(1K = 1°C in size) **Temperature & Heat transfer**

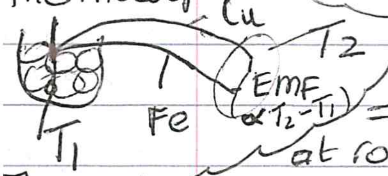
Temperature - a measure of the hotness/coldness of a body (really its the average kEnergy of ~~of~~ bodies molecules/atoms).

Unit = kelvin $0°C = 273.15K$
$-273°C = 0K$

Thermometric Property = property that changes measurably with Temp

e.g. Emf (Thermocouple), Colour, Volume, Length, Resistance (Thermistor), Length of Column, Pressure

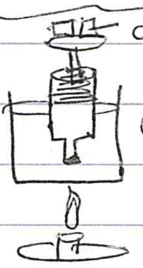
Thermocouple



Thermistor = semiconductor at room temp $\bar{e}$ trapped in covalent bonds (resistance = hi because no charge carriers) but at higher temp $\bar{e}$ free to conduct (resistance = low because carriers available)

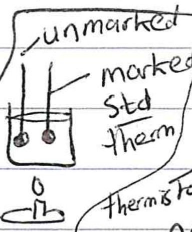
Volume varies with temp
as T>> V>>>
note: pressure = Constant

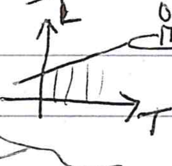
or keep volume constant and you note that Pressure varies with temp

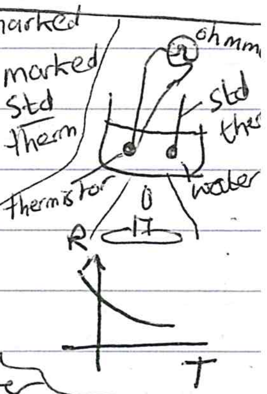


apply weights to keep Volume constant
Pressure = Weight (varies with temp)

Calibration curves to ensure different thermometers measure same temp.
- standard thermometer = mercury in glass thermometer
Mand. Exp: Plot calibration curve of a thermometer







Disagreement between thermometers because different thermometric properties vary differently with temp.

Body temp 37°C → can measure also using infrared thermometer
- I/R thermometer measures radiation (infrared) from ear drum

Heat can be transferred in 3 ways:

Convection: atoms or molecules heat up and become less dense so they 'float' in atoms/material that is more dense - hence the warmer atoms/molecules carry the heat upwards (where pull of gravity is less)

Conduction - vibrating atoms cause nearby atoms to vibrate, they in turn cause nearby atoms to vibrate and so on - the heat energy gets passed on. No actual movement of atoms out of place

Radiation: Heat comes off a hot object in the form of Electro Magnetic Radiation
This EM radiation has all same characteristics as any other EM waves (radiation)
It is InfraRed radiation. It is fully reflected by white/silver/shiny materials, absorbed by black materials. It can travel through a vacuum so it needs no medium to travel through. It's frequency is below the freq of red light, so it has less energy than red light. It travels at the speed of light. One source of IR radiation is the Sun, or any hot body

If a bodies temp is hot enough it will also give off light - red, orange yellow --- as it gets hotter. White if <u>all</u> colours given off

Should know Exp to demonstrate conduction

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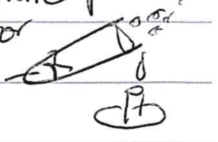
to demo Convection

show water poor conductor



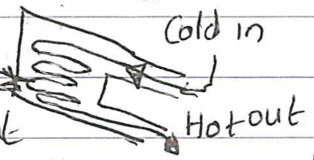
U value = of a material
= amount of heat energy conducted per sec thro $1m^2$ of the material when there is 1°C between it's ends (or 1K)

So high U value ⇒ a lot of heat conducted per sec ⇒ Good CONDUCTO

low U value ⇒ little heat conducted per sec ⇒ Good INSULATOR

U value units joules per sec, per m^2 per K = $W/m^2/K = Wm^{-2}K^{-1}$
(rem 1 watt = 1 joule per sec)

Solar Heating:



SOLAR CONSTANT = amount of Sun's energ falling per sec at right angles to $1m^2$ of the Earth's atmosphere ($\sim 1{\cdot}35 kWm^{-2}$)

OR Photocells can also be used to collect Sun's energy for electricity to then heat something

HEAT CAPACITY of a mass m = Heat required to change its temp by 1K

SPECIFIC HEAT CAPACITY = Heat require to change the temp of 1kg of a material by 1K

Specific Heat Capacity is a way to compare materials in terms of how much energy they need to make their temp. rise by 1K or how much energy they los when the 1kg loses 1°C or 1K

If (C = specific heat cap of material) then for a material of mass m to change temp by Δθ°C, it requires Energy = $mc\Delta\theta$ to raise it by Δθ° or it gives off $mc\Delta\theta$ to lower it by Δθ°

Latent Heat means 'hidden' heat = heat required to change the state of a body. Latent Heat of Vapourisation = heat required to change from liq to gas at same temp. Latent Heat of Fusion = heat req'd to change from solid to liquid at same temp

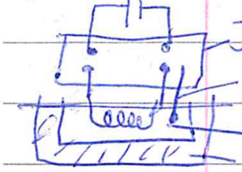
Specific Latent Heat of Vapourisation: heat required to change 1kg of a liquid to a gas at same temp = l_V
So heat required to change m kg from liquid to gas at same temp = ml_V

Specific Latent Heat of Fusion = Heat required to change 1kg of a solid to a liquid at same temp = l_F. So Heat required to change m_{kg} from solid to a liquid at same temp = ml_F

Equally l_V, = heat given off (lost) when 1kg gas → 1kg liquid at same temp

l_F = heat given off (lost) when 1kg liquid → 1kg solid at same temp

Exp to measure Specific heat capacity of water by electrical method



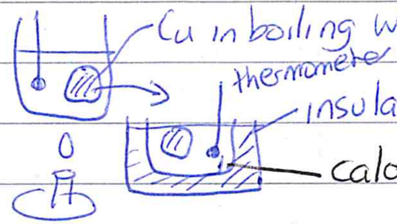
Heat added = Heat gained by water + Heat gained by calorimeter

$\downarrow$ read from Joulemeter or I^2Rt

$= m_W c_W \Delta\theta_W + m_c c_c \Delta\theta_c$

$\uparrow$ assumes no heat lost to outside

By non-electrical method



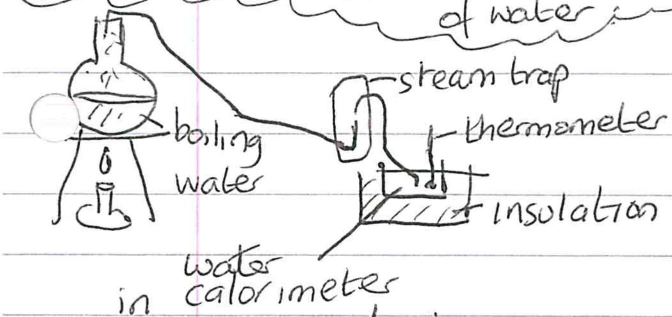
Heat lost by Cu mass = Heat gained by water + calorimeter

$m_c c_c \Delta\theta_c = m_W c_W \Delta\theta_W + m_c c_c \Delta\theta_c$

(copper mass) (Calorimeter)

To Measure Specific Latent Heat of Vapourisation of water:

Assumes no heat lost to outside or gained from outside



Heat lost by steam = Heat gained by water + calorimeter

steam 100° → water @ 100° + water 100° → water final temp = $m_w c_w \Delta\theta_w + m_c c_c \Delta\theta_c$

$m_s l_v + m_s c_w \Delta\theta_w$

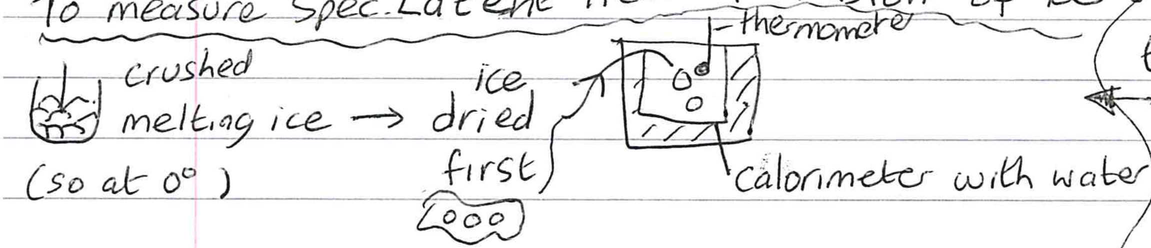
$\Delta\theta_w$: 100 − Final temp

$\Delta\theta_c$: Final temp − Initial temp

to minimise error due to heat loss you can start exp with water below room temp. Any heat thro' insulator will enter into water in calorimeter until temp of water goes above room temp then any heat escaping will go from water to outside – thus cancelling out the heat entering earlier.

Exp calculations assume only steam enters water to guarantee that no water enters with steam a steamtrap is used

To measure Spec. Latent Heat of Fusion of Ice:



Heat gained by ice = Heat lost by water + cal.

ice 0° → water 0° + water 0° → water Final temp = $m_w c_w \Delta\theta_w + m_c c_c \Delta\theta_c$

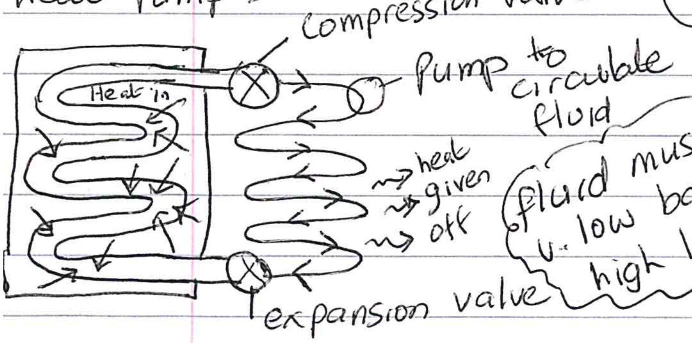
$m_i l_F + m_i c_w \Delta\theta_w = m_w c_w \Delta\theta_w + m_c c_c \Delta\theta_c$

$\Delta\theta_w$: Final temp

$\Delta\theta_w$: (Initial Temp − Final Temp)

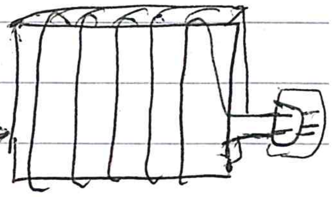
* can start with water above room temp so that at start any heat getting through insulator goes from inside to outside and at end of exp it goes from outside in thus both cancel out making overall heat loss/gain = 0.

Heat Pump:



Fluid must have v. low boiling point and high latent heat of vapourisation

STORAGE HEATER



Material has hi specific Heat Capacity so it stores a lot of heat energy per °C. It is heated at night when electricity is cheaper. Then heat is given off during the day as needed.

Fluid has very low Boiling point so that it should be a gas at the low fridge/freezer temp. It is too compressed outside fridge and is a liquid. As it enters the fridge it can expand and as it expands it takes latent heat of vapourisation energy from fridge to do so. It has a high latent heat of vapourisation. As it leaves the fridge it is compressed and therefore gives off its energy as it turns from gas to liquid.