higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

ENGINEERING PHYSICS N6

26 JULY 2018

This marking guideline consists of 8 pages.

Copyright reserved

QUESTION 1

1.1 1.1.1 False
1.1.2 True
1.1.3 True
1.1.4 True
1.1.5 True

(5 × 1) (5)

1.2 1.2.1 $f_1 = \frac{vf}{V - Uo} = \frac{340 \times 950}{340 - 12,5}$ ✓

$f_1 = 986,26$ Hz ✓

1.2.2 $f_1 = \frac{vf}{V + Uo} = \frac{340 \times 950}{340 + 12,5}$ ✓

$f1 = 916,31$ Hz ✓

(2 × 2) (4)

1.3 Wave length of the wiggles is $\lambda = 0,1 \times 10^{-4}$m, so they pass the needle at the rate of:

$f = \frac{v}{\lambda} = \frac{0,25 \text{ m/s}}{0,1 \times 10^{-4}}$ ✓✓
$= 25\,000$ Hz ✓ (3)

1.4 $f = f$ maar Vo = Vs

$f = f\frac{(V \pm Vo)}{(V \pm Vo)}$

$5\,100 = 5\,000\frac{(344 + Vo)}{(344 - Vo)}$ ✓

$1,02 = \frac{(344 + Vo)}{(344 - Vo)}$ ✓

$1,02\ (344 - Vo) = 344 + Vo$ ✓

$350,88 - 1,02\ Vo = 344 + Vo$

$350,88 - 344 = 1,02\ Vo + Vo$

$6,88 = 2,02\ Vo$

$Vo = \frac{6,88}{2,02}$

$Vo = 3,4059$ m/s ✓ (4)

1.5 1.5.1 $\mu = \frac{\text{mass}}{\text{Length}}$

$\mu = \frac{5,8 \times 10^{-4}}{0,731}$

$\mu = 7,934 \times 10^{-4}$ kg/m✓

$c = \frac{\sqrt{T}}{\sqrt{\mu}} = \frac{\sqrt{80}}{\sqrt{7,934}}$✓

V = 317,53 m/s✓

1.5.2
- Frequency Fundamental note = 317,53/2 × 0,731 = 217,19 Hz
- Frequency: First overtone = 2 × 217,19 Hz = 434,38 Hz
- Frequency: Second overtone = 3 × 217,19 Hz = 651,57 Hz

(2 × 3) (6)

1.6 $L = \frac{c}{2 \times f} = \frac{344}{2 \times 65}$
L = 2,646 m✓
$L = \frac{c}{2 \times f} = \frac{344}{2 \times 2\,090}$
L = 0,082 m✓✓ (3)
[25]

QUESTION 2

2.1 2.1.1 P_1 = 700 kPa V_1 = 2,5 dm^3 T_1 = 1 100 °C of 1373 K
P_2 = 270 kPa
$P_1 \times V_1^n = P_2 \times V_2^n$
$V_2 = \left(\frac{700}{270}\right)^{0,769} \times 2,5 \times 10^{-3}$✓
V_2 = 0,0052 m^3✓

2.1.2 $\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$
$T_2 = \frac{270 \times 5,2 \times 1\,373}{700 \times 2,5 \times 10^{-3}}$✓
T_2 = 1 102,3 K or 829 °C✓

2.1.3 Work done = $\frac{P_1 \times V_1 - P_2 \times V_2}{\alpha - 1}$

Work done = $\frac{700 \times 2,5 - 270 \times 5,202}{1,3 - 1}$✓

Work done = 1,1512 Joule✓

2.1.4 $P_1 \times V_1 = m \times R \times T$

$m = \frac{700 \times 2,5}{289 \times 1373}$✓

$m = 4,4103 \times 10^{-3}$ kg✓

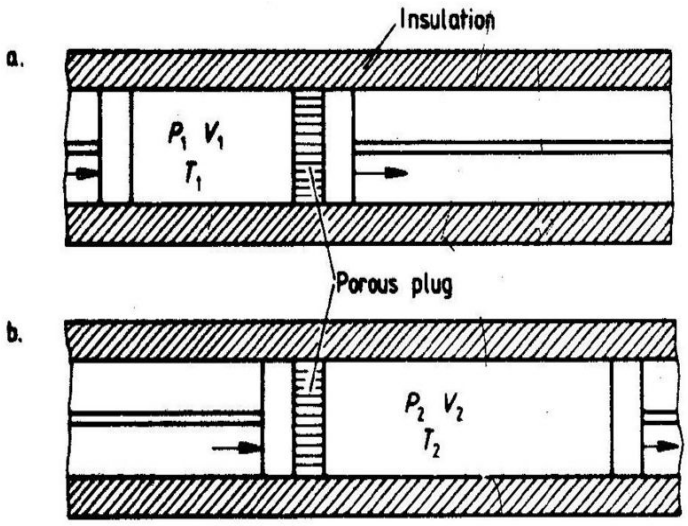
(4 × 2) (8)

2.2 (1 kg L) + (4 187 × 1 × 30) = (4 187 × 19 × 30)✓

L = 238 6590 – 125 610✓

L = 2260,98 kJ/kg✓ (3)

2.3 The experiment shows that ΔT = 0 when an ideal gas expands under the condition w = O. By careful measurements Joule and Thomson found a small temperature change, usually negative, when a real gas expanded adiabatically through a porous plug. The experimental arrangement is shown in the sketch below.



ADIABATIC EXPANSION OF A REAL GAS THROUGH A POROUS PLUG

The Joule-Thomson experiment. Adiabatic expansion of a real gas through a porous plug. (a) Initial state. (b) Final state. The pressures P_I and P_2 are kept constant during the expansion. The work supplied to the gas on the left hand side of the porous plug is P_1V_I, and the work carried out by the gas on the right hand side of the porous plug is P_2V_2. (5)

2.4 2.4.1 320 ˚C = 593 K and 60 ˚C = 333 K

$$\eta = \frac{T_1 - T_2}{T_1} \times 100$$

$$\eta = \frac{593 - 333}{593} \times 100\checkmark$$

$$\eta = 43{,}8\%\checkmark \quad (2)$$

2.4.2 Work done/cycle = $m \times C \times \log \times \frac{V_2}{V_1} \times (T_1 - T_2)\checkmark$

Work done/cycle = 0,25 × 0,28 × log 2,2 (260)

= 14,35 kJ✓ (2)

2.5 Heat gained to melt ice and to heat water to

$= 0{,}05 \times L_{hice} \times 0{,}05 \times 4{,}18 \times 40$
$= 0{,}05 \times L_{h\,ice} \times 8{,}374.\checkmark$

Heat lost by water to condensate

$= 0{,}2 \times 4{,}187 \times 10^3 \times 30 + mc \times cc \times 30$
$= 25{,}122 + 30\ mc \times cc.\checkmark$

Heat gained to melt ice and to heat water to

$= 0{,}08 \times L_{hice} \times 0{,}08 \times 4{,}18 \times 10$
$= 0{,}08 \times L_{h\,ice} \times 3{,}3496.\checkmark$

Heat lost by water to condensate

$= 0{,}2 \times 0{,}05 \times 4{,}187 \times 10^3 \times 30 + mc \times cc \times 30$
$= 31{,}4025 + 30\ mc \times cc.\checkmark$

Heat lost if steam condensate and water cools down to ˚C

$$= -0{,}03\ L_h + 5{,}024 = -6{,}2805$$

$$L_{h\ \mathbf{ice}} = \frac{-6{,}2805 - 5{,}0244}{-0{,}03}$$

$L_{h\,ice} = 376{,}83$ kJ/kg.K✓ (5)

[25]

QUESTION 3

3.1 When a capacitor is being charged, at any moment the potential difference ΔV is due to the charge already on its plates, is in the opposite direction to the applied EMF and thus tends to oppose the flow of additional charge.✓ For this reason, a capacitor does not require its final charge, the instant it is connected to a battery or other sources of EMF. The product RC of the resistance R in the circuit and the capacitance C governs the rate at which the capacitor reaches its ultimate charge of Q = CV.✓ The quantity RC is called the time constant of the circuit; the smaller the time constant, the more rapidly a capacitor in a circuit can be charged or discharged.✓ (3)

3.2 A Coulomb is the quantity of electrical charge which moves through a conductor✓ in one second when a constant current of one ampere flows through the conductor.✓ (2)

3.3 The smaller the value for r, the bigger the value for V.✓ Thus the charge density reaches a maximum when the radius is a minimum, or where the curvature is the largest.✓ (2)

3.4 $E_A = \frac{kQ_1Q_2}{r^2} = \frac{9 \times 10^9 \times 3 \times 10^{-6}}{(1)^2} = 2,7 \times 10^4$ N/C

$E_C = \frac{kQ_1Q_2}{r^2} = \frac{9 \times 10^9 \times 5 \times 10^{-6}}{(1)^2} = 4,5 \times 10^4$ N/C✓✓

$E_B = \frac{kQ_1Q_2}{r^2} = \frac{9 \times 10^9 \times 4 \times 10^{-6}}{(1)^2} = 3,6 \times 10^4$ N/C

$E_D = \frac{kQ_1Q_2}{r^2} = \frac{9 \times 10^9 \times 5 \times 10^{-6}}{(1)} = -4,5 \times 10^4$ N/C✓✓

$\sum E_{AC} = (4,5 - 2,7) \times 10^4$ N/C $= 1,8 \times 10^4$ N/C in the direction OA

$\sum E_{DB} = (4,5 + 3,6) \times 10^4$ N/C $= 8,1 \times 10^4$ N/C in the direction OD✓✓ (6)

3.5 The resultant electrical field strength E by P is the sum of the vector of the field strength has the result of the individual loads.

$E = \frac{kQ_1}{r^2} + \frac{kQ_2}{r^2}$ thus $= \frac{k(Q_1 + Q_2)}{r^2}$

$= \frac{9 \times 10^9 (20 + 5) \times 10^{-8}}{(0,05)^2}$✓

$= 9 \times 10^5$ N/C or 9×10^5 V/m✓

$F = EQ = 9 \times 10^5 \times 4 \times 10^{-8}$✓
$= 3,6 \times 10^{-2}$ N towards the right✓ (4)

3.6 3.6.1 F up = F down

Where Eq = m × g

And $q = \frac{m \times g}{E}$

but $E = \frac{V}{S}$ ✓

Therefore, $q = \frac{m \times g \times s}{V}$ ✓

3.6.2 $q = \frac{m \times g \times s}{V}$

$q = \frac{4{,}8 \times 10^{-15} \times 10 \times 25 \times 10^{-3}}{2\ 500}$ ✓

$= 4{,}8 \times 10^{-19}$ ✓

3.6.3 Amount of electrons = $\frac{4{,}8 \times 10^{-19}}{1{,}9 \times 10^{-19}}$ ✓

= 2,526 use 3 ✓

3.6.4 $W = V \times Q = 2\ 500 \times 8 \times 10^{-16}$ ✓

$W = 2 \times 10^{-12}$ ✓

(4 × 2) (8)

[25]

QUESTION 4: ATOMIC PHYSICS

4.1
- Carry a negative charge.
- Move in a straight line unless deflected by a field
- Let metals (platinum) glows if they collide. (3)

4.2 The process by which free electrons are emitted from the surface of a metal when external heat energy is applied is called thermionic emission.
Thermionic emission occurs in metals that are heated to a very high temperature. In other words, thermionic emission occurs, when large amount of external energy in the form of heat is supplied to the free electrons in the metals. (2 × 2) (4)

4.3 Mass spectrometer (1)

4.4 $E = V \times Q$

$= 1{,}5 \times 10^{-6} \times 3\ 200$ ✓

$E = 4{,}8 \times 10^{-3}$ J ✓ (2)

4.5 4.5.1 $I = Q/t$

$$I = \frac{6 \times 10^{14} \times 4{,}8\ 10^{-31}}{1}\checkmark$$

$I = 2{,}88\ 10^{-5}$ A✓ (2)

4.5.2 $W = Q.V$

$$V = \frac{W}{Q}$$

$$V = \frac{4{,}8 \times 10^{-16}}{1{,}6 \times 10^{-19}}\checkmark\checkmark$$

V = 3 000 Volt✓ (3)

4.6 Kinetic Energy $K_E = ½ \times m \times V^2$

$K_E = ½ \times 9{,}1 \times 10^{-31} \times (10^7)^2$✓✓

$K_E = 4{,}55\ 10^{-17}$ J✓ (3)

4.7 4.7.1 $E = hf$

$$E = \frac{h}{\lambda}.$$

$$E = \frac{\left(6{,}6\ x\ 10^{-34}\right) x\ (3\ x\ 10^{8})}{9{,}1\ x\ 10^{-7}}\checkmark$$

$= 2{,}18 \times 10^{-19}$ J✓

4.7.2 $I = hf - W$

$I = 2{,}18 \times 10^{-19} - 1{,}8 \times 10^{-19}$✓

$I = 3{,}755\ 10^{-22}$J✓

(2 × 2) (4)

4.8 $E = \frac{k(Q_1 \times Q_2)}{r^2}$

$$= \frac{9 \times 10^9\ (1{,}6 \times 10^{-19})^2}{(4{,}5 \times 10^{-11})^2}\checkmark\checkmark$$

$= 1{,}137 \times 10^{-7}$N✓ (3)

[25]

TOTAL: 100

Copyright reserved