higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ENGINEERING PHYSICS N6

(15070126)

21 November 2024 (X-paper)
09:00–12:00

Non-programmable calculators may be used.

This question paper consists of 7 pages and a formula sheet of 2 pages.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ENGINEERING PHYSICS N6
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer all the questions.
2. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Take the values for STP as when then temperature is equal to 0 °C and the pressure is equal 101,3 kPa.
5. Gravitational acceleration (g) should be taken as 9,81 m/s^2.
6. Use only a black or blue pen.
7. Write neatly and legibly.

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QUESTION 1: SOUND

1.1 Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (1.1.1–1.1.10) in the ANSWER BOOK.

1.1.1 A standing wave is formed when a wave does not move forward through a medium but is reflected just as much as it is transmitted, so that the total movement of the wave is zero.

1.1.2 The period of a wave is the time taken for one wave cycle to be completed.

1.1.3 The pitch of a sound depends on its frequency.

1.1.4 A high note is produced by high frequency.

1.1.5 The loudness of a sound depends on the amplitude of the wave were a high amplitude will produce a soft sound.

1.1.6 A pure tone is free of undertone.

1.1.7 Sound will resonate in closed tubes if the wavelength is four times the length of the tube.

1.1.8 Frequency is determined by the number of revolutions per minute and the number of holes in the wheel.

1.1.9 If two waves travelling in opposite directions through the medium have the same wavelength and the same amplitude, their effect is to set up a steady vibration in the medium. These steady vibrations are called stationary waves.

1.1.10 Overtones are also multiplied by the fundamental frequency, but these multiplications are not always a whole number ratio.

(10 × 1) (10)

1.2 One and a half kilogram of gas at a temperature of 302 °K and pressure of 126,25 kPa is compressed adiabatically to a pressure of 958 kPa. Use the following values: Cp = 861 J/kg.°C and Cv = 615 J/kg.°C

Calculate the work done during the compression. (6)

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1.3 The horn of a moving train is sounded at a frequency of 1 250 Hz. The speed of sound in air is 340 m/s.

Calculate the following:

1.3.1 The frequency heard by a person, standing at a train station, while the train approaches him at a speed of 60 km/h (2)

1.3.2 The frequency heard by the person when the train is just passing him (3)

1.4 An organ pipe has a fundamental frequency of 268 Hz. Neglect end correction. The velocity of sound in air is 334 m/s.

Determine the length:

1.4.1 When it is open

1.4.2 When it is closed

(2 × 2) (4)

[25]

QUESTION 2: THERMODYNAMICS

2.1 Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (2.1.1–2.1.5) in the ANSWER BOOK.

2.1.1 An isothermic process is not when $P_1V_1 = P_2V_2$.

2.1.2 In an adiabatic process the energy is conserved in the system; thus, the temperature rises after compression and does not give off to the environment. The pressure is higher or the volume is less.

2.1.3 A reversible process proceeds in any direction, forms mechanical energy to heat energy or visa-versa.

2.1.4 Carnot's principle is a machine that operates on reversible processes which will have the highest possible efficiency.

2.1.5 Entropy is an indication of the amount of thermodynamic degradation that takes place and has the same unit as heat capacity.

(5 × 1) (5)

2.2 Calculate the final temperature if 550 g of water and 100 g of ice are mixed with 200 g steam at 100 °C. Use the heat capacity of ice as 3,35 kJ/kg and that of steam as 2,26 MJ/kg. (6)

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2.3 The volume of one kilogram of air at a temperature of 200 °C is 58 litres. The air is heated to a temperature of 450 °C while the pressure is kept constant. The pressure is then reduced to 650 kPa by cooling the air while its volume is kept constant.

Calculate the change in entropy for each of these processes.

Take Cp = 1,006 kJ/kg.K and Cv = 0,717 kJ/kg.K (6)

2.4 A boiler (water tank) of 280 litre is heated from 25 °C to 96 °C by using coal. Use the heat value for coal as 35 MJ/kg and the specific heat value for water as 4,2 kJ/kg.K. The installation of the system is only 92% effective.

Determine the amount of coal to be used. (8)

[25]

QUESTION 3: ELECTROSTATICS

3.1 Define the *electric field intensity* at a point in an electric field. (2)

3.2 An isolated spherical conductor with a radius of 0,125 m has a positive electric charge of $1,5 \times 10^{-7}$ Coulomb.

Calculate the following:

3.2.1 The electric field intensity at a point on the surface of the sphere

3.2.2 The electric potential at a point on the surface of the sphere

(2 × 3) (6)

3.3 The distance between two positive electric point charges of 15 µC and 10 µC is 8 cm.

Calculate the work that must be done to move one charge 4 cm closer to the other. (3)

3.4 An electric field intensity is 11,25 kV/m and the distance between the two plates is 1,5 cm.

Determine the following:

3.4.1 The potential difference between the two plates

3.4.2 The force on the 2 nC charge between the two plates

3.4.3 The energy on the charge to move 1nC from one plate to the other plate

(3 × 2) (6)

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3.5 Through an experiment, it was found that in dry air, a sphere with a radius of 1 cm can reach a maximum potential of 30,000 volts without experiencing corona discharge.

Calculate the following:

3.5.1 The charge density on the area of the sphere

3.5.2 The maximum field intensity on the area of the sphere. Regard the permittivity of free space as $8,85 \times 10^{-12}$ F/m.

(2 × 2) (4)

3.6 Indicate the definition that represent the following statements. Write the answer next to the question number (3.6.1–3.6.4) in the ANSWER BOOK.

3.6.1 States that the magnitude of the electrostatic force between two point charges is directly proportional to the product of the magnitude of the charges and inversely proportional to the square of the distance between them.

3.6.2 In an adiabatic system the energy is conserved in the system, thus the temperature rises after compression and does not give off to the environment, thus the pressure is higher or the volume is greater.

3.6.3 A reversible process proceeds in any direction, forms mechanical energy to heat energy or visa-versa.

3.6.4 Carnot's principle is a machine that operates on reversible processes which will have the highest possible efficiency.

(4 × 1) (4)

[25]

QUESTION 4: ATOMIC PHYSICS

4.1 A thundercloud is forming over the highveld area, covering a horizontal area of 25 km² and reaching a height of 1,250 m above the ground. Using this information as a capacitor, calculate the electrical energy stored in the system, given that the potential difference in the cloud is 1,2 MV and the dielectric constant d is 2,75.

The permittivity of free space is $8,9 \times 10^{-12}$ F/m (4)

4.2 In an experiment done by students with a cathode-ray tube, the number of electrons striking the screen each second = 63×10^{-19}; the average kinetic energy as it reaches the screen is $8,4 \times 10^{-16}$ J per electron.

Calculate the following:

4.2.1 The total current in the electron beam (3)

4.2.2 The potential difference through which the electrons have been accelerated (2)

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4.3 In the photoelectric effect, light directed at the surface of certain metals cause electrons to be emitted. In the case of potassium, 2,5 eV of work must be done to remove an electron from the surface.

Calculate the following:

4.3.1 The maximum energy of the photoelectrons that emerge, if the light of a wavelength $5,753 \times 10^{-7}$ m falls on a potassium surface. (2)

4.3.2 If light with a wavelength of 4×10^{-7} m falls on the same surface, calculate whether the photoelectrons will have more or less energy.

Use Planck's constant = $6,65 \times 10^{-34}$ J.s and 1 eV = $1, 6 \times 10^{-19}$ J. (3)

4.4 At a certain instant, a piece of radioactive material contains 10^{12} atoms. The half-life of the material is 30 days.

Calculate the following:

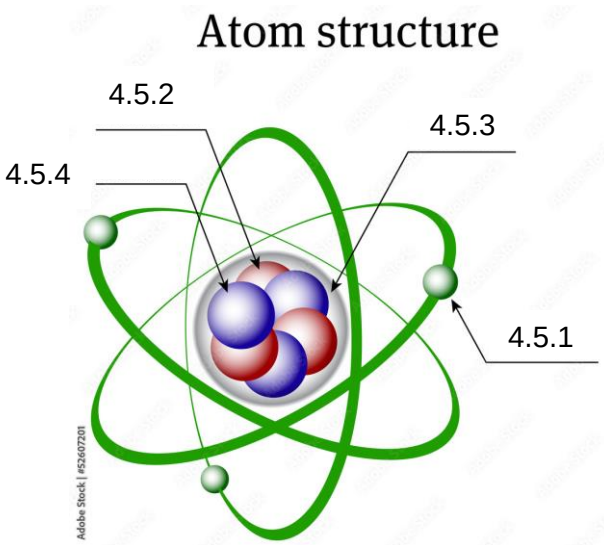
4.4.1 The number of disintegrations in the first second (3)

4.4.2 The time that will elapse before 10^4 atoms remain (2)

4.4.3 The count rate at this time (2)

4.5 FIGURE 1 (below) shows a simple atom.

Name each part indicated and its electrical charge by writing only the answer next to the question number (4.5.1–4.5.4) in the ANSWER BOOK.



(4)

[25]

TOTAL: 100

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ENGINEERING PHYSICS N6

FORMULA SHEET

The list is not necessarily complete. Any other applicable formula may also be used.

$$E = \frac{T_1 - T_2}{T_1} = 100\%$$

$$\frac{\gamma P}{\rho} = \frac{\gamma RT}{m} = v^2$$

$$\eta = \frac{W}{Q_1} = 1 - \frac{T_2}{T_1} \times 100\%$$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$W = mC_v(T_2 - T_1)$$

$$Q = W = P_1V_1 \ln \frac{V_2}{V_1}$$

$$S_f = 4{,}187 \ln \frac{T_f}{273}$$

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

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

$$PV = mRT$$

$$Q_1 = m_1 c \Delta T$$

$$Q = mL_v$$

$$U = mC_v(T_2 - T_1)$$

$$\left(\frac{V_2}{V_1}\right)^{\gamma-1} = \frac{T_1}{T_2}$$

$$\gamma = \frac{C_p}{C_v}$$

$$R = C_p - C_v$$

$$W = mRT_1 \ln\left(\frac{P_1}{P_2}\right)$$

$$P_1V_1^{\gamma} = P_2V_2^{\gamma}$$

$$W = mR \ln \frac{V_1}{V_2}(T_1 - T_2)$$

$$f' = \frac{fV}{V - v}$$

$$f' = \frac{F(V + v)}{V}$$

$$v = \lambda f$$

$$f = \frac{C}{2l}$$

$$V = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\frac{\gamma RT}{m}}$$

$$v = \sqrt{\frac{F}{\mu}}$$

$$\frac{V_1}{\lambda_1} = \frac{V_2}{\lambda_2}$$

$$f' = f\left(\frac{v \pm v_o}{v \pm v_z}\right)$$

$$f = \frac{1}{2L}\sqrt{\frac{P}{m}}$$

$$E = \frac{F}{Q_1} = \frac{Q}{4\pi e_o r^2}$$

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$W = QV$

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

$E_k = W = Vq$

$Q = CV$

$E = hf$

$F = qE$

$E = \frac{1}{2}CV^2$

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

$t = RC$

$S = \frac{W}{F}$

$E_k = hf - W$

$r = \frac{Q}{4\pi \in_o r}$

$v = \frac{kQ}{r}$

$C = \in_r . \in_o . \frac{A}{d}$

$F = \frac{kq_1q_2}{r^2}$

$E_k = QV$

$e = \frac{v}{d}$

$\frac{1}{c} = \frac{1}{c_1} + \frac{1}{c_2}$

$I = \frac{Q}{t}$

$v = \lambda f$

$\mathrm{W} = \frac{1}{2}\mathrm{QV}$

$m = EQ = \left(\frac{V}{r}\right)Q$

$C = k \in_o \frac{A}{d}$

$a = \frac{F}{m} = \frac{Eq}{m} = \frac{Vq}{S_m}$

$W = Vq = \frac{1}{2}mv^2$

$r = \sqrt{\frac{kq_1q_2}{F}}$

$\sigma = \frac{Q}{4\pi r^2}$

$W = \frac{1}{2}cv^2$

$T = \frac{1}{\lambda} . \ln 2$

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