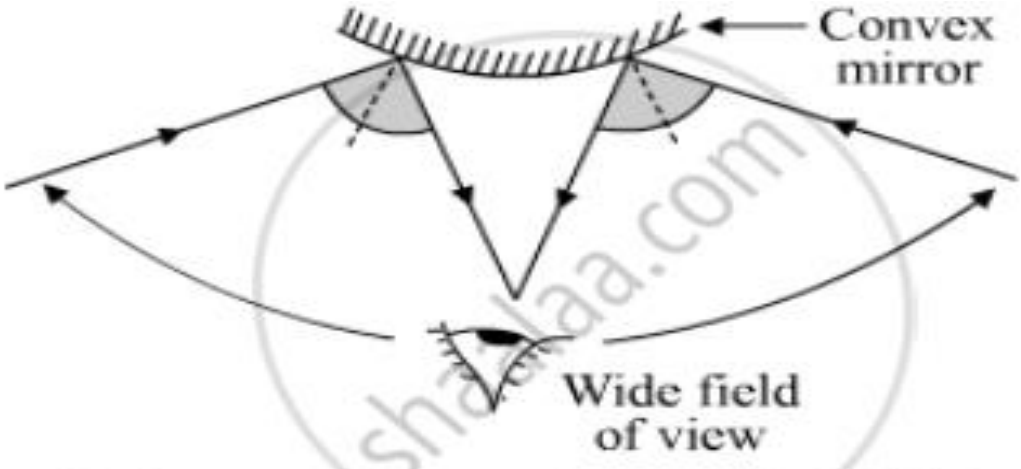
**THE SECOND ANNUAL NATIONAL O-LEVEL PHYSICS SEMINAR HELD ON 12TH JULY 2025 AT HOLY CROSS LAKEVIEW S.S.S, JINJA, AND ORGANISED IN CONJUNCTION WITH SEPTA**

**ITEM ONE**

a)Convex mirror




(*a*) A convex mirror gives a wide field of view (or large field of view).

**Why a Convex Mirror**

**Wider Field of View**: A convex mirror can see a wider field as the rays from different directions converge to a single point after reflection. Therefore, the hidden/blind corners in the shop/supermarket can easily be monitored.

**Inexpensive**: Unlike CCTV cameras, convex mirrors are relatively cheap and easy to install and maintain.

**b) Other Applications of a Convex Mirror**

Convex mirrors are widely used in many places for **surveillance and safety** purposes:

1. **Road Safety**: At sharp bends or driveway exits, they help drivers see oncoming traffic.
2. **ATMs**: Positioned above cash machines so users can see behind them for security.
3. **Parking Lots**: To help drivers view approaching vehicles or pedestrians.
4. **Hospitals and Schools**: In hallways or corridors, to avoid collisions at intersections.

**c) Estimate the Width of the Nile River.**

Given: Speed of sound = 340 m/s, Time taken for sound to travel = 0.5 seconds

The sound (whistle) travels from one side of the river to the other.

Therefore:

Distance = speed x time

Width of the river =340 × 0.5

= 170m

The estimated width of the Nile River at that point is 170 meters.

**d) Why a Whistle is Preferred Over a Direct Call**

1. **Higher pitch**: A whistle produces a sharp, high-pitched sound that travels a longer distance compared to a human voice.
2. **Less Energy**: Blowing a whistle requires less effort than shouting.
3. **Easily Recognizable Signal**: A whistle is a clear, intentional signal, reducing confusion.
4. **Omnidirectional**: Unlike the human voice, which may be directional, the sound from a whistle spread in all directions effectively.

**ITEM TWO**

a) **Understanding the Old Woman's Sight Challenge and How It Can Be Minimized**

The old woman has a sight challenge called **Presbyopia.** This is the inability of the eye to accommodate, which is commonly caused by old age. As one grows old, the ciliary muscles that support the lens in the eye weaken and stop either contracting to stretch the lens, increasing its focal length to view distant objects, or relaxing to make the lens flatten, reducing the focal length to view nearby objects.

**How It Can Be Minimized**:

This can be minimized by using a bifocal lens.

b) **Calculating the Money to Be Paid for the Hole Dug**

Given:

Speed of sound = 330 m/s

Time taken for echo to return = 0.36 seconds

Rate of pay = shs. 5000 per meter

$V=2d/t$

$330 = 2d/0.36$

$d= (330x0.36)/2$

$d=59.4m$

$Payment=59.4\times5000$

Payment shs 297,000.

Therefore, the workers should be paid Shs 297,000 by the old woman.

**ITEM THREE**

a**) i) Cause of Miners' Failure to Achieve Desired Developments**

The miners and their families spend most of their income on treating persistent diseases such as:

- Skin irritation
- Persistent fatigue
- Unexplained sickness (e.g., nodding disease)

The rocks collected from the gold mines show that they contain radioactive sources that emit radiation, which is dangerous to human health. These radiations cause health issues like cancer; they weaken the body's immunity by destroying white blood cells; and they can lead to genetic mutations, among other problems.

Therefore, their constant exposure to radioactive materials without protection is the main reason many become sick and cannot save or invest their money. Most of it goes toward medical treatment.

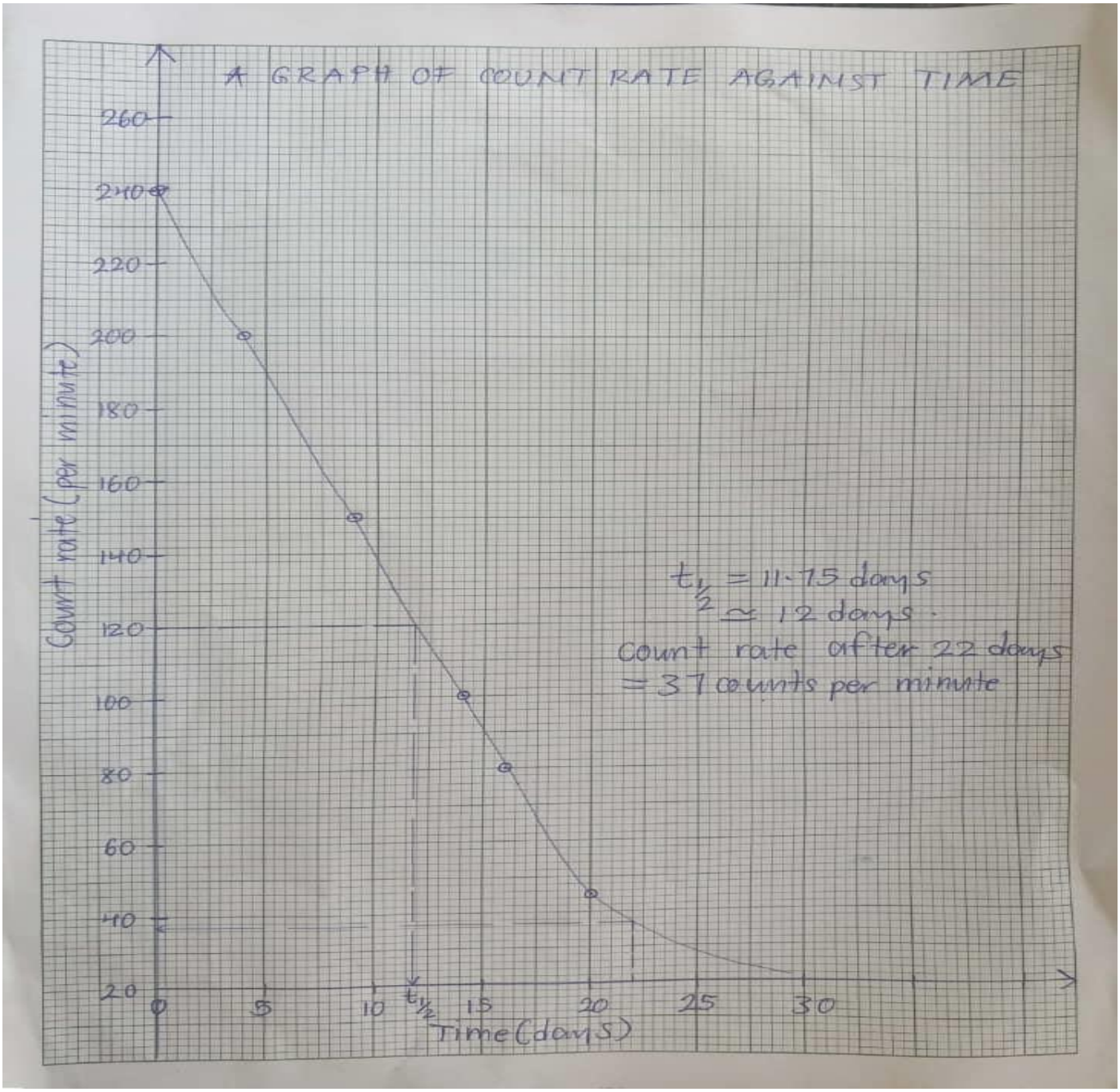
a) ii) How Miners Can Mitigate These Challenges

- Protective Gear: Wear gloves, masks, long-sleeved clothing, and boots to limit skin and respiratory exposure.


- Time, Distance, and Shielding (Radiation Safety Principles): Minimize time spent near radioactive materials.
- Increase the distance from radioactive sources.
- Use shielding materials like lead or thick plastic where possible.

- Safe Waste Disposal: Do not discard mining waste near homes or water sources.
- Set up designated dumping zones far from residential areas.
- Health Monitoring: Regular health check-ups for early detection of radiation-related illnesses.
- Awareness & Training: Educate the mining community about radiation dangers and safe practices.

b)



From the graph, the half-life is 12 days, and the count rate after 22 days is 37 counts per minute

**Other relevant information**

- Other uses of the radioactive substances found in the rocks
- Methods of storing them safely.
- How to handle these radioactive materials safely.

**ITEM FOUR**

**a i) How the Leakage Can Be Traced Using Iodine-131**

Iodine-131 is a radioactive tracer. It emits radiation that can be detected with a Geiger-Müller tube (radiation detector). When added to water:

It flows with the water through the pipe.

At any point of leakage, iodine-131 escapes into the surroundings.

Workers walk along the pipeline with a radiation detector.

The detector shows increased radiation levels at any leaking point.

This method precisely locates where the pipe is leaking.

Advantage: No need to dig the entire pipe.

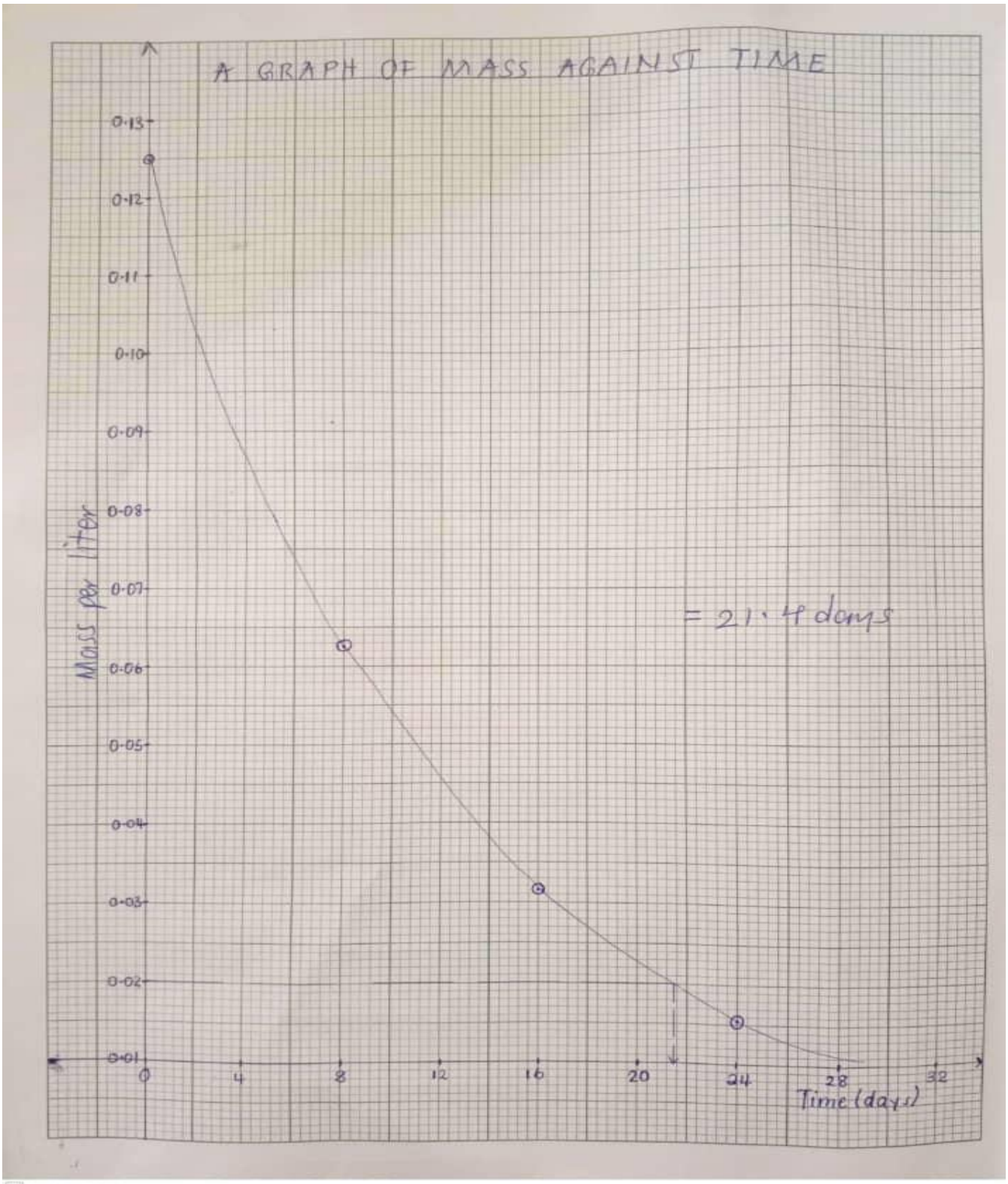
**a ii) Why Iodine-131 Is Preferred**

Iodine-131 is ideal for tracing water leaks because:

- Soluble in water – it mixes easily and flows naturally.
- Short half-life (about 8 days) – doesn't stay radioactive for long.
- Low required quantity – only tiny amounts needed.
- Eventually decays to a safe level, like the natural level in fresh water.

**b)**

| Time (Days) | Mass per liter |
|---|---|
| 0 | 0.125 |
| 8 | 0.0625 |
| 16 | 0.03125 |
| 24 | 0.015625 |




**It will take 22 days for the workers to replenish the water supply.**

c) **Explain the Mode of Operation of CRT-TV**

CRT = Cathode Ray Tube TV

**How it works**:

- A cathode (heated filament) at the back of the tube emits electrons.
- These electrons are focused and accelerated across the vacuum, extra high tension.
- The beam is deflected (bent) by X or Y plates
- When the beam of electrons hits the screen, it fluorescence, forming a bright spot

**ITEM FIVE**

**a) How the Destruction Was Reduced in a Short Time**

**How Destruction Was Stopped Quickly**:

Effective communication methods like SMS received on phones provided accurate information on the locusts. TVs and radios that use satellites deliver precise data about locusts, such as the size of the swarm, their direction and speed, and wet regions, since locusts breed in wet soils.

**Other Technologies:**

- GPS and drones for targeting specific locations.
- Spray vans and planes to distribute pesticides quickly over affected areas.
- Communication tech (SMS, radio, TV) informed farmers on what to do fast action

Quick, targeted intervention prevented major crop losses and famine.

b) **Understanding the Relative Speed of the Satellites**

Given:

Altitude of satellite above Earth: 35,000 km

Radius of Earth = 6,300 km

Total distance from Earth's center:

r=6300+35,000=41,300 km

Geostationary Satellites Orbit Earth once every 24 hours, the same as Earth's rotation.

They appear stationary above the same point on Earth.

Relative Speed (Orbital Speed):

Orbital speed v is given by:

□ = 2□□/□

Where:

r=41,300,000 meters

T=24×3600=86,400 seconds

□ = 2□ ×41,300,000/86,400

≈2,998m/s

≈3km/s

Satellite moves at ~3 km/s, enough to stay above the same point as Earth rotates, ideal for constant monitoring.

c) Circuit Diagram and Truth Table Using Logic Gates

**From the Description:**
The engine starts only if:

The switch is ON,

The seatbelt is fastened,

The thumb is pressed.

This is an AND logic gate scenario:

All conditions must be true (1) for the engine to start.

Truth Table for AND Gate

| Switch | Seatbelt | Thumb | Engine (Output) |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 1 |

**ITEM 6**

**a) How Energy in the Sun is Produced**

The Sun produces energy through a process called nuclear fusion.

In the core of the Sun, temperatures are extremely high (~15 million °C).

Hydrogen atoms fuse to form helium.

$$^{2}_{1}H + {}^{2}_{1}H = {}^{4}_{2}He + Energy$$

During this fusion, a small amount of mass is lost, and it's converted to energy using Einstein's equation**:**

$E=mc^2$

Where:

E = Energy

m = Mass lost

c = Speed of light ($3.0 \times 10^8$ m/s)

This is the energy that radiates as sunlight and powers life on Earth.

b) Heat from the sun is used to preserve our food.

It provides vitamin D

It causes the heating sensation(infrared) to maintain the body temperature

Energy from the sun supports the photosynthesis of crops that support the life of both human beings, animals, and birds

**c) Average Rate of Temperature Drop from Sun to Earth**

Given:

Temperature of Sun's surface: ~5500°C = 5773 K

Temperature at Earth: 27°C = 300 K

Distance from Sun to Earth = 1 AU = 149,600,000 km = $1.496 \times 10^8$ km

Average rate of temperature drop = (Temp at Sun −Temp at Earth)/Time

= $(5773\ K - 300K)/(1.496 \times 10^{11} km/3.0 \times 10^8)$

≈ $10.98 Ks^{-1}$

The average rate of temperature drop from the Sun to Earth is about $10.98 Ks^{-1}$

d) Power System Required for the School

Given:

4 LED lamps, each 15W

4×15=60 W

1 small computer = 60 W

Total Power = 60 + 60 = 120 W

Needed for 5 hours per evening

Energy Needed Per Day:

Energy=Power×Time=120×5=

600 Wh

**The power system required should have 600Wh**

**ITEM SEVEN**

a) We are told:
- Critical bleeding altitude = 43,000 m
- Barometric pressure at sea level = 76 cmHg
- Barometric pressure at the mountain top = 72.12 cmHg
- Density of mercury (ρ_Hg) = 13,600 kg/m³
- Density of air (ρ_air) = 1.2 kg/m³
- g = 9.8 m/s²

Using pressure difference:
ΔP = (76 - 72.12) cmHg = 3.88 cmHg = 0.0388 mHg
ΔP = hρg = 0.0388 × 13600 × 9.8 ≈ 5150.94 Pa

Altitude:
h = ΔP / (ρ_air × g) = 5150.94 / (1.2 × 9.8) ≈ 438 m
Conclusion: Since 438 m < 43,000 m, the tourists will not bleed at this altitude.
b) Boiling Point at the Top of the Mountain

$$Q = MC\theta$$

294,000=1 X4200X($\theta - 26$)

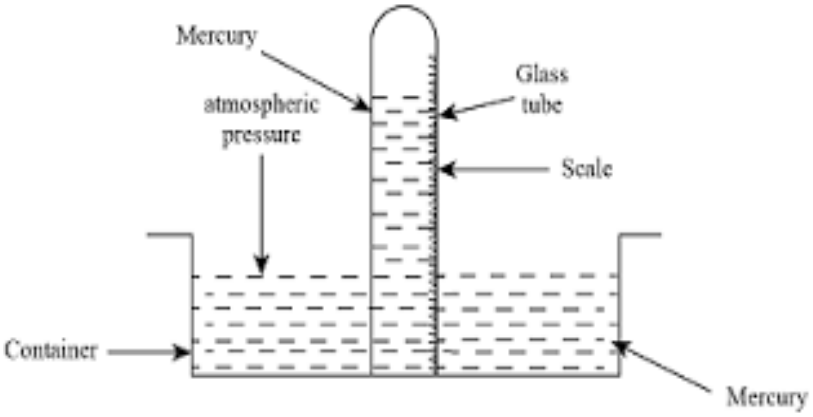
$\theta$ =96 °C

Implication:
when water boils at 96 °C, it has got a less heating effect on the food as compared to the water that boils at 100 °C. Therefore, cooking on a mountain takes longer
(c) Simple Barometer Design

Apparatus:
- One-meter-long glass tube
- Mercury
- Water dish

Steps:

1. Fill the tube completely with mercury.
2. Invert it into a mercury-filled dish without letting air enter.
3. A vacuum forms at the top.
4. The height of mercury represents the atmospheric pressure.




Use:
As atmospheric pressure decreases with altitude, the height of mercury in the tube falls.

**ITEM EIGHT**

(a) Electrical Appliance Recommendation

The hotel attendant should buy a pressure cooker. A pressure cooker works by increasing the pressure inside the container, which raises the boiling point of water above 100°C. This allows food to cook faster because the higher temperature increases the rate of heat transfer to the food.

(b) Mass of Ice Needed

Given:
- Initial temp of tea = 85°C
- Final temp of tea = 30°C
- Mass of tea = 0.25 L = 0.25 kg
- c (tea) = 4200 J/kg·K
- Latent heat of fusion (Lf) = 334,000 J/kg

Heat lost by tea =heat required to melt the ice + heat required to raise the temperature of the ice from 0 to 30°C

Heat lost by tea: $Q = mc\Delta T = 0.25 \times 4200 \times (85 - 30) = 57{,}750$ J

Heat gained by ice: $Q = m \times Lf$
$= m \times 334000$

Heat required to raise the temperature of the ice from 0 to 30°C =m x 4200 x (30-0) =126,000 m

This implies

57,750 J = m × 334000 + 126,000 m
57,750 J =460,000m

**M=0.125kg**

Therefore, about 125 grams of ice are needed to cool the tea.
(c) Cause of Room Hotness and Solutions

The room becomes hot during the day, likely due to poor ventilation and absorption of heat through walls or the roof (especially if metallic).

Solutions:
- Install proper ventilation (windows or air vents)
- Use light-colored paint or reflective roofing
- Add curtains
- Plant trees for shade

(d) Sweating and Temperature Regulation

Sweating is a natural cooling mechanism. When sweat evaporates from the skin, it absorbs the latent heat of vaporization from the body, thereby lowering body temperature. This process helps the body maintain a stable internal temperature, especially in hot conditions.

**ITEM NINE**

(a) Color Codes and Circuit Features

Color Codes:
- Red: Live wire
- Black/Blue: Neutral wire
- Green/Yellow: Earth wire

Main Features:

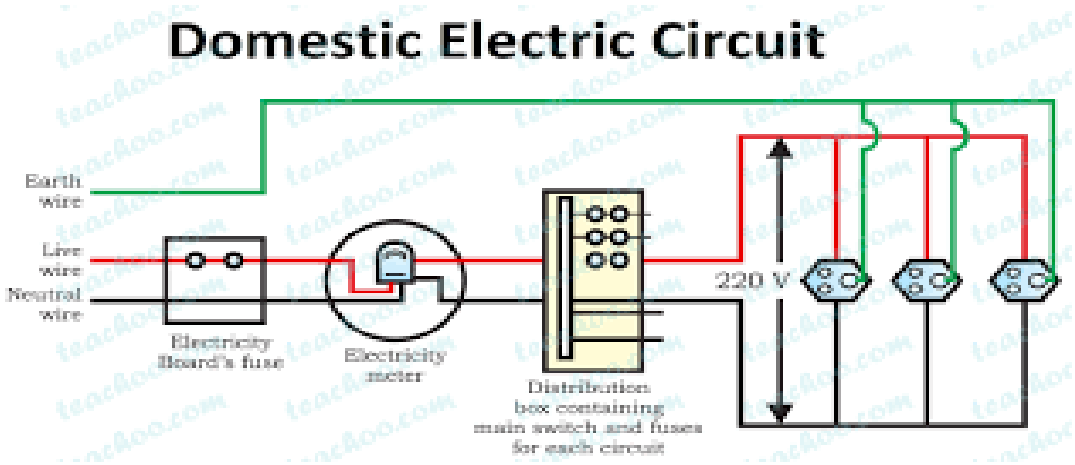
Meter box: It is the connection point of the service cable to the wiring system in the house

Consumer unit (Fuse box). It has the main that disconnects electricity in case of any fault.it has fuses connecting the live wires to the different electrical systems in the house.

Switches: connected to the live wire

Sockets

Earth wire: which protects the user in case of excess charge flowing




(b) Electromagnet Design and Strength Improvement

Design: Coil a conducting wire around the iron rod and connect it to the battery.

To improve strength:
- Use more turns of wire
- Use a soft iron core
- Increase current through better cells or parallel arrangements

(c) Battery Arrangement for Longer Life

**ITEM TEN**

(a) Why Stepping Down Voltage is Necessary

High voltages (e.g. 13kV) are used in transmission to minimize energy loss. After generation, the voltage is stepped up and the current is reduced using step-up transformers and it is stepped down to 240V using a step-down transformer to ensure safety and compatibility with household appliances.

(b) Why the Step-Down Might Be Delayed

- Transformer installation takes time due to setup and approvals.
- Availability of compatible transformers
- Safety checks and grid connection permissions

(c) Ensuring More Current to Houses

Given: $R_1$ = 10Ω, $R_2$ = 12Ω

1. Ensure houses are connected in parallel, not series.
2. Parallel connection reduces overall resistance:
1/R_total = 1/10 + 1/12 → R_total ≈ 5.45Ω

More current flows because I = V/R is larger when R is smaller.

A fault in one house cannot affect the flow of current in the other houses