higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

INDUSTRIAL INSTRUMENTS N6

(8080216)

1 April 2021 (X-paper)
09:00–12:00

Nonprogrammable calculators and drawing instruments may be used.

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

011Q1A2101

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

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. Start each section on a new page.
5. Use only a black or blue pen.
6. Write neatly and legibly.

SECTION A

QUESTION 1

Choose the correct term from those in brackets. Write only the answer next to the question number (1.1–1.5) in the ANSWER BOOK.

1.1 Integral action is also known as (rate/reset).

1.2 After (proportional/integral) action was applied, the process may oscillate and finally stabilise out at a point of equilibrium which may not be the desired value.

1.3 (Class/Division) designates the degree of hazardous material in a location.

1.4 A (calorie/joule) is the quantity of heat required to raise the temperature of one kilogram of water with one degree centigrade.

1.5 A (boiler/condenser) is a heat-transfer device that reduces a thermodynamic fluid from its vapour phase to its liquid phase.

(5 × 1) **[5]**

QUESTION 2

Choose ONE term from the list below for each of the following descriptions and write it next to the question number (2.1–2.5) in the ANSWER BOOK.

equal-percentage characteristic; quick-opening characteristic; valve actuator; control valve; fan interlock; low airflow interlock; close-loop control; cascade control loop; flashing; cavitation

2.1 Small-percentage valve opening resulting in a large amount of flow.

2.2 Device used to vary the flow of the control agent in response to a signal received from the controller.

2.3 All fuel shut off upon loss of airflow to the furnace.

2.4 Control loop consisting of two controllers where 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.

2.5 Phenomenon where pressure through a restriction recovers to a point greater than the vapour pressure of the fluid.

(5 × 1) **[5]**

QUESTION 3

Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (3.1–3.6) in the ANSWER BOOK. Correct the statement if it is FALSE.

3.1 Screwed connections are suitable for large-sized valves and flanges for small-sized valves when the valves are connected to the plant.

3.2 When the X-ray diffraction method is used to determine crystalline materials, the lines are broad and indistinct.

3.3 If the pressure within the throat falls below the vapour pressure of the liquid, vapour bubbles will form, causing flashing.

3.4 Sealing and immersion occur when the equipment is immersed in a liquid or solid material, usually sand or inert oil.

3.5 Air-to-open means that an increase in air pressure on the diaphragm causes the valve to close, which will result in a decrease in flow through the valve.

3.6 A split range occurs when two or more control loops are connected to a common valve in such a way that, under normal conditions, the normal control loop is in command of the valve.

[10]

TOTAL SECTION A: 20

SECTION B

QUESTION 4: ANALYSERS

4.1 Explain, with the aid of a sketch, the principle of operation of a Cutler-Hammer recording gas calorimeter. (6 + 6) (12)

4.2 Name the THREE most commonly used methods of excitation in emission spectrometers and state the most common application of each method. (3 × 2) (6)

4.3 Sketch a multisource excitation unit as used in an optical-emission spectrochemical analyser. (5)

[23]

QUESTION 5: AUTOMATIC CONTROL AND VALVES

5.1 Make a neat, labelled sketch of the components in a feedback control loop. (5)

5.2 Define each of the following terms:

5.2.1 Measurement lag

5.2.2 Process lag

5.2.3 Transfer lag

(3 × 2) (6)

5.3 The instrument gas supply on a particular plant was reduced from 10,85 bar to 2,3 bar using a control valve which has a C_v of 2,021.

Calculate the maximum quantity of gas in standard cubic metre per hour that could be drawn through the valve if the temperature of the gas is 86 °C and the barometric pressure is 1,0135 bar. The specific gravity of the gas is 0,86. (4)

5.4 Choose a term from COLUMN B that matches a description in COLUMN A. Write only the letter (A–E) next to the question number (5.4.1–5.4.5) in the ANSWER BOOK.

COLUMN A		COLUMN B	
5.4.1	When two or more control loops are connected to a common control valve in such a way that, under normal conditions, the normal control loop is in command of the valve	A	range ability
		B	turndown
		C	split-range control
5.4.2	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	D	valve coefficient
		E	override control
5.4.3	When one common controller signal commands two or more control valves		
5.4.4	Control valve based not upon the actual maximum flow of the valve, but upon the normal operating maximum flow		
5.4.5	Quantity of water that will pass through a specific valve size at maximum valve lift and one psi pressure drop		

(5 × 2) (10)

[25]

QUESTION 6: DISTILLATION COLUMN AND BOILERS

6.1 Complete the following paragraphs by writing only the missing word or words next to the question number (6.1.1–6.1.7) in the ANSWER BOOK.

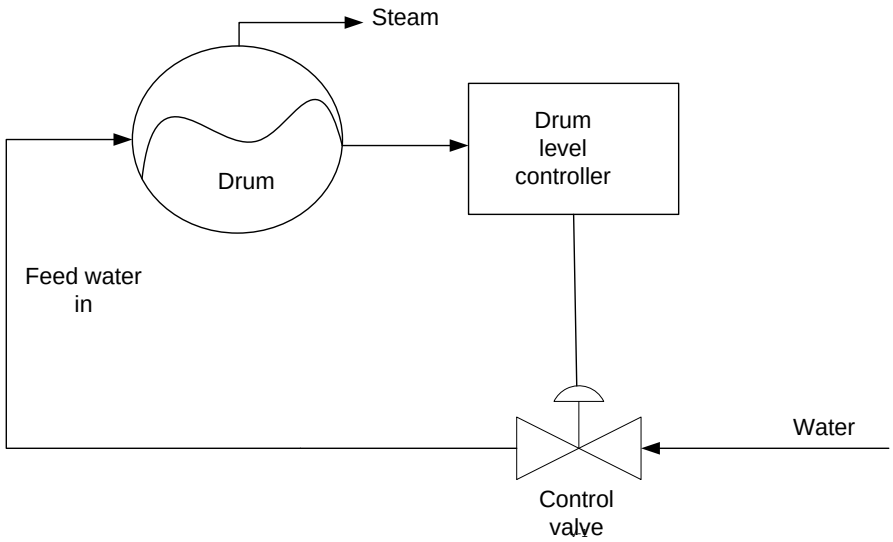
(6.1.1 …), is a process of heating a liquid until its more (6.1.2 ...) pass into the (6.1.3 …) phase, then cooling the vapour to recover such constituents in liquid form by (6.1.4 …)

A steam boiler consists of a (6.1.5 …) where air and (6.1.6 …) are combined and burned to produce (6.1.7 ...)

(7 × 1) (7)

6.2 Explain why fuel and air in boilers should be controlled in parallel rather than series. (3)

6.3



6.3.1 Which type of feedwater control system is shown in the sketch? (1)

6.3.2 Explain the working principle of the system shown in the sketch. (5)

6.4 Differentiate between *measurable fuel* and *unmeasurable fuel* and give ONE example of each. (2 + 2) (4)

[20]

QUESTION 7: INTRINSIC SAFETY

7.1 State SIX conditions that must be met simultaneously to create an explosion hazard. (6)

7.2 Which SIX steps of analysis are essential when designing for intrinsic safety? (6)

[12]

TOTAL SECTION B: 80
GRAND TOTAL: 100

FORMULA SHEET

1. $C_v = 1{,}16Q\sqrt{\frac{G_f}{\Delta P}}$

2. $C_v = \frac{1{,}16W}{\sqrt{G_f \Delta P}}$

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

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

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

6. $\text{Point of inflection} = \frac{\text{reaction range}}{2}$

8. $\%\text{ change in variable} = \frac{\text{point of inflection}}{\text{process range}} \times 100$

9. $R = \frac{\%\text{ change in variable}}{\text{time in minutes}}$

10. $\text{Proportional band} = \frac{100RL}{\Delta P}$

11. $\text{Proportional band} = \frac{110RL}{\Delta P}$

12. $\text{Integral rate(r / m)} = \frac{0{,}3}{L}$

13. $\text{Proportional band} = \frac{83RL}{\Delta P}$

14. $\text{Integral rate(r / m)} = \frac{0{,}5}{L}$