20 Lead shot consists of small lead spheres.

Originally lead shot was made by dripping molten lead through a copper sieve from the top of a 'shot tower'. The lead cooled as it fell, before landing in water and producing solid lead spheres. Figure 1 shows a shot tower, and figure 2 shows the process of making lead shot in a shot tower.

(Source: © Espresso Addict)

Figure 1

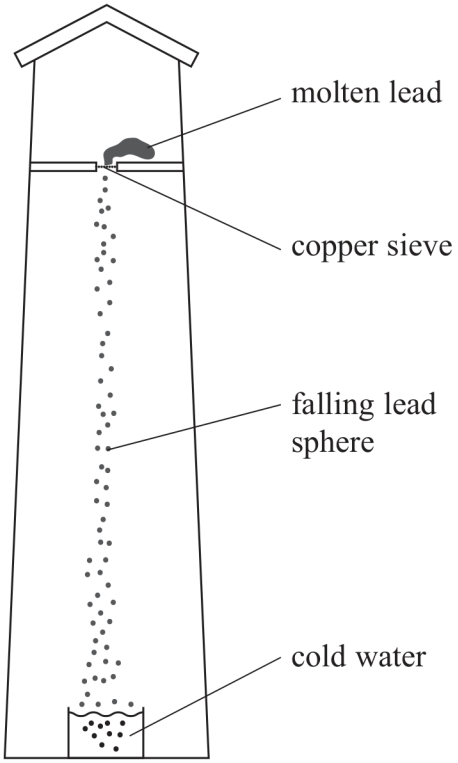

Figure 2

To avoid producing steam, the temperature of a lead sphere was below 100 °C as it reached the cold water.

(a) (i) A lead sphere falls through a distance of 41.5 m.

Show that it takes about 3 s for the lead sphere to fall through this distance. Assume that resistive forces are negligible.

(2)

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(ii) The lead sphere has a radius of 1.2 mm. As it falls it cools from 615 K to 370 K. The molten lead solidifies at 601 K.

Calculate the mean rate at which energy is transferred from the lead sphere to the surroundings. You should assume that the specific heat capacities of liquid lead and solid lead are the same.

density of lead = $1.13 \times 10^4\,\text{kg m}^{-3}$
specific latent heat of lead = $2.47 \times 10^4\,\text{J kg}^{-1}$
specific heat capacity of lead = $130\,\text{J kg}^{-1}\,\text{K}^{-1}$

(6)

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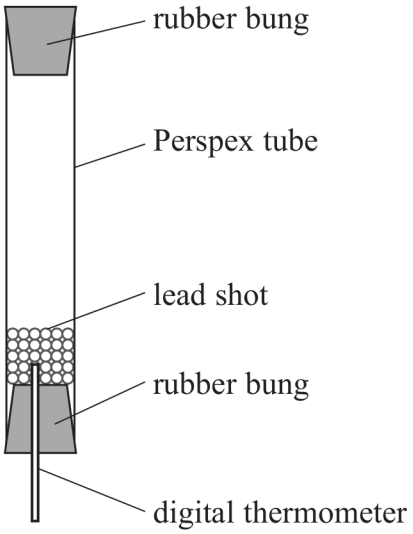
Mean rate of energy transfer from lead = ...

(b) A teacher demonstrates a mechanical method to determine the specific heat capacity of lead. Some lead shot at room temperature is placed in a Perspex tube.



The teacher turns the tube upside down, and the lead shot falls through a distance d.

The teacher repeats this N times and measures the final temperature of the lead shot. The change in temperature $\Delta\theta$ of the lead shot is calculated.

The teacher uses the values of d, N and $\Delta\theta$ to determine a value for the specific heat capacity c of the lead.

(i) Explain why the mass of lead shot in the tube should not affect the value of $\Delta\theta$.

(2)

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(ii) Assess whether this method would produce an accurate value for c.

(2)

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(Total for Question 20 = 12 marks)