



**higher education
& training**

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

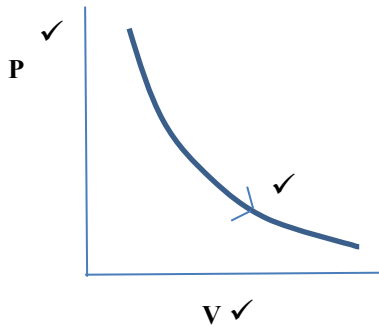
POWER MACHINES N5

13 July 2022

This marking guideline consists of 7 pages.

QUESTION 1

1.1



(3)

1.2 Heat flows spontaneously from a substance at a higher temperature to a substance at a lower temperature✓ and does not flow spontaneously in the reverse direction.✓

(2)

1.3 1.3.1 Condenser
1.3.2 Heat value(s)

(2 × 1) (2)

1.4 1.4.1 A
1.4.2 C
1.4.3 A

(3 × 1) (3)
[10]**QUESTION 2**

$$\begin{aligned} \frac{V_1}{V_2} &= \frac{3}{1} & \checkmark \\ \frac{4,2}{V_2} &= \frac{3}{1} & \checkmark \\ V_2 &= 1,4 \text{ m}^3 & \checkmark \end{aligned}$$

(3)

$$\begin{aligned} P_1 V_1 &= m R T_1 & \checkmark \\ m &= \frac{120 \times 4,2}{0,288 \times 295} & \checkmark \\ m &= 5,932 \text{ kg} & \checkmark \end{aligned}$$

(3)

$$\begin{aligned} P_1 V_1 &= P_2 V_2 & \checkmark \\ P_2 &= \frac{120 \times 4,2}{1,4} & \checkmark \\ P_2 &= 360 \text{ kPa} & \checkmark \end{aligned}$$

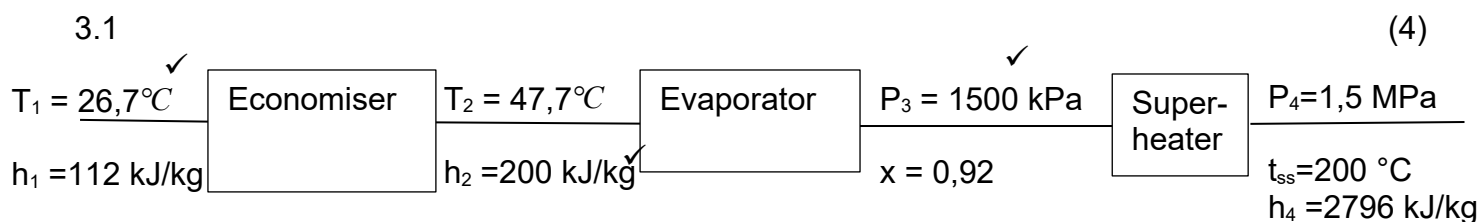
(3)

$$\begin{aligned} WD &= P_1 V_1 \ln \frac{V_2}{V_1} & \checkmark & \checkmark \\ WD &= (120)(4,2) \ln \left(\frac{1}{3} \right) & \checkmark \\ WD &= -553,701 \text{ kJ} \end{aligned}$$

(4)

2.5 $\Delta U = 0 \text{ kJ}$
 $Q = WD$
 $Q = -553,701 \text{ kJ}$ (3)

3.6 $\Delta S = R \ln \frac{V_2}{V_1} + C_v \ln \frac{T_2}{T_1}$ ✓
 $\Delta S = 0,288 \ln \frac{1}{3} + 0$ ✓
 $\Delta S = -0,316 \frac{\text{kJ}}{\text{kg}} \times 5,932 \text{ kg}$ ✓
 $\Delta S = -1,875 \text{ kJ}$ (4)
[20]✓

QUESTION 3

3.2 $\frac{m_s}{m_f} = \frac{2500}{200}$ ✓
 $\frac{m_s}{m_f} = 12,5 \frac{\text{kg steam}}{\text{kg fuel}}$ (1)

3.3 $\text{Heat transferred to the economiser} = \frac{m_s}{m_f} (h_2 - h_1)$
 $= \frac{12,5}{1} (200 - 112)$
 $= 110 \text{ kJ/kg}$ (2)

3.4 $h_2 = h_f + x h_{fg}$ ✓
 $h_2 = 845 + (0,92)(1845)$ ✓
 $h_2 = 2634,4 \text{ kJ/kg}$ ✓

$\text{Heat transferred to the evaporator} = \frac{m_s}{m_f} (h_3 - h_2)$
 $= \frac{12,5}{1} (2634,4 - 200)$ ✓
 $= 30430 \text{ kJ/kg}$ (5)

3.5 $\text{Heat transferred to the superheater} = \frac{m_s}{m_f} (h_4 - h_3)$
 $= \frac{12,5}{1} (2796 - 2634,4)$ ✓
 $= 2020 \text{ kJ/kg}$ (2)

3.6

$$\eta = \frac{m_s}{m_f} (h_4 - h_1)$$
$$= \frac{12,5}{1} \frac{(2796 - 112)}{35000} \times 100 \%$$
$$= 96 \%$$

(3)

3.7

$$EE = \frac{m_s}{m_f} (h_4 - h_1) \quad \checkmark$$

$$\checkmark \frac{12,5}{1} \frac{(2796 - 112)}{2257} \quad \checkmark$$

$$\checkmark 14,865 \frac{\text{kg steam}}{\text{kg fuel}} \quad \checkmark$$

(3)
[20]

QUESTION 4

4.1

Heat emitted by steam = Heat absorbed by water

$$m_s [x h_{fg} + c_p (t_{ss} - t_s)] J = m c_p (T_2 - T_1)$$

$$100 \text{ l } (0,75 \times 2393) + 4,187 (45,8 - 43,8) J = 1850 \times 4,187 (T_2 - 22) \quad \checkmark$$

$$100 \text{ l } (1794,75) + 8,375 J = 7745,95 (T_2 - 22)$$

$$\frac{180312,4}{7745,95} = (T_2 - 22) \quad \checkmark$$

$$T_2 = 45,278^\circ\text{C} \quad \checkmark$$

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

$$m_s [x h_{fg} + c_p (t_{ss} - t_s)] J = m c_p (T_2 - T_1)$$

$$100 \text{ l } 192 + (0,75 \times 2393) - (183) J = 1850 \times 4,187 (T_2 - 22)$$

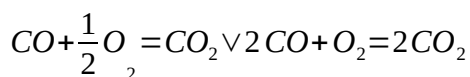
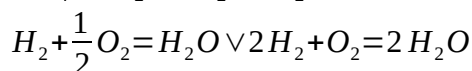
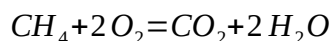
$$100 \text{ l } 1803,75 J = 7745,95 (T_2 - 22)$$

$$\frac{180375}{7745,95} = (T_2 - 22)$$

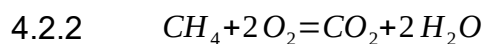
$$T_2 = 45,286^\circ\text{C} \quad (6)$$

4.2

4.2.1



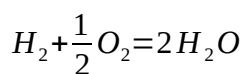
(3)



$$V_{O_2} = 2 \times 0,30$$

$$\hookrightarrow 0,6$$

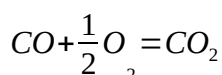
✓



$$V_{O_2} = \frac{1}{2} \times 0,42$$

$$\hookrightarrow 0,21$$

✓



$$V_{O_2} = \frac{1}{2} \times 0,2$$

$$\hookrightarrow 0,1$$

✓

$$V_{O_2} = 0,6 + 0,21 + 0,1 = 0,91 \frac{m^3 \text{ oxygen}}{m^3 \text{ fuel}}$$

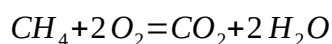
✓

$$V_{air} = \frac{100}{21} \times 0,91 = 4,333 \frac{m^3 \text{ air}}{m^3 \text{ fuel}}$$

✓

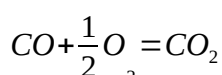
$$V_{N_2} = \left(\frac{100}{79} \times 4,333 \right) + 0,08 = 5,565 \frac{m^3 \text{ Nitrogen}}{m^3 \text{ fuel}}$$

✓



$$V_{CO_2} = 0,30$$

✓



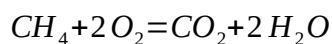
$$V_{CO_2} = 0,2$$

✓

$$V_{CO_2} = 0,3 + 0,2$$

✓

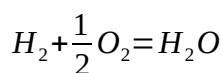
$$\hookrightarrow 0,5 \frac{m^3 CO_2}{m^3 \text{ fuel}}$$



$$V_{H_2O} = 2 \times 0,30$$

$$\hookrightarrow 0,6$$

✓



$$V_{H_2O} = 0,42$$

✓

$$V_{H_2O} = 0,6 + 0,42$$

✓

$$V_{H_2O} = 1,02 \frac{m^3 H_2O}{m^3 \text{ fuel}}$$

(12)

$$\begin{aligned}
 4.2.4 \quad N_2 &= \frac{5,565}{7,085} \times 100 = 78,5 \% & \checkmark \\
 H_2O &= \frac{1,02}{7,085} \times 100 = 14,4 \% & \checkmark \\
 CO_2 &= \frac{0,5}{7,085} \times 100 = 7,1 \% & \checkmark \\
 Total &= 100 \% & \checkmark
 \end{aligned}$$

(2)
[20]

QUESTION 5

5.1

$$\begin{aligned}
 S_v &= V_1 - V_c & \checkmark \\
 V_c &= 0,03 S_v & \checkmark \\
 S_v &= V_1 - 0,03 S_v & \checkmark \\
 V_1 &= 1,03 S_v & \checkmark \\
 V_4 &= V_3 \left(\frac{P_2}{P_1} \right)^{\frac{1}{n}} \\
 V_4 &= 0,03 S_v \left(\frac{780}{102} \right)^{\frac{1}{1,35}} \\
 V_4 &= 0,135 S_v & \checkmark \\
 V_e &= V_1 - V_4 \\
 2 &= 1,03 S_v - 0,135 S_v \\
 2 &= 0,895 S_v \\
 S_v &= 2,235 \frac{m^3}{min} \times \frac{min}{300 rev} & \checkmark \\
 S_v &= 0,007 m^3 & \checkmark
 \end{aligned}$$

(5)

5.2

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

$$P = 102 \left(\frac{2}{60} \right) \left(\frac{1,35}{1,35-1} \right) \left[\left(\frac{780}{102} \right)^{\frac{1,35-1}{1,35}} - 1 \right] \quad \checkmark$$

$$P = 9,109 kW$$

(4)

5.3

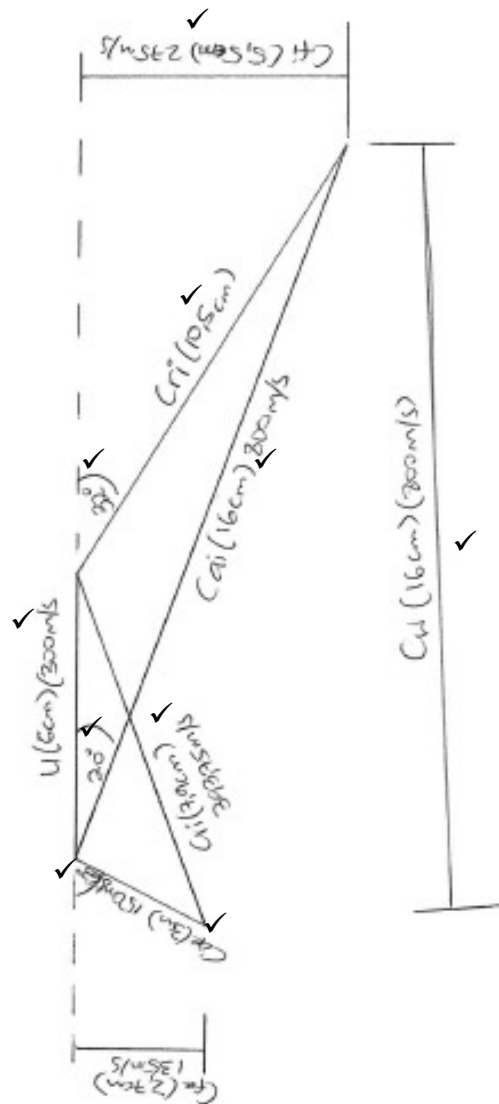
$$WD = 9,109 \frac{kJ}{s} \times \frac{min}{300 rev} \times \frac{60 s}{1 min} \quad \checkmark$$

$$WD = 1,82 kJ \quad \checkmark$$

(2)
[15]

6.1

QUESTION 6



(10)

$$6.2 \quad 6.2.1 \quad 32^\circ \checkmark \quad (1)$$

6.2.2 $63^\circ \checkmark$ (1)

$$\begin{aligned}
6.2.3 \quad & P = mU(C_{we} - (-C_{wi})) \quad \checkmark \\
& P = 2 \times 800 \times 300 \quad \checkmark \\
& P = 480 \text{ kW} \quad \checkmark
\end{aligned} \tag{3}$$

(3)
[15]

