higher education & training

Department:
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REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)

INSTRUMENTATION TECHNOLOGY
NQF LEVEL 4

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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 answer and write only the letter (A–D) next to the question number (1.1–1.10) in the ANSWER BOOK.

1.1 A(n) … analyser is characterised by manual sampling followed by discontinuous sample preparation, measurement and evaluation.

A in-line
B on-line
C off-line
D at-line

1.2 A method of tracking the change of level over a range of values:

A Point level measurement
B Continuous level measurement
C Direct level measurement
D Indirect level measurement

1.3 Analysers that are connected to a process and conduct automatic sampling:

A In-line analysers
B On-line analysers
C Off-line analysers
D At-line analysers

1.4 Devices that indirectly measure humidity by sensing changes in physical or electrical properties in materials due to their moisture content:

A Hydrometers
B Hygrometers
C Refractometers
D Nephelometers

1.5 The amount of matter within an object is called its …

A weight.
B mass.
C density.
D volume.

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1.6 A(n) …. analyser measures the voltage produced by an electrochemical reaction between the metals of the electrodes and the chemicals in a solution.

A oxidation-reduction potential
B conductivity
C dissolved oxygen
D turbidity

1.7 An … analyser is an instrument that is located in the process area and obtains frequent or continuous samples.

A in-line
B on-line
C off-line
D at-line

1.8 If the concentration of active hydrogen and active hydroxyl ions in a solution is of the same quantity, the solution has a …

A pH value equal to 7.
B pH value below 7.
C pH value above 7.
D pH value equal to 0.

1.9 A process input variable that is adjusted to steer the controlled variable towards the desired value:

A Controlled variable
B Measured value
C Disturbance variable
D Manipulated variable

1.10 A … prevents fuel from being admitted to a furnace until the furnace has been thoroughly air-cleansed to remove residual combustibles.

A purge interlock
B low airflow interlock
C fan interlock
D low water interlock

(10 × 1) **[10]**

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 Viscometers are used to measure the resistance to motion of liquids and gases.

2.2 Continuous level measurement is a method of level measurement where the only concern is whether the amount of material is within the desired limits.

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 A problem with the use of load cells is that rigid piping restraints cause errors in the weight readings.

2.5 Cascade control is a control strategy where a primary controller, which controls the ultimate measurement, adjusts the set point of a secondary controller.

(5 × 1) **[5]**

QUESTION 3

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

COLUMN A		COLUMN B	
3.1	Fluids having substantial weight generate pressure proportional to their density and to their vertical height	A	impulse piping
3.2	This alarm accepts one input, but has two high relays, each with its own trip point	B	alarm system
3.3	Level measurement is also done based on attenuation and radiation	C	acidic solution
3.4	The solution has a higher concentration of active hydrogen ions than that of hydroxyl ions	D	first-out alarms
3.5	An electrochemical analyser that measures the electrical conductivity of liquids and consists of two electrodes immersed in a solution	E	high/high alarm
3.6	An optical analyser that monitors changes in liquid composition by measuring the quantity of light reflected from particles in a sample	F	refractometer
3.7	A small gauge pipe that is used to connect a point in a pipe in which the pressure is measured at an instrument	G	transmitter
3.8	A feature that is available in annunciators and digital alarm systems that can identify the first of multiple closely tripped alarms	H	hydrostatic pressure
3.9	A device used to weigh large items that typically consists of piston cylinder devices that produce hydraulic output pressure	I	basic solution
3.10	A device that provides a visual and audible signal to the operator that something in the process is not normal	J	manipulated variable
		K	conductivity analyser
		L	load cell
		M	radio waves
		N	nucleonic level measurement
		O	nephelometer

(10 × 1) **[10]**

TOTAL SECTION A: 25

SECTION B

QUESTION 4

4.1 The most frequently used method of measuring levels is the method of measuring differential pressure, i.e. hydrostatic level measurement. There are, however, some disadvantages to this method.

Name THREE disadvantages of this method. (3)

4.2 An ultrasonic sensor is a level measuring instrument that uses ultrasonic sounds to measure levels.

4.2.1 Define the term *transit time* as applicable to ultrasonic level detectors. (2)

4.2.2 Name FOUR factors that affect the speed of the ultrasonic signal in level measurement. (4)

4.2.3 Explain the benefit of guided wave radar compared to pulsed radar. (3)

4.3 Certain types of nuclear radiation easily penetrate the walls of industrial vessels, but are attenuated by traveling through the bulk of the material stored in the vessels.

4.3.1 Under what circumstances would one use the radiation method for level measurement? (3)

4.3.2 What are the disadvantages of these radiation level measuring methods? (3)

4.3.3 Explain how nuclear level detectors are used for point level measurements. (10)

4.4 Guided wave radar uses a waveguide to direct a radar signal down a wire.

Make a neat, labelled sketch of a guided wave radar level measuring system. (6)
[34]

QUESTION 5

5.1 Weighing a vessel and its contents calls for the installation of load cells.

5.1.1 Explain the operational difference between the *piston cylinder load cell* and the *strain gauge load cell.* (4)

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

5.2 Explain THREE common types of load cell calibration methods. (6)

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5.3 Define the following terms:

5.3.1 Weight (2)

5.3.2 Density (2)

5.3.3 Convert 500 kg/m^3 to … lb./ft^3

HINT: 1 kg/m^3 = 0,1084 lb/ft^3 (3)

5.4 List THREE types of strain gauge load cells. (3)
[25]

QUESTION 6

6.1 Explain the purpose of the following in-line process analysers in the process industry:

6.1.1 Turbidity analyser

6.1.2 Humidity analyser

6.1.3 pH analyser

6.1.4 Viscosity analyser

6.1.5 Dissolved oxygen analyser

(5 × 2) (10)

6.2 List FIVE types of humidity in line process analysers. (5)

6.3 The moisture content of materials is very important in some processes. A simple method of measuring the moisture content of materials (humidity) is to obtain the dew point.

6.3.1 Explain the working principle of a dew point in-line analyser used in the process industry. (12)

6.3.2 What does *ORP* stand for? (3)

6.3.3 Explain the terms *oxidation* and *reduction* in terms of ORP analysers. (2)
[32]

QUESTION 7

7.1 Piping and connections are represented by several symbols. Draw the symbols for the following piping and connections:

7.1.1 Primary process flow

7.1.2 Connection to process

7.1.3 Pneumatic signal

7.1.4 Electrical signal

7.1.5 Electromagnetic signal

(5 × 2) (10)

7.2 Explain the main purpose of incorporating a safety system in control loops. (2)

7.3 List FIVE types of safety systems used in process control loops. (5)

7.4 The alarm contact actions can be either “open to alarm” or “close to alarm”.

Explain the difference between an *open to alarm contact action* and a *close to alarm contact action* as used in control systems. (5)

7.5 Electrical transmission was developed to eliminate the problems and limitations of pneumatic transmission.

Name FIVE advantages of electrical transmission. (5)

7.6 Explain the operation of the following elements in a process control system:

7.6.1 Actuator (4)

7.6.2 Positioner (3)

[34]

TOTAL SECTION B: 125

GRAND TOTAL: 150

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