**RATU NAVULA COLLEGE**

**WEEK 3 YEAR 12B : CHEMISTRY NOTES & ACTIVITIES**

**LESSON NUMBER: 44**

**STRAND: 3. REACTIONS**

**SUB-STRAND: 3.3 PHYSICAL CHEMISTRY**

**LEARNING OUTCOME:**

* industrial application of equilibrium rates of reaction
* Production of Ammonia – HABER Process

N2(g) + 3H2(g) 2NH3(g) [ΔH = -92 kJ/mol]

1 vol 3 vol 2 vol

4 moles 2 moles

In theory: to get a high yield the best conditions would be:

1. High pressure (since position of equilibrium will move to the right in order to try to decrease the pressure by increasing the rate of reaction which produces fewer molecules (or moles) or smaller volume)
2. High Concentration of reactants
3. Remove NH3 as it is formed
4. Use of low temperature (reaction is exothermic)
5. Use of catalyst

\*Note: High pressure apparatus are very expensive to buy and maintain.

Low temperature means low rate of reaction

In practice (to improve the yield)

1. A moderate pressure (250 atmospheres)
2. A moderate temperature (450-5000C)
3. High concentration of N2 and H2­
4. NH3 is removed as it is formed by liquefaction (under pressure)
5. Catalyst (surface catalyst) finely divided iron mixed with aluminium oxide and potassium oxide is used.

\*Note: N2 and H2 not used are recycled through this process over the catalyst.

Raw materials:

N2 is obtained from liquid air by fractional distillation

H2 is obtained from naptha ( a mixture of hydrocarbons containing 5-9 carbon atoms) or natural gas (CH4)

**INDUSTRIAL APPLICATION OF EQUILIBRIUM RATES OF REACTION**

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Exercise 11

1. Ammonia is manufactured by the Haber Process. The equation

N2(g) + 3H2(g)  2NH3(g)  [ΔH = -92 kJmol-1]

represents the reaction in this process.

i) is this reaction exothermic or endothermic? Give a reason.

ii) Explain why the addition of a catalyst to the reaction will not affect the equilibrium (amount of moles) of ammonia

**LESSON NUMBER: 45**

**STRAND: 3. REACTIONS**

**SUB-STRAND: 3.3 PHYSICAL CHEMISTRY**

**LEARNING OUTCOME:**

* Equilibrium Reactions In Aqueous System

Water Disassociation and Kw

H2O(l) H+(aq) + OH-(aq)

Kw = [H+][OH-] \*[] denotes concentration

10-14 = 10-7 x 10-7

Kw = 10-14

Kw is called the ionic product of water or equilibrium constant of water.

The pH value

- The pH number of the solution denotes the level of acidity of a solution.

- Acidic solution contains H+ ion and alkaline solution contains OH-

pH Scale

- Universal indicator – is a special mixture of indicators, which changes to different colours at different concentrations of H+ and OH- ions.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | increasing acidity | | | | | | | NEUTRAL | increasing alkalinity | | | | | | |
|  | ACIDS | | | | | | | ALKALIS | | | | | | |
| **pH** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** |
| COLOUR OF UNIVERSAL INDICATOR |  |  | RED |  |  | ORANGE | YELLOW | GREEN | BLUE-GREEN | BLUE | BLUE-PURPLE |  | PURPLE | |  |

\*litmus paper shows whether a solution is acidic, neutral or alkaline.

Exercise : 12

[H+] = anti log(-pH)

pH = -log[H+]

1. In an aqueous solution, the [H+] = 10-6 mol L-1, what is the pH of the solution?

2. the pH of a solution is 3, determine its [H+].

3. HCl solution has a pH of 2, determine the [H+].

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**STRAND: 3. REACTIONS**

**SUB-STRAND: 3.3 PHYSICAL CHEMISTRY**

**LEARNING OUTCOME:**

* Acids And Bases

Bronsted Lowry Theory

Acid – is any substance which donates a proton (H+)

Base – is any substance which accepts a proton (H+)

+ H+

E.g.

HCl(g) + H2O(l) 🡪 H3O+ + Cl-

- H+

ACID + BASE 🡪 CONJUGATE BASE + CONJUGATE ACID

Monoprotic Acids: these are acids that have only one ionisable hydrogen atom.

E.g. HCl, HNO3, CH3COOH

Polyprotic Acids: these contain more than one ionisable hydrogen atom. First one hydrogen atom ionizes and then the next.

E.g. H2SO4(l) + H2O(l) 🡪 H3O+(aq) + HSO4-(aq)

HSO4-(aq) + H2O(l) 🡪 H3O+(aq) + SO4-(aq)

Strengths of Acids and Bases

*Strong Acids*: ionizes completely in water to form hydrogen/hydronium ions e.g. HCl

*Weak Acids*: do not completely ionize in water to form hydrogen ions e.g. CH3COOH

*Strong Base*: a base which is completely ionized/dissociates into positive and negative ions e.g. NaOH

*Weak Base*: does not completely ionize in solution e.g. NH3

Alkalinity of Ammonia and Sodium Carbonate Solutions

NH3(g) + H2O(l) NH4+(aq) + OH-(aq)

Base acid conjugate acid conjugate base

Water acts as an acid because it donates a proton to the ammonia which is a base as it accepts a proton.

Sodium carbonate dissolves to form Na+ and CO32- ions. The Na+ is neither acidic nor basic, but the CO32- is a base because it accepts a proton:

CO32-(g) + H2O(l) HCO32-(aq) + OH-(aq)

Base acid

Sodium carbonate is therefore regarded as a base although the basic characteristics are due to the carbonate ion not the sodium ion. Na+is called **the spectator ion.**

\*Note: All alkalis are substances which have pH values greater than 7. For a base to be regarded as an alkali it must dissolve in water.

*Spectator Ion*: ions that do not undergo any change during the course of a reaction

Exercise 13:

Identify the acids, bases, conjugate base and conjugate acids in the following reactions:

* + 1. NH3 + H2O 🡪 NH4+ + OH-
    2. HCl + H­2O 🡪 H3O+ + Cl-
    3. HNO3 + H2O 🡪 H3O+ + NO3-

**LESSON NUMBER: 47**

**STRAND: 3. REACTIONS**

**SUB-STRAND: 3.3 PHYSICAL CHEMISTRY**

**LEARNING OUTCOME:**

The Characteristics of Acids and Bases

1. Dilute acids react with more reactive metals such as calcium, magnesium, iron and aluminium to form hydrogen and the corresponding salt.

Acid + Metal 🡪 Salt + H2

E.g. 2HCl(aq)+ Ca(s) 🡪 CaCl2(aq) + H2(g)

IONIC EQUATION:

2H+~~2Cl~~~~-~~ + Ca 🡪 Ca2+~~2Cl~~~~-~~ + H2

2H+ + Ca 🡪 Ca2+ + H2

1. Reaction with carbonates

Acids (dilute) react readily with carbonates to give off carbon dioxide which turns limewater milky. [EXOTHERMIC REACTION]

Acid + Carbonate 🡪 Salt + CO2 + H2O

E.g. 2HCl(aq) + CaCO3(aq) 🡪 CaCl2(aq) + CO2(g) + H2O(l)

2H+~~2Cl~~~~-~~ + ~~Ca~~~~2+~~CO32- 🡪 ~~Ca~~~~2+~~~~2Cl~~~~-~~ + CO2 + H2O

IONIC EQUATION:

2H+ + CO32- 🡪 H2O + CO2

Exercise 14:

Complete the following equation and work out the net ionic equation:

1. HNO3(aq) + MgCO3(s) 🡪
2. H2SO4(aq) + Na2CO3(s) 🡪
3. Indicators and Acids & Bases

|  |  |  |
| --- | --- | --- |
| **Solution** | **Colour of Litmus** | **Colour of Phenolphthalein** |
| Acid Solution | Red | Colourless |
| Alkali Solution | Blue | Red |

1. Complete the following equation and write/work out the net ionic equation:
   1. Mg(s) + H2SO4(aq) 🡪
   2. Fe(s) + 2HCl(aq) 🡪
   3. Al(s) + HCl(aq) 🡪
2. The pH of a sodium hydroxide solution is 12. What will be the concentration of the hydroxide ion?
3. Hydroiodic acid, HI, is a very strong acid. The pH in a 0.001 mol/L aqueous solution of HI would be?
   1. Explain the meaning of the term weak acid
   2. Ethanoic acid (CH3COOH) is an example of a weak acid.
      1. Write a balanced equation for the reaction between ethanoic acid and water
      2. Use the equation to explain why this is called a proton transfer equation
4. 1. What is meant by the term a strong acid? Give an example
   2. 1. The ammonium ion is a weak acid. Show what this means by writing the balanced equation for the reaction between ammonium ions and water.
      2. Use the equation to explain why the ammonium ions in this reaction act as an acid.

**LESSON NUMBER: 48**

**STRAND: 4. MATERIALS**

**SUB-STRAND: 4.1 INORGANIC CHEMISTRY**

**LEARNING OUTCOME:**

* **OXIDES OF SELECTED ELEMENTS**

- *Acidic Oxide*: oxides of non-metals that react with water to form acids.

- *Basic Oxide*: oxides of metals that react with water and form hydroxides (bases) – alkaline solution

- *Amphoteric Oxide*: oxides that show both acidic and basic properties eg. Al2O3, PbO

Properties of the Oxides:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Oxide** | **State** | **Melting Point** | **Intramolecular Bonding** | **Structure** | **Electrical Conductivity** | |
| *Solid State* | *Molten State* |
| Na2O | Solid | Very High | Ionic | Ionic | Poor | Good |
| MgO | Solid | Very High | Ionic | Ionic | Poor | Good |
| Al2O3 | Solid | Very High | Ionic | Ionic | Poor | Good |
| SiO2 | Solid | High | Covalent | Macromolecular | Poor | Poor |
| SO3 | Gas | Low | covalent | Simple molecular | Poor | Poor |

Hydrolysis of the Oxides:

|  |  |  |
| --- | --- | --- |
| **Oxide** | **Effect of Adding Water to Oxide** | **pH** |
| Na2O | Na2O + H2O 🡪 2NaOH (forms sodium hydroxide)  2Na+O2-(s) + H2O(l) 🡪 2Na+(aq) + 2OH-(aq) | Basic (alkaline) |
| MgO | MgO + H2O 🡪 Mg(OH)2 (forms magnesium hydroxide)  Mg2+O2-(s) + H2O(l) 🡪 Mg2+(aq) + 2OH-(aq) | Basic (weakly alkaline) |
| Al2O3 | Does not react with water | Amphoteric |
| SiO2 | Does not react with water | Acidic |
| SO2 | SO2(g) + H2O(l) 🡪 H2SO3(aq) (forms sulphurous acid) | Acidic |
| SO3 | SO3(g) + H2O(l) 🡪 H2SO4(aq) (forms sulphuric acid) | acidic |

Al2O3 does not react with water but reacts with acids and alkalis:

With acid: Al2O3(s) + 6H+(aq) 🡪 2Al3+(aq) + 3H2O(l)

3H2SO4 Al2(SO4)3

With alkali: Al2O3(s) + 2OH-(aq) + 3H2O(l) 🡪 2Al(OH)-4(aq)

2NaOH 2NaAlO2 + H2O (aluminate)

SiO2 has a giant molecular structure with strong covalent bonds therefore does not react with water but reacts with concentrated alkali to form the silicate ion:

SiO2(s) + 2(OH)-(aq) 🡪 SiO32-(aq) + H2O(l)

2NaOH Na2SiO3

Exercise 15

* 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
    3. the oxide that exists as a gas at room temperature