

THE COLLEGE OF THE BAHAMAS
NATURAL SCIENCES DIVISION

FINAL EXAMINATION 04-2001

CHEM 235 - INORGANIC CHEMISTRY

Time: 3 hours

INSTRUCTIONS: Answer all questions
This paper has TWO sections.

Section A: 40 Multiple choice questions
Follow the instructions at the top of the answer sheet.

Section B: 6 Structured questions
Answer there in the spaces provided on the question paper.

SECTION A: Multiple Choice questions (40 marks)

For each of the following questions mark the letter corresponding to most appropriate answer on the multiple choice answer sheet provided

- For the electron shell with $n = 3$, what are the possible values of secondary quantum number l ?
 (A) 0, 1, 2, 3
 (B) -3, -2, -1, 0, 1, 2, 3
 (C) 1, 2, 3
 (D) 0, 1, 2
 (E) 4,2,1
- What is the designation of the subshell for which $n = 3$ and $l = 1$?
 (A) 4s (B) 3p (C) 3d (D) 2p (E) 4p
- What is the total number of electrons that a shell with $n = 2$ will hold?
 (A) 2 (B) 6 (C) 8 (D) 18 (E) 21
- "No two electrons in the same atom can have all four quantum numbers identical." This is a statement of:
 (A) Hund's Rule. (B) Aufbau Principle. (C) Pauli Exclusion Principle. (D) Lewis Rule.
 (E) Avogadro's rule
- In the following sets of elements, which sequence shows decreasing first ionization energies from left to right?
 (A) {F, Na, Cl, Cs}
 (B) {F, Cl, Na, Cs}
 (C) {Cs, Cl, Na, F}
 (D) {Cs, Na, Cl, F}
 (E) None of above
- The halogen that is a liquid under room condition is
 (A) chlorine (B) iodine (C) fluorine (D) bromine (E) None of above
- One of the following substances dissolves in water giving a solution that conducts electricity very well. Which one?
 (A) glucose, $C_6H_{12}O_6$
 (B) carbon tetrachloride, CCl_4
 (C) magnesium chloride, $MgCl_2$
 (D) ethane, C_2H_6
 (E) bromine, Br_2
- Which of the following molecules is linear?
 (A) CH_4 (B) CO_2 (C) H_2O (D) SO_3 (E) H_2S
- The shape of the ammonia molecule is
 (A) tetrahedral (B) linear (C) planar (D) pyramidal (E) square
- Which of the following is a weak acid?
 (A) HCN (B) HCl (C) H_2SO_4 (D) HNO_3 (E) KOH
- Three of the species listed are isoelectronic. Pick the one that does not belong:
 (A) P^{3-} (B) Ar (C) Cl^- (D) Ca^+ (E) None of above
- The electron configuration of sulfur (S) is $[Ne]3s^23p^4$. In view of that, which species is expected to form most readily?
 (A) S^{3+} (B) S^{2+} (C) S^- (D) S^{2-} (E) None of above
- One of the following substances is a strong base. Which one?
 (A) NH_3 (B) KOH (C) H_2CO_3 (D) KNO_3 (E) CH_3COOH
- From its position in the Periodic Table, the most stable ion of the $Z = 55$ element Cesium is likely to be:
 (A) Cs^+ (B) Cs^{2+} (C) Cs^{3+} (D) Cs^{2-} (E) Cs
- Which oxide forms nitrous acid upon dissolving in water?
 (A) N_2O (B) NO (C) NO_2 (D) N_2O_5 (E) All the above
- Which of the following compounds exhibits hydrogen bonding?
 (A) CH_4 (B) H_2O (C) PH_3 (D) HI (E) NaH

17. Consider the Lewis dot structures of the following molecules. Which one is held together by a covalent double bond?
 (A) H_2 (B) NH_3 (C) PBr_3 (D) O_2 (E) C_2H_6
18. The hydrides of Silicon is known as
 (A) Silica (B) Silates (C) Silanes (D) Silones (E) None of above
19. Which of the following atoms has the largest size?
 (A) Ca (B) Mg (C) P (D) F (E) S
20. Which of the following species has the smallest size?
 (A) N (B) N^- (C) N^+ (D) N^{2+} (E) All have the same size
21. What is the formula of the neutral compound formed when phosphorus reacts with sulfur if phosphorus has a +5 charge and sulfur has a -2 charge?
 (A) PS
 (B) PS_2
 (C) PS_3
 (D) P_2S_5
 (E) P_5S_2
22. . Which of the following compounds exhibits hydrogen bonding?
 (A) C_2H_2
 (B) HF
 (C) BH_3
 (D) H_2S
 (E) PH_3
23. The cyanide ion (CN^-) has a/an _____ bond between the carbon and nitrogen.
 (A) single (B) double (C) triple (D) ionic (E) None of the above
24. A bond where the electrons are unequally shared is called a/an _____ bond.
 (A) polar covalent (B) nonpolar covalent (C) diatomic (D) ionic (E) James
25. Which bond is the least polar? (Electronegativities: H = 2.2; N = 3.0; O = 3.5; P = 2.1; S = 2.5)
 (A) N-H (B) P-H (C) O-H (D) S-H (E) All of above are non-polar
26. Which of the following is **NOT** true for an ionic compound?
 (A) formed by electron transfer
 (B) low melting points
 (C) very strong bonds
 (D) the smallest grouping is called a formula unit
 (E) all are true
27. The electron configuration of sulfur (S) is $[\text{Ne}]3s^23p^4$. In view of that, which species is expected to form most readily?
 (A) S^{3+} (B) S^{2+} (C) S^- (D) S^{2-} (E) S^{3-}
28. What is the total number of valence electrons in $[\text{ClO}_4]^-$ anion?
 (A) 32 (B) 31 (C) 30 (D) 24 (E) None of the above
29. A natural source of Aluminum is
 (A) trona (B) limestone (C) Brine (D) aluma (E) bauxite
30. What is the shape of SbCl_6^- ion?
 (A) tetrahedral (B) trigonal bipyramidal (C) octahedral (D) planar hexagonal
 (E) None of above
31. Aluminum is prepared by
 (A) reduction of AlCl_3 with CO
 (B) reduction of Al_2O_3 with H_2
 (C) electrolysis of a melt of Al_2O_3 dissolved in Na_3AlF_6 .
 (D) calcining an aluminum ore
 (E) None of above.
32. Sulfur trioxide dissolves in water forming:
 (A) sulfurous acid. (B) sulfite ions. (C) sulfide ions. (D) sulfuric acid. (E) sulfur monoxide.

33. $\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2$ is:
 (A) cadmium acetate
 (B) calcium acetate
 (C) cadmium carbonate
 (D) calcium carbonate
 (E) calcium sulfate
34. Which of the following molecule is linear.
 (A) N_3^- (B) BF_3 (C) CO_2 (D) H_2O (E) B_2H_6
35. The electron configuration of an element is $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$
 (A) The element is in group VA of the Periodic Table and is a metalloid.
 (B) The element is a transition metal and shows different oxidation states in its compounds.
 (C) The element is a halogen which forms anions with a charge of -1 in its compounds with metals.
 (D) The element reacts rapidly with water to form hydrogen gas and a conducting solution.
 (E) The element is a metal and will not conduct electricity.
36. The most powerful reducing agent among the following five species is:
 (A) Na metal. (B) Na^+ ions. (C) Au metal. (D) Au^{3+} ions. (E) H_2 gas.
37. Carbon dioxide dissolves in water forming:
 (A) carbonate ions, CO_3^{2-} (B) bicarbonate ions, HCO_3^- (C) carbonic acid, H_2CO_3
 (D) acetic acid, CH_3COOH (E) none of these
38. The elements in this pair do NOT have similar chemical properties
 (A) boron and silicon (B) lithium and magnesium (C) fluorine and argon
 (D) beryllium and magnesium (E) None of above
39. The oxidation number of chlorine in ClO_4^- is
 (A) +8 (B) +7 (C) +3 (D) +1 (E) -1
40. The compound of KO_2 is
 (A) Normal oxide (B) peroxide (C) super oxide (D) all the above. (E) None of above

SECTION B

Answer all questions in the spaces provided

- 1a. Distinguish clearly between sigma and pi bonding (1)

Draw all the orbitals that can combine to form sigma bond and show how they combine. (3)

- b. When ammonia and boron trifluoride (BF_3) are mixed, a reaction occurs and a compound of molecular formula NBH_3F_3 is formed. Draw to show the covalent and the dative bond in the compound. (1)

c. The bond angles of the following hydrides CH_4 , NH_3 and H_2O are 109, 107 and 104 respectively

(i) Using VSEPR theory draw the shape of each of the molecule. (3)

(ii) Suggest why there are variations in the bond angles. (1)

d. (i) What is a polar covalent bond? (1)

(iii) In what circumstances will a covalent bond be polar? (1)

(iv) In what circumstances will an anion be polarized? (1)

(v) The table below shows electronegativity values for some atoms.

H	N	O	F	Cl	Cs
2.1	3.0	3.5	4.0	3.0	0.7

Use the data above in the table to suggest the nature of the bonding in each of the following substances. Give reasons for your suggestion. (3)

(i) cesium fluoride

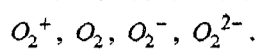
(ii) water

(iii) Chlorine

2. When one electron is added to oxygen molecule, a superoxide ion (O_2^-) is formed. The addition of two electrons gives a peroxide ion (O_2^{2-}). Removal of electron from O_2 leads to O_2^+ .

(a) Construct the molecular diagram for O_2^{2-} . (3)

(b) Give molecular electronic configuration for each of the following:



(4)

(c) Work out the bond order of each species.

(4)

(d) Predict the order of increasing bond energy among the species.

(1)

(e) Predict which species should be paramagnetic.

(1)

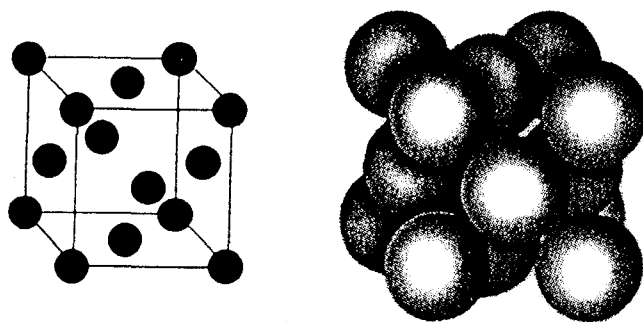
3a. Using the Born-Haber cycle calculate the lattice energy of calcium chloride, $CaCl_2$, from the following data:

standard heat of formation of $CaCl_2$	=	-794 kJ mole ⁻¹ .
Heat of sublimation of Ca(s)	=	+193 kJ mole ⁻¹ .
Dissociation energy of $Cl_2(g)$	=	+242 kJ mole ⁻¹ .
Ionization energy of Ca(g) to $Ca^{2+}(g)$	=	+1725 kJ mole ⁻¹ .
Electron affinity of Cl(g)	=	-347 kJ mole ⁻¹ .

(3)

- 3b. Rubidium crystallizes in the bcc system, the radius of the atom being 2.47 Å. What is the density? (Atomic mass of Rubidium = 85.47) (5)

- 3c. The following diagram represents the crystalline structure of Iron at room temperature (293K).



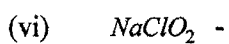
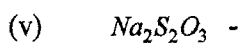
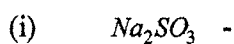
- (i) What is the name given to the above structure. (1)
- (ii) What is the coordination number of the central Iron in the given structure? (1)
- (iii) The atomic radii of atoms can be determined by measuring the side of the cubic structure. If the side of the above cube is 363 pm. Calculate the radius of the iron atom, state any assumptions you make. Note: $1 \text{ pm} = 10^{-12} \text{ m}$ [molar mass of iron = 55.8] (4)

- 4a The s-block elements form three kind of oxide, Normal oxide, peroxide and superoxide, using ionic equations only show how each of these oxide will react with water. (4)
- b. (i) What gives rise to diagonal relationship in the periodic table? (1)
- (ii) Give two anomalous behavior of lithium when compare with the rest of the element in the group. (2)
- (iii) Give reasons for these strange behaviors of lithium. (1)
- c. Write chemical equation to show the thermal decomposition of the following compound.
- (i) Barium hydroxide (1)
- (ii) Lithium nitrate (1)
- (iii) Sodium carbonate (1)
- (iv) Magnesium nitrate (1)
- d. Explain each of the following statement.
- (i) Boron does not form simple compounds containing the B^{3+} ion. (1)
- (ii) Aluminum chloride is predominantly covalent whereas aluminum fluoride is predominantly ionic. (1)

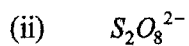
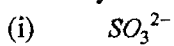
5a. Compare and contrast the properties of the Group IV chloride by completing the table below. (3)

	Tetrachloromethane	Silicon tetrachloride	Lead (II) chloride
Physical state at room temperature			
Electrical conductivity when liquid			
Effect of adding water at room temperature			
Type of bonding			

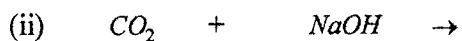
b. Give names for the following compound: (3)



c. Show by Lewis diagrams, indicating all lone pairs and bonding pair in (2)



d. Complete and balance the following equation (2)



6. (a) The following are the oxides of Chlorine:
chlorine monoxide, Cl_2O ; chlorine dioxide, ClO_2 ; chlorine hexoxide, Cl_2O_6 ; chlorine heptoxide, Cl_2O_7 . Write a balance ionic equations for each oxide to show their reaction with alkaline solution (OH^-). (4)

- (b) The following are oxy acid of chlorine
 $HOCIO$, $HOCIO_3$, $HOCIO_2$, $HOCl$.

(i) Arrange the following acids in increasing order of the strength of the acid. (1)

(ii) Give reason(s) for the arrangement. (1)

- c. Give all the properties of a Transition metals (4)