Experimental Physics I
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Lecture – 43
Determination of specific heat of the given solid metals using Dulong – Petit's law

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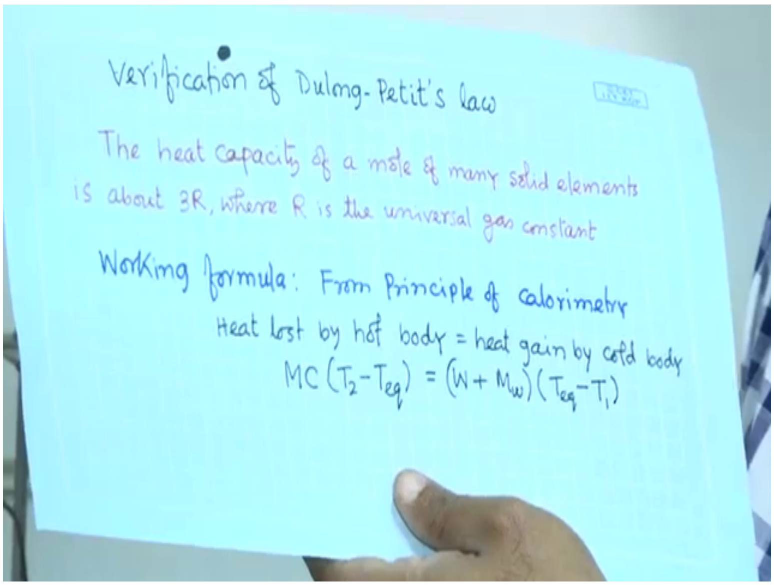

So, today I will demonstrate basically the verification of Dulong Petit's law; verification of Dulong Petit's law ok. What is that? The heat capacity of a mole of many solid elements is about 3 R, where R is the universal gas constant. It's a just like Ohm's law; where current and voltage are proportional ok. So, similarly in case of heat so this is the another law Dulong Petit law. It tells that the for any metal most of the metal elemental metal ok, for most of the metal elemental metal it's heat capacity heat capacity molar heat capacity basically, heat capacity of a mole is 3 (Refer Time: 00:00); R is the universal gas constant.

It's value is around 2 calorie per Kelvin ok, 2 calorie per Kelvin per mole of course. So, it's a this value R will be around 6 calorie, not R heat; capacity molar heat capacity will be around 6 calorie per Kelvin per mole of course, that will be there. So, this is our this is the this is the experiment today I will demonstrate is a very easy experiment; it's working principle formula is very simple.

So, working formula I have written; this is a basically from the principle of calorimetric ok. So, what is the principle of colorimetric heat lost by the hot body equal to the heat lost by the cool body, when they touch each other when they touch other when they are in contact one is hot body and another is cold body. So, 1 will lose heat and another will gain heat and then they will come in a equilibrium temperature; they will come at a equilibrium temperature.

So, these arrangement is done the wherever it is done is the it is called calorie meter it is done calorie meter right it is done calorimeter. So, now if I take a so here as I told for metal solid metal we want to verify this law so; that means, I have to find out the molar heat capacity of the metal. So, if I take metal say here metal 3 pieces of same metal, I have taken 3 pieces of same metal I have taken. So, mass of this metal mass of this metal is say M here in this formula it is M and it’s molar heat capacity is C molar heat capacity is C ok.

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And now, it’s temperature is T 2; it’s temperature is t 2 and when it will so when if it is a hot body it is hot body I have to make it hot see it’s temperature T 2. Now if I put it in a cold body I will put in a water in a calorimeter ok. So, in calorimeter water as well as this copper container will be there and they are sealed in a in a thermal radiation so that there should not be any loss of loss of this loss of this loss of this I think I have to it’s a boiling. Let me switch off this one, yes ok.

So, in calorimeters, what about the equilibrium temperature? T equilibrium so MC T 2 minus T 1 so that is the change of heat of this hot body equal to. Now in calorimeter as I told water and this container is there. So this is a mass of water and these we have written W is the water equivalent of the equivalent of the container ok, it's the water mass equivalent of the container ok. So, that I will show you see, this is not mass into the specific heat basically of that material.

So, that is the water equivalent we tell so that is W. So this is the total see can say mass of the container and the and the water. So, this now its temperature was initially say T 1, now it is increased to T equivalent; so difference of this temperature so this is the. So, this amount of heat is gain by this by this water and container and this amount of heat lost by this hot body.

So, this is the working principle of this work, So, what I need to do? So, I need to do this I have to take metal. So this I have taken metal I have to find out the specific heat molar specific heat of this metal. Now, I have to heat it, I have to take at higher temperature; I have to make it hot body.

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So, here you see water is boiled just I kept it in boiled boiling condition, because then we will lose time we will not lose time. So, this is a thermocouple is put in the; so this is the heater on this heater I put water in a container I took water this power is given from there to the heater, to the heater and then it's a water is boiled is now it is boiling so I think 10 15 minutes back I just switch on this one. Now I switched off this one.

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So, this thermocouple is there, so this is the here we are getting the reading of the temperature from this thermocouple ah. So, this is the I think this is the yes; this thermometer is a thermocouple type. So, there it's a here this reading of this water temperature of this water is 97.8 is decreasing, so I think I will switch on this 1 now; so ah. So, this type of metal already another metal i put it here, you see here I think it's a aluminum ok. So yeah this is the aluminum metal ok.

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So, already I have put here, so it’s a hot it’s temperature is it’s temperature is this one ok. So, now this hot body now what I have to do so this mass I have to take. So, that will take we have balanced.

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So, we will measure the mass of this hot body. So, before give me putting there we I should take mass ok. So, it is showing this 178.5 gram this one. So, we will do this experiment for 3 metal. So one is aluminium there one is this is iron basically ok. It is a iron this metal is iron and this material is brass basically, here another sets of material I have taken ok. So, this is the copper zinc alloy so it’s brass basically ok.

So, we will so, similar way you should take mass and note down the mass of the metal; so now we you can ask me this why we have taken 3 pieces why not 1 pieces. So, you see one pieces means it will bigger one ok, so then to get uniform heat of this bigger 1 inside heat has to go inside you know; so it may not this metal this temperature, that may not be uniform in this in this in single piece ok. So, if we take small piece, so you can make sure that the temperature throughout this material is uniform.

So, that is why we have taken 3 pieces ok; and see the one pieces, so mass of this metal 3 pieces 3 types of metal we have taken mass of 3 types of metal we have taken. Now here we have to take mass of water and mass of this container calorimeter.

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So, this is the basically calorimeter. It is the copper container calorimeter ok. So, and this is the stirrer so you get the uniform temperature, so we will use this stirrer. So with this stirrer so, we will take this weights of this ok, this is the 91.1 gram. And the specific heat of this scope of material is will be given is supplied is known. So I will multiply with this mass into this specific heat of this copper.

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So, that is basically W whatever the formula I have shown you that is the water equivalent we tell water equivalent, so this is W and this M w is the mass of water ok.

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So, here I will take mass, I will take water, so I have water here I think this is the dirty water I need clean water so I think just I can put some water this way from this bucket. So put some water; I put some water ok. Now again container pass this water so it is a 312.1 gram ok. So, minus this earlier reading for container we have taken, so then we will get the mass of water only ok. So, all the stirring you should note down.

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Now, I will put this one in thermal insulator you know; I will put this one in thermal insulator; I put this one is thermal insulator put thermal insulator fine. And I have 1 so here I need so I have to seal as much as possible; so I think it is a stirrer I can use how to how to put I have to see stirrer. Can you tell me this stirrer how I will take this stirrer, how? Here through this ok; because I use the another set of so that is why is bye.

So, this stirrer this of the length of the stirrer I have taken out, and this I need to measure the temperature of that so and so for that I have to I will use this ok; thermometer this is a mercury thermometer it is a opposite side yes ok. Then I will just keep in a position that is a thermal as much as possible we have to seal it thermally this ok. So now it's, I have to note down the temperature initial temperature of this cold body. Now this is the cold body water and the container it's cold body I have to note down this temperature.

Now I will fill typical this to take reading ok, I can see it is 20, 20 yes 22 this temperature of the water. I can see this is the 22. Yes, so one can one should use this then it is a easy to take reading. Yes it is 22; it's the 22. And I have to note down the least count of this thermometer that is 1 degree ok. So, now, I have hot body now hot body. So this temperature is 90 I have to note down this is 99.0, then I should take it slightly close to it ok and then just quickly I should put this mass into this ok.

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I should quickly I should put this mass into this I think I will take this way, then I will take this mass out and very quickly I have to put itand then just this way yes ok. So, take away slightly here I will keep it ok. So, now you see hot body and cold body are together in a calorimeter; now just I will stir it. So why because this hot body is in contact with water. So, that water close to the hot body that it is a hotter that will be the temperature will increase that other area this is the water the temperature will be differ.

So, here we have to stir it so that temperature of this cold water it is a uniformly increase ok; taking the taking the heat energy from the hot body so that is why we need to stir it. So I think it is a continuously one should stir it ok. And then also I will like to see this temperature, and whether it is coming towards steady. So I can see now temperature is 32, now I can see temperature is 32, so from 32 it is it has come it is 32. I think in camera it’s maybe slightly difficult to see camera may be that I do not know whether you can see in camera this reading ok.

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So, sometimes it happens and in the mean time I can put another piece of things to heat it ok; so because to come in equilibrium temperature it is the it will take some time. So, so it's will it is so I will not repeat the experiment. So, this way one your using for measurement other one you just put for heating ok. So, but I think this just one has to repeat, but I will this one let me just stop it, because I will not repeat the experiment just I showed you how to how to repeat the experiment.

So, this in the meantime when this will complete then I will use the second one, but again I have to throw this water take fresh water and measurement, so everything you have to repeat for another meter ok. So, let me I think I should do this I should do this so what is the reading. Let me see it is almost steady it is this either 30 I can see it is 32 to 30 33 I can take this reading as a 33 and for longer time it is 33 ok. So, it depends equilibrium temperature you will get 33 or 43 it depends what is the quantity of your water because I have taken more water it seems ok.

So, that's why this equilibrium temperature it is 33. So, it is in equilibrium it is in equilibrium, but I should check I should take at least 3 readings to check whether it is in same it is giving same reading or not let me check it let me check it, I think I have to do tightened yes it is in same position 33 it is in same position 33 so taking reading from the thermometer is not difficult one.

So, you can take so now fine ok. So, I will note down this is t equilibrium T eq whatever I showed this is the temperature I have to note down I have to note down this temperature what is this another part I have ok. So, this as I told this for 3 metal we will do experiments, so presently we are doing for aluminum ok.

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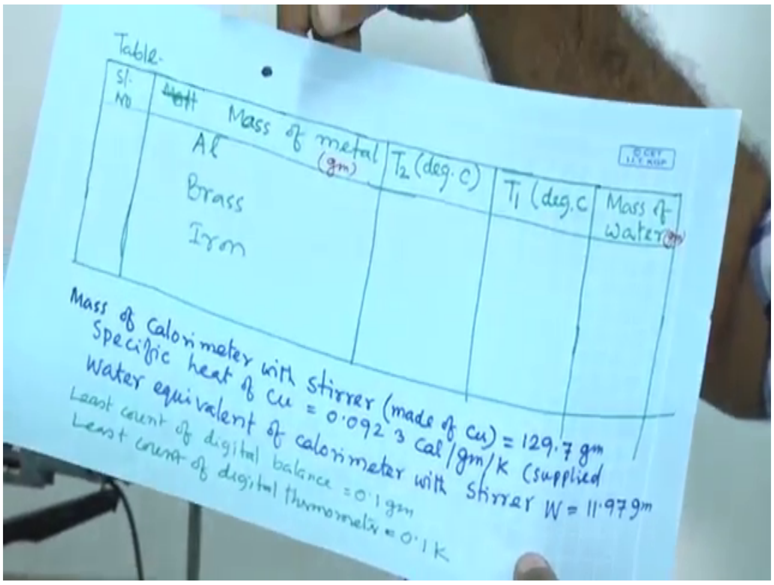

Now mass of the mass of the metal I noted I I 91.2 probably I yeah I have to write this one and then temperature T 2 as a 99 temperature T 2 this I have noted down this temperature T 1 so that was 22 that I have to write; and then mass of water in gram mass of water I have so mass of the metal is the mass of the mass of water.

So, that I have to write because every time I am changing the water right for T T 1; so I am changing this one I am changing the metal ok. So, that’s why I have taken in table because with this so this 2 will change so, but other mass of the container water equivalent of the container it is the remain same ok. So, then I should yeah then finally, I should note down this t equivalent, then I should note down T equivalent.

So, now using the formula using the formula one can calculate the C one can calculate the C, because I have all reading using my hand. And as I told I will tell what is what a equivalent mass of calorimeter with stirrer this mass of copper; the basically this is the mass of copper that is equal to this 129.7 gram 7 gram. So, this is for another container this data is for another container we have bigger container the smaller container in our it is a 91.2 you should write 91.2 these reading I have written for another container I think I have bigger container, here I have bigger container; so that yes so this one I have bigger container.

So, this mass of this 1 is 129.7 gram, but now I am not using this one I have I have I am using the smaller one. So, that is 91.2 gram and this specific heat of copper is known this given this one ok. So, now if you so water equivalent of calorimeter with stirrer is basically W whatever is formula you have written. So, that W equal to I have to multiply this with the mass, but not for this mass if mass is this, then it will be this value 1, but in our case present case one has to find out. So, this is the water equivalent how to calculate water equivalent this ok.

And as I told least count of the digital balance you have to write this is 0.1 gram and least count of the digital thermometer digital thermometer this is the 0.1 gram least count of this 41 we are measuring this one T 1 and T 2 balance. So, this one least count is 1 degree not 0.1 degree; so 1 degree that we have to note down ok. So, then just all data is available you calculate you calculate this specific and the calculate the heat capacity molar heat capacity for these 2 metals. And see these all these 3 metals will give more or less same value of same value it is closed to 3 R.

If so if these 3 gives the same value, approximately same value then you can conclude that Dulong Petit law is verified. And that value should be equal to around 6 calorie per Kelvin per mole ok. So, this is the experiment very simple experiment, but very interesting this it’s a law; it’s ifI this heat capacity molar heat capacity is independent of material this is the beauty of this law ok. So, that is why this simple process way one can verify this law which is Dulong Petit law. So I will stop here.

Thank you for your attention.