In an engineering lab, a student is characterizing thermal properties of materials. She drops a 120 g sample of a solid at 94 °C into a container with 180 g of water at 24 °C. Earlier she had measured the specific heat of this solid material to be 0.25 cal/g °C. The specific heat of water is 1.0 cal/g °C. The experiment is well insulated so that heat exchange with the environment can be safely ignored. She also gently stirs the solid around in the container.

a) Why does the student have to stir the contents of the container?

She has to stir the water to ensure that the heat lost by the solid is distributed uniformly throughout the water. If she does this, there will be no hot spots and the final temperature of the entire mass of water will be at its highest value when the water and the solid are at the same temperature.

b) Calculate the highest temperature that this student can expect to record with a thermometer placed in the water.

Heat lost by solid: \[ H_{\text{lost}} = m \cdot s \cdot AT_s \]
\[ = 120 \text{ g} \times 0.25 \text{ cal}/\text{g} \cdot \degree \text{C} \times AT_s \]
\[ = 30 \text{ cal} \cdot AT_s \]

Heat gained by water: \[ H_{\text{gained}} = m \cdot s \cdot AT_w \]
\[ = 180 \text{ g} \times 1 \text{ cal}/\text{g} \cdot \degree \text{C} \times AT_w \]
\[ = 180 \text{ cal} \cdot AT_w \]

Heat lost = Heat gained
30 \text{ cal} \cdot AT_s = 180 \text{ cal} \cdot AT_w
\[ AT_s = 6 \cdot AT_w \]

i.e. for every 1 °C change in the temperature of water, the temperature of the solid will change by 6 °C.

<table>
<thead>
<tr>
<th>Heat transferred (cal)</th>
<th>Water temp °C</th>
<th>Solid temp °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>24</td>
<td>94</td>
</tr>
<tr>
<td>180</td>
<td>26</td>
<td>88</td>
</tr>
<tr>
<td>360</td>
<td>27</td>
<td>76</td>
</tr>
<tr>
<td>900</td>
<td>32</td>
<td>46</td>
</tr>
<tr>
<td>360</td>
<td>34</td>
<td>34</td>
</tr>
</tbody>
</table>

Table courtesy of Greg Valentine.
Parts c) and d) have to be calculated separately.

c) How much heat did the solid lose in total?

\[ \text{Heat lost} = m \times s \times \Delta T_s \]
\[ = 1209 \times 0.25 \text{ Cal/}^\circ C \times (94^\circ C - 34^\circ C) \]
\[ = 1800 \text{ Cal} \]

d) How much total heat did the water gain?

\[ \text{Heat gained} = m \times s \times \Delta T_w \]
\[ = 180 \times 1 \text{ Cal/}^\circ C \times (34^\circ C - 24^\circ C) \]
\[ = 1800 \text{ Cal} \]