higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1270(E)(A8)T
**APRIL EXAMINATION**

# NATIONAL CERTIFICATE

# POWER MACHINES N5

(8190035)

**8 April 2014 (Y-Paper)**
**13:00–16:00**

**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 1 formula sheet of 3 pages.**

# DEPARTMENT OF HIGHER EDUCATION AND TRAINING
# REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
POWER MACHINES N5
TIME: 3 HOURS
MARKS: 100

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**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.

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## QUESTION 1

2,682 kg of gas is expanded at a constant pressure of 680 kPa from 22 °C to 0,34 $m^3$. The gas is then further expanded adiabatically to a pressure of 180 kPa. The specific heat capacity of this gas at a constant pressure and constant volume is 1,05 kJ/kg.K and 0,779 kJ/kg.K respectively.

Calculate the following:

1.1 The volume at the commencement of the first process and at the end of the second process (10)

1.2 The absolute temperature at the end of each of the processes (6)

1.3 The total work done (4)

**[20]**

## QUESTION 2

The clearance volume of a single-cylinder, single-acting, air compressor is 6,5% of the swept volume. Air is sucked in at 100 kPa and 23 °C and is delivered at 778 kPa. The compressor runs at 300 r/min and the stroke to diameter ratio is 1,6. The air is consumed at a rate of 46 kg/min whilst the compressor has a mechanical efficiency of 75%. The gas constant for air is 0,286 kJ/kg.K and the index n = 1,37.

Calculate the following:

2.1 The volumetric efficiency (6)

2.2 The piston diameter and the stroke length (10)

2.3 The power required to drive the compressor (4)

**[20]**

## QUESTION 3

3.1 50% excess air is used to burn 1 $m^3$ of gas. The gas consists of the following:

$H_2$ = 43%
$CH_4$ = 23%
CO = 22%
$N_2$ = 12%
Air contains 21% oxygen by volume.

Calculate the following:

3.1.1 The volume of oxygen required (6)

3.1.2 The volume of air required to completely burn the gas (2)

3.1.3 The volume of each of the dry products of combustion (10)

3.2 Air pumps are used to remove air from the condenser to maintain a vacuum in the condenser.

Name TWO types of air pumps. (2)

**[20]**

## QUESTION 4

4.1 5 kg of gas is delivered to a single-stage impulse turbine every second. The nozzles are inclined at an angle of 19° and the velocity of the gas is 1 000 m/s. The gas loses 24% velocity due to friction over the blades. The outlet angle of the moving blade is 22° and the peripheral speed of the wheel is 400 m/s.

4.1.1 Use a scale of 1 cm = 50 m/s and construct a velocity diagram in the ANSWER BOOK. Enter all the values (m/s) onto the diagram.

NB: No marks will be awarded if the values (m/s) are not entered onto the diagram and if the diagram is not constructed to the given scale.

HINT: Use the answer page in the landscape format to construct the diagram. (8)

4.1.2 Determine the following from the diagram:

A The inlet angle of the moving blades (1)

B The power developed by the turbine (3)

C The diagram efficiency (3)

D The exit angle of the gas from the turbine (1)

4.2 Knowledge and skill is required to burn fuel efficiently.

Give TWO reasons why fuel should be burnt efficiently. (2)

4.3 Name TWO types of dead weight governors. (2)

**[20]**

## QUESTION 5

5.1 4,2% wet steam which is in a main line at a pressure of 2 MPa is passed through a separating and throttling calorimeter. The conditions in the throttling calorimeter are 140 °C and 200 kPa. The specific heat capacity for superheated steam is 2,09 kJ/kg.K.

Calculate the dryness fraction as recorded in the separating calorimeter. (8)

5.2 A boiler, which has an efficiency of 73%, produces 5 500 kg of steam per hour at a temperature of 350 °C and 4 000 kPa. The water enters the boiler at a temperature of 39 °C. The calorific value of the coal used is 35 MJ/kg.

Calculate the following:

5.2.1 The mass of coal consumed every minute (7)

5.2.2 The equivalent evaporation from and at 100 °C (3)

5.3 Name the TWO theoretical calorific values of a fuel. (2)

**[20]**

**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. $Q = P_1 V_1 \ln \dfrac{V_2}{V_1}$

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

7. $W = P_1 \Delta V$

8. $W = P_1 V_1 \ln \dfrac{V_2}{V_1}$

9. $W = \dfrac{P_1 V_1 - P_2 V_2}{n - 1}$

10. $W = \dfrac{P_1 V_1 - P_2 V_2}{\gamma - 1}$

11. $R = C_p - C_v$

12. $\gamma = \dfrac{C_p}{C_v}$

13. $\dfrac{P_1 V_1}{T_1} = \dfrac{P_2 V_2}{T_2}$

14. $PV = mRT$

15. $P_1 V_1 = P_2 V_2$

16. $P_1 V_1^n = P_2 V_2^n$

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

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

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

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

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

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

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

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

25. $U = H - PV$

26. $gZ_1 + U_1 + P_1 V_1 + \dfrac{1}{2} C_1^2 + Q = gZ_2 + U_2 + P_2 V_2 + \dfrac{1}{2} C_2{}^2 + W$

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

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

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

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

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