



ZIMBABWE

**MINISTRY OF HIGHER AND TERTIARY EDUCATION,
INNOVATION, SCIENCE AND TECHNOLOGY DEVELOPMENT**

**HIGHER EDUCATION EXAMINATIONS COUNCIL
(HEXCO)**

NATIONAL DIPLOMA

**IN
APPLIED CHEMICAL TECHNOLOGY**

MODULE: Analytical Instrument Operation PAPER NO: 501/23/M05

DURATION: 3 Hours

JUNE 2026 EXAMINATION

REQUIREMENTS

INSTRUCTIONS TO CANDIDATE

1. Answer any five (5) questions.
2. Each question carries a total of twenty (20 marks).
3. Do not write on the question paper.
4. Do not write your name on the answer script.

This paper consists of 3 printed pages.

PAPER NO: 501/23/M05- ANALYTICAL INSTRUMENT OPERATION

QUESTION 1

"In analytical Chemistry, sample preparation is not just preliminary step, it is the foundation upon which accurate and reliable results are built".

Discuss

(20 marks)

QUESTION 2

- a) Outline the ideal characteristics of detectors for gas chromatography (GC). (10 marks)
- b) Discuss the principle of operation of flame ionisation detector (FID). (10 marks)

QUESTION 3

Outline the principles and instrumentation of high-performance liquid chromatography (HPLC). (20 marks)

QUESTION 4

Discuss the theory, operations and applications of infrared spectroscopy instruments. (20 marks)

QUESTION 5

- a) Examine the importance of calibrating instruments. (10 marks)
- b) Discuss the limitations of Beer lambert law. (10 marks)

QUESTION 6

- a) Draw schematic labelled diagram to show components of mass spectroscopy. (10 marks)
- b) Outline the basic principles of Flame Atomic Absorption Spectrophotometry (FAAS). (10 marks)



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NATIONAL DIPLOMA

IN

APPLIED CHEMICAL TECHNOLOGY

MODULE: Chemical Analysis II

PAPER NO: 501/23/M02

DURATION: 3 Hours

JUNE 2026 EXAMINATION

REQUIREMENTS

Data Booklet

INSTRUCTIONS TO CANDIDATE

- 1. Answer any five (5) questions.**
- 2. Each question carries twenty (20) marks.**

This paper consists of 3 printed pages.

QUESTION 1

- a) Describe the test-tube reactions used to confirm the presence of various organic functional groups in a given sample specifying the reagents, reaction conclusions and expected observations
- i) Aldehydes (3marks)
 - ii) Ketones (3marks)
 - iii) Alkenes (3marks)
 - iv) Tertiary alcohols (3marks)
- b) Name the following complexes
- i) $K_3[Fe(CN)_6]$ (3marks)
 - ii) $[Cu(NH_3)_4(H_2O)_2]Cl_2$ (3marks)
 - iii) $[Al(H_2O)_6]$ (2marks)

QUESTION 2

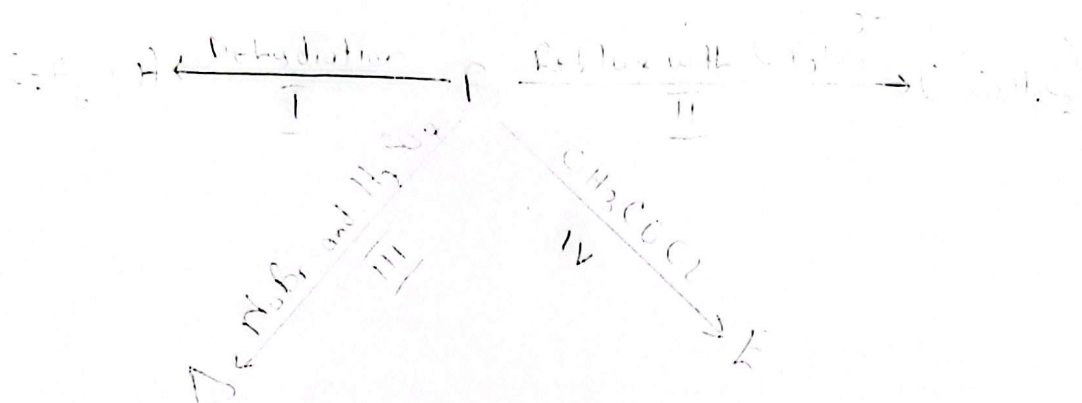
With the aid of a well-labelled flow diagram, describe the Solvay process
(20marks)

QUESTION 3

- a) A solution is prepared by dissolving $CuCl_2$ in water and the solution appears blue-green. You are tasked with analysing this solution to determine the concentration of $Cu(II)$ ion the solution outline a suitable method of analysis. (15marks)
- b) Explain why $[Cu(H_2O)_6]^{2+}$ is blue in colour (5marks)

QUESTION 4

The diagram below shows reactions of an organic compound A to the final product E



- a) Name compounds A, B, C, D and E (5marks)
- i) Name the reaction II (1mark)
 - ii) Write an equation for reaction IV (3marks)
 - iii) Name suitable reagents and conditions that can be used in place of CH_3COCl in reaction IV (2marks)
- b) Outline a laboratory test for differentiating 1° , 2° and 3° amines (9marks)

QUESTION 5

- a) Compare and contrast dyes and pigments (10marks)
- b) Discuss the applications of pigments (10marks)

QUESTION 6

Discuss any four analytical methods used to analyse organic compounds (20marks)

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NATIONAL DIPLOMA

IN

**CHEMICAL ENGINEERING/APPLIED CHEMICAL
TECHNOLOGY/INDUSTRIAL METALLURGICAL
ASSAYING/INDUSTRIAL METALLURGY**

**MODULE: Quality Assurance and Quality
Control**

PAPER NO: 501/23/M07

DURATION: 3 Hours

JUNE 2026 EXAMINATION

REQUIREMENTS

INSTRUCTIONS TO CANDIDATE

1. Answer any five (5) questions.
2. Each question carries 20 marks.

This paper consists of 3 printed pages.

QUESTION 1

- a) Define a Quality Manual. (2 marks)
- b) State the three (3) key elements of a Quality Policy Statement. (3 marks)
- c)
 - i) Discuss the importance of a Quality Manual in an organisation. (10 marks)
 - ii) How does a Quality Manual ensure Quality objectives and customer satisfaction. (5 marks)

QUESTION 2

- a) Describe a suitable sampling plan for incoming raw materials including the type of sample size and frequency. (10 marks)
- b) Outline the proper sample handling conditions to prevent contamination and damage. (5 marks)
- c) State the appropriate sample storage conditions for raw materials. (5 marks)

QUESTION 3

- a) Describe the key objectives of an inspection in ensuring product quality. (10 marks)
- b) Explain how to establish acceptable limits for each quality characteristic. (10 marks)

QUESTION 4

- a) Define the audit objective, scope and criteria in relation to their use in the audit process. (10 marks)
- b) State and explain the key elements of effective audit plan including procedures and timeline. (10 marks)

QUESTION 5

Describe the process of determining a certified reference material (CRM) focusing on the factors to be considered in ensuring CRM is suitable for intended use. (20 marks)

QUESTION 6

- a) Outline steps for verifying the effectiveness of corrective and preventive actions. (10 marks)
- b) Describe the evaluation criteria for assessing a manufacturing plant's compliance with safety regulations. (10 marks)

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IN

APPLIED CHEMICAL TECHNOLOGY

**MODULE: Process Instrumentation and
Control I**

PAPER NO: 501/23/M03

DURATION: 3 Hours

JUNE 2026 EXAMINATION

REQUIREMENTS

1. Scientific calculator.
2. Answer booklet.

INSTRUCTIONS TO CANDIDATE

1. Answer any five (5) questions.
2. Each question carries twenty (20) marks.

This paper consists of 4 printed pages.

QUESTION 1

- a) Define the following terms as they are used in process instrumentation and control
- i) Response time (2 marks)
 - ii) Lag (2 marks)
 - iii) Fidelity (2 marks)
 - iv) Speed of response (2 marks)
- b) Explain the sources of the following two measurements of a physical quantity
- i) Systematic error (2 marks)
 - ii) Random error (2 marks)
- c) Distinguish between static and dynamic characteristics of measuring instruments. (4 marks)
- d) The volume, V of a cylinder of length, L and radius, R is given by the equation

$$V = \pi R^2 L$$

Calculate the radius of the cylinder and its uncertainty given that

$$V = (25.0 \pm 0.3)m^3$$

$$L = (20.0 \pm 0.1)cm$$

(4 marks)

QUESTION 2

- a) Discuss the basic requirements of a good quality transducer. (5 marks)
- b) Distinguish active transducer from passive transducer. (4 marks)
- c) i) With the aid of a diagram explain the principle of operation of a venturimeter. (7 marks)
- ii) A venturimeter has a cross-sectional area of $2 \times 10^{-3}m^2$ and $4.6 \times 10^{-4} \times m^2$ in the wider and narrow area respectively. The velocity of liquid in wider area is $0.45 ms^{-1}$

Calculate the velocity of fluid in the narrow area.

(4 marks)

QUESTION 3

- a) Explain five (5) factors which contribute to drift instruments. (10 marks)
- b) i) Given thermometer with absolute error of $\pm 0.2^{\circ}\text{C}$. Determine the temperature range when the thermometer gives a reading of 39.5°C when, measuring temperature. (2 marks)
- ii) Determine the static error when a thermometer reads 38.5°C , given that the actual value of temperature value is 38.2°C (2 marks)
- c) Define the following terms as used in process instrument control
- i) Sensitivity (2 marks)
- ii) Resolution (2 marks)
- iii) Span (2 marks)

QUESTION 4

- a) Compare closed loop and open loop system. (8 marks)
- b) Discuss the following
- i) Proportional control mode (3 marks)
- ii) Integral control mode (3 marks)
- iii) Derivative control mode (3 marks)
- iv) Composite control mode (3 marks)

QUESTION 5

- Discuss four (4) main functions performed by instruments. (20 marks)

QUESTION 6

- a) Distinguish the following classes of measuring instruments:
- i) Absolute (primary) and secondary (4 marks)
 - ii) Indicating and recording (4 marks)
 - iii) Mechanical and electronic (4 marks)
- b) Illustrate analogue to digital conversion. (8 marks)

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NATIONAL DIPLOMA

IN

APPLIED CHEMICAL TECHNOLOGY

MODULE: Research and Development PAPER NO: 501/23/M06

DURATION: 3 Hours

NOVEMBER/DECEMBER 2025 EXAMINATION

REQUIREMENTS

Non programmable scientific calculator

INSTRUCTIONS TO CANDIDATE

- 1) Answer any four (4) questions.
- 2) Each question carries a total of twenty five (25) marks.
- 3) Do not write on the question paper.

This paper consists of 2 printed pages.

QUESTION 1

- a) Describe five (5) material and equipment requirements for a manufacturing process. (10 marks)
- b) State five (5) advantages and five (5) disadvantages of implementing ISO 9001 in an organisation. (10 marks)
- c) Explain the concept of participative budgeting including its merits. (5 marks)

QUESTION 2

Determine the review and evaluation criteria for a production development process. Including the identification of key performance Indicators (IKPIs). (25 marks)

QUESTION 3

Identify and discuss the importance of various research instruments that can be used for qualitative and quantitative studies. (25 marks)

QUESTION 4

Explain the significance of data presentation and analysis in research. (25 marks)

QUESTION 5

- a) A researcher wants to determine if there is a significant difference in the yield of a chemical reaction using two different catalyst as shown:

Catalyst A	25	30	28	32	27
Catalyst B	35	30	33	36	31

- i) Calculate the mean of catalyst A and catalyst B. (6 marks)
 - ii) Comment on the mode of the data sets. (4 marks)
- b) Discuss the five (5) major product validation activities in research and product development. (15 marks)

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IN

APPLIED CHEMICAL TECHNOLOGY

**MODULE: Safety, Health and Environmental PAPER NO: 501/23/M08
Management**

DURATION: 3 Hours

NOVEMBER/DECEMBER 2025 EXAMINATION

REQUIREMENTS

Pen and pencil

INSTRUCTIONS TO CANDIDATE

- 1) Answer any five (5) questions.**
- 2) Do not write anything on the question paper.**
- 3) Do not write your name (s) on or inside the answer booklet.**

This paper consists of 3 printed pages.

QUESTION 1

- a) Define the term Ergonomics. (3 marks)
- b) Discuss the significance of ergonomics in the workplace. (5 marks)
- c) How can ergonomic principles be applied to reduce work related musculoskeletal disorders (WMSDs). (12 marks)

QUESTION 2

- a) Define the concept of regulatory compliances in the context of occupational health and safety. (2 marks)
- b) Explain the importance of regulatory compliance for organisations. (5 marks)
- c) Discuss the steps an organisation can take to ensure compliance with occupational health and safety regulations. (13 marks)

QUESTION 3

- a) Define the concept of workplace hazard. (2 marks)
- b) Describe the different types of workplace hazards. (8 marks)
- c) Provide examples of control measure for each type of hazard. (10 marks)

QUESTION 4

- a) Explain the significance of air quality monitoring in industrial settings. (5 marks)
- b) Describe the methods used to monitor air quality in a chemical plant. (5 marks)
- c) Discuss the potential health effects of poor air quality on workers. (10 marks)

QUESTION 5

- a) Define hazardous waste (2 marks)
- b) Explain the importance of proper hazardous waste management. (6 marks)

- c) Outline the steps involved in the safe disposal of hazards waste in a chemical laboratory. (12 marks)

QUESTION 6

- a) Explain the concept of environmental impact assessment (EIA). (1 mark)
- b) Describe the process of conducting an EIA for a chemical plant. (14 marks)
- c) Highlight the benefits of conducting an EIA before project implementation. (5 marks)

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IN

APPLIED CHEMICAL TECHNOLOGY

MODULE: Analytical instrument Operation PAPER NO: 501/23/M05

DURATION: 3 Hours

NOVEMBER/DECEMBER 2025 EXAMINATION

REQUIREMENTS

Non – programmable scientific calculator.

INSTRUCTIONS TO CANDIDATE

- 1. Answer any five (5) questions.**
- 2. Each question carries a total of twenty (20) marks.**
- 3. Do not write on the question paper.**

This paper consists of 3 printed pages.

QUESTION 1

Outline the principle, instrumentation and applications of high performance liquid chromatography (HPLC). (20 marks)

QUESTION 2

- (a) Elaborate on the principles of UV-Vis spectrophotometry, detailing how it quantifies absorbance and transmittance. (10 marks)
- (b) Discuss the factors that can lead to deviations from Beer's Law in practical applications. (10 marks)

QUESTION 3

Discuss the theory, applications and operations of infrared spectrophotometry instruments. (20 marks)

QUESTION 4

A researcher is investigating the concentration of sulphate ions in a wastewater sample. They decide to use conductometric titration with a barium chloride solution as the titrant.

- (a) Explain how conductometric titration can be utilised to determine the concentration of sulphate ions in this context. (10 marks)
- (b) Describe how the endpoint of the titration can be identified using conductivity measurements. (5 marks)
- (c) Briefly discuss potential interferences that might affect the accuracy of the results and how they could be mitigated. (5 marks)

QUESTION 5

With aid of relevant examples give an overview of calibration, highlighting importance of calibration in analytical instruments operations. (20 marks)

QUESTION 6

- (a) Draw and label schematic diagrams for the following:-
 - (i) X-ray emission (6 marks)
 - (ii) X-ray diffraction (6 marks)
- (b) Elaborate on the basic principles of mass spectroscopy. (8 marks)



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IN

APPLIED CHEMICAL TECHNOLOGY

MODULE: Chemical Analysis 1

PAPER NO: 501/23/M01

DURATION: 3 hours

JUNE 2026 EXAMINATION

REQUIREMENTS

1. Non-programmable scientific calculator
2. Chemistry data booklet

INSTRUCTIONS TO CANDIDATE

1. Answer any five (5) questions.
2. Each question carries a total of twenty (20) marks.

This paper consists of 3 printed page.

PAPER NO: 501/23/M01 – CHEMICAL ANALYSIS 1

QUESTION 1

- a) Describe three (3) types of sampling techniques and provide an example for each technique. (12 marks)
- b) State any four (4) errors that can occur during sampling. (8 marks)

QUESTION 2

Calculate:

- a) milligrams in 0.250mmol of Fe_2O_3 (Ferric Oxide). (4 marks)
- b) the number of grams in one mole of $CaSO_4 \cdot 7H_2O$. (4 marks)
- c) the number of moles in 500mg of Na_2SO_4 . (4 marks)
- d) the concentration of Potassium ion in grams per litre after mixing 100ml of 0.250M KCl and 200ml of 0.100M K_2SO_4 . (8 marks)

QUESTION 3

- a) State four (4) characteristics of a primary standard. (4 marks)
- b) Describe how you would prepare a 1 000ppm stock solution of Iron (Fe) using $FeCl_3$. (6 marks)
- c) Explain three (3) key precautions to take when preparing and storing standard solutions. (10 marks)

QUESTION 4

Discuss the role of Standard Operating Procedures (SOPs), Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMPs) in sampling and sample preparation for chemical analysis. (20 marks)

QUESTION 5

Examine any five (5) key features of an ideal chemical store room. (20 marks)

QUESTION 6

With reference to Le Chatelier's principles discuss factors that affect chemical equilibrium. (20 marks)

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IN

APPLIED CHEMICAL TECHNOLOGY

**MODULE: Process Instrumentation and
Control I**

PAPER NO: 501/23/M03

DURATION: 3 Hours

NOVEMBER/DECEMBER 2025 EXAMINATION

REQUIREMENTS

Answer booklet.

INSTRUCTIONS TO CANDIDATE

- 1. Answer any five (5) questions.**
- 2. Do not write your name in the answer booklet.**
- 3. Each question carries 20 marks.**

This paper consists of 3 printed pages.

QUESTION 1

Explain the main functional elements of a measurement system. (20 marks)

QUESTION 2

- (a) Distinguish between analogue and digital signal. (10 marks)
- (b) Outline the factors one should consider while choosing an instrument for a particular application. (10 marks)

QUESTION 3

- (a) Write short notes on the following types of instruments
- (i) Indicating instruments (4 marks)
 - (ii) Recording instruments (4 marks)
 - (iii) Integrating instrument (4 marks)
- (b) Discuss the functional elements of a laboratory thermometer. (8 marks)

QUESTION 4

- (a) Explain the following terms: -
- i) Accuracy (2 marks)
 - ii) Sensitivity (2 marks)
 - iii) Range (2 marks)
 - iv) Reproducibility (2 marks)
- (b) Describe the term noise. Give common sources of noise. (12 marks)

QUESTION 5

- (a) Explain the effects of the following error in measurements.
- (i) Systematic error (7 marks)
 - (ii) Random error (7 marks)

- (b) Explain why it is mandatory to comply with manufactures instructions for installation of a particular equipment. (6 marks)

QUESTION 6

- (a) Discuss different types of transducers. (12 marks)

- (b) Explain the following characteristics of measuring instruments.

(i) Static (4 marks)

(ii) Dynamic (4 marks)

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