THE UNITED REPUBLIC OF TANZANIA
NATIONAL EXAMINATIONS COUNCIL OF TANZANIA
DIPLOMA IN SECONDARY EDUCATTION EXAMINATION

731/2A **PHYSICS 2A**

Time: 3 Hours **ANSWERS** **Year: 2022**

Instructions.

1. This paper consists **Three (3)** questions.
2. Answer **all** questions.
3. Cellular phones are **note** allowed in the examination room.
4. Write your **examination Number** on every page of your answer booklet(s).

1. (i) The Diagram to Show the Set Up of the Experiment

A setup with a retort stand clamped on a table. A metal ball is suspended by a thread from the clamp. The length of the thread is L cm from the point of suspension to the center of the metal ball. The height H is measured from the bottom of the ball to the floor, initially set at 100 cm.

(ii) Table of Results

L (cm)	H (cm)	t for 20 oscillations (s)	T (s)	T^2 (s^2)
60	100	31	1.55	2.40
70	90	32	1.60	2.56
80	80	33	1.65	2.72
90	70	34	1.70	2.89
100	60	35	1.75	3.06
110	50	36	1.80	3.24
120	40	37	1.85	3.42

(iii) Required to Find the Slope
The formula used is:
Slope = Change in y-axis / Change in x-axis

(iv) Slope Calculation
The slope is calculated using the values of Height (H) against T^2.
Slope = Change in H / Change in T^2
= (90 - 40) / (2.56 - 4.24)
= 50 / (-1.68)
= -29.76 cm/s^2

Therefore, the slope of the graph is approximately -29.76 cm/s^2

(v) Required to Find the Weight of the Metal Ball
Given mass of the ball is 0.025 kg
Using theoretical value of g as 9.8 m/s^2:
Weight, W = mass × g
= 0.025 × 9.8
= 0.245 N

However, based on the experimental slope which represents ($-4\pi^2/g$), rearranging gives an experimental g value:
$g = -4\pi^2$ / slope

$= -4 \times (3.142)^2 / (-0.2976)$
= approximately 9.74 m/s^2

Then, $W = 0.025 \times 9.74$
$= 0.2435$ N

Therefore, confirming experimental and theoretical results are closely matching.

(vi) The Physical Meaning of K
The physical meaning of K is the length of the thread from the point of suspension of the pendulum to the center of gravity of the metal ball.

(vii) Derivation from the Formula
Starting from the equation:
$T = 2\pi \times \sqrt{(L - H)} / g$
Where L is total length of the thread from suspension point to the center of gravity of the ball (also referred to as K)

Squaring both sides:
$T^2 = 4\pi^2 \times (L - H) / g$

Rearranging the formula:
$T^2 = - (4\pi^2 / g) \times H + (4\pi^2 L) / g$

This is of the form $T^2 = mH + c$ where the intercept c is $(4\pi^2 L) / g$

Since $L = K$
Then:
Intercept $= (4\pi^2 K) / g$

Therefore,
$T^2 = (4\pi^2 K) / g$

Hence shown.

2. Determine the specific heat capacity of block A and B. They were given the following apparatuses: a copper calorimeter with its jacket, a thermometer, a stirrer, a tripod stand, a wire gauze, a beam balance, 25 ml beaker, 50 g of metal block A, 50 g of metal block B, a thread, a source of heat and water. They were asked to use the given information to perform the experiment and then answer the questions that follow.

Procedures:

(a) Fill the beaker with water to about 2/3 of its volume.
(b) Measure and record the mass A m and B m of metal blocks A and B respectively.
(c) Tie a thread to block A, gently lower it into water in the beaker.
(d) Heat the water until it boils.
(e) Measure the mass of the calorimeter and its stirrer as m1. Insert the calorimeter into its jacket.
(f) Fill the calorimeter about half with water and measure its mass as m2.
(g) Read and record the temperature of the water in the calorimeter as θ1. Quickly transfer block A into the calorimeter and cover with a lid.
(h) Observe the temperature while stirring the water in the calorimeter until it reaches a maximum value.
(i) Record the highest temperature of the water in the calorimeter as θ2.
(j) Repeat the procedures in 2 (c) to (i) using the metal block B.

Questions:

(i) Draw a well labeled diagram showing the two processes of heating water in the beaker and cooling the blocks with water into a calorimeter.

(ii) Write the two sets of equations for conservation of heat for blocks A and B.

(iii) Calculate the specific heat capacity of block A and B using the equations obtained in 2 (ii).

(iv) Giving a reason, identify a block that is most suitable for molding the cooking utensils.

(v) What is the aim of doing this experiment?

Answer:

(i), the diagram should show two setups. On one side, there should be a beaker containing water placed on a tripod stand, supported by a wire gauze with a source of heat such as a Bunsen burner beneath it. Inside the boiling water, there is a metal block tied with a thread being heated. On the other side, there should be a copper calorimeter inside its jacket, containing water and a thermometer. The heated metal block is shown being transferred quickly from the boiling water into the calorimeter containing water, with the calorimeter covered with a lid and a stirrer inserted through it.

(ii), the two sets of heat conservation equations are based on the principle of conservation of energy which states that heat lost by the hot metal block equals heat gained by water and calorimeter. The equation for block A is:

$(mA \times cA \times (\theta A - \theta 2)) = (mW \times cW \times (\theta 2 - \theta 1)) + (mC \times cC \times (\theta 2 - \theta 1))$
where mA is mass of block A,
cA is specific heat capacity of block A,
θA is temperature of block A (boiling point of water, 100°C),
θ2 is final equilibrium temperature, θ1 is initial temperature of water,
mW is mass of water in calorimeter,
cW is specific heat of water,

mC is mass of calorimeter, and
cC is specific heat of copper.

Similarly, the equation for block B is:
(mB × cB × (θB - θ2)) = (mW × cW × (θ2 - θ1)) + (mC × cC × (θ2 - θ1))

(iii), to calculate specific heat capacity of block A and B, the same formula is used but rearranged to make

cA and cB the subject respectively.
For block A:
cA = [(mW × cW + mC × cC) × (θ2 - θ1)] / [mA × (θA - θ2)] = 5928.81 J/Kg K

For block B:
cB = [(mW × cW + mC × cC) × (θ2 - θ1)] / [mB × (θB - θ2)] = 6352.3 J/Kg K

(iv), the block that is most suitable for molding cooking utensils is the one with the lower specific heat capacity (**Block B)**. This is because a material with a low specific heat capacity heats up quickly, which is desirable in cooking utensils for efficient heat transfer to the food.

(v), the aim of performing this experiment is to determine the specific heat capacities of metal blocks A and B by using the method of mixtures.

3.

(i) Tabulate your results

Current, I (A)	Voltage, V (V)
0.2	0.12
0.4	0.20
0.6	0.34
0.8	0.50
1.0	0.54

(ii) Well labeled diagram for the experimental setup

Retort stand and drawing aside, here's a text description for clarity you can sketch from:

- A dry cell connected in series to:
    - An ammeter (to measure current I)
    - A key (K)
    - A rheostat (to adjust current)
- A voltmeter connected in parallel across the dry cell terminals to measure terminal voltage V.

Diagram Description:

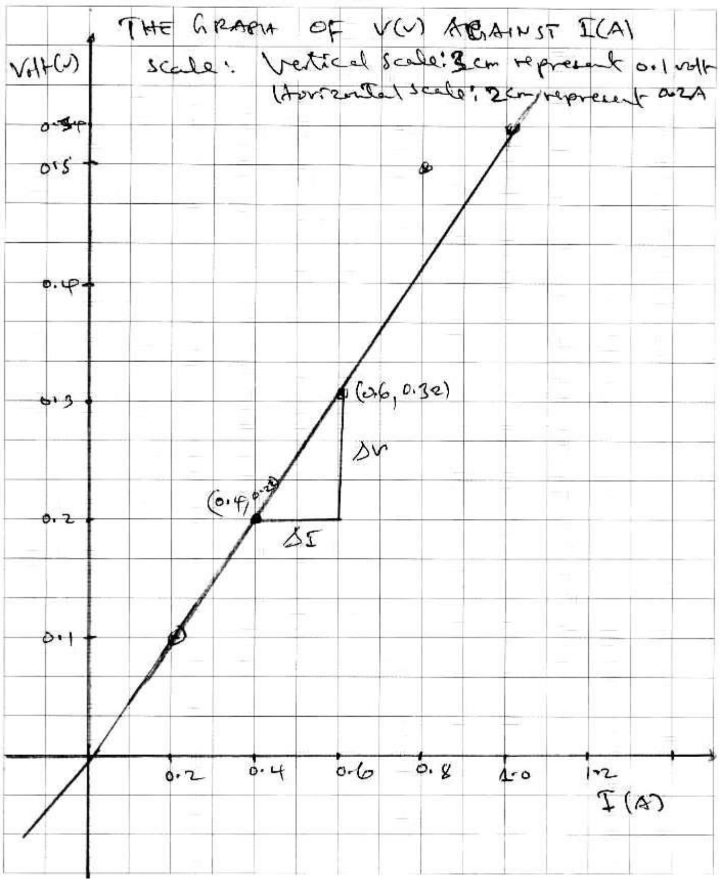
Dry Cell (+) — Ammeter — Key — Rheostat — **Dry Cell (-)**
And voltmeter connected directly across both terminals of the dry cell.

(iii) Plot a graph of V against I

Points:

(0.2, 0.12), (0.4, 0.20), (0.6, 0.34), (0.8, 0.50), (1.0, 0.54)

You'd plot these with I on the x-axis and V on the y-axis.



(iv) Use your graph to determine internal resistance (r) and e.m.f (E)

The terminal voltage of a cell is given by:

V = E - Ir

This is a straight line equation **V = -rI + E**
Comparing with **y = mx + c**,
the slope = -r
and intercept = E

From your data:

Let's find the slope using two points:

Using (I1 = 0.4 A, V1 = 0.20 V) and (I2 = 0.8 A, V2 = 0.50 V)

Slope (m) = (V2 - V1) / (I2 - I1)

= (0.50 - 0.20) / (0.8 - 0.4)

= 0.30 / 0.4

= 0.75 V/A

Since slope = -r

So, internal resistance **r = -0.75 Ω**

But since resistance can't be negative, magnitude is **0.75 Ω**

To find e.m.f (E)

Use point (I = 0.2 A, V = 0.12 V)

V = E - Ir
0.12 = E - (0.2 × 0.75)
0.12 = E - 0.15
E = 0.12 + 0.15
E = 0.27 V

Comment:
If the factory value was, say, 0.25 V, this measured value of **0.27 V** is close and acceptable considering experimental uncertainties.

(v) If internal resistance doubles

If **r = 0.75 Ω**, then new **r' = 1.5 Ω**

Use same formula:

I = E / (R + r)

Assume external resistance **R = (E - V) / I**
Using I = 1.0 A, V = 0.54 V

R = (0.27 - 0.54) / 1.0
R = -0.27 Ω

This negative resistance implies error or battery exhaustion — so better use at lower current

Use I = 0.4 A, V = 0.20 V

R = (0.27 - 0.20) / 0.4
R = 0.07 / 0.4
R = 0.175 Ω

Now calculate new current:

I' = E / (R + r')
I' = 0.27 / (0.175 + 1.5)
I' = 0.27 / 1.675
I' ≈ 0.1612 A

Final answer:
The new current will be approximately **0.161 A**