Lesson 13:2
(Please listen to the explanations, fill in the blanks and then complete the 5 questions enclosed which will be discussed in the class.)

2. Heat capacity C and specific heat capacity c

1. **Heat capacity C of a substance**: is the amount of __________ energy ΔQ supplied to it to produce a unit rise in __________________.

- The greater the heat capacity a body is, the smaller the temperature rise experienced for a given amount of heat supplied.

$$C = \frac{\Delta Q}{\Delta T} \quad \text{--- (1)}$$

Specific heat capacity c of a substance: is the amount of heat energy ΔQ supplied to a __________ of the substance to produce a _____ rise in temperature.

$$c = \frac{\Delta Q}{m\Delta T} \quad \text{--- (2)}$$

∴ An amount of heat energy ΔQ is supplied to a mass m, which has a specific heat capacity c, for a rise in temperature ΔT.

$$\Delta Q = mc\Delta T \quad \text{--- (3)}$$

Q1: What is meant by "water has a specific heat capacity of 4.2kJ $kg^{-1}\,{}^{o}C^{-1}$?

4.2 kJ of heat energy is absorbed to increase one kg of water by one degree Celsius in temperature.

Q2: Is a specific heat capacity of 4.2kJ $kg^{-1}\,{}^{o}C^{-1}$ equivalent to 4.2kJ $kg^{-1}\,K^{-1}$? Explain.

Yes, it's because the change in temperature of one Celsius is equivalent to that of one kelvin.

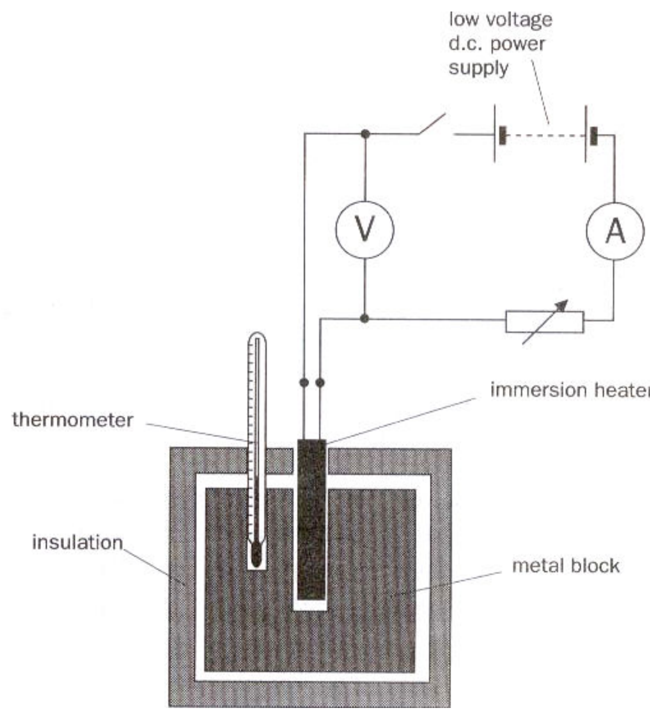
Examples

Substances	Specific heat capacity, c / $Jkg^{-1}\,{}^{o}C^{-1}$ (at 1 atm & 20 °C)
Alum:inium	900
Ethyl	2400
Copper	390
Iron	450
Mercury	140
Water	4186
Ice (-5 °C)	2100
Steam (110 °C)	2010

3. Determination of specific heat capacity using electrical method

a. For solids, e.g. a metal block.

1. Two holes are made in the block before the mass *m* is measured.
2. The block is *well* __________ with expanded felt/ polystyrene so as *to minimise heat loss to the surroundings*.
3. The holes are filled with oil to provide *good* __________________ between the heater and the thermometer and the metal block
   - The initial temperature T_i of the block is recorded.
   - After switch is closed, timing starts, the heater current I and p.d. V are recorded.
   - Heating is continued for a measured time *t* such that a significant temperature rise has been produced.
   - When the final temperature T_f is recorded, timing stops.



Electrical energy supplied to the heater = heat energy absorbed by the block + heat loss to surroundings

$$I\,V\,t = m\,c\,\Delta T + h \quad \text{---(4)}$$

c : specific heat capacity
h : heat loss to surroundings

4. Assuming the rate of heat dissipated to surroundings h is _____________, hence, the heat loss h can be eliminated by repeating the procedure for the same time interval, *t* but with different current and p.d. values (I_2 and V_2) to obtain a different temperature rise.

Experiment 1:
$I_1 V_1 t = mc\,\Delta T_1 + h$ ----- (a)

Experiment 2:
$I_2 V_2 t = mc\,\Delta T_2 + h$ ----- (b)

(a) – (b):
$[I_1 V_1 - I_2 V_2]\,t = mc\,[\Delta T_1 - \Delta T_2]$

c = ―――――――――――――― ----- (5)

Q3: Explain if the calculated value of specific heat capacity is an overestimate or underestimate of the actual value, if only one measurement is carried out?

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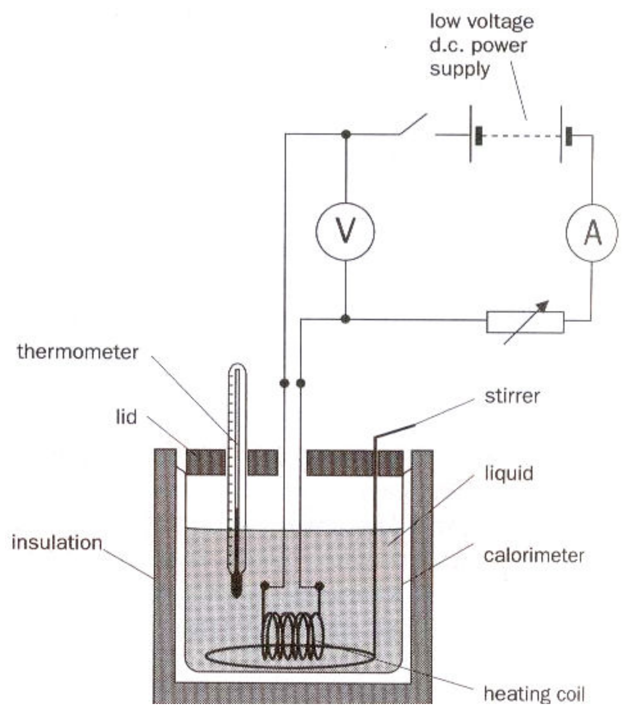
b. For liquid, e.g. water.

1. The sample liquid of mass m is contained in a polished copper or aluminium can called *calorimeter*.
2. It is insulated to minimise heat losses.
   Heat energy is provided by a heating coil which is totally immersed in the liquid.
3. The liquid is ________continuously during the experiment to ensure that the distribution of heat supplied to all parts of the liquid before a ____________temperature is recorded.
4. The initial temperature T_i of the liquid is recorded.
   - After the switch is closed, timing starts. The heater current *I* and p.d. V recorded.
   - Heating is continued for a measured time *t* such that a significant temperature rise has been produced.
   - When the final temperature T_f is recorded, timing stops.



Electrical energy supplied to the heater = heat absorbed by the liquid + energy gained by calorimeter and stirrer+ heat loss to surroundings

$$I\,V\,t = m\,c\,\Delta T + m_c\,c_c\,\Delta T + h \text{ ----- (6)}$$

c : specific heat capacity of the liquid
m_c : mass of calorimeter and stirrer
c_c : specific heat capacity of calorimeter and stirrer
h : heat loss to surroundings

Measurements are repeated at different values of I and p.d. with the same heating time *t*. two equations are formed to eliminate heat losses to surroundings and apparatus *h*.

Questions on Specific Heat Capacity:

1. How much heat is required to raise the temperature of silver container 20kg from 10 ^oC to 90^oC?
   (Mean specific heat capacity of silver = 230$Jkg^{-1o}C^{-1}$)
   What the heat capacity of the container? [368kJ, 4.6kJ/^oC]

2. A solid aluminium block of mass 1.5kg is heated for 7.5 minutes by an electric immersion heater embedded in the block. The mean values of the current through the heater and the p.d. across it are 2.5A and 12.0V respectively. Assuming that the heat losses and the heat capacity of the heater are negligible, calculate the temperature rise of the block. [10^oC]
   (Mean specific heat capacity of aluminium = $9.1\times10^2 Jkg^{-1}K^{-1}$)

3. A small electric immersion heater is used to heat up 200g of milk in a bottle. The heater operates at a p.d. of 240V and takes a current of 1.0A. If the bottle is wrapped in a thick towel during heating so that heat loss to the surroundings may be taken as negligible. How long does it take for the temperature of the milk to rise from 18^oC to 38^oC? The bottle has a heat capacity of 24 JK^{-1} and the specific heat capacity of milk = 3.9×10^3 $Jkg^{-1}K^{-1}$ [67s]

4. If 200cm^3 of tea at 95 ^oC is poured into a 150g glass cup initially at 25 ^oC, what will be the final temperature T of the mixture when equilibrium is reached? Assume that there is no heat flowing to the surroundings. [85.8 ^oC]
   (specific heat capacity of tea = 4186$Jkg^{-1o}C^{-1}$, of glass 840$Jkg^{-1o}C^{-1}$)

5. An alloy of 150g is heated to 540 ^oC. It is then quickly placed in 400g of water at 10.0 ^oC, which is contained in a 200g aluminium calorimeter cup. The final temperature is 30.5 ^oC.
   a. State any assumption made prior to the calculation of specific heat of the alloy
   b. Calculate the specific heat capacity of the alloy. [497 $Jkg^{-1o}C^{-1}$]
   (specific heat capacity of water = 4186$Jkg^{-1o}C^{-1}$, of aluminium = 900$Jkg^{-1o}C^{-1}$)