

**Analytical Chemistry**

**CHEM234**

**Sec 1**

**Exp2: Title**

**Standardization of HCl solution and determination of sodium carbonate**

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**The submission: 26\7\2021**

**Abstract:**

The major objective of this experiment are to standardize the HCl solution using standard sodium carbonate, and then utilize the previously standardized HCl solution to determine out how much carbonate is in an unknown sample. The hydrochloric acid solution to sodium hydroxide that was previously standardized by using methyl red is used as the indicator, and the ~0.1 M hydrochloric acid solution standardized (titrated) with sodium carbonate (Na2CO3). Methyl red is used as an indicator to monitor reaction progress by changing the color from yellow to peach at the end point. Strong hydrochloric acid reacts with base Na2CO3 in the following way: **In our experience, the most common reaction was:**

**2HCl(aq) + Na2CO3(aq) 🡪 NaCl(aq) + H2O(l) + CO2(g)**

The molarity of HCL solution is 0.1143 ± 0.01775 mol/L, and the % CO3 2-  in the unknown sample is (28.20 ± 0.06196) %, according to the 95% confidence interval.

* **Data table\_1: Standardization of HCl solution with primary-standard sodium carbonate (Na2 CO3)**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Trial 1** | **Trial 2** | **Trial 3** |
| **Mass of Na2Co3 (g)** | 0.2 g | 0.2 g | 0.2 g |
| **Initial buret reading (mL)** | 0.00 ml | 0.00 ml | 0.00 ml |
| **Final buret reading (mL)** | 30.10 ml | 35.80 ml | 33.60 ml |
| **Volume of HCl used (mL)** | 30.10 ml | 35.8 ml | 33.60 ml |
| **Volume of HCl used (L)** | 0.0301 L | 0.0358 L | 0.0336 L |
| **Moles of Na2Co3** | 1.8870 \*10-3 mol | 1.8870 \*10-3 mol | 1.8870 \*10-3 mol  |
| **Moles of HCl** | 3.7740 \*10-3 mol | 3.7740 \*10-3 mol | 3.7740 \*10-3 mol |
| **Molarity of HCl** | 0.1253 M | 0.1054 M | 0.1123 M |
| **Average Molarity of HCl** | 0. 1143 M |
| **Standard deviation in the HCl molarity** | 7.1451 \* 10-3 |
| **95 % confidence interval** | 0.1143 ± 0.01775 |

* **Calculations: Trial\_1 /table\_1 (KNOWN):**
1. **Volume of HCl
 =** final buret reading (ml) – initial buret reading (ml)= 30.10ml – 0 mL = 30.10 mL
2. **Volume of HCL used (L) = 30.10** /1000= 0.0301 L
3. **Moles of Na2Co3
= mass of sodium carbonate/ molar mass of Na2Co3
= 0.2 g / 106.00
= 1.8870 \* 10-3 moles**
4. **Moles of HCL**

**= Moles of Na2CO3 \* 2**

**= 1.8870 \*10-3 \* 2
 = 3.7735 \* 10-3 mol**

1. **Molarity of HCL
=**  moles of solute / volume of HCL =  **3.7735 \* 10-3**/ 0.0301 L = 0.1253 M
2. **Average Molarity of HCL
=** (molarity of trial 1) +(molarity of trial 2) + (molarity of trial 3)/3
= ((0.1253 + 0.1054 + 0.1123) / (3)) = 0.1143 M
3. **Standard deviation in the HCL Molarity**
(s) =$\frac{\sqrt{\sum\_{}^{}(xi-x(mean))2}}{n-1}$

$ =\frac{\sqrt{\left(0.1253-0.1143\right)^{2}}+\left(0.1054-0.1143\right)^{2}+\left(0.1123-0.1143\right)^{2}}{3-1}=$

$$7.1451\*10^{-3}$$

**8. Q test & Q table:**

* **Q testfor trial 3**

= |suspension value – nearest neighbor value| / range
= | 0.1253 – 0.1143| / (0.1253 - 0.1054)

= 0.6532
- The susp value isn’t outlier because the Q table > Q test
- **The Q table** confidence level of 95% & n = 3 = **0.97**0

**9. 95 % confidence interval(**$ μ)=x\frac{\pm ts}{\sqrt{n}}$
= 0.1143 ± ((4.303 \* 7.1451 \* 10-3 ) / $\sqrt{3}$
= 0.1143 ± 0.01775

* **Data table\_2: determination total CO3-2 an unknown sample.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Unknown letter: 45** | **Trial 1** | **Trial 2** | **Trial 3** |
| **Mass of unknown (g)** | 0.2514 g | 0.2648 g | 0.2613 g |
| **Initial buret reading (mL)** | 0.00 ml | 0.00 ml | 0.00 ml |
| **Final buret reading (mL)** | 20.60 ml | 22.30 ml | 21.10 ml |
| **Volume of HCl used (mL)** | 20.60 ml | 22.30 ml | 21.10 ml |
| **Volume of HCl used (L)** | 0.0206 L | 0.0223 L | 0.0211 L |
| **Molarity of HCl (M)** | 0.1143 M | 0.1143 M | 0.1143 M |
| **Moles of HCl** | 2.3545 \*10-3 mol | 2.5489 \*10-3 mol | 2.4117 \*10-3 mol |
| **Moles of Na2CO3** | 1.1773 \*10-3 mol | 1.2744 \*10-3 mol | 1.2058 \*10-3 mol |
| **Moles of CO3 2-** | 1.1773 \*10-3 mol | 1.2744 \*10-3 mol | 1.2058 \*10-3 mol |
| **Mass of CO3 2- (g)** | 0.07065 g | 0.07648 g | 0.07236 |
| **% mass of CO3 2- in unknown** | 28.10 % | 28.88 % | 27.69 % |
| **Average % mass of CO3 2- in unknown** | 28.20 % |
| **Standard deviation in the % mass of CO3 2-** | 0.4274 % |
| **95 % confidence interval** | 28.20 ± 0.06196% |

* **Calculations: Trial\_1 /table\_2 (UNKNOWN):**
1. **Volume of HCl
 =** final buret reading (ml) – initial buret reading (ml)= 20.60 ml – 0 mL = 20.60 mL
2. **Volume of HCL used (L) = 20.60** /1000= 0.0306 L
3. **Average Molarity of HCL
=** (molarity of trial 1) +(molarity of trial 2) + (molarity of trial 3)/3
= ((0.1253 + 0.1054 + 0.1123) / (3)) = 0.1143 M
4. **Moles of HCL = Molarity of HCL \* Volume of HCL used**

**=** 0.1143 \* 0.0206

= 2.35458 \* 10-3 mol

1. **Moles of Na2CO3
= Moles of HCL/ 2
=** 2.3545 \* 10-3/2 = 1.1773 \* 10-3 mol
2. **Moles of Co3-2 = moles of Na2Co3 = 1.1773 \* 10-3 mol**
3. **Mass of CO3-2
= number of moles of Co3-2 \* molar mass of Co3-2**= 1.1773 \* 10-3 mol \* 60.01 = 0.07065 g
4. **% mass of CO3-2 in unknown
= ((mass of CO3-2/ mass of unknown)\* (100))**
= ((0.07065 / 0.2514) \* (100))
= 28.10 %
5. **Average % mass of CO3-2 in unknown**= **m1 + m2 + m3 / 3**
= ((28.10 + 28.88 + 27.69) / (3))

= 28.22 %

1. **Standard deviation in the % mass of CO3-2**(s) =$\frac{\sqrt{\sum\_{}^{}(xi-x(mean))2}}{n-1}$

$ =\frac{\sqrt{\left(28.10-28.22 \right)^{2}}+\left(28.88-28.22\right)^{2}+\left(27.69-28.22\right)^{2}}{3-1}=$

$$0.4274 $$

1. **Q test & Q table:**

**Q testfor trial 3**
= |suspension value – nearest neighbor value| / range
= | 28.88 – 28.10| / ( 28.88 – 27.69) = 0.6554
- The susp value isn’t outlier because the Q table > Q test
- **The Q table** confidence level of 95% & n = 3 = **0.97**0

1. **95 % confidence interval(**$ μ)=x\frac{\pm ts}{\sqrt{n}}$
= 28.20 ± ((4.303 \* 0.4274 ) / $\sqrt{3}$
= 28.20 ± 0.06196
* **Discussion & Conclusion:**

In the table\_1 the average molarity of HCL of 3 trial = 0.1143 M, and the Standard deviation in the HCL molarity = 7.1451 \* 10-3

In table\_2 shows that no rejected samples were produced using the 95 percent Q-Test that we used on our results in table\_2 of evaluating the unknown sample. As a result, the mean of the three trials' percentages of CO3-2 is ((28.10 + 28.88 + 27.69) / (3)) = 28.20 percent, with a standard deviation in the % mass of 0.4274 percent.

The Q test shows whether the values are far from each other or close \* and if the value is more than 0.970 (Q table), this means that the value is outlier and should not be taken and if the value is less than 0.970 we take the value because it is true. however, my result was 0.6532 in the known value while unknown my value was 0.6554. The both values are less than 0.970, so they are both true.

The indicator Methyl red was used, which when the solution reaches the endpoint of titration, the color of the solution in the flask becomes peach.

The final result of 95% confidence interval for unknown = 28.20 ± 0.06196%

The final result of 95% confidence interval for known = 0.1143 ± 0.01775, the average 0.13205 to 0.09655.

There are many methodological errors that exist, and one of these common errors is that when the solution is poured into buret in the presence of a glass funnel, it isn’t removed during titration after the required solution has been poured causing an increase in the error rate, because it may be contaminated or otherwise, and it is possible that The buret is contaminated and reading through the buret may be inaccurate. One common error is bubbles in the buret. Finally, these errors should be avoided by paying attention that when filling the burette with the solution, we remove the glass funnel in order to take the reading correctly and that we wash the buret properly.