higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

POWER MACHINES N5

(8190035)

12 August 2021 (X-paper)
09:00–12:00

REQUIREMENTS: **Properties of water and steam (BOE 173)**
Superheated steam tables (Appendix to BOE 173)

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 6 pages and a formula sheet of 3 pages.

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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. Start each question on a new page.
5. Only use a black or blue pen.
6. Write neatly and legibly.

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QUESTION 1

1.1 State THREE particulars to be marked on the shell of every new boiler according to factory law C95. (3)

1.2 Which TWO elements form a hydrocarbon compound? (2)

1.3 Complete the following sentences by filling in the missing word or words. Write only the word or words next to the question number (1.3.1–1.3.2) in the ANSWER BOOK.

1.3.1 A\An … is stable if for each speed within the working range there is only one radius of rotation for equilibrium.

1.3.2 Fuel and oxygen are basic reactants in a\an … reaction.

(2 × 1) (2)

1.4 Various options are given as possible answers to the following questions. Choose the correct answer and write only the letter (A–D) next to the question number (1.4.1–1.4.3) in the ANSWER BOOK.

1.4.1 What is the volume of wet steam at a pressure of 180 kPa with a dryness fraction of 0,85?

A 0,9342
B 0,0992
C 0,8306
D 0,05

1.4.2 TWO types of common pumps:

A Watt and Porter
B Edwards and Hamilton
C Cooling tower and condenser
D Impulse and reaction

1.4.3 An equipment that raises the temperature of feed water:

A Orsat apparatus
B Bomb calorimeter
C Air preheater
D Economiser

(3 × 1) (3)

[10]

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QUESTION 2

100 kJ of heat is used to raise the temperature of a certain gas from an initial temperature of 288 K and a volume of 0,5 m^3 to a temperature of 350 K at a constant pressure. The specific heat capacity at constant pressure and at constant volume is 1 kJ/kg.K and 0,707 kJ/kg.K, respectively.

Determine the following:

2.1	The mass of the gas in kg	(3)
2.2	The characteristic gas constant in kJ/kg.K	(2)
2.3	The original pressure	(2)
2.4	The volume at the end of the isobaric process	(3)
2.5	The work done during the isobaric process in kJ	(4)
2.6	The change in internal energy in kJ	(3)
2.7	The change in entropy (ΔS) of the gas in kJ/kg	(3)

[20]

QUESTION 3

Steam at a pressure of 2 300 kPa and a temperature of 230 ^oC expands to 280 kPa with a dryness fraction of 0,85. The specific heat capacity of superheated steam is 2 kJ/kg.K. Take n = 1,3.

Determine the following:

3.1	The enthalpy of the steam before expansion in kJ/kg	(3)
3.2	The volume of the steam before expansion in m^3/kg	(3)
3.3	The internal energy before expansion in kJ/kg	(3)
3.4	The specific enthalpy after expansion in kJ/kg	(3)
3.5	The volume after expansion in m^3/kg	(3)
3.6	The internal energy after expansion in kJ/kg	(3)
3.7	The change in internal energy lost in kJ/kg	(2)

[20]

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QUESTION 4

4.1 The capacity of an air pump installed in a condenser is 1,3 m^3 per minute, while the condensate and the air suction pump have a temperature of 32,9 ^oC and 34 ^oC, respectively. The barometer reading is 775 mmHg and the manometer reading is 680 mmHg.

R = 0, 293 kJ/kg.K and Cp_{water} = 4,187 kJ/kg.K

Determine the following:

4.1.1 The total pressure in kPa (2)

4.1.2 The mass of air in kilogram per minute (4)

4.2 A sample of 1,01 kg of coal contains the following analysis by mass:

C = 80%
H_2 = 10%
S = 5%
O_2 = 5%

The heat value of carbon, hydrogen and sulphur is 35 MJ/kg, 145 MJ/kg and 9 MJ/kg, respectively. The latent heat of steam formed in the exhaust gas is 2 433 kJ/kg. The specific heat capacity of the exhaust is 1,045 kJ/kg.K

Determine the following:

4.2.1 The higher heat value in MJ/kg (5)

4.2.2 The lower heat value in MJ (5)

4.2.3 The available heat value in MJ, if the mass of the dry products obtained is 0,5 kg and the rise in temperature is 32 ^oC (4)

[20]

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QUESTION 5

A single-acting, single-cylinder air compressor delivers air at a pressure of 600 kPa. The compressor runs at a speed of 320 r/min, while air enters the compressor at 100 kPa. The compressor has a volumetric efficiency of 73%. The clearance volume is 0,014 m^3. The index of compression is given as n = 1,35.

Determine the following:

5.1	The stroke/swept volume in m^3	(5)
5.2	The effective volume of air in m^3	(4)
5.3	The work done in kJ	(4)
5.4	The work done in kJ per minute	(2)
		[15]

QUESTION 6

An impulse turbine has an average diameter of 318 mm. The speed of the turbine wheel is 300 r/min. The moving blade inlet angle is 30°. The gas leaves the turbine at an angle of 80°. The relative inlet velocity is 450 m/s. The coefficient of friction is 0,8.

6.1	Calculate the peripheral velocity in m/s.	(3)
6.2	Construct a velocity diagram on LANDSCAPE ORIENTATION. Indicate all angles and velocity values in m/s. Use a scale of 1 cm = 50 m/s.	(10)
6.3	Determine the following:	
6.3.1	The nozzle angle	
6.3.2	The blade outlet angle	
	(2 × 1)	(2)
		[15]

TOTAL: 100

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

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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. $$\theta_1 = t_c - twi$$

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

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