higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

PLANT OPERATION THEORY N3

(11040023)

27 November 2024 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

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

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
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NATIONAL CERTIFICATE
PLANT OPERTION 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

Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (1.1–1.10) in the ANSWER BOOK.

1.1 Sulphur is noncombustible component of fuel.

1.2 The steam drum is where heat is generated by combustion of the fuel.

1.3 Petro graphical is the description and classification of rocks.

1.4 Pyrometer is an instrument used to measure pressure.

1.5 The purpose of the condenser is to heat liquids.

1.6 Haber process is used in the production of sulphuric acid.

1.7 Avogadro's law state that total pressure of a mixture of gases is the sum of individual partial pressures.

1.8 In boosters, the suction pressure is higher than atmospheric pressure.

1.9 Sublimation is the change of state from solid to gas.

1.10 Pressure and temperature are energy variables.

(10 × 1) **[10]**

QUESTION 2: CHEMISTRY AND CHEMICAL PROCESSES

2.1 Describe THREE properties of thermo-setting plastics like Bakelite. (3 × 2) (6)

2.2 Name any FOUR transition metal oxide used as catalysts during hydrogenation and dehydrogenation. (4)

2.3 Define or explain the term *dehydrogenation.* (2)

2.4 Write down the balanced chemical reaction of decomposition of potassium chlorite to form potassium chloride and oxygen using a suitable catalyst. (5)

2.5 Define what is meant by the term *catalyst*. (2)

[19]

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QUESTION 3: COMBUSTION, FUELS AND THERMAL INSULATION

3.1 The analysis of a solid fuel is as follows:

Carbon (C) = 80%
Sulphur (S) = 15%
Ash = 5%

Calculate the quantity of combustion air needed for complete combustion of 2 kg of this fuel, if the combustion takes place in the presence of 3,5% excess combustion air. (14)

3.2 Name FOUR classifications of coal. (4)

3.3 List FOUR characteristics for a suitable insulation material. (4)
[22]

QUESTION 4: STEAM BOILERS AND STEAM TRAPS

4.1 Give a short description for each of the following terms:

4.1.1 Specific heat capacity

4.1.2 Dry saturated steam

(2 × 1) (2)

4.2 A steam boiler produces steam for clothing factory heating system.

Calculate the energy per hour added, to produce the steam under the following conditions:

Delivery steam pressure is 15 Bar (absolute)
Dry saturated steam factor (*x*) is 0,85
Boiler feed water (Bfw.) temperature is 100 °C
Bfw. pressure 1 100 kPa (gauge)
Atmospheric pressure is 100 kPa (absolute)
Steam production is 5,3 t/h (8)

4.3 Define the term *latent heat*. (2)

4.4 State any FOUR advantages of steam traps. (4)
[16]

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QUESTION 5: HEAT TRANSFER

5.1 Explain what a *pyrometer* is used for. (2)

5.2 Heat can be generated from an existing source.

Name FOUR sources of heat. (4)

5.3 Name FOUR types of heat exchangers that are classified according to the purposes they are used for. (4)

5.4 Describe the THREE disadvantages of cooling towers. (3)

5.5 Explain the purpose of coolers. (2)

[15]

QUESTION 6: COMPRESSSION, PUMPS, COOLING AND INSTRUMENTATION

6.1 Explain the *displacement* or *capacity* of a pump. (2)

6.2 Name THREE types of reciprocating pumps. (3)

6.3 Determine the final pressure in kPa if a gas is compressed from a volume of 50 m^3 at a temperature of 250 °C and a pressure of 670 kPa to a volume of 20 m^3 at a temperature 320 °C. (3)

6.4 Draw a labelled diagram of isothermal and adiabatic curves of compression of gas. (4)

6.5 Name FOUR types of compression. (4)

6.6 Explain what is meant by a *refrigeration* or a *cooling system*. (2)

[18]

TOTAL: 100

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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. $\rho = \frac{F}{A}$
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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STEAM TABLE

The properties of steam have been determined by calculation and experiment and are listed in steam tables. This is only a shorten reproduction of the steam tables available.

NB: Pressure quoted in steam tables refers to absolute pressure.

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

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