higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

POWER MACHINES N6

12 APRIL 2019

This marking guideline consists of 8 pages.

✓= 1 mark

√= ½ mark

QUESTION 1

1.1 $$Q_{econ} = (m_a + 1)C_p(t_{in} - t_{out})$$
$$= (18+1) \times 1,05(300 - 200) \quad ✓$$
$$= 1\,995 kJ / kg \ \ fuel \quad ✓$$ (2)

1.2 $$Q_{\sup} = (m_a + 1)C_p(t_{in} - t_{out})$$
$$= (18+1) \times 1,05(465 - 300) \quad ✓$$
$$= 3\,291,75 kJ / kg \ \ fuel \quad ✓$$ (2)

1.3 $$\eta_{th} = \frac{Q_{econ.} + Q_{evap.} + Q_{\sup.}}{CV} \quad ✓$$
$$0,82 = \frac{1\,995 + Q_{evap.} + 3\,291,75}{31\,000} \quad ✓$$
$$Q_{evap.} = 20\,133,25 kJ / kg \ \ fuel \quad ✓$$ (3)

1.4 $$At\ 2\,000\ kPa;\ h_f = 908 kj / kg;\ h_{fg} = 1\,889 kJ / kg;\ t_s = 212,4°C \quad ✓$$
$$At\ 107,1°C;\ h_{fw2} = 449 kJ / kg$$

$$Q_{evap.} = \frac{m_s}{m_f}\left[h_f + x.h_{fg} - h_{fw2}\right] \quad ✓$$
$$20\,133,25 = \frac{9,5}{1}\left[908 + x.1\,889 - 449\right] \quad ✓$$
$$x = 0,879 \quad ✓$$ (4)

1.5 $$Q_{\sup.} = \frac{m_s}{m_f}\left[(1-x)h_{fg} + C_p(t_{su} - t_s)\right] \quad ✓$$

$$3\,291,75 = \frac{9,5}{1}\left[(1-0,879) \times 1\,889 + 2,6(t_{su} - 212,4)\right] \quad ✓✓$$
$$t_{su} = 257,758°C \quad ✓$$ (4)

1.6

$$\%_{chimney} = \frac{m_g C_{pg}\left(t_{chim.} - t_{atm.}\right)}{CV} \quad \checkmark$$
$$= \frac{(18+1)\times 1,05(200-24)}{31\,000}\times 100\% \quad \checkmark$$
$$= 11,326\% \quad \checkmark$$

$$\eta_{unaccounted} = 100\% - \eta_{plant} - \eta_{chimney}$$
$$= 100\% - 82\% - 11,326\% \quad \checkmark$$
$$= 6,674\% \quad \checkmark$$

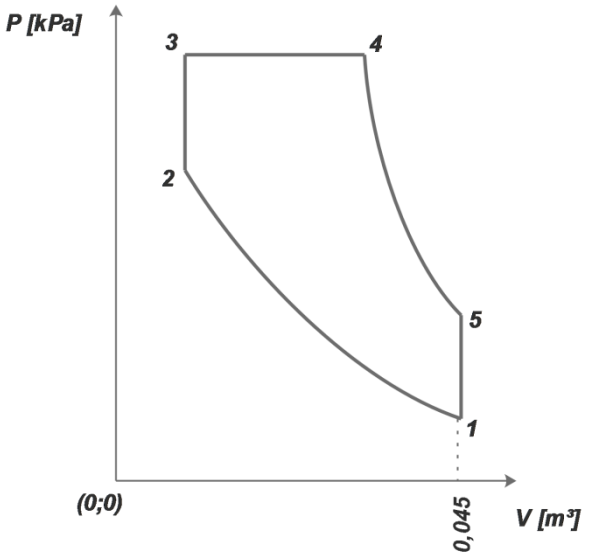
(5)
[20]

QUESTION 2

2.1

$$V_c = V_2 = V_3 \quad \checkmark$$
$$= \frac{V_1}{r_c}$$
$$= \frac{0,045}{9} \quad \checkmark$$
$$= 0,005m^3 \quad \checkmark$$

$$V_4 = 2,4V_c$$
$$= 2,4\times 0,005$$
$$= 0,012m^3 \quad \checkmark$$



(4)

2.2

$$r_e = \frac{V_1}{V_4}$$
$$= 0,045 : 0,012 \quad \checkmark$$
$$= 3,75 : 1 \quad \checkmark$$

(2)

2.3

$$\gamma = \frac{C_p}{C_v}$$
$$= \frac{1,005}{0,718} \quad \checkmark$$
$$= 1,4 \quad \checkmark$$

(2)

2.4

$$T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1}$$
$$= 304(9)^{0,4} \quad \checkmark$$
$$= 732,1K \quad \checkmark$$

$$T_3 = \frac{P_3}{P_2} \times T_2$$
$$= 1,5 \times 732,1 \quad \checkmark$$
$$= 1\,098,15K \quad \checkmark$$

$$T_4 = \frac{V_4 T_3}{V_3}$$
$$= \frac{0,012 \times 1\,098,15}{0,005} \quad \checkmark$$
$$= 2\,635,56K \quad \checkmark$$

OR

$$T_4 = r_c \times T_3$$
$$= 2,4 \times 1\,098,15$$
$$= 2\,635,56K$$

$$T_5 = T_4\left(\frac{V_4}{V_5}\right)^{\gamma-1}$$
$$= 2\,635,56\left(\frac{0,012}{0,045}\right)^{0,4} \quad \checkmark$$
$$= 1\,553,318K \quad \checkmark$$

(8)

2.5

$$Q_{in} = Q_{2-3} + Q_{3-4}$$
$$= mC_v(T_3 - T_2) + mC_p(T_4 - T_3) \quad \checkmark$$

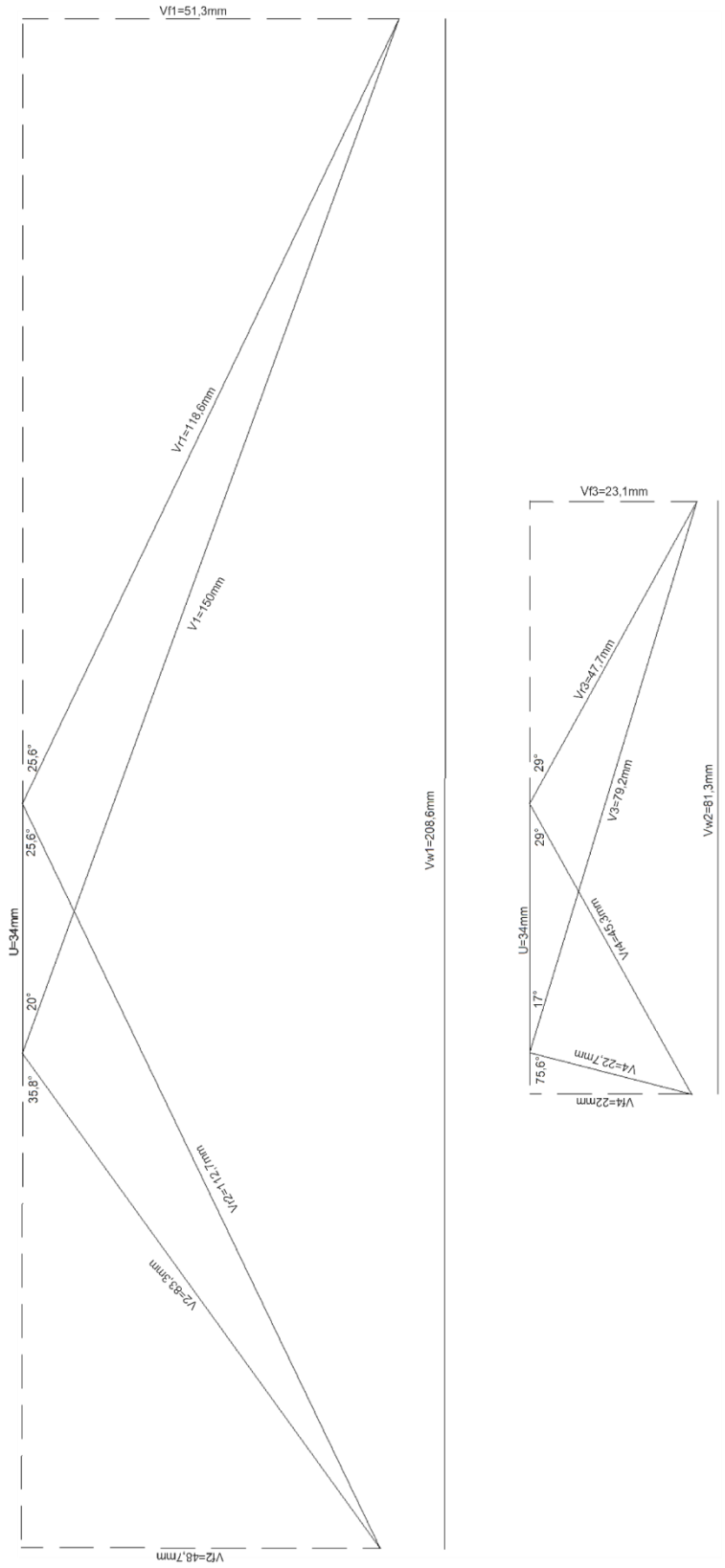
$$= 1 \times 0,72(1\,098,15 - 732,1) \quad \checkmark \quad + \quad 1 \times 1,008(2\,635,56 - 1\,098,15) \quad \checkmark$$
$$= 1\,813,265kJ/kg \quad \checkmark$$

(4)

[20]

QUESTION 3

3.1



Award ½ mark for each correct length or angle, up to a maximum of 5 marks per stage. (10)

3.2 3.2.1 $\theta_1 = \phi_1 = 25,6°$ ✓ (1)

3.2.2 $\theta_2 = \phi_2 = 29°$ ✓ (1)

3.2.3 $\beta_1 = 35,8°$ ✓ (1)

3.2.4 $\beta_2 = 75,6°$ ✓ (1)

3.2.5 $V_2 = 83,3 \times 5 = 416,5 m/s$ ✓ (1)

3.2.6 $V_3 = 79,2 \times 5 = 396 m/s$ ✓ (1)

3.2.7 $F_{ax.} = m\left[\left(V_{f1} - V_{f2}\right) + \left(V_{f3} - V_{f4}\right)\right]$ ✓
$= 20\left[\left(51,3 - 48,7\right) \times 5\right.$ ✓ $+ \left.\left(23,1 - 22\right) \times 5\right]$ ✓
$= 370N$ ✓ (4)

[20]

QUESTION 4

4.1 4.1.1 $At\ 2\ 000kPa$ and $250°C: h_1 = 2\ 904 kJ/kg$
$At\ 1\ 150kPa: h_g = 2\ 781 kJ/kg; t_s = 186,1°C$

$h_c = h_g + C_p\left(t_{su} - t_s\right)$ ✓
$= 2\ 781 + 2,3\left(188 - 186,1\right)$ ✓
$= 2\ 785,37 kJ/kg$ ✓

4.1.2 $C_c = \sqrt{2\ 000\left(h_1 - h_c\right)}$ ✓
$= \sqrt{2\ 000\left(2\ 904 - 2\ 785,37\right)}$ ✓
$= 487,09 m/s$ ✓

4.1.3 $V_c = \dfrac{n-1}{n}\left[\dfrac{h_c - 1\ 941}{P_c}\right]$ ✓
$= \dfrac{0,35}{1,35}\left[\dfrac{2\ 785,37 - 1\ 941}{1\ 150}\right]$ ✓
$= 0,19 m^3/kg$ ✓

4.1.4 $$A_c = \frac{mV_c}{C_c} \quad \checkmark$$

$$= \frac{\left(\frac{510}{60}\right) \times 0,19}{487,09} \times 10^6 \quad \checkmark$$

$$= 3\,315,609 mm^2 \quad \checkmark$$

(4 × 3) (12)

4.2 4.2.1 $At\ 700kPa: h_f = 697kJ/kh;\ h_{fg} = 2\,065kJ/kg;\ v_g = 0,272\,7m^3/kg$

$$\Delta h = h_1 - h_2$$
$$200 = 2\,904 - h_2 \quad \checkmark$$
$$h_2 = 2\,704kJ/kg \quad \checkmark$$

(2)

4.2.2 $$h_2 = h_f + x.h_{fg} \quad \checkmark$$
$$2\,704 = 697 + x \times 2\,065 \quad \checkmark$$
$$x = 0,972 \quad \checkmark$$

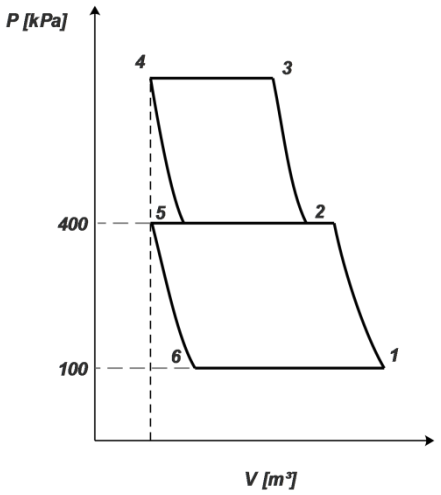
(3)

4.2.3 $$V_2 = x.v_g \quad \checkmark$$
$$= 0,972 \times 0,272\,7 \quad \checkmark$$
$$= 0,265m^3/kg \quad \checkmark$$

(3)
[20]

QUESTION 5

5.1 $$P_1V_{e1} \times N = mRT_1 \quad \checkmark$$
$$100 \times 54\,000 \times 10^{-6} \times 300 = m \times 0,288 \times 299 \quad \checkmark$$
$$m = 18,813kg/\min \quad \checkmark$$



(3)

5.2

$$T_2' = T_1\left(\frac{P_2}{P_1}\right)^{\left(\frac{n-1}{n}\right)} \quad \checkmark$$

$$= 299\left(\frac{400}{100}\right)^{\left(\frac{0,3}{1,3}\right)} \quad \checkmark$$

$$= 411,726K \quad \checkmark$$

(3)

5.3

$$Q_{\text{int.}} = mC_p\left(T_2' - T_2\right) \quad \checkmark$$

$$26 \times 60 = 18,813 \times 1,008\left(411,726 - T_2\right) \quad \checkmark$$

$$T_2 = 329,463K \quad \checkmark$$

(3)

5.4 5.4.1

$$\eta_{vol.} = \frac{V_{e1}}{V_{s1}} \quad \checkmark$$

$$0,89 = \frac{54\,000 \times 10^{-6}}{V_{s1}} \quad \checkmark$$

$$V_{s1} = 0,061m^3 \text{ / } stroke \quad \checkmark$$

(3)

5.4.2

$$V_{s1} = \frac{\pi}{4}D_1^{\,2}L_1$$

$$= \frac{\pi}{4}D_1^{\,2} \times 1,2D_1$$

$$= \frac{1,2\pi}{4}D_1^{\,3}$$

$$D_1 = \sqrt[3]{\frac{4V_{s1}}{1,2\pi}} \quad \checkmark$$

$$= \sqrt[3]{\frac{4 \times 0,061}{1,2\pi}} \times 1\,000 \quad \checkmark$$

$$= 401,501mm \quad \checkmark$$

$$L_1 = 1,2D_1$$

$$= 1,2 \times 401,501 \quad \checkmark$$

$$= 481,801mm \quad \checkmark$$

(5)

5.5

$$\frac{P_2V_{e2}}{T_2} = \frac{P_1V_{e1}}{T_1} \quad \checkmark$$

$$\frac{400 \times V_{e2}}{329,463} = \frac{100 \times \left(54\,000 \times 10^{-6}\right)}{299} \quad \checkmark$$

$$V_{e2} = 0,014\,88m^3 \text{ / } stroke \quad \checkmark$$

OR

$$V_{e2} = \frac{mRT_2}{P_2 \times N}$$

$$= \frac{18,813 \times 0,288 \times 329,463}{300 \times 400}$$

$$= 0,014\,88m^3 \text{ / } stroke$$

(3)

[20]

TOTAL: 100