higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1310(**E**)(A5)T

NATIONAL CERTIFICATE

PLANT OPERATION THEORY N3

(11040023)

5 April 2018 (X-Paper)
09:00–12:00

This question paper consists of 4 pages, 1 page of steam tables and 1 formula sheet.

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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. Sketches must be large, neat and fully labelled.
5. Write neatly and legibly.

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QUESTION 1: CHEMISTRY AND CHEMICAL PROCESSES

1.1 Explain why polybutadiene can be vulcanised but polyethylene cannot. (4)

1.2 Sketch the structure of Perspex or polymethyl methacrylate. (5)

1.3 Name the FOUR groups of catalysts suitable for use in the dehydrogenation processes. (4)

1.4 Explain the term *synthesis* and give an applicable example. (4)

1.5 Define the term *homogeneous catalysis*. (2)
[19]

QUESTION 2: COMBUSTION, FUELS AND THERMAL INSULATION

2.1 Determine the theoretical quantity of air needed to complete combustion of 1,8 kg of C_6H_{12}. The combustion takes place in the presence of 2% excess oxygen. (7)

2.2 Name the products formed when the following are oxidised:

2.2.1 Hydrogen. (2)

2.2.2 Carbon. (2)

2.2.3 Sulphur. (2)

2.3 Wet steam has a dryness factor smaller than one and it determines the quality of steam.
Define the *dryness factor.* (2)
[15]

QUESTION 3: STEAM BOILERS AND STEAM TRAPS

3.1 Discuss TWO advantages of dry saturated steam above superheated steam. (4)

3.2 A steam boiler produces steam for a hospital heating system.

The following information is applicable:

- Delivery steam pressure is 16,0 Bar (absolute)
- Dry saturated steam factor (X) is 0,9
- Boiler feed water (bfw) temperature is 101,4 °C
- Boiler feed water pressure 1 300 kPa (gauge)
- Atmospheric pressure is 100 kPa (absolutely)
- Steam production is 18 t/h
- Steam boiler thermal efficiency is 90%
- Fuel oil energy value is 18,232 GJ/ton

Calculate the fuel oil consumption per hour. (10)

3.3 Give FIVE reasons for installing steam traps in steam lines. (5)
[19]

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QUESTION 4: HEAT TRANSFER AND HEAT EXCHANGERS

4.1 State the FOUR uses of shell and tube heat exchangers and briefly discuss the applications thereof. (8)

4.2 Explain the *heat transfer coefficient* (U). (5)

4.3 List EIGHT basic components of a shell and tube heat exchanger. (8)
[21]

QUESTION 5: COMPRESSION, COOLING, PUMPS AND INSTRUMENTATION

5.1 State EIGHT characteristics that a refrigeration medium (refrigerant) must possess to be suitable for use in refrigeration systems. (8)

5.2 Briefly explain the FOUR classes of control systems. (8)

5.3 State Charles's law and illustrate it using an equation. (4)

5.4 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write 'true' or 'false' next to the question number (5.4.1-5.4.6) in the ANSWER BOOK.

5.4.1 In the centrifugal pump, the impeller forces the liquid from the outside walls to the centre of the pump by means of centrifugal forces.

5.4.2 The centrifugal pump is also known as a reciprocating pump.

5.4.3 The relief valve is installed as part of a power driven reciprocating pump, to safeguard the pump against possible damage due to overpressure.

5.4.4 The diaphragm pump isolates the fluid being pump from the reciprocating mechanism by means of a flexible metal or non-metallic material.

5.4.5 The rotary pump uses one or more pistons to force the liquid in rotation between one or more stages given very high pressures.

5.4.6 All pumps need a pressure relief valve except the positive displacement pumps.

(6×1) (6)
[26]

TOTAL: 100

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STEAM TABLES/STOOMTABELLE

P kPa	ts °C	vg m^3/kg	hf kJ/kg	hfg kJ/kg	hg kJ/kg	sf kJ/kg.K	sg kJ/kg.K
900	175.4	0.215	743	2030	2773	2.094	6.619
950	177.7	0.204	753	2022	2775	2.117	6.601
1000	179.9	0.194	763	2014	2777	2.138	6.583
1050	182.0	0.186	772	2006	2778	2.159	6.566
1100	184.1	0.177	781	1999	2780	2.179	6.550
1150	186.1	0.170	790	1991	2781	2.198	6.534
1200	188.0	0.163	798	1984	2782	2.216	6.519
1250	189.8	0.157	807	1977	2784	2.234	6.505
1300	191.6	0.151	815	1971	2786	2.251	6.491
1350	193.4	0.146	823	1964	2787	2.268	6.478
1400	195.0	0.141	830	1958	2788	2.284	6.465
1450	196.7	0.136	838	1951	2789	2.299	6.453
1500	198.3	0.132	845	1945	2790	2.315	6.441
1600	201.4	0.124	859	1933	2792	2.344	6.418
1700	204.3	0.117	872	1922	2794	2.371	6.396
1800	207.1	0.110	885	1910	2795	2.398	6.375
1900	209.8	0.105	897	1899	2796	2.423	6.355
2000	212.4	0.100	908	1889	2797	2.447	6.337
2100	214.9	0.950	920	1878	2798	2.470	6.319
2200	217.2	0.910	931	1868	2799	2.492	6.302
2300	219.6	0.087	942	1858	2800	2.514	6.285
2400	221.8	0.083	952	1849	2801	2.534	6.269
2500	223.9	0.080	962	1839	2801	2.554	6.254
2600	226.0	0.077	972	1830	2802	2.574	6.239
2700	228.1	0.074	981	1821	2802	2.592	6.224
2800	230.1	0.071	991	1811	2802	2.611	6.210
2900	232.0	0.069	1000	1802	2802	2.628	6.197
3000	233.8	0.067	1008	1794	2802	2.646	6.184

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

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