90547 Lanthanum		58 Ce 140.116 Cerium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		70 Yb 173.054 Ytterbium
	89 Ac [227] Actinium		90 Th 232.03806 Thorium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		71 Lu 174.9668 Lutetium
	57 La 138.90547 Lanthanum		58 Ce 140.116 Cerium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		72 Yb 173.054 Ytterbium
	89 Ac [227] Actinium		90 Th 232.03806 Thorium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		73 Lu 174.9668 Lutetium
	57 La 138.90547 Lanthanum		58 Ce 140.116 Cerium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		74 Hf 178.49 Hafnium
	89 Ac [227] Actinium		90 Th 232.03806 Thorium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		75 Re 186.207 Rhenium
	57 La 138.90547 Lanthanum		58 Ce 140.116 Cerium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		76 Os 190.23 Osmium
	89 Ac [227] Actinium		90 Th 232.03806 Thorium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		77 Ir 192.217 Iridium
	57 La 138.90547 Lanthanum		58 Ce 140.116 Cerium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		78 Pt 195.084 Platinum
	89 Ac [227] Actinium		90 Th 232.03806 Thorium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		79 Au 196.966569 Gold
	57 La 138.90547 Lanthanum		58 Ce 140.116 Cerium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		80 Hg 200.59 Mercury
	89 Ac [227] Actinium		90 Th 232.03806 Thorium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		81 Tl 204.3833 Thallium
	57 La 138.90547 Lanthanum		58 Ce 140.116 Cerium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		82 Pb 207.2 Lead
	89 Ac [227] Actinium		90 Th 232.03806 Thorium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		83 Bi 208.98040 Bismuth
	57 La 138.90547 Lanthanum		58 Ce 140.116 Cerium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		84 Po [209] Polonium
	89 Ac [227] Actinium		90 Th 232.03806 Thorium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		85 At [210] Astatine
	57 La 138.90547 Lanthanum		58 Ce 140.116 Cerium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		86 Xe 131.293 Xenon
	89 Ac [227] Actinium		90 Th 232.03806 Thorium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		87 Rn [222] Radon
	57 La 138.90547 Lanthanum		58 Ce 140.116 Cerium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		88 Ra [226] Radium
	89 Ac [227] Actinium		90 Th 232.03806 Thorium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		89 U 238.02891 Uranium
	57 La 138.90547 Lanthanum		58 Ce 140.116 Cerium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		90 Th 232.03806 Thorium
	89 Ac [227] Actinium		90 Th 232.03806 Thorium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		91 Pa 231.03588 Protactinium
	57 La 138.90547 Lanthanum		58 Ce 140.116 Cerium		80 Hg 200.59 Mercury		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		92 U 238.02891 Uranium
	89 Ac [227] Actinium		90 Th 232.03806 Thorium		80 Hg 200.59 Mercury										

Standard Electrode Potentials in Aqueous Solution at 25°C

Cathode (Reduction) Half-Reaction	Standard Potential E (volts)
$\text{Li}^+(\text{aq}) + \text{e}^- \rightarrow \text{Li}(\text{s})$	-3.04
$\text{K}^+(\text{aq}) + \text{e}^- \rightarrow \text{K}(\text{s})$	-2.92
$\text{Ca}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ca}(\text{s})$	-2.76
$\text{Na}^+(\text{aq}) + \text{e}^- \rightarrow \text{Na}(\text{s})$	-2.71
$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mg}(\text{s})$	-2.38
$\text{Al}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Al}(\text{s})$	-1.66
$2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$	-0.83
$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Zn}(\text{s})$	-0.76
$\text{Cr}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Cr}(\text{s})$	-0.74
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.41
$\text{Cd}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cd}(\text{s})$	-0.40
$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ni}(\text{s})$	-0.23
$\text{Sn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Sn}(\text{s})$	-0.14
$\text{Pb}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Pb}(\text{s})$	-0.13
$\text{Fe}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.04
$2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$	0.00
$\text{Sn}^{4+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Sn}^{2+}(\text{aq})$	0.15
$\text{Cu}^{2+}(\text{aq}) + \text{e}^- \rightarrow \text{Cu}^+(\text{aq})$	0.16
$\text{ClO}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{ClO}_2^-(\text{aq}) + 2\text{OH}^-(\text{aq})$	0.17
$\text{AgCl}(\text{s}) + \text{e}^- \rightarrow \text{Ag}(\text{s}) + \text{Cl}^-(\text{aq})$	0.22
$\text{Cu}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$	0.34
$\text{ClO}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{ClO}_2^-(\text{aq}) + 2\text{OH}^-(\text{aq})$	0.35
$\text{IO}_3^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{I}^-(\text{aq}) + 2\text{OH}^-(\text{aq})$	0.49
$\text{Cu}^+(\text{aq}) + \text{e}^- \rightarrow \text{Cu}(\text{s})$	0.52
$\text{I}_2(\text{s}) + 2\text{e}^- \rightarrow 2\text{I}^-(\text{aq})$	0.54
$\text{ClO}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{ClO}^-(\text{aq}) + 2\text{OH}^-(\text{aq})$	0.59

Continued

$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{aq})$	0.77
$\text{Hg}_2^{2+}(\text{aq}) + 2\text{e}^- \rightarrow 2\text{Hg}(\text{l})$	0.80
$\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag}(\text{s})$	0.80
$\text{Hg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Hg}(\text{l})$	0.85
$\text{ClO}^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{Cl}^-(\text{aq}) + 2\text{OH}^-(\text{aq})$	0.90
$2\text{Hg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Hg}_2^{2+}(\text{aq})$	0.90
$\text{NO}_3^-(\text{aq}) + 4\text{H}^+(\text{aq}) + 3\text{e}^- \rightarrow \text{NO}(\text{g}) + 2\text{H}_2\text{O}(\text{l})$	0.96
$\text{Br}_2(\text{l}) + 2\text{e}^- \rightarrow 2\text{Br}^-(\text{aq})$	1.07
$\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}(\text{l})$	1.23
$\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14\text{H}^+(\text{aq}) + 6\text{e}^- \rightarrow 2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O}(\text{l})$	1.33
$\text{Cl}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{Cl}^-(\text{aq})$	1.36
$\text{Ce}^{4+}(\text{aq}) + \text{e}^- \rightarrow \text{Ce}^{3+}(\text{aq})$	1.44
$\text{MnO}_4^-(\text{aq}) + 8\text{H}^+(\text{aq}) + 5\text{e}^- \rightarrow \text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}(\text{l})$	1.49
$\text{H}_2\text{O}_2(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow 2\text{H}_2\text{O}(\text{l})$	1.78
$\text{Co}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Co}^{2+}(\text{aq})$	1.82
$\text{S}_2\text{O}_8^{2-}(\text{aq}) + 2\text{e}^- \rightarrow 2\text{SO}_4^{2-}(\text{aq})$	2.01
$\text{O}_2(\text{g}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{O}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$	2.07
$\text{F}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{F}^-(\text{aq})$	2.87

Constants Provided:
 $1 F = 96,500 \text{ C} \cdot \text{mol}^{-1}$
 $1 F = 96,500 \text{ J} \cdot \text{V}^{-1} \cdot \text{mol}^{-1}$
 $R = 8.314 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$
 $R = 0.0821 \text{ L} \cdot \text{atm} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$
 $1 \text{ C} = 1 \text{ A} \times 1 \text{ s}$
 $\Delta G^\circ = -nFE$
 $\Delta G^\circ = -RT \ln K$
 $0^\circ \text{C} = 273 \text{ K}$

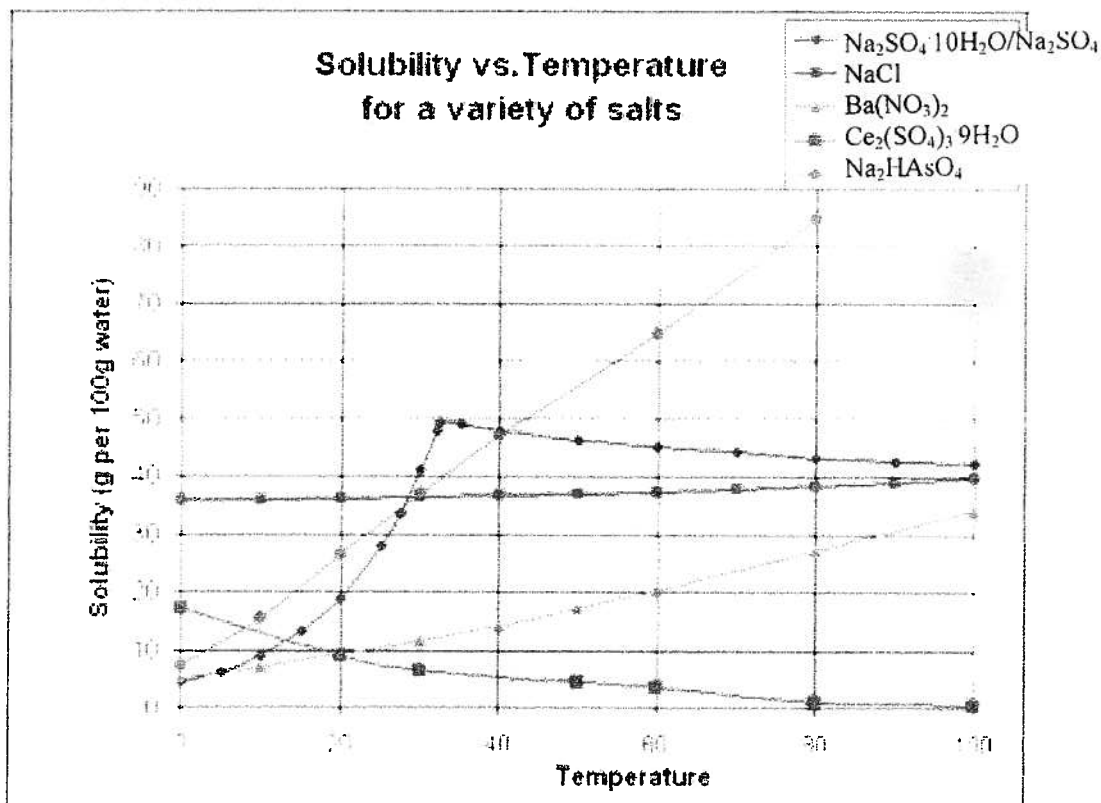
Nernst Equation: $E = E^\circ - \frac{RT}{nF} \ln Q$

Coulomb C
 Faraday constant F
 temperature, K T
 moles of electrons n
 free energy G
 Reaction quotient Q
 electromotive force E
 standard cell potential E°

School name _____ Team # _____

KENSTON SCIENCE OLYMPIAD INVITATIONAL 1-15-11

CHEMISTRY LAB—AQUEOUS SOLUTIONS—50 points



The solubility curves above are for some solid inorganic salts. Use the chart to answer the following questions. (1 point each) **USE ANSWER SHEET**

1. How much Ba(NO₃)₂ is soluble in exactly 100g of water at 75°C
2. How much Na₂HAsO₄ is soluble at 45°C in 400 g water?
3. What does the slope of the Ce₂(SO₄)₃·9H₂O graph indicate?
4. Give an explanation for the graph of the Na₂SO₄·10 H₂O/Na₂SO₄. (TB#3)
5. At what temperature does the solubility of Na₂SO₄·10 H₂O in 100g of water equal the solubility of Ba(NO₃)₂ at 70°C ?
6. How much more Na₂HAsO₄ is soluble in 200g water at 80 °C than NaCl at the same temperature and volume of water? **SHOW WORK ON YOUR ANSWER SHEET FOR CREDIT.**
7. What type of solution (saturated, unsaturated or supersaturated) would result if 16.0 g of Ba(NO₃)₂ was dissolved completely in 50g of water at 55 °C?
8. What is the molality of Na₂HAsO₄ (MM = 186g/mol) in 100g water at 20 °C? **SHOW WORK!**

MULTIPLE CHOICE (1 point each)

9. What is true of a supersaturated solution?
a. More solute can dissolve
b. The solution is unstable and may explode.
c. More solute added will cause crystallization until the solution becomes saturated
d. The solute will become unsaturated.
e. More solute added will cause crystallization until the solution becomes unsaturated.
10. Which compound forms a colorless solution when dissolved in H₂O? (TB #4)
a. Co(NO₃)₂ b. Na₂Cr₂O₇ c. KMnO₄ d. ZnCl₂
11. What is the percent by mass concentration for a 0.500 M KI solution? (Assume the density is 1.10 g/mL.)
a. 7.55% b. 0.550 % c. 9.13% d. 1.33% e. 8.30%
12. What is the molal concentration for 5.00 g of sodium carbonate in 100 g of water?
a. 0.602 m b. 0.573 m c. 0.0476 m d. 0.472 m e. 0.449 m
13. What is the molarity of KI in a solution that is 5.00% KI by mass and has a density of 1.038 g/ml?
a. 0.0301 M b. 0.313 M c. 0.500 M d. 0.625 M
14. What is the concentration of the solution that results from mixing 40.0 mL of 0.200 M HCl with 60.0 mL of 0.100 M NaOH? (You may assume the volumes are additive.)
a. 0.150 M NaCl
b. 0.0200 M NaCl and 0.0200 M HCl
c. 0.0200 M NaCl and 0.0600 M HCl
d. 0.0600 M NaCl and 0.0200 M HCl
15. A 0.1 M solution of which salt will have a pH less than 7?
a. NaCl b. NH₄Br c. KF d. NaO₂CCH₃
16. A 2.5 kg sample of groundwater was found to contain 8.26x10⁻⁵ moles of Zn⁺². What is the concentration of Zn⁺² in parts per million?
a. 2.2 ppm b. 9.9 ppm c. 330 ppm d. 0.0033 ppm e. 3.0 ppm
17. A 100. mL portion of 0.250 M calcium nitrate solution is mixed with 400. mL of 0.100 M nitric acid solution. What is the final concentration of the nitrate ion?
a. 0.180 M b. 0.125 M c. 0.0900 M d. 0.0625 M
18. Aqua regia, the reagent that can be used to dissolve gold, is a 3:1 mixture of which acids?
a. hydrochloric and sulfuric acids c. hydrochloric and nitric acids
b. hydrofluoric and nitric acids d. perchloric and sulfuric acids
19. Which is the net ionic equation for the reaction when 0.10 M solutions of silver nitrate and sodium sulfide are mixed?
a. Ag⁺(aq) + S⁻(aq) → AgS(s) c. Ag²⁺(aq) + S⁻(aq) → AgS₂(s)
b. Ag²⁺(aq) + S²⁻(aq) → AgS(s) d. 2Ag⁺(aq) + S²⁻(aq) → Ag₂S(s)

CHEMISTRY LAB—Aqueous Solutions Answer Sheet
Kenston Science Olympiad Invitational

January 15, 2011

School _____ Team # _____

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____ **SHOW WORK**

7. _____

8. **SHOW WORK.**

9. _____ 12. _____ 15. _____ 18. _____

10. _____ 13. _____ 16. _____ 19. _____

11. _____ 14. _____ 17. _____

20-24. #20-24. Turmeric, a natural compound, is added to mustard for flavor and color. It (5pts) changes color from yellow to red at a pH of 7.4. Mustard also contains acetic acid (CH_3COOH). A 0.50 gram sample of mustard is titrated with 5.0 ml of a 0.050 M NaOH. Determine the mass percentage of acetic acid in mustard.
SHOW WORK.

Periodic Table of the Elements

<http://chemistry.about.com>
 ©2010 Todd Helmenstine
 About Chemistry

1A	1 H 1.00794 Hydrogen	2A	4 Be 9.012182 Beryllium	3A	5 B 10.811 Boron	4A	6 C 12.0107 Carbon	5A	7 N 14.0067 Nitrogen	6A	8 O 15.9994 Oxygen	7A	9 F 18.9984032 Fluorine	8A	2 He 4.002602 Helium			
	3 Li 6.941 Lithium		12 Mg 24.3050 Magnesium		13 Al 26.9815386 Aluminum		14 Si 28.0855 Silicon		15 P 30.973762 Phosphorus		16 S 32.065 Sulfur		17 Cl 35.453 Chlorine		10 Ne 20.1797 Neon			
	11 Na 22.989769 Sodium				13 Al 26.9815386 Aluminum		14 Si 28.0855 Silicon		15 P 30.973762 Phosphorus		16 S 32.065 Sulfur		17 Cl 35.453 Chlorine		18 Ar 39.948 Argon			
	19 K 39.0983 Potassium		20 Ca 40.078 Calcium		31 Ga 69.723 Gallium		32 Ge 72.64 Germanium		33 As 74.92160 Arsenic		34 Se 78.96 Selenium		35 Br 79.904 Bromine		36 Kr 83.798 Krypton			
	37 Rb 85.4678 Rubidium		38 Sr 87.62 Strontium		49 In 114.818 Indium		50 Sn 118.710 Tin		51 Sb 121.760 Antimony		52 Te 127.60 Tellurium		53 I 126.90447 Iodine		54 Xe 131.293 Xenon			
	55 Cs 132.9054519 Cesium		56 Ba 137.327 Barium		81 Tl 204.3833 Thallium		82 Pb 207.2 Lead		83 Bi 208.98040 Bismuth		84 Po [209] Polonium		85 At [210] Astatine		86 Rn [222] Radon			
	87 Fr [223] Francium		88 Ra [226] Radium		113 Uut [284] Ununtrium		114 Uuq [289] Ununquadium		115 Uup [288] Ununpentium		116 Uuh [293] Ununhexium		117 Uus [294] Ununseptium		118 Uuo [294] Ununoctium			
				21 Sc 44.955912 Scandium	28 Ni 58.6934 Nickel	29 Cu 63.546 Copper	30 Zn 65.38 Zinc	47 Cd 112.411 Cadmium	48 In 114.818 Indium	80 Hg 200.59 Mercury	81 Tl 204.3833 Thallium	82 Pb 207.2 Lead	83 Bi 208.98040 Bismuth	84 Po [209] Polonium	85 At [210] Astatine	86 Rn [222] Radon		
				26 Fe 55.845 Iron	27 Co 58.933195 Cobalt	28 Ni 58.6934 Nickel	29 Cu 63.546 Copper	30 Zn 65.38 Zinc	47 Cd 112.411 Cadmium	80 Hg 200.59 Mercury	81 Tl 204.3833 Thallium	82 Pb 207.2 Lead	83 Bi 208.98040 Bismuth	84 Po [209] Polonium	85 At [210] Astatine	86 Rn [222] Radon		
				44 Ru 101.07 Ruthenium	45 Rh 102.90550 Rhodium	46 Pd 106.42 Palladium	47 Cd 112.411 Cadmium	48 In 114.818 Indium	80 Hg 200.59 Mercury	81 Tl 204.3833 Thallium	82 Pb 207.2 Lead	83 Bi 208.98040 Bismuth	84 Po [209] Polonium	85 At [210] Astatine	86 Rn [222] Radon	87 Fr [223] Francium		
				76 Os 190.23 Osmium	77 Ir 192.217 Iridium	78 Pt 195.084 Platinum	79 Au 196.966569 Gold	80 Hg 200.59 Mercury	112 Cn [285] Copernicium	113 Uut [284] Ununtrium	114 Uuq [289] Ununquadium	115 Uup [288] Ununpentium	116 Uuh [293] Ununhexium	117 Uus [294] Ununseptium	118 Uuo [294] Ununoctium	87 Fr [223] Francium		
				108 Hs [270] Hassium	109 Mt [276] Meitnerium	110 Ds [281] Darmstadtium	111 Rg [280] Roentgenium	112 Cn [285] Copernicium	113 Uut [284] Ununtrium	114 Uuq [289] Ununquadium	115 Uup [288] Ununpentium	116 Uuh [293] Ununhexium	117 Uus [294] Ununseptium	118 Uuo [294] Ununoctium	87 Fr [223] Francium	87 Fr [223] Francium		
				61 Pm [145] Promethium	62 Sm 150.36 Samarium	63 Eu 151.964 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.92535 Terbium	66 Dy 162.500 Dysprosium	67 Ho 164.93032 Holmium	68 Er 167.259 Erbium	69 Tm 168.93421 Thulium	70 Yb 173.054 Ytterbium	71 Lu 174.9668 Lutetium	87 Fr [223] Francium	87 Fr [223] Francium		
				93 Np [237] Neptunium	94 Pu [244] Plutonium	95 Am [243] Americium	96 Cm [247] Curium	97 Bk [247] Berkelium	98 Cf [251] Californium	99 Es [252] Einsteinium	100 Fm [257] Fermium	101 Md [258] Mendelevium	102 No [259] Nobelium	103 Lr [262] Lawrencium	87 Fr [223] Francium	87 Fr [223] Francium		
				57 La 138.90547 Lanthanum	58 Ce 140.116 Cerium	59 Pr 140.90765 Praseodymium	60 Nd 144.242 Neodymium	61 Pm [145] Promethium	62 Sm 150.36 Samarium	63 Eu 151.964 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.92535 Terbium	66 Dy 162.500 Dysprosium	67 Ho 164.93032 Holmium	68 Er 167.259 Erbium	69 Tm 168.93421 Thulium	70 Yb 173.054 Ytterbium	71 Lu 174.9668 Lutetium
				89 Ac [227] Actinium	90 Th 232.03806 Thorium	91 Pa 231.03586 Protactinium	92 U 238.02891 Uranium	93 Np [237] Neptunium	94 Pu [244] Plutonium	95 Am [243] Americium	96 Cm [247] Curium	97 Bk [247] Berkelium	98 Cf [251] Californium	99 Es [252] Einsteinium	100 Fm [257] Fermium	101 Md [258] Mendelevium	102 No [259] Nobelium	103 Lr [262] Lawrencium

Lanthanides

Actinides

**PROBLEMS -----SHOW ALL WORK FOR CREDIT.
Unsupported answers will NOT BE GIVEN PTS!**

#20-24. Turmeric, a natural compound, is added to mustard for flavor and color. It (5pts) changes color from yellow to red at a pH of 7.4. Mustard also contains acetic acid (CH_3COOH). A 0.50 gram sample of mustard is titrated with 5.0 ml of a 0.050 M NaOH. Determine the mass percentage of acetic acid in mustard.
SHOW WORK FOR CREDIT ON ANSWER SHEET--(No work, No credit)

USE THIS AREA FOR PRACTICE WORK

#25-28. It takes 26.23 mL of a 1.008 M NaOH solution to neutralize a solution of 5 g of (3pts) an unknown monoprotic acid in 150.2 mL of solution. What is the molecular weight of the unknown?
SHOW WORK FOR CREDIT ON ANSWER SHEET--(No work, No credit)

USE THIS AREA FOR PRACTICE WORK

29-32 Determine the boiling point and freezing point of a solution that contains (4pts) 25.0 g of CaCl_2 (111 g/mol) in 200.g of H_2O ? Assume the calcium chloride ionizes completely. [HINT : $\Delta T = i K_f m$ or $\Delta T = i K_b m$]
 $K_f = 1.86^\circ\text{C}/m$ $K_b = 0.51^\circ\text{C}/m$

USE THIS AREA FOR PRACTICE WORK

DRY LAB—How much sugar is in a can of 7-Up ? (18 pts)

Materials needed: ruler, non-programmable calculator

Other than water, high fructose corn syrup is one of the main ingredients in all non-diet sodas. In this lab a refractometer was used to analyze 7-Up soda for its sugar content. In this device, light from an outside source was passed through the solution and, as it slows down a little, it bends. This bending of light is proportional to the density of the solution that determines its specific gravity. The greater the concentration of the fructose solution, the greater its density, and its specific gravity, the greater is the angle of refraction.

The data collected is shown in this chart. Trials are summarized below:

Trial Number	0.400 M $C_6H_{12}O_6$ (mL)	H_2O (mL)	Concentration of $C_6H_{12}O_6$ (mol/L)	Specific Gravity
1	0.00	20.0	?	1.000
2	5.00	15.0	?	1.011
3	10.0	10.0	?	1.022
4	15.0	5.00	?	1.033
5	20.0	0.00	?	1.043
7-Up	10 mL 7-Up	10 mL H_2O	?	1.034

1. Calculate the concentration of fructose for each solution and complete the data table. (5pts)
2. Construct the graph plotting **Fructose Concentration (x axis) vs. Specific Gravity (y axis)**. Circle all data points and label the graph. Make the best line possible. (5 pts)
3. Using the specific gravity of the 7-Up, determine from the graph the fructose molarity of the diluted sample. (1 pt)
4. What is the concentration of the undiluted 10ml sample of 7-Up? (1pt)
5. Calculate the number of moles of $C_6H_{12}O_6$ from the known volume (10.0 mL) of the fructose/7-Up solution. (1pt)
6. Calculate the number of grams in the 10ml sample. (1 pt)
7. If 8 fluid ounces are equivalent to 240. mL, how many milliliters are equivalent to a 12 ounce can of soda? (1pt)
8. How many grams are in a 12 ounce can of soda? (1pt)
9. If 1 teaspoon is 4 grams, how many teaspoons of sugar are in each can? (1pt)
10. Since it is reported that a 12-ounce can of 7-Up contains 39.0 grams of sugar, calculate the percent error based upon your answer to question #8. (1pt)

#25-28. It takes 26.23 mL of a 1.008 M NaOH solution to neutralize a solution of 5 g of (3pts) an unknown monoprotic acid in 150.2 mL of solution. What is the molecular weight of the unknown?

SHOW WORK.

29-32 Determine the boiling point and freezing point of a solution that contains 25.0 g of CaCl_2 (111 g/mol) in 200.g of H_2O ? Assume the calcium chloride ionizes completely. [HINT : $\Delta T = i K_f m$ or $\Delta T = i K_b m$]

SHOW WORK.

DRY LAB--KEY

The data collected is shown in this chart. Trials are summarized below:

Trial Number	0.400 M $\text{C}_6\text{H}_{12}\text{O}_6$ (mL)	H_2O (mL)	Concentration of $\text{C}_6\text{H}_{12}\text{O}_6$ (mol/L)	Specific Gravity
1	0.00	20.0	?	1.000
2	5.00	15.0	?	1.011
3	10.0	10.0	?	1.022
4	15.0	5.00	?	1.033
5	20.0	0.00	?	1.043
7-Up	10 mL 7-Up	10 mL H_2O	?	1.034

1. Calculate the concentration of fructose for each solution and complete the data table. (5pts)
2. Construct the graph plotting **Fructose Concentration (x axis) vs. Specific Gravity (y axis)**. Circle all data points and label the graph. Make the best line possible. (5 pts)
3. Using the specific gravity of the 7-Up, determine from the graph the fructose molarity of the diluted sample. (1 pt)

4. What is the concentration of the undiluted 10ml sample of 7-Up? (1pt)

5. Calculate the number of moles of $C_6H_{12}O_6$ from the known volume (10.0 mL) of the fructose/7-Up solution. (1pt)

SHOW WORK.

6. Calculate the number of grams in the 10ml sample. (1 pt)

SHOW WORK.

7. If 8 fluid ounces are equivalent to 240. mL, how many milliliters are equivalent to a 12 ounce can of soda? (1pt)

SHOW WORK.

8. How many grams are in a 12 ounce can of soda? (1pt)

SHOW WORK.

9. If 1 teaspoon is 4 grams, how many teaspoons of sugar are in each can? (1pt)

SHOW WORK.

10. Since it is reported that a 12-ounce can of 7-Up contains 39.0 grams of sugar, calculate the percent error based upon your answer to question #8. (1pt)

SHOW WORK.

Team # _____

Determination of Sugar in 7-Up

