FORT PORTAL SECONDARY SCHOOL.

SENIOR FIVE GROUP DISCUSSION QUESTIONS SET ONE

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Make groups of four members and answer the following questions. Make research where possible. Ensure that your work is marked by 20th March,2026 without fail

TOPIC ONE: DIMENSIONS

ITEM ONE

A student sets up an experiment to determine the acceleration due to gravity g using a simple pendulum. The time period T of the pendulum is given by:

Either $T = 2\pi\sqrt{\frac{l}{g}}$ or $T = 2\pi\sqrt{\frac{l}{v}}$ where v is velocity and l is the length of the simple pendulum but the student is not sure of the correct formula to use.

TASK

a) Help the student in choosing the right formula
b) Explain any two applications of dimensions
c) What are some limitations of dimensional analysis?

ITEM TWO

In a physics laboratory, a student investigates the flow of liquid through a narrow tube. The rate of flow Q (volume per unit time) is believed to depend on:

- the pressure difference across the tube P,
- the radius of the tube r,
- the viscosity of the liquid η, and
- the length of the tube l.

The student proposes the relation: $Q = \frac{\pi p r^2}{8\eta l}$. However, one student noted that the equation was incorrect. They agreed to confirm its dimensional consistence and if it is not correct, then correct it. They have come to you for help. Help them

ITEM THREE

A researcher is studying the speed v of waves on the surface of deep water. The speed is assumed to depend on: the acceleration due to gravity g, the wavelength of the wave λ, and the density of water ρ. His colleague said that it velocity of sound in this case does not depend on density. They have chosen to come to you as a student of physics to help them settle the disagreement. Help them out

ITEM FOUR

Teacher Nyaruhuma of Kisomoro put up three equations

a) $\left(P + \frac{a}{v^2}\right)(V - b) = RT$
b) $F = k_1 \eta r v$
c) $T = 2\pi\sqrt{\frac{m}{k_2}}$

Where a, b,k_1 and k_2 are constants. V in a) is volume while in b) is velocity, T is period in c). The teacher wants you to use these to teach your fellows that some constants are dimensionless while others are not. He also wants you to clarify to your fellows that Nkg^{-1} and ms^{-2} are equivalent units. Prepare your presentation.

ITEM SIX

For waves on a liquid surface, the angular frequency ω is given by: $\boldsymbol{\omega^2 = gk + \frac{\gamma}{\rho}k^3}$ ω = angular frequency of the wave , g = acceleration due to gravity , $k = \frac{2\pi}{\lambda}$, γ = surface tension and ρ = density of liquid . Katekaine wonders whether this equation is correct and wants to understand the meaning of dimensions, fundamental quantities and derived quantities. She also wishes to know how to come with dimensions of Young's modulus of elasticity.
Task
As a student of physics, help Katekaine.

ITEM SEVEN

During a university engineering competition, a student proposed a new equation for calculating the power output of a small hydroelectric turbine they had designed. The equation combined variables like water density, flow rate, gravitational acceleration, and turbine radius. Before building a prototype, the team's physics advisor suggested they check the dimensional consistency of the proposed equation to avoid fundamental flaws in their design logic. This step would save them considerable time and resources by ensuring the mathematical relationship between the physical quantities made sense before moving to the experimental phase.

Tasks

(a) State the fundamental reason why checking dimensional consistency is a crucial step in formulating physical equations.
(b) The proposed equation for power is $P = k\rho A v^3$
where ρ is density, A is area, and v is velocity. Determine the dimensions of the constant k.
(c) Explain what the result of your dimensional analysis implies about the physical validity of the student's equation.

TOPIC TWO: THERMOMETRY

ITEM ONE

During a science exhibition at Makerere University, students from different schools were asked to calibrate thermometers using various temperature scales. One group used the Celsius scale, another used the Kelvin scale, while a third group preferred the Fahrenheit scale. To compare results, the judges asked the teams to convert their readings into a common scale before presenting their findings.
At one point, a student reported that the boiling point of water was measured as **212°F**, while another group recorded it as **100°C**. The judges then challenged the teams to show how the different scales relate to each other and to explain why scientists often prefer the Kelvin scale in advanced physics experiments

Tasks

(a) State two reasons why it is important to have standard temperature scales in scientific work.
(b) Derive the relationship between the Celsius and Fahrenheit scales.
(c) Convert the boiling point of water from **212°F** into Celsius and Kelvin.
(d) Explain why the Kelvin scale is more suitable than the Celsius or Fahrenheit scales in thermodynamic studies.

ITEM TWO

At a district science fair, students calibrated a thermometer using the ice point and steam point.

Tasks:

(a) Define the term *fixed point*.
(b) Explain why fixed points are essential in constructing temperature scales.
(c) Describe how the Celsius scale is established using fixed points.
(d) State two limitations of relying only on ice and steam points for calibration.

ITEM THREE

Two groups measured the same hot liquid: one used a mercury-in-glass thermometer, the other a resistance thermometer. Their readings differed slightly.

Tasks:

(a) Give the reasons why different thermometers may not agree on the same temperature.
(b) Explain how a resistance thermometer works.
(c) Describe how a constant-volume gas thermometer can be used to calibrate other thermometers.
(d) State two advantages of the constant-volume gas thermometer over liquid-in-glass thermometers.

During a physics laboratory session at Makerere College, students were asked to calibrate a mercury-in-glass thermometer. The thermometer had a uniform bore and the mercury column length was measured at different fixed points.

- At the **ice point (0°C)**, the mercury column length was **5.0 cm**.
- At the **steam point (100°C)**, the mercury column length was **25.0 cm**.
- When placed in an unknown hot liquid, the mercury column length was **17.0 cm**.

The students were required to determine the temperature of the liquid, explain the calibration process, and discuss possible sources of error.

Tasks

(a) Explain what is meant by calibration of a thermometer.
(b) Using the given data, calculate the temperature of the unknown liquid.
(c) State two assumptions made when calibrating a liquid-in-glass thermometer.
(d) Discuss two possible sources of error when using a liquid-in-glass thermometer.

ITEM THREE

During an industrial visit to the Uganda Electricity Generation Company, senior six physics students observed engineers measuring the temperature of a furnace. Because the furnace was extremely hot, ordinary liquid-in-glass thermometers could not be used. Instead, the engineers demonstrated two instruments: an **optical pyrometer** and a **digital infrared (IR) thermometer**. The students were asked to compare these instruments and discuss their calibration and limitations.

Tasks

(a) Explain the principle of operation of an optical pyrometer.
(c) Describe how a digital infrared thermometer measures temperature without contact.
(d) State two advantages and two limitations of using optical pyrometers compared to digital IR thermometers.

ITEM THREE

A regional hospital in Gulu is upgrading its medical equipment, including various types of thermometers for different departments. The procurement committee must choose between mercury-in-glass, clinical, digital, and infrared thermometers based on accuracy, safety, and specific use cases. The pediatric ward requires non-invasive options for children, while the intensive care unit needs highly precise and continuous monitoring capabilities. The hospital's chief medical officer has organized demonstration sessions from different suppliers, emphasizing the importance of understanding the working principles of each thermometer type to make informed purchasing decisions that will serve their diverse patient needs effectively while adhering to national healthcare standards.

(a) Describe the working principle of a liquid-in-glass thermometer.

(b) Explain two advantages of digital thermometers over mercury thermometers in clinical settings.

(c) A resistance thermometer has a resistance of 120 Ω at 0∘C and 165 Ω at 100∘C. Calculate the temperature when the resistance is 140 Ω.

(d) Suggest why different departments in a hospital might require different types of thermometers.

ITEM FOUR

An industrial complex in Jinja houses both a steel manufacturing plant and a pharmaceutical company, requiring diverse temperature monitoring systems. The steel plant needs thermometers that can measure extremely high temperatures in furnaces, while the pharmaceutical company requires precise temperature control for drug formulation processes. Engineers are evaluating **thermocouples, resistance thermometers, and radiation pyrometers** for different applications. The complex management has initiated a cross-departmental training program to educate technicians about the appropriate selection, installation, and maintenance of various thermometer types to optimize industrial processes and ensure workplace safety standards are consistently met.

Tasks

(a) Explain how a thermocouple thermometer generates an electromotive force (emf).

(b) Describe two situations where a radiation pyrometer would be preferred over other types of thermometers.

(c) A thermocouple produces an emf of 12 mV at 200∘C and 18 mV at 300∘C. Calculate the expected emf at 250∘C, assuming a linear relationship.

(d) Discuss the importance of selecting appropriate thermometer types for different industrial applications.

ITEM FOUR

At **Uganda Breweries**, engineers are monitoring the fermentation tanks where temperature control is critical for product quality. A resistance thermometer is installed alongside a constant-volume gas thermometer to ensure accuracy.

The resistance of the thermometer at a Celsius temperature θ, as measured by the gas thermometer, is given by: $R_\theta = 40 + 0.15\theta + 2X10^{-4}\theta^2$ If the gas thermometer reads **40 °C**,

a) Calculate the temperature indicated on the scale of the resistance thermometer
b) Explain the disagreement
c) Describe how a constant volume gas thermometer can be used to measure temperature