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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

POWER MACHINES N5

29 November 2022

This marking guideline consists of 7 pages.

MJ

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√ = ½ mark
✓ = mark

QUESTION 1

1.1 Joule's law states that mechanical energy and heat energy✓ are mutually convertible.✓

OR

Joule's law states that heat and work are interchangeable.

Clausius' statement states that heat can flow from a hot substance to a cold substance unaided,✓ but it is impossible for heat to flow from a cold substance to a hot substance without the aid of external work.✓ (4)

1.2
- Separating calorimeter
- Throttling calorimeter
- Combined separating and throttling calorimeter
- The burrel (4)

1.3
- A jet condenser
- A surface condenser (2)

[10]

QUESTION 2

2.1 $R = C_P - C_V$

$C_V = 1{,}005 - 0{,}285$✓

$C_V = 0{,}72\ {}^{kJ}/_{kg.K}$✓

$\gamma = \frac{C_P}{C_V}$

$\gamma = \frac{1{,}005}{0{,}72}$✓

$\gamma = 1{,}395$✓
$\gamma \approx 1{,}4$ (4)

2.2 $P_1V_1 = mRT_1$ ✓

$V_1 = \frac{1{,}32 \times 0{,}285 \times 293}{105}$✓

$V_1 = 1{,}049\ m^3$✓ (3)

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2.3 $\frac{V_1}{V_2} = \left(\frac{P_2}{P_1}\right)^{\frac{1}{\gamma}}$ ✓

$V_2 = \frac{1,049}{\left(\frac{1\,500}{105}\right)^{\frac{1}{1,395}}}$ ✓

$V_2 = 0,156\ m^3$ ✓

OR use $\gamma = 1,4$

$\frac{V_1}{V_2} = \left(\frac{P_2}{P_1}\right)^{\frac{1}{\gamma}}$

$V_2 = \frac{1,049}{\left(\frac{1500}{105}\right)^{\frac{1}{1,4}}}$

$V_2 = 0,157\ m^3$ (3)

2.4 $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$ ✓

$T_2 = 293\left(\frac{1\,500}{105}\right)^{\frac{1,395-1}{1,395}}$ ✓

$T_2 = 622,132\ K$ ✓

OR use $\gamma = 1,4$

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

$T_2 = 293\left(\frac{1500}{105}\right)^{\frac{1,4-1}{1,4}}$

$T_2 = 625,382\ K$ (3)

2.5 $\Delta U = mC_V(T_2 - T_1)$ ✓

$\Delta U = 1,32 \times 0,72(625,382 - 293)$ ✓

$\Delta U = 315,896\ {}^{kJ}/_{kg}$ ✓ (3)

2.6 $W = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$

$W = \frac{(105 \times 1,049) - (1500 \times 0,157)}{1,4 - 1}$ ✓ ✓ ✓

$W = -313,388\ kJ$ ✓

OR use $\gamma = 1,4$

$W = \frac{mR(T_1 - T_2)}{\gamma - 1}$

$W = \frac{1,32 \times 0,285(293 - 625,382)}{1,4 - 1}$

$W = -312,605\ kJ$ (4)

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QUESTION 3

3.1 $h_{su} = h_g + C_p(t_{ss} - t_s)$✓

$h_{su} = 2782 + 2(230 - 188)$✓

$h_{su} = 2866\ {}^{kJ}/_{kg}$✓ (3)

3.2 $V_{su} = \frac{n-1}{n}\left(\frac{h_{su}-1941}{1200}\right)$✓

$V_{su} = \frac{1,3-1}{1,3}\left(\frac{2866-1941}{1200}\right)$✓

$V_{su} = 0,178\ {}^{m^3}/_{kg}$✓ (4)

3.3 $U_1 = h_1 - P_1V_1$

$U_1 = 2866 - (1200 \times 0,178)$ ✓ ✓

$U_1 = 2652,4\ {}^{kJ}/_{kg}$✓ (3)

3.4 $h_{wet} = h_f + xh_{fg}$

$h_{wet} = 640 + (0,8 \times 2107)$ ✓ ✓

$h_{wet} = 2652,6\ {}^{kJ}/_{kg}$✓ (3)

3.5 $V = (xV_g)$

$V = 0,8 \times 0,3727$✓

$V = 0,2997\ {}^{m^3}/_{kg}$✓ (2)

3.6 $U_2 = h_2 - P_2V_2$

$U_2 = 2652,6 - (500 \times 0,2997)$ ✓ ✓

$U_2 = 2203,1\ {}^{kJ}/_{kg}$✓ (3)

3.7 $\Delta U = m(U_1 - U_2)$

$\Delta U = 2,3(2652,4 - 2203,1)$✓

$\Delta U = -1033,39\ kJ$✓ (2)

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QUESTION 4

4.1 $P_T = 8{,}5\ kPa$

$At\ 36{,}2^o\ P_s = 6\ kPa$

$P_T = P_s + P_a$

$P_s = 8{,}5 - 6$✓

$P_s = 2{,}5\ kPa$✓

$m_a = \frac{0{,}08}{100} \times 6200$✓

$m_a = 4{,}96\ \frac{kg}{hr}$✓

$T_a = 36{,}2 + 273$
$T_a = 307{,}2\ K$✓

$V_a = \frac{mRT_a}{P_a}$✓

$V_a = \frac{4{,}96 \times 0{,}298 \times 309{,}2}{60 \times 2{,}5}$✓

$V_a = 3{,}047\ {}^{m^3}/_{min}$✓ (8)

4.2 4.2.1 $\eta = \frac{V_e}{S_v} \times 100\%$✓

$76 = \frac{12}{S_v} \times 100\%$✓

$S_v = 15{,}789\overset{✓}{} \frac{m^3}{min} \times \frac{min}{120\ r}$✓

$S_v = 0{,}132\ m^3$✓ (5)

4.2.2 $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}$✓

$T_2 = (273)\left(\frac{850}{104}\right)^{\frac{1{,}3-1}{1{,}3}}$✓

$T_2 = 443{,}316\ K$✓ (3)

4.2.3 $P = P_1 V_e \left(\frac{n}{n-1}\right)\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right]$✓

$P = 104 \times \overset{✓}{\frac{12}{60}}\left(\frac{1{,}3}{1{,}3-1}\right)\left[\left(\frac{850}{104}\right)^{\frac{1{,}3-1}{1{,}3}} - 1\right]$✓

$P = 56{,}231\ kW$✓ (4)

[20]

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QUESTION 5

5.1

$\boldsymbol{symbol}$	$\boldsymbol{vol}\ \%$	$\boldsymbol{MM}$	$\% \times \boldsymbol{MM}$	$\boldsymbol{mass}\ \%$
CO_2	25	44√	1 100	36,912
CH_4	20	16√	320√	10,738✓
N_2	50	28√	1 400√	46,979✓
O_2	5	32√	160√	5,369✓
			2 980√	100✓

(8)

5.2 $m\omega^2 h = g(M + m)$

$2{,}1\omega^2 h = 9{,}81(15 + 2{,}1)$✓

$\omega^2 h = 79{,}881$

$\sqrt{\omega^2} = \sqrt{\frac{79{,}881}{h}}$✓

$\omega = \sqrt{\frac{79{,}881}{0{,}22}}$✓

$\omega = 19{,}055\ {}^{rad}/_{s}$✓

$\omega = 2\pi N$

$19{,}055 = 2\pi N$✓

$N = 3{,}033\ rps \times 60$✓

$N = 181{,}98\ r/min$✓

(7)

[15]

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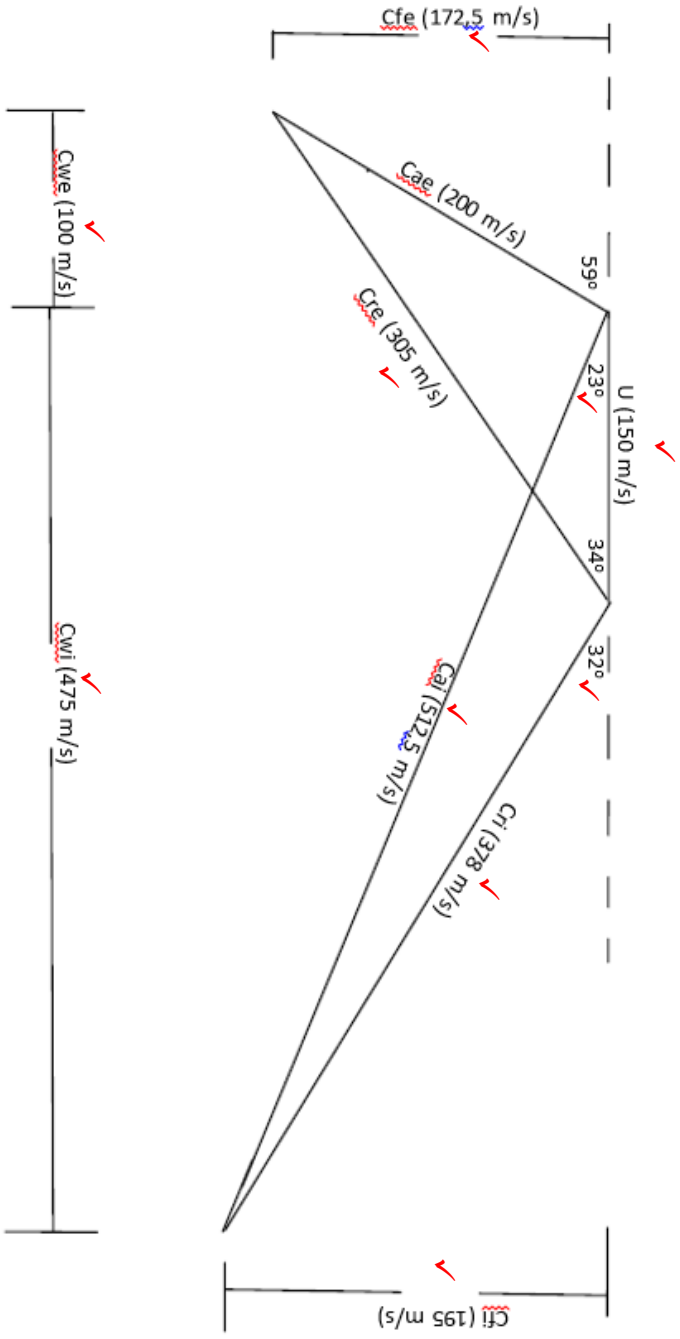
QUESTION 6

6.1



(10)

6.2 6.2.1 $\propto = 23^o$

6.2.2 $C_{ri} = 378\ m/s$

(2 × 1) (2)

6.3 $P = mUC$✓

$P = 2{,}3 \times 150 \times 575$✓

$P = 198375\ W$✓

(3)

[15]

TOTAL: 100

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