

NASSAU

FREEPORT

**COLLEGE OF THE BAHAMAS
SCHOOL OF NATURAL SCIENCES AND ENVIRONMENTAL
STUDIES
DEPARTMENT OF CHEMISTRY
FINAL EXAMINATION, SPRING SEMESTER 01-2003
CHEMISTRY 235: INORGANIC CHEMISTRY
TIME: 3 HOURS
CODE: R**

INSTRUCTIONS TO CANDIDATES

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

This paper has 12 pages including the cover sheet. There are forty questions in section I and 4 questions in section II. Each section has its own directions.

COMPLETE THE FOLLOWING CAREFULLY

YOUR STUDENT NUMBER _____

YOUR FULL NAME (PRINT CAREFULLY) _____

YOUR LECTURER'S NAME _____

(FOR OFFICIAL USE ONLY)

TOTAL MARKS ON PAPER _____ / = _____ %

SECTION I: Multiple Choice Questions

Indicate the letter corresponding to the best or most appropriate alternative on the separate answer sheet provided, according to the instructions thereon. There is one mark for each question in this section.

QUESTIONS 1 to 5

The elements may be classified as:

- A metals
- B extended structures with covalent bonds
- C diatomic molecules
- D monatomic molecules
- E elements with appreciable characteristics of both metals and non-metals

Into which classification would you place the elements which have the characteristics described below?

- 1) An outer electronic configuration of s^2p^6 .
- 2) The lowest electronegativity.
- 3) The highest melting point and boiling points.
- 4) Group VII elements.
- 5) The elements above tin in group IV.

QUESTIONS 6 to 11

These questions concern the following types of substance.

- A hydride of an alkali metal or alkaline earth metal
- B chloride of a non-metallic element
- C halogen
- D d-block element
- E compound of a d-block element

Select from A to E the type of substance described in each statement below. Each response may be used once, more than once, or not at all.

- 6) A solid at room temperature which reacts with water to give a colourless, flammable gas and a solution of high pH.
- 7) An orange solid which forms an orange solution in water. Iodine was liberated when aqueous potassium iodide was added.
- 8) A colourless liquid which is insoluble in water.
- 9) A substance which is a good conductor of electricity in the solid state. The substance is insoluble in water and reacts with dilute hydrochloric acid to liberate a colourless gas.

- 10) A liquid at room temperature which reacts vigorously with water to form a solution of low pH. This solution liberates a colourless, flammable gas when granulated zinc is added to it.
- 11) A coloured liquid at room temperature which disproportionates when heated with concentrated aqueous sodium hydroxide.

QUESTIONS 12 to 17

These questions concern the elements of group 4 of the periodic table. Each response may be used once, more than once, or not at all.

- A Carbon
- B Silicon
- C Germanium
- D Tin
- E Lead

Select from A to E the element which:

- 12) has the highest first ionization energy.
- 13) has an outer electron shell configuration of $4s^24p^2$
- 14) forms an oxide which on warming with sodium chloride and concentrated sulphuric acid gives chlorine gas.
- 15) forms a chloride which is used in organic chemistry as a reducing agent in solution.
- 16) in the +4 oxidation state forms a chloride which is resistant to hydrolysis.
- 17) in a mixture with hydrochloric acid is used as a reducing agent, especially in organic chemistry.

QUESTIONS 18 TO 22

These questions concern the following hybridisation states:

- A sp
- B sp^2
- C sp^3
- D sp^3d
- E sp^3d^2

Indicate the appropriate hybridisation state in each of the following cases. (Each response may be used once, more than once, or not at all.)

- 18) Nitrogen in the nitrate ion.
 19) Lead in plumbane, PbH_4
 20) Beryllium in beryllium dichloride, BeCl_2 .
 21) Phosphorus in phosphorus pentachloride.
 22) Sulfur in sulfur hexafluoride, SF_6 .

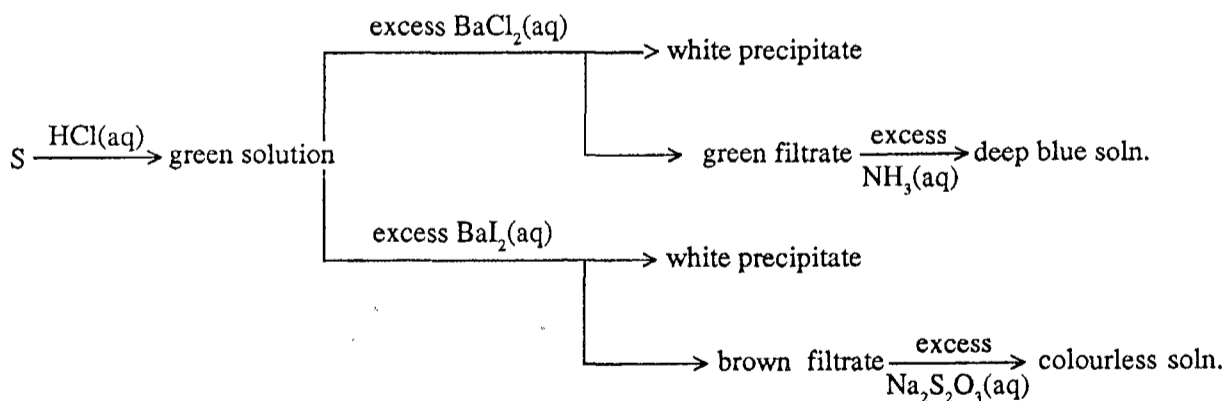
QUESTIONS 23 TO 28

These questions concern the following substances:

- A zinc sulfite
 B sodium thiosulfate
 C lead(II) sulfate
 D nickel(II) nitrate
 E potassium nitrate

In each of the following cases suggest which one of the above compounds is best described by the following tests. (Each response may be used once, more than once, or not at all.)

- 23) A colourless solution of this solid reacts with dilute sulfuric acid to liberate a choking gas that turns potassium dichromate paper green, whilst a pale yellow precipitate forms in the solution.
 24) A green solution of this compound gives a pale green precipitate, insoluble in excess, with sodium hydroxide solution. A similar



- 30) Above is a reaction scheme for a salt S. What is S?
 A Chromium(III) chloride
 B Chromium(III) sulphate
 C Copper(II) chloride
 D Copper(II) sulphate
 E iron(II) sulphate
- 31) Which one of the following statements about sulphur and oxygen is true?
 A Both consist of diatomic molecules in the solid state.
 B Both form hydrides which have acidic properties.

precipitate, but which dissolves in excess to give a green solution, is formed with aqueous ammonia. With ammonia, precipitation is suppressed by first adding ammonium chloride solution.

- 25) A colourless solution of Q gives no precipitate with either barium chloride solution or silver nitrate solution. The colour of iron(III) chloride solution is unchanged by the addition of the solution of Q. What is Q?

- 26) A flame test on this solution gives a lilac colour.

- 27) This white compound is insoluble in water, and dilute ammonia, but soluble in sodium hydroxide solution due to the formation of a soluble hydroxo-complex of the cation.

- 28) This compound is white when solid and dissolves in water to give a colourless solution. Addition of dilute acid liberates a sharp-smelling gas which turns orange acidified potassium dichromate paper green but no precipitate is formed.

- 29) An element X forms an oxide which is readily hydrolysed by water to produce an acidic solution. Select from the following the element most likely to be X.

- A Sodium
 B Caesium
 C Neon
 D Calcium
 E Sulphur

- C Both form ionic chlorides.
 D Neither forms ionic compounds.
 E Neither can easily be reduced.
- 32) Which one of the following chlorides **cannot** be prepared by the action of chlorine on the element?
 A sodium chloride
 B magnesium chloride
 C phosphorus trichloride
 D tetrachloromethane (CCl_4)
 E aluminium chloride
- 33) Which one of the following statements regarding the characteristics of elements within any one group of the periodic table is correct?
 A The elements are either all metals or all non-metals.
 B The melting and boiling points always increase with increasing atomic number.
 C The first ionization energy of the elements usually decreases with increasing atomic number.
 D The hardness of the solid elements always increases going down the group.
 E The acidity of the oxides always increases going down a group.
- 34) A metal reacts on heating with both dry chlorine and also dry hydrogen chloride to give a different **solid** product in each case. Which of the following metals behaves in this way?
 A Iron
 B Magnesium
 C Zinc
 D Aluminium
 E Lead
- 35) Sodium is normally extracted from its ores by
 A reducing them with potassium vapour.
 B reducing them with coke at high temperatures.
 C electrolysis.
 D roasting them in air.
 E blowing oxygen through the molten ore.
- 36) Which one of the following substances is **NOT** produced at some stage during the Solvay (ammonia/soda) process?
 A carbon dioxide
 B calcium chloride
 C calcium oxide
 D ammonium chloride
 E calcium carbonate
- 37) In the extraction of aluminium from its oxide by electrolysis, *cryolite*, Na_3AlF_6 , acts as a/an
 A cathode.
 B anode.
 C metallic conductor.
 D solvent.
 E separator.
- 38) Which one of the following electronic configurations does **NOT** represent an atom of an alkali metal?
 A 2.1
 B 2.8.8.1
 C 2.8.18.1
 D 2.8.18.8.1
 E 2.8.18.18.8.1
- 39) The electronic configuration of the element radium can be represented as [noble gas] $7s^2$. Which one of the following statements is **UNLIKELY** to be correct on the basis of the known trends in the properties of elements in the same group?
 A Radium has an oxidation number of +2 in all its compounds.
 B Radium decomposes water at room temperature, liberating hydrogen.
 C Radium carbonate is ionic.
 D Radium hydroxide is amphoteric.
 E Radium hydride is a stable gas.
- 40) Only one third of the total chlorine in a compound with the empirical formula $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ can be precipitated by silver nitrate solution at room temperature. Which one of the following shows the most likely structure for the compound?
 A $[\text{CrCl}(\text{H}_2\text{O})_5]^{2+}(\text{Cl}^-)_2 \cdot \text{H}_2\text{O}$
 B $[\text{CrCl}_2(\text{H}_2\text{O})_4]^+(\text{Cl}^-) \cdot 2\text{H}_2\text{O}$
 C $[\text{CrCl}_3(\text{H}_2\text{O})_3] \cdot 3\text{H}_2\text{O}$
 D $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}(\text{Cl}^-)_3$
 E $\text{Cr}^{3+}(\text{Cl}^-)_3 \cdot 6\text{H}_2\text{O}$

- c) Iodine is often used in solution in aqueous potassium iodide rather than in pure water. Why is this? What is responsible for the characteristic red colour of these solutions? (3)

- d) i) Hydrogen fluoride is produced by the reaction of calcium fluoride with a suitable reagent. Name the reagent and write an equation for the reaction. (1)

- ii) Hydrogen fluoride has the highest boiling point of all the hydrogen halides and hydrogen chloride the lowest. Why is this? (4)

- e) i) Write an equation for the reaction of aluminium chloride with a large excess of water. (1)

- ii) Briefly explain why sodium chloride does not behave in this way. (2)

- 2) This question concerns the oxides, sulphides, and oxo-anions of sulphur. (20)

- a) Give the complete electronic configurations of oxide and sulphide ions showing the occupation of each orbital. (2)

oxide: _____

sulfide: _____

b) Give two methods each (four in all) of forming oxides and sulphides. For each method, give an equation to represent a specific example.

i) Oxides: (4)

ii) Sulphides: (4)

c) Give names for each of the following oxo-anions: (5)

SO_3^{2-} : _____

$\text{S}_2\text{O}_3^{2-}$: _____

$\text{S}_2\text{O}_8^{2-}$: _____

SO_4^{2-} : _____

$\text{S}_2\text{O}_6^{2-}$: _____

d) Show by means of Lewis structures (including lone pairs) the bonding in: (5)



3) Francium (Fr), the last member of Group I, has not been extensively studied since it is extremely radioactive. From what you know of the chemistry of Group I deduce what the properties of francium are likely to be, with respect to: (20)

a) the reaction of the metal with water. (2)

b) the nature of its hydride and the reaction of its hydride with water. (3)

c) combination with nitrogen. (1)

d) combination with oxygen. (3)

e) the acid/base properties of the hydroxide and its solubility. (2)

f) the action of heat on the carbonate, hydrogen carbonate and nitrate. (3)

g) the solubility of its salts in water and organic solvents. (2)

h) the nature of the bonding in its chloride, its melting and boiling points, and its behaviour with water. (2)

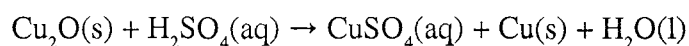
d) Choose a hexa-coordinated complex ion of a d-block element and

i) write its formula, (1)

ii) give its name, (1)

iii) draw its shape, (1)

e) copper(I) oxide reacts with dilute sulfuric acid to form copper(II) sulfate and copper:



How do you account for the difference between this reaction and the reaction of copper(II) oxide with dilute sulfuric acid? (2)

f) Briefly explain how iron is extracted from its ores. (2)

5) This question is concerned with molecular orbital theory. (20)

a) What is meant by the terms:

i) atomic orbital? (1)

ii) molecular orbital? (1)

b) Sketch the bonding and antibonding molecular orbitals formed from the merging of:

i) two s-orbitals (2)

ii) two p-orbitals (4)

iii) a p-orbital and an s-orbital. (2)

d) i) Write down the electronic structure of boron in terms of orbitals. (1)

ii) Draw a labelled energy-level diagram for the B_2 molecule using only valence shell orbitals. (4)

iii) Calculate the bond-order in the above molecule. (1)

iv) What magnetic properties would you expect the molecule to have? Why? (2)

v) What conclusions can you draw about the length and strength of the bond in B_2^+ as compared with B_2 ? Explain your conclusions. (2)
