higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

ENGINEERING PHYSICS N6

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This marking guideline consists of 8 pages.

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QUESTION 1: SOUND

1.1 1.1.1 Pure tone
1.1.2 power
1.1.3 Kinetic
1.1.4 Doppler
1.1.5 Sound

(5 × 1) (5)

1.2 1.2.1 resonate
1.2.2 closed tube
1.2.3 directions
1.2.4 amplitude
1.2.5 vibrations
1.2.6 stationary waves

(6 × 1) (6)

1.3 1.3.1 Speed of sound $V_0 = 334\ m/s$; $Vs = 65\ km/h = 18{,}056\ m/s$

$$f_o = \frac{F\,(V + V_0)}{(V - V_s)}$$
$$= \frac{2\,800(330 + 0)}{(330 - 18{,}056)}\checkmark$$
$$= \frac{1\,000\,(334)}{317{,}333}$$
$$= 2\,962{,}07\ Hz\checkmark$$

1.3.2 $$Fo = \frac{2\,800(330 + 0)}{(v + vs)}$$

$$= \frac{2\,800\,(330 + 0)}{(330 + 18{,}07)}\checkmark$$

$$= \frac{924\,000}{(348{,}07)}$$

$$= 2\,654{,}638\ Hz\checkmark$$

1.3.3 $$Fo = \frac{(v + vo)}{(v + vs)}$$

$$Fo = \frac{2\,800(330 + 4{,}1667)}{(330 + 18{,}07)}\checkmark$$

$$= \frac{935\,666{,}76}{348{,}667}$$

$$= 2\,688{,}157\ Hz\checkmark$$

(3 × 2) (6)

1.4 If the plant operates at 74% efficiency, it must have a total heat and shc of water = 4,187 × 103 J/kg.K.

$$\text{Input of } 540 \text{ kW} = \frac{100 \times 450 \text{ kg/s}}{74}\checkmark$$

$$\text{Therefore: Input} = \frac{100 \times 540 \times 10^6}{74}\checkmark$$

$$= 729{,}73 \times 10^6 \text{ W}\checkmark$$

$$\text{Of this } Q = m \times c \times \Delta T$$

$$540 \times 10^6 \times 0{,}84 = 8{,}1 \times 10^4 \times 4\,187 \times \Delta t\checkmark$$

$$\Delta t = \frac{540 \times 10^6 \times 0{,}84}{8{,}1 \times 10^3 \times 4\,187}\checkmark\checkmark$$

$$\Delta t = 13{,}38\,^{\circ}\text{C}\checkmark\checkmark$$ (6)

1.5 1.5.1

$$V_R = \frac{Vg \times L}{\ell}$$

$$= \frac{330 \times 0{,}75}{0{,}065}\checkmark$$

$$= 3\,807{,}692 \text{ m/s}\checkmark$$

1.5.2

$$V_R = f \times \lambda_R$$

$$f = \frac{v_R}{\lambda r}$$

$$= \frac{330}{0{,}75 \times 0{,}2}\checkmark$$

$$= 2\,200 \text{ Hz}\checkmark$$

(2 × 2) (4)

[27]

QUESTION 2: THERMODYNAMICS

2.1 2.1.1 isothermic
2.1.2 amount
2.1.3 temperature
2.1.4 pressure
2.1.5 work done

(5 × 1) (5)

2.2 2.2.1 $R = Cp - Cv = 1,025 - 0,755$
$= 0,270 \text{ kJ/kg.K}$

Therefore:

$P_1V_1 = mRT_1$

$m = \frac{P_1V_1}{RT_1}$

$m = \frac{222 \times 10^3 \times 0,0142}{0,27 \times (273 + 122)}$ ✓

$m = 29,588 \text{ kg}$ ✓

2.2.2 $(P_1V_1)^n = (P_2V_2)^n$

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

$= 0,0142 \times \left(\frac{222}{1\,500}\right)\frac{1}{1,3}$ ✓

$= 0,0142 \times 0,221$

$= 0,23 \text{ m}^3$ ✓

2.2.3 $S_2 - S_1 = Cp \times \ln \frac{V_2}{V_1} + Cv \times \ln \frac{P_2}{P_1}$

$S_2 - S_1 = 1,025 \ln \frac{0,23}{0,0142} + 0,75 \ln \frac{1\,500}{222}$

$S_2 - S_1 = 2,854 + 0,1433$

$S_2 - S_1 = +2,997 \text{ kJ/kg. K}$ ✓

But there is 30,112 kg of gas

Change in entropy $= +2,997 \times 29,588$
$= +88,684 \text{ kJ/K}$ therefore is an increase ✓

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2.2.4 $W = \frac{P_1V_1 - P_2V_2}{n - 1}$

$= \frac{(222 \times 0{,}0142) - (1\,500 \times 0{,}23)}{1{,}3 - 1}$✓

$= -1\,139{,}492$ kJ✓

(4 × 2) (8)

2.3 The specific heat capacity of a substance is the amount of energy needed to change✓ the temperature of 1 kg of the substance by 1 °C.✓ (2)

2.4 Carnot efficiency $= (1 - \frac{T2}{T1}) \times 100$ $T_1 = 285 + 273 = 558$ K

Carnot efficiency $= (1 - \frac{558}{360}) \times 100$✓ $T_2 = 87 + 273 = 360$ K✓

Carnot efficiency $= 55\%$✓ (3)

2.5 $S_{steam} - S_{water} = \frac{m \times Q}{T_1}$

$S_{steam} - S_{water} = \frac{82 \times 2\,558}{361}$✓

$S_{steam} - S_{water} = 581{,}042$ J/g.K✓ (2)

2.6 Heat gained by the water (Q) = m × shc × Δt

$Q = 260 \times 4\,187 \times (94 - 15)$✓
$= 86$ MJ✓

Heat lost by the coal = m × HV

$Q_{lost} = Q_{gained}$

$m \times HV = 81\,646\,500 \times \eta$

$= \frac{86 \times 100}{32{,}5 \times 68}$✓

$= 3{,}891$ kg✓ (5)
[25]

QUESTION 3: ELECTROSTATICS

3.1 The ratio of the capacitance✓ with and without the dielectric between the plates is called the dielectric constant or relative permittivity.✓ (2)

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

3.3 3.3.1 $C = Q \div C$

Thus: Capacitance = charge in coulomb ÷ potential difference

$$\text{Charge} = 59 \times 10^{-6} \times 220 \text{ V}$$
$$= 0{,}01298 \text{ C}✓$$

When the capacitors are connected in parallel, the total capacitance is 35 µF and the charge of 0,01298 C is divided between the two capacitors.

$$0{,}01298 \text{ C} = 35 \times 10^{-6} \times \text{V}✓$$
$$\text{V} = 370{,}857 \text{ V}✓$$

3.3.2 $\text{Electrostatic energy} = ½C\text{ V}^2$
$$= ½ \times 59 \times 10^{-6} \times (220)^2$$
$$= 1{,}4278 \text{ J}✓$$

$\text{Electrostatic energy} = ½C\text{ V}^2$
$$= ½ \times 59 \times 10^{-6} \times (146{,}667)^2✓$$
$$= 0{,}635 \text{ J}✓$$

(2 × 3) (6)

3.4 $$C = \frac{Eo \times Er\ (n - 1)A}{d}$$

$$= \frac{8{,}8 \times 10^{-12} \times 7(6 - 1) \times 0{,}046}{0{,}00054}✓$$

$$= 2{,}624 \times 10^{-8} \text{ F}✓$$

$$= 0{,}02624 \times 10^{-6} \text{ F}$$

$$= 0{,}02624 \text{ µC}✓$$ (4)

3.5 $F_{up} = F_{down}$

$$Q = \frac{mg}{E}$$

$$Q = \frac{2{,}44 \times 10^{-15} \times 9{,}8}{5{,}5 \times 10^{4}}$$ ✓

$Q = 4{,}37 \times 10^{-19}$ C✓

$$\text{Number of excess electrons} = \frac{4{,}347 \times 10^{-19}}{1{,}6 \times 10^{-19}}$$

$= 2{,}717$ e$^-$ use 3 e$^-$✓ (3)

3.6
3.6.1 electrical charge
3.6.2 one second
3.6.3 current
3.6.4 ratio
3.6.5 dielectric
3.6.6 relative permittivity

(6 × 1) (6)
[23]

QUESTION 4: ATOMIC PHYSICS

4.1
- Carries a negative charge
- Moves in a straight line unless deflected by a field
- Makes metals glow if they collide (3)

4.2
- Activate photographic plates
- When X-rays strike many materials they make them fluoresce
- Wave form
- Highly penetrating – according to the speed of the electrons, which depends on the applied voltage (Any 3 × 1) (3)

4.3 $E = ½CV^2$
$E = ½ \times (1{,}85 \times 10^{-6}) \times (2\,600)^2$✓
$E = 6{,}253$ J✓ (2)

4.4 4.4.1 $V = \text{emf per cell} \times \text{number of cells}$
$= 2{,}5 \times 4 = 10$ V✓

$\text{Power} = \text{volts} \times \text{rate per second}$
$= 10 \times 16$✓
$= 160$ W✓ (3)

4.4.2 $\text{The amount of energy} = \text{power} \times \text{time}$
$= 160 \times 2 \times (60 \times 60)$✓
$= 1{,}152\ \text{MJ}$✓ (2)

4.5
- Affects a photographic plate
- Ionises air or gas (2)

4.6 4.6.1 $I = Q/t$

$$I = \frac{5{,}75 \times 10^{14} \times 1{,}6\ 10^{-19}}{1}$$✓✓

$I = 9{,}2\ 10^{-5}\ \text{A}$✓ (3)

4.6.2 $W = QV$

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

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

$V = 2\,875\ \text{V}$✓ (2)

4.7 4.7.1 $E = h \times f$

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

$$E = \frac{(6{,}5 \times 10^{-34}) \times (2{,}85 \times 10^{8})}{9{,}45 \times 10^{-7}}$$✓✓

$E = 1{,}96 \times 10^{-19}\ \text{J}$✓ (3)

4.7.2 $EQ = hf - W$
$= 1{,}96 \times 10^{-19} - 1{,}9 \times 10^{-19}$✓
$= 6{,}03 \times 10^{-21}\ \text{J}$✓ (2)

[25]

TOTAL: 100

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