higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)

INSTRUMENTATION TECHNOLOGY
NQF LEVEL 4

(6060474)

15 November 2024 (X-paper)
09:00–12:00

This question paper consists of 9 pages.

223Q1N2415

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)
INSTRUMENTATION TECHNOLOGY
NQF LEVEL 4
TIME: 3 HOURS
MARKS: 150

INSTRUCTIONS AND INFORMATION

1. Answer all the questions.
2. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Use only a black or blue pen.
5. Write neatly and legibly.

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SECTION A

QUESTION 1

Various options are given as possible answers to the following questions. Choose the correct answer and write only the letter (A–D) next to the question number (1.1–1.10) in the ANSWER BOOK.

1.1 A liquid analyser that measures the amount of suspended solids in a liquid by the measurement of light scattering from the suspended particles



A Turbidity analyser
B Humidity analyser
C Viscosity analyser
D Liquid density analyser

1.2 Measures level by the attenuation of gamma rays passing through a process vessel

A Radar level gauge
B Hydrostatic level gauge
C Ultrasonic level gauge
D Nuclear level gauge

1.3 Measurement that cannot be used in a vacuum or with liquids that are covered with foam

A Nucleonic level
B Radar level
C Microwave level
D Ultrasonic level



1.4 A level measuring detector consisting of a cable or rod as the wave carrier extending from the emitter down to the bottom of the vessel and electronics to measure the transit time

A Laser level
B Pulsed radar
C Microwave level
D Guided wave radar

1.5 The type of load cells that are considered in remote locations, as they do not require a power supply.



A Hydraulic load cells
B Pneumatic load cells
C Capacitive load cells
D Strain gauge load cells

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1.6 A force balance device that measures the weight as a change in pressure of the internal filling fluid

A Hydraulic load cell
B Pneumatic load cell
C Capacitive load cell
D Strain gauge load cell

1.7 The amount of water vapor in a given volume of air or other gases

A Density
B Viscosity
C Humidity
D pH

1.8 An electrochemical analyser consisting of a cell that generates an electric potential when immersed in a sample

A Liquid analyser
B Humidity analyser
C Viscosity analyser
D pH analyser

1.9 A control strategy that only controls the inputs to a process without feedback from the output of the process

A Feedback control
B Feedforward control
C Cascade control
D Open loop control

1.10 A simplified sketch that uses symbols to identify instruments and vessels and to describe the primary flow path through a unit

A Process and instrument drawing
B Block flow diagram
C Piping and instrument design
D Process flow diagram

(10 × 1) **[10]**

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QUESTION 2

Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (2.1–2.5) in the ANSWER BOOK.

2.1 A standard pH measurement electrode produces potential when the process solution's pH value is exactly 7.0.

2.2 The fundamental difference between a radar instrument and an ultrasonic instrument is that radar instruments use radio waves instead of sound waves.

2.3 A piping and instrumentation diagram (P&ID) is a schematic diagram of the relationship between instruments, controllers, piping, and system equipment.

2.4 Pneumatic load cells are sometimes used where intrinsic safety and hygiene are desired.

2.5 Ultrasonic level sensors are not affected by the changing speed of sound due to moisture, temperature, and pressures.

(5 × 1) **[5]**

QUESTION 3

Choose a term from COLUMN B that matches a description in COLUMN A. Write only the letter (A–L) next to the question number (3.1–3.10) in the ANSWER BOOK.

COLUMN A		COLUMN B	
3.1	Analysers which are connected to process and conduct automatic sampling	A	cascade control
3.2	A method of sending and receiving binary information, in the form of low-level DC voltage pulses, between multiple devices using a common wiring format and procedure	B	buffered solution
3.3	A device that provides the power and motion to manipulate the moving parts of a valve, used to control fluid flow through a final element	C	electrolyte
3.4	Any substance that enhances electrical conductivity when dissolved in water	D	unbuffered solution
3.5	A device that indirectly measures the amount of moisture by sensing changes in physical or electrical properties in materials due to their moisture	E	latching alarm
3.6	A solution of an acid or a base and another chemical compound in water where one of the parts of the compound is more reactive with the acid or base than the other	F	digital communications
3.7	The temperature to which air must be cooled for the air to be saturated with water	G	high/high alarm
3.8	An alarm where the relay cannot automatically reset once tripped	H	in-line analyser
3.9	The set point to the control loop is fed into the primary controller while the output of the primary controller becomes the set point to the secondary controller	I	dew point
3.10	Upon loss of the induced draft fan, the forced draft fan is stopped immediately	J	fan interlock
		K	at-line analyser
		L	low air flow interlock
		M	actuator
		N	humidity analyser

(10 × 1) **[10]**

TOTAL SECTION A: 25

SECTION B

QUESTION 4: LEVEL MEASUREMENT

4.1 Any gas or vapor pressure accumulation in an enclosed vessel will add to the hydrostatic pressure at the bottom, causing any pressure-sensing instrument to falsely register a high level.

Make a neat, labelled sketch of a hydrostatic level sensor (DP) showing how you would connect DP to compensate for the buildup pressure at the top of the tank. (5)

4.2 A design of an ultrasonic level instrument for point level measurement uses two similar crystals or transducers.

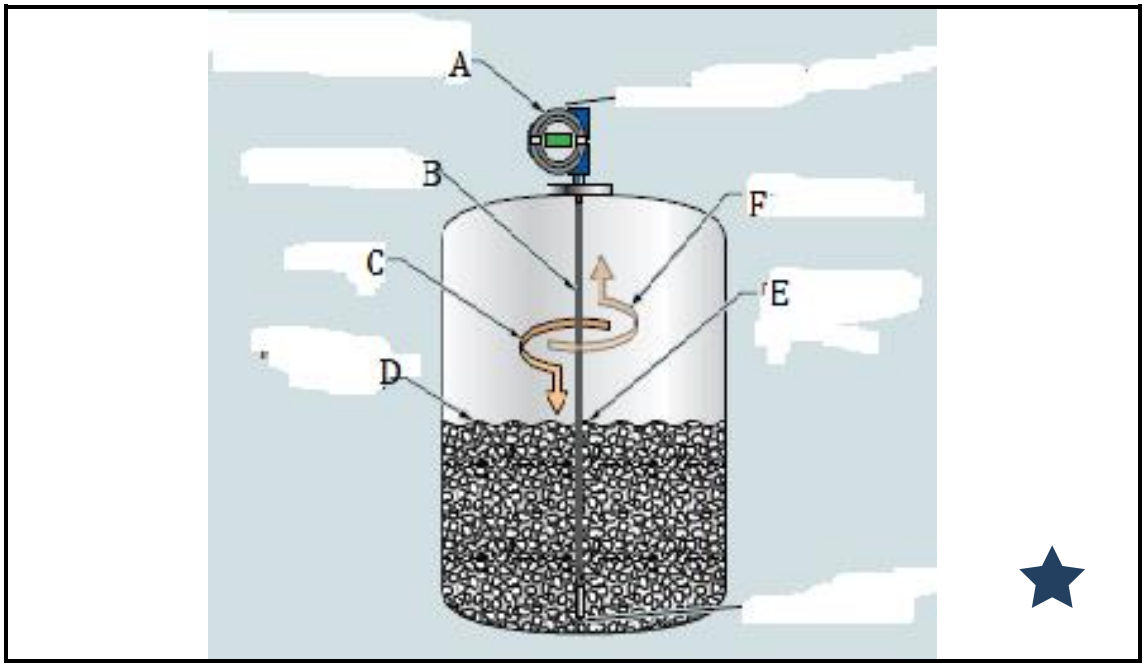
4.2.1 Explain the purpose of each crystal or transducer. (2)

4.2.2 Define the term *transit time* with respect to ultrasonic level measurement. (2)

4.2.3 Name FIVE advantages of ultrasonic level transmitter. (5)

4.3 Radar or microwave level instruments measure the distance from the transmitter (located at some high point) to the surface of a process material located farther below in much the same way as ultrasonic transmitters.

Study the figure below and answer the questions:



4.3.1 What type of a radar measuring instrument is shown in the sketch? (2)

4.3.2 Provide labels for the components marked A, B, C, D, E and F. (6)

4.3.3 Explain the working principle of this type of radar level measuring system. (5)

4.4 Make a neat, labelled sketch of a continuous nucleonic level measurement system. (6)

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QUESTION 5: MASS MEASUREMENT

5.1 A load cell is a transducer which converts force into a measurable electrical output.

5.1.1 Types of load cells can be distinguished according to the type of output signal generated.

Name THREE types of load cells according to their output signal. (3)

5.1.2 Explain the construction and operating principle of strain gauge load cells as applicable to mass measurement. (5)

5.2 Name and explain the FIVE common issues associate with load cells. (5 × 2) (10)

5.3 There are several types of strain gauge load cells.

5.3.1 Name any FOUR types of strain gauge load cells.

5.3.2 Name any FOUR possible sources of error associated with strain gauge load cells.

(2 × 4) (8)

[26]

QUESTION 6: IN-LINE PROCESS ANALYSER

6.1 Define the following terms:

6.1.1 An oxidation-reduction potential (ORP) analyser (3)

6.1.2 pH (2)

6.2 The pH is normally measured by chemical indicators or by pH meters. The pH probe is made of two separate electrodes.

6.2.1 What is the range of a pH scale? (1)

6.2.2 Make a neat, labelled sketch of a pH meter. (6)

6.2.3 Name the TWO electrodes and explain their purpose. (8)

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6.3 The most primitive form of a conductivity sensor, sometimes referred to as a conductivity cell, measures the electrical conductivity of a liquid solution by passing an electric current through it.

6.3.1 Make a neat, labelled sketch of two-electrode conductivity analyser. (6)

6.3.2 What is a *conductivity cell*? (2)

6.3.3 Explain how fouling affects the operation of a two-electrode conductivity cell. (4)

6.3.4 Which method can be used to eliminate the problem of a two-element conductivity cell? (2)

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QUESTION 7: CONTROL SYSTEMS

7.1 Explain the following terminology used in process control:

7.1.1 Set point (2)

7.1.2 Deviation (2)

7.1.3 Interlock (2)

7.1.4 Distributed control system (DCS) (3)

7.1.5 Supervisory control and data acquisition (SCADA) (3)

7.2 Name FIVE elements of which a SCADA system usually consists. (5)

7.3 A limit alarm trip monitors a process signal and compares it against a preset limit. If the process signal moves to an undesirable condition, the alarm trip activates one or more of its relay outputs.

7.3.1 Name THREE common types of alarm relay configurations. (3)

7.3.2 There are two types of alarm trip relay responses, namely Normally Open and Normally Closed configuration. Explain both. (6)

7.3.3 What will happen to the condition of a high limit alarm when the variable being measured exceeds a preset value? (2)

7.3.4 Make neat, labelled sketches of a NO and NC relay contact of an alarm configurations (4)

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TOTAL SECTION B: 125
GRAND TOTAL: 150

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