



higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

POWER MACHINES N6

17 April 2026

This marking guideline consists of 6 pages.

QUESTION 1

- 1.1 Clearance volume is the gap✓ between the cylinder top and the piston✓ when the piston is at the top dead centre.

OR

The small volume of gas that is left inside the cylinder after the delivery but before the expansion stroke.

Its importance is to prevent the piston from hitting✓ the cylinder✓ or parts of the valves.

(4)

- 1.2 1.2.1

Power of the 1-stage Compressor	Power of the 2-stage Compressor
$r_{p1} = \frac{p_{del}}{p_1} = \frac{1050}{100} = 10,5$ $P_{ind} = \frac{n}{n-1} \times p_1 v_1 \left[(r_p)^{\frac{n-1}{n}} - 1 \right] \checkmark$ $= \frac{1,35 \times 100 \times 16}{0,35 \times 60 \checkmark} \left[(10,5 \checkmark)^{\frac{0,35}{1,35}} - 1 \right]$ $= 86,372 \text{ kW} \checkmark$	$r_{p2} = \sqrt[n]{\frac{p_{del}}{p_1}} = \sqrt[2]{\frac{1050}{100}} = 3,24$ $P_{ind} = x \checkmark \left\{ \frac{n}{n-1} \times p_1 v_1 \left[(r_p)^{\frac{n-1}{n}} - 1 \right] \right\}$ $= 2 \left\{ \frac{1,35 \times 100 \times 16}{0,35 \times 60} \left[(3,24 \checkmark)^{\frac{0,35}{1,35}} - 1 \right] \right\}$ $= 73,304 \text{ kW} \checkmark$
Client Advice: The less costly option is the 2-stage compressor. ✓	

- 1.2.2

1-stage Compressor (Option 1)	2-stage Compressor (Option 2)
$T_2 = T_1 (r_{p1})^{\frac{n-1}{n}} \checkmark$ $= 294 (10,5 \checkmark)^{\frac{0,35}{1,35}}$ $= 540,879 \text{ K}$ $= 276,88 \text{ °C} \checkmark$	$T_4 = T_3 (r_{p2})^{\frac{n-1}{n}}$ $= 294 \checkmark (3,24 \checkmark)^{\frac{0,35}{1,35}}$ $= 398,76 \text{ K}$ $= 125,76 \text{ °C} \checkmark$
Client Advice: The highest compression (Minimum input energy) is when <u>output temperature is close to the input temperature</u> ✓ (approaching isothermal compression). Since option 2 has a delivery temperature closer to the input temperature, <u>option 2 is the advisable</u> ✓ option.	

(2 × 8)

(16)

[20]

QUESTION 2

2.1 The device inside which nuclear reaction takes place, to produce heat. OR The device in which nuclear fission occurs under controlled conditions. OR The equivalent of the boiler combustion chamber in a coal-fired steam plant. (3)

2.2 2.2.1
$$h_1 = h_f = 101 \frac{\text{kJ}}{\text{kg}} \checkmark \quad h_2 = h_f = 351 \frac{\text{kJ}}{\text{kg}} \checkmark$$

$$h_3 = h_f + xh_{fg} \checkmark = 1050 + 0,985 \times 1752 = 2775,72 \text{ kJ/kg} \checkmark$$

$$h_4 = h_g + c_{ps}(t_{sup} - t_s) \checkmark = 2802 + 3,3(304,2 - 242,5 \checkmark)$$

$$= 3005,61 \checkmark \text{ kJ/kg} \quad (7)$$

2.2.2
$$Q_{econ} = m_s(h_2 - h_1) \checkmark \Rightarrow m_s = \frac{2190 \checkmark}{351 - 101} = 8,76 \checkmark \text{ kg}_s/\text{kg}_c \quad (3)$$

2.2.3
$$Q_{boil} = m_s(h_3 - h_2) \Rightarrow 8,76(2775,75 - 351) = 21240,55 \checkmark \frac{\text{kJ}}{\text{kg}_c}$$

$$\%Q_{boil} = \frac{Q_{boil}}{CV} = \frac{21240,55 \times 100}{31610} = 67,2 \checkmark \%$$

$$Q_{a.heat} = m_a c_{pa}(t_2 - t_1) = 19 \checkmark \times 1,01(125 - 25) = 1919 \checkmark \frac{\text{kJ}}{\text{kg}_c}$$

$$\%Q_{a.heat} = \frac{Q_{a.heat}}{CV} = \frac{1919 \times 100}{31610} = 6,07 \checkmark \%$$

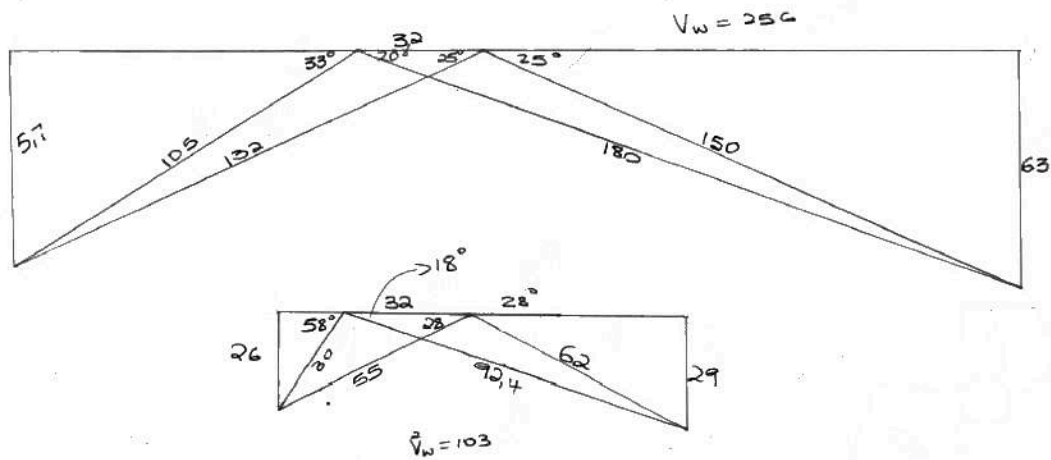
$$Q_{gas} = m_g c_{pg}(t_{chim} - t_{atm}) = 20 \times 1,05(185 - 25) = 3360 \checkmark \frac{\text{kJ}}{\text{kg}_c}$$

$$\%Q_{gas} = \frac{Q_{gas}}{CV} = \frac{3360 \times 100}{31610} = 10,63 \checkmark \%$$

(7)
[20]

QUESTION 3

3.1



(12)

3.2 3.2.1 $V_{r1} = 375 \frac{m}{s} \checkmark$ and $V_{r2} = 330 \frac{m}{s} \checkmark$

(2)

3.2.2 $V_{2,2} = 75 \frac{m}{s} \checkmark$ and $\beta_2 = 58^\circ \checkmark$

(2)

3.2.3 $P = mU(\Sigma V_w) \checkmark = \frac{4500 \times 80 \times (897,5)}{60 \checkmark} = 5,385 \checkmark \text{ MW} \checkmark$

(4)
[20]

QUESTION 4

4.1 $C_c = \sqrt{2000[h_1 - h_c]} \checkmark = \sqrt{2000 \times 97} = 440,454 \frac{m}{s} \checkmark$

$h_1 = h_g = 2731 \frac{kJ}{kg}$ and $s_1 = s_g = 6,939 \frac{kJ}{kg \cdot K} = s_c \checkmark$

$s_c = s_f + x_c(s_g - s_f) \Rightarrow x_c = \frac{6,939 - 1,53 \checkmark}{7,127 - 1,53} = 0,9664 \checkmark$

$v_c = x_c v_g \checkmark = 0,9664 \times 0,8854 \checkmark = 0,856 \frac{m^3}{kg} \checkmark$

$A_c = \frac{mv_c}{C_c} \checkmark = \frac{0,113 \times 0,856 \times 10^6}{440,454} = 219,6 \text{ mm}^2 \checkmark$

(10)

4.2 $\Delta h = 534 - 0,12 \times 534 = 469,92 \checkmark \frac{kJ}{kg} \Rightarrow$

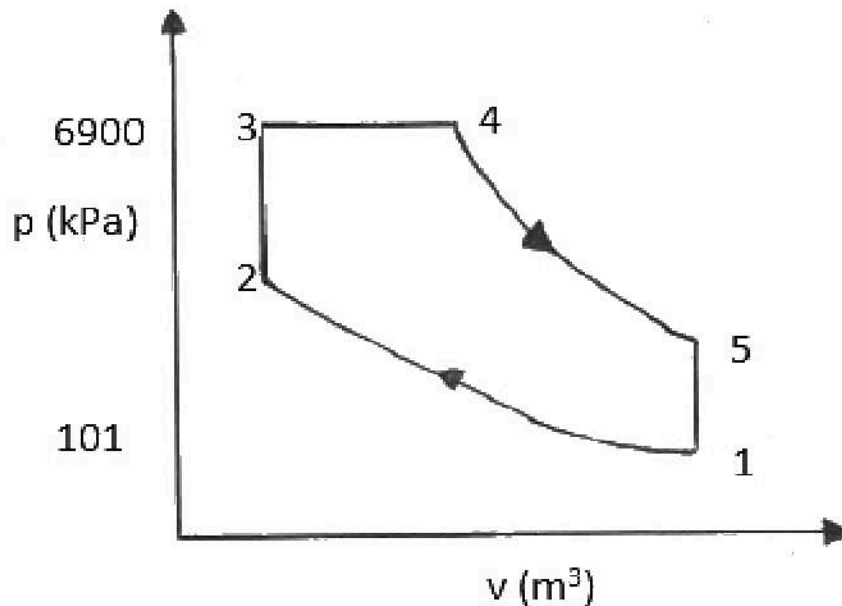
$h_2 = 2731 - 469,92 = 2261,08 \text{ kJ/kg} \checkmark$

$h_2 = h_f + x_2 h_{fg} \checkmark \Rightarrow x_2 = \frac{2261,08 - 192}{2393 \checkmark} = 0,865 \checkmark$

(5)

QUESTION 5

5.1



- 1 mark for labelling pressure and volume on the correct axis.
- 1 mark for the correct shape of the graph.
- 1 mark for labelling direction on the graph (arrows/1, 2, 3/ a, b, c).
- 1 mark for each pressure value in its correct position.

(5)

5.2

$$\frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{\gamma-1} \checkmark \Rightarrow T_2 = 293(18)^{0,4} = 931,058 \text{ K} \checkmark$$

$$p_1 v_1^\gamma = p_2 v_2^\gamma \checkmark \Rightarrow p_2 = p_1 \left(\frac{v_1}{v_2}\right)^\gamma = 101(18)^{1,4} = 5777,01 \text{ kPa} \checkmark$$

(4)

5.3

$$\frac{p_2 v_2}{T_2} = \frac{p_3 v_3}{T_3} \checkmark \text{ but } v_2 = v_3 \Rightarrow p_2 T_2 = p_3 T_3$$

$$T_3 = \frac{6900 \times 931,058}{5777,01} = 1112,05 \text{ K} \checkmark$$

$$Q_{cv} = c_v(T_3 - T_2) \checkmark = 0,718(1112,05 - 931,058) = 129,95 \text{ kJ/kg} \checkmark$$

$$Q_{cv} = Q_{cp} = c_p(T_4 - T_3) \Rightarrow T_4 = \frac{129,95}{1,005} + 1112,05 = 1241,36 \text{ K} \checkmark$$

(6)
[15]

QUESTION 6

6.1 $A = \frac{\pi}{4} d^2 = \frac{\pi}{4} \times 5^2 = 19,635 \text{ m}^2$

$$\omega = \frac{2\pi N}{60} \checkmark = \frac{2\pi \times 130}{60} = 13,614 \frac{\text{rad}}{\text{s}} \checkmark$$
$$v_{turb} = \omega r \checkmark = 13,614 \times 5 \times 0,5 = 34,035 \frac{\text{m}}{\text{s}} \checkmark$$
$$\lambda = \frac{v_{turb}}{v_{wind}} \checkmark = \frac{34,035}{10} = 3,404 \checkmark \quad (5)$$

6.2 $P_{wind} = 0,5 \rho A v_{wind}^3 \checkmark = 0,5 \times 1000 \times 19,635 \times 10^3 = 11,62 \text{ kW} \checkmark$

$$v_{turb} = \frac{P_{turb}}{P_{wind}} \checkmark = \frac{1}{11,62} = 0,0861 \checkmark \quad (5)$$

[10]

TOTAL: 100