higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

INDUSTRIAL INSTRUMENTS N6

(8080216)

21 November 2023 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 6 pages and 1 formula sheet.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
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NATIONAL CERTIFICATE
INDUSTRIAL INSTRUMENTS N6
TIME: 3 HOURS
MARKS: 100

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. Sketches must be large, neat and fully labelled.
5. Write neatly and legibly.

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SECTION A

QUESTION 1

1.1 Choose an option from COLUMN B that matches a description in COLUMN A. Write only the letter (A–J) next to the question number (1.1.1–1.1.10) in the ANSWER BOOK.

COLUMN A		COLUMN B	
1.1.1	An analyser that has a limitation in the sense that it can only measure binary mixtures accurately	A	division
1.1.2	A simple control system that contains no feedback loop and therefore the measured variable is not controlled or corrected	B	reference detector
1.1.3	Until an unfired furnace has been air-cleansed, no fuel may be admitted to the furnace	C	glow wire
1.1.4	Specifies the probability of finding a particular material in the hazardous area	D	cyclone burner
1.1.5	Used to enhance component separation in a distillation column	E	thermal conductivity analyser
1.1.6	Used to provide compensation for changes in line voltage and source decay	F	cascade control
1.1.7	An analyser that uses a single-sample cell and phototube	G	flicker photometer
1.1.8	A water-cooled horizontal cylinder into which fuel is fed and mixed with air	H	open-loop control
1.1.9	An infrared radiation source	I	trays
1.1.10	A control that is used to reset the set point of a secondary controller by the output of the primary controller	J	air purge interlock

(10 × 1) (10)

1.2 Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (1.2.1–1.2.5) in the ANSWER BOOK.

1.2.1 An interlock is a device used to help prevent a machine from harming its operator or damaging itself by stopping the machine when tripped.

1.2.2 A valve coefficient is defined as the quantity of water that will pass through a specific valve size at the maximum valve lift and one psi pressure drop.

1.2.3 Turndown is the ratio of the maximum to the minimum flows measured at constant pressure drop across the valve, through which a control valve maintains an equal percentage characteristic.

1.2.4 In optical emission spectrochemical analysis, the wavelength of the atomic transitions reveals the concentration of the elements within the sample.

1.2.5 A positive filter is filled with the overlapping gas to prevent other components in the sample from interfering in absorption.

(5 × 1) (5)
[15]

TOTAL SECTION A: 15

SECTION B

QUESTION 2: ANALYSERS

2.1 Make a neat, labelled sketch of an air-absorption continuous-gas calorimeter (for example a Cutler-Hammer) and describe its operation. (12)

2.2 Make a sketch of a positive-filter-type infrared analyser. (5)

2.3 What is actually determined by an infrared analyser? (3)

2.4 What are the main functions of optical filters in an ultraviolet analyser? (2)

2.5 Name TWO general recording methods that can be used in emission spectrometers. (2)
[24]

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QUESTION 3: AUTOMATIC CONTROL AND VALVES

3.1 Calculate the quantity of gas flow for the following:

Cv of valve	=	2,2
SG of gas	=	0,8
Temperature of gas	=	80 °C
Upstream pressure	=	22 bars
Downstream pressure	=	8 bars

(8)

3.2 Describe the systematic, experimental method of adjusting the controller settings of a proportional plus derivative controller on the plant. (6)

3.3 Give practical examples and reasons where the following are used:

3.3.1 Air-to-open action valve

3.3.2 Air-to-close action valve

(2 × 2) (4)

3.4 State FIVE factors to be considered in the choice of a valve. (5)

3.5 Define the *turndown of a control valve*. (2)

[25]

QUESTION 4: DISTILLATION COLUMN AND BOILERS

4.1 In your own words explain how and why computers (PLC's) are used to control a distillation column. (8)

4.2 State the disadvantage of using on/off control to control a steam boiler. (2)

4.3 Explain why proper boiler operation requires that the level of water in the steam drum is maintained within a certain band. (4)

4.4 Name THREE types of drum-level control designs. (3)

4.5 The pressure control in a distillation column can be complicated by the presence of inert gases.

How do these gases influence the column pressure? (3)

[20]

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QUESTION 5: INTRINSIC SAFETY

5.1	Define *hazardous location*.	(2)
5.2	What is the purpose of a barrier circuit?	(2)
5.3	Define THREE types of purging installations according to the ISO (International Organisation for Standardisation) standards.	(6)
5.4	What is meant by the term *minimum ignition energy*?	(2)
5.5	Make a sketch and label an acceptable installation for a type Y purging system.	(4)
		[16]

TOTAL SECTION B: 85
GRAND TOTAL: 100

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INDUSTRIAL INSTRUMENTS N6

FORMULA SHEET

1. $$C_v = 1.16Q\sqrt{\frac{G_f}{\Delta P}}$$

2. $$C_v = \frac{1.16\,W}{\sqrt{G_f \Delta P}}$$

3. $$C_v = \frac{Q}{295}\sqrt{\frac{G.T}{\Delta P(P_1 + P_2)}}$$

4. $$C_v = \frac{47{,}2\,W}{\sqrt{\Delta P(P_1 + P_2)}}$$

5. $$C_v = \frac{72{,}4\,W}{\sqrt{\Delta P(P_1 + P_2)}}$$

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