



**higher education
& training**

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

**NATIONAL CERTIFICATE
PLANT OPERATION THEORY N3**

(11040023)

**25 August 2021 (X-paper)
09:00–12:00**

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 4 pages and 1 formula sheet.



158Q1G2102

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
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PLANT OPERATION THEORY N3
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 question on a new page.
 5. Only use a black or blue pen.
 6. Write neatly and legibly.
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QUESTION 1: CHEMISTRY AND CATALYSTS

- 1.1 Explain how monomers grow in a chain to form polymers in the following basic conditions used for practical polymerisation:
- 1.1.1 Polymerisation in solution  (6)
- 1.1.2 Polymerisation in emulsion (4)
- 1.2 Sketch the structural formula of the following:
- 1.2.1 Polyvinyl Fluoride (2)
- 1.2.2 Ethanol  (3)
- 1.3 Name FIVE pure metals that have only one or two vacant orbitals in their electron structures. (5)
- [20]**


QUESTION 2: COMBUSTION; COOKING AND GASIFICATION OF COAL

- 2.1 Calculate the air fuel ratio if 5kg of carbon is completely combusted and if air contains 26% of oxygen by mass.  (5)
- 2.2 Calculate the energy supplied by the fuel to produce 2kg of steam if a boiler has an efficiency of 30%. The feed water is 20°C when it enters the evaporation tank. The pressure of the steam is 1 300 kPa and the steam has a dryness factor of 0,9.
- GIVEN [$h_f = 815$; $h_{fg} = 1971$] (5)
- 2.3 Describe FOUR forms in which sulphur appear in coal. (4)
- 2.4 Name THREE types of chemical compositions of coal. (3)
- 2.5 Gas is produced by introducing air and steam into a thick, hot layer or bed of coal or other combustible solids.  (8)
- Give FIVE reactions to illustrate the process of the production of fuel gas. (8)
- [25]**


QUESTION 3: HEAT TRANSFER, HEAT EXCHANGER AND THERMAL INSULATION

- 3.1 Heat is a form of energy and cannot be destroyed.
List FOUR sources of heat.  (4)
- 3.2 Make a labelled sketch to illustrate the simple circuit of a resistance thermometer and Wheatstone bridge of electrical effect. (4)
- 3.3 Rearrange the substances below in a sequence according to their capacity to conduct heat by starting with the lowest capacity to conduct heat to the highest capacity to conduct heat. i.e.:
Copper, aluminium, water and silver.  (4)
- 3.4 Sketch a labelled diagram of a double pass (shell and tube) heat exchanger. (10)
- 3.5 Explain the U-factor in referring to the efficiency of a heat exchanger. (3)
[25]

QUESTION 4: PUMPS AND COMPRESSION

- 4.1 Name THREE types of positive displacement pumps.  (3)
- 4.2 Explain TWO operating procedures when using centrifugal pumps. (6)
- 4.3 Explain each symbol in the formula, $PV=mRT$, not the units please. (6)
- 4.4 Give THREE advantages of piston type compressors. (3)
[18]

QUESTION 5: INSTRUMENTATION AND CONTROL SYSTEM

- 5.1 List THREE components of pneumatic control valves. (3)
- 5.2 Make a labelled drawing to illustrate the temperature controller of a closed and open loop control system.  (5)
- 5.3 Name FOUR automatic control actions performed by controllers. (4)
[12]

TOTAL: 100

FORMULA SHEET

Any applicable formula may be used.

1. $\rho = \frac{p}{gh}$
2. $V = \ell bh$
3. $V = \pi \frac{d^3}{6}$
4. $V = 4\pi \frac{r^3}{3}$
5. $V = x \left(\frac{\pi d^2 h}{12} + V_1 \right)$
6. $\Delta P = \rho gh$
7. $V = \pi \frac{d^2}{4} \times h$
8. $p = \frac{F}{A}$
9. $A = \pi r^2$
10. $A = \pi \frac{d^2}{4} = \pi r^2$
11. $\rho_1 gh = \rho_2 gh$
12. $Q = Av$
13. $k = \frac{Q}{\sqrt{h}}$
14. $E = \frac{mv^2}{2}$
15. $E = mgh$
16. $V = \pi DN$
17. $V = \frac{a}{t}$
18. $V = \sqrt{2gh}$
19. $PA = mg$
20. $h_{su} = m \{ (h_f + gh_{fg}) + C_s(t_{su} - t_s) - (C_w \times t_w) \}$
21. $m = \rho v$
22. $A = \frac{F}{p}$
23. $Pv = cT$
24. $m = \frac{Pv}{RT}$
25. $n = \frac{Pv}{R_0T}$
26. $V = A \ell N n R$
27. $K = \frac{Qx}{A \Delta t}$