higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T610**(E)**(J30)T

NATIONAL CERTIFICATE

ENGINEERING PHYSICS N6

(15070126)

30 July 2019 (X-Paper)
09:00–12:00

This question paper consists of 6 pages and a formula sheet of 2 pages.

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. Keep subsections of questions together.

5. Rule off across the page on completion of each question.

6. ALL calculations should consist of at least THREE steps:

   6.1 The formula used or manipulation thereof
   6.2 Substitution of the given data in the formula
   6.3 The answer with the correct SI unit

7. The constant values, as they appear on the attached formula sheet, must be used when possible.

8. Answers must be rounded off to THREE decimal places.

9. Use g = 9,8 m/s^2.

10. Write neatly and legibly.

QUESTION 1: SOUND

1.1 Describe, with the aid of neat sketches, how the pitch of sound can be determined. (2)

1.2 Distinguish between the concepts *node* and *antinode* applicable to standing waves. (2)

1.3 What is the difference between a *displacement node* and a *displacement antinode* applicable to stationary or standing waves and what is the distance between two adjacent nodes or between two adjacent antinodes? (3)

1.4 A steel pipe is 57 cm long with its lower part clamped vertically in water so that the length of the air column can be changed. The pipe resonates for the first time with a vibrating tuning fork at a frequency of 535 Hz when the air column is 16,7 cm long and again when the column is 49,7 cm. End correction must be taken into consideration.

Determine the lowest frequency at which resonance takes place if the pipe is open at both ends.

HINT: $\ell + c = \frac{V}{4f}$ and $\ell_1 + c = \frac{3V}{4f}$ (7)

1.5 A bat flies towards a radio mast (radio-signal receiver tower). The bat emits sound waves at a frequency of 51 000 Hz and detects sound waves of 49 000 Hz. The velocity of sound in air is 325 m/s.

Determine the speed of the bat flying towards the radio mast. (4)

1.6 An electrical train sounds its horn of 1 200 Hz. The speed of sound can be taken as 325 m/s.

Calculate the following:

1.6.1 What frequency does a person hear standing on the platform while the train approaches at a speed of 65 km/h? (3)

1.6.2 What frequency does the person hear when the train is passing him? (2)

1.6.3 What will the frequency be if the person runs after the electrical train at a speed of 18 km/h? (2)

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QUESTION 2: THERMODYNAMICS

2.1 In practice a process can be obtained as near as possible to a true isothermal process.

Explain what is meant by an isothermal process and explain how it is obtained. (2)

2.2 The third law of thermodynamics state that the absolute freezing point can be reached. Is this statement true or false? (1)

2.3 Explain *specific heat capacity* of a gas. (2)

2.4 The following test was done in a laboratory: 150 g steam at 255 °C was mixed with 425 g of water at 18 °C in a glass vessel. The specific heat capacity of the glass vessel is 0,25 cal/g and the mass of the vessel is 125×10^{-3} kg.

Calculate the final temperature of the test. (6)

2.5 A volume of 0,018 m^3 of a certain substance has an initial pressure of 680 kPa. It is allowed to expand adiabatically to a pressure of 148 kPa.
Use Cp = 1,066 kJ/kg.K and Cv = 0,785 kJ/kg.K

Calculate the following:

2.5.1 Substance gas constant for this gas (2)

2.5.2 Volume of the substance of this gas at the latter pressure (2)

2.5.3 Amount of work done by the substance (2)

2.5.4 Change in internal energy of the substance (1)

2.6 A gas completes the Carnot cycle of which the temperature limits are 293 °C and 52 °C. The mass of the gas is 0, 23 kg and the ratio between the volumes of isothermal parts of the cycle is 2,5. R for the gas is 0, 28 kJ/kg.K.

Calculate the following:

2.6.1 Thermal efficiency of the cycle

2.6.2 Work done during ten cycles

(2 × 2) (4)

2.7 Cooling water enters the condenser of a steam plant at a temperature of 19 °C and leaves it at 46 °C. The steam enters the condenser at 110 °C and leaves it as water at 70 °C. Steam condenses at the pressure concerned at 100 °C and 21 liters of water are required to condense 1 kilogram of steam. Use the specific heat capacity of water as equal to $4,187 \times 10^3$ J/kg.K.

Determine the specific latent heat of vaporisation of water. (3)

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QUESTION 3: ELECTROSTATICS

3.1 Explain *dielectric constant* on a capacitor. (2)

3.2 Give the definition of the unit of electrical charge. (2)

3.3 Explain *electrostatic induction*. (2)

3.4 A capacitor of 55 µF is charged from a 240 V supply. After the capacitor has reached its maximum charge it is disconnected from the supply and immediately connected in parallel to a 35 µF capacitor.

Determine the following:

3.4.1 Potential difference across the combination

3.4.2 Electrostatic energies before and after the capacitors are connected in parallel

(2 × 3) (6)

3.5 Determine the capacitance in microfarads of a parallel-plate capacitor made with five metal plates and separated by sheets of mica having a thickness of 0,4 ram and a relative permittivity of 7. The area of one side of the plate is 450 cm^2.

Use the permittivity of free space as 8,85 × 10^{-12} F/m. (4)

3.6 Calculate the number of excess electrons on the drop in a Millikan experiment if a negatively charged oil drop of mass 2,4 × 10^{-15} kg is held stationary in a vertical electric field with an intensity of 5 × 10^4 V/m. (3)

3.7 Complete the following paragraphs by using the words in the list below. Write only the word next to the question number (3.7.1–3.7.6) in the ANSWER BOOK. Each word may only be used ONCE.

current; dielectric; one second; ratio; electrical charge; relative permittivity

A coulomb is the amount of (3.7.1) … through a cross-section of a conductor in (3.7.2) … if a constant (3.7.3) … of I amp flows through the conductor.

The (3.7.4) … of the capacitance with and without the (3.7.5) … between the plates is called the dielectric constant or (3.7.6) … of the material used.

(6 × 1) (6)

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QUESTION 4: ATOMIC PHYSICS

4.1 Complete the following sentences by writing the missing word/s next to the question number (4.1.1–4.1.5) in the ANSWER BOOK.

4.1.1 Gamma rays are electromagnetic waves of exactly the same type as X-rays, and differ from X-rays only in being …

4.1.2 By magnetic deflections the beta particles were shown to be …

4.1.3 Alpha particles have a charge of +2 electron units and a mass of …

4.1.4 In 1899 Ernest Rutherford found that a type radioactive radiation was stopped or absorbed by a thin 0,002 cm sheet of aluminium. He called this addition …

4.1.5 Rutherford also found that another particle required a few millimetres of aluminium to be stopped or absorbed. This radiation was called …

(5 × 1) (5)

4.2 When a metal is heated, electrons are ejected.

4.2.1 What name is given to this phenomenon? (1)

4.2.2 Briefly explain why electrons are ejected. (2)

4.2.3 Explain why ejected electrons would return to the hot metal. (2)

4.3 Describe *photoelectric emission* and also explain what will happen to the external and internal electron. (4)

4.4 Explain how the internal photoelectrical effect is used when light intensity is measured by, for instance, a photographic exposure meter when a light is shined on different metals. (6)

4.5 Make a neat, labelled sketch of an atom. (3)

4.6 Explain *isotope* by referring, among other things to the concepts proton and neutron. (2)

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TOTAL: 100

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FORMULA SHEET

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

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

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

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

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

$$W = mC_v(\mathrm{T_2 - T_1})$$

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

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

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

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

$$PV = mRT$$

$$Q_1 = m_1 c \Delta T$$

$$Q = mL_v$$

$$U = mC_v(\mathrm{T_2 - T_1})$$

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

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

$$R = C_p - C_v$$

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

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

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

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

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

$$v = \lambda f$$

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

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

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

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

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

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

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

$$W = QV$$

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

$$E_k = W = Vq$$

$$Q = CV$$

$$E = hf$$

$$F = qE$$

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

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

$$t = RC$$

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

$$E_k = hf - W$$

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

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

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

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

$$E_k = QV$$

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

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

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

$$v = \lambda f$$

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

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

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

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

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

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

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

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

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