



higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

POWER MACHINES N5

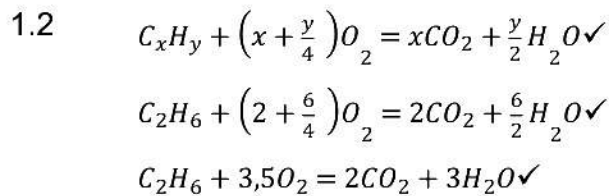
9 April 2024

This marking guideline consists of 9 pages.

QUESTION 1

- 1.1 1.1.1 C
 1.1.2 D

(2 × 1) (2)



(3)
[5]

QUESTION 2

2.1 $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} \checkmark$

$$\ln\left(\frac{T_2}{T_1}\right) = \frac{n-1}{n} \ln\left(\frac{P_2}{P_1}\right)$$

$$\ln\left(\frac{370}{280}\right) = \frac{n-1}{n} \ln\left(\frac{810}{180}\right) \checkmark$$

$$\frac{n-1}{n} = \frac{0,279}{1,504} \checkmark$$

$$n-1 = 0,186n \checkmark$$

$$n = 1,229 \checkmark$$

(5)

2.2 $P_1V_1 = mRT_1 \checkmark$

$$V_1 = \frac{(2,39)(0,287)(280)}{(180)} \checkmark$$

$$V_1 = 1,067 \text{ m}^3 \checkmark$$

(3)

2.3 $\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^n \checkmark$

$$\left(\frac{810}{180}\right)^{\frac{1}{1,229}} = \frac{1,067}{V_2} \checkmark \checkmark$$

$$V_2 = 0,314 \text{ m}^3 \checkmark$$

Alternative

$$P_2V_2 = mRT_2 \checkmark$$

$$V_2 = \frac{(2,39)(0,287)(370)}{(810)} \checkmark \checkmark$$

$$V_2 = 0,313 \text{ m}^3 \checkmark$$

$$2.4 \quad WD = \frac{P_1 V_1 - P_2 V_2}{n - 1} \checkmark$$

$$WD = \frac{(180)(1,067) - (810)(0,313)}{1,229 - 1} \checkmark \checkmark$$

$$WD = 268,279 \text{ kJ} \checkmark$$

Alternative

$$WD = \frac{mR(T_1 - T_2)}{n - 1} \checkmark$$

$$D = \frac{(2,39)(0,287)(280 - 370)}{1,229 - 1} \checkmark \checkmark$$

$$WD = -269,579 \text{ kJ} \checkmark$$

(4)

$$2.5 \quad \Delta S = m \left[R \ln \left(\frac{V_2}{V_1} \right) + C_v \ln \left(\frac{T_2}{T_1} \right) \right] \checkmark$$

$$\Delta S = (2,39) \left[(0,287) \ln \left(\frac{0,313}{1,067} \right) + (0,72) \ln \left(\frac{370}{280} \right) \right] \checkmark \checkmark$$

$$\Delta S = -0,3616 \frac{\text{kJ}}{\text{K}} \checkmark$$

OR

$$\Delta S = m \left[R \ln \left(\frac{V_2}{V_1} \right) + C_v \ln \left(\frac{T_2}{T_1} \right) \right] \checkmark$$

$$\Delta S = (2,39) \left[(0,287) \ln \left(\frac{0,314}{1,067} \right) + (0,72) \ln \left(\frac{370}{280} \right) \right] \checkmark \checkmark$$

$$\Delta S = -0,3594 \frac{\text{kJ}}{\text{K}} \checkmark$$

Alternative

$$R = C_p - C_v$$

$$0,287 = C_p - 0,72$$

$$C_p = 1,007 \frac{\text{kJ}}{\text{kg.K}} \checkmark$$

$$\Delta S = m \left[C_v \ln \left(\frac{P_2}{P_1} \right) + C_p \ln \left(\frac{V_2}{V_1} \right) \right] \checkmark$$

$$\Delta S = (2,39) \left[(0,72) \ln \left(\frac{810}{180} \right) + (1,007) \ln \left(\frac{0,314}{1,067} \right) \right] \checkmark$$

$$\Delta S = -0,3557 \frac{\text{kJ}}{\text{K}} \checkmark$$

Alternative

$$R = C_p - C_v$$

$$0,287 = C_p - 0,72$$

$$C_p = 1,007 \frac{\text{kJ}}{\text{kg.K}} \quad \checkmark$$

$$\Delta S = m \left[R \ln \left(\frac{P_1}{P_2} \right) + C_p \ln \left(\frac{T_2}{T_1} \right) \right] \checkmark$$

$$\Delta S = (2,39) \left[(0,287) \ln \left(\frac{180}{810} \right) + (1,007) \ln \left(\frac{370}{280} \right) \right] \checkmark$$

$$\Delta S = -0,3609 \frac{\text{kJ}}{\text{K}} \checkmark$$

[20]

QUESTION 3

3.1 $P = 3\,000 \text{ kPa}$ and 250°C ✓

$$h_{su} = 2\,858 \frac{\text{kJ}}{\text{kg}} \checkmark$$

$$V_{su} = 0,0706 \frac{\text{m}^3}{\text{kg}} \checkmark$$

$$U = h - PV$$

$$U = 2\,858 - (3\,000)(0,0706) \checkmark$$

$$U = 2\,646,2 \frac{\text{kJ}}{\text{kg}} \checkmark$$

$$P = 800 \text{ kPa} \checkmark$$

$$h_{wet} = h_f + x h_{fg}$$

$$h_{wet} = 721 + (0,82)(2\,047) \checkmark$$

$$h_{wet} = 2\,399,54 \frac{\text{kJ}}{\text{kg}} \checkmark$$

$$V_{wet} = x V_g$$

$$V_{wet} = 0,82 \times 0,2403 \checkmark$$

$$V_{wet} = 0,19704 \frac{\text{m}^3}{\text{kg}} \checkmark$$

$$U = h - PV$$

$$U = 2\,399,54 - (800)(0,19704) \checkmark$$

$$U = 2\,241,94 \frac{\text{kJ}}{\text{kg}} \checkmark$$

$$\Delta U = m(U_1 - U_2) \checkmark$$

$$\Delta U = (0,3)(2\,646,2 - 2\,241,94) \checkmark$$

$$\Delta U = 121,278 \text{ kJ} \checkmark$$

Alternative

$$\Delta U = m(U_2 - U_1)$$

$$\Delta U = (0,3)(2\,241,94 - 2\,646,2)$$

$$\Delta U = -121,278 \text{ kJ} \quad (15)$$

3.2 3.2.1 $h_f = 101 \frac{\text{kJ}}{\text{kg}} \checkmark$

$h_g = 2781 \frac{\text{kJ}}{\text{kg}} \checkmark$

$h_{\text{required}} = 2\,100(2\,781 - 101)$

$h_{\text{required}} = 5,628 \frac{\text{MJ}}{\text{hr}} \checkmark \quad (3)$

3.2.2 $V_g = 0,1700 \frac{\text{m}^3}{\text{kg}}$

$V_g = 2\,100 \times 0,1700 \checkmark$

$V_g = \frac{357}{3\,600}$

$0,0992 \frac{\text{m}^3}{\text{s}} \checkmark \quad (2)$

[20]

QUESTION 4

4.1 $P = (B_m - M_m) \frac{101,325}{760}$

$P = (705 - 635) \frac{101,325}{760} \checkmark$

$P = 9,333 \text{ kPa}$

$P \approx 9 \text{ kPa} \checkmark$

Heat emitted by steam = Heat absorbed by water

$$h_1 = h_2$$

$$m_s[xh_{fg} + h_c] = mC_p(T_2 - T_1) \quad \checkmark$$

$$m_s[xh_{fg} + C_p(t_s - t_c)] = mC_p(T_2 - T_1)$$

$$2\,500[(0,85 \times 2\,398) + (4,187)(43,8 - 37)] = m(4,187)(21) \checkmark$$

$$\checkmark \quad \checkmark \quad m = 58\,763,849 \frac{\text{kg}}{\text{hr}} \times \frac{1 \text{ hr}}{60 \text{ min}} \checkmark$$

$$m = 979,397 \frac{\text{kg}}{\text{min}}$$

Alternative *Heat emitted by steam = Heat absorbed by water*

$$h_1 = h_2$$

$$m_s[h_f + xh_{fg} - h_c] = mC_p(T_2 - T_1) \checkmark$$

$$2\,500[183 + (0,85 \times 2\,398) - (4,187 \times 37)] = m(4,187)(21) \checkmark$$

$$m = 58\,752,744 \frac{\text{kg}}{\text{hr}} \times \frac{1 \text{ hr}}{60 \text{ min}} \checkmark$$

$$m = 979,212 \frac{\text{kg}}{\text{min}} \checkmark \quad (8)$$

4.2

SYMBOL	% BY VOLUME	MOLECULAR MASS	% XMM	% BY MASS
CO ₂	22	44	22 × 44 = 968✓	✓30,479
N ₂	72	28	72 × 28 = 2 016✓	63,476
O ₂	6	32	6 × 32 = 192✓	✓✓6,045
			3 176	✓100

(7)
[15]

QUESTION 5

5.1 5.1.1 $S_V = V_1 - V_3$

$$V_e = V_1 - V_4$$

$$V_3 = V_c = 0$$

$$V_4 = V_3 \left(\frac{P_3}{P_4} \right)^{\frac{1}{n}}$$

$$V_4 = 0$$

$$S_V = V_1$$

$$V_e = V_1$$

$$S_V = V_e \checkmark$$

$$S_V = \frac{2 \text{ m}^3}{\text{min}} \times \frac{\text{min}}{320 \text{ r}} \checkmark$$

$$S_V = 0,00625 \text{ m}^3 \checkmark$$

$$S_V = \frac{\pi d^2 l}{4}$$

$$S_V = \frac{\pi (1,5 \text{ l})^2 l}{4} \checkmark$$

$$0,00625 = \frac{2,25 \pi l^3}{4}$$

$$l = \sqrt[3]{\left(\frac{4 \times 0,00625}{2,25\pi}\right)}$$

$$l = 0,152 \text{ m} \checkmark$$

$$d = 1,5 \text{ l} \checkmark$$

$$d = 1,5 \times 0,152 \checkmark$$

$$d = 0,228 \text{ m} \checkmark$$

(8)

5.1.2

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

$$T_2 = (298) \left(\frac{810}{108}\right)^{\frac{1,2-1}{1,2}} \checkmark$$

$$T_2 = 416,927 \text{ K} \checkmark$$

(3)

5.1.3

$$P = \frac{n}{n-1} P_1 V_e \left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1 \right] \checkmark$$

$$P = \frac{1,2}{1,2-1} (108) \frac{2}{60} \left[\left(\frac{810}{108}\right)^{\frac{1,2-1}{1,2}} - 1 \right] \checkmark$$

$$P = 8,62 \text{ kW} \checkmark$$

(4)

5.2

$$h = 0,26 \cos 30^\circ$$

$$h = 0,225 \text{ m} \checkmark$$

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

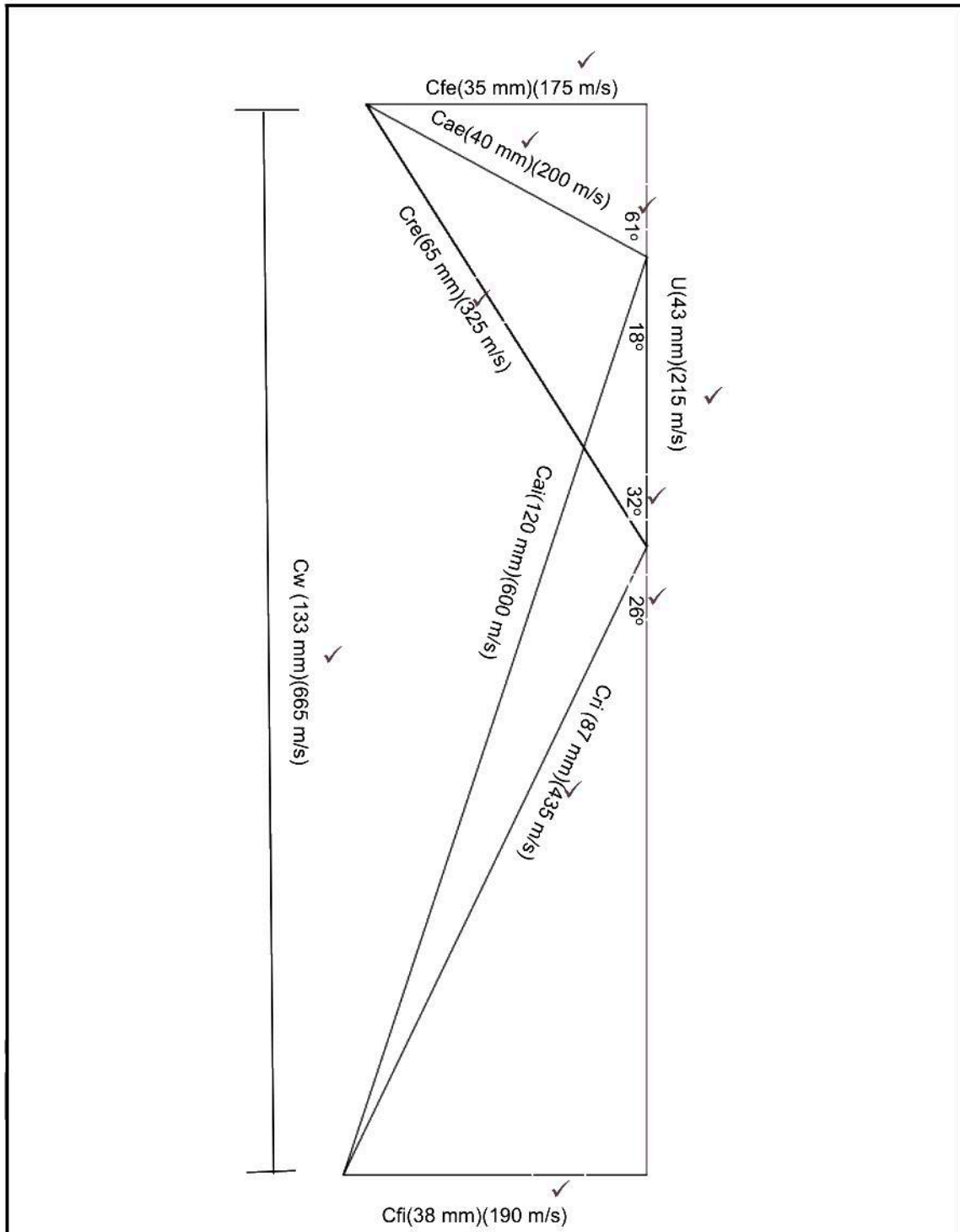
$$1,2 \left(\frac{2\pi 150}{60}\right)^2 (0,225) = (1,2 + M)9,8 \checkmark$$

$$M = 5,597 \text{ kg} \checkmark$$

(5)
[20]

QUESTION 6

6.1



(10)

6.2 6.2.1 $\theta = 26^\circ$ ✓
 $\beta = 61^\circ$ ✓

(2)

6.2.2 $F = m(C_{fi} - C_{fe})$ ✓
 $F = (2,8)(190 - 175)$ ✓✓
 $F = 42 \text{ N}$ ✓

...

6.2.3 $P = mUC_w$ ✓

$$P = \frac{(2,8)(215)(665)}{1\,000}$$
 ✓

$$P = 400,33 \text{ kW}$$
 ✓

(4)
[20]

TOTAL: 100