

SCHOOL NAME _____ TEAM NUMBER _____

PARTICIPANT NAMES: _____ AND _____

General Safety Considerations

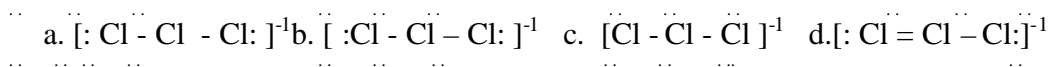
Wear protective glasses and an apron or clothing that covers down to your shoes (no open toes) at all times. Avoid skin contact with solids and solutions. Dispose of all solutions in the containers provided by your teacher. Wash your hands before leaving the laboratory.

IF YOUR GOGGLES FOG UP—COME TO THE FRONT OF THE ROOM AND ASK PERMISSION TO REMOVE YOUR GOGGLES—otherwise it is a DQ!

PART I: MULTIPLE CHOICE. Clearly write the letter for the best answer on the blank space provided on the answer sheet.

1. The hybridization of the central atom shown at the right is
- $$\begin{array}{c} \text{F} \\ / \\ \text{F} - \text{Xe} - \text{F} \\ \backslash \\ \text{F} \end{array}$$
- a. sp b. sp² c. sp³ d. dsp³ e. d²sp³
2. The resulting shape of the molecule in problem #1 is
- a. trigonal planar d. linear g. trigonal bipyramid
 b. bent e. octahedral h. trigonal pyramidal
 c. tetrahedral f. seesaw i. square planar
3. Atoms having greatly different electronegativities (> 1.7) would be expected to form:
- a. no bonds b. polar covalent bonds c. ionic bonds d. nonpolar covalent bonds
4. In which case is the bond polarity incorrect?
- a. H - F b. K - O c. Mg - H d. Cl - I e. Si - S
 $\delta^+ \quad \delta^-$ $\delta^+ \quad \delta^-$ $\delta^+ \quad \delta^-$ $\delta^+ \quad \delta^-$ $\delta^+ \quad \delta^-$
5. Based on electronegativities, which of the following would you expect to be the most ionic in character?
- a. N-N in N₂ b. Ca-F in CaF c. C-O in CO₂ d. C-H in CH₄ e. C-F in CF₄
6. The hybridization of the central atom shown at the right is
- $$\begin{array}{c} \text{F} \quad \text{F} \\ \backslash \quad / \\ \text{Cl} \\ | \\ \text{F} \end{array}$$
- a. sp b. sp² c. sp³ d. dsp³ e. d²sp³
7. The resulting shape of the molecule in problem #1 is
- a. trigonal planar e. linear i. trigonal bipyramid
 b. seesaw f. square pyramid j. T-shape
 c. bent g. octahedral k. trigonal pyramidal
 d. square planar h. tetrahedral
8. How many of the following molecules or ions contain double OR triple bonds?
- NH₃ NH₄⁺ HCN CO₂ NO₂⁻¹ N₂ H₂O
 a. 0 b. 1 c. 2 d. 3 e. 4 ab. 5 cd. 6

9. Which of the following is a valid Lewis structure for Cl_3^{-1} ?



10. A covalent bond could best be described as

- the overlap of two filled orbitals
- the overlap of two filled valence orbitals
- the overlap of two empty valence orbitals
- the overlap of two half-filled valence orbitals
- the overlap of a half-filled orbital and a filled orbital
- True love :)

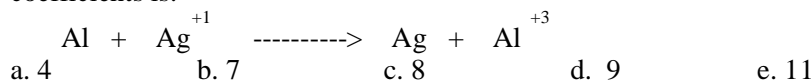
11. Which of the following species violate the octet rule?

- I. BF_3 II. XeCl_2 III. CO IV. CHF_3 V. SF_4 VI. Br_2
- I, II, III and VI
 - I and II
 - I, II, VI
 - I, III, VI
 - I, II, V

12. Which of the following has a coordinate covalent bond?

- BF_3
- XeCl_2
- CO
- CHF_3
- SF_4
- Br_2

13. When the following redox reaction is correctly balanced the sum of the final coefficients is:



14. In an electrochemical cell, one half cell contains, Mg metal in Mg^{+2} ion solution and the other half cell contains Pb in Pb^{+2} ion solution, which is the substance being oxidized?

- Mg
- Mg^{+2}
- Pb
- Pb^{+2} [see foot note for voltages]

15. In the electrochemical cell above, the voltage for the reaction is

- 2.50 v
- +2.50 v
- +2.24 v
- 2.24 v

16. When the following equation is balanced in basic solution, what is the coefficient of the water molecule? $\text{CN}^{-1}(\text{aq}) + \text{MnO}_4^{-1}(\text{aq}) \longrightarrow \text{CNO}^{-1}(\text{aq}) + \text{MnO}_2(\text{s})$

- 1
- 2
- 3
- 4
- 5

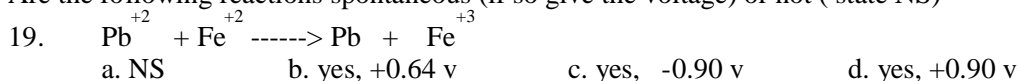
17. When water is electrolyzed, hydrogen gas is produced at

- the cathode
- the anode
- midpoint between anode and cathode

18. Of the following pairs, which is the most likely to be reduced Silver metal or Tin metal?

- Ag
- Si
- Sn
- Ti

Are the following reactions spontaneous (if so give the voltage) or not (state NS)



PART II: LAB SIMULATION #1: COPPER RECYCLING!

Situation: a piece of copper is subjected to a series of redox, double replacement and dehydration reactions with the recovery of pure copper. The stages of the reaction are displayed in the test tubes placed throughout the room. You may observe them at any time, but DO NOT SHAKE the tubes.

TEST TUBE #1:

1. A 0.50 gram piece of clean copper wire is placed in a test tube.

**PLACE ALL ANSWERS
ON ANSWER SHEET**

TEST TUBE #2

This page is not scored!

1. 5.0 ml of concentrated nitric acid is added to the copper in a fume hood and the reaction is allowed to proceed. A brown gas, nitrogen dioxide, is given off during this exothermic reaction.

This is the unbalanced redox reaction: $\text{Cu (s)} + \text{HNO}_3 \text{ (aq)} \rightarrow \text{Cu (NO}_3)_2 \text{ (aq)} + \text{NO}_2 \text{ (g)}$

- Q1. What substance is being oxidized?
- Q2. What substance is being reduced?
- Q3. Write the balanced net ionic oxidation half reaction in acidic solution.
- Q4. Write the balanced net ionic reduction half reaction in acidic solution:
- Q5. Write the balanced overall equation for this reaction.

TEST TUBE #3

1. 25 ml of 3M NaOH has been added to test tube #2 and stirred.
2. The solid material formed is copper (II) hydroxide, $\text{Cu(OH)}_2\text{(s)}$.

Q6. Write the balanced net ionic equation for this reaction.

TEST TUBE #4

1. The contents of the reaction in test tube #3 has been heated to near boiling.
2. The reaction is now complete and the contents have been allowed to settle. The supernatant liquid was decanted. About 150 ml of hot water was added with stirring and then the precipitate allowed to settle. This is done twice to wash the solid.
3. This product is copper (II) oxide, CuO(s) .

Q. 7: What spectator ions was/were removed when the sample was washed?

Q. 8: What does the term "decanted" mean?

THIS PAGE IS NOT SCORED. PUT ANSWERS ON ANSWER SHEET!!!

QUESTIONS ANSWERED ON THIS PAGE WILL NOT BE GRADED.
USE THE AREA FOR SCRAP PAPER.

ANSWER ON THE ANSWER SHEET ONLY!!

TEST TUBE #5

1. To the washed solid in test tube #4, 25 ml of 3.0 M H_2SO_4 is added and the contents stirred thoroughly.

Q. 9: What is the net ionic reaction for this step in the procedure?

TEST TUBE #6

1. A precut piece of zinc (in excess) is added to the test tube and placed in a cold water bath because the reaction is so exothermic.
2. The products forming in this step are hydrogen gas. Zinc chloride and pure copper.
3. The excess zinc was removed, the copper, washed and dried. It was found that 0.40 g of the copper was recovered.

Q.10: Write the balanced net ionic redox equation for the formation of the pure copper.

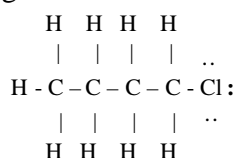
Q.11: Write the balanced net ionic equation for the redox reaction in the formation of the hydrogen gas.

Q. 12: What is the percent yield of this copper recycling process?

PART III: MOLECULAR MODEL PROBLEM #1

Observe the molecular model in the bag nearest you. This is to be shared by several groups. If any pieces are loose, please notify the event supervisor immediately. The black pieces represent carbon atoms, the small whitish pieces represent hydrogen and the blue piece represents oxygen. The connecting tubes represent covalent bonds.

1. Draw the Lewis Dot structure of the model in front of you on the answer sheet, showing each atom.



An **EXAMPLE** is shown here

Show your drawing of the actual model on the answer sheet! (TB #3)

2. What name is the root for the compound **modeled in the bag**?
a. pentane b. pentene c. pentyne
d. hexane e. hexene f. hexyne
3. What is the name for the functional group attached to this molecule?
a. ketone b. carboxylic acid c. amine d. alcohol e. ester
4. What type of isomer is shown in this structure?
a. trans b. cis c. no isomer present
5. How many isomers of this compound are possible?
a. 0-5 b. 6-10 c. 11-15 d. 16-20 e. 21-25 f. 26 or more
6. How many sigma bonds are present in this molecule?
a. 0 b. 1 c. 6 d. 10 e. 11 f. 14 g. 15 h. 16
7. How many pi bonds are present in this molecule?
a. 0 b. 1 c. 6 d. 10 e. 11 f. 14 g. 15 h. 16

PART IV: MOLECULAR MODELING PROBLEM #2 [USE ANSWER SHEET]

Consider the fulminate ion, CNO^{-1} (listed in order they are bonded to each other).

1. Draw the Lewis Dot structure for this ion and show any resonance structures, if they exist.
2. Give the hybridization of the central atom (N)

PART V: OXIDATION NUMBERS

[USE ANSWER SHEET]

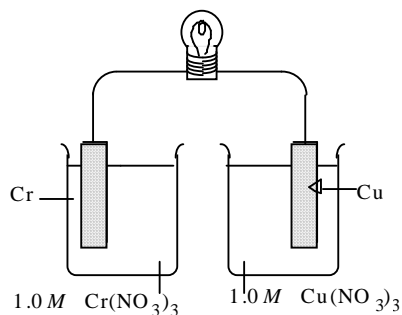
In each of these compounds or ions give the oxidation number of the bold, italicized and underlined atom:

1. Ga**A**sO₄
2. **C**₂H₆
3. **N**H₄Cl
4. **S**₈
5. **S**O₄⁻²

PART VI: CHEMICAL CELLS**[USE ANSWER SHEET]**

A galvanic cell is constructed using a chromium electrode in a 1.00-molar solution of $\text{Cr}(\text{NO}_3)_3$ and a copper electrode in a 1.00-molar solution of $\text{Cu}(\text{NO}_3)_2$. Both solutions are at 25°C .

1. Write a balanced net ionic equation for the spontaneous reaction that occurs as the cell operates. A partial diagram of this cell is shown here:



2. Identify the oxidizing agent.
3. Identify the reducing agent.
4. Which metal is the cathode?
5. What additional component is necessary to make the cell operate?
6. What is the cell voltage produced?
7. How does the potential of this cell change if the concentration of $\text{Cr}(\text{NO}_3)_3$ is changed to 3.00-molar at 25°C ? (Multiple choice)
 - a. increases
 - b. decreases
 - c. remains the same

PART VII: FUEL CELLS

1. Select a statement that is NOT true of fuel cells.
 - a. The reducing agent is consumed by the reaction.
 - b. The oxidizing agent is consumed by the reaction
 - c. A reducing agent and an oxidizing agent react to produce electrical energy.
 - d. No separation is required between the anode and cathode regions of the cell.
2. Fuel cells were first described around the year _____.
 - a. 1910
 - b. 1945
 - c. 1776
 - d. 1840
 - e. 1925
3. Fuels cell(s):
 - a. are renewed by refilling the reservoirs of reactants.
 - b. are only those voltaic cells that use a hydrogen anode and an oxygen cathode.
 - c. reactants are recycled by recharging the fuel cell with electricity.
 - d. are renewed by recharging with electricity

4. In this drawing of a Direct Methanol Fuel Cell (DMFC), which statement is not true?
- Methanol is electrochemically oxidized at the anode
 - All the free energy associated with this reaction is converted to electrical energy.
 - The anode produces electrons which travel through the external circuit to the cathode where they are consumed together with oxygen in a reduction reaction.
 - The circuit is maintained within the cell by the conduction of protons in the electrolyte.

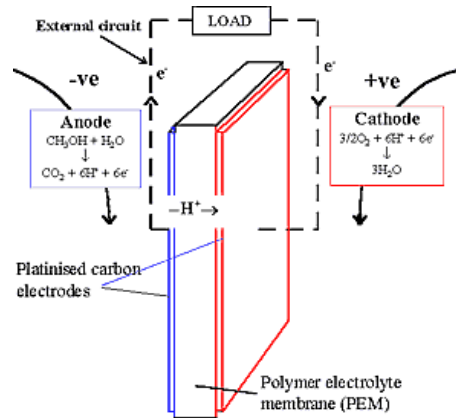


Diagram from: <http://www.staff.ncl.ac.uk/p.a.christensen/dmfc1.htm>