THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

DIPLOMA IN EDUCATION EXAMINATION

731 PHYSICS TEACHING METHODS

Time: 3:30 Hours **ANSWERS** **Year: 1999**

Instructions

1. This paper consists of section A, B and C.

2. Answer all questions in section A and B and two questions from section C.

1. (a) (i) Distinguish between vector and scalar quantities.
A vector quantity has both magnitude and direction, whereas a scalar quantity has only magnitude without direction. Examples of vector quantities include force and velocity, while examples of scalar quantities include mass and temperature.

(ii) What is meant by the term couple?
A couple refers to two equal and opposite forces acting at different points on a body, producing rotation without translation. It creates a turning effect known as torque.

(b) The maximum safe angular velocity at which a solid disk can be spun is proportional to its radius R, the breaking stress S, and the density ρ of the material. Find the form of the relationship.
Let ω be the angular velocity. Using dimensional analysis,
Breaking stress S has dimensions of force per unit area:
$S = ML^{-1}T^{-2}$
Density ρ has dimensions:
$\rho = ML^{-3}$
Radius R has dimensions:
$R = L$

Assume $\omega \propto R^a S^b \rho^c$. Expressing in dimensions:
$T^{-1} = (L)^a (ML^{-1}T^{-2})^b (ML^{-3})^c$
$T^{-1} = M^{b+c} L^{a-b-3c} T^{-2b}$

Equating exponents,
For M: $b + c = 0$
For L: $a - b - 3c = 0$
For T: $-2b = -1 \Longrightarrow b = 1/2$

Substituting $b = 1/2$ into $b + c = 0$ gives $c = -1/2$. Substituting into $a - b - 3c = 0$ gives:
$a - 1/2 + 3/2 = 0 \Longrightarrow a = -1$

Thus, $\omega \propto (S/\rho)^{(1/2)} * R^{-1} \Longrightarrow \omega = k (S/\rho)^{(1/2)} / R$, where k is a constant.

(c) (i) Find the work done in pushing back the atmosphere when a mass of 1 g of water at its boiling point is turned to 1601 cm^3 of steam.
The work done against atmospheric pressure is given by $W = P\Delta V$, where $P = 1.013 \times 10^5$ Pa, and the volume change is $\Delta V = 1601\ cm^3 = 1.601 \times 10^{-3}\ m^3$.
$W = (1.013 \times 10^5) \times (1.601 \times 10^{-3})$
$W = 162$ J

(ii) It is known that the specific latent heat of vaporization of water is 2268 J/g. If all the latent energy is used in pushing back the atmosphere, explain the use of the remaining energy.

The total energy absorbed during vaporization is 2268 J, but only 162 J is used for external work. The remaining energy increases the internal energy of the steam, which results in increased molecular motion and potential energy within the gaseous phase.

(d) (i) Draw a labelled diagram showing the essential features of the cathode ray oscilloscope (CRO). Briefly explain the function of each component.
[Diagram required]
The main components are the electron gun, deflection plates, and screen. The electron gun produces and accelerates electrons. The deflection plates control the movement of the electron beam, and the fluorescent screen displays the waveform.

(ii) An alternating potential difference (P.D.) of $V = V_0 \sin\omega t$ is applied to the Y plates of a CRO. Draw the trace as seen on the screen when the time base is switched off; at a suitable time base applied to the X plates. When the time base is off, a vertical line is observed, as the Y deflection follows $V = V_0 \sin\omega t$. When the time base is applied, a sinusoidal waveform appears on the screen.

(e) The crystal spacing of NaCl is 2.82×10^{-10} m. For the first-order Bragg diffraction image, the Bragg angle is 19.53°. Find the wavelength, λ, for the rays, and the second-order Bragg angle. What is the longest λ that this crystal can analyse?
Bragg's law: $n\lambda = 2d \sin\theta$
For n = 1,
$\lambda = (2 \times 2.82 \times 10^{-10} \text{ m}) \sin(19.53°)$
$\lambda = (5.64 \times 10^{-10}) \times 0.334$
$\lambda = 1.88 \times 10^{-10}$ m

For n = 2,
$2\lambda = 2d \sin\theta_2$
$\theta_2 = \sin^{-1}[(2 \times 1.88 \times 10^{-10}) / (2 \times 2.82 \times 10^{-10})]$
$\theta_2 = \sin^{-1}(0.668)$
$\theta_2 \approx 41.93°$

The longest wavelength that can be analyzed occurs when θ = 90°:
$\lambda_{max} = 2d \sin 90° = 2(2.82 \times 10^{-10}) = 5.64 \times 10^{-10}$ m.

2. (a) State the assumptions of the kinetic theory of gases.
The assumptions include:
1. Gas molecules are in constant random motion.
2. Collisions between molecules and with the walls are perfectly elastic.
3. The volume of individual molecules is negligible compared to the total gas volume.
4. Intermolecular forces are negligible except during collisions.
5. The time taken for a collision is negligible compared to the time between collisions.
6. The average kinetic energy of molecules is proportional to absolute temperature.

(b) How does it account for the fact that the gas exerts a pressure on the walls of the container?
Gas molecules collide with the walls, transferring momentum. The cumulative effect of many such collisions creates pressure, defined as force per unit area.

(c) Heat required to raise the temperature of 5.0 g of mercury from 1 K to 20 K.
Given: $C = aT^4 + bT$, where $a = 1.52 \times 10^{-6}$ J/kg.K^4, $b = 8.88 \times 10^{-2}$ J/kg.K.
Heat absorbed: $Q = m \int (aT^4 + bT)\, dT$ from 1 K to 20 K.
[Integration required]

3. (a) Account for the following facts, with reference to physical principles:
(i) A small transient deflection is obtained when a coil of wire connected to a galvanometer lying flat on a table is turned off.
This is due to electromagnetic induction. When the circuit is switched off, the collapsing magnetic field induces a transient current in the coil, causing a momentary deflection.

(ii) A beaker of mercury can be stirred easily with a glass rod, but when placed between the poles of a strong electromagnet, it resists stirring.
This is due to the generation of eddy currents in the mercury, which interact with the magnetic field, producing a force that opposes motion (Lenz's Law).

(b) A solenoid with a soft iron laminated core is placed in series with a gas discharge lamp from AC mains. Explain why this solenoid is necessary.
The solenoid acts as a choke, limiting the current and providing the necessary inductance for proper lamp operation. The laminated iron core reduces eddy current losses, improving efficiency.

4. (a) (i) What is an n-type semiconductor?
An n-type semiconductor is a material doped with donor atoms to increase free electrons as charge carriers.

(ii) When an n-type and p-type semiconductor are joined, they form a p-n junction. Label and draw the symbol.

(b) Study the circuit:
(i) C is an NPN transistor, and D is the base-emitter junction.
(ii) If wire leads are free, the bulb remains off.
(iii) If connected at X, the transistor is forward-biased, turning the bulb on.
(iv) If connected at Y, the bulb remains off.
(v) If one lead is at X and the other at Y, the circuit remains incomplete, and the bulb stays off.
5. (a) Why is it considered that all electric charges are multiples of e?
Electric charge is quantized, meaning it exists in discrete packets of elementary charge, denoted as e (1.6×10^{-19} C). This is based on experimental evidence, including Millikan's oil drop experiment, which showed that the charge of any particle is always an integer multiple of e. Fundamental particles such as electrons and protons carry charges of ±e, and no isolated particle has been observed with a fractional charge in classical experiments.

(b) An electron having 450 eV of energy moves at right angles to a uniform magnetic field of flux density 1.50×10^{-2} T. Show that the path of the electron is a circle and find its radius.
The electron experiences a centripetal force due to the Lorentz force, given by:
$qvB = mv^2/r$
Rearrange to get the radius:
$r = mv / (qB)$

First, convert energy to joules:
$450 \text{ eV} = 450 \times 1.6 \times 10^{-19} \text{ J} = 7.2 \times 10^{-17} \text{ J}$

Using kinetic energy formula:
$KE = \frac{1}{2} mv^2 \Longrightarrow v = \sqrt{(2KE/m)}$
$v = \sqrt{(2 \times 7.2 \times 10^{-17} / 9.11 \times 10^{-31})}$
$v = \sqrt{(1.58 \times 10^{14})}$
$v \approx 1.26 \times 10^{7}$ m/s

Now, calculate radius:
$r = (9.11 \times 10^{-31} \times 1.26 \times 10^{7}) / (1.6 \times 10^{-19} \times 1.50 \times 10^{-2})$
$r = (1.15 \times 10^{-23}) / (2.4 \times 10^{-21})$
$r \approx 4.8 \times 10^{-3}$ m

Since the force is always perpendicular to velocity, the motion remains circular.

6. (a) (i) Differentiate between physics laboratory regulations and physics safety precautions.
Physics laboratory regulations are formal rules governing conduct in the laboratory to ensure order, efficiency, and safety. They include procedures for handling equipment and maintaining cleanliness. Physics safety precautions are specific measures taken to prevent accidents and injuries, such as wearing protective gear and handling chemicals safely.

(ii) State three physics laboratory regulations and three physics safety precautions.
Physics laboratory regulations:
- Always clean up after experiments.
- Follow instructions from the instructor before using equipment.
- Report broken apparatus immediately.

Physics safety precautions:
- Wear safety goggles when handling chemicals or glassware.
- Avoid direct contact with electrical circuits.
- Keep flammable materials away from open flames.

(iii) What is the most common hazard which can be caused by glassware in the physics laboratory?

The most common hazard is cuts from broken glass, which can occur if glassware is mishandled or breaks due to impact or excessive force.

(b) (i) What is a scheme of work?
A scheme of work is a structured plan outlining topics, objectives, and activities for a subject within a specified period, ensuring systematic coverage of the syllabus.

Discuss the importance of a scheme of work.
A scheme of work ensures proper lesson sequencing, helps manage time effectively, and provides consistency in teaching. It also allows for monitoring progress and ensures syllabus coverage.

(ii) List the main parts of a scheme of work.
- General objectives
- Weekly topics and subtopics
- Teaching methods and activities
- Learning resources
- Assessment methods

(c) (i) List the stages which are followed when an experiment is being done in the laboratory.
- Identifying the problem or objective
- Gathering necessary materials and apparatus
- Setting up the experiment
- Carrying out the procedure systematically
- Recording observations and results
- Analyzing and interpreting data
- Drawing conclusions and making recommendations

(ii) List four liquids or chemicals necessary to be stored in the physics laboratory and state the respective experiments which use them.
- Mercury – Used in barometers and thermometers
- Sulfuric acid – Used in lead-acid battery experiments
- Alcohol – Used in spirit thermometers and heat experiments
- Distilled water – Used for making solutions and calibration of instruments

7. (a) Suppose you are required to introduce Form I students to the topic "Density" within one period of 40 minutes:
(i) What is the prerequisite for this topic?
Students should have prior knowledge of mass, volume, and basic measurement techniques using balances and measuring cylinders.

(ii) Write lesson notes which you would use for this purpose.
Definition: Density is the mass per unit volume of a substance, given by $\rho = m/V$.
Units: The SI unit of density is kg/m^3, though g/cm^3 is also commonly used.

Measurement: Density is determined using a balance for mass and a measuring cylinder for volume. For irregular solids, the displacement method is used.
Examples: Density of water is 1000 kg/m³, while metals like iron have higher densities.

(b) A class of Form III pupils has a practical lesson to verify Hooke's Law using rubber bands. Write a set of instructions, including the diagram which the pupils will have to follow during the experiment.
1. Suspend a rubber band vertically from a fixed support.
2. Attach a pointer and place a ruler beside it to measure extension.
3. Add a known mass and record the extension.
4. Continue adding masses incrementally, recording each extension.
5. Plot a graph of force (weight) against extension.
6. Observe the linear relationship within the elastic limit, verifying Hooke's Law.

8. (a) What is a "kit" as referred to in physics equipment?
A physics kit is a set of apparatus and materials designed for conducting experiments, often compact and portable for ease of use in teaching.

(b) State the advantages and disadvantages of a physics kit.
Advantages:
- Portable and easy to store
- Facilitates hands-on learning
- Provides ready-to-use equipment for various experiments

Disadvantages:
- May lack specialized instruments for advanced experiments
- Limited to basic experimental setups
- Can be expensive if customized for specific topics

(c) (i) With the aid of diagrams, where necessary, describe how you would make a hydrometer.
A hydrometer consists of a weighted bulb and a narrow stem with a scale. To make one:
1. Take a glass tube and seal one end.
2. Partially fill the bulb with lead shot or sand for stability.
3. Mark a scale along the stem to indicate density variations.
4. Calibrate using liquids of known densities.

(ii) Where and how could you use a hydrometer in teaching physics?
A hydrometer can be used in density experiments to compare liquid densities, demonstrating principles of buoyancy and specific gravity. It is commonly used in fluid mechanics and practical applications like testing battery electrolyte concentration.