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Department:  
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**REPUBLIC OF SOUTH AFRICA**

## **NATIONAL CERTIFICATE INDUSTRIAL INSTRUMENTS N4**

(8080194)

**17 April 2020 (X-paper)  
09:00–12:00**

**This question paper consists of 8 pages and 1 formula sheet.**

297Q1A2017

**DEPARTMENT OF HIGHER EDUCATION AND TRAINING**  
**REPUBLIC OF SOUTH AFRICA**  
NATIONAL CERTIFICATE  
INDUSTRIAL INSTRUMENTS N4  
TIME: 3 HOURS  
MARKS: 100




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**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. Start each section on a new page.
  5. Write neatly and legibly.
-

**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 ... is defined as the opposition to the generation of magnetic fields.
- A Inductance
  - B Piezo-electric effect
  - C Reluctance 
  - D Dielectric
- 1.2 Mathematical expression or formula for stress:
- A  $E\varepsilon = \sigma$
  - B  $\varepsilon L = \Delta L$
  - C  $K = (\Delta R/R)/(\Delta L/L)$
  - D  $F = ma$
- 1.3 Device measuring temperature of a hot object by means of intensity of radiant energy exiting a phototube:
- A Thermistor
  - B Potentiometer
  - C Pyrometer 
  - D Resistance thermometer
- 1.4 Bernoulli primary flow element measuring average velocity of a stream:
- A Pitot tube
  - B Flow nozzle
  - C Annubar
  - D Orifice plate
- 1.5 ONE of the following can be used to compensate for ambient temperature changes:
- A Vapour pressure expansion thermometer
  - B Bimetallic expansion thermometer
  - C Liquid expansion thermometer
  - D Gas expansion thermometer
- 1.6 ... is used to eliminate offset in process control.
- A Proportional action
  - B Derivative action 
  - C Integral action
  - D Feedback control action

- 1.7 Control process requiring direct human intervention:
- A Open-loop control
  - B Closed-loop control
  - C Cascade control
  - D Fuzzy control 
- 1.8 Relay valve increasing output when nozzle back-pressure decreases:
- A Direct-acting continuous bleed relay valve
  - B Reverse-acting continuous bleed relay valve
  - C Nonbleed relay valve
  - D Butterfly valve
- 1.9 Stators of a magstrip system consist of an internally slotted laminated iron ring with three sets of windings arranged in slots at angles of ... to one another.
- A 30°
  - B 60°
  - C 120° 
  - D 180°
- 1.10 Associated with calibration faults in Bourdon tube devices:
- A Hysteresis error
  - B Capillary error
  - C Parallax error
  - D Systematic error

(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.

- 2.1 400 °F is equivalent to 204 °C.
- 2.2 A capacitive level sensor measures the level in a tank where the liquid serves as dielectric.
- 2.3 In an ultrasonic level sensor, the time travelled by the transmitted pulse back to the receiver is an indication of the level in a tank.
- 2.4 The relationship between the pipe diameter and the diameter of a hole in the orifice plate cannot influence the calibration of this gauge. 
- 2.5 Derivative action time is defined as the time it takes for a proportional action to repeat a derivative action.

(5 × 1) [5]

**QUESTION 3**

Choose a term from COLUMN B that matches a description in COLUMN A. Write only the letter (A–I) next to the question number (3.1–3.5) in the ANSWER BOOK.

<b>COLUMN A</b>		<b>COLUMN B</b>	
3.1	Algebraic difference between the highest and the lowest calibration point of an instrument	A	fundamental interval
		B	orifice plate
3.2	Ability of some crystals to generate an emf proportional to the pressure variation	C	integral action time
		D	derivative action
3.3	Resistance difference of a thermometer between 100 °C and 0 °C	E	resistance thermometer
3.4	It consists of a disc with a hole placed in a pipe between two flanges	F	drift
		G	span
3.5	Time taken for the integral action to repeat the proportional action if the measured variable has a constant deviation	H	open channel
		I	piezo-electric effect

(5 × 1)

**[5]****TOTAL SECTION A:****[20]**

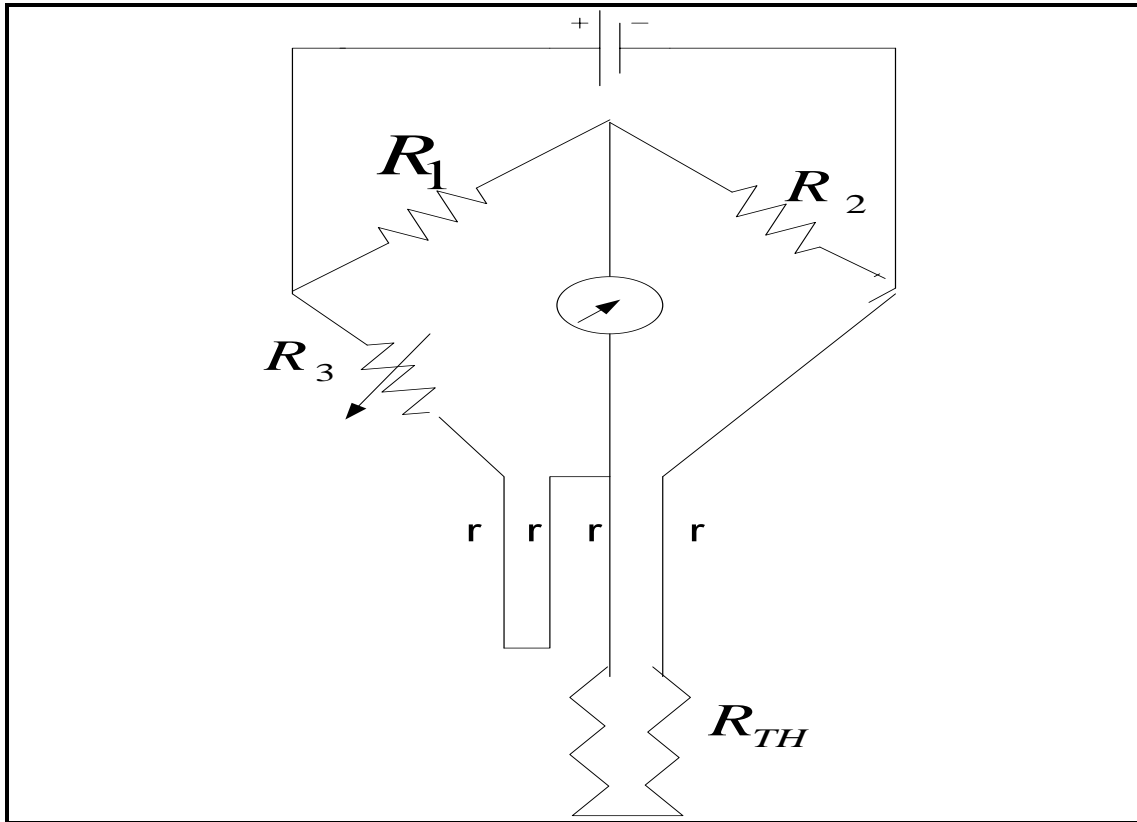
**SECTION B****QUESTION 4: ELECTRICAL AND NONELECTRICAL PRESSURE MEASUREMENT**

- 4.1 Calculate the applied differential pressure of an inclined manometer using mercury as a sealing liquid if the following information is known:
- Angle of tube with horizontal =  $45^\circ$
  - Area of cistern =  $0,039 \text{ m}^2$
  - Area of tube =  $0,00009 \text{ m}^2$
  - Scale reading =  $15 \text{ cm}$
- (5)
- 4.2 Calculate the resistance of a conductor with a length of 50 m, a diameter of 1 mm and a specific resistance of  $8 \times 10^{-5} \Omega/\text{m}$ . (4)
- 4.3 Explain the relationship between *inductance* and *reluctance*. (1)
- 4.4 Transducers are used to change mechanical signals to electrical signals.
- 4.4.1 Make a neat, labelled sketch of a piezo-electric pressure transducer. (5)
- 4.4.2 Explain how this transducer converts a mechanical signal to an electrical signal. (2)
- 4.4.3 Name THREE disadvantages of this type of a transducer. (3)
- [20]**

**QUESTION 5: NONELECTRICAL AND ELECTRICAL TEMPERATURE MEASUREMENT**

- 5.1 An analogue millivolt meter consisting of a moving coil meter can be used to monitor the output of a thermocouple.
- 5.1.1 Make a neat, labelled sketch of a moving coil meter. (5)
- 5.1.2 Explain the operating principle of the moving coil meter in QUESTION 5.1.1. (4)
- 5.2 What combination of metals is generally used in the construction of a bimetal thermometer? (2)

5.3 Study the circuit diagram and answer the questions.




**CIRCUIT DIAGRAM**

- 5.3.1 Name the circuit diagram. (1)
- 5.3.2 Calculate the output of the resistance thermometer  $R_{TH}$  at a temperature of 100 °C if its resistance is 10 Ω at 0 °C .The thermometer wire has a positive temperature coefficient of 0,004 Ω/Ω °C. (3)
- 5.3.3 State the conditions which must be met for the circuit so that it will compensate at any change of ambient temperature. (4)
- 5.3.4 Determine the value of  $R_3$  if the circuit compensates at any change of ambient temperature. (1)


**[20]**



**QUESTION 6: AUTOMATIC CONTROL AND TELEMETERING**

- 6.1 Draw simple electronic circuit diagrams showing each of the actions below in an operational amplifier. Clearly indicate the output for each of the control actions if a step input is used.
- 6.1.1 Integral control action (4)
- 6.1.2 Derivative control action (4)
- 6.2 Sketch the characteristic curves (% flow against valve opening) of a butterfly valve.  (2)
- 6.3 Make a labelled sketch of a resonant impedance bridge telemetering system. (7)
- 6.4 State the functions of the feedback element of a pneumatic telemetering system. (3)
- [20]**

**QUESTION 7: LEVEL AND FLOW MEASUREMENT**

- 7.1 The pressure difference across the narrowing in a pipe is 50 mm water at a flow rate of 80 m<sup>3</sup>/h.
- What will the flow rate be at a pressure difference of 100 mm water?  (3)
- 7.2 Explain the operating principle of a Pitot tube with the aid of a simple sketch. (11)
- 7.3 Make a neat, labelled sketch of a bellows-type level-measuring device consisting of a transmitter bellows in the tank and a receiver bellows at the pressure gauge. (6)
- [20]**

**TOTAL SECTION B: 80**  
**GRAND TOTAL: 100**

## INDUSTRIAL INSTRUMENTS N4

### FORMULA SHEET

$$(1) \Delta P = \rho gh$$

$$(2) \Delta P = \rho gh \left[ \frac{A_2}{A_1} + 1 \right]$$

$$(3) \Delta P = \rho gL \left[ \sin\theta + \frac{A_2}{A_1} \right]$$

$$(4) P_1 - P_2 = \frac{r_2 M g \sin\theta}{Ar_1}$$

$$(5) P_1 - P_2 = \frac{M g r \sin\theta}{AL}$$

$$(6) F = ma$$

$$(7) P = \frac{F}{A}$$

$$(8) A = \frac{\pi d^2}{4}$$

$$(9) R = \frac{\rho L}{A}$$

$$(9) {}^\circ\text{F} = \frac{9}{5} {}^\circ\text{C} + 32$$

$$(10) R_T = R_0(1 + \alpha T)$$

$$(11) R_T = R_0(1 + \alpha T + \beta T^2)$$

$$(12) Q = k\sqrt{h}$$

$$(13) H_L = \left[ \frac{\rho_m}{\rho_L} \right] \times h - \frac{h}{2}$$

$$(14) H_L = \left[ \frac{\rho_m}{\rho_L} \right] \times h - H_1 - \frac{h}{2}$$