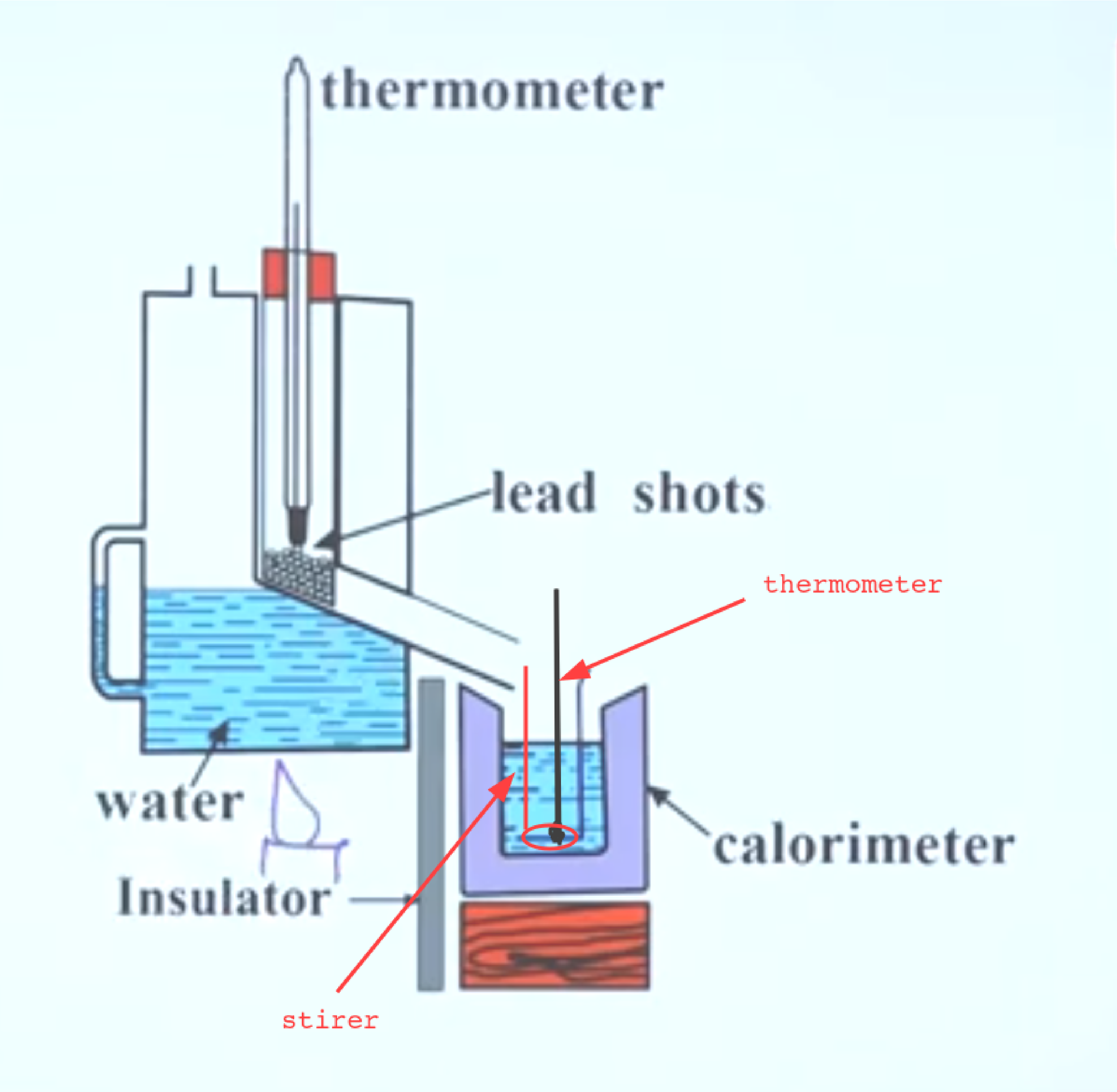
- Concept

When 2 substances of 2 different temperatures are mixed together, the temperature gained by the cold substance is equal to the temperature lost by the warm substance

- Initial setup



- Measurements you need to take in the correct order.

1. Measure the mass of the calorimeter with the stirrer. M_1 - (M_c)
2. Fill the calorimeter with water and then measure the mass. M_2 - $(M_c + M_w)$
3. Measure the initial temperature of water. θ_1
4. After heating the lead shots (in the steam bath), get the temperature θ_2 (This can be taken as 100C if needed)
5. After adding the heated lead shots to the calorimeter, get its maximum temperature θ_3

6. Final mass of the calorimeter with its contents M_3

After taking these readings, we can find the specific heat capacity of the lead shots using the equation $H = mS\theta$

$$\begin{aligned} M_m &= Mass\ of\ the\ metal\ balls\ (lead\ shots)(M_3 - M_1) \\ M_w &= Mass\ of\ the\ water(M_2 - M_1) \\ M_c &= Mass\ of\ the\ calorimeter\ +\ Stirer(M_1) \end{aligned}$$

$$\begin{aligned} S_m &= Spefic\ heat\ capacity\ of\ metal\ balls \\ S_w &= Spefic\ heat\ capacity\ of\ water(4200) \\ S_c &= Spefic\ heat\ capacity\ of\ calorimeter(4000) \end{aligned}$$

$$\begin{aligned} H &= mS\delta\theta \\ M_m S_m \delta\theta &= (M_C S_c + M_w S_w)\delta\theta \\ M_m S_m(\theta_2 - \theta_3) &= (M_C S_c + M_w S_w)(\theta_3 - \theta_1) \end{aligned}$$

$$\therefore S_m = \frac{(M_C S_c + M_w S_w)(\theta_3 - \theta_1)}{M_m(\theta_2 - \theta_3)}$$

Important points

- Why do we use a boiling tube to heat the lead shots instead of using a water bath to heat them?

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If we use a water bath, once the lead shots are heated and we want to put them in to the calorimeter, the lead shots would be wet and have water around them. And since we can't change the amount of water (which would lead to an error in the calculation), we need to use the boiling tube to heat it.
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- Why can't we heat the lead shots directly?

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Because its hard to maintain a uniform temperature both inside and outside the lead shots if we heat them directly. Since we only measure the outside temperature of the shots, you will not be able to make sure that the inside of the shots are at the same temperature as the outside.
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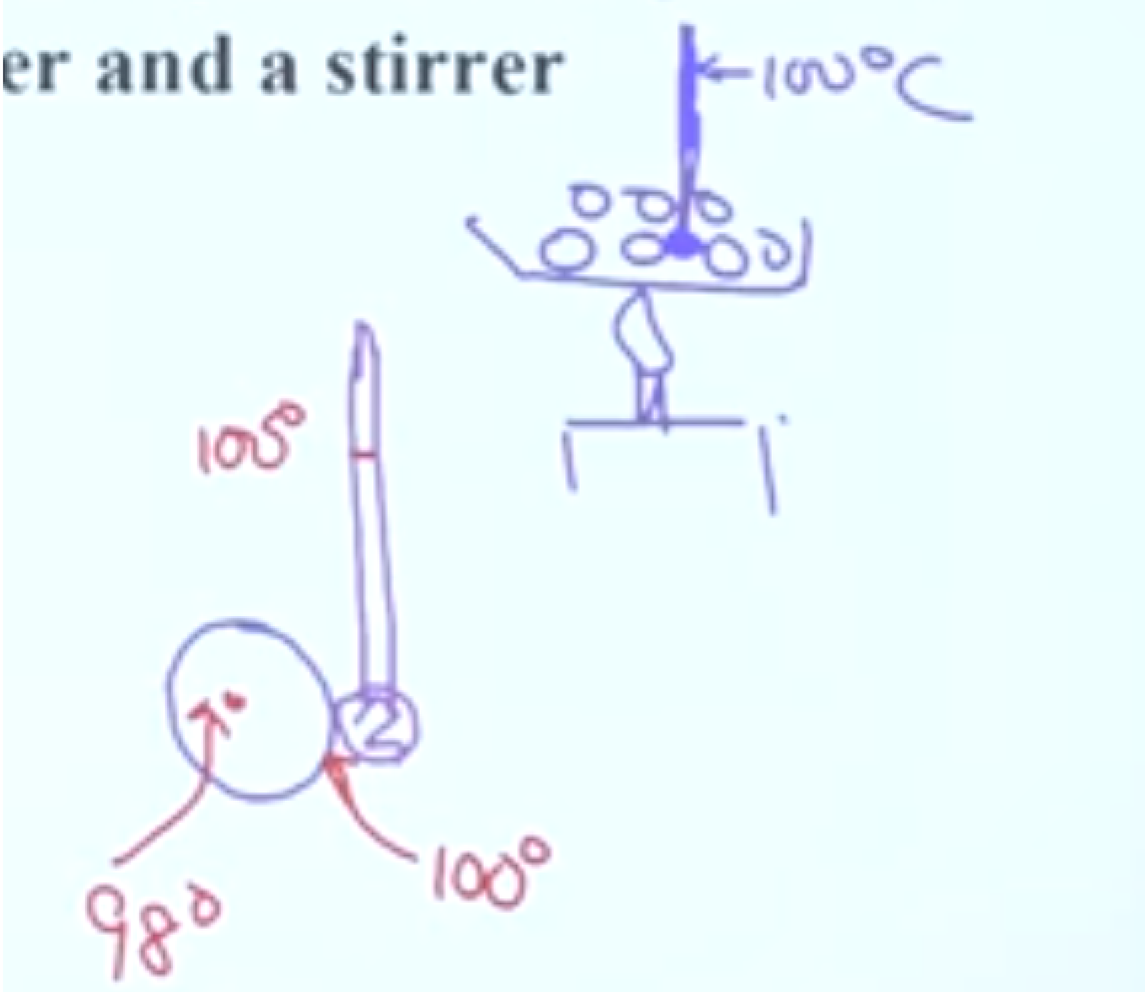


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So to maintain a uniform temperature of the shots, we need an instrument as below and heat the shots.

With this, when we heat the water, at 100C its gonna stay the same till all the water is vaporised (due to latent heat). So we can make sure the temperature is uniform for a while till both inside and the outside of the lead shots are at thermal equilibtrium.
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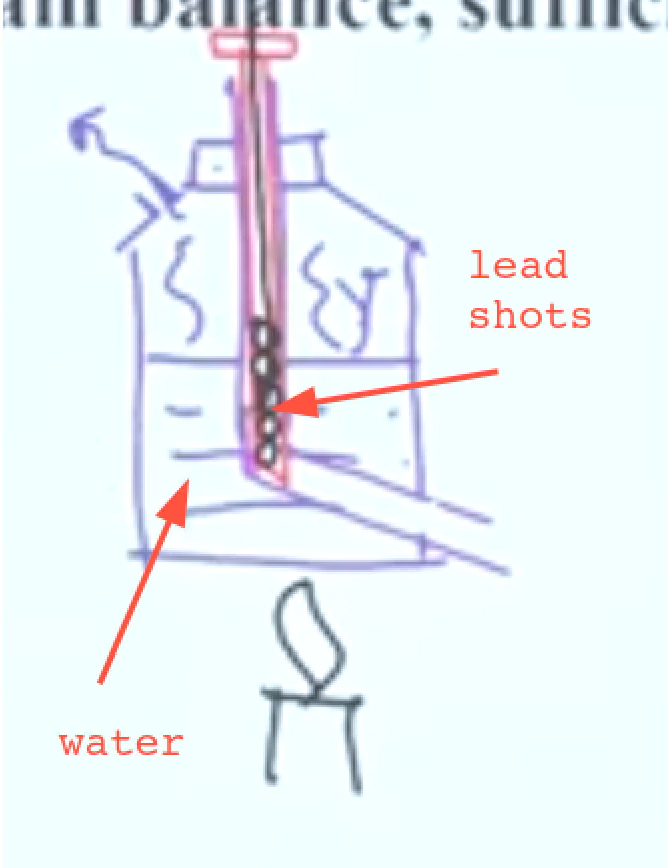
lead
shots
water

- Why do the lead shots have to be completely submerged in the water inside the calorimeter?

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Because if not, the heat from the lead shots would be released to the environment
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- Why do we use the method of cooling correction to do this experiment?

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When we do this experiment, there is always gonna be a heat loss to be environment no matter
what. So to reduce this we use the cooling correction method.

Cooling correction: Lets assume that the room temperature is 30C. Instead of starting the
experiment at the room temperature, we cool the system to 25C and start it. So once the lead
shots are put to the calorimeter, as the system is cooler than the environment, heat will be
gained to the system. Then after it goes above 30C, since the system is hotter than the
environment, heat will be lost from the system.

Therefore we can make an assumption that the heat gain at the first part and the heat lost at
the last part of this process are equal and hence there was no net loss of heat to the system.
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- When taking the temperature of the water in the calorimeter after putting the lead shots (θ_3), what temperature should be taken?

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When you start putting the heated lead shots the temperature will rise. After putting all the
shots there will be a temperature you see in the thermometer, dont take that. Keep stiring and
that temperature will increase by a little (Because stiring will uniformly distribute the
temperature). Then after sometime the temperature will go down (as its losing heat to the
environment).

The temperature we should take is the maximum temperature that was seen within the
calorimeter.
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- Why can't we use either a huge block of lead or small lead pieces for this experiment?

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A huge lead block can't be used as there is a considerable difference between the surface
temperature and the internal temperature of the block. Also the big block with take a longer
time to come to an heat equilibrium with water as the surface area is less - hence taking
longer time for the experiment (hence more heat loss).

Small lead dust can't be used as these particle may occupy the inner surface of the
calorimeter above the water level when stiring.
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- What is the ideal level of water that need to be added to the calorimeter?

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Water should be filled upto 2/3 of the calorimeter.

It can't be filled completely as it can spill out when the lead shots are added. And there
can't be too less water as water level should cover the lead shots completely.
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- Why is using steam better to heat the lead shots in the experiment?

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Becuase the temperature of boiling water is hard to kept constant since it doesn't contain
latent heat. But steam does contain latent heat and has the temperature of 100 Celsius which
doesn't change.
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- How do we prevent the heat loss to the environment from the calorimeter?

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To prevent,

Conduction - Insulate/lag the calorimeter with a regiform or an insulating material
Convection - Close the calorimeter with a lid
Radiation - Make the calorimeter's surface shinny
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- Why do we heat the lead shots up to 100C?

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To maintain the uniform temperature in both inside and outside of the lead shots for a while
without changing (as boiling point doesn't change).
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