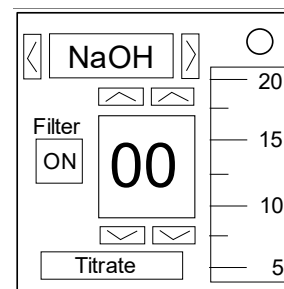


## On the Subject of Neutralization

*The rules are simple: neutralize or be neutralized.*

- The module is disarmed by successfully neutralizing an acid contained in a tube by titrating it with a chemical base.
- In order to solve the module, the type of base, amount of base, and filter state must all be correct.
- Once the appropriate conditions are set, press “Titrate” to confirm the solution.
- An incorrect input yields a strike. The correct answer remains unchanged.
- Useful info may be found in **Appendix NT27: Chemical Information**.



## Determining Titrants

The acid type can be determined using the following chart:

| <u>Solution Color</u> | <u>Acid Type</u>  |
|-----------------------|-------------------|
| Red                   | Hydrogen bromide  |
| Yellow                | Hydrogen fluoride |
| Green                 | Hydrogen chloride |
| Blue                  | Hydrogen iodide   |

The base that must be used to titrate can be determined via the following ruleset:

- If the bomb has an NSA indicator and exactly 3 batteries, add ammonia.
- Otherwise, if the bomb has a lit CAR, FRQ, or IND indicator, add potassium hydroxide.
- Otherwise, if the bomb has no ports and the serial number has a vowel, add lithium hydroxide.
- Otherwise, if the acid's chemical formula has a letter in common with an indicator present on the bomb, add potassium hydroxide.
- Otherwise, if the number of D batteries is greater than the number of AA batteries, add ammonia.
- Otherwise, if the anion's atomic number is less than 20, add sodium hydroxide.
- Otherwise, add lithium hydroxide.

### Determining Concentrations

The concentration of the acid can be determined via the following process:

- Start with the atomic number of the anion of the acid.
- Subtract the atomic number of the cation of the base.
- If the anion or cation has a vowel in the chemical symbol, subtract 4.
- If the anion and cation's chemical symbols have the same number of characters, multiply by 3.
- Take the least significant digit of the result (removing negative signs).
- If the number is 0, the number becomes the volume of acid doubled then divided by 5.
- Divide by 10. This is the concentration of the acid.

The concentration of the base can be determined via the following ruleset:

- If there are more battery holders than port types or indicators, the concentration is 5.
- If there are more port types than battery holders or indicators, the concentration is 10.
- If there are more indicators than battery holders or port types, the concentration is 20.
- If there are any ties for the most, the concentration is either 5, 10, and 20, whichever is closest to the cation's atomic number.
- However, if the titration combination is HI and KOH or HCl and NH<sub>3</sub>, the concentration is always 20.

### Determining Drop Count

- Start with 20 and divide by the concentration of the base.
- Multiply by the volume of acid and concentration of the acid.
- The result is the number of drops required to successfully titrate.

### Determining Solubility

- If the module's acid/base combination on the following chart has "NS" for "Not Soluble", the filter must be turned ON before the base is added.
- Otherwise, the filter must be turned OFF.

|            | <u>NH<sub>3</sub></u> | <u>KOH</u> | <u>LiOH</u> | <u>NaOH</u> |
|------------|-----------------------|------------|-------------|-------------|
| <u>HBr</u> | S                     | NS         | NS          | S           |
| <u>HF</u>  | NS                    | S          | NS          | S           |
| <u>HCl</u> | NS                    | NS         | S           | NS          |
| <u>HI</u>  | S                     | S          | S           | NS          |

## **APPENDIX NT27: Chemical Information**

### **NT27.1: Bases**

| <b><u>Name</u></b>  | <b><u>Chemical<br/>Formula</u></b> | <b><u>Cation</u></b> | <b><u>Chemical<br/>Symbol</u></b> | <b><u>Atomic<br/>Number</u></b> |
|---------------------|------------------------------------|----------------------|-----------------------------------|---------------------------------|
| Ammonia             | NH <sub>3</sub>                    | Hydrogen             | H                                 | 1                               |
| Lithium hydroxide   | LiOH                               | Lithium              | Li                                | 3                               |
| Sodium hydroxide    | NaOH                               | Sodium               | Na                                | 11                              |
| Potassium hydroxide | KOH                                | Potassium            | K                                 | 19                              |

### **NT27.2: Acids**

| <b><u>Name</u></b> | <b><u>Chemical<br/>Formula</u></b> | <b><u>Anion</u></b> | <b><u>Chemical<br/>Symbol</u></b> | <b><u>Atomic<br/>Number</u></b> |
|--------------------|------------------------------------|---------------------|-----------------------------------|---------------------------------|
| Hydrofluoric acid  | HF                                 | Fluorine            | F                                 | 9                               |
| Hydrochloric acid  | HCl                                | Chlorine            | Cl                                | 17                              |
| Hydrobromic acid   | HBr                                | Bromine             | Br                                | 35                              |
| Hydroiodic acid    | HI                                 | Iodine              | I                                 | 53                              |