higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

PLANT OPERATION THEORY N3

(11040023)

23 November 2022 (X-paper)
09:00–12:00

This question paper consists of 5 pages, 1 formula sheet and 1 steam table.

162Q1E2223

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
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. Use only a black or blue pen.
6. Write neatly and legibly.

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QUESTION 1: CHEMISTRY AND CATALYSTS

1.1 Differentiate between *thermoplastics* and *thermosetting plastics*. (4)

1.2 Sketch the molecular structures of each of the following:

1.2.1 Polymer (3)

1.2.2 Polyethylene (2)

1.3 Explain the synthesis of ammonia. (8)

1.4 Define the term *synthesis* and give an example. (3)
[20]

QUESTION 2: COMBUSTION, COKING AND GASIFICATION OF COAL

2.1 Make a labelled sketch of a bomb calorimeter. (11)

2.2 Explain each of the following:

2.2.1 Free ash (4)

2.2.2 Sulphur content in coal (4)

2.3 Give TWO advantages when steam and oxygen are used at high pressure during gasification. (4)

2.4 Define the term *fractionation*. (2)
[25]

QUESTION 3: HEAT TRANSFER, HEAT EXCHANGER AND THERMAL INSULATION

3.1 Name TWO methods of heat transfer. (2)

3.2 Name FIVE factors on which heat transfer by conduction depends. (5)

3.3 Give the name of a product produced in the catalytic cracking of hydrocarbons. (1)

3.4 Explain the construction and operation of a shell-and-tube heat exchanger. (4)

3.5 Name EIGHT components of shell-and-tube heat exchangers. (8)

3.6 Give an advantage of a floating-head heat exchanger. (2)
[22]

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QUESTION 4: PUMPS AND COMPRESSION

4.1 Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (4.1.1–4.1.5) in the ANSWER BOOK. Give a reason for each answer in (4.1.1-4.1.5).

4.1.1 In a single-acting pump valves are placed at both ends of the cylinder. (2)

4.1.2 Multicylinders have two cylinders and one piston. (2)

4.1.3 The action of a plunger pump and a piston pump are the same in both cases. (2)

4.1.4 Avogadro's law states that pressure is inversely proportional to volume provided that the temperature remains constant. (2)

4.1.5 Dalton's law states that when a container is filled with different gases, the total pressure of the gases will be the sum of the pressures that would be exerted separately by each of the gases of the same temperature. (2)

4.2 Calculate the volume delivered per hour by a pump of which the piston has a diameter of 250 mm and a stroke length of 200 mm. Its double action runs at 350 revolutions per minute. (4)

4.3 Explain each of the following compressors that are classified according to the pressures under which it operates:

4.3.1 Blowers (2)

4.3.2 Boosters (2)

4.3.3 Vacuum pumps (2)

[20]

QUESTION 5: INSTRUMENTATION AND CONTROL SYSTEMS

5.1 Make a labelled sketch of a pneumatic transmitter. (7)

5.2 Give ONE description for each of the following statements by writing it next to the question number (5.2.1–5.2.3) in the ANSWER BOOK.

5.2.1 Action performed by a controller to control the variables of a process (2)

5.2.2 Action that considers the magnitude, speed and direction of the variations of a measured variable (2)

5.2.3 Transmitter consisting of bellows, a flapper and a nozzle (2)
[13]

TOTAL: 100

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STEAMTABLES

P **kPa**	**ts** **°C**	**hf** **kJ/kg**	**hfg** **kJ/kg**	**hg** **kJ/kg**	**sg (C_s)** **kJ/kg.K**
100	99,6	418	2 258	2 676	7,360
300	133,5	561	2 163	2 724	6,991
500	151,8	640	2 107	2 747	6,819
700	165,0	697	2 065	2 762	6,705
900	175,4	743	2 030	2 773	6,619
1 200	188,0	798	1 984	2 782	6,519
1 500	198,3	845	1 945	2 790	6,441
2 000	212,4	908	1 889	2 797	6,337
2 500	223,9	962	1 839	2 801	6,254
3 000	233,8	1 008	1 794	2 802	6,184
5 000	263,9	1 155	1 640	2 795	5,974
8 000	295,0	1 317	1 443	2 760	5,747
10 000	311,0	1 408	1 320	2 728	5,620
14 000	336,6	1 572	1 071	2 643	5,380
18 000	357,0	1 735	779	2 514	5,113
22 000	373,7	2 011	185	2 196	4,186
22 120	***374,16***	2 107	***0***	2 107	4,443

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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. $h_{su} = m\{\rightleftarrows(h_f + gh_{fg}) + C_s(t_{su} - t_s) - (C_w \times t_w) \rightleftarrows \rightleftarrows\}$
21. $m = \rho v$
22. $A = \frac{F}{p}$
23. $Pv = cT$
24. $m = \frac{Pv}{RT}$
25. $n = \frac{Pv}{R_0 T}$
26. $V = A\ell NnR$
27. $K = \frac{Qx}{A\Delta t}$

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