

analysis

May 13, 2023

1 Modules

```
[ ]: import pandas as pd
```

2 Data

```
[ ]: calorimeter = pd.read_csv("calorimeter.txt")
neutralization = pd.read_csv("neutralization-reaction.txt")
solution = pd.read_csv("solution.txt")
m_water_cold = 20 #g
m_water_hot = 10 #g
c_water = 4.18/1000 # kJ/gC
m_NaOH = 20 #g
m_HCl = 20 #g
mols_U = 1 / 60
mols_HCl = 20 * (10**-3)
m_water_solution = 40 #g
```

```
[ ]: calorimeter
```

```
[ ]:      Tc(C)  Th(C)  deltaT(C)
0    16.1    45.5         7.4
1    18.5    50.0         7.8
```

```
[ ]: neutralization
```

```
[ ]:      Ti(C)  Tf(C)  deltaT(C)
0    17.2    22.8         5.9
1    16.9    23.1         6.2
```

```
[ ]: solution
```

```
[ ]:      Ti(C)  Tf(C)  deltaT(C)
0    17.2    16.5        -0.7
1    17.5    17.0        -0.5
```

3 Calorimeter

The heat capacity of the water is $4.182 \frac{J}{g \cdot ^\circ C}$

$$C_{calorimeter} = -\frac{c_{water}}{\Delta T_{water\ cold}}(m_{water\ hot}\Delta T_{water\ hot} + m_{watercold}\Delta T_{water\ cold})$$

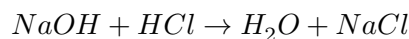
```
[ ]: delta_water_cold = calorimeter["deltaT(C)"]
delta_water_hot = calorimeter["Tc(C)"] + delta_water_cold - calorimeter["Th(C)"]

c_calorimeter = -( c_water / delta_water_cold )*(
    ↪ m_water_hot*delta_water_hot + m_water_cold*delta_water_cold )
mean_c_calorimeter = c_calorimeter.mean().round(2) #kJ
std_c_calorimeter = round( c_calorimeter.std(),3 ) #kJ

"C calorimeter = "+str(mean_c_calorimeter)+" +- "+str(std_c_calorimeter)+" KJ/
↪ °C"
```

```
[ ]: 'C calorimeter = 0.04 +- 0.002 KJ/°C'
```

4 Heat of reaction of neutralization



$$E = -\Delta T(c_{calorimeter} + m_{solution}c_{water})$$

In standard conditions (1 bar of pressure and 298K) the enthalpy of neutralization is $60 kJ/mol HCl$, however, in the laboratory these conditions are not met, since Bogota has a pressure lower than atmospheric pressure and a temperature lower than 298K.

```
[ ]: enthalpy = -neutralization["deltaT(C)"] * (c_calorimeter + (m_HCl+m_NaOH)*
    ↪ c_water)
mean_enthalpy = round( enthalpy.mean() , 1 )
std_enthalpy = round( enthalpy.std() ,2 )

mol_enthalpy = mean_enthalpy / mols_HCl
std_mol_enthalpy = std_enthalpy / mols_HCl

"enthalpy reaction " + str(mean_enthalpy) + " +- " + str(std_enthalpy) + " kJ, ↪
↪ " + "enthalpy reaction per mol HCl " + str(mol_enthalpy) + " +- " +
↪ str(std_mol_enthalpy) + " kJ/mol HCl "
```

```
[ ]: 'enthalpy reaction -1.3 +- 0.06 kJ,   enthalpy reaction per mol HCl -65.0 +- 3.0
kJ/mol HCl '
```

5 Enthalpy of solution of CON_2H_4

```
[ ]: enthalpy = -solution["deltaT(C)"] * (c_calorimeter + m_water_solution * c_water)
mean_enthalpy = round( enthalpy.mean(),2)
std_enthalpy = round( enthalpy.std() ,2)

mol_enthalpy = round( mean_enthalpy / mols_U)
std_mol_enthalpy = round(std_enthalpy / mols_U)

"enthalpy solution " + str(mean_enthalpy) + " +- " + str(std_enthalpy) + " kJ, ␣
↪ " + "enthalpy solution per mol of Urea " + str(mol_enthalpy) + " +- " +␣
↪str(std_mol_enthalpy) + " kJ/mol Urea "
```

```
[ ]: 'enthalpy solution 0.13 +- 0.03 kJ,    enthalpy solution per mol of Urea 8 +- 2
kJ/mol Urea '
```