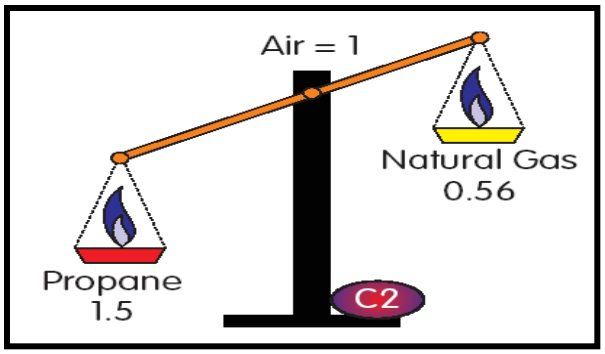
Relative Density

- Water = 1.0
- Aluminium = 2.7
- Zinc = 7.1
- Cast Iron = 7.2
- Tin = 7.3
- Copper = 8.9
- Lead = 11.3
- Air = 1.0
- Methane = 0.6
- Propane = 1.5
- Butane = 2.0
- Class C oil = 0.79

- The weight of a substance per volume a cubic metre of water & **air weighs 1000kg and have relative density of 1.**
- Therefore looking at the table opposite we can see that certain metals are heavier than water/ air & other gases / materials are lighter.
- Often relative density can be described simply by some materials sink if heavier than water & air & some float if lighter than water or air.
- Any item that has a relative density of less than 1 such as class C oil will therefore float, any thing heavier than 1 will sink such as lead at 11.3.

Density of liquids



- **Water is less dense when heated.**
- As the temperature of water increases its molecules move further apart so the density decrease.
- Upon cooling the molecules move closer together so the density increases.
- $1m^3$ of water at $4°C$ has a mass weight of 1000kg.
- $1m^3$ of water at $82°C$ has a mass weight of 967kg.
- Velocity of water flowing through a pipe can also be a problems to prevent possible erosion the velocity should be kept below 2m/s.

Density Questions

- Water at its maximum density is 4°C, $1m^3$ of water at this temperature weighs 1000kg and is said to have a relative density of 1.
- Simply divide by 1000 to obtain relative density
- Multiply the relative density of the object by 1000 to obtain the weight for $1m^3$ of the material.
- **Question:** At 4°C, $1m^3$ of water weighs 1000kg and has a relative density of 1, if copper has a relative density of 8.9, what would $1m^3$ of copper weigh?
- **Question**: $1m^3$ of propane weighs 1500kg what is its relative density?

Pressure

- Pressure can be defined as the **force acting on a given area:**

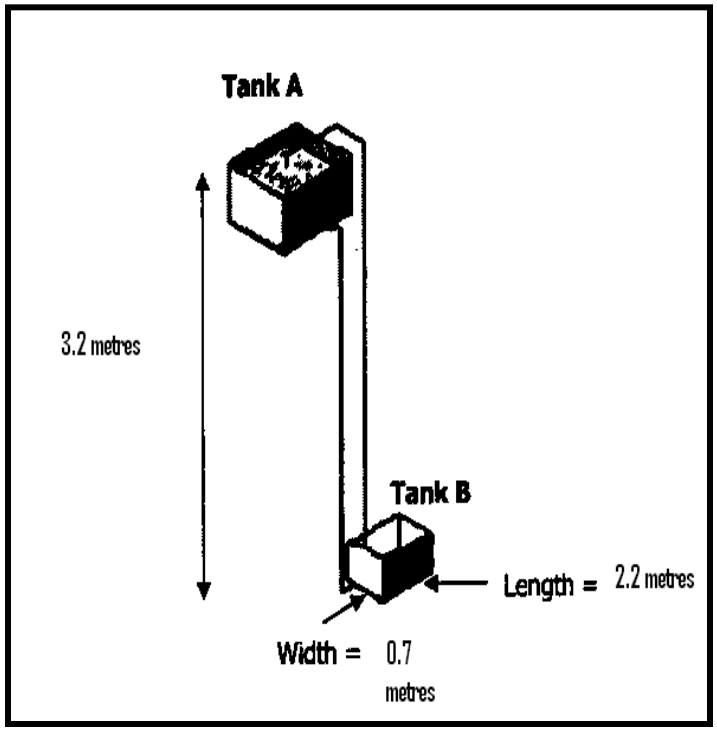
- **Pressure can be shown in many forms:**
- The SI unit for pressure is Pascal (Pa)
- 1Pa = $1N/M^2$
- 1bar = 100,000 N/M^2
- Atmospheric pressure at sea level = 101.325N/m^2

- Pressure can be calculated in **Pascal's by multiplying Newton's & square metres.**

- **1 Bar pressure = 10 metre head** approx.

Intensity of Pressure Questions

1/ From the illustration below show all your workings to calculate the intensity of pressure at tank B?

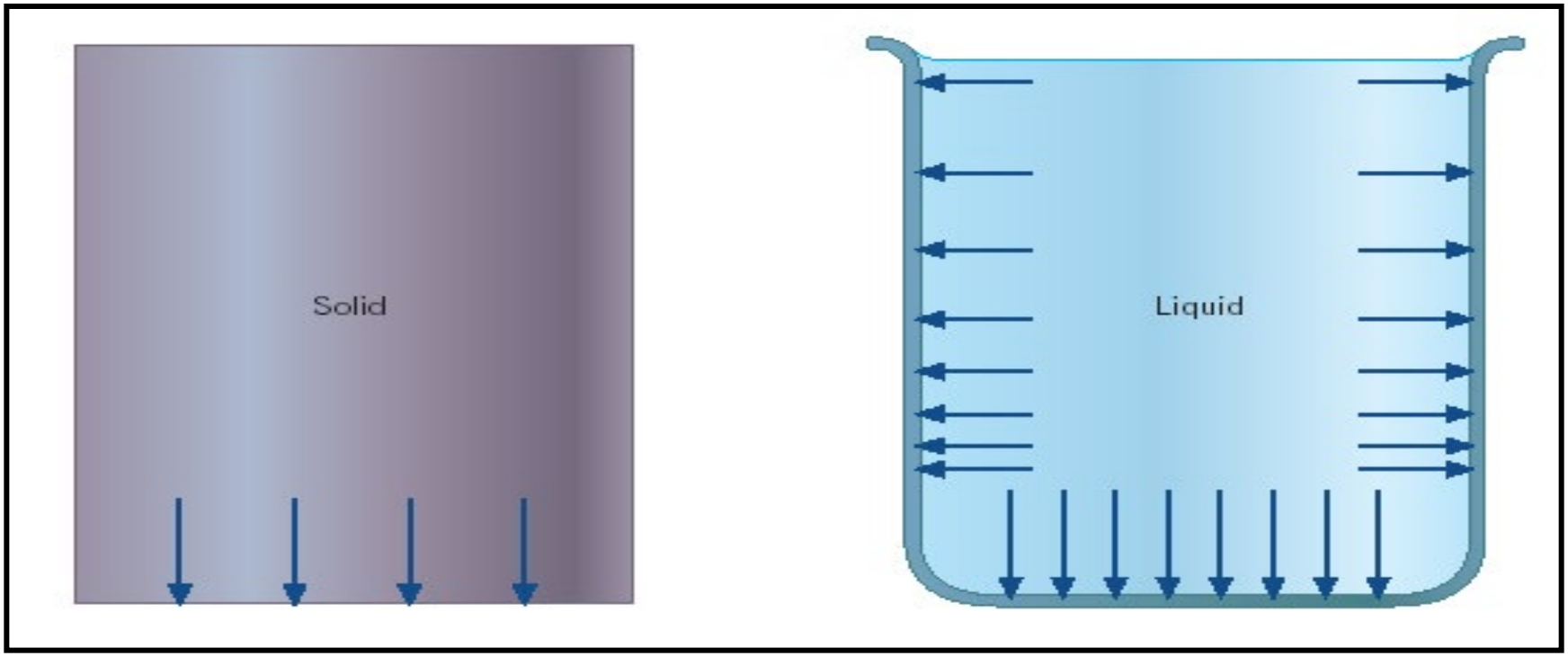


3.2 m x 9.81 = **31.392 k N / m²**

2/ now work out the total pressure on tank B?

31.392 k N / m² X 0.7 X 2.2 = **48.344KN**

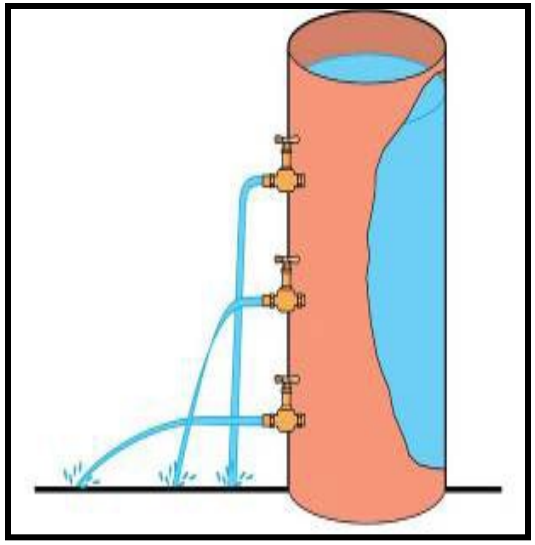
Pressure exerted by solids and liquids



Solids in a downward direction only

Liquids however exert pressure downwards and outwards

Pressure through pipe work



1/ Which outlet will create the greatest pressure?

2/ Which outlet will create the least pressure?

- **It should be noted that head gives pressure** not pipe size.

Resistance in Pipe-work

- Changes of direction & the fitting of valves **create resistances in plumbing pipe-work** the chart below shows resistances that need to be taken into account when pipe sizing.

Expansion joints

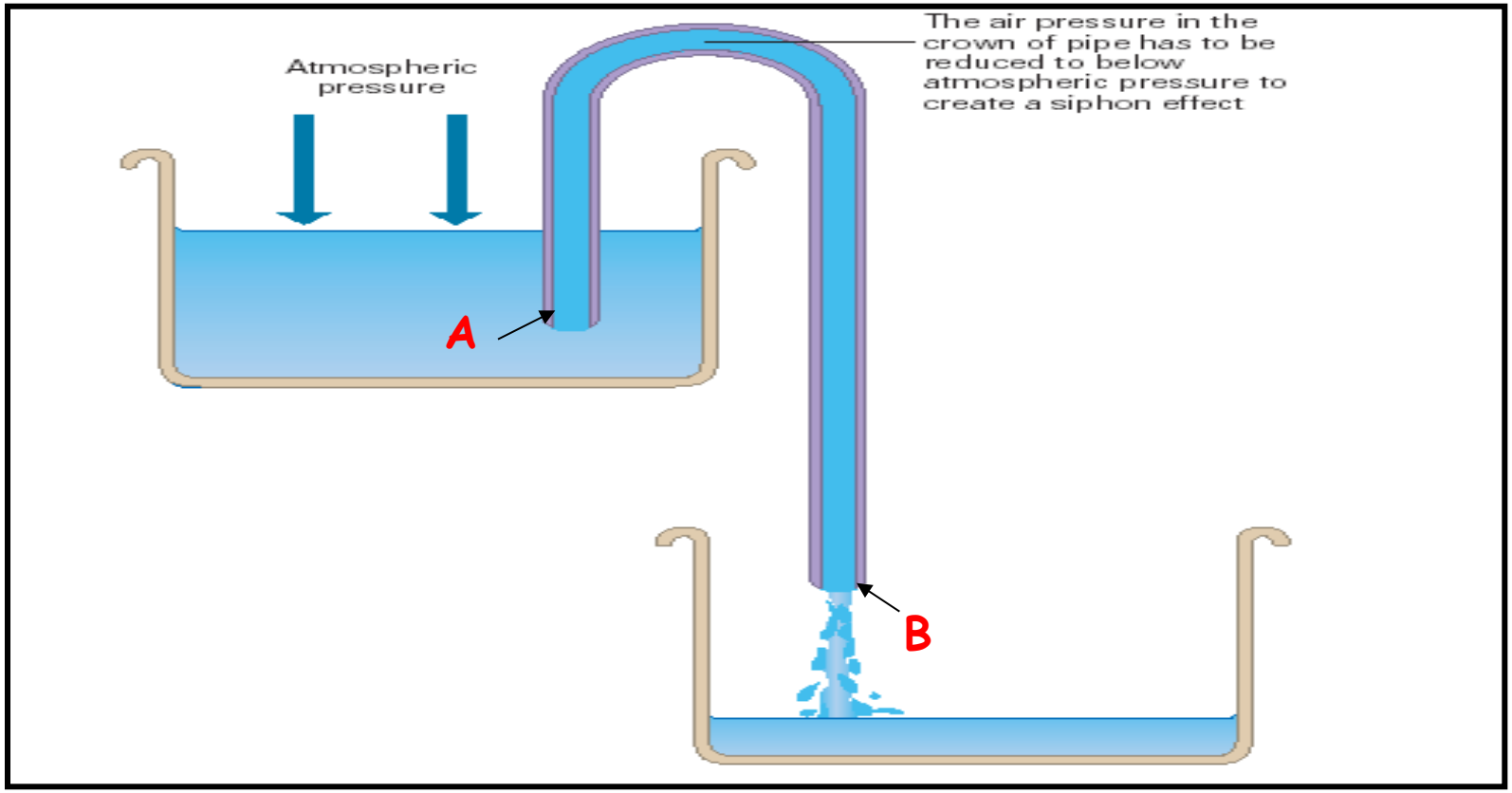
- **Elbow** = 0.5metres on 15mm copper tube.
- **Tee** = 0.6 metres on 15mm copper tube.
- **Stop valve** = 4.0 metres on 15mm copper tube.
- **Check valve** = 2.5 metres on 15mm copper tube.
- **Pulled bend** = 0.3 metres on 15mm copper tube.

- Generally speaking the **greater the number of fittings used to change direction the greater the resistance, the more pulled bends used creates less resistance.**

- Plumbing materials also create resistance **galvanised LCS** for instance offers a greater frictional resistance than other pipes as it has a **rougher internal pipe wall**.

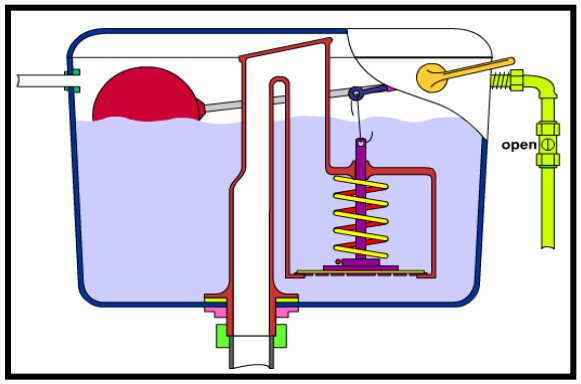
- Reducing the diameter of a piece of system pipe work **would increase the pressure after the pipe reduction. (Hose pipe?)**.

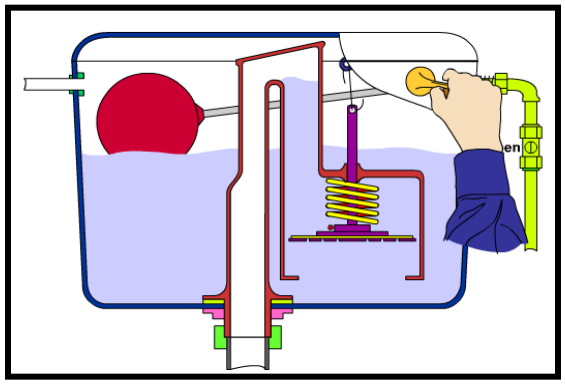
Siphonage

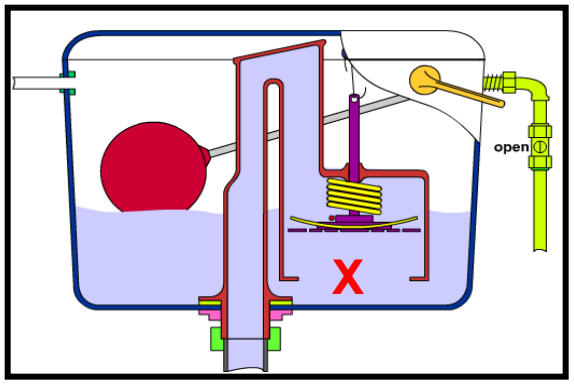


"By lower the pressure below that of atmospheric at **B** the water flows from ***A***"

Siphon action WC flushing Mechanism





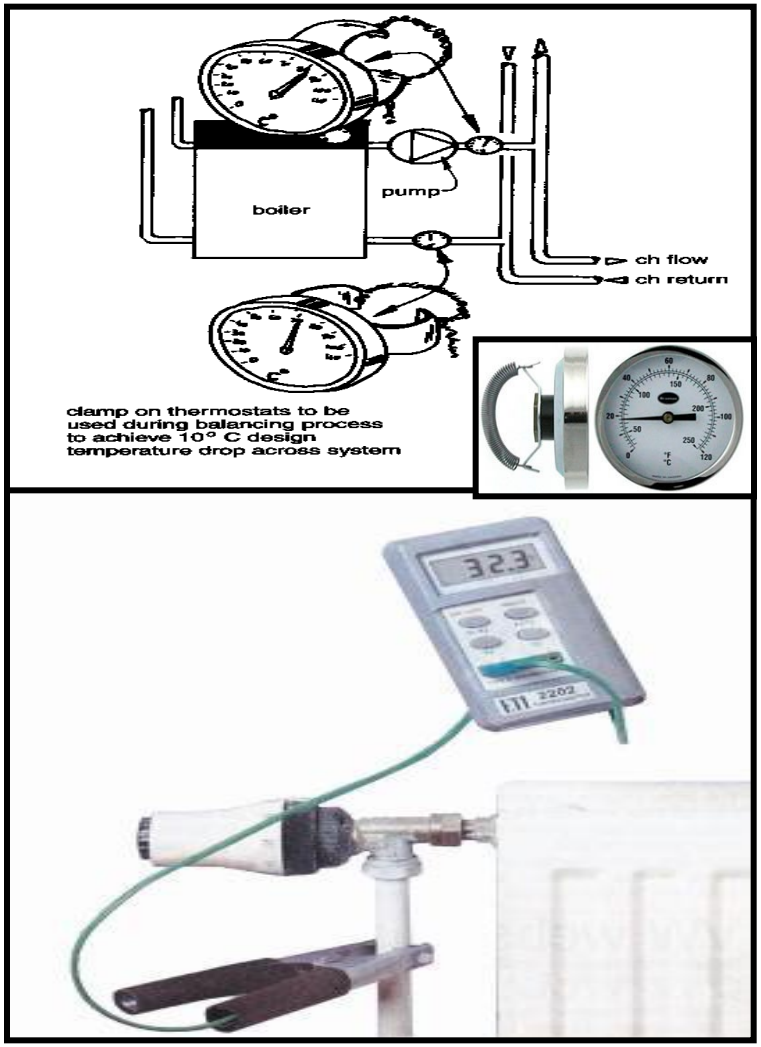


- Siphonage works by lowering the pressure inside the siphon or hose pipe to below **atmospheric pressure.**
- When this occurs water will siphon from a hose pipe or in this case through the toilet siphon.
- In this mechanism the flush is instigated by the diaphragm washer pushing water up and over the crown of the siphon, lowering the air pressure inside the crown of the siphon to below atmospheric pressure starting the siphon effect.
- The siphon will be broken once air enters the underside of the toilet siphon marked x.

Measuring Pipe temperatures

- To check the temperature difference between flow and return temperatures on primary flow and return pipe work to boilers and cylinders **a surface mounted thermometer can be used.**

- Today however this type of thermometer has been replaced by **digital electronic thermometers** which can attach to the pipe work via leads.



Specific Heat Capacity

- This can be defined as: **The amount of heat required to raise 1 KG of substance through 1 degree centigrade.**
- Specific heat values change as the temperature increases.
- To find out how much heat would be required to heat water from 1 temperature to another use the following formula:

- **Specific heat values**
- Water = 4.186kj/kg
- Aluminium = 0.887kj/kg
- Cast iron = 0.554kj/kg
- Zinc = 0.397kj/kg
- Lead = 0.125kj/kg
- Copper = 0.385kj/kg
- Mercury = 0.125kj/kg

Remember all specific heat capacities are expressed as:

KJ/kg/°C

- **Specific heat x kg x temperature rise**

Specific Heat Capacity questions

- **Definition** = The amount of heat required to raise 1kg of material 1°C
- **Formula: = Specific heat x kg x temperature rise**
- **Question**: If lead has a SHC of 0.125, how much energy would be required to raise it 500g by 1°C?
- **Answer** = study the definition we have the SPH, we have the temp rise and half the weight so we simply half the SPC.
- **Therefore 0.125 divided by 2 =0.0625kj.**
- **Question**: Water has a specific heat capacity of 4.186kj/kg°C how much heat would be required to raise 5kg of water from 25 to 90 degrees centigrade?
- **Answer: 4.186KJ/KG/°C** X 5KG X 65 °C =1360Kj

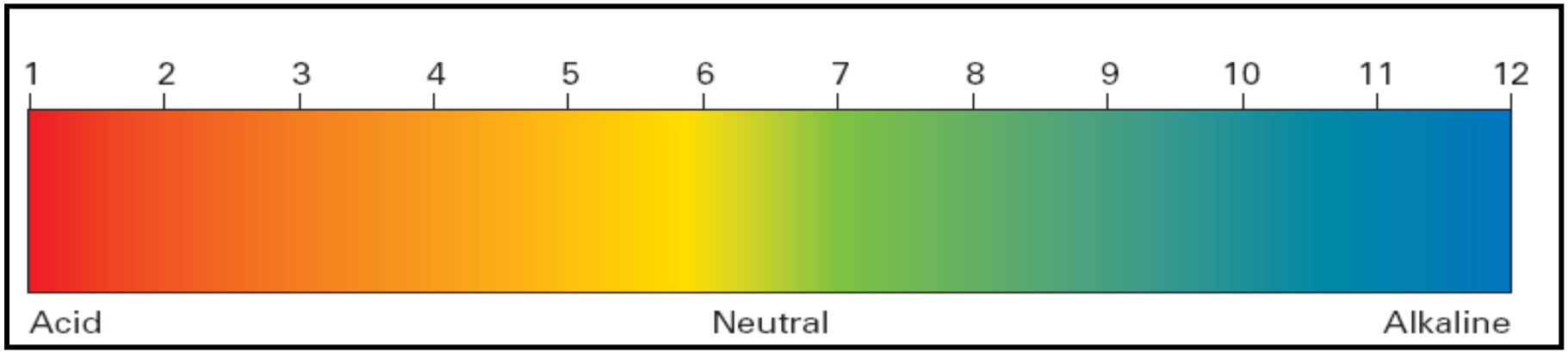
Specific Heat Capacity questions

- **Question:** Copper has a specific heat capacity of 0.385, if 2310kj of heat energy were applied to 1kg of copper what would the temperature rise be?
- Formula = **Specific heat x kg x temperature rise.**

- **Answer:** SHC = 0.385 X 1 = 0.385 now we need to work out **how many degrees centigrade** multiplied by our answer will equate to 500kj of heat energy?
- 0.385 x 2°C = 0.77 which = 770kj no good
- 0.385 x 4°C = 1.536 which = 1536kj no good
- 0.385 x 6°C = 2.31 which = 2310kj our answer.

- **Therefore our answer = 6°C would be needed.**

pH Scales



The pH scale identifies **the degree of Acidity or Alkalinity the liquid has** this can be checked against the table above!

Pure water normally has a **pH value of 7**.

pH stands for **potential hydrogen**.

Definitions of metals

- **Alloy** = a mixture of more than one metal.
- **Ferris metal** = a metal which will rust.
- **A non-Ferris metal** = a metal that does not rust.
- **A pure Metal** = a metal which is mined directly from the ground.

Electrolytic Corrosion

- COPPER — Cathodes
- TIN
- LEAD
- NICKEL
- IRON
- ZINC
- ALUMINIUM
- MAGNESIUM — Anodes

- **The higher the metal on the list will destroy the lower the metal on the list**, i.e. copper connected direct to lead will **corrode the lead.**
- **Cathode will slowly destroy the anode.**
- Never mix dissimilar metals.
- **The rate of corrosion depends upon the water & the distance between the metals on the electromotive series list opposite!**
- Because of this type of corrosion which is increased in acidic water areas **sacrificial anodes often made of magnesium are often fitted inside the bottom of copper cylinders!**

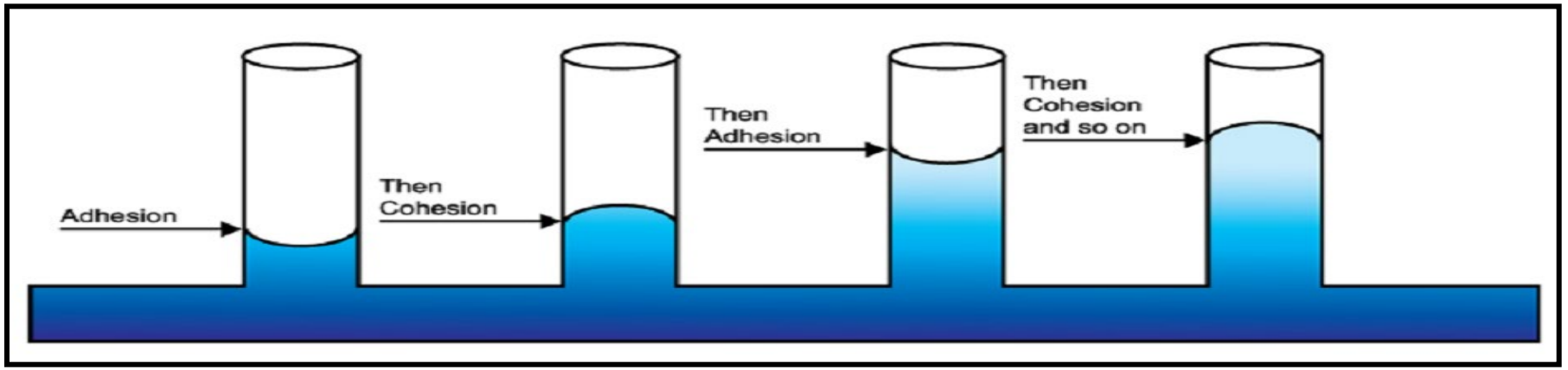
Atmospheric Corrosion

- Lead & Copper produce a **natural Patina** which protects the surface of the material naturally.

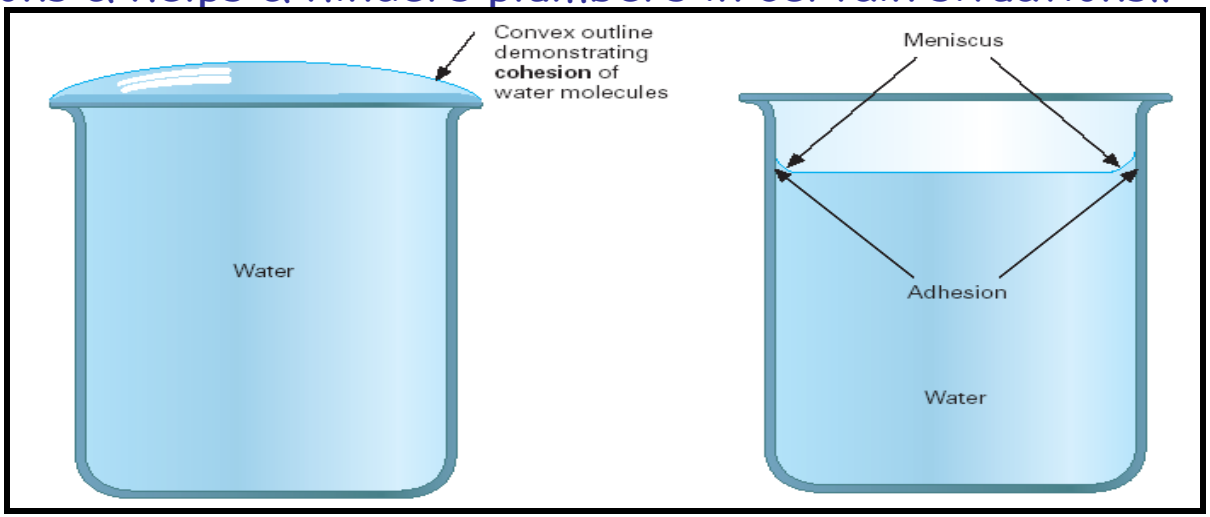
- Ferris metals {metal's containing iron} however need to be **protected from the elements**, if water or moisture is present combined with air the metal **will rust** to protect Ferris metals they are often wrapped in denso tape
- {a wax bandage} or painted with red oxide oil based paint & lagged.

- If LCS is used in plumbing systems which are **regularly oxygenated** then galvanised LCS is used to prevent pin holing.

Capillarity



Water is drawn between two surfaces first through adhesion & then cohesion the **closer the surfaces are together the greater the rate of capillary attraction**. This process happens in both vertical & horizontal positions & helps & hinders plumbers in certain situations!!

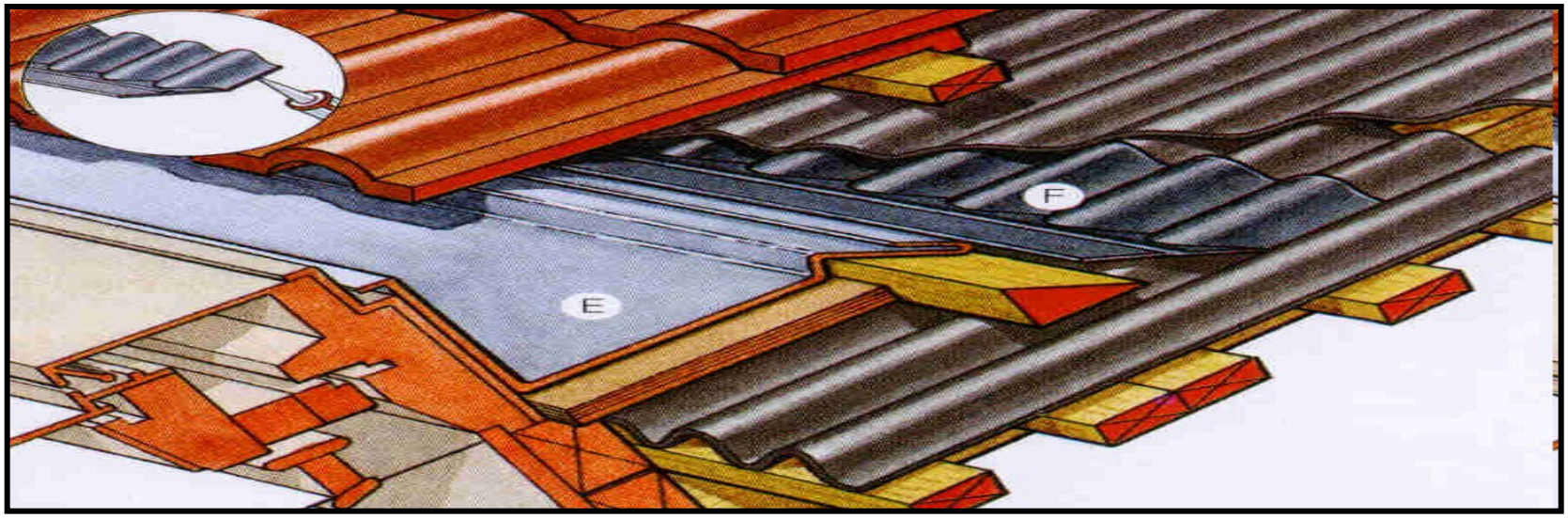


Molecules clinging together adhesion

Capillarity

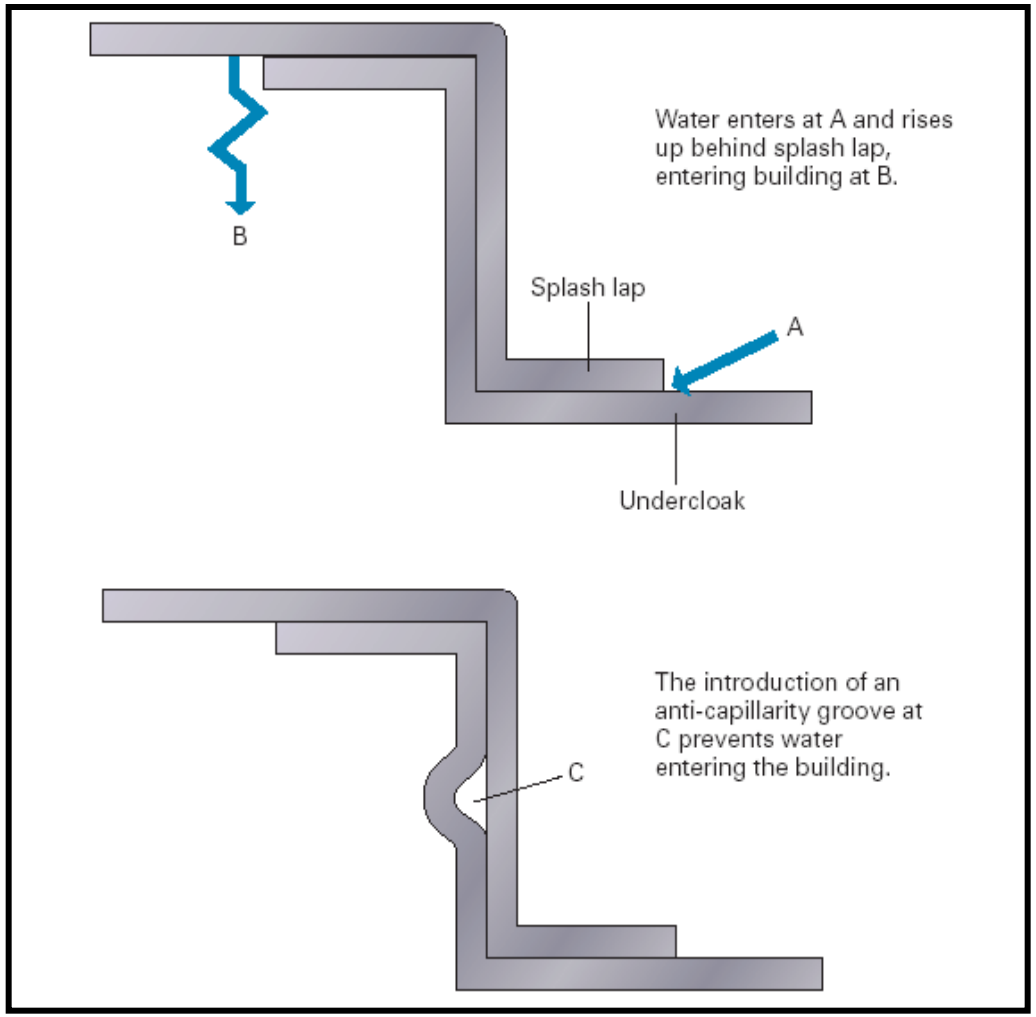
- Liquids have the ability through adhesion & cohesion to be drawn **vertically & horizontally** between surfaces the closer the mating surfaces the worse the results!

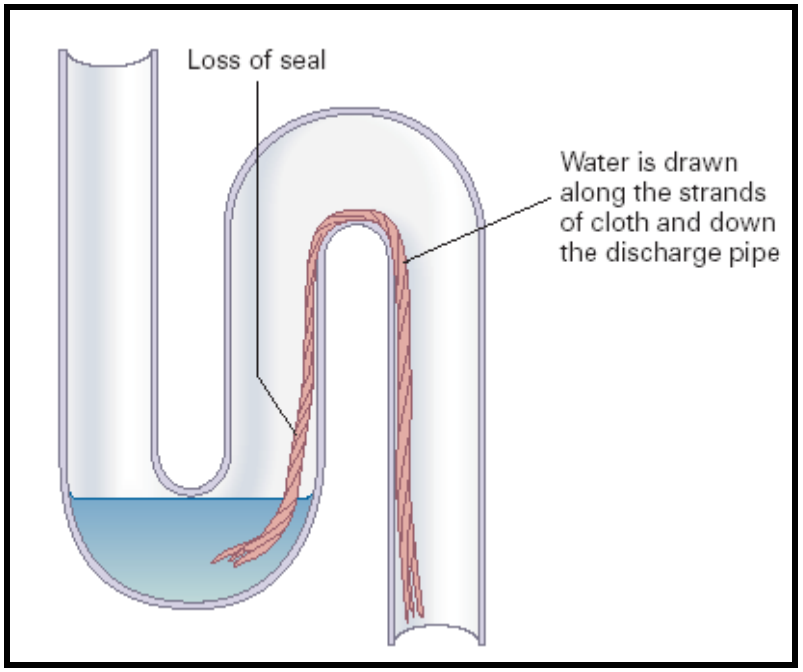
- To prevent capillary attraction **tilting fillets** are used on lead.



- **Anti capillary grooves are used on drip edges & window sills etc.**

Capillary action cont.





Coefficients of Linear Expansion

- Plastic (UPVC) = 0.00018.
- Lead = 0.000029.
- Copper = 0.000016
- Steel = 0.000011

- As we see from the coefficient's of expansion **plastic (PVC)** expands the most.

- **E.G** so we need to make sure we do not engage our black plastic gutter for example past the expansion lines on the fitting other wise stop ends have been known to fall off causing a nuisance value when it rains!

- FORMULA: **Original length x Temp rise x coefficient of linear expansion.**

Lets try a Coefficient expansion question!

- FORMULA: Original length x Temp rise x coefficient of linear expansion.

- **Question:** plastic has a coefficient of linear expansion of 0.00018, if the temperature rise of the guttering is 11°C, how much does 12 metres of plastic guttering expand by?

- **Answer:** 12000mm of gutter x 11°C x 0.00018 = 23.7mm

Electrical Fuse Sizes in a Consumer Unit

- If re-wireable fuses are used sometimes the ampage is slightly lower than the sizes shown!

- Make sure the correct fuse wire is used when rewiring a re-wireable fuse **as the cross sectional area of wire** is very important.
- **MCB circuits**
- **Ring Main** = 32 amp
- **Cooker** = 32 amp
- **Water Heater** = 16 amp
- **Lighting** = 6 amp

Ammeter for measuring the current in the circuit

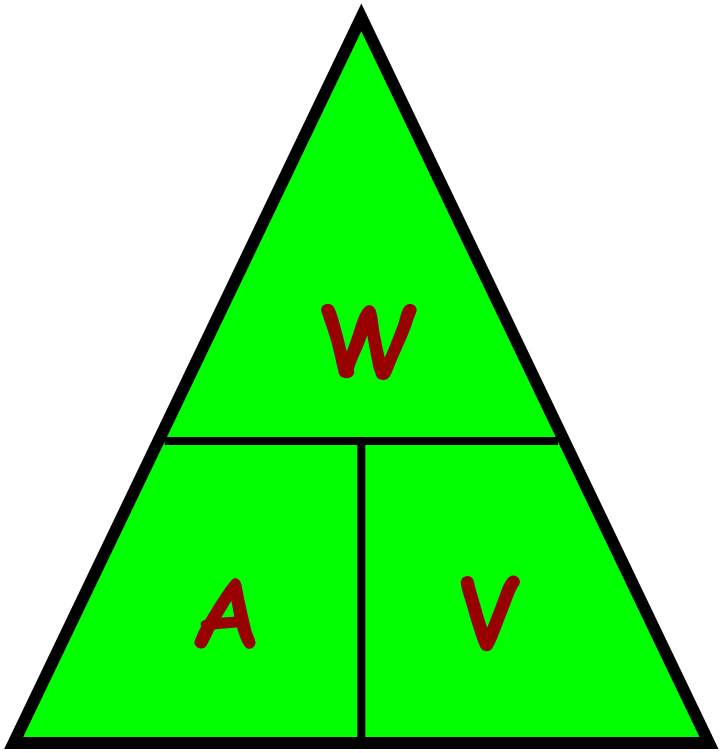
- **Mains voltage in the UK is between 230 and 240 volts.**

- **On construction sites however 110 volt supply is used.**

Electrical Units

- **Units of Electricity:**
- **Volt** = pressure
- **Current** = Amperes
- **Joule / Watt** = Power
- **Ohm** = resistance

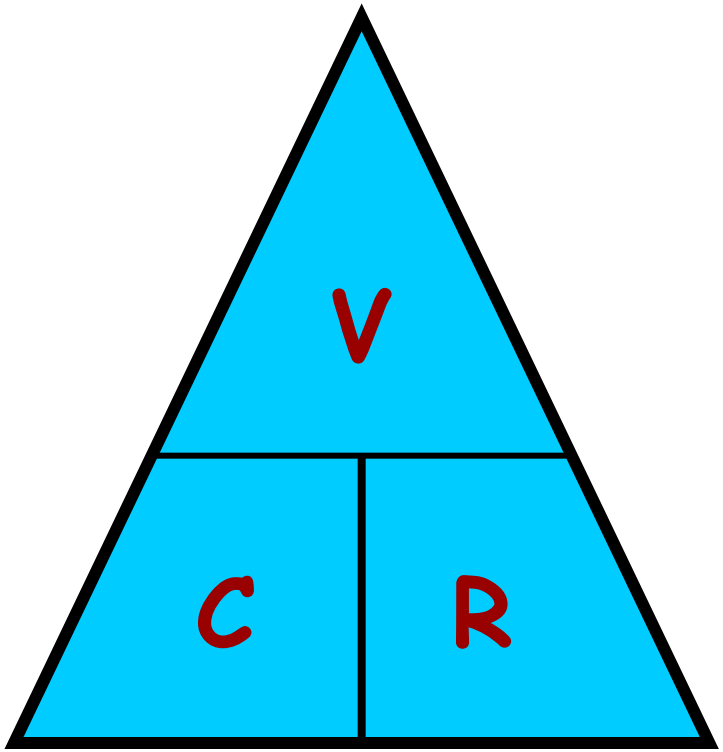
Working out the size of a fuse



- **Transposition of Formula:**
- Watts = Amps multiplied by Volts.
- Amps = Watts divided by volts.
- Volts = Watts Divided by Amps.
- **Remember: What Are Virgins?**

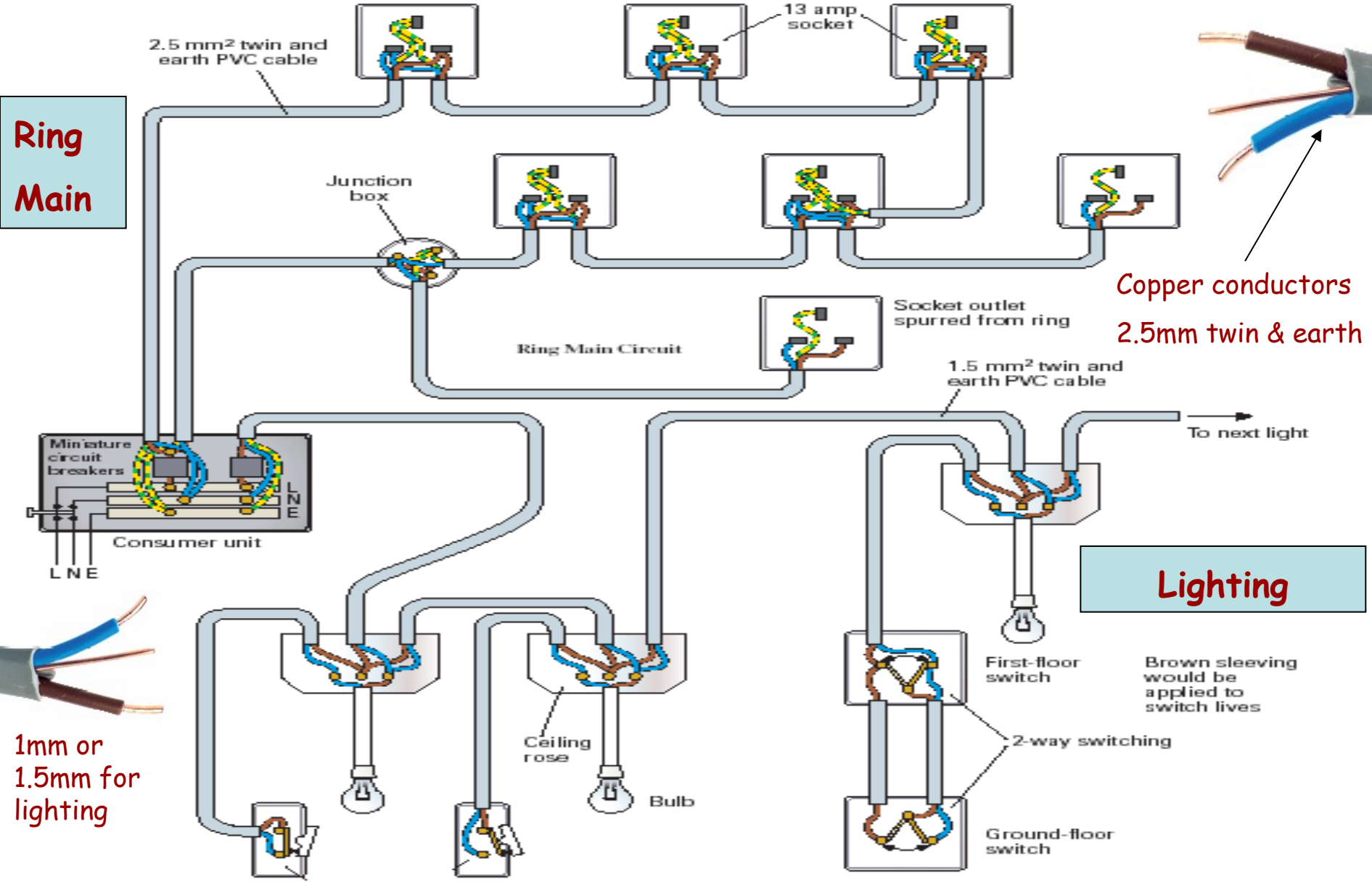
Ohms Law

- **Transposition of Formula:**
- To find the voltage multiply the current by the resistance.
- To find the resistance divide the voltage by the current.
- To find the current divide the voltage by the resistance.
- ***Remember the little saying Video Cassette Recorder***



Electrics for Plumbers!

Ring Main



Copper conductors

2.5mm twin & earth

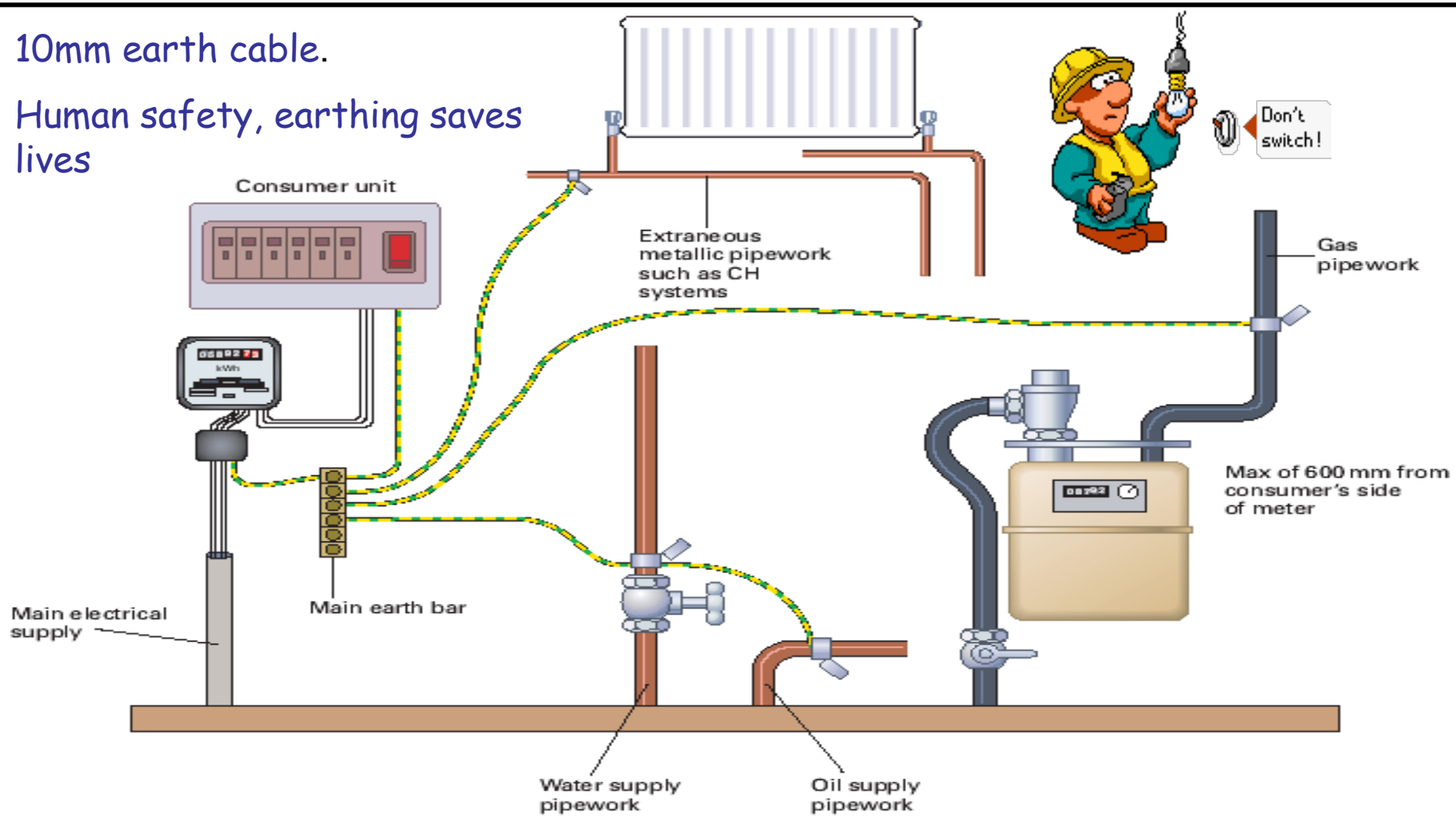
Lighting

1mm or 1.5mm for lighting

Equipotential bonding of pipe work in dwellings

10mm earth cable.

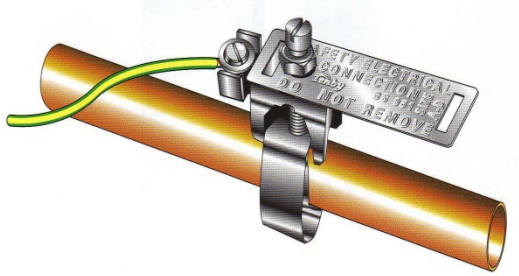
Human safety, earthing saves lives



Supplementary cross Bonding

4mm to 6mm earth cable

Where plastic fittings are used cross bonding must be used!



Metal bath and basin taps

Exposed pipework

Radiator

Metallic waste pipe

Supplementary Cross Bonding

Earth Continuity

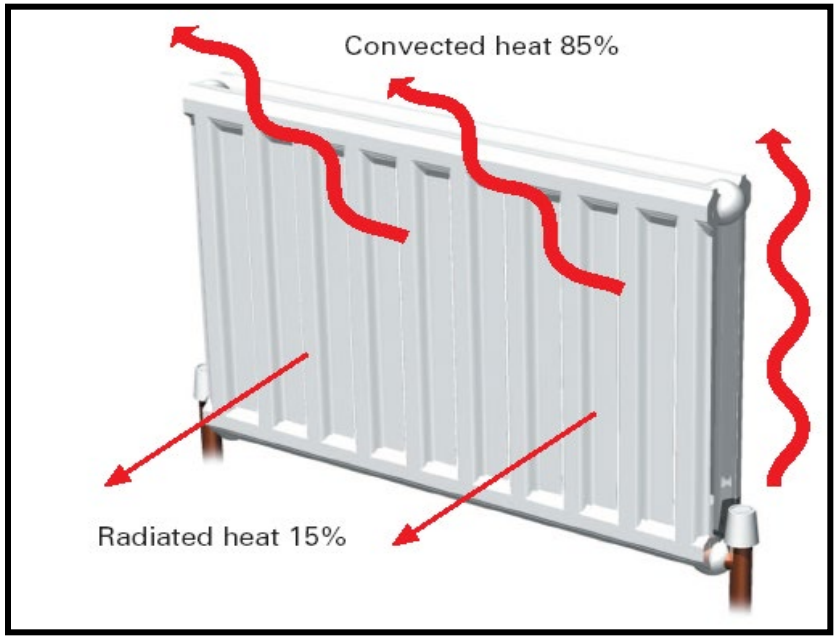
Changes of State

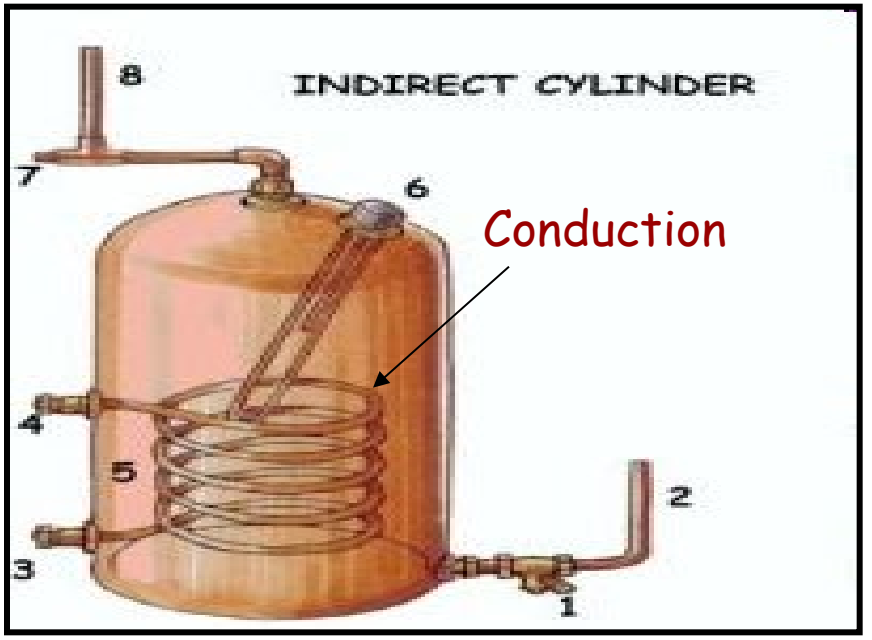
- **Liquid to Solid** = Molecules move closer together.
- **Liquid to gas** = molecules move further apart.
- **Molecules in solids** are very close together, as the solid starts to melt the molecules move further apart & as the liquid boils & expands & changes to gas they move even further apart.

Heat Transfer

- **Heat transfer is always in a direction from higher to the lower temperature.**
- **Conduction** = heat passing through or along a solid.
- **Convection** = As liquids & gases are heated they become less dense & rise as they cool they regain there density & sink.
- **Radiation** = Heat transfer to the body in straight lines and through a vacuum.

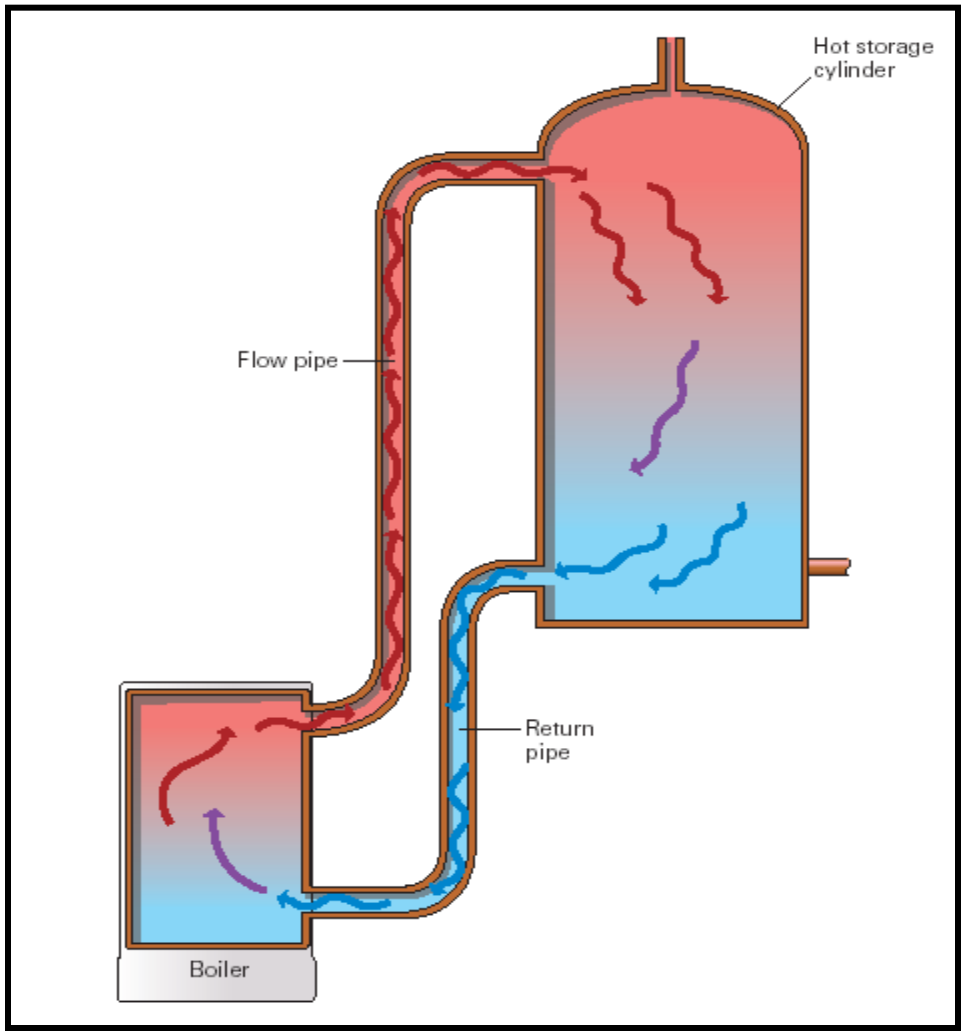
Heat Transfer cont





- Air is drawn up behind and through the radiator fins, **producing convection currents** the hot air is then convected around the room.
- The central heating water passing through the coil inside the cylinder heats up the copper coil **through conduction** this hot coil then heats the hot water through convection.

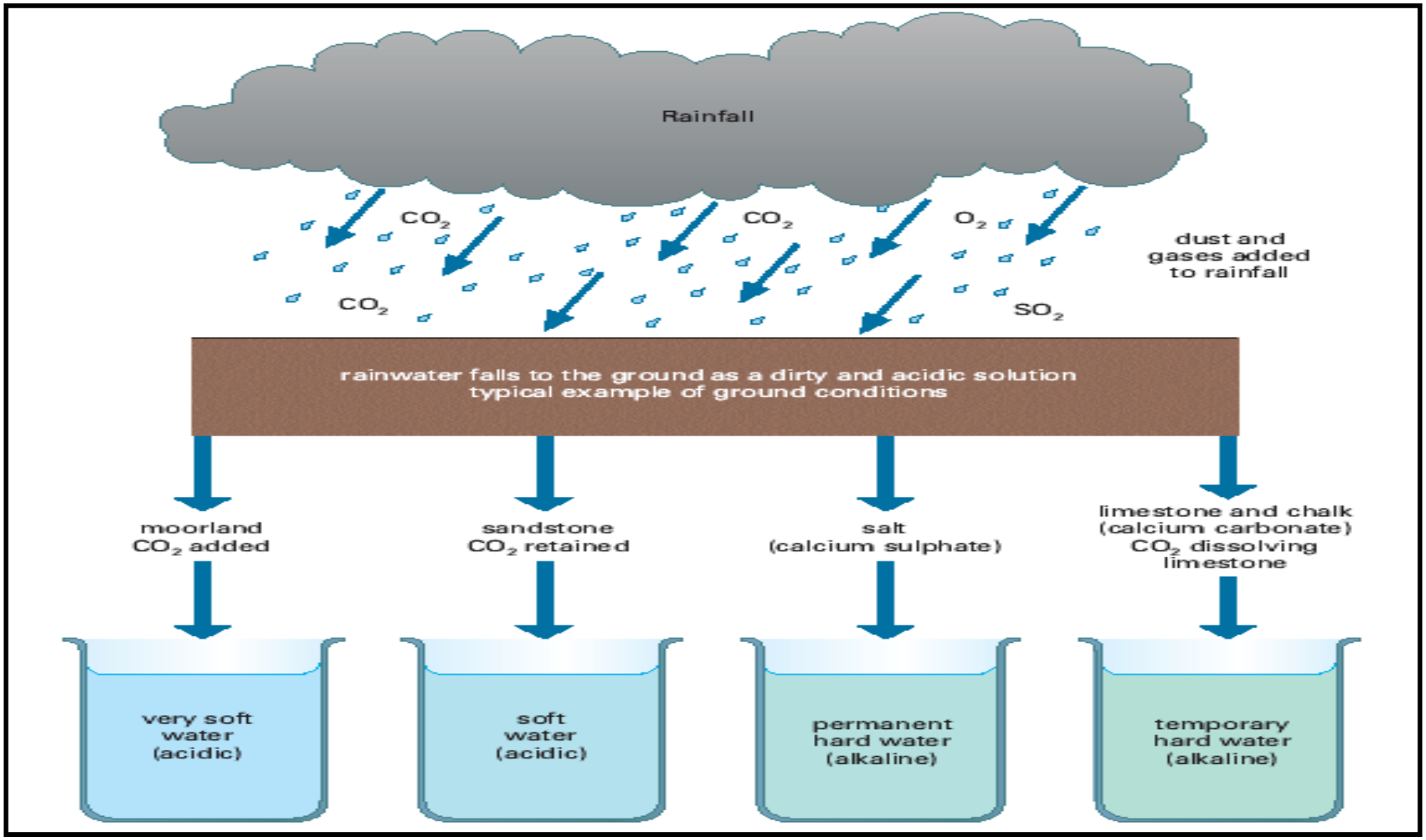
Convection



Convection currents occur in **liquids & gases due to them changing in density** as water is heated it becomes less dense & so rises upon cooling it regains its density & becomes heavier falling.

This is best understood by plumbers who have experiences of old gravity hot water heating systems where the rise & fall of pipe-work before pumped technology was critical in getting systems to function correctly!

Classification of Water



Hardness in Water

- Lime scale deposits in systems is caused by **hard water these are often referred to as calcium deposits**.
- They will act as an insulator and decrease system efficiency.
- Depending upon what strata water falls through will depend upon whether its **hard or soft**.
- Two types of hardness are present in water **Temporary hardness & Permanent hardness**.
- It is the Temporary hardness that most hinders our systems because if **hot water** is allowed to be stored at **65 degrees centigrade or above** the carbon dioxide is given up by calcium bicarbonate turning it back into a **calcium carbonate salts** leaving pipes clogged with lime scale deposits on pipe, boiler & cylinder walls!
- Therefore the **maximum temperature in our cylinders should be 60°C.**

Hardness in Water

- **Temporary hardness in water** causes plumbers the most problems due to **lime scale formation. <u>all hard water is Alkaline</u>.**
- When rain falls it picks up carbon dioxide from the atmosphere.
- As it passes through limestone & chalk, water takes into solution calcium carbonate from the chalk& limestone.
- The Co2 converts them into calcium bicarbonates.
- This is held in suspension until water is heated to over 65 degrees centigrade, this **hot water** then gives up the co2 & converts back from calcium bicarbonate to **calcium carbonate.**
- We no this as **lime scale** which builds up on pipe walls & insulates.
- The result of this being more fuel is used to heat the water to its normal 60 degree temperature.
- Temporary hardness in water **can be removed by boiling**

Heat Conductivity

- **Thermal Conductivity**
- Copper **Good conductors**
- Aluminium
- Iron
- Glass
- Brick
- Water
- Wood
- Still Air **Bad Conductors**

- **The transfer of heat through or along a solid.**
- Heat travels through all materials but the speed through which it passes varies.
- The **faster it travels the better conductor the material is considered to be.**
- **High density materials** are generally better conductors
- The term heat conductance means the **ability a material has to transmit heat across matter.**

SI units

Attribute	SI unit	Abbreviation
Length	Metre	m
Mass	Kilogram	kg
Time	Second	s
Electric Current	Ampere	A
Temperature	Kelvin	K
Area	Square metres	m^2
Volume	Cubic metres	m^3
Capacity	Litre	l
Speed	Metres per second	m/s
Acceleration	Metres per second per second	m/s or m/s^2
Force	newtons	N

Temperature

- The SI unit for temperature is **degrees Kelvin**.
- The **kelvin** (symbol: **K**) is a unit increment of temperature and is one of the seven SI base units.
- The **Kelvin scale** is a thermodynamic (absolute) temperature scale where **absolute zero**, the theoretical absence of all thermal energy, is zero (0K)
- The Kelvin scale and the Kelvin are named after the British physicist and engineer William Thomson, 1st Baron Kelvin (1824–1907), who wrote of the need for an "absolute thermometric scale".

Properties of materials

- Mass & weight are different on earth and on the moon!

- Mass = the amount an object weighs

- On earth the gravitational pull = $9.8 m/s^2$
- Therefore an object with a mass of 1kg on earth would weigh 9.8 newtons.

- On the moon the gravitational pull = $1.633 m/s^2$
- Therefore an object with a mass of 1kg on the moon would weigh 1.633 newtons.

- **FORMULA:** Weight in (Newton's) = mass x acceleration due to gravity

- **FORMULA**: Density = $\frac{\text{Mass}}{\text{Volume}}$