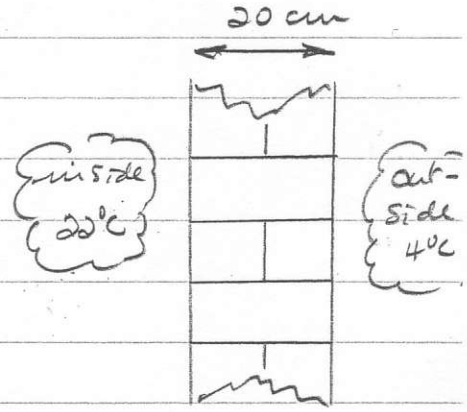
Topic Test — HEAT 1 — page 1 — A Physics

covering... kinetic theory, heat energy transfer, specific heat capacity, latent heat, thermal conduction.

1. A house wall is made of solid brick, thermal conductivity 0.8 $W m^{-1} K^{-1}$.

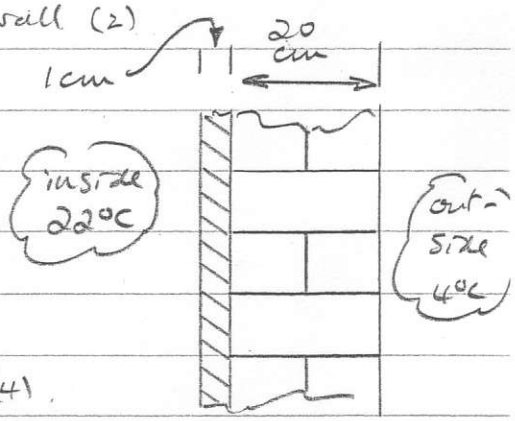


a) Calculate the rate of heat loss through an area of 5 m^2 of wall. (3)

b) In practice the rate of heat loss is less than your answer in (a). Explain why this happens, — you can use a diagram to help your answer (in fact it would be quite a good idea to do so). (3)

c) Calculate the U-value of the brick wall (2)

d) The inside of the wall is covered with a 1 cm thick layer of polystyrene, thermal conductivity 0.05 $W m^{-1} K^{-1}$. Calculate the rate of heat loss through 5 m^2 of the wall now. (4)



(e) Sketch the temperature profile across the wall. (2)

14

2. An impoverished Physics student works nights in a restaurant. He is thawing a 600 g block of frozen sauce in a microwave.

a) Sketch the general shape of the temperature-time graph for the sauce heated from fully frozen to lukewarm. Mark on the sketch where melting starts and ends (4)

b) The student takes the sauce from the freezer, at −18°C, and puts it straight into the microwave, set at 120 W power. He notes that the sauce is just beginning to melt at 0°C after 5 min 30 s. Calculate the specific heat of the frozen sauce. (3)

2 (c) If the latent heat of fusion of the sauce is 3.3×10^5 J/kg, calculate the time for all the sauce just to melt. (2)

d) The student turns up the microwave power setting, and when all the sauce is melted he notes that the temperature is going up at a rate of 0.12 K s^{-1}.
Calculate the new microwave power setting. (3) [12]
(The specific heat capacity of the liquid sauce is 4200 J/kg/K.)

3 Use your knowledge of Kinetic Theory to explain why ....

(a) gases are very poor conductors of heat (2)

(b) metals are better thermal conductors than non metals (3)

(c) a warmed region of liquid rises (4)

Marking summary Q... 1 2 3

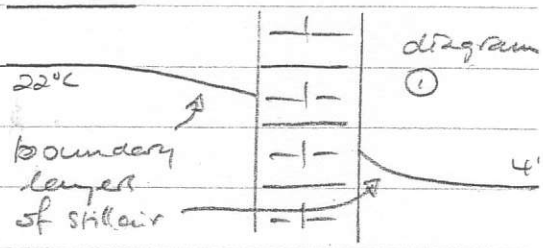
Out of 14 12 9 /35.

TLN
10.99

Topic Test – HEAT 1 – Answers — A Physics

1. a) Q/t (J/s) $= k A \Delta\theta / \Delta L = 0.8 \times 5 \times (22-4)/0.2 =$ **360 J/s** ①

b) Still air in **boundary layers** ① ① near the wall either side, carry some of the temperature drop ①



c) U value = rate of heat loss /m²/ k ①

$= 360 (J/s) / 5 \times 18 = 4$ W/m²/k

d) for polystyrene — Temp. of junction = θ_J

$Q/t = k_{poly} A \Delta\theta_p / x_p = k_{brick} A \Delta\theta_b / x_b$ ①

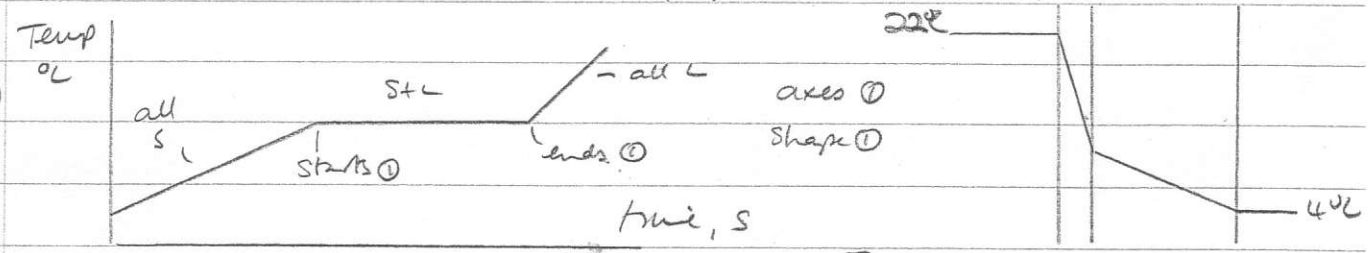
so $0.05 \times (22 - \theta_J)/0.01 = 0.8 \times (\theta_J - 4)/0.2$ ①

$110 - 5\theta_J = 4\theta_J - 16 \Rightarrow \theta_J = 14$ °C ①

So rate of heat loss $Q/t = 0.05 \times 5 \times (22-14)/0.01 =$ **200 W** ①

(or .... $\Delta\theta$ brick is now $14 - 4 = 10$°C so $Q/t = 360 \times 10/18 = 200$ W)

(e) general idea ① steep profile in polystyrene ① ignore boundary layer



2. a)

b) Energy input = power × time ① $= m C_{ice} \Delta\theta$ ①

$120 \times 330_{(sec)} = 600 \times C \times 18 \rightarrow C_{ice} =$ **3.7 J/g/k**

c) Energy input = m × latent heat ①

$120 \times t = 0.6 \times 3.3 \times 10^5 \rightarrow t =$ **1650 sec** ①

d) Power input Q/t (J/s) $= m C_{liquid} (\Delta\theta/\Delta t)$ — rate of rise (k/sec)

so $Q/t = 0.6 \times 4200 \times 0.112 =$ **302 W** = new power setting

3 a) particles far apart in a gas .... ① do not collide + pass on heat energy very often ①

b) in solids heat energy passed atom to atom by collisions ① ... in metals are electrons ① ... free to move ① + carry/pass on heat energy

c) heated liquid .... atoms vibrate with bigger amplitude ... move further apart / liquid expands ..... less dense .... cooler denser liquid sinks ①

TH 10.99

① ... 1/14 2/12 3/9 /35