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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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APRIL 2011

NATIONAL CERTIFICATE

POWER MACHINES N5

(8190035)

6 April (X-Paper)
09:00 – 12:00

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

Candidates will require drawing instruments, pens and ruler.

Calculators may be used.

This question paper consists of 5 pages and a 3-page formula sheet.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
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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 correctly according to the numbering system used in this question paper.
4. Write neatly and legibly.

QUESTION 1

1.1 State the purpose of the Orsat apparatus. (2)

1.2 Name TWO types of axial flow turbines. (2)

1.3 Name TWO types of steam boilers. (2)

1.4 State the SI unit for thermodynamic temperature. (2)

1.5 Name TWO types of steam condensers. (2)
[10]

QUESTION 2

0,5 kg of gas is expanded from 2 068 kPa and a volume of 0,0566 m^3 to 103,4 kPa according to the law $PV^{1,4} = C$. The gas constant 'R' is 0,288 kJ/kg.K and Cv is 0,72 kJ/kg.K.

Calculate the following:

2.1 The final volume (3)

2.2 The original absolute temperature (3)

2.3 The final absolute temperature (3)

2.4 The work done in kilojoules (3)

2.5 The heat received or rejected in kilojoules (3)
[15]

QUESTION 3

11,5 kg of water, at a pressure of 880 kPa and a temperature of 48 °C is heated to boiling point, then dry to saturated steam and then to superheated steam, with a temperature of 210 °C. The specific heat capacity of superheated steam is
2,1 kJ/kg.°C and that of water is 4,187 kJ/kg.°C.

Calculate the following with the aid of steam tables:

3.1 The enthalpy of the sensible heat in MJ (3)

3.2 The enthalpy of the latent heat in MJ (3)

3.3 The enthalpy of the superheat in kJ (3)

3.4 The enthalpy of the total heat required for superheating the water in MJ (3)

3.5 The saturation temperature of the steam (3)
[15]

QUESTION 4

4.1 A boiler must supply 1 850 kg of steam per hour, at a pressure of 1 MPa and a temperature of 250 °C. The feed water temperature is measured at 26,7 °C and the thermal efficiency of the boiler is 72%. The heat value of the coal burnt is 32,5 MJ/kg.

Calculate the following:

4.1.1 The mass of coal used per hour (7)
4.1.2 The equivalent evaporation from and at 100 °C (3)

4.2 Steam is throttled from a pressure of 760 kPa to a pressure of 400 kPa and a temperature of 150 °C.

Calculate the dryness fraction of the steam. (5)
[15]

QUESTION 5

The volumetric composition of a gas is:

Hydrogen	6,5%
Carbon monoxide	16%
Methane (CH_4)	4,5%
Carbon dioxide	13%
Oxygen	5%
Nitrogen	55%

The atomic masses are:

Hydrogen	1
Carbon	12
Nitrogen	14
Oxygen	16

Draw a table using the following headings: Symbol; % by volume; molecular mass; % volume × molecular mass, % by mass and determine the composition of the gas by mass. **[15]**

QUESTION 6

A double-acting, single stage air compressor is required to deliver 6,5 kg of air per minute at a pressure of 510 kPa. The temperature and pressure at the end of the suction stroke are 21 °C and 98 kPa respectively. The compressor runs at 245 r/min and it has a clearance volume of 5% of the stroke volume. The index for compression and expansion is 1,33 and R for air is 0,287 kJ/kg.K. The stroke length is 242 mm and the piston diameter is 200 mm.

Calculate the following:

6.1 The swept volume (3)

6.2 The volume 'V1' (3)

6.3 The volume 'V3' (3)

6.4 The volume 'V4' (3)

6.5 The compressor power (3)
[15]

QUESTION 7

An impulse turbine has a blade ring which is 1,91 m in diameter and it rotates at 3 500 r/min. The blade speed is 0,35 of the steam velocity leaving the nozzles, which are inclined at 20° to the plane of the wheel. The velocity coefficient of friction is 0,9 and there is no axial thrust.

7.1 Calculate the blade velocity of the turbine in m/s. (3)

7.2 Calculate the velocity of the steam leaving the nozzles. (3)

7.3 Use scale 1 cm = 50 m/s and construct a velocity diagram in the ANSWER BOOK (landscape) and enter ALL the values (m/s) onto the diagram. (5)

7.4 Use the diagram and determine the following:

7.4.1 The diagram efficiency (2)
7.4.2 The power developed per kilogram of steam per second (2)
[15]

TOTAL: 100

POWER MACHINES N5

FORMULA SHEET

1. $Q = W + \Delta U$
2. $\Delta U = mC_v \Delta T$
3. $Q = mC_v \Delta T$
4. $Q = mC_p \Delta T$
5. $Q = P_1V_1 \ln \frac{V_2}{V_1}$
6. $\Delta S = m\left(C_v \ln \frac{T_2}{T_1} + R \ln \frac{V_2}{V_1}\right)$
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. $R = C_p - C_v$
12. $\gamma = \frac{C_p}{C_v}$
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. $$(m+M)g=m\omega^2h$$

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