**RATU NAVULA COLLEGE**

**WEEK 4 YEAR 12B : CHEMISTRY NOTES & ACTIVITIES**

**LESSON NUMBER: 49**

**STRAND: 4. MATERIALS**

**SUB-STRAND: 4.1 INORGANIC CHEMISTRY**

**LEARNING OUTCOME:**

* **Properties of the chlorides of the period 3 elements.**

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| * **PROPERTIES OF CHLORINE**   - pale greenish-yellow gas which is more dense than air  - is easily liquefied, without cooling, by simply compressing the gas  - has a suffocating and irritating smell  - extremely poisonous  - does not burn and extinguishes a burning spirit | | |
| * **Patterns in the properties of second row chlorides**  |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Formula of Chloride** | **State of Chloride at RTP** | **MP and BP** | **Conduction of Electricity (Molten or Solid)** | **Structure** | | NaCl | Solid | High | good | Giant ionic | | MgCl2† | | Al2Cl6\*† | Fairly high | Very poor | Simple molecular | | SiCl4 | Liquid | low | nil | | PCl3 | | PCl5 | Solid | | S2Cl2 | Liquid |   \*Aluminium Chloride exists as separate molecules (AlCl3) in the vapour form, but in a solid statte, it exists as a dimolecular unit (Al2Cl6).  Magnesium Chloride and Aluminium chloride also exist as hydrated salts – MgCl2.6H2O and AlCl3.6H2O    Hydrolysis of second row chlorides:  H2O  Note: HCl(aq)  H+(aq) + Cl-(aq)   |  |  |  | | --- | --- | --- | | **Chloride** | **Effect of adding water to chloride** | **pH** | | NaCl | Dissolves readily  NaCl(s) + H2O(l) 🡪 Na+(aq) + Cl-(aq) | Neutral | | MgCl2 | Dissolves readily  MgCl2(s) + H2O(l) 🡪 Mg2+(aq) + 2Cl-(aq) | Neutral | | Al2Cl6 | Reacts with water  AlCl3 + H2O 🡪 Al(H2O)63+ + 3Cl-  Hydrate Al ion undergoes hydrolysis  Al(H2O)63+(aq) + H2O(l) ↔ Al(OH)(H2O)52+(aq) + H3O+(aq) | Acidic | | SiCl4 | Reacts with water to form HCl acid  SiCl4(l) + 2H2O(l) 🡪 SiO2(s) + 4H+(aq) + 4Cl-(aq)  (4HCl) | Acidic | | PCl3 | Reacts with water to form HCl acid  PCl3(l) + 3H2O(l) 🡪 H3PO3(aq) + 3H+(aq) + 3Cl-(aq)  Phosphine acid + 3HCl | Acidic | | S2Cl2 | Reacts with water to form HCl acid  2S2Cl2(l) + 2H2O(l) 🡪 3S(s) + SO2(aq) + 4HCl(aq) | Acidic |   Structure and Bonding of Chlorides:  - sodium and magnesium chloride have giant ionic structures and the oppositely charged ions are attracted  to each other by strong electrostatic forces in ionic bonds. As a result it has high melting and  boiling points and conducts electricity in molten form as the ions are free to move.  - all other chlorides are simple discrete molecules held together by relatively weak van der waals’ forces  of attraction.  Because of this, these chlorides have low boiling points. In a liquid state, there are no charged particles,  therefore they are non-conductors of electricity.  EXERCISE 16   1. Which of the following is a correct statement about magnesium chloride (MgCl2)?      * 1. Has high melting point.   2. Reacts violently with water.   3. Conductor of electricity in solid form.   4. Colourless liquid at room temperature.  **(1 mark)**     **LESSON NUMBER: 50**  **STRAND: 4. MATERIALS**  **SUB-STRAND: 4.1 INORGANIC CHEMISTRY**  **LEARNING OUTCOME:**   * Laboratory and industrial preparation of chlorine gas.  |  | | --- | |  |   **LABORATORY PREPARATION OF CHLORINE**   * heating manganese(IV) oxide (MnO2) with concentrated hydrochloric acid.   PRECAUTION – chlorine is a poisonous gas, therefore this preparation method should be carried out in  a fume cupboard or where there is proper ventilation.  **Method of Collection – downward delivery / upward displacement of air because it is more dense than air.**  Concentrated HCl  MnO2  White paper  Chlorine gas  Concentrated H2SO4 to dry Cl2  Water to remove HCl fumes  WARM GENTLY  **MnO2 + 4HCl 🡪 MnCl2 + Cl2 + 2H2O**  Other methods of preparing chlorine   1. electrolysis of sodium chloride solution   2NaCl(aq) + 2H2O(l) 🡪 2NaOH(aq) + H2(g) + Cl2(g)   1. by the action of dilute hydrochloric acid (or any other dilute acid) on bleaching powder Ca(ClO)2   4HCl(l) + Ca(ClO)2(g) 🡪 CaCl2(aq) + 2Cl2(g) + 2H2O(l)   1. by the oxidation of concentrated hydrochloric acid with such oxidizing agents as potassium permanganate   or lead (IV) oxide (lead dioxide, PbO2)  2KMnO4 + 16 HCl 🡪 2KCl + 2MnCl2 + 5Cl2 + 8H2O   1. By pouring cold sulphuric acid on a mixture of sodium chloride and manganese (IV) oxide and heating   the flask gently  H2SO4(l) + NaCl(s) 🡪 HCl(l) + NaHSO4(aq)  4 HCl(l) + MnO2(s) 🡪 MnCl2(aq) + 2H2O(l) + Cl2(g)  **Exercise 17**   1. The presence of chlorine gas (Cl2) can be tested by introducing a damp starch-iodide paper in a gas jar full of chlorine gas.   The incomplete equation for the reaction occurring on the starch-iodide paper is given below.  2KI(aq)  + Cl2(g)  KCl(aq)  +  **X**   * 1. State the colour of the starch-iodide paper if the test is positive.      * 1. Determine the **name** or **formula** of substance **X** responsible for the observed colour change in part (i) above.   **LESSON NUMBER: 51**  **STRAND: 4. MATERIALS**  **SUB-STRAND: 4.1 INORGANIC CHEMISTRY**  **LEARNING OUTCOME:**   * Uses and reactions of chlorine * **REACTIONS OF CHLORINE**  1. turns moist blue litmus paper red and then bleaches it. Bleaching action is due to hypochlorous acid (HClO);   dry Cl2 gas does not bleach [test for chlorine]   1. fairly soluble in water, forming yellowing chlorine water which is a mixture of two acids (hypochlorous and 2. hydrochloric)   H2O(l) + Cl2(g) 🡪 HClO(aq) + HCl(aq)  If the solution is left to stand in the sunlight for a few days, both the colour and the strong chlorine odour will disappear.  Hypochlorous acid is unstable and decomposes into hydrochloric acid and oxygen.   1. is a highly reactive element and combines directly with most metals and many non-metals.   e.g. iron reacts with chlorine if the gas is passed over rust-free iron in a combustion tube.  Fe starts to react as soon as it glows red hot.  2Fe + 3Cl2 🡪 2FeCl3 (black crystals)  This shows that chlorine acts as an oxidizing agent (oxidizes iron metal to Fe(III))  Fe(s) 🡪 Fe3+(s)   1. Action of Chlorine on Alkalis   a) cold dilute sodium hydroxide solution (solution becomes pale yellow and smells of chlorine)  2NaOH(aq) + Cl2(g) 🡪 NaCl(aq) + NaClO(aq) + H2O(l)  (sodium hypochlorite)  2OH-(aq) + Cl2(g) 🡪 Cl-(aq) + ClO-(aq) + H2O(l)  🡪 Cl atoms are both oxidized (Cl-) and reduced (ClO-)  b) warm concentrated sodium hydroxide solution  6NaOH(aq) + 3Cl2(g) 🡪 5NaCl(aq) + NaClO3(aq) + 3H2O(l)  (sodium chlorate)  6OH-(aq) + 3Cl2(g) 🡪 5Cl-(aq) + ClO3-(aq) + 3H2O(l)  c) aqueous slurry of calcium hydroxide 🡪 colour and smell of the gas disappears, showing that is  has been bleached  Ca(OH)2(s) + Cl2(g) 🡪 H2O(l) + CaOCl2(s)  (bleaching powder / calcium hypochlorite)  🡪 shows that Cl2 is acidic since it reacts with alkalis to form salt and water.   * **INDUSTRIAL MANUFACTURE OF CHLORINE**   + by electrolysis of aqueous sodium chloride (brine)     Cl2  GRAPHITE ANODE  +  -  DEPLETED BRINE  SATURATED BRINE  FLOWING MERCURY  In the electrolysis chlorine is liberated at the graphite anodes (positive electrodes) while sodium is liberated at  the mercury cathode (negative electrode).  Anode (+) graphite = 2Cl-(aq) 🡪 Cl2 + 2e-  Cathode (-) mercury = 2Na+(aq) + 2e- 🡪 2Na(l)  - sodium dissolves in the mercury forming an amalgam which then flows in the second cell where it reacts with  water to form a solution of water to form sodium hydroxide.   * **COMMERCIAL PREPARATION OF SODIUM HYPOCHLORITE (NaClO)**   - sodium hypochlorite is made by reacting chlorine with NaOH solution:  2NaOH + Cl2 🡪 NaClO + NaCl + H2O  - sodium hypochlorite is a good oxidizing agent and its bleaching properties are due to its ability to oxidize stains.  - it is also a good disinfectant, the substance responsible for this is hypochlorous acid (HClO)  ClO- + H2O ↔ HClO + OH-   * **USE OF Cl2 AND NaClO**   - used in pulp and paper industry (bleaching stages)  1. Chlorination stage  Chlorination of the unbleached pulp in the first stage converts the lignin into soluble chlorolignins and also oxidizes some of  the lignin and other coloured materials found in wood pulp.  THE PURPOSE OF BLEACING IS TO WHITEN THE PULP  Lignin + chlorine 🡪 chlorolignin + HCl  2. Caustic soda extraction stage  The soluble lignin compounds formed are removed by ALKALINE EXTRACTION by treating the washed pulp with caustic soda solution (sodium hydroxide)  After alkaline treatment pulp the pulp is washed to remove soluble material  Following this treatment, pulp has the same dull colour as the unbleached stock, but responds rapidly to further  treatment with caustic soda.  3. Sodium hypochlorite bleaching  The purification is usually by means of a hypochlorite bleach (sodium hypochlorite)  The lignin and other coloured compounds remaining after chlorination and alkali extraction are  by oxidation and sodium hypochlorite is a suitable reagent for this reaction.  Only a certain level of brightness can be obtained.  - Cl2 is used in 🡪 PVC (poly vinyl chloride) preparation from ethane  🡪 C2 solvents  🡪 dichloromethanes  🡪 propene oxide  **Exercise 18**   1. State the steps involved in the paper-pulp industry.   **LESSON NUMBER: 52**  **STRAND: 4. MATERIALS**  **SUB-STRAND: 4.1 INORGANIC CHEMISTRY**  **LEARNING OUTCOME:**   * Solubility rules for ionic compounds * Precipitation reactions and Net-ionic equations | | |
| * **PRECIPITATION REACTIONS**   - occur when the mixing of aqueous solution leads to the formation of an insoluble substance  - an insoluble salt can be prepared by this method.  - In industry precipitation reactions are used for removing unwanted substances or for preparing a salt.  - Precipitation reactions are also used for identification of anions.   * **TO PREPARE AN INSOLUBLE SALT BY PRECIPITATION REACTION**   + mix together a solution of a salt containing the positive ion of the salt to be prepared and   a solution containing the negative ion.   * + The precipitate can be separated by filtration; washed with water and then dried. * **SOLUBILITY RULES**  1. All nitrates are soluble in water 2. All suphates are soluble except barium, calcium and lead sulphate 3. All chlorides are soluble except lead and silver chloride 4. All carbonates are insoluble except potassium, sodium and ammonium 5. All hydroxides are insoluble except potassium, sodium and ammonium 6. All ammonium salts are soluble 7. All sodium salts are soluble 8. All potassium salts are soluble   **Exercise 19**   1. Predict if the salt formed is a precipitate or a soluble product. Write the ionic equation for each reaction.   Example: 1. Ba(NO3)2(aq) + Na2SO4 🡪 BaSO4 + 2NaNO3  Barium sulphate is INSOLUBLE so is a precipitate and the ionic equation is:  Ba2+ 2NO3- + 2Na+ SO42- 🡪 BaSO4 + 2Na+ 2NO3-    Ba+(aq) + SO42-(aq) 🡪 BaSO4(s)  2. Pb(NO3)2 + 2 KCl 🡪 PbCl2 + 2KNO3  3. ZnCl2 + Na2CO3 🡪 ZnCO3 + 2NaCl  4. FeCl3 + 3NaOH 🡪 Fe(OH)3 + 3NaCl  5. FeSO4 + 2NaOH 🡪 Fe(OH)2 + Na2SO4  6. MgCl2 + K2CO3 🡪 MgCO3 + 2KCl  **LESSON NUMBER: 53**  **STRAND: 4. MATERIALS**  **SUB-STRAND: 4.1 INORGANIC CHEMISTRY**  **LEARNING OUTCOME:**   * Confirmatory tests for ionic species. * **IDENTIFICATION TESTS FOR ANIONS**  1. Carbonate Ion (CO32-)    * add any dilute acid (HCl) to the sample of salt    * if effervescence occurs (bubbles of gas given off) and the gas turns limewater milky,   then the salt is a carbonate.  CO32-(S) + 2H+(aq) 🡪 CO2(g) + H2O(l)  CO2(g) + Ca(OH)2(aq) 🡪 CaCO3(s) + H2O(l)  Limewater milky substance   1. Chloride Ion (Cl-)    * add silver nitrate solution to the solution of this salt    * the white ppt formed should turn violet when exposed to sunlight   Ag+(aq) + Cl-(aq) 🡪 AgCl(s) (white ppt)   * + this ppt will be insoluble in all dilute mineral acids (HCl, H2SO4 and HNO3)   + to confirm : add aqueous ammonia solution, precipitate should dissolve   Ag+(aq) + 2NH3(aq) 🡪 [Ag(NH3)2]+   1. Sulphate Ion (SO42-)    * add barium chloride solution to the solution of the salt    * a white ppt forms that will be insoluble in three acids (dilute HCl, H2SO4 and HNO3)    * will not change colour when exposed to sunlight    * will not dissolve in aqueous ammonia  * **DETECTION OF METAL IONS**  1. Using sodium hydroxide:    * to a solution of the metal ion, add sodium hydroxide solution in small quantities until it is present in excess.  |  |  |  | | --- | --- | --- | | **Observation** | **Inference** | **Equation** | | 1. White ppt, insoluble in excess | Ag+ / Mg2+ ion | Ag+(aq) + OH-(aq) 🡪 Ag(OH)(s) // Mg2+(aq) + 2OH-(aq) 🡪 Mg(OH)2(s) | | 2. White ppt, soluble in excess | Al3+ ion | Al3+(aq) + 3OH-(aq) 🡪 Al(OH)3(s) 🡪🡪 Al(OH)3(s) + OH-(aq) 🡪 Al(OH)4-(aq) | | 3. green ppt, insoluble in excess | Fe2+ ion | Fe2+(aq) + 2OH-(aq) 🡪 Fe(OH)2(s) | | 4. reddish brown ppt, insoluble in excess | Fe3+ ion | Fe3+(aq) + 3OH-(aq) 🡪 Fe(OH)3(s) | | 5. blue ppt, insoluble in excess | Cu2+ ion | Cu2+(aq) + 2OH-(aq) 🡪 Cu(OH)2(s) |  1. Confirmatory test using ammonia solution    * add aqueous ammonia to the solution, in small quantities at a time until it is present in excess  |  |  |  | | --- | --- | --- | | **Observation** | **Inference** | **Equation (for solubility)** | | 1. White ppt, insoluble in excesss | Al3+ / Mg2+ ion | Al(OH)3 dissolves in excess sodium hydroxide solution while Mg(OH)2 does not. | | 2. White ppt, soluble in excess | Ag+ ion | Ag+(aq) + 2NH3(aq) 🡪 [Ag(NH3)2]+(aq) | | 3. green ppt, insoluble in excess | Fe2+ ion | - | | 4. reddish brown ppt, insoluble in excess | Fe3+ ion | - | | 5. blue ppt, soluble in excess | Cu2+ ion | Cu(OH)2(s) + 4NH3(aq) 🡪 [Cu(NH3)4]2+(aq) + 2OH-(aq)  Deep blue solution (tetramine copper (II) ion) |  1. Confirmatory test for Iron Salts    * add potassium thiocyanate solution    * Fe3+ ion 🡪 deep red solution forms (Iron (III))    * Fe2+ ion 🡪 no reaction (Iron (II))   **EXERCISE 20**  REVISION QUESTIONS   * 1. From the key list select the answered to the questions a), b) and c)   KEY LIST i) magnesium ii) Sulphur iii) argon  iv) aluminium v) chlorine   * + 1. The atom of which element has completely filled outer shells of electrons?     2. Which element will burn to form an oxide that turns moist blue litmus paper red?     3. Which element forms a stable ion with charge 2+?   1. An element M, in group 2 of the periodic table combined with an element, X, in group 7.   The formula of the halide is likely to be:  a) MX b) MX2 c) M2X d) M2X7 e) M7X2   * 1. Lithium, sodium, potassium and rubidium are alkali metals. From your knowledge of the properties of   the alkali metals select the statement about rubidium that is INCORRECT  Rubidium:   * + 1. is a good conductor     2. is a metal     3. will not react with oxygen     4. will react with water     5. will form an ionic chloride   1. From the key list select the answered to the questions a), b) and c)   KEY LIST: Na2O MgO Al2O3 SiO2 SO2   * + 1. the oxide that would dissolve in water to give the most basic solution     2. the oxide, solid at room temperature that reacts with both sodium hydroxide and   hydrochloric acid   * + 1. the oxide that exists as a gas at room temperature   1. A colourless solution was formed from a white ppt when barium chloride solution was added.   The solution was filtered and when hydrochloric acid was added to the residue no reaction took place.  The colourless solution contained:  a) Cl- ions b) NO3- ions c) SO42- ions d) CO32- ions | | |
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