

State Examination Commission – Physics Higher Level, 2011

Question 7

a) When making a hot drink, steam at 100°C is added to 160 g of milk at 20°C . If the final temperature of the drink is to be 70°C , what mass of steam should be added?. You may ignore energy losses to the surroundings.

A metal spoon, with an initial temperature of 20°C is then placed in the hot drink, causing the temperature of the hot drink to drop to 68°C . What is the heat capacity of the spoon? You may ignore other possible heat transfers. (24)

b) Name two processes by which a hot drink cools. How is the energy lost by each of these processes reduced for a hot drink supplied in a disposable cup. (14)

c) A thermocouple is used to measure the temperature of the steam.

How would you demonstrate the principle of operation of the thermocouple?

Describe how to establish a calibration curve for a thermocouple.

(18)

($c_{\text{milk}} = 3.90 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}$, $c_{\text{water}} = 4.18 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}$, $c_{\text{hot drink}} = 4.05 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}$, specific latent heat of vaporization of water = $2.4 \times 10^6 \text{ J kg}^{-1} \text{ K}^{-1}$)

a) When making a hot drink, steam at 100°C is added to 160 g of milk at 20°C . If the final temperature of the drink is to be 70°C , what mass of steam should be added?. You may ignore energy losses to the surroundings.

$$\begin{aligned} \text{Heat gained by milk} &= \text{heat lost by steam.} \\ 0.160 \times 3.90 \times 10^3 \times 50 &= (m \times 2.4 \times 10^6) + (m \times 4.18 \times 10^3 \times 30) \\ \text{Solving gives } m &= 0.0124 \text{ kg (12.4 g)} \end{aligned}$$

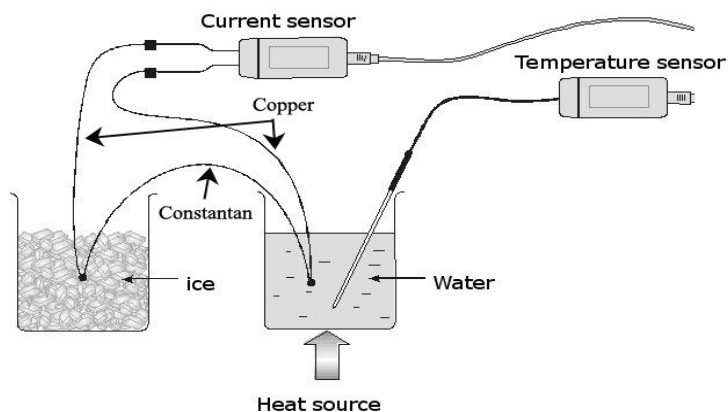
A metal spoon, with an initial temperature of 20°C is then placed in the hot drink, causing the temperature of the hot drink to drop to 68°C . What is the heat capacity of the spoon? You may ignore other possible heat transfers. (24)

$$\begin{aligned} \text{Heat gained by spoon} &= \text{heat lost by hot drink} \\ c_{\text{spoon}} \times 48 &= (0.160 + 0.0124) \times 4.05 \times 10^3 \times 2 \\ \text{Solving gives } c_{\text{spoon}} &= 29.1 \text{ J K}^{-1} \end{aligned}$$

b) Name two processes by which a hot drink cools. How is the energy lost by each of these processes reduced for a hot drink supplied in a disposable cup. (14)

Conduction and convection. The cup could be made from non conducting expanded polystyrene to reduce heat loss by conduction, and, to reduce heat loss by convection, could be fitted with a lid in which there is a small drink hole.

c) A thermocouple is used to measure the temperature of the steam.



How would you demonstrate the principle of operation of the thermocouple?

Set up apparatus as above, using a thermocouple made from copper and constantan wires welded together. If the reference junction is in an ice-water mixture, and the "hot" junction at a different temperature, a current will flow. When the temperature of the hot junction increases, the size of the current increases also.

Describe how to establish a calibration curve for a thermocouple.

(18)

Place a mercury thermometer in the hot water bath above, along with the “hot” junction. Note the current value every 10°C as the water is heated up. Plot a graph of current against temperature, as recorded by the thermometer. This is the calibration curve for the thermometer.

Instead of measuring current, a voltmeter could have been used to record how the p.d. between the two junctions varied with temp.