higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

PLANT OPERATION THEORY N3

(11040023)

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

Drawing instruments and nonprogrammable calculators may be used.

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

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

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QUESTION 1: CHEMISTRY AND CHEMICAL PROCESSES

1.1	Draw the structure of polyisoprene.	(4)
1.2	Briefly explain why the molecular mass of a polymer is important.	(3)
1.3	Describe FOUR properties of thermoplastics.	(4)
1.4	Draw a labelled diagram or graph describing the role of a catalyst during a chemical reaction.	(4)
1.5	Define the term *dehydrogenation.*	(2)
1.6	Use a chemical reaction of dehydrogenation of ethanol to acetaldehyde to illustrate the dehydrogenation process.	(3)

[20]

QUESTION 2: COMBUSTION, FUELS AND THERMAL INSULATION

2.1	Explain what is meant by combustion of a fuel.	(2)
2.2	Determine the quantity of fuel or combustion air needed for a combustion of 1 kg of a fuel that consists of 65% carbon, 30% sulphur and 5% ash if 3,5% of excess air must be supplied.	(7)
2.3	Name FIVE impurities found in coal.	(5)
2.4	List FOUR types of thermal insulation material.	(4)
2.5	Explain the term *coefficient of thermal conductivity* (k).	(2)

[20]

QUESTION 3: STEAM BOILERS AND STEAM TRAPS

3.1	Explain what is meant by the dryness factor of steam.	(2)
3.2	A steam boiler produces superheated steam at a temperature of 298 °C. The steam boiler operating pressure is 22 Bar (absolute). Calculate the energy value of the superheated steam.	(5)
3.3	Briefly explain the function of the economiser in steam boilers.	(2)
3.4	List SIX reasons for a steam trap to be installed.	(6)
3.5	Name THREE types of steam traps.	(3)

[18]

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QUESTION 4: HEAT TRANSFER

4.1 Define the term *radiation*. (2)

4.2 Name SIX media that pass through the tube side in the *shell and tube heat* exchanger. (6)

4.3 Name any FIVE reasons for poor work performance of heat exchangers. (5)

4.4 Draw a labelled graph or diagram to illustrate the flow patterns of the heat of hot and cold medium in the heat exchanger. (8)

4.5 State THREE disadvantages of cooling towers. (3)

[24]

QUESTION 5: COMPRESSSION, PUMPS, COOLING AND INSTRUMENTATION

5.1 State *Charles's Law of Air Compression*. (2)

5.2 Describe the difference between *isothermal* and *adiabatic* compression. (4)

5.3 A mass of 9,4 kg of nitrogen is compressed to 500 litres, the temperature increases to 75 °C. The nitrogen gas constant is 0,297 kJ/kg K.

Calculate:

5.3.1 The final pressure of the nitrogen.

5.3.2 The final volume in m^3 of nitrogen if the pressure is 101,325 kPa.
Given: PV = mRT

(5 + 3) (8)

5.4 Name TWO general types of positive displacement compressors. (2)

5.5 Define the term *refrigeration* or *cooling system*. (2)

[18]

TOTAL: 100

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(11040023)

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. $\rho = \frac{F}{A}$
9. $A = \pi d^2$
10. $A = \pi \frac{d^2}{4} = \pi r^2$
11. $A = 4\pi r^2$
12. $R = \frac{output}{input} \times 100\%$
13. $\rho_1 gh = \rho_2 gh$
14. $Q = Av = C$
15. $k = \frac{Q}{\sqrt{h}}$
16. $E = \frac{mv^2}{2}$
17. $E = mgh$
18. $V = \pi DN$
19. $V = \frac{a}{t}$
20. $V = \sqrt{2gh}$
21. $PA = mg$
22. $h_{su} = m\{(h_f + gh_{fg}) + C_s(t_{su} - t_s) - (C_w \times t_w)\}$
23. $m = \rho v$
24. $A = \frac{F}{p}$
25. $K = \frac{mv^2}{2}$
26. $K = Wm^2K$
27. $Pv = cT$
28. $m = \frac{Pv}{RT}$
29. $n = \frac{Pv}{R_0 T}$
30. $V = A\ell NnR$
31. $K = \frac{Qx}{A\Delta t}$

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P	t_s	v_g	h_f	h_{fg}	h_g	s_f	s_g
kPa	°C	m^3/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg.K	kJ/kg.K
1 450	196,7	0,136 0	838	1 951	2 789	2,299	6,453
1 500	198,3	0,131 7	845	1 945	2 790	2,315	6,441
1 550	199,9	0,127 5	852	1 939	2 791	2,330	6,429
1 600	201,4	0,123 7	859	1 933	2 792	2,344	6,418
1 650	202,9	0,120 1	865	1 927	2 792	2,358	6,407
1 700	204,3	0,116 6	872	1 922	2 794	2,371	6,396
1 750	205,7	0,113 4	878	1 916	2 794	2,385	6,385
1 800	207,1	0,110 3	885	1 910	2 795	2,398	6,375
1 850	208,5	0,107 4	891	1 905	2 796	2,410	6,365
1 900	209,8	0,104 7	897	1 899	2 796	2,423	6,355
1 950	211,1	0,102 0	903	1 894	2 797	2,435	6,346
2 000	212,4	0,099 54	908	1 889	2 797	2,447	6,337
2 050	213,6	0,097 16	914	1 883	2 797	2,459	6,328
2 100	214,9	0,094 89	920	1 878	2 798	2,470	6,319
2 150	216,1	0,092 72	926	1 873	2 799	2,481	6,310
2 200	217,2	0,090 65	931	1 868	2 799	2,492	6,302
2 250	218,4	0,088 67	936	1 863	2 799	2,503	6,293
2 300	219,6	0,086 77	942	1 858	2 800	2,514	6,285
2 350	220,7	0,084 95	947	1 853	2 800	2,524	6,277
2 400	221,8	0,083 20	952	1 849	2 8.01	2,534	6,269
2 450	222,9	0,081 52	957	1844	2 801	2,544	6,261
2 500	223,9	0,079 91	962	1 839	2 801	2,554	6,254
2 550	225,0	0,078 35	967	1 834	2 801	2,564	6,246
2 600	226,0	0,076 86	972	1 830	2 802	2,574	6,239
2 650	227,1	0,075 41	977	1 825	2 802	2,583	6,232
2 700	228,1	0,074 02	981	1 821	2 802	2,592	6,224
2 750	229,1	0,072 68	986	1 816	2 802	2,602	6,217
2 800	230,1	0,071 39	991	1 811	2 802	2,611	6,210
2 850	231,0	0,070 14	995	1 807	2 802	2,620	6,204
2 900	232,0	0,068 93	1 000	1 802	2 802	2,628	6,197
2 950	232,9	0,067 76	1 004	1 798	2 802	2,637	6,190
3 000	233,8	0,066 63	1 008	1 794	2 802	2,646	6,184
3 100	235,7	0,064 47	1 017	1 785	2 802	2,662	6,171
3 200	235,7	0,062 44	1 025	1 777	2 802	2,679	6,159
3 300	239,2	0,060 53	1 034	1 768	2 802	2,695	6,146
3 400	240,9	0,058 73	1 042	1 760	2 802	2,710	6,134
3 500	242,5	0,057 03	1 050	1 752	2 802	2,725	6,123
3 600	244,2	0,055 41	1 058	1 744	2 802	2,740	6,112
3 700	245,8	0,053 89	1 065	1 736	2 801	2,755	6,100
3 800	247,3	0,052 44	1 073	1 728	2 801	2,769	6,090
3 900	248,8	0,051 06	1 080	1 721	2 801	2,783	6,079
4 000	250,3	0,049 75	1 087	1 713	2 800	2,797	6,069
4 100	251,8	0,048 50	1 095	1 705	2 800	2,810	6,058
4 200	253,2	0,047 31	1 102	1 698	2 800	2,823	6,048
4 300	254,7	0,046 17	1 109	1 690	2 799	2,836	6,038

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