SCIENCE

Activity : Spectrophotometric quantification of Cu-ion concentration

TIMINGS	ACTIVITY
9:00	**Industry Judges arrive at host sites.**
9:15	**Welcome speech given by guest judges / visitor**
10:00	**Competitions start promptly.**
1:00 - 2:00	**Lunch break/Network (provided for visiting students and judges by the host college).**
2:00 - 3:00	**Competition wrap-up: Judges and teaching teams share feedback with competitors.**
3 – 3.30	**Closing from host**

Scenario:

A solution of copper sulphate has been located in the laboratory.

The bottle is labelled copper sulphate and dated as being only two days old, but the person who prepared it omitted to put the concentration on the label. Instead of discarding the material, you have been assigned the task of finding the concentration of the copper sulphate.

Aims and objectives:

Quantifying the copper sulphate concentration as accurately as you can by:

- Preparing a copper sulphate reference solution
- Diluting this solution to prepare a total of five different standard concentrations
- Recording a standard curve from the absorbance of the standard solutions
- Measuring the absorbance of the unknown solution and determining its concentration using the standard curve

Chemicals:

- Copper sulphate hexahydrate

- Unknown solution of copper sulphate
- Ultra-pure water

Material:

- Weighing scales and boats
- Volumetric flasks
- Volumetric pipettes
- Test tubes and rack
- Micropipette (P1000) and tips
- Cuvettes (macro)
- Spectrophotometer

Health & Safety and Environmental protection:

Please review the MSDS of all chemicals to be used. Describe which H & S and Environmental protection measures are necessary, considering procedures and equipment as well as the chemicals. Follow them accordingly!

Time allowance:

3 h – including H&S review and report writing.

1. Calculate the amount of copper sulphate hexahydrate needed to prepare 100 mL of a 0.100 M solution.
2. Prepare your 0.100 M copper sulphate solution in the volumetric flask.
3. Prepare the following four concentrations of copper sulphate by diluting your 0.100 M solution with water into separate test tube. Work out how much you need and complete Table 1 below.

Table 1: preparation of copper sulphate standard solutions.

Concentration (M)	Amount of stock solution (mL)	Amount of deionized water(mL)	Total amount of solution (mL)
0.10			
0.08			

0.06			
0.04			
0.02			

4. Prepare separate cuvettes with a blank (ultrapure water), the five standard solutions and your unknown sample.

5. Set the spectrophotometer to the optimal wavelength for $CuSO_4$ and justify your choice and zero the reading with your blank.

6. Measure and tabulate the absorbance for your standards and sample.

7. Plot absorbance against copper sulphate concentration for your five standards.

8. You may repeat any analysis if you are not satisfied with your results and have enough time left.

9. Tidy up your workbench and analyse your results.

Results:

Produce a report comprising of your notes and showing your results table, standard curve and calculations. Present a final result for the concentration of the copper sulfate solution and evaluate your analysis

CORE COMPETENCIES

Competitors taking part in this competition should demonstrate their abilities in,

• Reading and application of technical documents such as instructions related to analysis or procedures, formulations, and specifications of substances, diagrams, and manuals for equipment.

• Handling of the laboratory devices, apparatus, and equipment to be used, safe handling of the chemicals used in laboratories, implementing safety data sheets and the measures and procedures to be derived from them.

• Accurate quantitative weighing and volumetric techniques to prepare

solutions and dilutions including any required calculations.

• Preparation and processing of samples, as well as separation processes for mixtures of liquids and solids.

• Determination of physical parameters and matter constants such as, temperature, density, pH value, refractive index, melting point, and conductivity.

• Application of instrumental and electroanalytical methods such as Spectrophotometry, Chromatography, Potentiometry, and Conductometry.

• Logging, graphic evaluation and interpretation of results, and documentation by using IT and statistical methods.

• Performance of work taking into consideration relevant norms, as well as quality, safety, and environmental standards.

• Appropriate written and oral command of language, specialist terminology, and use of job-related foreign language.

Marking Guide

Assessment Criteria	**3 Marks**	**2 Marks**	**1 Mark**	**0 Marks**
Preparation of 0.100 M solution	Solution prepared with precise measurements to 3 decimal places, with no loss of material during the process, and the procedure followed exactly.	Solution prepared with measurements accurate to 2 decimal places, with no significant loss of material, and minor deviation from the procedure without affecting the solution's concentration.	Solution prepared with measurements accurate to 1 decimal place, material spillage observed, and notable deviation from the procedure leading to an approximate concentration.	Solution not prepared, significant material loss, or incorrect procedure resulting in an unusable solution.
Preparation of standard solutions	All four standard solutions prepared with exact concentrations (±0.001 M) and	All four standard solutions prepared with acceptable concentration errors (±0.005 M) and	At least three standard solutions prepared, but concentrations or volumes deviate	Less than three standard solutions prepared or all solutions deviate significantly from

	volumes (within 1% of target volume).	volumes (within 5% of target volume).	significantly, outside of ±0.005 M or 5%, respectively.	target concentrations and volumes, making them unusable.
Standard curve plotting	Curve plotted with all five data points accurately represented, axis labels are correctly placed, and graph is neat and clearly readable.	Curve plotted with all five data points, with minor inaccuracies in axis labels or graph presentation.	Curve plotted with fewer than five data points or with multiple errors in data plotting, axis labels, or graph presentation, making it difficult to interpret.	Curve not plotted or plotted with significant errors, rendering it unusable.
Use of spectrophotometer	Spectrophotometer used correctly, wavelength set accurately within ±1 nm, and all absorbance readings are within acceptable error margins (±0.01 absorbance units).	Spectrophotometer used correctly, with wavelength set within ±5 nm and most absorbance readings within acceptable error margins (±0.05 absorbance units).	Spectrophotometer used with errors in wavelength setting (±6-10 nm) or many measurements outside acceptable error margins (±0.1 absorbance units).	Spectrophotometer not used, or wavelength setting is incorrect by more than ±10 nm, leading to unusable results.
Final report quality	Comprehensive report including all required sections (standard curve, calculations, analysis, and evaluation) with no grammatical or calculation errors, and a clear and logical structure.	Report contains all required sections, but includes up to 2 minor grammatical or calculation errors, and structure is mostly clear.	Report is missing up to 2 required sections or contains 3-5 errors in grammar or calculations, and structure is difficult to follow.	Report missing more than 2 required sections, contains more than 5 errors, or is incoherent and incomplete.