THE COLLEGE OF THE BAHAMAS

NASSAU	
FREEPORT	

EXAMINATION FOR THE FALL SEMESTER, 9904

DIVISION: NATURAL SCIENCE

COURSE NUMBER: CHEMISTRY 235

COURSE TITLE: INORGANIC CHEMISTRY

Date and Time: Tues 7th Dec 2 pm
(To be entered by Examination Office)

Duration: 3 Hours

INSTRUCTION TO CANDIDATES: This paper has 10 pages. Section I have 40 questions, Section II has 3 questions and Section II has 2 questions. Follow instructions given.

COMPLETE THE FOLLOWING CAREFULLY

YOUR LECTURER'S NAME _____
YOUR SECTION NO. _____
GIVE YOUR STUDENT NUMBER _____

GIVE YOUR FULL NAME (PRINT CAREFULLY)

_____

(FOR OFFICIAL USE ONLY)
MARKS FOR MULTIPLE CHOICE _____/
MARKS FOR SECTION II _____/
MARKS FOR SECTION III _____/
TOTAL MARKS ON PAPER _____/ = _____%

SECTION I: Multiple Choice Questions

Mark 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, making a total of 40 marks.

QUESTIONS 1 to 5

These questions involve the following types of attractive force between particles:

A hydrogen bonding
B London dispersion force
C dipole/dipole interaction
D covalent bonding
E ionic bonding

Which of the above is most relevant to each an explanation of the following observations or statements? Each response may be used once, more than once, or not at all.

1) The boiling point of phosphine (PH_3) is lower than that of hydrogen sulfide.
2) The boiling point of silicon dioxide is higher than that of carbon dioxide.
3) The boiling point of ammonia is higher than that of phosphine (PH_3).
4) The melting point of sodium chloride is higher than that of sodium.
5) Fluorine is much more reactive than chlorine partly because this force or bond is weaker in fluorine than in chlorine.

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 $4s^2 4p^2$
14) forms an oxide which on warming with sodium chloride and concentrated sulphuric acid gives chlorine gas.
15) forms a chloride which may be used 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) Krypton in krypton difluoride.
21) Chlorine in chlorine trifluoride.
22) Xenon in the XeF_5^+ ion.

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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 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.

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.

28) This compound is white when solid and dissolves in water to give a colourless solution. Addition of aqueous ammonia precipitates a white solid soluble in excess.

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29) An element X forms a ***liquid*** chloride which is readily hydrolysed by water. Select from the following the element most likely to be X.
A Sodium
B Caesium
C Neon
D Calcium
E Sulphur

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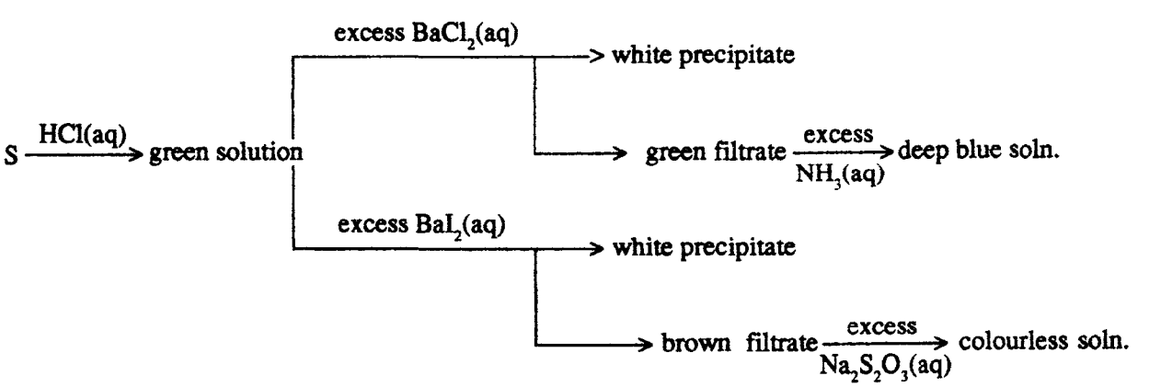

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30) Above is a reaction scheme for a salt S. What is S?
A Chromium(III) chloride
B Chromium(III) sulphate
C Copper(II) chloride
D Copper(II) sulphate
E iron(II) sulphate

31) Which one of the following statements about sulphur and oxygen is true?
A Both normally consist of diatomic molecules in the solid state.
B Both form hydrides which have acidic properties.
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) Potassium is normally extracted from its ores by
A reducing them with sodium 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* acts as a/an
A cathode.
B anode.
C metallic conductor.
D solvent.
E electrolyte.

38) Which one of the following electronic configurations does **NOT** represent an atom of an alkali metal in the ground state?
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?
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 more stable than calcium carbonate with respect to thermal decomposition.
D Radium hydroxide is amphoteric.
E Radium sulphate is insoluble in water.

40) Only one third of the total chlorine in a compound with the empirical formula $CrCl_3 \cdot 6H_2O$ can be precipitated by silver nitrate solution at room temperature. Which one of the following is the most likely structure for the compound?
A $[CrCl(H_2O)_5]^{2+}(Cl^-)_2.H_2O$
B $[CrCl_2(H_2O)_4]^+Cl^-.2H_2O$
C $[CrCl_3(H_2O)_3].3H_2O$
D $[Cr(H_2O)_6]^{3+}(Cl^-)_3$
E $Cr^{3+}(Cl^-)_3.6H_2O$

SECTION II: Short answer questions

Answer each of the following questions in the spaces provided on your question paper. Illustrate your answers with chemical equations wherever appropriate.

1) This question concerns the halides of various elements. (17)

a) Describe how you could obtain a reasonably pure sample of anhydrous aluminium chloride in the laboratory, starting with aluminium metal. (2)

b) In standard bond dissociation enthalpy

HF > HCl > HBr > HI ... (i)

In thermal stability

HF > HCl > HBr > HI ... (ii)

In acid strength

HF < HCl < HBr < HI ... (iii)

Explain how statements (ii) and (iii) follow from statement (i) (4)

c) i) Draw a diagram showing the shape of a molecule of BCl_3. (1)

ii) What term is used to describe this shape? (1)

iii) What type of hybridisation of atomic orbitals is used to explain this shape? (1)

d) 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? (2)

e) i) Write an equation for the reaction of calcium fluoride with concentrated sulphuric acid. (1)

ii) Hydrogen fluoride is used for etching glass. Upon what chemical property of hydrogen fluoride does this depend? (2)

Property: _____

Equation: _____

f) 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. (13)

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

oxide: _____

sulfide: _____

b) Give one method, other than by direct combination of the elements, of forming oxides and sulphides. For each, give an equation to represent a specific example.

i) Oxide: _____ (2)

ii) Sulphide: _____ (2)

c) Give names for the following oxo-anions: (3)

SO_3^{2-}: _____

$S_2O_3^{2-}$: _____

$S_2O_8^{2-}$: _____

d) Show by means of Lewis structures (including lone pairs) the bonding in:
SO_3^{2-} (2)

$S_2O_8^{2-}$ (2)

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: (12)

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

b) combination with nitrogen. (1)

c) combination with oxygen. (3)

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

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

SECTION III: Short answer questions

Answer **ANY ONE** of the following questions in the spaces provided on your question paper. Illustrate your answers with chemical equations wherever appropriate. (NB. If you answer both questions only the first will be marked.)

1) This question concerns the d-block elements. (18)

a) State, in terms of electronic structure, what is meant by the term d-block element. (2)

b) Give the electronic configurations of $_{29}Cu^{+}$, $_{26}Fe^{2+}$, and $_{25}Mn^{2+}$. You may use the abbreviation [Ar] if you wish. (Z for argon = 18) (3)

Cu^{+}: _____

Fe^{2+}: _____

Mn^{2+}: _____

c) How do you account for the fact that

i) Fe^{2+} ions are readily oxidized to Fe^{3+} ions, but Mn^{2+} ions are not readily oxidized to Mn^{3+} ions? (3)

ii) in solution Cu^{+} ions are colourless but Fe^{2+} and Mn^{2+} ions are coloured? (4)

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) Write equations for the reactions with dilute sulphuric acid of

i) copper(I) oxide (1)

ii) copper(II) oxide (1)

How do you account for the difference in the two reactions? (1)

2) This question is concerned with molecular orbital theory. (18)

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)

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.
(3)

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. (3)