Last Name: **ID #** **# on the signature list:**
First Name: (to be entered by the teacher)

Professor: Dr. G. DÉNÈS Chem242-FE.W2011

CHEMISTRY 242/4 -51 Winter 2011

Final Examination Thursday April 21, 2011

Total number of pages: 24 **19:00-22:00**

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Enter your name and your Concordia ID number on the top of this page, in the space provided, and your Concordia ID number on the top of each subsequent page, in the space provided.

Answer all questions on this questionnaire. Balance all equations.
Explain your answers, starting from the periodic table, whenever possible.
Examination time: 6:00 - 7:00pm

No booklet

No book, note or periodical table allowed.
No scrap paper allowed. Use the back of the questionnaire sheets for scrap.
Printed translation dictionaries are allowed.
No scientific, technical, definition, or electronic dictionary is allowed
This final examination counts for 50 marks, out of a total of 100 marks.
If you do better in % in the final exam than in the midterm exam, the midterm exam will not count and the final exam will count for 75% instead of 50%.
When the question asks to compare values, such as distances, radii, energies, etc..., you are expected to tell whether numbers are larger, smaller, or about the same, and explain why if an explanation is requested. No numerical value is expected, unless requested.

This exam is made of two parts:

- Part I requires only short answers
- Part II requires full explanations

Answer all questions in the space provided on the questionnaire. You can use the back of the pages for scrap if you wish; it will not be graded.

Part I starts here. Give only short answers in the space provided. No explanation required unless requested.

1: Give the name of the scientists who did the following:

- designed a method to determine the *electron pair geometry* and *molecular shape* by evaluating repulsion between electron :

- designed a rule to show the variation of *health response of nutrient with intake dose*:

- determined the *maximum number of electrons that can be contained in an orbital* :

- determined the *electroneutrality rule* that allows to evaluate which of several non-equivalent Lewis structures represent best a molecule or polyatomic ion:

- designed the most used scale of electronegativity, that has 4.0 for F and 0.7 for Fr:

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2: Draw the electron dot diagram of the cyanide CN^- ion (no explanation required):

and answer the following questions regarding it:

- Formal charge on C: - Formal charge on N:

- Oxidation number on C: - Oxidation number on N:

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3: Give the *valence electronic structure* of the element located in group 16, period 5:

Give the *symbol* and *name* of the same element:

Give the *expected oxidation number(s)* of the same element:

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4: Give the type of all interatomic interactions that exist in liquid NH_3 (anhydrous) and what they are responsible for.

Interaction type	Responsible for

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5: Compare qualitatively (using the sign < and the ions symbol) the *ionic radius* of the ion obtained when Se, Br, Rb and Sr achieve the nearest noble gas configuration. Explain in 2 or 3 lines only.

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6: Circle the letter a, or b, or c, or... for the answer that applies best to the properties of most ionic compounds in the given conditions in each question below:

6.1 At ambient temperature, most ionic compounds are:

a. Hard and brittle
b. Hard but not brittle
c. Soft
d. Malleable
e. Ductile

6.2 At ambient temperature, most ionic compounds are:

a. Good electrical conductors
b. Semiconductors
c. Insulators

6.3 At ambient temperature, most ionic compounds are:

a. Gases
b. Liquids
c. Low melting point solids
d. High melting point solids

6.4 At ambient temperature:

a. Most ionic compounds dissolve in non-polar solvents and the solution does not conduct electricity.
b. Most ionic compounds dissolve in non-polar solvents and the solution conducts electricity.
c. All ionic compounds dissolve in high polarity solvents and the solution does not conduct electricity.
d. All ionic compounds dissolve in high polarity solvents and the solution conducts electricity.
e. Only some ionic compounds dissolve in high polarity solvents and for those that dissolve the solution does not conduct electricity.
f. Only some ionic compounds dissolve in high polarity solvents and for those that dissolve the solution conducts electricity.

6.5 When heated to the molten state in a non-reactive atmosphere, most ionic compounds behave as follows:

a. They decompose.
b. They do not decompose and they conduct electricity.
c. They do not decompose and they do not conduct electricity.

6.6 Find the incorrect statement.

a. Ionic compounds cannot be composed of only non-metals
b. Ionic compounds can be made of metals and non-metals.
c. Ionic compounds cannot be made of metals only.
d. An ionic bond is extreme case of a polar bond.
e. A small and highly charged cation can make covalent a bond that would otherwise be ionic

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7: The combustion reaction of hydrogen in oxygen to give hydrogen peroxide has a negative Gibbs free energy.

7.1 Write the balance equation for the above reaction.

7.2 However, the above reaction does not take place. Write the balanced equation for the combustion reaction of hydrogen in oxygen that actually takes place.

7.3 Compare qualitatively the Gibbs free energy of the reaction that actually takes to that of the reaction that gives hydrogen peroxide.

7.4 Using the position of oxygen in the periodic table, justify why the compound obtained by combustion of hydrogen in oxygen is the compound shown in your answer to question 7.2, rather than hydrogen peroxide.

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8. Fill in the missing word in the following sentences:

8.1 A semiconductor <u>not</u> doped with impurity is called an _____ semiconductor.

8.2 The theory that explains bonding and the electrical properties of metals based on the presence of a very large number of molecular orbitals very close to one another to form a continuum is called the _____ theory.

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9. Answer the following questions regarding the bcc structure of a metal:

9.1 Tell what bcc stands for:

9.2 Tell what is the radius of a metal atom versus the bcc unit-cell edge *a*:

9.3 Tell how many number of metal atoms there are in a bcc unit-cell:

9.4 Tell what is the coordination number of each metal atom in a bcc unit-cell:

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10: Answer the following questions about acids and bases.

10.1 An acid stronger than 100% sulfuric acid is called a _____.

10.2 *Magic acid* is made of _____.

10.3 *Magic acid* is used in the petroleum industry for breaking bonds between

and _____.

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11. Complete and balance the following reactions of hydrogen:

11.1 $CuO_{(s)} + H_{2(g)} \rightarrow$

11.2 $H_2C = CH_{2(g)} + H_{2(g)} \rightarrow$

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12. Answer the following questions about *ionic hydrides*:

12.1 They contain hydrogen in the following form (circle your answer):

H H_2 H^+ H^- Neutral, positive, negative for covalent

12.2 In addition to hydrogen, they contain one of the following element:

a. An alkali metal or an alkaline earth metal

b. A transition metal

c. A metalloid covalent hydride

d. A non-metal covalent hydride

12.3 Their structure is:

a. Similar to the metal, with similar electrical and magnetic properties

b. Molecular covalent hydride

c. Similar to a halide salt

d. Polymeric

12.4 Choose the correct statement about their structure:

a. At ambient temperature, they are gases, liquids or soft solids covalent hydrides

b. They melt at high temperature to give stable electrically non-conducting melts

c. They melt at high temperature to give stable electrically conducting melts

d. They decompose at high temperature, on melting or before.

12.5 Choose the correct statement about their reactivity with moisture:

a. They do not react with moisture

b. They react with moisture to give an acid and hydrogen gas

c. They react with moisture to give a base and hydrogen gas covalent hydrides

d. They react with moisture to give hydrogen gas only

e. They react with moisture to give ammonia.

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13. Circle the following species that have an octahedral molecular geometry:

2- not -

$[BrF_6]^-$ $[AsF_6]^-$ $[SnF_6]^-$ XeF_6

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14. Answer the following questions about the electrolysis of sodium chloride to produce sodium metal.

14.1 Tell what is the physical form of the sodium chloride electrolyzed:

2 NaCl (s) —> 2 Na (s) + Cl2 (g)

14.2 Tell what electrode produces sodium:

Iron cathode

14.3 Tell what is produced at the other electrode:

At carbon anode, oxidation to Cl- gas occurs

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15. Circle in the following list the mixed-oxidation state compounds:

PbO PbO_2 Pb_2O_3 Pb_3O_4 In_2O_3 InO

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16. Comparing group 1 and group 11 elements:

16.1 Give the list of the elements of group 11 and their electronic structure.

16 .2 Compare the reactivity of group 1 and group 11 elements with water, and use their electronic structure to explain the similarities/differences.

Text

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17. Beryllium oxide dissolves in both acids and bases.

17.1 This ability to dissolve in both acids or bases has two names. Give the two names:

amphoteric OR amphiprotic

17.2 Write the two balanced reactions:

BeO (s) + H2O + 2H3O+ —> [Be(OH2)4]2+

BeO (s) + H2O + 2OH- —> [Be(OH)4]2-

17.3 The name of the beryllium ion obtained in an acid is tetraaquarberyllium ion.

The name of the beryllium ion obtained in a base is tetrahydroxoberyllate ion.

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18. The shortest mercury-mercury distance in Hg_2F_2 is 2.51 Å.
Given that the ionic radius of the fluoride ion is 1.17 Å and that of the chloride ion is 1.67 Å, estimate the shortest mercury-mercury distance in Hg_2Cl_2. Justify your answer.

Approximately the same distance of Hg-Hg in Hg2Cl2. Hg prefers to be bonded to electronegative halogen compounds.

Due to relativistic effects, the distance will change slightly (2.51 to 2.53) but not much more.

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19. The molecular formula of $B(OH)_3$ is also written H_3BO_3.

19.1 Draw the molecule and show the polarity of the most polar bonds only.

19.2 Give the name of the compound:

Boric acid

19.3 Choose the correct answer in the following list:

a. $B(OH)_3$ is a weak base

b. $B(OH)_3$ is a strong base

c. $B(OH)_3$ is a weak acid

d. $B(OH)_3$ is a strong acid

e. $B(OH)_3$ is neither an acid nor a base

19.4 Give the molecular geometry of the $B(OH)_3$ molecule: Trigonal planar

19.5 Give the hybridization of boron in the $B(OH)_3$ molecule: sp2

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20. Positive oxidation states of group 14 elements:

20.1 Give the two positive oxidation states of group 14 elements and the trend within the group in terms of their stability.

+4 and +2

For Pb +2 is stable and in the +4 oxidation state, it is oxidizing

20.2 In one of their oxidation states, there is a lone pair, that can be *stereoactive* or *non-stereoactive*.

20.2.1 Explain in a few lines, using a drawing for each, what is a *stereoactive lone pair* and what is a *non -stereoactive lone pair*:

20.2.2 Give the difference between a *stereoactive lone pair* and a *non -stereoactive lone pair* in terms of the following:

a. Orbital hybridization:

b. Bonding:

c. Coordination number:

d. Regularity/distortions of the polyhedron of coordination:

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21. *Dinitrogen monoxide*, also called *laughing gas*, is a dissymmetric molecule

21.1 Give its formula:

21.2 Draw all its Lewis structures and write the formal charge of each atom above, in each Lewis structure:

21.3 Tell which of the Lewis structures is best representative of bonding in dinitrogen monoxide, and give the name and inventor of the law used to make this prediction:

21.4 Give the hybridization of the central atom:

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22. Compare oxygen to the rest of its group in terms of the following:

22.1 Physical state:

22.2 Catenation (also define *catenation*):

22.3 Bond stability versus bond order, with a short explanation:

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24. Group 17 elements:

24.1 Give the name of group 17:

24.2 Given the relative electronegativities of oxygen and fluorine, answer the following with a short explanation (no more than two lines each):

a. Tell which of oxygen or fluorine should bring out the highest oxidation state of xenon, according to their electronegativity:

b. The highest stable oxidation state compounds of xenon obtained with oxygen and fluorine are XeO_4 and XeF_6, respectively. Tell why.

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Part II starts here. Give your answers in the space provided. Detailed explanation required

25: Copper(I) chloride crystallizes in the fcc lattice, with the following ionic positions: metal ions in 0 0 0 and anions in 1/4 1/4 1/4 . The length of the edge of the unit-cell of copper(I) chloride is 5.416 Å.

25.1. Give the chemical formula of copper(I) chloride:

25.2. Tell what *fcc* means:

25.3. Give the list of lattice translations present in a fcc lattice:

25.4. Derive the list of all copper and chloride ions contained in the unit-cell (show calculation):

25.5. Draw a three-dimensional picture of the unit-cell and place all the ions inside;

25.6. Draw an appropriate projection of the unit-cell and place all the ions inside and give their height;

25.7. Determine the number of each kind of ions in the unit-cell (explain);

25.8. Check that the stoichiometry of the unit-cell is in agreement with that of the compound formula;

25.9. Determine the number of unit formulas in the unit-cell; show the formula used;

25.10. On the above projection, draw all the bonds for one Cu, and the same for one Cl, showing the three-dimensionality of the coordination of each ion.

Use the figure to give the coordination number and shape of the polyhedron of coordination for both ions.

25.11. Show on the figure one of each of the nearest Cu-Cu, Cl-Cl, and Cu-Cl distances and determine their numerical values. Show the detail of the calculations.