INORGANIC CHEMISTRY EXPLANATION QUESTIONS

1. When sodium hydroxide is added to a solution of chromium (III) chloride followed by excess hydrogen peroxide, **a green precipitate** is formed and later a **yellow solution.**

   Ans: *The Chromium (III) ions react with the hydroxide ions to form Chromium(III) hydroxide which is a green solid hence a green precipitate. The Chromium (iii) hydroxide is oxidized by hydrogen peroxide solution in the alkaline medium to chromate ions* (CrO_4^{2-}) *which has a characteristic yellow*

   $$Cr^{3+}(aq) + 3\,OH^-(aq) \longrightarrow Cr(OH)_{3(s)}$$

   $$Cr(OH)_{3(s)} + 3OH^-(aq) \longrightarrow Cr(OH)_6^{3-}(aq)$$

   $$2\,Cr(OH)_6^{3-}(aq) + 3H_2O_2\,(aq) \longrightarrow 2CrO_4^{2-}(aq) + 2\,OH^-(aq) + 8H_2O(l)$$

2. Potassium manganate(VII) **cannot be acidified** using dilute hydrochloric acid.

   ***Ans**: Dilute hydrochloric acid is not used because it is oxidizes by the manganate (vii) solution forming chlorine gas which is an interference to the desired reaction*

   $$2KMnO_4\,(aq) + 16HCl\,(aq) \longrightarrow 2MnCl_2\,(aq) + 2KCl(aq) + 5Cl_{2(g)} + 8H_2O(l)$$

   Note: Dilute nitric acid is not used because itself like potassium manganate (vii) is an oxidizing agent and therefore would interfere with the desired reaction.

3. Solutions of potassium manganate(VII) **should be kept** in dark bottles. (*For the student*)
4. Rusting of iron is an **electrochemical process**.(*For the student*)
5. When concentrated hydrochloric acid is added to a solution of cobalt(II) sulphate, the solution becomes **deep blue**; when the deep blue solution is cooled, it **turns to pink**.(*For the student*)
6. The boiling points of the hydrides increase down the group. (*Down the group the magnitude of the intermolecular Van der Waal's forces increase with increase in molecular mass*).

7. Both the melting and boiling points of the halogens **increase from one element to the next one** down the group.
   Ans: *The halogens exist as diatomic molecules i.e.* F_2*,* Cl_2*,* Br_2 *and* I_2*.*
   Down the group the molecular mass increases. The increase in molecular mass leads to an increase in the magnitude of the intermolecular van der waal's forces and hence increases in both melting and boiling points.

8. The carbon-chlorine bonds in tetrachloromethane molecule **are polar** and yet tetrachloromethane molecule **as a whole is non polar**.
   Ans*: Because chlorine is more electronegative than carbon, the electrons in the carbon-chlorine bonds in* CCl_4 *are attracted more towards the chlorine atoms. The chlorine atoms develop partial negative charges and the carbon atom partial positive charge i.e. the carbon-chlorine bonds are polar. But because the 4 bonds are in opposite directions and are all equal, the polar*

effect cancel each other and overall CCl_4 is non polar.

9. Both H_2O and H_2S molecules **adopt v- shaped** but the bond angle in H_2O is **greater than** that in H_2S.

   ***Ans**: Oxygen atom being more electronegative than sulphur pulls the bond electrons more towards its self and in the process drawing the bond pairs of electrons nearer. This increases the repulsion between the bond pairs and to reduce the repulsion to a minimum, the bond angle increases. In H_2O therefore the two bond electrons repel each other more strongly than those in H_2S. The greater the repulsion between the bonds pairs the greater the bond angle.*

10. All group I metals react with water **more vigorously** than their group II counterparts to form corresponding hydroxide and hydrogen gas. The vigor of reaction **increases** down the group.

    ***Ans:** A group I element loses one electron while a group II element loses two electrons. Therefore less energy is required to remove one electron than two from the outer most shell and as such group I metals react faster with water than their neighbouring metals of group II.*

    As the atomic radius increases down the group, ionization energy decreases therefore increasing reactivity in each group. The lower the ionization energy, the lower the activation energy for reaction and the faster the reaction.

    $2X(s) + H_2O(l) \longrightarrow 2XOH(aq) + H_2(g)$. X = Li, Na, K, Rb, Cs

11. The solubility of group II hydroxides **increases** down the group.

Ans: *Down the group, the radius of the cations increases while the charge on them remains the same. This leads to a decrease in both the lattice and hydration energies. But the decrease in lattice energy of the hydroxides is more rapid than the decrease in hydration energy. As such the lattice energy is easily superseded by the hydration energy thus facilitating solubility of the hydroxides.*

*12.*Compounds of group II elements **are less ionic than** their corresponding group I compounds.

Ans: *The cations of group II have smaller ionic radius than corresponding group I. Also group II cations are doubly charged while those of group I are singly charged. Therefore cations of group II have higher charge density and more polarizing power than corresponding group I cations. As such compounds of group II are less ionic than corresponding group I compound. e.g. Magnesium chloride is less ionic than Sodium chloride.*

13.Fluorine is has a **fixed oxidation state** of -1 while the other halogens have **more than one oxidation states**. (*For the student. Hint; Electron configuration*)

Ans: *This is because fluorine lacks a d sub shell while the other halogens have.*

14.Hydrogen fluoride is **a liquid** while other hydrogen halides are **gases at room temperature**. (*For the student*)

Ans: This is due to the strong hydrogen bonds between hydrogen fluoride molecules as a result of high electronegativity of fluorine atom.

15. Fluorine forms the **least acidic hydride** whereas the hydrides of other members are **fairly more acidic** in aqueous solution. (*This is due to the high strength of the H-F bond*).
16. Fluorine is the **most reactive** halogen (*This is due to its low bond dissociation energy and high electronegativity*).
17. Fluorine forms compounds with **more ionic** character (*due to its high electronegativity*).
18. Fluorine forms hydride with the highest boiling point (*due to extensive hydrogen bonds*).

19. Potassium ion (K^+) and chloride ion (Cl^-) **are isoelectronic** (have same number of electrons, 18) but K+ is **smaller than** Cl^-.(*For the student*)
20. The melting points of aluminium, silicon and phosphorous are 660^{0}C, 1423^{0}C and 44^{0}C respectively.(*For the student. Hint: size, structure*).
21. The melting point of aluminium Chloride is **abnormally low** compared to that of Aluminium oxide. (*For the student. Hint: covalent character and number 140*)
22. In going from sodium to chlorine along the 2nd short period there is a **decrease** in size. (*For the student. Hint: nuclear attraction, shielding effect*)
23. Lithium chloride is much **more soluble** in ethanol than sodium chloride.(*For the student*)
24. Calcium hydroxide is **not precipitated** by Ammonia solution whereas magnesium hydroxide is (*For the student*).
25. Lithium iodide is **more soluble** in ethanol than lithium chloride (*For the student*).

26. A solution of potassium chloride **slowly turns brown** when left standing in air (*For the student*).
27. Zinc hydroxide **was precipitated** from an aqueous solution of zinc sulphate by both sodium hydroxide and ammonia solution and in each case; the **precipitate dissolved** when more of the reagent was added.

    Ans*: the white precipitate which dissolves in excess alkalis to form a colourless solution due to formation of soluble complex compounds*

    $Zn^{2+}(aq) + 2OH^{-}(aq) \rightarrow Zn(OH)_2(s)$ *White precipitate*

    $Zn(OH)_2(s) + 2OH^{-}(aq) \rightarrow Zn(OH)^{2-}(aq)$ *colorless solution*

    $Zn(OH)_2(s) + 4NH_3(aq) \rightarrow Zn(NH_3)_4^{2+}(aq) + 2OH^{-}(aq)$

28. A solution of sodium thiosulphate **becomes cloudy** with the formation of a yellow precipitate when left standing in air.(*For the student*)
29. Oxygen is **a gas** whereas sulphur is **a solid** at room temperature. (*For the student. Hint: molecular mass*) (05 marks)
30. Vanadium exists in +5 oxidation in a solution of ammonium vanadate, **which is yellow**. When heated with zinc and hydrochloric acid (in absence of oxygen) the solution changes progressively **to blue, to green and finally to violet**. The violet solution contains vanadium (II) ions. On exposing the violet solution to oxygen it changes to **green and finally to blue** (*For the student*).
31. When excess cold concentrated hydrochloric acid is added to lead(IV) oxide, **brown solid dissolves** to **a bright yellow liquid** which formed **a pale**

yellow precipitate on addition of concentrated solution of ammonium chloride. (05marks)

Ans: *Lead (IV) oxide oxidizes strong hot concentrated hydrochloric acid to chlorine gas*

$PbO_2 (s) + 4HCl (aq) \longrightarrow Cl_2 (g) + PbCl_2 (s) + H_2O (l)$

When excess concentrated hydrochloric acid is reacted with lead (IV) oxide at 0^oC *it forms a complex ion*

$PbO_2 (s) + 4HCl (aq) + 2Cl^- (aq) \longrightarrow PbCl_6^{2-} (aq) + 2H_2O (l)$

Addition of concentrated ammonium chloride to the complex produces a yellow precipitate. i.e.

$PbCl_6^{2-} (aq) + 2NH_4^+ (aq) \longrightarrow (NH_4)_2PbCl_6 (s)$

32. When sulphur was warmed separately with concentrated nitric acid and concentrated sulphuric acid, **sulphuric acid and sulphur dioxide** were respectively formed as one of the products. (*For the student*).(05marks)
33. The second ionization energy of sodium is **much higher than** the first ionization energy than the third ionization energy to the second ionization energy. (*For the student*). (05marks)
34. Aluminium triflouride is **ionic**, while aluminium trichloride is **covalent**. (*For the student. Hint: covalent character, the same as number 140*).(05marks)
35. Boron trichloride BCl_3 is **non polar molecule** whereas nitrogen trichloride, NCl_3 is **polar**(*For the student*). (4marks)

36. Hydrogen chloride gas can be prepared by reacting concentrated sulphuric acid with sodium chloride however hydrogen bromide cannot be obtained from sodium bromide using the same method. (5 marks)

    Ans: *Hydrogen bromide and hydrogen iodide cannot be prepared by a similar method using concentrated sulphuric acid because hydrogen bromide and hydrogen iodide are strong reducing agents which can be oxidised by concentrated sulphuric acid to bromine and iodine respectively.* ***Include the equations*** (*For the student*).

37. Potassium is a **stronger reducing** agent than Sodium (*For the student. Hint: size*).
38. Group I elements are **stronger reducing** elements than Group II (*For the student. Hint: number of valence electrons*).
39. Group I compounds are **more ionic** than the corresponding compounds of group II. (*For the student. Hint: polarization)*.
40. Hydrated copper (II) sulphate crystals **dissolve endothermically** while anhydrous salt dissolves **exothermically**.

    Ans: *This is because for hydrated salt, the ions are already partly hydrated therefore hydration energy is lost thus when the crystals are dissolved in water this hydration energy is not enough to outweigh lattice energy. For anhydrous salt, the hydration energy is readily available and able to outweigh lattice energy.*

41. Aluminium hydroxide **dissolves** in sodium hydroxide solution while Magnesium hydroxide **does not.** (*For the student. Hint: formation of a complex*).

42. Copper (I) chloride and Lead (II) chloride are **both insoluble** in water but **dissolves** in concentrated hydrochloric acid

    Ans: Lead (II) chloride is more soluble in concentrated hydrochloric acid than in water due to formation of a soluble complex of tetrachloro plumbate (II)

    $PbCl_2\,(s) \quad + \quad 2Cl^-\,(aq) \rightleftharpoons PbCl_4^{2-}\,(aq)$

    The chloride dissolves in concentrated hydrochloric acid to form a yellow-green solution of tetrachloro cupricate

    $CuCl_2\,(s) \quad + 2Cl^-\,(aq) \longrightarrow CuCl_4^{2-}\,(aq)$

43. A blue solution of Copper (II) chloride **turns green** on addition of chloride ions (*For the student*).
44. The melting points of group I metals **decreases** down the group (*For the student*).
45. Ethylamine is a **stronger base** than phenylamine although both are primary amines. (*For the student.*).(4 marks)
46. Dilute hydrofluoric acid is **a weaker acid** than dilute hydrochloric acid. (*For the student.*).
47. The melting point of sodium salts of the halogens are **in the order** NaCl > NaBr>NaI. (*For the student.*)

    This is because of the decreasing ionic nature of the halides from NaCl to NaI due to increased ionic polarization of the halides ions as they become bigger in size thus becoming less ionic

48. The bond dissociation energies of group (IV) hydrides are **in the order** $CH_4 > SiH_4 > GeH_4 > PbH_4$. However, their boiling points are **in the reverse** order. (*For the student.*) (05 marks)
49. Magnesium belongs to group(II) in the periodic table and yet its chemistry and that of its compound **resemble** that of lithium·(*The same for aluminium and beryllium, silicon and boron*)

    Ans: *The reasons why the chemistry of the above 3 pairs of elements resemble can be summarized as follows:*

    The cations in each pair have similar charge densities & similar polarizing powers.

    Similar electropositivities of the elements.

    Similar hydration energies of the cations,

    Similar electrode potentials,
50. The elements of group (II) of the Periodic Table **are harder and have higher** melting points and boiling points than those of group (I) elements. (*For the student.*) (02marks)
51. When dilute hydrochloric acid is added to a solution of lead (II) nitrate, a **white precipitate is formed**, but if the concentrated acid is used, there is **no precipitate**. (*For the student.*)
52. Lead (II) chloride is **more soluble** in concentrated hydrochloric acid than in dilute hydrochloric acid (5marks)

    Lead(II) chloride is fairly insoluble salt in water and, , it would form an insoluble layer over the lead(II) oxide if dilute hydrochloric acid is used stopping the reaction from going on.

$$PbO(s) + 2HCl(aq) \longrightarrow PbCl_2(s) + H_2O(l).$$

However, using concentrated hydrochloric acid the large excess of chloride ions in the concentrated acid react with the lead(II) chloride to produce a yellow soluble complex $PbCl_4^{2-}$.

$PbCl_2^{4-}(s) + 2Cl\text{-}(aq) \qquad PbCl_4^{2-}(aq)$

53. When lead(IV) oxide is **warmed** with concentrated hydrochloric acid, effervescence of a greenish yellow gas occurs. (*For the student. Hint: number 36*) (3 ½ marks)
54. Iron(III) chloride and tin(II) chloride **cannot exist** together in aqueous solution. (*For the student.*) (03 marks)
55. Lithium **does not form** peroxide or superoxides like other group I elements (3 marks)

    Ans: *Lithium is not capable of forming higher oxides due to the fact that Li+ is very small, with high charge density & high polarizing power. Thus the larger oxides cannot be accommodated around it otherwise the compound would be highly covalent & unstable.*

56. Carbon forms **four single covalent bonds** with hydrogen in methane (CH_4) (*For the student.*) 2marks
57. The second ionization energy of magnesium is **higher than** its first ionization energy although the two electrons occupy the same energy level. (*For the student.*)
58. Beryllium carbide and calcium carbide **do not give** the same product(s) on hydrolysis. (*For the student.*)

59. A **white precipitate** is formed when an aqueous sodium carbonate is added to a solution of aluminium ions. (*For the student.*)

$[Al(H_2O)_6]^{3+}(aq)+3H_2O(l) \qquad [Al(H_2O)_3\,3OH](s) + 3H_3O+(aq)$

60. Aluminium oxides shows a melting point of 1750°C but aluminium chloride sublimes at 180°C. (*For the student. hint: covalent character, and number 140*)

61. The solubility of group (II) hydroxide in water **increases down the group** (II) whereas the solubility of group (II) sulphates decreases. (*For the student.*)

62. When hydrogen sulphide gas was bubbled through iron(III) chloride solution, a **yellow precipitate** was observed. (*For the student.*) (3½ marks)

$$H_2S_{(g)} + 2Fe^{3+}_{(aq)} \longrightarrow 2H^{+}_{(aq)} + 2Fe^{2+}_{(aq)} + S_{(s)}$$

63. Alkenes undergo **electrophilic addition** while carbonyl compounds undergo **nucleophilic addition**.

64. When ammonia solution is added to aqueous manganese (II) sulphate, a **white precipitate** is formed but when ammonia solution is added to manganese (II) sulphate in the presence of ammonium chloride, there **is no observable change**(*For the student.*).

65. Why fluorine shows **some differences** in its properties from the rest of the group 7 elements (chlorine, bromine, and iodine) of the periodic table.

Ans:

- *Fluorine is the most electronegative halogen.*
- *The bond dissociation energy of fluorine molecule is lower than expected.*
- *Fluorine has a high positive value of standard electrode potential*

- *Fluoride ion having the smallest radius compared to other halides has the highest charge density and enthalpy of hydration.*
- *Fluorine lacks a d sub shell.*

66. Sodium chloride **melts at 800^{0}C** whereas aluminium chloride **sublimes at 180^{0}C**. (*For the student.*) (03marks)
67. Graphite and copper are **both conductors of electricity**. (*For the student.*) (04marks)
68. Iodine is much **more soluble** in potassium iodide than water. (*For the student. Hint: formation of a soluble complex*) (03marks)
69. Lead (IV) oxide dissolves in cold concentrated hydrochloric acid to give a **deep yellow** solution from which a **yellow solid separates** on addition of a saturated solution ammonium chloride. (*For the student.*)
70. Hydrochloric acid and nitric acid are not used to acidify volumetric analysis potassium permanganate.

    Ans: *Dilute hydrochloric acid is not used because it is oxidizes by the manganate (VII) solution forming chlorine gas which is an interference to the desired reaction*

    $2KMnO_4\,(aq) + 16HCl(aq) \longrightarrow 2MnCl_2\,(aq) + 2KCl(aq) + 5Cl_2(g) + 8H_2O(l)$

    Dilute nitric acid is not used because itself like potassium manganate (vii) is an oxidizing agent and therefore would interfere with the desired reaction.

71. Oxygen and sulphur are in group (VI) of the Periodic Table. Oxygen is **a gas** but sulphur is **a solid**. (*For the student.*)
72. Hydrated sodium carbonate **dissolves in water endothermically** while anhydrous sodium carbonate **dissolves exothermically**. (*For the student. Hint: number 40*)
73. The first ionization energy of aluminium is **less than that** of magnesium. (4 marks). (*For the student.*)
74. Silicon tetrachloride **fumes** in moist air. (*For the student.*) (04 marks)
75. The bond dissociation enthalpy and thermal stability of the hydrides of group (VI) **decrease in the Order** HF>HCl > HBr>HI whereas the acidic Strength of the hydrides **is in the order** HF<HCl< HBr<HI.

    Ans: *The acidity of the hydrides is in the order H-F <H-Cl< H-Br< H-I.*

    H-F is the weakest acid because the H-F bond is very strong as a result of small atomic radius and high electronegativity of Fluorine atom. It is weakly dissociated in solution releasing fewer H+ ions.

    In addition, the presence of hydrogen bonding between HF molecules and water molecules inhibits the ionization of HF in aqueous solution.

    However, as the group is descended, electronegativity decreases whereas atomic radius increases.As such the H- halide bonds become progressively longer and weaker. They dissociate in solution releasing more hydrogen ions. For the dissociation energy, As the halogen atom gets bigger, the bonding pair gets more and more distant from the nucleus. The attraction is less, and the bond gets weaker.

76. When an excess of potassium iodide solution is added to aqueous solution to a copper(II) salt, **a white precipitate and a brown solution** are formed(*For the student.*).
77. Magnesium readily reacts with concentrated nitric acid whereas beryllium does not react with concentrated nitric acid. (*For the student.*) 3 marks
78. Ice is **less dense** than water. 3 marks

    Ans: *Hydrogen bonds increase the volume and lowers the density.*
    Each oxygen atom is tetrahedrally attached to four hydrogen atoms i.e two are normal covalent bonds and the other are longer hydrogen bond. This arrangement gives ice a more open structure hence an increased volume therefore a fixed mass for water, the density decreases as it freezes.

79. Calcium forms compounds **containing Ca^{2+} ions but none containing Ca^{+} ions** even though the second ionisation energy of calcium is greater than its first ionisation energy. (*For the student.*)
80. Although $SiCl_4$ is readily hydrolyzed by water, CCl_4 is not.

    Ans: *Carbon tetrachloride (CCl4) does not undergo hydrolysis in water. This is due to the absence of a d sub shell in carbon and as such it cannot expand its octet. However, other tetrachlorides undergo hydrolysis in water. This is attributed to availability of the empty d-orbitals which allow the elements to expand their octet and show a covalency of more than +4. These empty d-orbitals accept the lone pairs of electrons from the oxygen atom of water molecule thus facilitating the hydrolysis of the tetra chlorides.*

81. Solid $BeCl_2$ **is soluble** in ethoxyethane. (*For the student. Hint: covalent character and polarity*)
82. A solution of aluminium nitrate **boils at a higher temperature** than a solution of sodium nitrate of the same molar concentration. (*For the student.*)
83. The ionic radius of sodium is **smaller than** its atomic radius but chloride ions **have larger radius** than the chloride atoms. (*For the student.*)
84. The 1st ionization energy of that of potassium is smaller than that of sodium. (*For the student.*)
85. The 1st electron affinity of chlorine **is greater (more exothermic)** than that of iodine. (*For the student.*)
86. $BeCl_2$ has some **covalent bonding** but $CaCl_2$ is **ionic**. (*For the student.*)
87. Chlorine is **more electronegative** than Bromine. (*For the student.*)
88. The **decrease** in atomic radius from scandium (d-block elements) to zinc is **very small**.

    Ans: *This is because the increase in nuclear charge from one atom to the next one is roughly balanced by the increase in screening effect on the outer 4s electrons by the electrons in the inner shells as the number of electrons on the inner 3d sub shell (penultimate shell) increases. The effective nuclear charge therefore is more or less the same throughout and the atomic radius as well.*

89. Barium Carbonate **decomposes at higher** temperature than Magnesium Carbonate. (*For the student.*)

90. Calcium Oxide **melts at higher temperature** than Sodium Chloride. (*For the student.*)
91. When ammonia solution is added to silver nitrate dropwise until in excess a brown **precipitate** is formed which **dissolves** in excess ammonia to give a **colourless solution**. (*For the student.*) (3 marks)
92. Ammonia has an **abnormally high boiling point** than other group (v) hydrides. (*For the student. Hint: hydrogen bonding*)
93. When aqueous sodium carbonate is added to zinc chloride solution a precipitate is formed, whereas when the carbonate solution is added to acidified zinc chloride solution no precipitate is formed. (*For the student.*)
94. When dilute hydrochloric acid is added to a solution of lead (II) ethanoate a **white precipitate** is formed, **the precipitate is soluble in excess** concentrated hydrochloric acid. (*For the student.*)
95. When separately added to copper(II) sulphate solution, potassium iodide **forms a white precipitate in a brown solution** while potassium chloride gives **no observable change**. (*For the student.*) (03 marks)
96. When sodium hydroxide solution was added to aluminium sulphate solution, a **white precipitate** was formed which dissolved to form a **colourless solution**. (*For the student.*) (05 marks)
97. The solubilities of lead (II) halides **increase** in the order $PbI_2 < PbBr_2 < PbCl_2$. (*For the student.*)
98. Lead(IV) **readily decomposes** to lead(II) chloride and chlorine while lead(II) chloride is not affected by heat(*For the student.*).
99. Beryllium hydroxide **cannot be prepared** by precipitation method.

Ans: Because Beryllium hydroxide is amphoteric and therefore it forms complex .

$Be(OH)_2$ (s) + 2OH- (aq) $\longrightarrow$ $Be(OH)_4^{2-}$ (aq)

100. The reactivity of a metal **increases as one goes down the group** but that of a halogen decreases as one goes down the group (*For the student.*) (3 marks)

101. Although Na^+ and Mg^{2+} have **same electronic configuration**, Mg^{2+} is smaller than Na^+ (*For the student. Hint: effective nuclear attraction for the*)

102. Sulphur combines with fluorine to form **SF_6** but chlorine forms **SCl_4.** (*For the student.*)

103. when dilute sulphuric acid is added to copper (i)oxide **reddish brown solid and blue solution** are formed(*For the student.*)

104. Addition of Barium chloride solution to solution of Potassium dichromate (VI) gives a **yellow precipitate**. (*For the student.*)

105. The compound $CrCl_3.6H_2O$ exists in three forms, all produce precipitate with silver nitrate but in different molar proportions.

This salt of chromium exhibits hydration isomerism i.e. existence of compounds with the same molecular formula but different structural formulae due to the difference in the number of water molecules directly bonded to the central chromium (iii) ion.

The following are the isomers of hydrated chromium (iii) chloride:

$[Cr(H_2O)_6]^{3+}$ $3Cl^-$ *(Hexaquachromium (iii) chloride)*

$[Cr(H_2O)_5Cl]^{2+}.2Cl^-.H_2O$ *(Chloropentaqua chromium (iii) chloride monohydrate)*

$[Cr(H_2O)_4Cl_2]^+.Cl^-.2H_2O$ *(Dichlorotetraaqua chromium (iii) chloride dihydrate)*

106. The tendency of group 2 elements **to form complex** ions is in order. Be > Mg > Ca > Ba(*For the student. Hint: properties which favour formation of complexes*) (4marks)

107. The bond angle in a water molecule **is 104⁰** whereas that in a molecule of ammonia **is 107⁰** (4marks) (*For the student.*)

108. A solution of aluminium nitrate turns **blue litmus paper red**. (*the same idea is applied on number 115*) (03 marks)

109. Carbonic acid (H_2CO_3)and sulphurous acid (H_2SO_3) are both weak acids but their molecules **exhibit different** bond angles. (*For the student.*) (04 marks)

110. Iron(II) salts are **easily oxidised** to iron(III) salts but manganese(II) salts **cannot easily be** oxidised to manganese(III) salts.(03 marks) (Atomic numbers of Manganese and iron are 25 and 26 respectively) (*For the student. Hint: use the electron configuration*)

111. Potassium chloride is more soluble in water than in concentrated hydrochloric acid whereas lead (II) chloride is more soluble in concentrated hydrochloric acid than in water. (*For the student.*) (05 marks)

112. Sodium carbonate solution was added to aqueous solution of iron (III) sulphate. **Bubbles of a colourless gas and a brown precipitate were observed.**

Ans: *Due to high charge density, the hydrated ion undergoes hydrolysis to form insoluble iron (III) hydroxide and hydrogen ions which cause the solution to be acidic i.e.*

$$[Fe(H_2O)_6]^{3+}(aq) \rightleftharpoons [Fe(H_2O)_3(OH)_3](s) + 3H^+(aq)$$

Or $[Fe(H_2O)_6]^{3+}(aq) + 3H_2O(l) \longrightarrow [Fe(H_2O)_3(OH)_3](s) + 3H_3O^+(aq)$

The hydrogen ions react with carbonate ions from sodium carbonate to form carbondioxide gas which is a colourless gas.

$$H^{+}(aq) + CO_3^{2-}(aq) \longrightarrow CO_2(g) + H_2O(l)$$

113. Lead **does not form** lead tetra bromide. (*For the student.*)

Ans: The bromide ion has a lager radius than the chloride ion, hence the bromide ion is a stronger reducing agent than the chloride ion. So the bromide ion reduces lead(IV) ions to lead(II) ions thus lead(IV) bromide cannot exist.

114. Chromium (III) sulphate **dissolves in water** to form a solution whose **pH is less than 7** (Acidic) (*For the student. Idea is applied on number 112*)

115. Transition metals of period 4 **having higher melting point and boiling point** than non-transition metals of the same period.

Ans: *Melting points of metals depend on the number of electrons available for metallic bond formation.*

Transition elements use both the 4s and 3d-electrons in metallic bond formation. The greater the number of electrons contributed to the metallic bond, the higher the melting point. Transition elements therefore have high melting and boiling points. Compare with the non-transition

116. The melting point of Aluminium chloride is **abnormally low** compared to that Aluminium Oxide. (*For the student.*)

117. Lithium carbonate **decomposes** while other carbonates of group **I do not.** (*For the student. as number 116*)

Ans: *It is because the Lithium ions have a high charge density hence easily polarize the carbonate ions to form a covalent compound which is held by weak Vander Waals forces which makes it easily decompose.*

118. The melting point of Calcium oxide **is higher than** of Calcium chloride. (*For the student. Hint: number 117*)

119. Copper(II) sulphate solution turns **blue litmus red**. (*This applies to other solutions of magnesium (II), Beryllium(II), etc*)

Ans: This is the most stable oxidation state of copper and in aqueous solution exists as $[Cu(H2O)4]^{2+}$ *which is a blue solution. It slowly undergoes hydrolysis forming acidic solution.*

$$[Cu\ (H2O)4]^{2+}(aq) \longrightarrow [Cu(H2O)3OH]^{+}\ (aq) + H^{+}(aq)$$

120. A solution of Iron (III) chloride is **acidic to litmus**.

Ans: *The iron (III) ions have a high charge density and are heavily hydrated therefore in aqueous solution they exist as* $[Fe(H_2O)6]3+$ *hence it undergoes hydrolysis to release protons which cause the solution to be acidic*

$$[Fe(H_2O)_6]^{3+}\ (aq) \rightleftharpoons [Fe(H_2O)_5OH]^{2+}\ (aq) + H^{+}\ (aq)$$

Complete hydrolysis is represented as

$$[Fe(H_2O)_6]^{3+}\ (aq) \rightleftharpoons [Fe(H_2O)_3(OH)_3]\ (s) + 3H^{+}\ (aq)$$

121. When sodium hydroxide solution is added to aqueous solution of chromium (III) sulphate **a green precipitate** is formed which **dissolves in excess alkali** to form **a green solution**. The solution changes to yellow when heated with hydrogen peroxide solution (6marks)

Chromium (III) is precipitated as a green solid on addition of sodium hydroxide solution to a solution containing Chromium (III) ions

$Cr^{3+}(aq) + 3OH^{-}(aq) \longrightarrow Cr(OH)_3$

It is an amphoteric hydroxide and thus dissolves in sodium hydroxide solution to form a green solution.

$Cr(OH)3\ (s) + OH^{-}(aq) \longrightarrow Cr(OH)4^{-}\ (aq)$

It is oxidized by hydrogen peroxide in alkaline medium to form a yellow chromate (VI) solution

$2Cr^{3+}(aq) + 3H2O2\ (aq) + 10\ OH^{-}(aq) \longrightarrow 2CrO4^{2-}(aq) + 8H2O\ (l)$

122. When sodium hydroxide is added to a solution of manganese (II) chloride a **white precipitate is formed which quickly changes to brown**. The precipitate is **insoluble** in excess sodium hydroxide. (4marks) (*For the student.*)

123. When a solution of manganese (II) chloride is heated with lead (IV) oxide and concentrated nitric acid, **the solution changes to purple**. (3marks) (*For the student.*)

124. When potassium iodide solution was added to copper(II) sulphate solution, **a white precipitate and a brown solution were formed**, however when potassium bromide solution was used, there **was no observable change.**(05 marks) (*For the student.*)

125. When concentrated hydrogen peroxide solution was added to lead(II) sulphide, the **black solid turned to a white solid**.(03 marks) (*For the student.*)

126. When an aqueous solution of sodium hydrogencarbonate is added to aluminium chloride solution, **a white precipitate and bubbles of a colourless** gas are observed.(05 marks) (*For the student. Hint: number 120*)

127. When concentrated ammonia solution was added to cobalt(II) chloride solution, **a blue precipitate was formed** which **dissolved in excess** ammonia solution to form **a pale brown solution**. (05 marks) (*For the student.*)

128. When ammonia solution is added to a solution of magnesium sulphate a **white precipitate** is formed. However, when it is added to the same solution in the presence of ammonium chloride solution no **precipitate is formed**.(5mks) (*For the student.*)

129. Hydrogen fluoride is **a liquid** at 20^0C whereas hydrogen chloride is **a gas.** (4marks) (*For the student.*)

130. Zinc chloride **dissolves** in dilute hydrochloric acid **but not** in ethanoic acid or water. (*For the student.*)

131. Aluminium hydroxide **is soluble in** dilute sodium hydroxide solution, yet **insoluble in** aqueous ammonia whereas zinc hydroxide **readily dissolves in both**. (*For the student. Hint: number 27*)

132. Addition of Ammonium thiocyanate to an aqueous solution of iron (III) chloride **produces a blood red solution**. (*For the student.*)

133. Calcium carbonate is **less soluble in water** than calcium chloride (3 marks) (*For the student.*)

134. The salts of group I elements are generally **more soluble than** those of the corresponding group II salts (6 marks) (*For the student.*)

135. Ammonia **boils at -33^{0}C** whereas phosphine, PH3, **boils at -88^{0}C** (4mark) (*For the student.*)

136. The lattice energy of Lithium fluoride and sodium fluoride are – **1029kJmol^{-1} and – 904kJmol^{-1}** respectively while that magnesium chloride and magnesium oxide **are -2492 and -3933 kJmol-1** respectively.4 marks (*For the student.*)

137. The standard electrode potential of lithium **is greater than that** of potassium although potassium **reacts more vigorously in water** than lithium. (*For the student.*)

138. Hydrofluoric acid is a weak acid but its strength **increases with increase in concentration**. (*For the student.*)

139. Aluminium carbonate **does not exist.**

Ans: *Most metal carbonates are insoluble and so are prepared by precipitation. Therefore the preparation of aluminium carbonate would involve mixing aqueous solutions of a soluble aluminium salt with an aqueous solution of a soluble metal carbonate. However, aqueous solutions of aluminium salts contain hydrated aluminium ions which undergo hydrolysis to form hydrogen ions(or hydroxonium ions) which make the solution acidic.*

The hydrogen ions (or hydroxonium ions) would then react with the carbonate ions liberating carbondioxide and precipitation of insoluble aluminium hydroxide instead of aluminium carbonate.

$$2Al^{3+}(aq) + 3CO_3^{2-}(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_3(s) + 2CO_2(g)$$

$$2[Al(H_2O)_6]^{3+}(aq) + 3CO_3^{2-}(aq) \longrightarrow 2[Al(H_2O)_3(OH)_3](s) + 3CO_2(g) + 3H_2O(l)$$

140. Aluminium fluoride **is ionic** while aluminium chloride is **covalent.**

Ans: *The fluoride ion has a smaller radius than the chloride ion. The valency (outer most electrons) of the fluoride ion are strongly attracted by the nucleus. Therefore the fluoride ion is weakly polarized by the aluminium ion, so aluminium fluoride is ionic. The chloride ion has a bigger ionic radius than the fluoride ion. The valency electrons of the chloride are weakly attracted by the nucleus thus the chloride ion is strongly polarized by the aluminium cation. This makes aluminium chloride covalent.*

141. The stability of the +2 oxidation state **increases down** the group (from carbon to lead) while the stability of the +4 oxidation state decreases down the group.

Ans: *The increase in stability of the +2 oxidation state down the group is due to inert pair effect –ie the inability of a pair of electrons in s-orbitals of the outermost energy level to take part in bonding.*

The inert pair effect increase down group(IV) elements because from one element to the next, the number of electrons in the d- and f-orbitals with a poor shielding effect increases. The ineffectiveness of the inner d- and f-orbital electrons to shield the outer most s-orbital electrons from the increasing nuclear charge increases. The s-orbital which are spherical in shape tend to penetrate and enter the atomic core, rendering the s-orbital electrons less available for bonding.

142. Carbon dioxide is **a gas** at room temperature while silicon dioxide is a **solid with a very high melting point.**

Ans: *Carbon is very electronegative and has a very small atomic radius. Therefore carbon is capable of forming strong double bonds with oxygen to form discrete molecules carbon dioxide at room temperature with weak van der Waals of attraction of attraction between the molecules hence gaseous. Silicon has a lower electronegativity and a larger atomic radius hence cannot form multiple (double) bonds with oxygen but forms single silicon-oxygen bonds with each silicon atom bonded to four oxygen atoms in a three- dimensional giant covalent structure which is strong, hence silicon dioxide is a solid with a high melting point.*

143. Thermal stability **decreases** from carbon tetrachloride to lead tetrachloride(or down the group)

Ans: *The atomic radius of group IV elements increases down the group (or from carbon to lead), so the covalent bond between group IV atom and chlorine b becomes longer and weaker down the group. Thus amount of energy required to break the covalent bonds in the tetrachlorides decreases hence decrease in thermal stability. Thus* CCl_4, $SiCl_4$ *and* $GeCl_4$ *are stable even at high temperatures, whereas* $SnCl_4$ *and* $PbCl_4$ *decomose readily –* $SnCl_4$ *decomposes on heating, whereas* $PbCl_4$ *decomposes even at room temperature to form the dichlorides and chlorine.*

$SnCl_4(l) \longrightarrow SnCl_2(s) + Cl_2(g)$

$PbCl_4(l) \longrightarrow PbCl_2(s) + Cl_2(g)$

144. The solubility of the sulphates of group(II) elements **decrease down** the group.

ANS: *This is because down the group, both lattice energy and hydration energy while the nuclear charge remains constant and cationic radius increases, however hydration energy decrease much more rapidly than lattice energy and the enthalpy of solution becomes less negative, hence the solubility decreases.*

145. Aluminium **does not react with** (is rendered passive by) nitric acid at any concentration.

ANS*: this is because nitric acid is a strong oxidising agent therefore it favours formation (build up) of the aluminium oxide, a protective oxide layer on the surface of aluminium which prevents further reaction.*

146. First electron affinity is **an exothermic process**.

ANS: *This is because the incoming electron experiences a greater attraction from the nucleus than repulsion from the electrons already present.*

147. Second electron affinity is an **endothermic process**.

ANS: *This is attributed to greater repulsive force which the electron being added experiences from electrons al- ready present than the attraction from the nucleus, thus work must be done to overcome the effect of repulsion. This work involves input of heat energy.*

148. Across the period, electronegativity **increases from one element to the next.**

ANS: *As one traverses a period from one element to the next, additional electron is added to shells with the same energy. As such the nuclear charge increases progressively while the screening effect of the inner complete shells of electrons remains almost unchanged. As a result, the effective nuclear charge increases leading to increased nuclear attraction for the electrons in the covalent bond and hence increase in the electronegativity.*

149. Electro positivity **increases** in moving down the group in the periodic table.

ANS: *Down any group in the periodic table, the increase in the screening effect out-weighs that due to nuclear charge due to an extra shell of electrons added from one element to the next. This decreases the effective nuclear charge as a result the attraction for the outer most electrons reduces hence they can easily be lost leading to an increase in electro positivity.*

150. Electro positivity **decreases in moving across** the period.

ANS: *Across the period, the nuclear charge progressively increases while the screening effect of the inner complete shells remains almost unaltered from one element to the next as additional electron is added to shells with the same energy. This increases the effective nuclear charge as such electrons in the outer most shell are attracted more strongly leading to increase in electro positivity.*

151. $HClO_2$ is a **weaker acid** than $HClO_4$

152. Copper(II) chloride is **green** while copper(I) chloride is a **white solid.**

153. Chlorine is a **stronger oxidising agent** than bromine(*For the student.*)

154. Transition metals commonly act as **catalysts** in chemical reactions (*For the student.*)

155. Transition metals form **complexes**. (*For the student.*)

Thank you