higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1390**(E)**(D1)T

NATIONAL CERTIFICATE

POWER MACHINES N5

(8190035)

1 December 2017 (X-Paper)
09:00–12:00

REQUIREMENTS: **Steam Tables (BOE 173).**
Superheated Steam Tables (Appendix to BOE 173)

Candidates need drawing instruments.
Calculators may be used.

This question paper consists of 5 pages and 3 formula sheets.

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NATIONAL CERTIFICATE
POWER MACHINES N5
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. Write neatly and legibly.

QUESTION 1

1.1 State THREE compounds with their chemical symbols that are formed when the combustion of fuel is complete. (3 × 2) (6)

1.2 State TWO functions of a steam condenser. (2 × 2) (4)
[10]

QUESTION 2

Air in a cylinder has a pressure of 95 kPa and a temperature of 38 °C. The air is compressed according to the law $PV^{1,24} = C$, until the pressure is 650 kPa. The initial volume of air is 1,25 m^3. Take the gas constant R as 0,287 kJ/kg.

Calculate:

2.1 The mass of the air (4)

2.2 The final volume of the air after compression (3)

2.3 The final absolute temperature of the air after compression (4)

2.4 The work done on the air during compression (4)
[15]

QUESTION 3

Feedwater enters an economiser at a temperature of 32,9 °C in a steam boiler plant. The boiler has a pressure of 2 500 kPa and uses 650 kg of coal per hour. The calorific value of the coal is 33 MJ/kg. Feedwater from the economiser enters the boiler at a temperature of 90 °C. The boiler produces 5 000 kg of wet steam per hour and the steam is 0,95 dry.

Calculate:

3.1 The quantity of heat absorbed by the feedwater in the economiser (4)

3.2 The thermal efficiency of the boiler (7)

3.3 The equivalent evaporation (EE) from and at 100 °C (4)
[15]

QUESTION 4

The barometer and manometer readings of a surface condenser are 755 mmHg and 650 mmHg respectively. The condenser receives 200 kg of steam per minute and is 10% wet. The inlet temperature of the cooling water is 15 °C and the outlet temperature is 23 °C. The condensate leaves the condenser at a temperature of 45,8 °C.

Take specific heat capacity of water as 4,187 kJ/kg.K.

Calculate:

4.1 The absolute pressure (3)

4.2 The mass of cooling water (9)

4.3 The logarithmic temperature difference (3)
[15]

QUESTION 5

A liquid fuel C_7H_{18} of 1 kg mass with 40% excess air is completely burned. The atomic masses of these elements are:

Hydrogen = 1
Oxygen = 16
Carbon = 12

Assume that air consists of 23% oxygen and 77% nitrogen by mass.

Calculate:

5.1 The theoretical mass of air required for complete combustion of 1 kg of the fuel (5)

5.2 The actual mass of air required for the combustion of 1 kg of the fuel (2)

5.3 The mass of each product of combustion (4)

5.4 The percentage of each mass of combustion (4)
[15]

QUESTION 6

1 kg mass of air enters a single cylinder, single-stage air compressor at a pressure of 103 kPa and a temperature of 22 °C. The air is then compressed according to the law $PV^n = C$ to a pressure of 900 kPa and a volume which is $\frac{1}{6}$ of the initial volume. Ignore clearance volume. Take R for air as 0,287 kJ/kg.K.

Calculate:

6.1 The compression index (n) (5)

6.2 The absolute temperature compression (3)

6.3 The volume after compression (3)

6.4 The work done per kg of air (4)
[15]

QUESTION 7

The velocity of a gas leaving the nozzle of a single-stage impulse turbine is 900 m/s and the nozzle angle is 20°. The blade velocity is 300 m/s and the blade velocity of the coefficient is 0,7. The mass flow rate of the gas is 1 kg/s. The inlet and the outlet angles of the moving blade are equal.

7.1 Construct a velocity diagram in the ANSWER BOOK (landscape) and enter ALL the values (m/s) onto the diagram. Use the scale 1 mm : 5 m/s.

NOTE: NO marks will be given if the values are not indicated on the diagram and if the diagram is NOT constructed to scale. (8)

7.2 Determine the following from the velocity diagram:

7.2.1 The inlet velocity of the moving blade (1)

7.2.2 The outlet velocity of the moving blade (1)

7.2.3 The axial thrust (2)

7.2.4 The diagram efficiency (3)
[15]

TOTAL: 100

POWER MACHINES N5

FORMULA SHEET

1. $Q = W + \Delta U$

2. $\Delta U = mC_{\upsilon}\Delta T$

3. $Q = mC_{\upsilon}\Delta T$

4. $Q = mC_{p}\Delta T$

5. $Q = P_1V_1 \ln \frac{V_2}{V_1}$

6. $\Delta S = m\left(C_{\upsilon} \ln \frac{T_2}{T_1} + R \ln \frac{V_2}{V_1} \right)$

7. $W = P_1\Delta V$

8. $W = P_1V_1 \ln \frac{V_2}{V_1}$

9. $W = \frac{P_1V_1 - P_2V_2}{n-1}$

10. $W = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$

11. $R = C_p - C_{\upsilon}$

12. $\gamma = \frac{C_p}{C_{\upsilon}}$

13. $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

14. $PV = mRT$

15. $P_1V_1 = P_2V_2$

16. $P_1V_1^n = P_2V_2^n$

17. $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} = \left(\frac{V_1}{V_2}\right)^{n-1}$

18. $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$

19. $h = h_f + \chi h_{fg}$

20. $h = h_g + C_p\Delta T$

21. $h = h_f + h_{fg} = h_g$

22. $V_{sup} = \frac{n-1}{n}\left(\frac{h_{sup} - 1\,941}{P}\right)$

23. $\chi = \frac{V_m}{V_g}$

24. $\chi = \frac{M}{M + m}$

25. $U = H - PV$

26. $gZ_1 + U_1 + P_1V_1 + \frac{1}{2}C_1^2 + Q = gZ_2 + U_2 + P_2V_2 + \frac{1}{2}C_2^{\,2} + W$

27. $\eta = \frac{\dot{m}_s(h_2 - h_1)}{\dot{m}_f\, CV}$

28. $EE = \frac{\dot{m}_s(h_2 - h_1)}{\dot{m}_f\; 2\,257}$

29. $p = (B_m \pm M_m)\frac{101{,}325}{760}$

30. $$m = \frac{100}{23}\left[C\frac{8}{3} + 8H_2 + S - O_2\right]$$

31. $$C_xH_y + \left(x + \frac{y}{4}\right)O_2 = xCO_2 + \frac{y}{2}H_2O$$

32. $$H.C.V. = (CV_C.C) + CV_{H_2}\left(H_2 - \frac{O_2}{8}\right) + (CV_s.S)$$

33. $$L.C.V. = H.C.V. - h_{fg}\ (9H_2)$$

34. $$H.C.V. = \frac{(m_w + m_e)\ C_p\Delta T}{m_f}$$

35. $$W = P_1V_e\left(\frac{n}{n-1}\right)\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right] = mRT_1\left(\frac{n}{n-1}\right)\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right]$$

36. $$\eta_c = \frac{V_e}{V_s}.100 = 1 - \frac{Vc}{Vs}\left[\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} - 1\right] = 1 + \alpha - \alpha(r_p)^{\frac{1}{n}}$$

37. $$\eta_\alpha = \frac{V_\alpha}{V_s}.100$$

38. $$F_c = \dot{m}(C_{fe} - C_{fi})$$

39. $$P = \dot{m}U[C_{wi} - (-C_{we})]$$

40. $$\eta = \frac{2U[C_{wi} - (-C_{we})]}{C_{ai}{}^2}.100$$

41. $$U = \pi DN$$

42. $$\dot{m}V = AC$$

43. $$(m + M)g = m\omega^2 h$$

44. $$Vs = \frac{\pi}{4}D^2L$$

45. $\theta_1 = t_c - twi$

46. $\theta_2 = t_c - two$

47. $$Log.temp.diff. = \frac{\theta_1 - \theta_2}{\ell n \frac{\theta_1}{\theta_2}}$$

48. $$Piso = P_1 V_1 \ \ell n \left(\frac{P_2}{P_1} \right)$$

49. $$Pact = \frac{n}{n-1} P_1 V_1 \left[\left(\frac{P_2}{P_1} \right)^{\frac{n-1}{n}} - 1 \right]$$

50. $$Niso = \frac{Piso}{Pact} \bullet 100$$