**Experiment 1 – Chemical Reactions**

1.What are the purposes of today's lab work?

• To perform different types of chemical reactions, including acid-base, precipitation, gas forming, complex compound forming and oxidation-reduction reactions.  
• To identify the products in these reactions and describe the chemical changes.  
• To write and balance the chemical equations for the reactions observed.

2. What is a chemical reaction?

When a chemical reaction occurs, substances called **reactants** are transformed into different substances called **products** that often have different appearances and different properties

3. Please give examples of different types of chemical reactions?

Types of reactions: synthesis, decomposition, single displacement, double displacement, and combustion.

4. What are observable signs when chemical reactions occur?

Observable signs of chemical reactions can be a change in **color**, the formation of a **solid** (precipitation), the release of **gas**, and the production of **heat** and **light**.

5. What is a synthesis reaction? Give an example

A synthesis reaction occurs when **two or more reactants** combine to form a **single** product.

C + O2 🡪 CO2

6. What is a decomposition reaction? Give an example

A decomposition reaction can be defined as a chemical reaction in which **one reactant** breaks down into **two or more products**.

NaCl 🡪 Na + Cl

CaCO3 🡪 CaO + CO2

7. What is a single displacement reaction? Give an example

A single replacement reaction, sometimes called a single displacement reaction, is a reaction in which **one element** is substituted for **another element** in a compound.

Fe + 2HCl 🡪 FeCl2 + H2

8. What is a double displacement reaction? Give an example

A double displacement reaction is a type of reaction where part of **one reactant** is replaced by **part of another reactant**.

AgNO3 + NaCl 🡪 AgCl + NaNO3

9. What is a combustion reaction? Give an example

A combustion reaction is a type of chemical reaction in which a compound and an oxidant is reacted to produce heat and a new product.

C2H5OH + 3 O2 → 2 CO2 + 3 H2O

10. Please name all of the experiments that you will do in today's lab work?

**Reactions of Cu2+**

**Reactions of Silver halides**

**Section 1: Reactions of Potassium Chloride (KCl)**

**Section 2: Reactions of Potassium Bromide (KBr)**

**Reactions of H2O2**

**Reactions of KMnO4**

**Reactions of Fe2+ and Fe3+**

**Section 1: Ferric ion (Fe3+)**

**Section 2: Ferrous ion (Fe2+)**

**Reactions of Al3+**

**Flame tests**

11. What are molarity and normality?

* Molarity measures the number of **moles** of a solute in 1 litre solution
* Normality measures the number of **grams** of a solute in 1 litre solution

Diagram

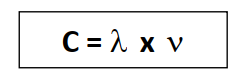
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Diagram

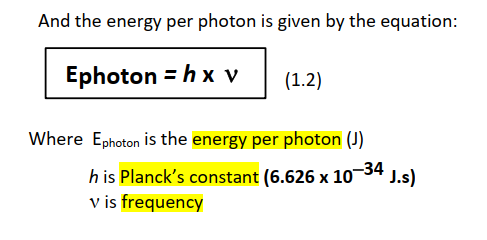
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12. What is the equation that shows the relationship between wavelength, frequency, and speed of an electromagnetic wave?



C is the speed of light **(3 x 108 m/s)**

is the wavelength (nm)

V is frequency



**Experiment 2: pH and Buffers**

1. What is the dissociation process? Write down the dissociation constant for CH3COOH + H2O ⇌ CH3COO- + H3O+?

dissociation, in chemistry, the **breaking up of a compound** into **simpler constituents**(part) that are usually capable of **recombining under other conditions**.

Dissociation is the process by which **chemical molecules** break down into simpler constituent.

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2. What are the concentrations of hydronium ions ([H3O+]) and hydroxyl ions ([OH-]) of pure water?

The **concentration** of a solute in a solution is the ratio of the solute to the solvent or total solution. Concentration is often represented as. However, solute concentration can also be represented in **moles** or volume units.

**Solution:**

The dissociation of the hydronium ion in pure water at 298 K is as follows below:

**H₃O⁺  ⇔  OH⁻ + H₂**

We know that pOH + pH = 14

So,  [OH⁻] + [H⁺] = 10⁻¹⁴

10⁻⁷ + 10⁻⁷ = 10⁻¹⁴

Thus, [H₃O⁺] = [OH⁻] = 10⁻⁷ g ion/liter

**Hence, the concentration of H₃O⁺ (hydronium ion) and OH⁻ (hydroxide ion) in pure water at 298 K is 10⁻⁷ g ion/liter.**

3. What is the product of the concentration of hydronium ions ([H3O+]) and hydroxyl ions ([OH-]) in any aqueous solution?

In an aqueous solution, the H+ from an **acid** is associated with **water** to form H3O+ (a hydronium ion), while a **base** accepts a proton from **water** to form OH– (a hydroxide  
ion).

4. What is pH? How do we define/calculate the pH value of a solution?

pH is a measure of how acidic/basic water is.

- Calculate the pH value of a solution:

The pH scale is a compact way to specify the acidity of a solution: pH = - log[H3O+]

- Define the pH value of a solution:

• Acidic solution: pH < 7 or [H3O+] > [OH-]

• Basic solution: pH > 7 or [H3O+] < [OH-]

• Neutral solution: pH = 7 or [H3O+] = [OH-]

5. If [H3O+] = 0.001 M. What is the pH value?

pH = - log[H3O+] = 3

6. What equipment can you use to measure the pH of prepared solutions?

pH meter

7. Please give the definitions of an acid and a base according to Arrhenius classification?

According to the Arrhenius theory, an acid is a substance that dissociates in water to form **hydronium** ion (H3O+), and a base is a substance that dissociates in water to form **hydroxide** (OH–) ions.

8. What is the conjugate base of CH3COOH?

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9. What is a buffer? What is its main characteristic?

A buffer is a solution of a **weak** acid or **weak** base and its conjugate **weak** base or **weak** acid, respectively.

Buffers have the function that resists a large change in pH on the addition of H+ or OH-. This is because the **weak** base, A-, will react with added H+ and the weak acid, HA, will react with added OH-. Changes in pH of buffer solutions can be determined using the **Henderson-Hasselbach** equation

10. Calculate the initial concentration of each substance when mixing 40.0 mL of 0.1 M CH3COOH and 10.0mL of 0.1 M CH3COONa?

To calculate the initial concentration of each substance, we need to use the equation for calculating the concentration of a solution, which is:

C1V1 = C2V2

Where C1 is the initial concentration,

V1 is the initial volume,

C2 is the final concentration, and

V2 is the final volume.

In this case, we can use the equation to calculate the initial concentration of CH3COOH and CH3COONa when they are mixed together.

We can assume that the volumes are additive, so the final volume is 50.0 mL (40.0 mL + 10.0 mL).

For CH3COOH: C1 × V1 = C2 × V2 C1 × 40.0 mL = (0.1 M) × 50.0 mL C1 = (0.1 M × 50.0 mL) / 40.0 mL C1 = 0.125 M Therefore, the initial concentration of CH3COOH is 0.125 M.

For CH3COONa: C1 × V1 = C2 × V2 C1 × 10.0 mL = (0.1 M) × 50.0 mL C1 = (0.1 M × 50.0 mL) / 10.0 mL C1 = 0.5 M Therefore, the initial concentration of CH3COONa is 0.5 M

11. If the original pH of buffer A is 4, if we add enough HCl to change pH by one unit, what is the final pH value?

Text

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Diagram

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4 = pKa + log() 🡪 pKa = 4 - log()

12. If the original pH of buffer A is 4, if we add enough NaOH to change pH by one unit, what is the final pH value?x

Diagram

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**Experiment 3: Redox Titration with KMnO4**

1. What are the objectives of today's lab work?

• Learn about the term of **gram equivalent weight**  
• Review of **oxidation-reduction reactions**• **Standardize** the concentration of KMnO4 solution and **determine the oxalic acid normality**

2. What is a redox reaction (oxidation-reduction reaction)?

An oxidation-reduction (redox) reaction is a type of chemical reaction that involves a **transfer of electrons between two species.** therefore, the oxidation states of atoms are changed.

3. In a redox reaction, what are the oxidizing agent and reducing agent?

The substance that **gains** electrons is said to be reduced; therefore, it is called the **oxidizing** agent.

The substance that **loses** electrons is said to be oxidized; thus, it is called  
the **reducing** agent.

Diagram

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The redox reaction involves two (02) **half-reactions**. **Oxidation** is the half-reaction in which there is a **loss** of electrons by a species (or an increase of the oxidation number of an atom). **Reduction** is the half-reaction in which there is a **gain** of electrons by a species (or a decrease in the oxidation number of an atom).

4. Balance the reaction between potassium permanganate (KMnO4) with oxalic acid (H2C2O4) in the  
presence of excess sulfuric acid (H2SO4)? Show your work

Diagram

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5. Please define **the gram equivalent weight (GEW)** of **oxidizing agent** and **gram equivalent weight of the reducing agent**

The equivalent weight (EW) of an **oxidizing or reducing agent** for a particular reaction is **equal to its formula weight divided by the total number of electrons gained or lost when the reaction occurs** (i.e. by the total change in valence). While, gram equivalent weight is the measure of the reactive capacity of a molecule. The solute's role in the reaction determines the solution's normality.

6. What is normality? How do you calculate the normality of a solution?

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7. What is the normality of an 1-M H2SO4 solution?

N = M x n = 1 x 2 = 2 N  
8. What is the normality of an 1-M HCl solution?

N = M x n = 1 x 1 = 1   
9. What is the titration technique? What is its principle?

**Titration** is a quantitative chemical analysis. It is used to determine an unknown concentration of a known substance in a sample

**A titration is a technique** where a solution of known concentration is used to determine the concentration of an unknown solution

**The principle of titration** is based on the concept of stoichiometry, which states that the amount of a substance involved in a chemical reaction is determined by the number of moles of the reactants in the balanced chemical equation. By measuring the amount of the standard solution needed to react with the unknown solution, the concentration of the unknown solution can be calculated.

10. Please watch the following video clip and list out all the steps of titration using a burette:  
<http://www.youtube.com/watch?v=9DkB82xLvNE>

Step 1: Prepare the burret and solutions

Step 2: Bring the burette down below eyes level

Step 3: Clean by rinsing water 3 times

Step 4: Noticing the bubbles will cause significant errors back to step 3

Step 5: Fill the burette

Step 6: Add indicator

Step 7: Titrate and record results

Step 8: Repeat

**Experiment 4: Chemical Equilibrium**

1. What are the objectives of today's lab work?

• To observe the effect of **applying stresses** on chemical systems at **equilibrium**  
• To apply **Le Chatelier’s Principle** to explain the changes in the system

2. What is **chemical equilibrium** in a **reversible chemical** reaction? And when the equilibrium state of a chemical reaction can be obtained?

**A reversible reaction** is a **chemical reaction** where the **reactants form products that, in turn**, react together to give the reactants back.

Reversible reactions will reach an equilibrium point where **the concentrations of the reactants and products will no longer change**.

A reversible reaction is denoted by a **double arrow pointing in both directions** in a chemical equation.

3. Please define dynamic equilibrium and static equilibrium

Difference between Static and Dynamic Equilibrium

The fundamental variations between dynamic and static equilibrium are given below.

* In most cases, static equilibrium is irreversible. Dynamic equilibrium is reversible in nature.
* There is no further chemical reaction in the system that is in static equilibrium. Dynamic equilibrium means that the products and reactants are still involved in physical reactions.
* In static equilibrium, the backward and forward reaction rates are null. In dynamic equilibrium, the backward and forward reaction rates are most probably equal.
* Static equilibrium can exist in both closed and open systems. Dynamic equilibrium can only exist in closed bodies or systems.

Dynamic Equilibrium can be defined as the state of a given system in which the **reversible reaction** taking place in it stops changing the ratio of reactants and products, but there is a **movement of substances** between the **reactants and the products**. This movement occurs at an equal rate and there is no net change of the reactant and product ratio.

static equilibrium, also known as mechanical equilibrium, refers to a state where a **reaction has stopped** and there is **no movement** between the **reactants and products**. In other words, the system is at rest, and the forward and reverse reaction rates are both

4. Please describe **factors** that can disturb a **reversible reaction** at its equilibrium state?

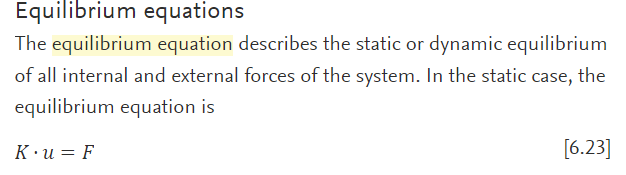
A reversible reaction at equilibrium can be disturbed if **stresses** are applied to it. Stresses can be changes in **concentration**, **temperature,** or **pressure**. The composition of the reaction mixture will shift until equilibrium has been reestablished.

5. What is Le Chatelier's Principle about?

A reversible reaction at equilibrium can be disturbed if **stresses** are applied to it. Stresses can be changes in **concentration**, **temperature,** or **pressure**. The composition of the reaction mixture will shift until equilibrium has been reestablished. This is known as **Le Chatelier’s principle**

* **how a system at equilibrium responds to changes in temperature, pressure, or concentration of reactants or products.**

6. Please write the Equilibrium equation K x u = F



7. Please fill out the following table

|  |  |  |
| --- | --- | --- |
| **K Value** | **Reaction favors (reactants / products)** | **Reaction lies to (left / center / right)** |
| K << 1 |  |  |
| K ~ 1 |  |  |
| K >> 1 |  |  |

8. Please predict the outcome of today lab work and fill out the following table

|  |  |  |  |
| --- | --- | --- | --- |
| **System No.** | **System name** | **Description of conditions** | **Predicted outcome** |
| **1** |  |  |  |