Heat Capacity — problems   A Physics

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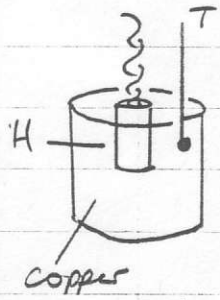
Data...

formula $\underset{J}{E} = \overset{g \text{ or } kg}{m}\, \underset{J/g \text{ or } J/kg}{c}\, \underset{°C \text{ or } K}{\Delta T}$

- $c_{water} = 4.2$ J/g/°C or 4,200 J/kg/°C
- Density of copper = 8.9 g/cm^3
- 1 cm^3 water has mass 1.0 g
- Energy content of peanut butter = 2500 J/100g

1. Specific heat capacity of copper



In this experiment, the copper cylinder is 4 cm in diameter, and 10 cm high.

(a) What is the volume? (2)

(b) What is the mass? (2)

(c) The student passes a current of 2.8A, with a p.d. of 8.5 V for 3 m 20s. Calculate the energy input (2)

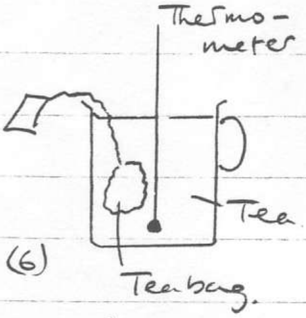
(d) The copper temperature rises from 19°C to 40°C. Calculate the specific heat of copper. (3)

(e) Draw a suitable electrical circuit for this (2)

$\boxed{11}$

2. Cold Tea

A beaker containing 200 cm^3 of hot tea cools as follows:-



t/min	0	1	2	3	4	5
temp./°C	90	75	63	54	47	42

(a) Draw a graph to show the cooling [axes 2×2, curve 2] (6)

How much energy is lost... (b) when the tea cools by 1°C (3)

(c) ... in the first minute ($t = 0$ to 1 min)? (2)

(d) ... in the fourth minute ($t = 3-4$ min.)? (2)

(e) Can you comment on your answers (c) and (d)? (2)

(f) Draw a tangent to your graph at $t = 2$ min, and use it to estimate the rate of heat loss (in J/sec) of the water (3)

$\boxed{18}$

3. Calling Dr. Scarpetta...

It has been estimated that an average 80 kg adult human body will cool by 1°C in 15 min if no heat energy is provided by food. (a) If we assume that the body has the same specific heat as water, how much heat energy is lost? (2)

(b) How much peanut butter would be needed to replace this energy? (2)

$\boxed{4}$

4. In the kitchen....

A kettle can bring 1 litre of water from 20°C to the boil in 3 min. (a) Use the data to calculate the power of the kettle (3) (b) Why is the actual power certain to be higher than your answer? (2)

$\boxed{5}$

Total /38

FN1098

Heat Capacity – Answers

A Physics

or...

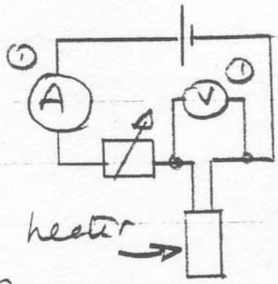
1. (a) $V = \pi r^2 h$ ① $= \pi \times 2^2 \times 10 = \underline{126\ cm^3} = \underline{126 \times 10^{-6}}\ m^3$ ① (2)

(b) $M = DV$ ① $= 8.9 \times 126 = \underline{1{,}118}$ g ① put in Memory (2)

(c) Energy input $E = Itv$ ① $= 2.8 \times 200 \times 8.5 = \underline{4760}$ ① J (2) *

(d) $E = mc\Delta\theta \rightarrow c_{copper} = E/m\Delta\theta = 4760/1{,}118 \times (40 - 19) = \underline{0.2\ J/g/°C}$

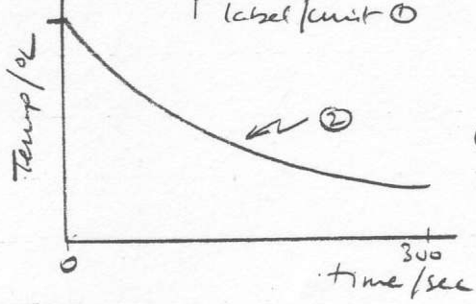
(e) → ① ① $\boxed{11}$



2.(a)

↑ Scale ① label/unit ①

→ Scale ① label/unit ①



(6)

(b) for 1°C cooling...

$E = mc\Delta\theta$ ①

$= 200 \times 4.2 \times 1 = 840$ J ① (2)

From the graph... (c) 1st minute $\Delta\theta = 15°C$ ① E loss = $\underline{12{,}600}$ ① J (2)

(d) 4th min $\Delta\theta = 7°C$ ① E loss: $\underline{5{,}880\ J}$ ① (2)

(e) The $\underline{\text{rate of heat loss}}$ ① (J/min, or J/sec) $\underline{\text{decreases}}$ ① as the water cools (gets nearer room temp)

(f) t = 2 min ... slope = 10°C/min = $\underline{0.17\ °C/sec}$ ① accept (0.15 – 0.2 J/s) (3)

so rate of heat loss (in J/sec) $E = mc\Delta\theta$ ① $= 200 \times 4.2 \times 0.17 = \underline{140\ J/sec}$ ①

$\Delta\theta$ in °C/sec

$\boxed{18}$

3. (a) Energy loss $E = mc\Delta\theta$ ① $= 80 \times 10^3 \times 4.2 \times 1 = \underline{336{,}000\ J} = \underline{336\ kJ}$ ①

(b) Peanut butter needed $= 336000/25$ ① $= 13{,}440$ g $= \underline{13.4}$ ① kg (4)

4. (a) Energy given to water $E = mc\Delta\theta = 1000\ (g) \times 4.2 \times 80 = \underline{336{,}000}$ ① J

Power of kettle $= \dfrac{\text{Energy supplied}}{\text{time}}$ ① $= \dfrac{336{,}000}{180} = \underline{1867}$ ① J/s = watts

(b) The actual power $\underline{\text{must}}$ be larger than the theoretical 1867 W because.. (1) some energy is needed to heat kettle + element ① (2) as soon as the water gets heated, some heat energy will be lost to the surroundings ① $\boxed{5}$

①....	1	2	3	4	
out of	/11	/18	/4	/5	Total /38

TW
10.98

* Error No. 72/c/ii – actual value for $C_{Cu} = 0.4$ J/g/°C (oh well..)