Chemistry 121

The University of British Columbia

Midterm Examination I

October 12, 2010

Put the first letter of your family/last name in this box.

Time: 60 minutes

Family/Last Name (printed):_____

First Name: _____

Signature:_____

Student Number:_____

Please check √ your lecture section:
___101 (MWF 1:00) Wolf
___102 (MWF 2:00) Chou
___103 (MWF 3:00) MacLachlan
___110 (MWF 10:00) Gates
___111 (MWF 11:00) Krems
___122 (T,Th 2:00) Lekhi
___133 (T,Th 3:30) Kunz
___188 (T,Th 8:00) Kunz
___199 (T,Th 9:30) McIntosh

INSTRUCTIONS

1. Write all answers on this examination paper, and show full details of your solutions for Part 2.
2. Read each question carefully.
3. Check that this examination consists of **10 PAGES PRINTED ON BOTH SIDES**, as well as a periodic table which may be detached for ease of use.
4. The only calculator allowed is the Sharp EL-510R. All other calculators will be confiscated. Cell phones or other electronic communication devices are not permitted.
5. Unassembled molecular model kits may be used.

RULES GOVERNING FORMAL EXAMINATIONS

1. Each candidate must be prepared to produce, upon request, a UBCcard for identification.
2. Candidates are not permitted to ask questions of the invigilators, except in cases of supposed errors or ambiguities in examination questions.
3. No candidate shall be permitted to enter the examination room after the expiration of 15 minutes from the scheduled starting time, or to leave during the first 15 minutes of the examination.
4. Candidates suspected of any of the following, or similar, dishonest practices shall be immediately dismissed from the examination and shall be liable to disciplinary action:
   - having at the place of writing any books, papers or memoranda, calculators, computers, sound or image players/recorders/transmitters (including telephones), or other memory aid devices, other than those authorized by the examiners;
   - speaking or communicating with other candidates; and
   - purposely exposing written papers to the view of other candidates or imaging devices. The plea of accident or forgetfulness shall not be received.
5. Candidates must not destroy or mutilate any examination material; must hand in all examination papers; and must not take any examination material from the examination room without permission of the invigilator.
6. Candidates must follow any additional examination rules or directions communicated by the instructor or invigilator.

Marks

Part	Question	Possible Marks	Marks
1		**14**	
2	**1**	**6**	
	2	**6**	
	3	**12**	
	4	**6**	
	5	**6**	
	6	**5**	
	7	**5**	
Total		**60**	

Part 1. Multiple Choice (14 marks total)
For each numbered statement below, circle the letter that corresponds to the best answer. There is only one correct answer per question. Each question answered correctly is worth 2 marks.

1. Which of the following compounds has a non-hydrogen atom that does not obey the octet rule?

   (a) arsenic trichloride
   (b) carbon dioxide
   (c) sulfur hexafluoride
   (d) ammonia
   (e) hydrazine (N_2H_4)

2. Arrange the following species in order of increasing size:

   $K, As^{3+}, Ge^{+}, Ga^{+}$

   (a) $As^{3+} < Ga^{+} < Ge^{+} < K$
   (b) $Ga^{+} < As^{3+} < Ge^{+} < K$
   (c) $Ge^{+} < K < Ga^{+} < As^{3+}$
   (d) $As^{3+} < Ge^{+} < Ga^{+} < K$
   (e) $As^{3+} < Ge^{+} < K < Ga^{+}$

3. Which one of the following statements is true?

   (a) Lithium does not react with water.
   (b) Sodium metal is mined in Northern Canada.
   (c) The electron affinity of rubidium is smaller in magnitude than that of sodium.
   (d) The chemical bonds between rubidium atoms in rubidium metal are ionic.
   (e) The reaction of cesium with water releases oxygen gas.

4. What is the oxidation state of Cr in $(NH_4)_2Mg(CrO_4)_2 \cdot 6H_2O$?

   (a) +2
   (b) +3
   (c) +4
   (d) +5
   (e) +6

5. Which of the following elements has 4 neutrons in the nucleus of its most abundant isotope?

(a) He
(b) Li
(c) Be
(d) B
(e) C

6. Molecules that have this shape are always polar.

(a) see-saw
(b) trigonal planar
(c) octahedral
(d) linear
(e) tetrahedral

7. Which of the following is expected to exist as an isolable molecule?

(a) C_4H_2
(b) H_3O
(c) N_2H_6
(d) F_4
(e) PH_6

Part 2. Short Answer Questions

6 marks 1. For this question, consider only the following elements as possible answers:

Li, Na, K, Rb, Cs
Be, Mg, Ca, Sr, Ba

For each part, give the symbol from the above list that makes the statement correct.

(a) _____ has the lowest first ionization energy.

(b) _____ forms an oxide with the largest lattice energy.

(c) _____ can form a compound with molar mass 78 g mol^{-1} that contains the peroxide ion.

6 marks 2. (a) Write a balanced equation for the reaction of magnesium with carbon dioxide.

(b) Write a balanced equation for the reaction of barium oxide with oxygen.

(c) Lithium metal reacts with nitrogen at room temperature to form lithium nitride (Li_3N). Sodium metal does not react with nitrogen under the same conditions. Provide a rationale for the difference of the reactivity of lithium and sodium with nitrogen.

12 marks 3. (a) Draw the best Lewis structure for each of the following molecules or ions. Draw only one structure when resonance is possible. Write any non-zero formal charges on the appropriate atoms, show all lone pairs of electrons as pairs of dots and all bond pairs as lines.

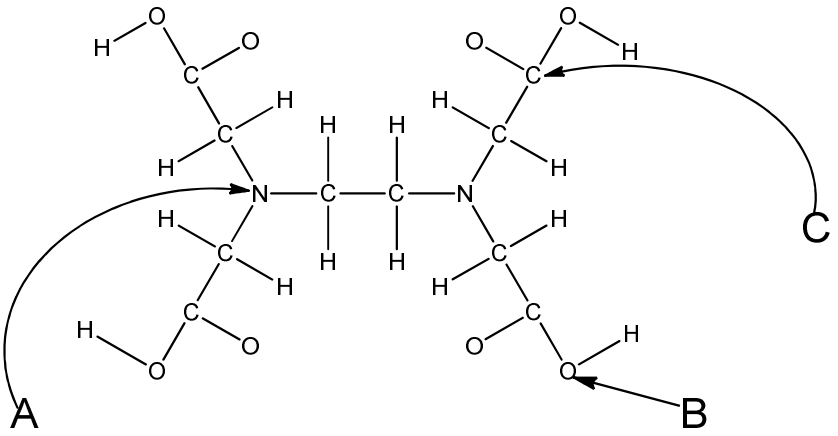
$[H_3O]^+$	NOF (N is the central atom)	$[SeO_3]^{2-}$

(b) Complete the following table by drawing the perspective diagram and specifying the molecular shape for each molecule. The central atom is underlined. In the last column, clearly write "YES" if the molecule is polar, or "NO" if it is not polar.

Formula	Perspective Diagram	Molecular Shape	Is the molecule polar?
$\underline{Se}Cl_4$			
$\underline{Br}Cl_3$			
$\underline{Xe}O_4$			

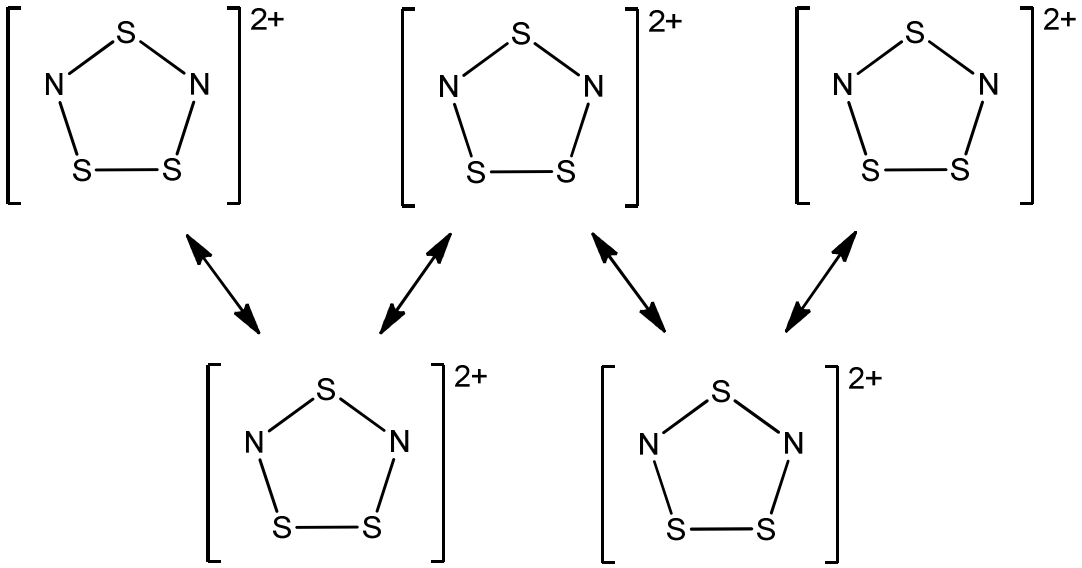
6 marks

4. EDTA (ethylenediamine tetraacetic acid) is a common food additive. EDTA traps metal impurities in food that result from modern-day food manufacturing. Once trapped by EDTA, the metal-EDTA complex is excreted from the body. The following diagram shows the skeletal structure of EDTA. Answer parts (a) – (f) concerning the molecule below by circling the best answer.



a) The molecular shape at the atom labeled **A** is (i) Tetrahedral (ii) Linear (iii) Trigonal Planar (iv) Bent (v) Trigonal Pyramidal	d) The number of carbon atoms with tetrahedral molecular shape in EDTA is (i) 0 (ii) 2 (iii) 4 (iv) 6 (v) 10
b) The estimated H-O-C bond angle at the atom labeled **B** is (i) 90° (ii) 120° (iii) 109° (iv) 145° (v) 60°	e) The formal charge on the atom labeled **A** in the best Lewis structure is (i) -2 (ii) -1 (iii) 0 (iv) +1 (v) +2
c) The estimated O-C-O bond angle at the atom labeled **C** is (i) 90° (ii) 120° (iii) 109° (iv) 145° (v) 60°	f) The oxidation state of the atom labeled **B** is (i) -2 (ii) 0 (iii) +2 (iv) +4 (v) none of the above

6 marks 5. The cation $[S_3N_2]^{2+}$ is known to exist as a ring with all VSEPR-predicted bond angles $\leq 120°$. Complete the templates below by adding lone pairs and bonds to show five best resonance Lewis structures for $[S_3N_2]^{2+}$. Show all lone pairs of electrons as pairs of dots and all additional bonds as lines. Write any non-zero formal charges on the appropriate atoms.



Space for rough work:

5 marks 6. Barium titanate has piezoelectric properties and is used in commercial products such as microphones and guitar pickups. Its structure consists of a simple cubic lattice of barium atoms where a titanium atom occupies the cubic hole and oxygen atoms occupy the middle of each face of the unit cell.

(a) What is the empirical formula of barium titanate?

Answer:

(b) How many oxygen atoms surround each titanium atom in barium titanate?

Answer:

(c) In barium titanate the radius of the oxygen ions is 1.26 Å, the radius of the barium ions is 1.56 Å and the radius of the titanium ions is 0.74 Å. What is the volume (in $Å^3$) of the unit cell of barium titanate?

Answer:

5 marks 7. A chemist found a bottle of an s-block metal, but the label had worn off so that the metal could not be identified. Under an argon atmosphere (to prevent any reaction with air or moisture), the chemist slowly added 5.00 g of the metal to an Erlenmeyer flask containing 500 g of bromine. A reaction occurred immediately (the flask became hot) and, after the reaction was complete, the excess bromine was evaporated to leave 9.67 g of a white solid.

(a) Identify the unknown metal with a chemical symbol? You must show your work for credit.

(b) Write a balanced equation for the chemical reaction observed.

End of Examination