Queensland Titration Competition – 2023

Teacher information – own school division

The samples

• For each team you will receive a packet containing 6 x 5 mL vials. Each vial will contain 0.3 – 0.5 g ($1.5 – 2.5 \times 10^{-3}$ mol) of potassium hydrogen phthalate (KHP), a soluble weak organic acid which is a primary standard. Each sample was weighed on the same semi-micro balance (5 dec. places) by the same person. Your email includes the same information as given on each Standard Sample label, just in case this is illegible on the label.
• Each student should be allocated a Standard and an Unknown Sample, preferably of the same number. The label on each Standard Sample (identified as S 123 for example) will provide the mass and number of moles of acid contained therein. The label on each Unknown Sample will simply be identified as for example U 123.

The Task

• The task for each student is to use 2 sets of acid-base titrations to firstly standardise a solution of NaOH, (supplied by the school) then to find the concentration and thus **the number of moles** of acid in the Unknown Sample.

You will need to provide the following (in addition to the glassware listed on the Student Instructions):

Sodium hydroxide solution

• For each student 300 mL of approximately 0.02 $mol.L^{-1}$ NaOH.

I suggest you make up a more concentrated stock solution and dilute this, rather than perhaps trying to weigh out small amounts of NaOH. For example you could make 1.0 $mol.L^{-1}$ and dilute that, initially to 0.10 and finally to 0.02 $mol.L^{-1}$. The concentration does not need to be exactly 0.02, as each student will use it to titrate their standard KHP solution, thus standardising the NaOH.

Each member of a team should have the same NaOH, so they will be able to compare the values they obtain for its concentration. You should warn students that they should not expect to get exactly the same value, as their volumetric glassware will be slightly different. They should each use their own value in subsequent calculations to compensate for the use of uncalibrated glassware. Because the analysis involves 2 sets of titrations, any errors due to uncalibrated glassware will "cancel out" only if the same volumetric flask, pipette and burette are used throughout.

Phenolphthalein

• You will also need to supply a dropper bottle of fresh phenolphthalein solution for each student (normally one per team to be shared, but with due consideration for COVID, please provide separate ones if possible).

Volumetric flasks (100 mL)

If you do not have these, your students will still be able to compete. Please contact the Coordinator (Titration@raci.org.au) or 0408877942 to discuss an alternative procedure if necessary.

Risk Assessment

The titration operation involved in this competition is not inherently high risk; however, precautions should be employed to minimise the low level of risk still further.

Use of Apparatus

By far the highest risk is in the improper use of **pipette fillers**, as, if the pipette is inserted while held by the stem far from the filler, the pipette may break and cause serious injury to the hands. **It is essential that all students be thoroughly taught the correct way to use a pipette filler** (see Safety below). You should also refer students to the RACI website where they will find a series of short video clips demonstrating various skills involved in doing a titration as well as the full procedure (RACI Titration).

Pasteur pipettes can potentially cause injury to another person if waved through the air. This should never happen. Serious injury would occur only if an eye was struck, and safety glasses should prevent this.

It is possible that any other of the glass apparatus may break and cause minor cuts. Clamping a burette too tightly may cause it to snap. Apparatus dropped on the floor will break, and minor cuts are possible. Students should be instructed not to attempt to clean up broken glass themselves.

Solutions

Acid and base solutions used are approximately 0.02 mol.L^{-1}. This is too dilute to cause damage if spilled on the skin. If spilled on clothing and not rinsed off, NaOH may eventually cause holes to form in the cloth. Any spills on skin or clothing should be rinsed off immediately. If any is splashed on the eyes (which should be prevented by safety glasses), it may sting but there would be no lasting damage if rinsed away rapidly. If any of the solutions were to enter the mouth (unlikely if pipette fillers are used), the taste would be unpleasant, but again no tissue damage would occur. The mouth should be rinsed, and if solutions were swallowed, copious water should be drunk.

Safety

While the hazards of handling solutions at the concentrations used in this competition are low, teachers should take the time to instruct students on the safe use of these chemicals and to also ensure that all solutions and chemicals (including indicator solutions) are labelled correctly, including any safety handling procedures and potential hazards.

Instruction on the safe use of pipettes, burettes and other glassware is also important**.** When students are using pipette fillers, ensure that they are taught the **correct procedure for inserting pipettes into fillers** as this presents possibly the greatest hazard in the competition. **The end of the pipette should be gently inserted into the filler** (again see the relevant video). Mouth pipetting is not permitted.

When filling **burettes**, the top of the burette should be below the level of the eyes so as to avoid accidently spilling solution onto the face and eyes. A lab step can be used, or the burette can be lowered or removed from the clamps and kept below eye level while being filled.

Students must wear fully **enclosed footwear** and **safety glasses** and **lab coats/aprons** at all times.

Volumetric Apparatus

The use of self-filling burettes or pipettes, pH meters, automatic titrators, and magnetic stirrers is not permitted.

As newer, modern designs and brands of pipettes and burettes are being developed, they are actively being marketed to schools and universities, as being safer for student use. If you intend to purchase new apparatus (or may have already done so recently), but are unsure if it meets the requirements of the RACI Titration Competition, please contact the RACI National Titration Coordinator, Elaine Bergmann (FRACI CChem) by email: Titration@raci.org.au

Time management

Your students will need about 2 hours to complete the whole exercise, which can be hard to manage in the school setting. The exercise can be successfully split into 2 shorter sessions, but you must take into account the fact that the concentration of dilute NaOH such as this is reduced to a noticeable extent by reaction with atmospheric CO_2. To allow for this, you could run 2 sessions for each practice and for the competition. In the first session, students make up both solutions, and store until the next session. They could pipette the aliquots into labelled flasks, cover (with parafilm, gladwrap or alfoil), and store safely until the second session. It is then a matter of rinsing and setting up the burette and running the 2 sets of titrations back to back. An experienced titrator will notice that even during the one set of titrations, the amount of NaOH required to reach the same endpoint does increase slightly due to the aforesaid reaction with CO_2.

In the past, a number of schools have not been able to submit their results by the closing date. You should plan for students to complete the analysis well before the due date, so that if a delay occurs an alternative date is available.

Suggestions for Practice

Many schools do not have access to an analytical balance, and possibly not to KHP or the 5 mL vials that are used for samples. If this is the case for you, you can split your practice into two components:

• learning to titrate, initially using 0.1 $mol.L^{-1}$ solutions, then switching to approx. 0.02 $mol.L^{-1}$. You could use HCl and NaOH, and once students are comfortable with the procedure, give them 2 bottles of the same HCl, labelled Standard or Unknown. Their accuracy can be determined by how close their value for the Unknown is to that given for the Standard (and that value for the Standard can be "made up" given that it is not a primary standard – e.g. 0.1023 or 2.043 x 10^{-2} $mol.L^{-1}$.

• learning to make up a standard solution.

Another point to consider is that the amount of acid provided makes only 100 mL of each of the acid solutions. Students should be given practice at working with this limited volume, to ensure that they can rinse the pipette adequately and still have enough for 3 or 4 titrations, depending on their pipette volume.