WORLDSKILLS SINGAPORE 2023
TECHNICAL DESCRIPTION
CHEMICAL LABORATORY TECHNOLOGY

Skill Competition

1. This competition covers the knowledge and skills required of technical professionals working in the chemical laboratory.

2. Conducted as an individual event, competitors are given about 18 hours over 3 days to complete the Test Projects for this competition.

3. Competitors need to abide by appropriate dress code for working in chemical laboratories i.e. toe covered shoes and comfortable fitting clothes. Long hair needs to be neatly secured.

Scope of Work

4. Competitors must be able to demonstrate competencies in the following areas:

4.1. Work Organization and Management

4.1.1. Safe handling practice

The competitor must know and understand:
- Regulatory guidelines on use of chemicals in the laboratory
- Globally Harmonized System of Classifications and Labeling of Chemicals (GHS)
- Use of Safety Data Sheet (SDS) for proper handling and disposal of chemicals
- Use of enclosure systems e.g. fume hood, biosafety cabinet, glove box etc. for laboratory work
- Adequate use of personal protective equipment (PPE) for experiment
- Risk Assessment based on risks to self, others and the environment for the work to be carried out

The competitor must be able to:
- Exercise judgement to use alternative safer chemicals
- Practice safe use and storage of chemicals
- Practice safe handling, labeling, storage and disposal of waste
- Minimize generation of chemical waste
- Practice good housekeeping

4.1.2. Planning and execution of experiments

The competitor must be able to:
- Develop goals and objectives to accomplish experiment
- Do detailed planning for experiments

- Organize time and resources efficiently to obtain data
- Inspect materials and apparatus to ensure that they are fit for the task

4.2. Communication and Interpersonal Skills

4.2.1. General communication and interpersonal skills

The competitor must know and understand:
- Different communication forms – verbal, written and body language
- Effective communication techniques – observe, listen, contribute etc.
- Ways to engage others with own work
- Differentiate and treat data for confidential vs. public channels appropriately

4.2.2. Chemical specialist communication

The competitor must be able to:
- Comprehend and articulate in scientific terminologies
- Search, reference and cite scientific information from relevant sources
- Use chemical names, symbols, drawings, formulae, numbers in scientific notation
- Communicate scientific data in a logical manner
- Show thought process to draw scientific conclusions
- Present scientific data and findings

4.3. Techniques, Procedures and Methods

The competitor must know and understand:
Fundamental Chemical Principles
- Atomic, molecular structure and states of matter
- Chemical equilibrium and stoichiometry
- Thermodynamics and chemical kinetics
- Electrochemistry – reaction types and processes
- Organic synthesis – strategies and technologies

Analytical skills and chemical instrumentation
- Qualitative and quantitative determination of compounds
- Representative sampling plan in relation to bias
- Physical and chemical sample preparation techniques
- Principles of instrument operation – pH meter, weighing balances, ovens, titrators, HPLC-DAD, GC-MS LC-MS, etc.
- Concept of measurement traceability to primary materials
- Concept of analytical results in relation to quality control of production processes, industrial testing, legal and regulatory limits, R&D, forensics investigations and medical diagnostics.

The competitor must be able to:

- Prepare the sample such that it is in a suitable format for final instrument detection or follow-on synthesis
- Use analytical techniques of chromatography, conductometry, potentiometry, electrolysis, gravimetry, microscopy, titrimetry, spectrometry and spectroscopy
- Perform synthesis reactions to construct desired compounds

4.3.1. Volumetric Titration

- Knowledge of titration types e.g. acid-base, redox, complexometric etc.
- Knowledge of titration behavior and curve types
- Knowledge of concentration units e.g. molarity, mmol, %, mg/l, μg/l etc.
- Able to set up apparatus independently for a titration experiment
- Perform proper weighing of samples
- Perform quantitative transfer of liquids and solids
- Perform titer determination with reference materials
- Perform manual titration with burettes and flasks
- Use suitable indicators for end-point determination
- Demonstrate repeatability of data using statistical principles
- Calculate and report the sample content

4.3.2. Thin Layer Chromatography (TLC)

- Knowledge of principles in planar chromatographic separation
- Working knowledge of solvents selectivity
- Working knowledge of stationary phases and plate format to use
- Working knowledge of calibration techniques
- Practical knowledge of sample preparation, application and plate development
- Practical knowledge of TLC plate detection – derivatization, UV and visible wavelength
- Interpretation of data from TLC plates

4.3.3. Instrumental Analysis – Qualitative and Quantitative

- Knowledge of analytical objectives – identification, assay, purity, impurity or profiling
- Knowledge of working principle of instruments
- Working knowledge of instrument limitations – LOD, LOQ, linearity etc.
- Working knowledge of different calibration methodologies using blanks and reference materials
- Operation of basic instruments like pH meter, stirrer plate, vortex mixer
- Working knowledge of representative sampling
- Able to prepare solutions of required concentrations

- Working knowledge of sample extraction e.g. SPE, sedimentation, liquid-liquid extraction
- Clean up techniques e.g. precipitation, filtration, ion exchange etc.
- Dilution and concentration techniques to prepare samples for final instrumental detection
- Interpret data from output of analytical instruments like FTIR, UV-VIS spectrophotometer, mass spectrometry, HPLC-DAD, GC-MS, titrator etc.
- Demonstrate repeatability of data using statistical principles
- Quantify and/or identify the sample with data obtained

4.3.4. Organic Synthesis

- Knowledge of chemical and physical properties of organic and inorganic compounds.
- Classes of organic compounds e.g. aliphatic, aromatic, saturated, unsaturated hydrocarbons and their basic properties.
- Knowledge of functional groups and their chemical reactions – aldehyde, amino, carbonyl, carboxyl, hydroxyl, phosphate, thiol, sulfhydryl groups.
- Concept of isomerism and its significance
- Working knowledge of reaction chemistries e.g. addition, elimination, substitution, rearrangement, photochemical and redox reactions
- Working knowledge of stoichiometry and its applications in practice
- Working knowledge of catalysts, experimental conditions and reaction rates
- Practical handling of moisture sensitive reactions
- Purification techniques e.g. filtration, chromatographic separation, crystallization, distillation, precipitation etc.
- Characterization of synthesized product to assess identity, assay and purity with various analytical techniques
- Calculate and obtain expected product purity and yield

4.4. Quality Management, Data Processing and Record Keeping

The competitor must know and understand:

- Requirements (through international standards) for competence, impartiality and consistent operation of laboratory
- Implementation of management system to support and demonstrate the consistent operation of a laboratory and to assure the quality of the laboratory results
- The need for proper record keeping in relation to good laboratory practice
- Security of laboratory records - chain of custody and traceability
- Procedures for entering and maintaining records
- Procedures for transfer of test data

- Concept of electronic records and signatures with analytical instrument output
- Concept of data handling in the laboratory – laboratory information management systems (LIMS)

The competitor must be able to:
- Document data in different media – in print and electronic format
- Process and collate data from different instrument output and sources
- Compile data in the form of graphs, charts, tables etc.
- Check and confirm accuracy and completeness

4.5. Analysis, Interpretation and Evaluation

The competitor must be able to:
- Extract data of relevance
- Apply relevant mathematical and statistical methods to treat experimental data
- Establish measurement limits for quantitative determination
- Use data points with appropriate significant figures and decimal points
- Use scientific principles/statistical methods to evaluate data points – good or bad (outlier) points data
- Discuss incorrect results objectively
- Relate with different sets of data to establish a pattern with the measurement made
- Express data in appropriate units of measurement
- Report results that are well supported with scientific principles and reasoning
- Decide on next course of action upon evaluation of data – whether a repeat is necessary or further investigation is required
- Establish the criteria for conclusive qualitative determination

4.6. Problem Solving Through Application of Scientific Methods

The competitor must be able to:
- Recognize errors and problems – from data, procedures, sample type etc.
- Troubleshoot in practical terms – procedures, instruments, reagents etc.
- Demonstrate critical thinking skills to solve a challenge or problem
- Develop methods based on scientific principles to solve problems
- Critique and suggest improvements to solve problems

4.7. Trends in Applied Chemistry

The competitor must be aware of current trends leading to future development in chemical technology:

- Laboratory process automation from receipt to data reporting
- The integrity of sample chain and data security
- Modern technology in reporting and presenting data – web based/intranet with mobile devices
- Adoption of environmentally sustainable practices
- Real-time point-of-use mobile analyses
- Miniaturized novel sensing methods and devices
- The collaboration between interdisciplinary sciences to solve scientific challenges

Assessment

5. Competitors will be assessed on measurement (objective) and judgement (subjective) marking.

6. The assessment criteria and relative weighting of marks are as follows:

Criterion		Marks
1	Work organization and management	10
2	Communication and interpersonal skills	10
3	Techniques, procedures and methods	35
4	Data processing and record keeping	10
5	Analysis, interpretation and evaluation	15
6	Problem solving through the application of scientific method	10
7	Trends in Applied Chemistry	10
	Total	**100**

Major Tools & Materials

7. The following instruments, tools and materials may be used in the competition:

7.1. UV-Vis spectrophotometer
7.2. HPLC instrument
7.3. GC instrument
7.4. FTIR instrument
7.5. Mass spectrometer
7.6. Automated titrator
7.7. Instrument accessories like columns, fittings and traps
7.8. pH meter

7.9. Weighing balance
7.10. Vacuum pumps
7.11. Rotary evaporator
7.12. Vortex mixer
7.13. Heater block
7.14. Vial crimper and decapper
7.15. Auto pipettors
7.16. Glassware
7.17. TLC developing chambers
7.18. TLC plates
7.19. TLC sprayer
7.20. UV viewing box
7.21. Retort stands with clamps and rings
7.22. Fritted glass chromatography column
7.23. Solid Phase Extraction (SPE) columns
7.24. Filters
7.25. Solvents
7.26. Reagents and Reference Materials
7.27. ICP-MS / ICP-OES