Standard solutions

When carrying out any quantitative work in chemistry, it is important to know the concentration of any solutions you use. Too great a concentration and some reactions will become dangerous, too low a concentration and some reactions will not work.

For most practical work, it is possible to get by making reasonably accurate solutions in the normal way. For instance weighing out the appropriate number of moles of solid and diluting to the required volume - or diluting a solution of concentrated acid. For analytical work, however (and this does crop up at Advanced Higher level), you sometimes need to know concentrations more accurately. This is achieved through a process called standardisation.

A number of chemicals can be used as primary standards meaning they can be used as references or yardsticks thereby allowing you to benchmark other reagents that will react with them.

Features of a primary standard include:

- **High purity** - if your compound is not pure, it is no use as a standard because you can never know its exact concentration.
- **Stability (low reactivity)** - if your compound is not stable, then you will only be able to use it as a reference if it is freshly obtained and even then you may not be entirely sure.
- **Low hygroscopicity and efflorescence** - similar to above. If your compound is absorbing or losing water, you cannot know its molecular mass accurately.
- **High solubility** - you need to be able to make a reasonably concentrated solution.
- **High molecular mass** - the higher the molecular mass, the more you weigh out to make a solution and so any error is proportionally less.
- Ideally, but not essentially, it should be of **low toxicity**, be readily available (and not too expensive) and not be too hazardous for the environment.

Some Common Primary Standards

Here are a few common chemicals that are suitable for use as primary standards:

- Sodium carbonate
- Potassium bromate
- Sodium chloride
- Potassium iodate
- Benzoic acid
- Potassium dichromate
- Sulphanilic acid
- Sulphamic acid

Table 1 *- Specific examples.*

Solution to be standardised	Standards used
Aqueous strong acids	Standard sodium carbonate solution (using methyl orange as an indicator).
Ethanoic and other weak acids	Pre-standardised sodium hydroxide (using phenolphthalein as an indicator).
Alkalis	Pre-standardised solution of hydrochloric acid (standardised as above) or benzoic acid (using phenolphthalein as an indicator) or sulphamic acid (using phenolphthalein as an indicator).
Sodium thiosulphate	Potassium iodate (or bromate) to release iodine and titrate against it (using starch as an indicator near the end-point). Each iodine molecule reacts with 3 moles $Na_2S_2O_3$.
Silver nitrate	Standard sodium chloride (using 5% potassium chromate solution as an indicator). Titrate until the first colour change.
Potassium permanganate	Standard ethanedioic (oxalic acid). No indicator needed. 2 moles of potassium permanganate react with 5 moles of ethanedioic acid.

Work out the mass of the primary standard you need for the chosen molarity of your solution. Weigh out slightly more than this mass - this measured mass need not be accurate. Dry your solid in an oven - usually at about 110-120°C and allow your chosen standard to cool in a dessicator.

Using the dried material, weigh out the exact amount of solid needed to make your solution and place it into a volumetric flask. Dissolve the material in less than the final amount of distilled/deionised water (ideally boiled out and cooled to remove dissolved gases). Use more of the distilled water to wash out the weigh boat and add the washings to the flask. Top up to the mark on the volumetric flask to obtain your standard solution.

It is a good idea to make up quite a concentrated solution that you can then dilute down - that way you will minimise any weighing errors.

Specific Examples

(See Table 1). This is just an overview. You will find details on how to standardise the above solutions on the SSERC website under the name of the solution to be standardised. Details of others can be found in books such as Vogel's 'Handbook of Quantitative Inorganic Analysis' [1]. If you do not have access to a suitable book and can't find the information on our website then get in touch and we'll find out for you.

References

[1] Svehla, G. (1996) Vogel's Qualitative Inorganic Analysis (7th Edition), Prentice Hall, ISBN-10: 0582218667.

Demonstration corner

The Whoosh Bottle

This is a tremendous demonstration from the RSC showing the exothermic nature of the combustion of alcohol. It looks particularly spectacular in a darkened room.

Preparation

You will need:

- An 18 litre, polycarbonate, "water-fountain" bottle. (There will be a PC mark if it is polycarbonate). Check the container for signs of cracks or frosting. If there are any, do not use. Make sure the container is clean and dry inside.
- A metre rule and some tape.
- Wooden splint.
- 40 cm^3 Industrial denatured alcohol (IDA is highly flammable) [1].

Carrying Out

1) Wear eye protection (demonstrator and onlookers).
2) Place the container so that there is at least 2.5 m of clearance between the top of the bottle and the ceiling - and that there is nothing above it that could catch light.
3) Ensure anything flammable (such as your ethanol) is at least 1 m from the bottle.
4) Ensure audience is more than 4 m away from the bottle.
5) Pour the alcohol into the container and insert a rubber bung. Roll the bottle on its side for 10 seconds.
6) Drain any excess alcohol back into the original bottle and remove to at least 1 m away from the demonstration area. Use care when removing the bung to ensure that any excess alcohol does not spray out.
7) Wipe off any excess alcohol from the outside of the bottle.
8) Attach a splint in a downward angle to the end of a metre rule.
9) Light the splint and hold over the neck of the bottle.

You will hear quite a loud 'whoosh' and see a blue flame (if the room is darkened) as the ethanol vapour burns rapidly.

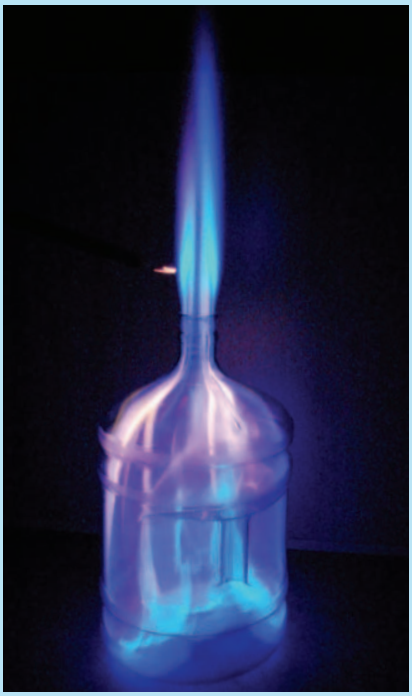

Figure 1 *- Whoosh bottle with methanol.*

On picking up the bottle afterwards, it is noticeably hot to the touch, though not too hot to hold.

References

[1] It is possible to use some other alcohols: Methanol will give a similar effect to ethanol but as it is much more toxic, there would seem to be no point. Propan-1-ol and propan-2-ol can also be used, they burn a little more slowly and you see bits of yellow in the flame rather than just blue.