**Item 1**

**Answers:**

(a) To prevent disturbing the hospital, the theatre management should:

- Install acoustic soundproofing materials (e.g., foam panels, acoustic curtains) to absorb sound.
- Use double-glazed doors and windows to reduce sound leakage.
- Direct speakers inward using directional sound systems.
- Control the volume of the sound, especially during sensitive times.
- Use sound-lock entryways (double doors) to minimize sound escape.
- Plant trees or install sound barriers between the theatre and hospital.

(b) The management should install **plane mirrors** in the changing rooms.

**Reason:** Plane mirrors form **virtual**, **upright**, and **same-size** images, which are ideal for personal grooming and dressing. Other mirrors (e.g., concave or convex) would distort the appearance of the user.

(c) The perceived colour change of their clothes is due to the presence of **coloured lighting** in the theatre:

- A **yellow dress** reflects red and green light. Under red and blue lights (no green), it reflects mostly red or appears darker.
- A **cyan dress** reflects blue and green light. Under blue and red lights (no green), it reflects blue or appears darker.

This change is due to the **absence of green light** in the environment, affecting how colours are perceived.

(d) Given:

$$\text{Speed of sound, } v = 330 \text{ m/s}$$
$$\text{Time interval, } t = 0.1 \text{ s}$$

The sound travels to the back wall and reflects back, so:

$$\text{Total distance} = v \times t = 330 \times 0.1 = 33 \text{ m}$$

Therefore, the distance to the back wall is:

$$\text{Distance to wall} = \frac{33}{2} = \boxed{16.5 \text{ m}}$$

**Item 2**

**Answers:**

(a) The observation in London of longer days and shorter nights is due to the **tilt of the Earth's axis** (about 23.5°) and its **orbit around the Sun**.

During **summer in the Northern Hemisphere**, places like London experience longer days and shorter nights because the North Pole is tilted toward the Sun. This results in the Sun being visible for more hours, sometimes up to 16 or more, depending on the location and date. Conversely, during winter, nights are longer than days.

(b) The elder's belief that stars die in the daytime and resurrect at night is a **misconception**.

Stars are always present in the sky both during the day and at night. However, during the **daytime**, the **Sun's light is so bright** that it scatters in the Earth's atmosphere and outshines the faint light coming from stars, making them invisible to the naked eye. At **night**, in the absence of sunlight, the stars become visible again.

(c) The changing shape of the moon observed over a month is known as the **phases of the Moon**.

These phases occur because the Moon orbits the Earth, and as it does so, the **portion of the Moon that is illuminated by the Sun** and visible from Earth changes.

The major phases include:

- **New Moon**: Moon is between Earth and the Sun; the side facing Earth is dark.
- **First Quarter**: Half of the Moon's disk is illuminated on the right.
- **Full Moon**: Earth is between the Moon and the Sun; the entire face is illuminated.
- **Last Quarter**: Half of the Moon's disk is illuminated on the left.

This cycle takes about **29.5 days**, known as a **lunar month**.

## SECTION B

**PART I (Answer one item from this part)**

**Item 3**

**Answers:**

(a) The car radiator is efficient because:

- It uses **water**, which has a **high specific heat capacity**, allowing it to absorb a lot of heat from the engine without quickly rising in temperature.
- The radiator has **metal fins** (usually copper or aluminum) that are good conductors of heat and increase surface area for cooling.
- It allows **air flow** through its structure, which enhances cooling by convection.

(b) The three states of water she used are:

- **Gas (steam)** – observed from the radiator and while steaming matooke.
- **Solid (ice)** – prepared for customers' drinks.
- **Liquid (water/drinks)** – in the radiator and the drinks served.

(c) Each state served its purpose effectively due to its properties:

- **Steam** carries a large amount of **latent heat of vaporization**, making it effective for cooking food like matooke by transferring heat efficiently.
- **Ice** absorbs heat when melting (due to latent heat of fusion), making it excellent for cooling drinks.
- **Liquid water** in the radiator absorbs engine heat without evaporating quickly, preventing overheating because of its high specific heat capacity.

(d) **Let us calculate the specific heat capacity of the special drink:**

Given:

$$\begin{aligned} m_{\text{ice}} &= 0.02 \times 4 = 0.08 \text{ kg} \\ c_{\text{ice}} &= 2100 \text{ J/kg·K} \\ L_f &= 336000 \text{ J/kg} \\ c_{\text{water}} &= 4200 \text{ J/kg·K} \\ m_{\text{drink}} &= 0.5 \text{ kg} \\ \Delta T_{\text{drink}} &= 30^\circ\text{C} - 10^\circ\text{C} = 20 \text{ K} \end{aligned}$$

**Heat absorbed by ice:**

$$\begin{aligned} Q_{\text{ice}} &= m_{\text{ice}} \cdot c_{\text{ice}} \cdot (0^\circ - (-10^\circ)) + m_{\text{ice}} \cdot L_f + m_{\text{ice}} \cdot c_{\text{water}} \cdot (10 - 0) \\ &= 0.08 \cdot 2100 \cdot 10 + 0.08 \cdot 336000 + 0.08 \cdot 4200 \cdot 10 \\ &= 1680 + 26880 + 3360 = 31920 \text{ J} \end{aligned}$$

**Let the specific heat capacity of the drink be** $c$.

Heat lost by drink:

$$Q_{\text{drink}} = m_{\text{drink}} \cdot c \cdot \Delta T = 0.5 \cdot c \cdot 20 = 10c$$

By conservation of energy (assuming no heat losses):

$$Q_{\text{drink}} = Q_{\text{ice}} \Rightarrow 10c = 31920 \Rightarrow c = \frac{31920}{10} = \boxed{3192 \text{ J/kg·K}}$$

**Item 4**

**Answers:**

**Given:**

- Density of salt-water: $\rho = 1050$ kg/m$^3$
- Capacity of tank: $V = 15400$ litres $= 15.4$ m$^3$
- Mass of salt-water: $m = \rho \cdot V = 1050 \times 15.4 = 16170$ kg
- Height of slope: $h = 5$ m
- Time taken: $t = 10$ s
- Speed: $v = 20$ m/s
- Acceleration due to gravity: $g = 10$ m/s$^2$
- Radius of tank: $r = 1.4$ m
- $\pi = 3.14$

(a) **Increase in potential energy (P.E.) of the salt-water:**

$$\text{P.E.} = mgh = 16170 \times 10 \times 5 = \boxed{808500 \text{ J}}$$

(b) **Power exerted by the truck's engine:**

Since power is energy per unit time:

$$P = \frac{\text{P.E.}}{t} = \frac{808500}{10} = \boxed{80850 \text{ W} = 80.85 \text{ kW}}$$

(c) **Pressure at the bottom of the tank:**

First, determine the height of the cylindrical tank:

$$V = \pi r^2 h \Rightarrow h = \frac{V}{\pi r^2} = \frac{15.4}{3.14 \times (1.4)^2} = \frac{15.4}{6.1576} \approx 2.5 \text{ m}$$

Pressure at the bottom due to the liquid:

$$P = \rho g h = 1050 \times 10 \times 2.5 = \boxed{26250 \text{ Pa}}$$

(d) **Length of the slope:**

Use trigonometry or Pythagoras theorem. Since truck moves up the slope at constant speed, and it takes 10 seconds to move at 20 m/s:

$$\text{Distance (length of slope)} = v \cdot t = 20 \times 10 = \boxed{200 \text{ m}}$$

**PART II (Answer one item from this part)**

**Item 5**

**Answers:**

(a) **How the voltage is changed:**

The voltage is changed using a device called a **transformer**. A transformer is used to either increase or decrease alternating current (AC) voltages. In this case, a **step-down transformer** is used to reduce the supply voltage from 13 kV (13,000 V) to 240 V.

Transformers only work with AC because they rely on electromagnetic induction, which requires a changing magnetic field. The step-down transformer has more turns in the primary coil and fewer in the secondary coil, reducing the voltage proportionally to the turn ratio.

(b) **How a DC machine can work with AC supply:**

Since the machine operates on direct current (DC) and the supply is alternating current (AC), a device called a **rectifier** is used to convert AC to DC.

A rectifier uses diodes or similar components to allow current to flow in only one direction, producing a unidirectional (DC-like) current. The output is usually smoothed using capacitors or filters to obtain a steady DC voltage suitable for the machine.

(c) **Will the machine work?**

First, calculate the input power from the supply:

$$P_{\text{input}} = V_{\text{input}} \times I_{\text{input}} = 13000 \times 0.05 = 650 \text{ W}$$

Since the process is 80% efficient, the useful output power is:

$$P_{\text{output}} = 0.8 \times 650 = 520 \text{ W}$$

This power is delivered at 240 V, so the current available to the machine is:

$$I = \frac{P}{V} = \frac{520}{240} \approx 2.17 \text{ A}$$

Since the machine operates efficiently between 2 A and 3 A, and the calculated current is approximately 2.17 A, **the machine will work efficiently**.

Yes, the machine will work.

**Item 6**

**Answers:**

(a) **Why the electrician recommended against series connection and emphasized earthing:**

- **Sockets should not be connected in series** because:
  - In a series connection, all devices share the same current, so if one appliance fails or is turned off, all others are affected.
  - Different appliances have different current requirements; a series connection would cause inefficient operation or damage.
  - Voltage is divided among devices in series, causing underperformance.
- **Earthing is essential** because:
  - It provides a safe path for electric current in case of a fault, preventing electric shock.
  - It protects appliances from voltage surges and enhances safety.

(b) **Determine if the UGX 70,000 budget is sufficient:**

**Energy consumption per day:**

- Cooker: 2900 W × 3 h = 8700 Wh = 8.7 kWh
- Lights: 10 × 40 W × 8 h = 3200 Wh = 3.2 kWh
- Water heater: 2900 W × 2 h = 5800 Wh = 5.8 kWh

$$\text{Total daily energy} = 8.7 + 3.2 + 5.8 = 17.7 \text{ kWh}$$

$$\text{Weekly energy} = 17.7 \times 7 = 123.9 \text{ kWh}$$

$$\text{Cost per week} = 123.9 \times 900 = 111510 \text{ UGX}$$

Since UGX 111510 $<$ UGX 70000, the budget is **not sufficient**.

No, the budget is not sufficient.

(c) **Ways to reduce the electricity bill:**

- Use energy-saving LED bulbs instead of ordinary lights.
- Reduce the usage time of high-power appliances like the cooker and water heater.
- Turn off lights and appliances when not in use.
- Invest in solar water heating or cooking solutions.
- Schedule heavy usage for off-peak hours if time-of-use tariffs apply.