OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA

DEPARTMENT OF CHEMISTRY

CHM 302: STRUCTURAL AND MAIN GROUP CHEMISTRY 4 UNITS

RAIN 2015/2016 MID-SEMESTER EXAMINATION

Attempt all questions **Time allowed 1 hr 30mins**

1. (a) Write down, in order, the names, and symbols of the elements in group IV. Classify the Elements in terms of metallic, semi-metallic or non-metallic behaviour. Give a general notation showing the ground state electronic configuration of each element.

   (b) The tetrahalides of Carbon are not hydrolysed by water while those of other members are readily hydrolysed. Discuss.

   (c) Balance the following equations:

   $SnO_2 + C \rightarrow$

   $2SiH_3Cl + Na \rightarrow$

   $2Ca_3(PO_4)_2 + 6SiO_2 + 10C \rightarrow$

2. (a) Using simple reaction equation **only (one each),** show the preparation of hydrogen
   i. In the lab ii. On an industrial scale

   (b) The following elements **B, Cs, Al, Pt, Hf, Be, O, Li, Mg** form hydride, state which the hydride would
   I react vigorously with water to yield hydrogen
   II form hydrogen bonding
   III undergo dimerization
   IV form polymeric hydrides
   V could be used as catalyst for hydrogenation reactions
   VI would form ionic hydride

   (c) The IR spectra of 1.0M 2-methylpropan-2-ol had a very strong broad peak at around 3300 cm^{-1}. 0.005M of this compound was prepared in CCl_4; in it spectra the band at 3300cm^{-1} disappeared and a sharp new peak appears at around 3610cm^{-1}. Explain this observation.

   (d) In not more than one sentence state why
   I Alkali metals are soft and have low melting points
   II They have low densities.

$Li^+_{(aq)}$ is a poor conductor of electricity.

(e) Complete and balance the following reactions.

a) $Na + O_2 \rightarrow$

b) $KO_2 + H_2O \rightarrow$

c) $K_2O_2 + O_3 \rightarrow$

d) $NaOH + CO_2 \xrightarrow[\Delta]{450K}$

e) $Al + NaOH + H_2O \rightarrow$

f) $CsH + H_2O \rightarrow$

g) $NaH + BCl_3 \rightarrow$

3. (a) Explain the term molecular crystals giving appropriate example.

(b) Using valence shell electron pair repulsion theory, predict the shape and hybridization type in the following: (i) H_2O (ii) SF_6 (iii) PF_5 (iv) NH_3 (v) ClF_3

4 What is a Crystalline solid? Explain the packing of ions/atoms in crystals giving their characteristic features.

OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA
RAIN SEMESTER EXAMINATION 2015/2016 SESSION
CHM 302: STRUCTURAL AND MAIN GROUP CHEMISTRY

ATTEMPT ANY FOUR QUESTIONS
TIME ALLOWED: 2 HOURS AND 30 MINUTES
Instructions:
Write your Name and Registration Number. Also, append your signature on your answer scripts.

1. a. What is an Amorphous solid?
   b. Explain the various differences between a crystalline solid and an amorphous solid.
   c. Explain the term stoichiometric defect and list the consequences of these defects in ionic crystals.
   d. Explain the structural pattern in any named AB_2 ionic crystal.
2. Write short notes on any four of the following:
   a. Evaporation method of growing crystals
   b. X-ray diffraction method
   c. valence shell electron pair repulsion theory
   d. covalent solids using a named structure
   e. Electron diffraction
3. a Give a brief explanation why the boiling point of
   i. Deuterated water is 101.4°C and ordinary water is100°C.
   ii H_2O is greater than SO_2
   b. Hydrogen atom has only one electron however H_2 reacts very slowly with other elements.
   i Explain why this is so and state ONLY the ways hydrogen can be made reactive.
   c Lithium reacts with water gently and sodium reacts vigorously. The reaction of potassium with water is very exothermic that it ignites the hydrogen produced while rhodium and caesium react explosively with water. Explain the reason for this reactivity.
   d Lithium has similarities with alkaline earth metals write any three of these similarities
   e. $BeCl_2$ is a covalent compound while other elements in its group are ionic. Explain the reason for this. Draw the various forms in which $BeCl_2$ exist.

f. What compounds are responsible for temporary and permanent hardness and how can they be removed?

4. a i. Briefly discuss the bonding in diborane molecules

aii. Explain why thallium being in group 3 but forms stable univalent compounds.

aiii. Write the boron compound produced in following reactions

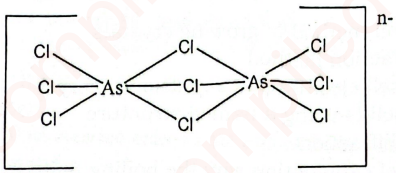
I. $BBr_3 + CH_3CH_2OH \longrightarrow$

II. $BBr_3 + (CH_3)_3N \longrightarrow$

III. $BBr_3 + H_2O \longrightarrow$

IV. $BBr_3 + PPh_3 \longrightarrow$

4 bi. In the given specie below, what is the value of n?



How many mole(s) of potassium ion will be required to impart electrical neutrality to it? Write the formula of the compound formed with potassium presence.

bii. Draw the structure of sulphur S_8 molecule and white Phosphorus P_4 following Compounds

biii. Which of the ~~hydrides~~ of group (V) element given below would form a complex of the type ~~BA→BF3~~ , ~~(A = N, P)~~: NH_3, PH_3 and NF_3. In case where ~~a hydride~~ it does not form, give reason.

5 a. Explain the following observation giving appropriate reason:

(i) $[CF_6]^{2-}$ ion does not exist while $[SiF_6]^-$ ion exist.

(ii) The boiling point of $SnCl_2$ is 652 °C whereas that of $SnCl_4$ is 114 °C

(iii) H_2O has a higher boiling point than H_2S

$A = [NH_3, PH_3 \text{ & } NF_3]$.

b. The A-H bond length for group (VI) element, (A = O, S, Se, Te) is given below as:

Molecule	Bond length (Å)
H_2O	0.96
H_2S	1.32
H_2Se	1.47
H_2Te	1.73

Use the above information to explain the trend in their thermal stability with reason.

c. In the equation below, identify which specie(s) is/are halide donor or acceptor. Identify the equation where the specie(s) was a donor or acceptor.

$AsF_3 + KF \rightarrow K^+ [AsF_4]^-$

$AsF_3 + SbF_5 \rightarrow [AsF_2]^+ [SbF_6]^-$

d. In tetravalent compounds of the type MX_4 (M = group (IV) element), the average bond energies of Silicon-Chloride (Si-Cl) is 391 $kJmol^{-1}$ and Silicon-Carbon (Si-C) is 335 $kJmol^{-1}$. The SI-Cl bond was however found to be more reactive and more susceptible to nucleophilic attack. Explain this observation.

OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA

DEPARTMENT OF CHEMISTRY

CHM302: STRUCTURAL AND MAIN GROUP INORGANIC CHEMISTRY
MID-SEMESTER EXAMINATION (2016/2017)

ATTEMPT ALL QUESTIONS **TIME ALLOWED: 1 HOUR**

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(1)

a. Using reaction equations only describe the extraction of boron from borax.

b. Explain why the melting point of magnesium is very high (650°C) compared to sodium (98°C) even though it next to sodium in the periodic table.

c. Complete and balance the reactions equations below:

i. $Ba + N_2 \xrightarrow{\Delta}$

ii. $K + O_2 \longrightarrow$

iii. $Sr + S_8 \xrightarrow{\Delta}$

iv. $Be_2C + H_2O \longrightarrow$

v. $B_2H_6 + CH_3CH{=}CHCH_3 \longrightarrow$

vi. $AlBr_{(g)} \longrightarrow$

vii. $\overline{Li} + O_2 \longrightarrow$

d. Generally, electronegativity decreases down the group but it in the case of group 3 elements there is anomaly going from aluminium to gallium. Briefly explain why this is so.

(2)

a. Account for the observed variation in the ability of the Group IV elements to catenate.

b. Consider the observations in b(i)-b(iii) and give reasons for each.
   i. CO_2 is a gas while SiO_2 is a high melting solid at room temperature and pressure.
   ii. PbI_4 does not exist.
   iii. Nitrogen is a gas at room temperature.

c. Illustrate, using balanced chemical equations only, the reaction of members of the group IV with:
   i. concentrated tetraoxosulphate(VI) acid
   ii. dilute tetraoxosulphate(VI) acid

d. Consider the chemical equation below used in the preparation of silicon, excess silicon dioxide is used, account for this.

$$SiO_2 + 2C \rightarrow Si + 2CO_2$$

V

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DEPARTMENT OF CHEMISTRY

CHM 302: STRUCTURAL AND MAIN GROUP INORGANIC CHEMISTRY

2016/2017 FIRST SEMESTER EXAMINATION

Attempt Four questions **Time allowed 2 hr 30mins**

1. a Explain the term crystalline solid
   b Discuss the simple crystal structures of AB type with coordination number 8:8, 6 and 4
   c Using valence shell electron pair repulsion theory, predict the shape and hybridization type in the following: (i) H_2O (ii) SF_6 (iii) PF_5 (iv) NH_3 (v) ClF_3

2. a What do you mean by lattice defects in ionic crystals?
   Explain stoichiometric defects in ionic solids
   Write short notes on electron diffraction method of determination of crystals
   d Describe the evaporation method of growing crystals

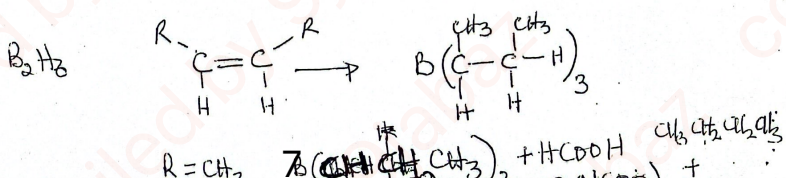
3. a Explain the following trends
   i Group I metals have larger atomic radii than group II metals.
   ii Group I metals are soft and have low melting points while group II metals are harder and have much higher melting points.
   iii Group I metals are stronger reducing agents than group II metals.

   b Predict the compounds A to E from the reactions equations below
   i. $B_2H_6 + CH_3CH=CHCH_3 \longrightarrow A$
   ii. $A + HCOOH \longrightarrow B + C$
   iii. $A + H_2O_2 \longrightarrow D + E$

   c There is a relationship between beryllium and aluminium, mention any three.

   d Group the following compounds based on their solubility in water.
   MgF_2, $LiCO_3$, $BeBr_2$, BCl_3, $NaSO_4$, CaO, AlF, Rb_2CO_3, $Ca(HCO_3)_2$, $MgSO_4$, CaH_2

4. a Explain the following:
   i. the large difference in acidities observed between water and methane in aqueous solution compared to their similar values observed in the gas phase.
   ii. the theory behind the non-stoichiometric compositions of metallic hydrides
   iii. metals show their highest oxidation states with fluorides in ionic halides
   b With examples, itemise 3 ways by which halogens achieve the octet state.



5. a List the allotropes of carbon, discuss any two of this allotropes, highlighting at least two of their distinctive features.

b(i) Silanes and alkanes have similar stoichiometries but widely divergent reactivity, give reasons for this.

(ii) Discuss the trihalides formed by the group V elements with reference to their structure.

c. Account for the observations below in c(i)-c(iii):

i There is a significant difference between the melting point of silicon and lead.

ii Although nitrogen exhibit +5 oxidation state it does not form pentahalides.

iii BiH_3 is the strongest reducing agent amongst the group V hydrides

d By means of balanced chemical equations only, illustrate how carbon, silicon, germanium, tin and lead may be obtained; give only one process per element.

e. Name the two series of oxy-acids formed by phosphorus, for each series identify and discuss two important members with emphasis on their:

(i) Structure

(ii) Basicity

(iii) Preparation

(iv) Oxidation state of phosphorus

OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA
DEPARTMENT OF CHEMISTRY

CHM302: MAIN GROUP CHEMISTRY
RAIN MID-SEMESTER EXAMINATION (2017/2018)

Answer All Questions **Time allowed: 50 mins**

1.

a. Highlight the 3 bonding patterns of hydrogen.
b. Explain the term "Agnostic" C – H ··· M interactions.
c. i. What are Saline Hydrides?
   ii. Comment on their similarity with the corresponding metallic fluorides.

2.

Give a brief explanation to each of the following statements:

a. The melting point of sodium is 98 °C and rubidium is 39 °C while of barium is 714 °C
b. The reactivity of alkaline metals increase down the group.
c. Lithium and magnesium have similar properties however the enthalpy of hydration of magnesium is −1920 kJ/mole while that of lithium is −519 kJ/mole.
d. Beryllium will form a covalent hydride but strontium will form an ionic hydride.
e. Boron can only form BF_3 but gallium can form both GaF_3 and GaF.
f. BCl_3 can reacted with triethylamine yielding a complex but when $InCl_3$ is reacted with triethylamine In_2Cl_6 is formed.

3.

a. Describe in not more than four (4) lines the following concepts:
   i. Ionic crystal
   ii. molecular crystal
   iii. covalent crystal
b. Explain briefly the packing of ions in crystals.

Agnostic C—H···M interaction are an interaction b/w C—H bond and transition metal M; ~~H in BOV~~ it occurs when the 2 electron involved ~~for~~ C—H bond co-ordinate ~~with~~ to co-ordinate with empty d-orbital of transition metal, resulting in a 3 center 2 electron bond.

Inorganometallic

OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA
DEPARTMENT OF CHEMISTRY
B.Sc. Degree (Chemistry) Examination (Part III)
CHM 302: Structural and Main Group Inorganic Chemistry
2017/2018 Rain Semester Examination

Time Allowed: 2½ Hours **Date: January 15, 2019**

Instructions: Answer ALL Questions.

1. (a) Explain the following (Not more than 3 lines):
   i. The stability of group I superoxides increases down the group.
   ii. The conductivity of caesium is greater than lithium.
   iii. The ionization energies of group II metals are greater than those of group I.
   iv. Boron forms only BF_3 while gallium forms both GaF and GaF_3.
   v. $LiAlH_4$ can form a 5-coordinate complex while $LiBH_4$ cannot.

   (b) Write name (or chemical formula) of one ore which lithium, beryllium and boron are extracted from and one of the uses of each of these metals.

   (c) Write the products and balance the following reaction equations:
   i. $NaCl + CaCO_3 \rightarrow$
   ii. $Cs + O_2 \rightarrow$
   iii. $S_8 + Mg \rightarrow$
   iv. $BaCO_{3(s)} \xrightarrow{\Delta}$
   v. $BBr_3 + CH_3CH_2OH \rightarrow$
   vi. $B_2H_6 + LiH \rightarrow$

2. (a) What is an ionic solid?
   (b) Give a detailed description of "packing of ions in crystals".
   (c) Write short notes on the following
   i. Trigonal sites
   ii. Tetrahedral sites
   iii. Octahedral sites

3. (a) Write short notes on:
   i. The larger bond angle of H_2O over F_2O.
   ii. The highly reactive nature of fluorine.
   iii. The hydrolysis of halogens.
   iv. The reduced C–C bond distance in graphite compared to that in diamond.
   (b) How does the ionic radius of Group IIA metals affect the stability of their hydroxides?
   (c) Mention any three ways with examples in which group VIA elements achieve the octet state.

4. (a)i. The first element of a Group in the periodic table exhibits anomalous behaviour compared to other members of the Group. Use oxygen to illustrate this statement giving any three anomalous behaviours.
   ii. Give three (3) reasons for the observed anomalous behaviour exhibited by oxygen in a(i) above.

(b)i. What are silicides?

ii. The melting point for elements in Group VA is given below:

Element	Symbol	M. Pt. (°C)
Phosphorus	P	44
Arsenic	As	814
Antimony	Sb	603
Bismuth	Bi	271

It is generally expected that physical properties, including melting point, for a given Group increases down the Group, account for the observed values and the discrepancies for the Group VA elements above.

(c)i. Enumerate the various classes of carbides formed by carbon. Give an example for each class. Using chemical equations only show the preparation of these examples.

ii. Graphite an allotrope of carbon occurs as α and β graphite; what are the distinguishing features between the two?

(d) Account for the following observations below:

i. Although nitrogen exhibits +5 oxidation state but it does not form pentahalides.

ii. H_2S is less acidic than H_2Te

iii. Nitrogen exists as a diatomic molecule while phosphorus exists as a tetramer.

iv. Graphite is thermodynamically more stable than diamond yet it is more reactive

(e)i. Discuss the halides formed by the Group VA elements in terms of bonding and shape of the molecule.

ii. Account for the observed order for the ease of thermal stability of the hydrides of Group VIA elements.

OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE

CHM302: STRUCTURE AND MAIN GROUP INORGANIC CHEMISTRY
MID-SEMESTER EXAMINATION (2018/2019)

ATTEMPT ALL QUESTIONS TIME ALLOWED: 80 MINS

(1)

a) Write just one reaction equation to illustrate the lab preparation of hydrogen gas.
b) Give a brief explanation why hydrogen might be considered (i) an alkaline metal or (ii) a halogen.
c) Briefly explain why the lattice enthalpies of the halides of lithium are greater than the corresponding halides of other group 1 metals.
d) Write the correct products of the following reaction equations and balance them.

(i) $NaOH_{(aq)} + \underset{\text{excess}}{CO_{2(g)}} \longrightarrow$

(ii) $NaOH_{(aq)} + \underset{\text{limited}}{CO_{2(g)}} \longrightarrow$

(iii) $NaOH_{(aq)} + CO_{(g)} \xrightarrow{450\,K}$

e) Rubidium and strontium are next to each other in the periodic table, give reasons why strontium harder than rubidium.
f) Diborane has 12 valence electrons, give a brief explanation on how it is able to form a stable compound.
g) Write the name (or chemical formula) of one ore of boron and aluminium.

(2)

a) Explain the term crystalline solid.
b) Distinguish between crystalline solids and amorphous solids.

(3)

a) i. Define the term silicide
ii. Enumerate the various possible bonding that may be observed in above named class of compound.
iii. Give two examples of this type of compound.
b) Account for the following observations below
i. Oxygen exists as a diatomic molecule and sulphur exists as a polymeric molecule.
ii. Nitrogen exists as a diatomic molecule and phosphorus exists as a tetramer.
iii. Carbon dioxide is a gas, silicon dioxide is a solid.
c) Discuss any three oxyacid of phosphorus with respect to:
i. Oxidation state of phosphorus
ii. Molecular formulae
iii. Preparation with the aid of a balanced chemical equation

OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA
DEPARTMENT OF CHEMISTRY
B.Sc. Degree (Chemistry) Examination Part III
CHM 302: STRUCTURAL MAIN GROUP CHEMISTRY
Rain Semester Examination 2018/2019 Session

Time Allowed: 2½ Hours **Date: December, 2019**
Instructions: Answer All Questions

1.

a. Briefly explain why $^{2}_{1}H_2O$ has a boiling point of 101.4 °C and $^{1}_{1}H_2O$ has a boiling point 100 °C

b. Hydrogen bonding maybe symmetrically or asymmetrically positioned with respect to the atoms it is interacting with. Distinguish between these positioning. (You may tabulate your answers)

c. What type of binary hydride are these **(i)** $(BeH_2)_n$ **(ii)** $TiH_{1.7}$ **(iii)** $[RuH_6]^{4-}$ **(iv)** BaH_2 **(v)** SnH_4?

d. Give two uses of sodium or any of it compounds.

e. The enthalpy of sublimation, lattice enthalpy, and ionization energy affect the enthalpy of formation of group I metal halides. Explain why the enthalpies of formation of group I fluorides decrease down the group while it is the reverse with the other group I halides.

f. Explain why **(i)** magnesium higher melting point than sodium **(ii)** the ionization energy of magnesium is greater than sodium.

g. The beryllium ion is hydrated in aqueous solution yielding $[Be(OH_2)_4]^{2+}$ but the solution is acidic. Explain the reason for this.

h. Define the following and give an example of each (i) alternation effect (ii) inert pair effect.

i. Write the expected product of the reactions below

1) $B_2H_6 + O_2 \longrightarrow$
2) $B_2H_6 + NH_3$ (Xs NH_3 at high tempt) $\longrightarrow$
3) $B_2H_6 + LiH \longrightarrow$.

2.

a. Discuss the group V elements with respect to their:
   i. Preparation.
   ii. Usage, give two per element.
   iii. Occurrence, give one per element.

b. Account for the following observations:

I. The dark blue colour of ozone
II. The high melting point associated with basic oxides.
III The melting point of lead (a metal) is lower than that of silicon (which occupies a higher position within the same group).
IV. Carbon dioxide is a gas but silicon dioxide is a solid.

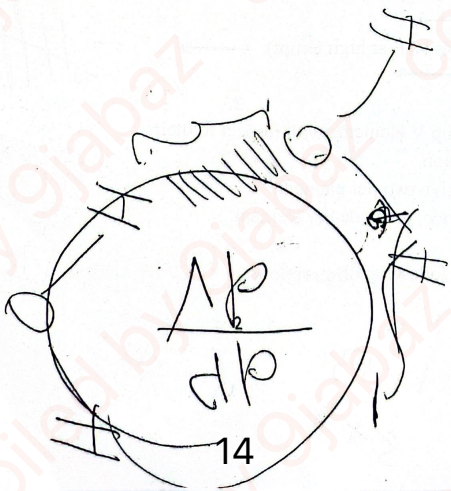
a. Discuss, using chemical equations only, the reactivity of the group VI elements in terms of reaction with:
   i. Air.
   ii. Hydrogen.
   iii. Metals.
   iv. Concentrated nitric acid.

3.

a. Highlight the energies involved in the formation of an ionic halide lattice and comment on the ionic halide most readily formed.
b. Describe the gas phase diffusion technique of growing crystals.
c. Enumerate the steps involved in obtaining diffraction patterns (peaks) for crystalline solids
d. Write short notes on the following:
   (i) Clathrate compounds
   (ii) Xenon fluorides and their geometries
   (iii) Differences between neutral and cationic interhalogen compounds

4.

a. Explain the term crystalline solid
b. Explain stoichiometric defects in ionic solids
c. Discuss any known simple crystal structure of AB type with coordination number
   (i) 8:8, **(ii)** 6:6, and **(iii)** 4:4



OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA
DEPARTMENT OF CHEMISTRY

CHM 302: STRUCTURAL AND MAIN GROUP INORGANIC CHEMISTRY
MID-SEMESTER EXAMINATION (2019/2020)

ATTEMPT ALL QUESTIONS **TIME ALLOWED: 90 mins**

1. State three reasons why fluorine is more reactive than other halogens and show the energetics involved in the formation of a metallic tetrahalide (MX_4).
2. Describe any two methods of growing high-quality crystals suitable for Single Crystal X-Ray Diffraction analysis.
3. Write 2 ways in which binary hydrides can be prepared. Use a reaction equation to illustrate anyone of them.
4. Explain the following why:
   a. Group 1 elements do not exist in the +2 oxidation state
   b. BeH_2 is the only covalent hydride in Group 2
5. Write two uses of boron or any of its compounds.
6. Determine the number of atom(s) present and the coordination number of an atom in the unit cell for each of the four closed-crystal packing arrangements.
7. How will you differentiate between clear samples of Quartz and Glass silicate material?
8. Explain the difference between the AX and AX_2 ionic crystals and give one example each of their crystal packing arrangement.

OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA

B.Sc. (CHEMISTRY) DEGREE EXAMINATION

2019/2020 Rain Semester

CHM 302: STRUCTURAL AND MAIN GROUP INORGANIC CHEMISTRY

TIME ALLOWED: 2½ hours **DATE: October 06, 2021**

Instructions: Write your Name and Registration Number. Also append your signature on your answer scripts.

ATTEMPT ALL QUESTIONS

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1. Hydrogen can be prepared by the electrolysis of acidified water.
   a. Write the redox reaction equation for the production of hydrogen
   b. At which electrode does this occur?
   c. Why is pure water not used?
   d. What is the role of tetraoxosulphate(VI) acid? *(5 marks)*

2. Explain the following
a. The lattice enthalpy of Group 1 bromides decreases down the group.
b. Why the hydration energy of Be^{2+} -2500kJ/mol while that of Li^{+} is -519 kJ/mol.
c. $BeCO_3$ is the only soluble carbonate of Group 2 element. *(6 marks)*

3. Classify the reactions below either as protolysis or complex formation, then write the products and balance the equations.
a. $BBr_3 + PPh_3 \rightarrow$
b. $BBr_3 + (CH_3)_3N \rightarrow$
c. $BBr_3 + (CH_3)_2CHOH \rightarrow$
d. $BBr_3 + (CH_3)_2NH \rightarrow$ *(4 marks)*

4. What is/are the difference(s) between stoichiometric and non-stoichiometric defects in ion crystals? *(3 marks)*

5. Describe in detail the two types of defects responsible for the electrical conductivity observed in stoichiometric ionic crystals. *(5 marks)*

6. Explain in detail the reason(s) for the purple-lilac colour observed for some potassium chloride ionic crystal. *(5 marks)*

7. List five of the crystal systems observable in solid structures. *(2 marks)*

8. Distinguish with examples between neutral and cationic interhalogen compounds *(5 marks)*

9. Write short notes on the following:
a. Clathrate compounds
b. Molecular ions
c. Fluoride compounds of Xenon *(5 marks)*

10. Describe how you would grow crystals of copper(II) chloride suitable for single crystal X-ray diffraction analysis with the following solubility in two different solvents:
a. Methanol (300 g/L)
b. Ethanol (2 g/L) *(5 marks)*

11. Discuss the general reactivity of carbon with both strong and weak acids, elucidating the reasons for the observed behavior.

12. Show, using chemical equations ONLY, the method of preparation of one member of the:
(i) Phosphorus acid series
(ii) Phosphoric acid series

13. Discuss the bonding observed in ozone.

14. Account for the following:
a. The elements of group 15 are more volatile than their corresponding neighbours.
b. The good absorbance property of kaolinite
c. Formation of hexafluoride by elements of group 16 with only fluorine
d. A large amount of energy is required to form an ionic oxide
e. $N(SiH_3)_3$ is planar and $N(CH_3)_3$ is pyramidal.

15. Briefly discuss the metallic character of the Group 15 elements.

16. Give three methods of obtaining germanium. Supporting your answers with balanced chemical equations.

17. Show, using chemical equations ONLY, how to prepare the hydride of ANY TWO (2) member of the Group 16 element

18. Give three processes of refining impure tin. *(Questions 11 to 19: - 25 marks)*

OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA
DEPARTMENT OF CHEMISTRY

CHM302: MAIN GROUP CHEMISTRY
RAIN MID-SEMESTER EXAMINATION (2021/2022)

Answer All Questions **Time allowed: 75 min**

(1)

a. What is the name of the following hydrogen species?
(i) H^+ (ii) H^- (iii) H_3O^+ (iv) H_2 (v) H

b. Li and Na belong to the same group, however Li_2CO_3 is insoluble in water and Na_2CO_3 is, why?

c. Mention 2 similarities between beryllium and aluminium.

d. Write the double decomposition reaction equation of gallium chloride with lithium hydride in ether

e. Draw the structure(s) of the gallium-products that would be formed if the gallium-product of (d) above is reacted with $[(CH_3)_3NH]^+Cl^-$ and then with $(CH_3)_3N$? (Reaction equations not required).

(2)

a. Account for the following observations
i. Carbon black is used to absorb large amount of gases and solutes from solids and solutions.
ii. Except for nitrogen other elements of Groups 15 do not form pπ-pπ multiple bonds.
iii. The dimerization of NO_2
iv. CO_2 is a discrete molecule and a gas but SiO_2 is a solid and forms infinite three dimensional structures.

b. Discuss diamond in terms of (i) Melting (ii) Bonding and structure

c. Nitrous acid is known to react both as an oxidizing and reducing agent; illustrate this using chemical equations only (one each).

d. Based on the acid/base characterization of oxides, which class does Al_2O_3 belong? Write balanced chemical equations to validate this.

(3)

a. Mention three major characteristics that can distinguish a galena crystalline from its amorphous for

b. What are the determinant factors for the type of closed-packed atomic arrangement adopted in metallic crystals?

c. State the major differences between hexagonal closed packed and face-centred closed pack arrangement in metallic crystals.

d. In a mining company, the waste slag contains both iron metal and iron(III) chloride crystallites, a chemist, how will you separate the mixture and give reason(s)?

e. State the reason(s) for the semi-conductivity phenomenon observed, sometimes in ionic crystals.

OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA

DEPARTMENT OF CHEMISTRY

B.Sc., Degree (Chemistry) Examination

Part III Rain Semester 2021/2022

CHM302: MAIN GROUP CHEMISTRY

Attempt ALL Questions **Time allowed: 3 Hours**

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(1)

a. Fluoride ions are added to drinking water, toothpaste and drugs used to treat osteoporosis (an excess of F^- is toxic to the body).

i. Hydrogen fluoride is an important reagent for introducing F into organic and other compounds, and it differs from the other hydrogen halides in being a weak acid in an aqueous solution (pKa = 3:45). Why? Support your answer with the relevant equations. **(5 marks)**

ii. The electron affinity of fluorine is slightly smaller than that of chlorine. How can this be reconciled with fluorine being a better oxidizing agent and more electronegative than chlorine. **(5 marks)**

b. A diver was rushed to the hospital where you were in charge of the laboratory. He was said to be in pain and had developed a condition called 'bends' upon diving into the deep sea; his laboratory test conducted by you reveals bubbles of N_2 in his blood. Based on your knowledge of gas cylinders used by divers,

i. Explain to the doctor what you think happened using your laboratory findings as evidence. **(4 marks)**

ii. Suggest two components of the diver's gas cylinder. **(2 marks)**

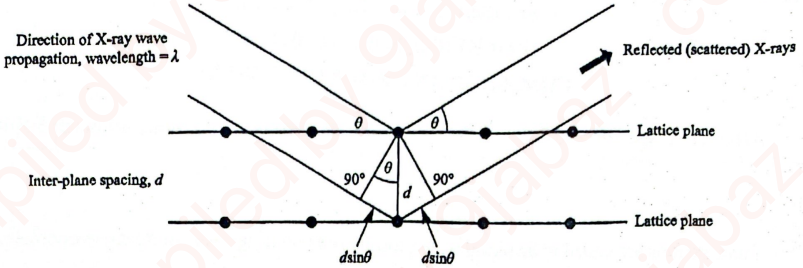
iii. Which of the two components will be in higher percentage? **(1 mark)**

iv. An IT student attached to a laboratory of a Chemical company aimed at growing a single crystal suitable for X-ray diffraction; he knows he has to employ a method that will lower the solubility of the compound in solution, but he is not sure which method to use. Suggest 3 methods to help him ensure the products fulfil his aim. **(3 marks)**

c. The Figure below is a Schematic representation of the interaction of X-rays with layers of atoms in a crystal. It shows an ordered array of atoms with atoms represented as black dots. The atoms are arranged in layers or lattice planes. Consider the case in which the two waves of incident radiation are in-phase with one wave reflected from an atom in the first lattice plane and the second wave reflected from an atom in the second lattice plane, as shown.

i. What is the only condition for the two waves to be in phase? **(2 marks)**

ii. For the two waves (originally in-phase) to stay in-phase as they are scattered, Bragg's equation must hold. What is Bragg's equation, and why is it important? **(3 marks)**



(2)

a. Discuss the hydrides formed by the members of group 16 elements in terms of:

i. Volatility ii. Thermal stability iii. Acidity

b. Write two balanced chemical equations (only), to illustrate the reactivity of ozone as an oxidizing agent.

c. Account for the following observation:

i. The ability of graphite to conduct electricity.

ii. The slippery feel characteristic of talcum powder

iii. The N-N bond is weaker than the single P-P bond.

iv. Hexafluorides are formed by group 16 elements.

v. The reaction vessel used by Kanayo Kanayo, a CHM 316 student, was in flames while warming the reaction solvent, paraffin (kerosene), used during one of the practical class.

d. Identify any two oxy-acids of nitrogen; discuss these two in terms of:

i. Structure of the anion of the acids

ii. The oxidation state of nitrogen

iii. A chemical equation to highlight the preparation of the acids

[15 marks]

(3)

a. What is the difference between Stoichiometric and Non-Stoichiometric Defects in Ionic crystals and give two examples of non-stoichiometry defects?

b. Determine the number of atom(s) present in the unit cells and the coordination number of face-centred cubic (fcc) and body centred cubic (bcc) closed packing arrangements.

2

c. Explain the difference between the AX and AX_2 ionic crystals and give one example each of their crystal packing arrangement.

d. State the difference between Schottky and Frenkel Defects in ionic crystals.

e. List five of the crystal systems observable in solid structures?

[15 marks]

(4)

a. List 2 physical properties of hydrogen gas.

b. List the isotopes of hydrogen you know along with their correct symbols.

c. Certain elements form covalent hydrides when they react with hydrogen, and these hydrides could be electron deficient, electron precise or electron rich.

   i. Write the chemical formula of an example of each

   ii. State which would act as a Lewis acid and which would be a Lewis base.

d. Provide an explanation each of the following trends.

   i. Sodium is more reactive than magnesium.

   ii. Group 2 elements can form +2 oxidation state but group 1 cannot.

e. Below are the steps taken for the extraction of rubidium from its ore. Provide the correct answers to **i – v**.

$$\mathbf{i} \xrightarrow{\text{conc } H_2SO_4} \mathbf{alum} \xrightarrow{\text{II}} \mathbf{Rb_2SO_4} \xrightarrow{\text{III}} \mathbf{RbOH} \xrightarrow{\text{IV}} \mathbf{RbCl} \xrightarrow{\text{V}} \mathbf{Rb}$$

f. Mention any 2 uses of boron and its compounds.

g. Give one example of when you have (i) alternation effect (ii) inert pair effect (iii) 2-electron 3-bond centre (structure required for iii).

h. These chlorides of group 13 below were treated with $N(C_2H_5)_3$, in each case what product would you expect and why?

(i) BCl_3

(ii) $GaCl_3$

[15 marks]

Manchester Metropolitan University

* Question on group 1 & 2 shall be assignment / test & Exam

OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA, DEPARTMENT CHEMISTRY

B.Sc./B.Edu. Degree Examination

CHM 302: Structural and Main-Group Inorganic Chemistry.

Rain mid-Semester Examination, 2022/2023 Session

Instructions: Answer all questions

Time: 1 Hour

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(1) The electronegativity value of some elements is given below:

H	C	Si	O	Ca	Cl
2.20	2.55	1.90	3.44	1.00	3.00

These elements form binary hydrides.

a. Use the data in the table above to predict the binary hydride that will be a:
   i. proton donor
   ii. hydride donor
   (Write ONLY the chemical formula of the binary hydride)

b. Give a brief explanation why
   i. Li_2CO_3 is insoluble in water while Na_2CO_3 is.
   ii. $BeCl_2$ is covalent while $MgCl_2$ is ionic.

c. Boron trihalide are covalent and gaseous and the boron in these compounds are sp^2 hybridized.
   What are the products of these reactions
   i. $(CH_3)_2NH + BCl_3 \longrightarrow$
   ii. $(CH_3)_3N + BCl_3 \longrightarrow$

   Which one of the reactions above involves?
   (iii) Transfer of H^+ to the halide?
   (iv) Transfer of a lone pair?
   (v) Use of the unhybridized p orbitals of BCl_3 ?
   (vi) Metathesis ?
   (Answer using equation of reactions in i or ii above)

2a. Account for the following observations:
   i. The unreactive nature of lead
   ii. The decrease in ionization energy from carbon to silicon, for group 14 elements.
   iii. Liquid/solid dioxygen is blue

2b. i. Write balanced chemical equations only to illustrate:
   ii. The synthesis of hydrazine
   iii. Two possible side reactions that may occur during this synthesis of hydrazine.

2c. i. Silicones are known for their high thermal and chemical stability. Give reasons for this observation:
   ii. Graphite has lower density than diamond, although both are allotropes of carbon, account for this.
   iii. List two classes of oxy-acids of phosphorus

(iii) Draw the probable structure and name of the compound.

c.) The following reactions are typical for interhalogen. Balance the reaction.

(i) $ClF + H_2O$ ——————— ?

(ii) What is the reason for the low dissociation energy of F_2 molecule?

(iii) Find the Oxidation States of the halogens in the following oxoacids of halogens (Halic Acids):

- $HOClO$
- $HOBrO_2$ and
- $HOIO_3$

Department of Chemistry
OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE
Part III B.Sc. Chemistry Degree Examination
RAIN SEMESTER EXAMINATION, 2022/2023 SESSION

CHM 302: Structural and Main-Group Inorganic Chemistry

INSTRUCTION: ANSWER ALL QUESTIONS.
TIME ALLOWED: 2 ½ Hrs

1 (a.) Given that the electron gain enthalpy values for $O \rightarrow O^-$ and $O \rightarrow O^{2-}$ is -141 and 702 kJ mol^{-1} respectively, how can you account for the formation of a large number of oxides having O^{2-} species and not O^-.

(b.) Give appropriate explanation for the following observations:
i. Monosilanols can only undergo dimerization
ii. Addition of glue or gelatin during the synthesis of hydrazine
iii. H_2S is less acidic than H_2Te
iv. The increase in the atomic size from As to Bi is small as compared from N to P

(c.) Using chemical equation(s) only, show how **MOST** of the oxygen present in the atmosphere is produced.
(d.) Account for the reducing behaviour of H_3PO_2

(e.) i. **Briefly** discuss the group 16 elements in terms of metallic character
ii. Illustrate using chemical equations **only** the reaction of the group 14 elements with oxygen (air).

2 (a.) Which of the following will have the higher boiling point and why?
(i) $^1H_2O^{16}$ (ii) $^1H_2O^{17}$ (iii) $^2H_2O^{16}$ (iv) $^2H_2O^{17}$

(b.) Which isotope of hydrogen is used in NMR and FTIR analysis and why?

(c.) Write the reaction equations for the industrial preparation of hydrogen from (i) methane (ii) carbon monoxide.
(d.) Write the name of the three major classes of binary hydride and give 2 examples each.

(e.) Calcium hydride is used as a drying agent for organic solvents. Why is this possible? Write the reaction equation between calcium hydride and water.

(f.) Li, Na, K and Mg all form oxides and their oxides are formed in combination with one of these oxide anions, $[O_2^-]$, $[O^{2-}]$, $[O_2^{2-}]$. Complete the table below:

Metal ion	Oxide anion	Product	Type of oxide
Li^+			
K^+			
Mg^{2+}			
Na^+			

(g.) Atomic radius plays a vital role in the physical and chemical properties of elements and their compounds. Give a brief explanation of its effect on the following:

i. Sodium reacts violently with water while magnesium reacts mildly.

ii. Li_2CO_3 is insoluble in water but Na_2CO_3 is.

iii. The electronegativity of gallium is greater than aluminum.

(h.) What is the nomenclature of the following boranes?

(i) B_4H_{10} (ii) B_3H_9 (iii) B_6H_{12} (iv) $B_{10}H_{16}$

(i.) Draw the structure of diborane and explain its bonding.

(j.) Diborane was subjected to hydroboronation by reacting it with but-2-ene to yield a product, **A**. **A** was then treated with propanoic acid to obtain two compound **B** and **C**. **A** was also reacted with hydrogen peroxide (alkaline) to obtain an alcohol, **D** and boric acid (H_3BO_3). By treating **A** with chromic acid (H_2CrO_4), **E** and $B_2(CrO_4)_3$ were formed. Write the reactions equation for the formation of the products **A** to **E** above.

3. Use the Table containing values of Born Exponent (n) below to answer the following questions.

Electronic configuration of ions in an ionic compound MX	Examples of ions	n (no units)
[He]	H^-, Li^+	5
[Ne]	F^-, O^{2-}, Na^+, Mg^{2+}	7
[Ar]	Cl^-, S^{2-}, K^+, Ca^{2+}, Cu^+	9
[Kr]	Br^-, Rb^+, Sr^{2+}, Ag^+	10
[Xe]	I^-, Cs^+, Ba^{2+}, Au^+	12

(a.) (i) Calculate the Born exponent (n) for Cesium Chloride and Sodium Chloride.
(ii) What is the change in the Born exponent in going from Cesium Chloride to Sodium Chloride.

(b.) (i) How many nearest neighbours does each ion have in the compounds above?
(ii) What is the coordination between the oppositely charged ions?
(iii) What is the geometry around the cations?

(c.) Magnesium Oxide (MgO) adopts the NaCl structure type. By using an electrostatic model, calculate the change in internal energy ΔU, (the lattice energy) at 0 K for MgO. (Avogadro's number (L) = 6.022×10^{23} mol^{-1}, $A = 1.7476$, $e = 1.602 \times 10^{-19}$ C, $\varepsilon_0 = 8.854 \times 10^{-12}$ Fm^{-1}, Internuclear distance of MgO = 212 pm)

4 (a.) Potassium nitrate crystallizes in an orthorhombic system with four molecules per unit cell. The unit cell dimensions are: a = 7.2 Å, b = 4.8 Å, c = 7.6 Å. If the molar mass is 18.18 g/mol. Calculate the density of the crystal.

(b.) The compound with the formula, IF_7 (Iodine heptafluoride) is an example of an Interhalogen. The structure is unusual.
(i) Show the electronic configuration of Iodine in the ground state and excited state to prove the existence of this structure.
(ii) What type of hybridization exist in this molecule.

OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA, DEPARTMENT CHEMISTRY

B.Sc./B.Edu. Degree Examination

CHM 302: Structural and Main-Group Inorganic Chemistry.

Rain Mid Semester Examination 2023/2024 Session

INSTRUCTIONS: ANSWER ALL QUESTIONS.
TIME : 1 HOUR.

1a (i) List 2 uses of lithium and sodium (or their compounds).

(ii). Explain why NaOH is soluble in water and LiOH is not.

1b. Complete and balance the following equation.

(i) $Mg_{(s)} + H_2O_{(g)} \rightarrow A + B$

(ii) $Mg_{(s)} + H_2O_{(l)} \xrightarrow{\Delta} C + D$

(iii) $Mg_{(s)} + H_2O_{(l)} \rightarrow E + F$

1c. Explain why BCl_3 will react with PEt_3 but $AlCl_3$ cannot (Et = $-C_2H_5$).

2a. Suggest reasons for the following observations:

(i) Nitrogen is less reactive at room temperature

(ii) There is a significant difference in the melting point between silicon (m.p 1410 °C) and lead (m.p 328 °C)

(iii) Water exist as a liquid and hydrogen Sulphide a gas at RT (room temperature).

2b. Give a chemical test to distinguish between carbon monoxide and carbon dioxide.

3a. Discuss and compare briefly the thermal stability, volatility, and acidity of the hydrides of Group VI elements

3b. (i) Draw and label the canonical structure of ozone, indicating formal charges on the atoms.

ii. Name and describe the type of hybridization in Sulphur dioxide (SO_2)

OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA
B.Sc./B.Edu. Degree Examination
RAIN SEMESTER EXAMINATION 2023/2024 SESSION

CHM 302: Structural and Main-Group Inorganic Chemistry

TIME ALLOWED: 2 Hours, 30 minutes **DATE: Monday, 7th July 2025**

INSTRUCTIONS: ANSWER ALL QUESTIONS IN SECTION A.
ANSWER ONLY ONE QUESTION IN SECTION B

Section A.

1(a). Explain in detail the reasons for the lilac-purple colouration observed in some pure potassium chloride crystal? (3 marks)

(b). Why do many metallic solids adopt hexagonal-closed packing (hcp) and face-centred close packing arrangements? (2 marks)

(c). State the reason(s) for the formation of different ionic arrangement observed in sodium chloride (NaCl; face-centred cubic) and Cesium chloride crystals (CsCl; body-centred cubic)? (3 marks)

(d). What are the determinant factors for the type of closed-packed atomic arrangement adopted in any crystalline solids? (2 marks)

(e). What is/are responsible for the discrepancies in the melting point of quartz and glass, despite having the same chemical formula? (5 marks)

(f). Give adequate reasons for the different responses observed in potassium metal and potassium chloride solids towards electrical potentials? (5 marks)

(h). State the reasons for categorizing Schottky and Frenkel defects as stoichiometric defects in ionic crystals? (5 marks)

[Total = 25 marks].

2(a). Account for the following observations:
i. Graphite is a good material for lead pencil
ii. Phosphorus is relatively more reactive compared to nitrogen, which is in the same group, at room temperature.
iii. Dimerization of nitrogen dioxide (NO_2)
iv. Hydrogen sulphide (H_2S) is less acidic than hydrogen telluride (H_2Te)

(b). Why does ozone (O_3) act as a powerful oxidizing agent?

(c). What is the most stable oxidation state for each of the elements: carbon, silicon and lead. (Note: answers to each question in number 2 should not exceed three lines) [15 marks]

3(a). Between alkaline metals and alkaline earth metals, which is the better reducing agents and why?

(b). Consider the following oxoacids: $NaHCO_3$, $Ca(HCO_3)_2$, $CaSO_4$, $CaCO_3$, $NaNO_3$, $Ca(NO_3)_2$
i. Which is/are responsible for temporary hardness in water?
ii. Which one(s) is/are soluble in water?
iii. Which one(s) would undergo thermal decomposition to its oxide and liberate CO_2?
iv. Which one(s) causes permanent hardness in water?
v. Which one is baking soda?

(c). Explain why BCl_3 will react with $P(CH_2CH_3)_3$, while $AlCl_3$ will not.

(d). Write the reaction equation between diborane and propene to yield an alkylborane

(e). Using the alkylborane in (d) above, write the correct reaction equations to illustrate the conversion of the alkylborane to a carboxylic acid.

[15 marks]

SECTION B.

4(a). Write down, in order, the names, and symbol of group 17 (Group VII) elements. Give a general notation showing the ground state electronic configuration of each element.

(b). For a given atom Y, the Y-F bond is usually stronger than the corresponding Y-Cl bond. Suggest a reason for this observation.

(c). The hydrogen bonding in hydrogen fluoride (HF) is stronger than that in water (H_2O), but water has a higher boiling point than hydrogen fluoride as shown in the table below. Explain Why?

Compounds	Boiling point °C	H-Bonding strength
HF	19.5	Stronger H- bonding
H_2O	100	Moderate H-bonding

4(d).(i) write equations showing how the hydrogen halides (HF, HCl, HBr and HI) ionise in aqueous solution.

(ii). What is the trend in Acidity going down the group? [15 marks]

5(a). Give two reasons why noble gases were historically considered inert and explain how the discovery of xenon fluorides changed this perception.

(b). Write the balanced equation for the preparation of xenon tetrafluoride (XeF_4). Mention the conditions required.

(c). Name and Describe the type of hybridisation involved in the formation of XeF_2.

(d). Draw and name the structure (or geometry) for compound XeF_2. [15 marks]