Theatre of Science IGCSE Physics: Solids Liquids and Gases 1: Density and Volume

Today's lesson will cover the following spec points (Pearson and Cambridge):

Know and use the relationship between density, mass and volume

Practical: investigate density using direct measurements of mass and volume

Describe the use of rulers and measuring cylinders to find a length or a volume

Define density as mass per unit volume; recall and use the equation ρ = m / V

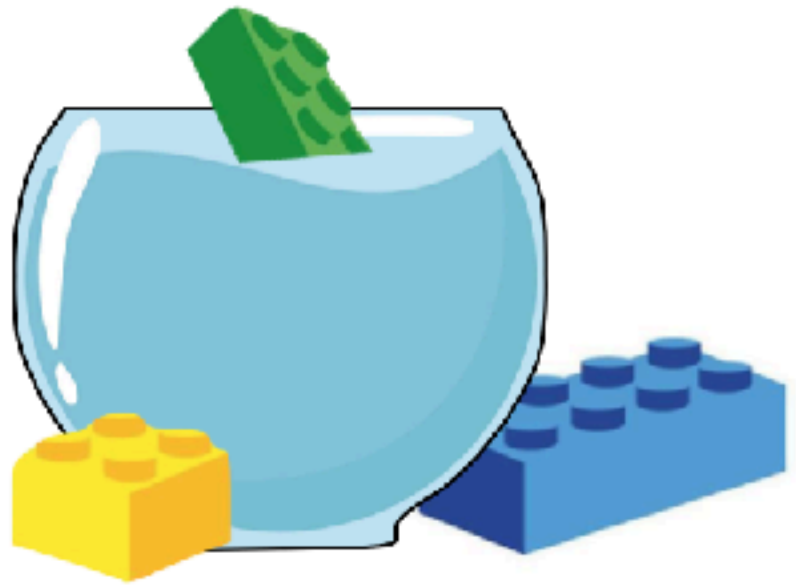
Describe how to determine the density of a liquid, of a regularly shaped solid and of an irregularly shaped solid which sinks in a liquid (volume by displacement), including appropriate calculations

Determine whether an object floats based on density data

Determine whether one liquid will float on another liquid based on density data given that the liquids do not mix

You only have as many (regular) Lego bricks as you like, and a cocktail stick / similar tiny stick.

Try and get Lego bricks to sink in water!



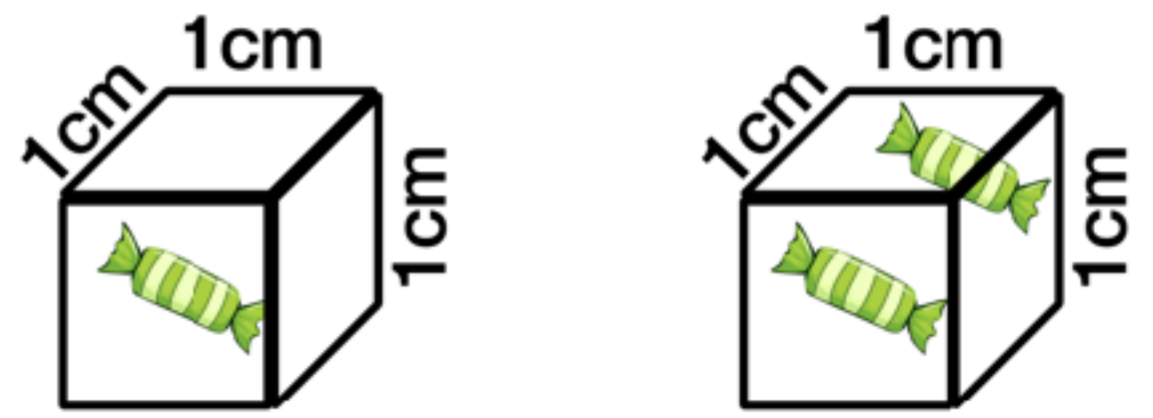
Density = mass / volume

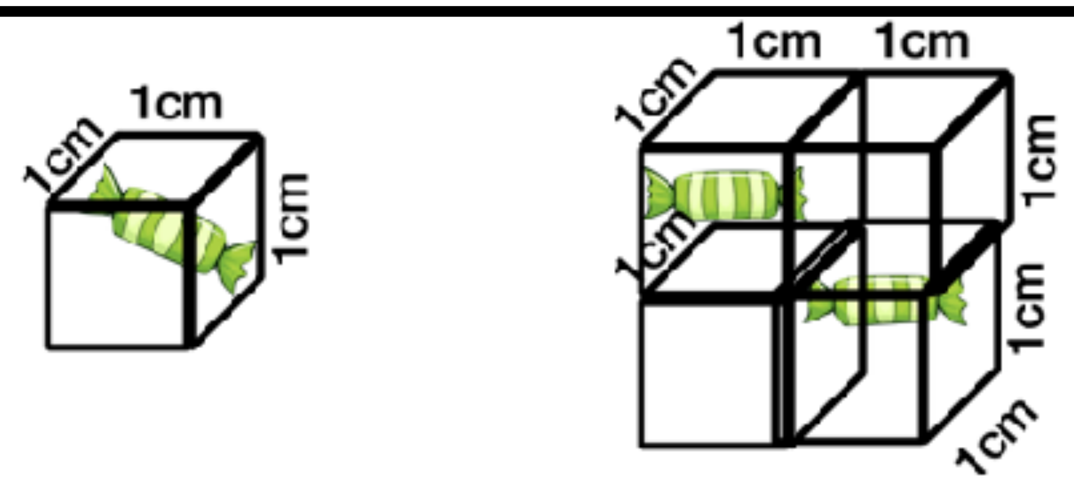
usually measured in...	usually measured in kg	usually measured in m^3

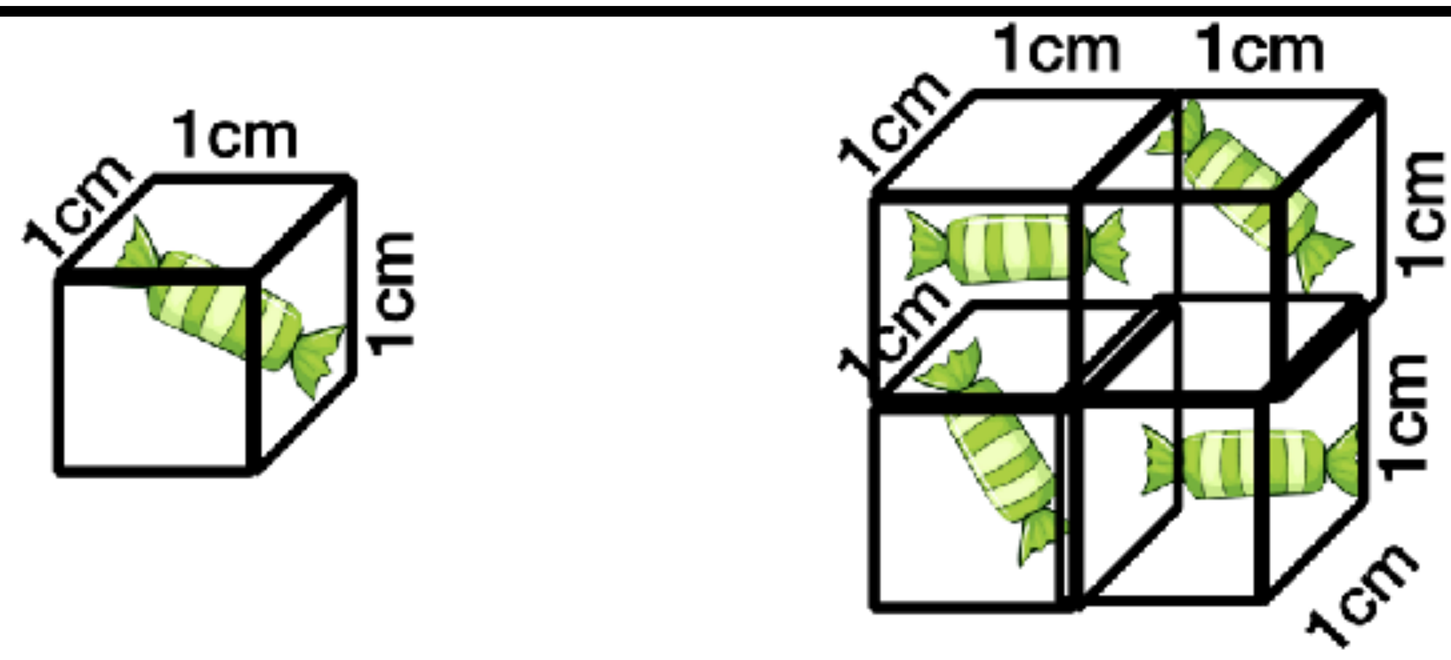
kg / m^3 "kilograms per metre cubed"

(Though obviously g / cm^3 might be more sensible if you're dealing with small amounts. Just make sure you write the units with your answer!)

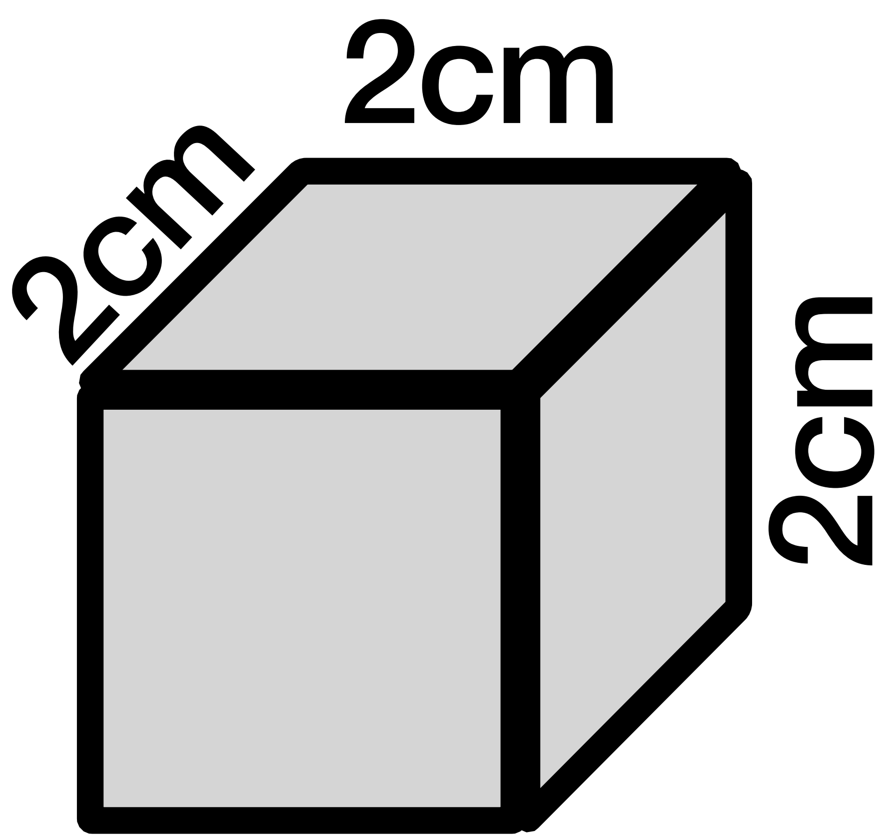
Let's play: "Which box is more densely packed?!" (Which box has *the most sweets per cm^3*)







Density = $\frac{\text{mass}}{\text{volume}}$



1) This cube of aluminium has a mass of 21.6g. What is the density of aluminium?

4) Tough one!
Give your answer for the density of aluminium in kilograms per metre cubed.

2) A 20mL tablespoon of golden syrup has a mass of 30g. What is its density?

5) How would you find the volume of this bronze statue?!

3) Water has a density of 1g / cm^3.
What is the mass of 75 cm^3 of water?

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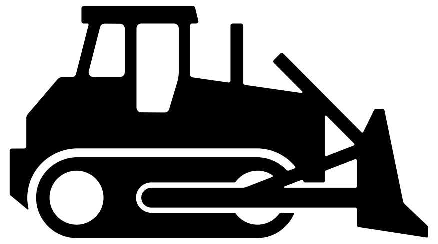
Theatre of Science IGCSE Physics: Solids Liquids and Gases 2: Pressure!

Which of these are an example of a low pressure being useful, which are high pressure being useful, which are both and which are neither?!

Today's lesson will cover the following spec points (Pearson and Cambridge):

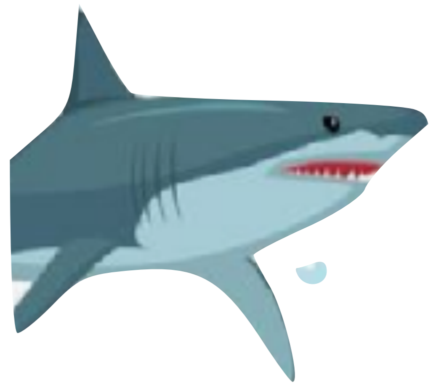
Define pressure as force per unit area; recall and use the equation $p = F A$

Describe how pressure varies with force and area in the context of everyday examples



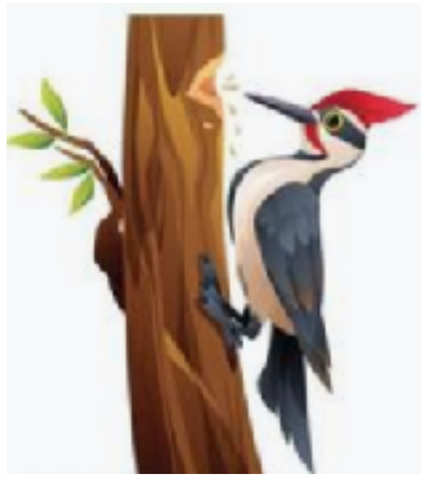
A bulldozer's caterpillar 'wheels'.

Useful: LP HP Both Neither



A shark's teeth

Useful: LP HP Both Neither



A woodpecker's beak

Useful: LP HP Both Neither

The base of a highchair being wide

Useful: LP HP Both Neither

Snow shoes

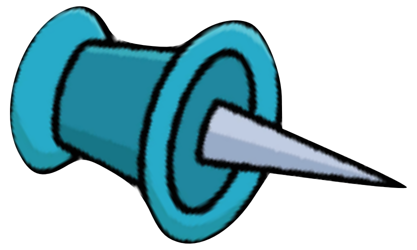
Useful: LP HP Both Neither

Ice skates

Useful: LP HP Both Neither

An umbrella

Useful: LP HP Both Neither



A drawing pin

Useful: LP HP Both Neither

Questions

Pressure (Pa) = Force (N) / Area (m^2)

1) A force of 40N acts over 5m^2. What is the pressure?

2) A force of 30N exerts 10Pa of pressure. What area is it acting over?

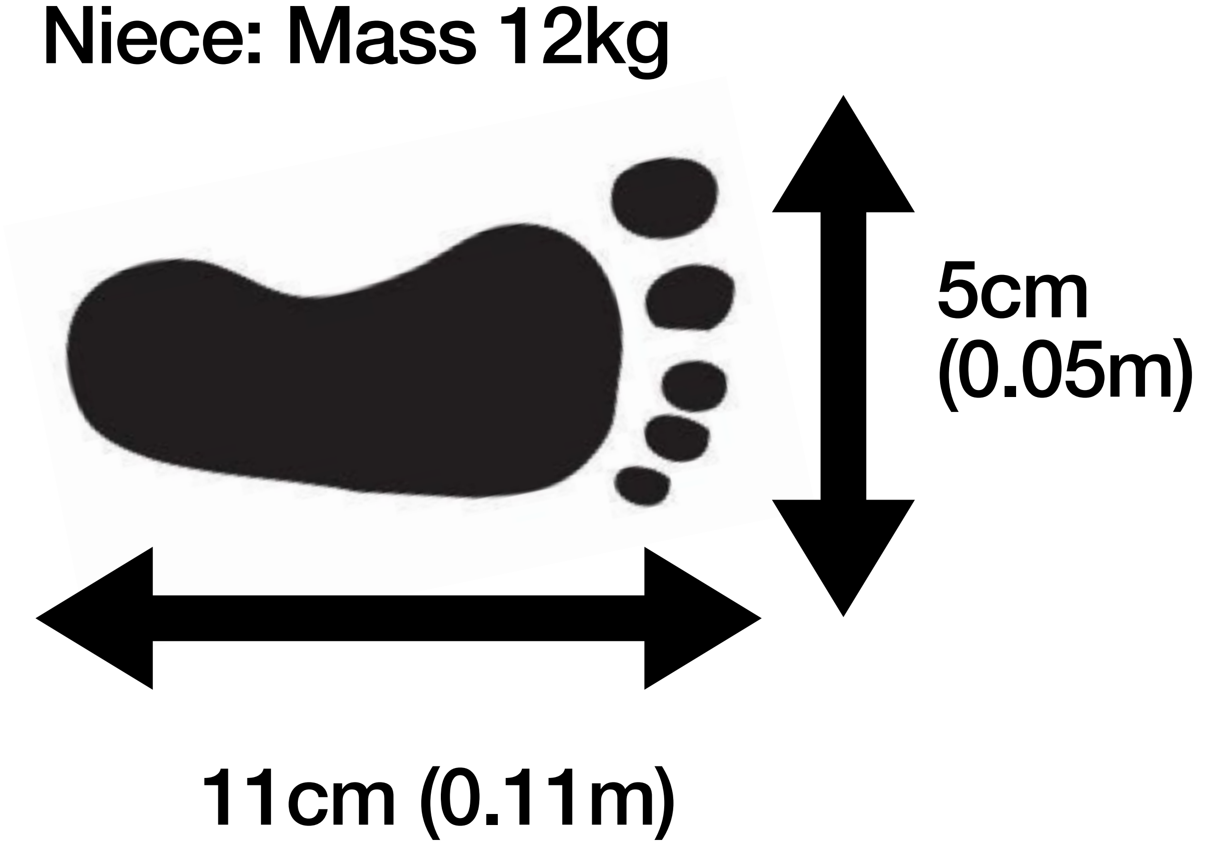
3) A 2m^2. table feels a pressure of 16Pa. How much force is pushing down on the table?

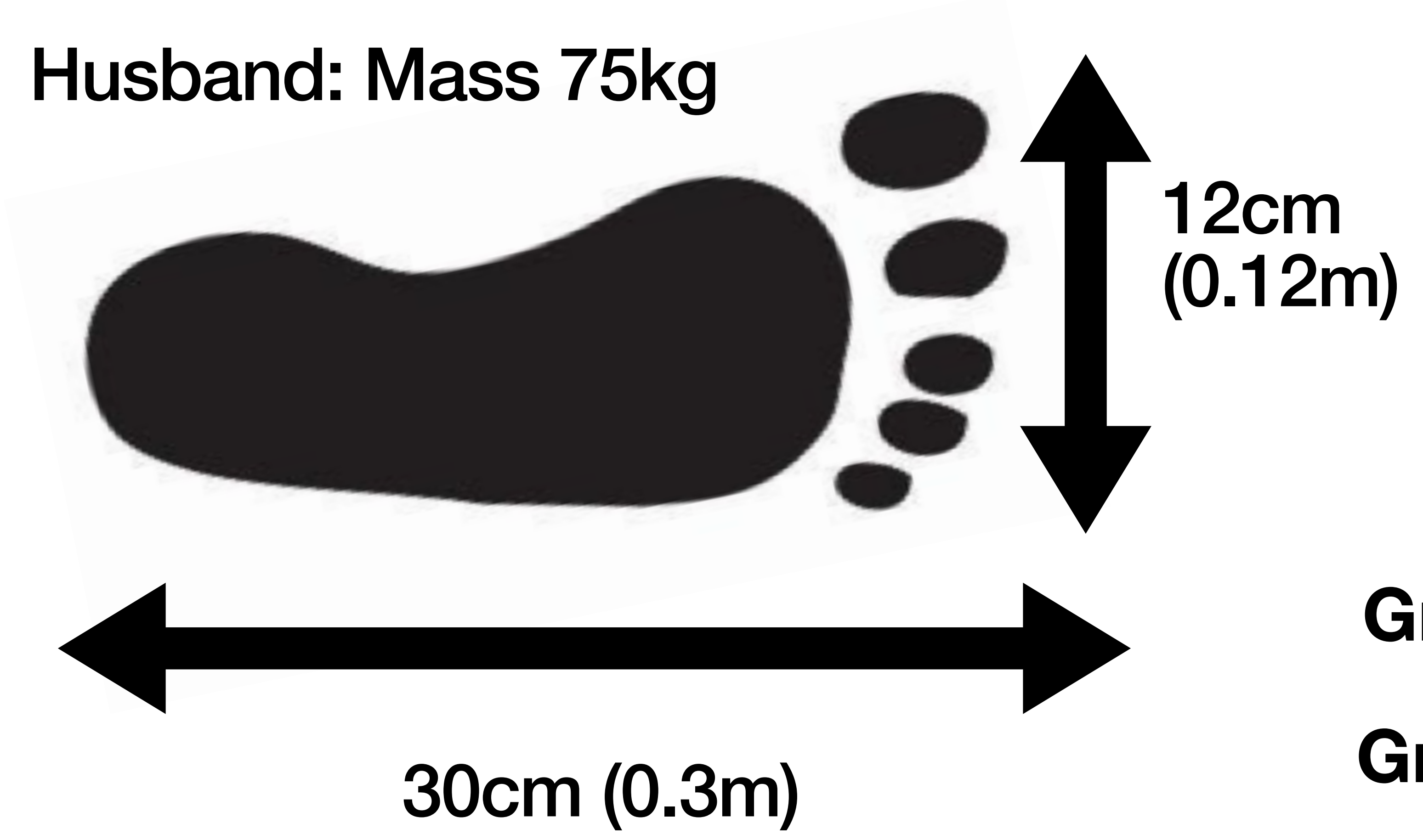
4) A truck weighs 400 000N. The surface area of each tyre is 1m^2. The truck has six wheels. How much pressure does the truck exert on the ground?

5) A shoe has an area of 0.05m^2. It exerts 800Pa of pressure on the ground. What is the weight of the owner (pictured!), in newtons?

6) An ice skate is 0.5 cm wide and 30 cm long. A skater weighs 850N. Newtons. How much pressure do they exert on the ice?

My two year old niece has a mass of 12kg and a foot roughly 5cm (0.05m) wide by 11cm (0.11m) long.
My husband has a mass of 75kg and a foot roughly 12cm (0.12m) wide by 30cm (0.30m) long.





Weight (N) = mass (Kg) x gravitational field strength (N/Kg)

Pressure (Pa) = Force (N) / Area (m^2)

Gravitational field strength on Earth = 9.8 N / kg

Gravitational field strength on Moon = 1.6 N / kg

Which one will cause the most pain if they step on my foot?!

How much pressure would my husband apply to the ground if he walked on the Moon. Assume a space suit weighs 50Kg!

Theatre of Science IGCSE Physics: Solids Liquids and Gases 3: Brownian Motion!

Today's lesson will cover the following spec points:

Know that the random motion of microscopic particles in a suspension is evidence for the kinetic particle model of matter

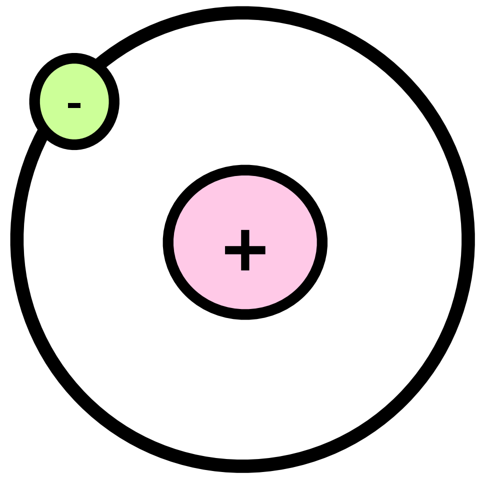
Describe and explain this motion (sometimes known as Brownian motion) in terms of random collisions between the microscopic particles in a suspension and the particles of the gas or liquid

Know that microscopic particles may be moved by collisions with light fast-moving molecules and correctly use the terms atoms or molecules as distinct from microscopic particles

1) Match the… thing to the describing word. Use each word as many times as you like.

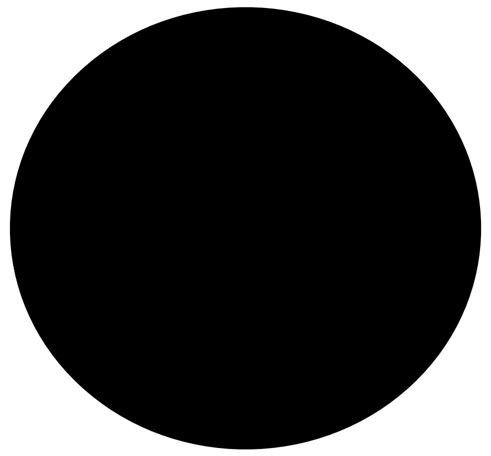
NOT TO SCALE!

Hydrogen

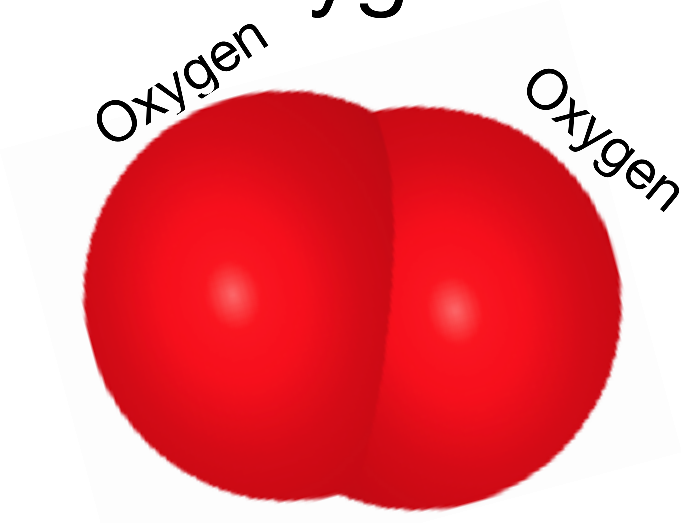


Pollen Grain

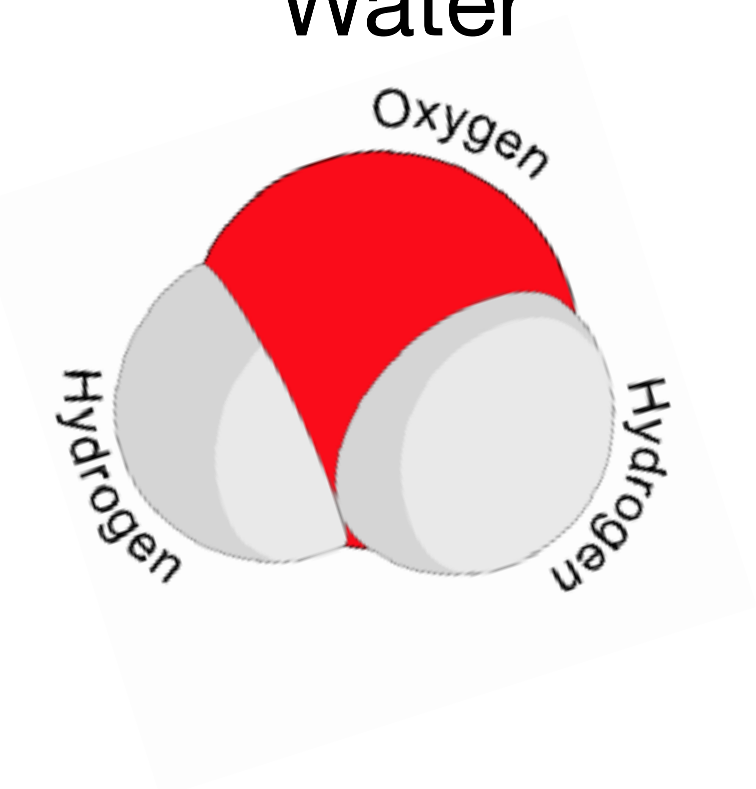
Piece of soot



Oxygen



Water



Particle **Electron** **Atom** **Proton** **Molecule**

2) Which of the above are microscopic? Write a small 'M' next to the ones you reckon.

3) Underline all the mistakes you can find in this paragraph and have a go at correcting them in the margins. (And tick all the bits you agree with!

Robert Brownian studied particles of pollen in water. He noticed they moved in random zig zag patterns. Sometimes they moved in curved paths. It turns out this motion is caused by microscopic water atoms colliding with the pollen!

What Robert saw proved once and for all that the particles in fluids move quickly and randomly

Theatre of Science IGCSE Physics: Solids Liquids and Gases 4: Pressure in Liquids!

Today's lesson will cover the following spec points:

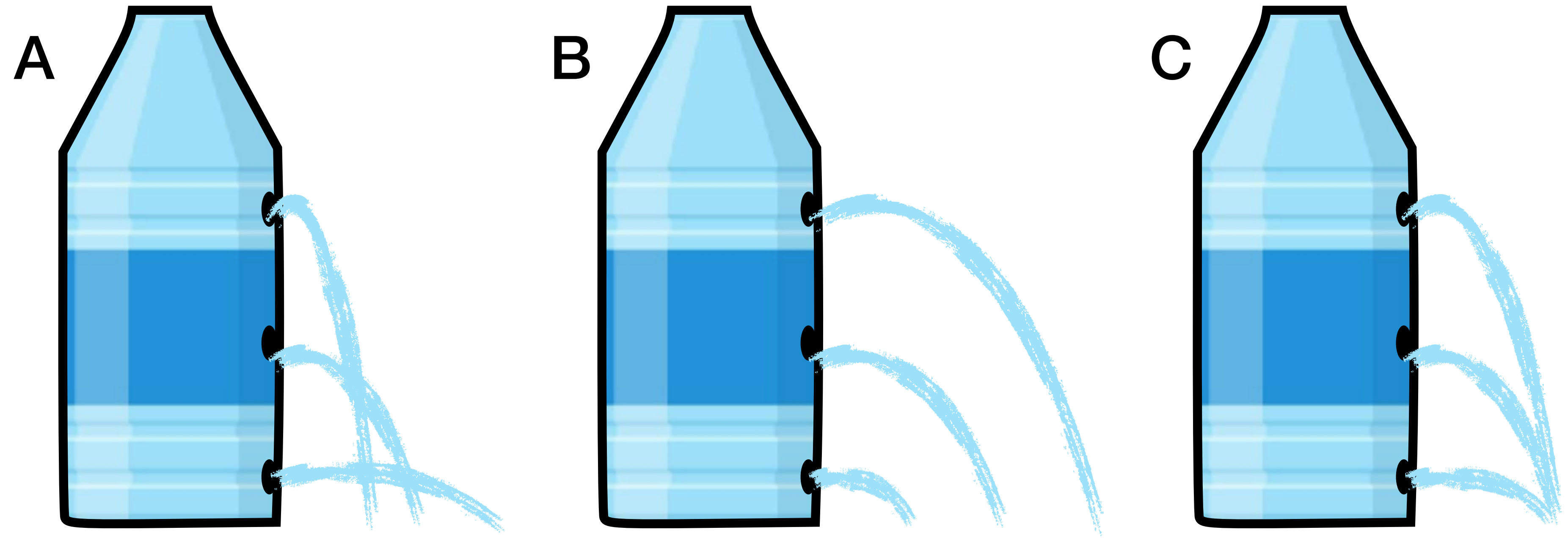
Describe, qualitatively, how the pressure beneath the surface of a liquid changes with depth and density of the liquid

Recall and use the equation for the change in pressure beneath the surface of a liquid $\Delta p = \rho g \Delta h$

To join in bring:

Small wine glass or small regular glass if not! Something tall filled 3/4 full with water that the glass will fit inside. Tall saucepan / bowl / top of a smoothie maker etc.
Toilet roll!
Calculator.

Which of these diagrams shows what would happen if you poked three identical holes in a water bottle? (Can you believe some people say physics is boring?! The suspense is killing you right?!)



Why do you think that?

How do you think the diagram would change if we used this bottle?

You are planning a journey to the bottom of a strange planet's ocean. The pressure on you will depend on… (circle all that you think apply)

The ocean's density

The ocean's mass

How deep you go

The planet's atmosphere

The volume of the ocean

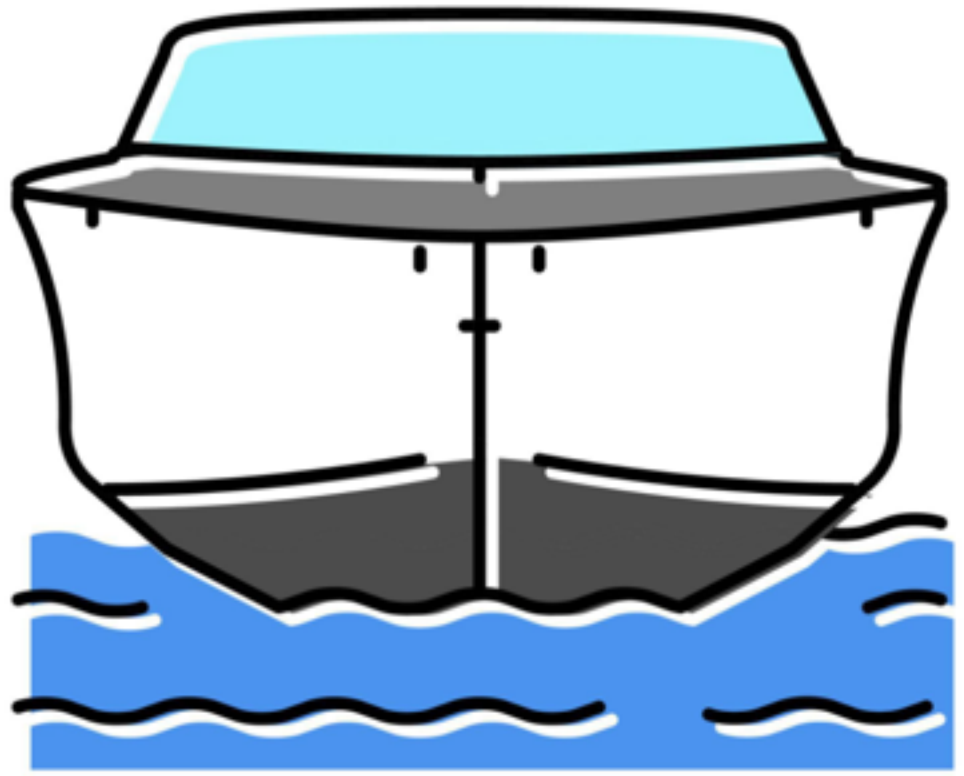
The planet's acceleration due to gravity (g).

Your weight

Questions!

Wilomena is taking a gap year and has gone exploring around a kitchen. She dives to the bottom of a bottle of golden syrup. If the syrup is 25 cm deep, with a density of 1400 kg / m^3, how much pressure acts on her?

The bottom of a boat is on the surface of the ocean, experiencing a pressure of 500 Pa. Weight is added and the boat moves down so the bottom of the boat is 2m below the surface. If the density of seawater is 1000 kg/m^3, what is the new pressure acting on the bottom of the ship?



Theatre of Science IGCSE Physics: Solids Liquids and Gases 5: Changes of State

Today's lesson will cover the following spec points:

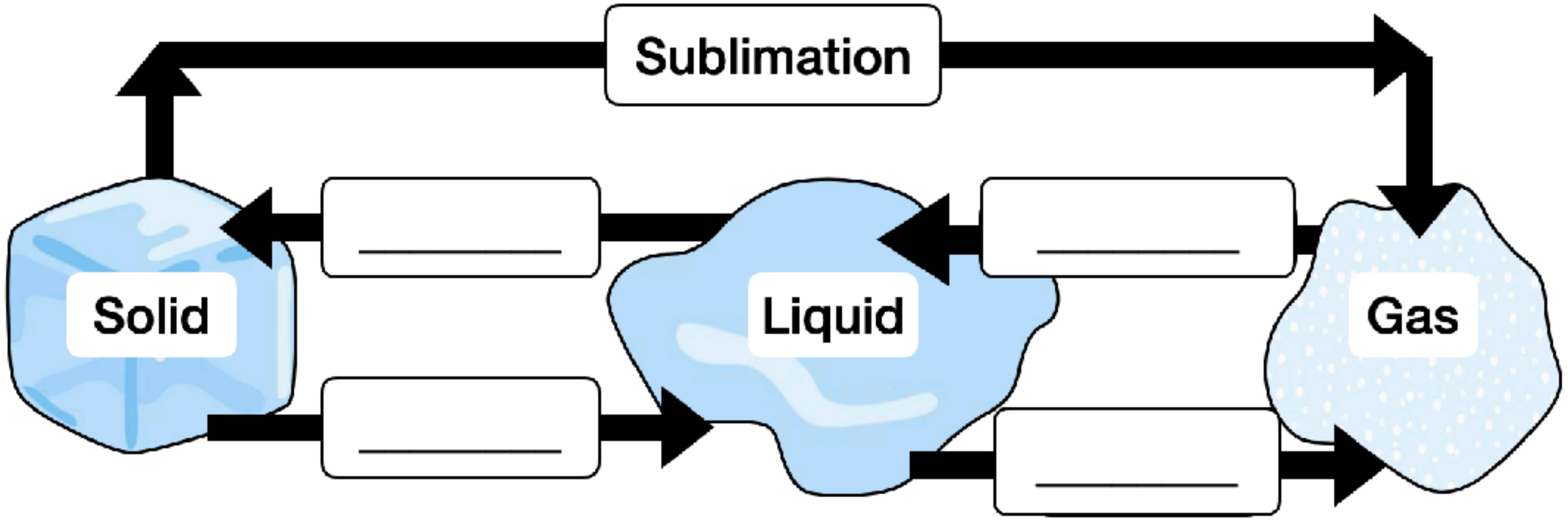
Know the terms for the changes in state between solids, liquids and gases (gas to solid and solid to gas transfers are not required)

From Pearson:
Explain why heating a system will change the energy stored within the system and raise its temperature or produce changes of state
Describe the changes that occur when a solid melts to form a liquid, and when a liquid evaporates or boils to form a gas
Practical: obtain a temperature–time graph to show the constant temperature during a change of state

Describe melting and boiling in terms of energy input without a change in temperature

Know the melting and boiling temperatures for water at standard atmospheric pressure

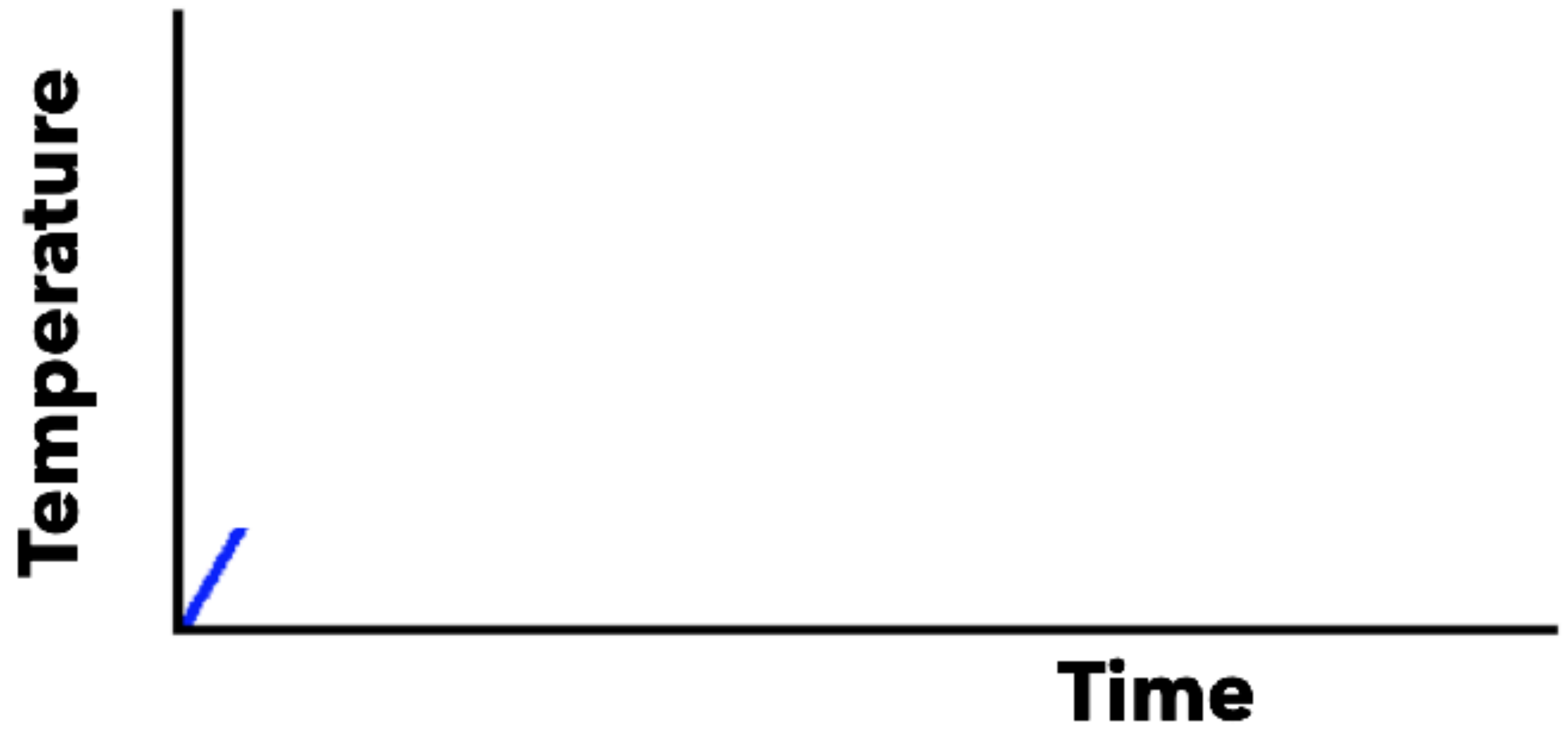
Describe condensation and solidification in terms of particles



While you're waiting for the lesson to start! Fill in these gaps with whatever you think. Wild guesses if necessary!

A solid block of frozen water is heated until it becomes a gas. Sketch a graph to show what you think would happen to the temperature of the water over time

Put your guess here:



1) SKETCH the answer (don't worry about perfection!)

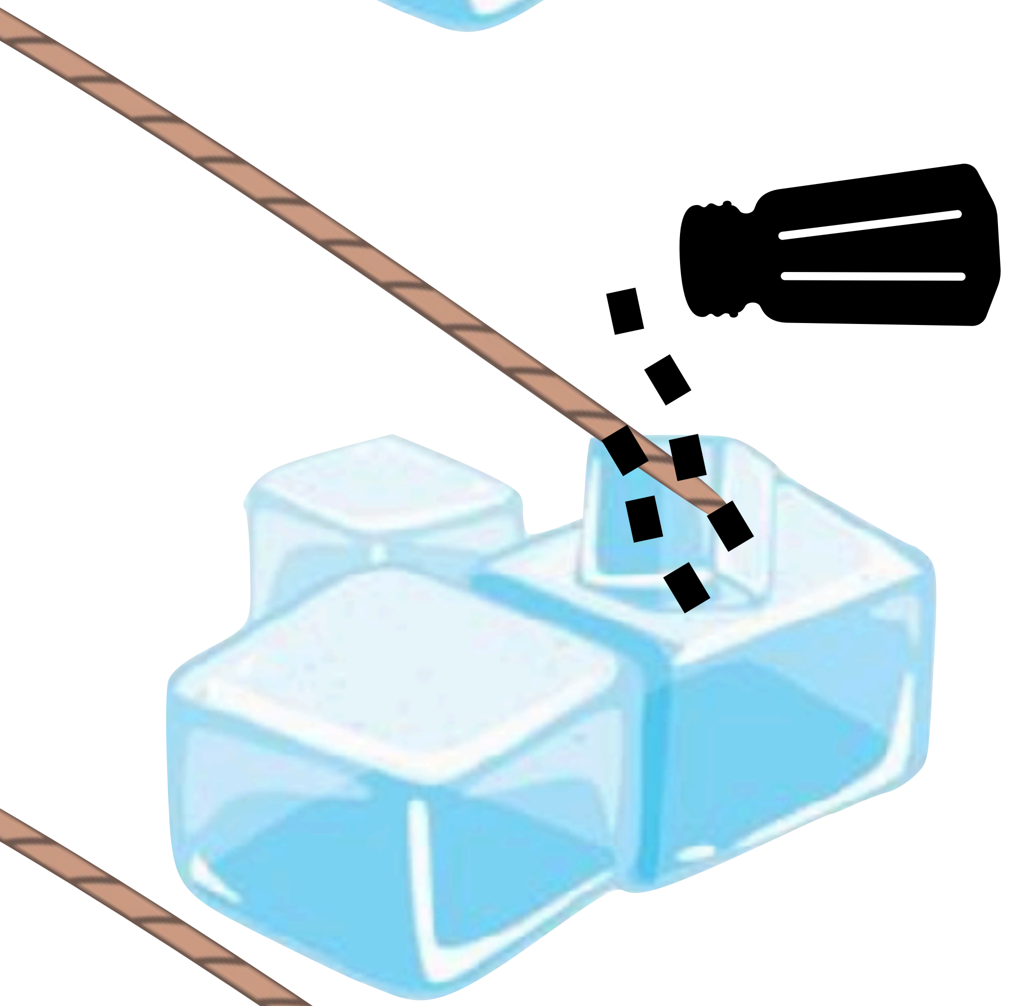
2) Put a wavy line under the bits of the graph where melting or boiling are happening and label them

3) Draw crosses to show where the melting & boiling points are and label them.

4) Do the same as 3) but for the freezing and condensing points!

Put a piece of string on some ice.

Why is the ice frozen?



Sprinkle on some salt and wait one minute.

What does the salt do to the bonds between the water particles?

What does this do to the freezing point of the water? (And the melting point?)

What happens?

Why does some water freeze around the string?

Theatre of Science IGCSE Physics: Solids Liquids and Gases 6: Evaporation!

To join in bring:
Two (ideally identical) cups of hot water, bowl.

Today's lesson will cover the following spec points:

Describe evaporation in terms of the escape of more energetic particles from the surface of a liquid Know that evaporation causes cooling of a liquid

Describe the differences between boiling and evaporation

Describe how temperature, surface area and air movement over a surface affect evaporation

Explain the cooling of an object in contact with an evaporating liquid

Questions to intrigue and annoy you. Answer with your best guess.

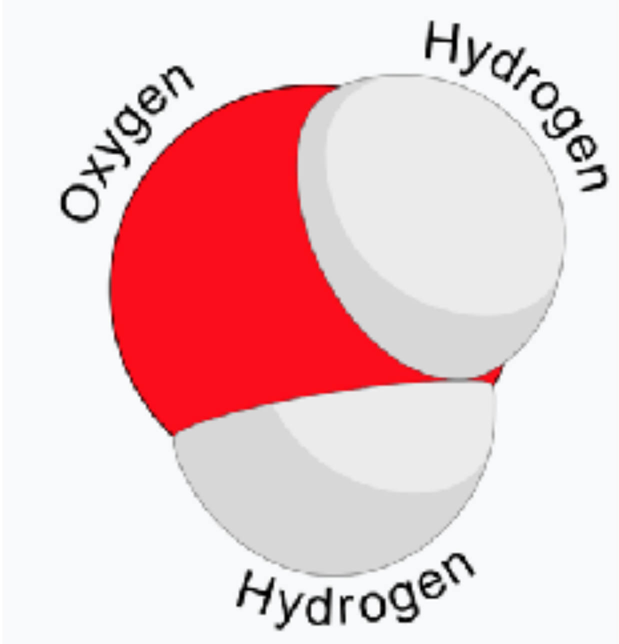
When you boil water it bubbles.

What are the bubbles made of?

What you think:

Answer:

A water molecule is two atoms of hydrogen bonded to one atom of oxygen.



What happens to the bonds between the atoms when water boils?

What you think:

Answer:

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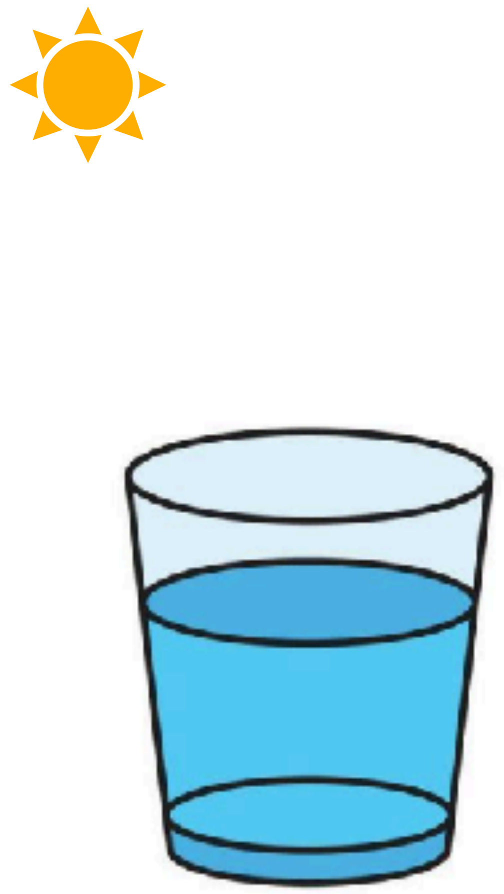
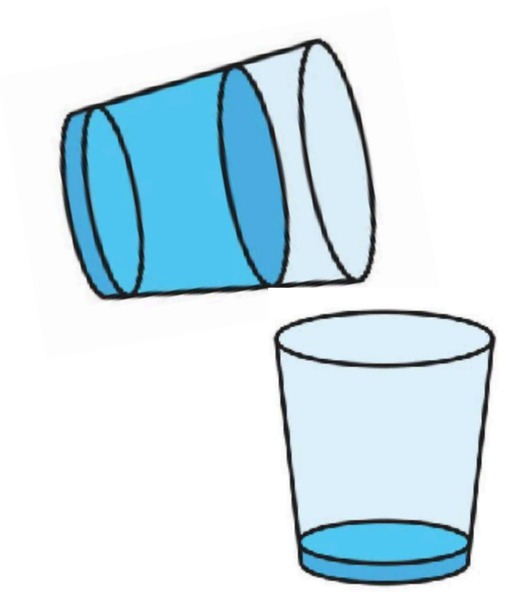
Which of these would make the water evaporate faster?
(For the ones that would, explain WHY in a couple of words).

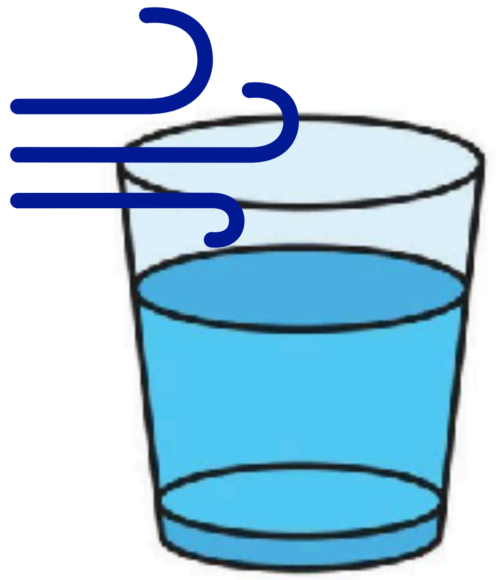
Moving water from the shade into the Sun



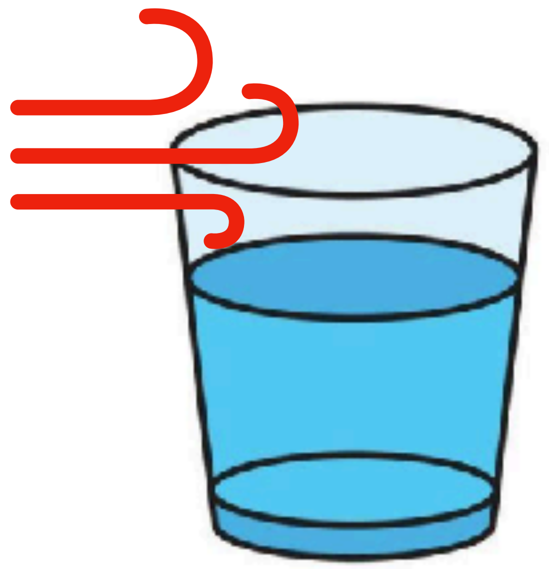
Repeatedly pouring water from one glass to another



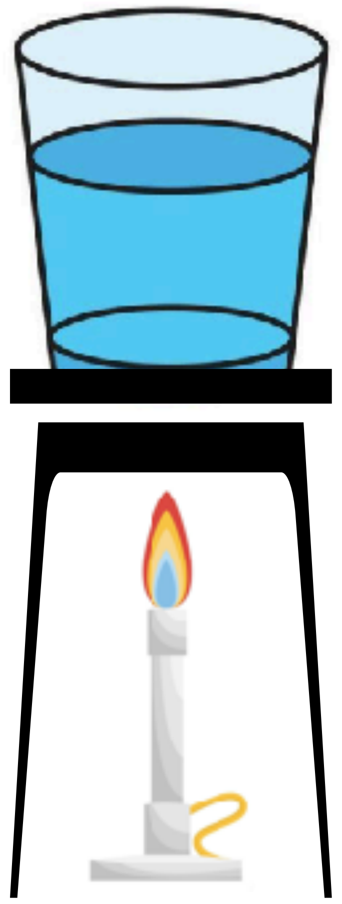
Blowing cold air over the surface of the water



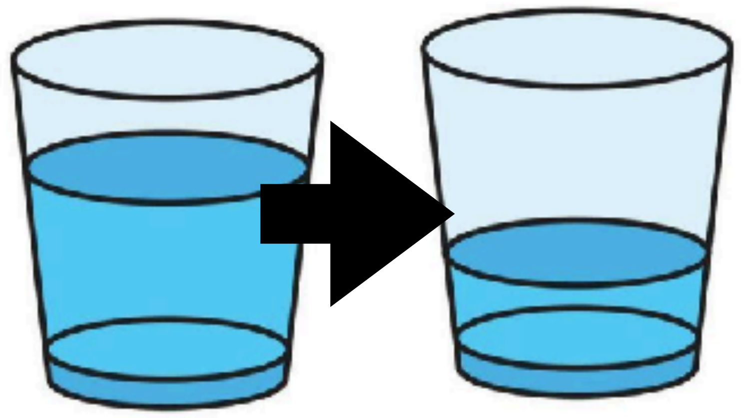
Blowing hot air over the surface of the water



Gently heating the bottom of the glass of water



Emptying half the water out



Which of these sentences describe boiling, which evaporating, which both, and which neither?!

(For you to make up; use a letter or pattern or something.)

Key

- ☐ Boiling
- ☐ Evaporating
- ☐ Both
- ☐ Neither

Only happens at the surface of a liquid

Happens at any temperature

Bonds between atoms are broken

Liquid turns into a gas

A change of state occurs

A liquid cools as it happens

Bonds between molecules are broken

Bubbles of gas form when it happens

Theatre of Science IGCSE Physics: Solids Liquids and Gases 7: Specific Heat Capacity!

To join in bring:
Calculator, cup of water, metal spoon.

Today's lesson will cover the following spec points:

Define specific heat capacity as the energy required per unit mass per unit temperature increase; recall and use the equation for specific heat capacity.

Describe experiments to measure the specific heat capacity of a solid and a liquid

Rearrange the equation to make m, c and Δθ the subject.

$$\Delta E = m\, c\, \Delta\theta$$

m =

Δθ =

c =

(Specific Heat Capacity of water = 4200 J/kg°C)
(Specific Heat Capacity of aluminium = 880 J/kg°C)

How much energy do you need to raise the temperature of…

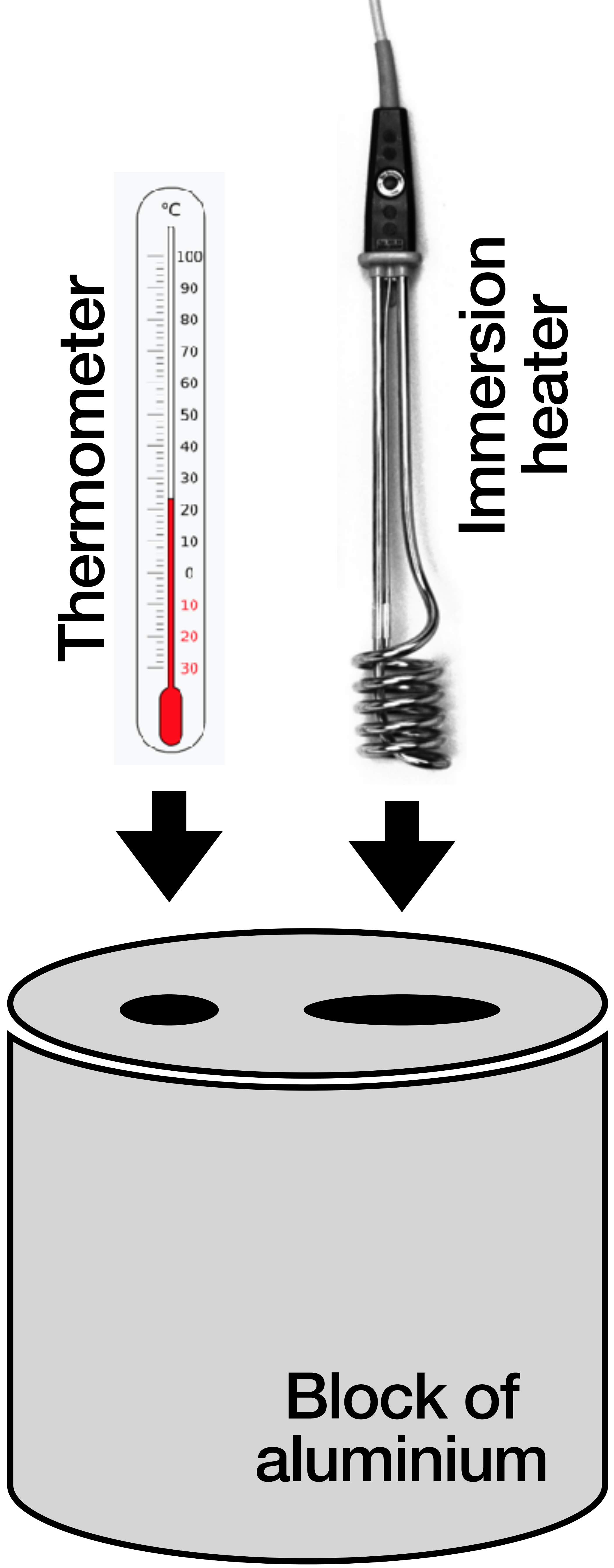
1) 2kg of water by 1°C?

2) 5kg of water by 0.8°C?

3) 300g of water by 4°C?

4) How much energy does a 3kg block of aluminium lose when it cools from 200°C to 50°C?

5) A pan contains 0.5kg of water at 6°C. 3150J of thermal energy shifts to the water. What is its temperature afterwards?



Experiment to find the Specific Het Capacity of Aluminium

1. Take the mass of the 1kg aluminium block using a balance (Why?)

2. Put the immersion heater into the block.

3. Put the thermometer into the other hole in the block and record the temperature.
(Spot any problem with this? Can you think of a solution?)

4. Wrap the block in insulating material. (Why?)

5. Connect an ammeter (which measures current) and voltmeter (which measures voltage) to the immersion heater, connect the heater to a power supply, and turn it on.

6. Allow the aluminium block to heat up for ten minutes. Record the ammeter and voltmeter readings.

7. When you switch the heater off the block will get slightly hotter; record the final temperature.

8. You have the current, voltage and time, so you can work out how much energy was supplied the block. And you have the temperature change. And you have the mass of the block. So you can work out the specific heat capacity of the aluminium!

Theatre of Science IGCSE Physics: Solids Liquids and Gases 7: Specific Heat Capacity!

To join in bring:
Calculator, cup of water, metal spoon.

Today's lesson will cover the following spec points:

Define specific heat capacity as the energy required per unit mass per unit temperature increase; recall and use the equation for specific heat capacity.

Describe experiments to measure the specific heat capacity of a solid and a liquid

Rearrange the equation to make m, c and Δθ the subject.

$$\Delta E = m\, c\, \Delta\theta$$

m =

c =

Δθ =

(Specific Heat Capacity of water = 4200 J/kg°C)
(Specific Heat Capacity of aluminium = 880 J/kg°C)

How much energy do you need to raise the temperature of…

1) 2kg of water by 1°C?

2) 5kg of water by 0.8°C?

3) 300g of water by 4°C?

4) How much energy does a 3kg block of aluminium lose when it cools from 200°C to 50°C?

5) A pan contains 0.5kg of water at 6°C. 3150J of thermal energy shifts to the water. What is its temperature afterwards?

Theatre of Science IGCSE Physics: Solids Liquids and Gases 8: The Kelvin Scale!

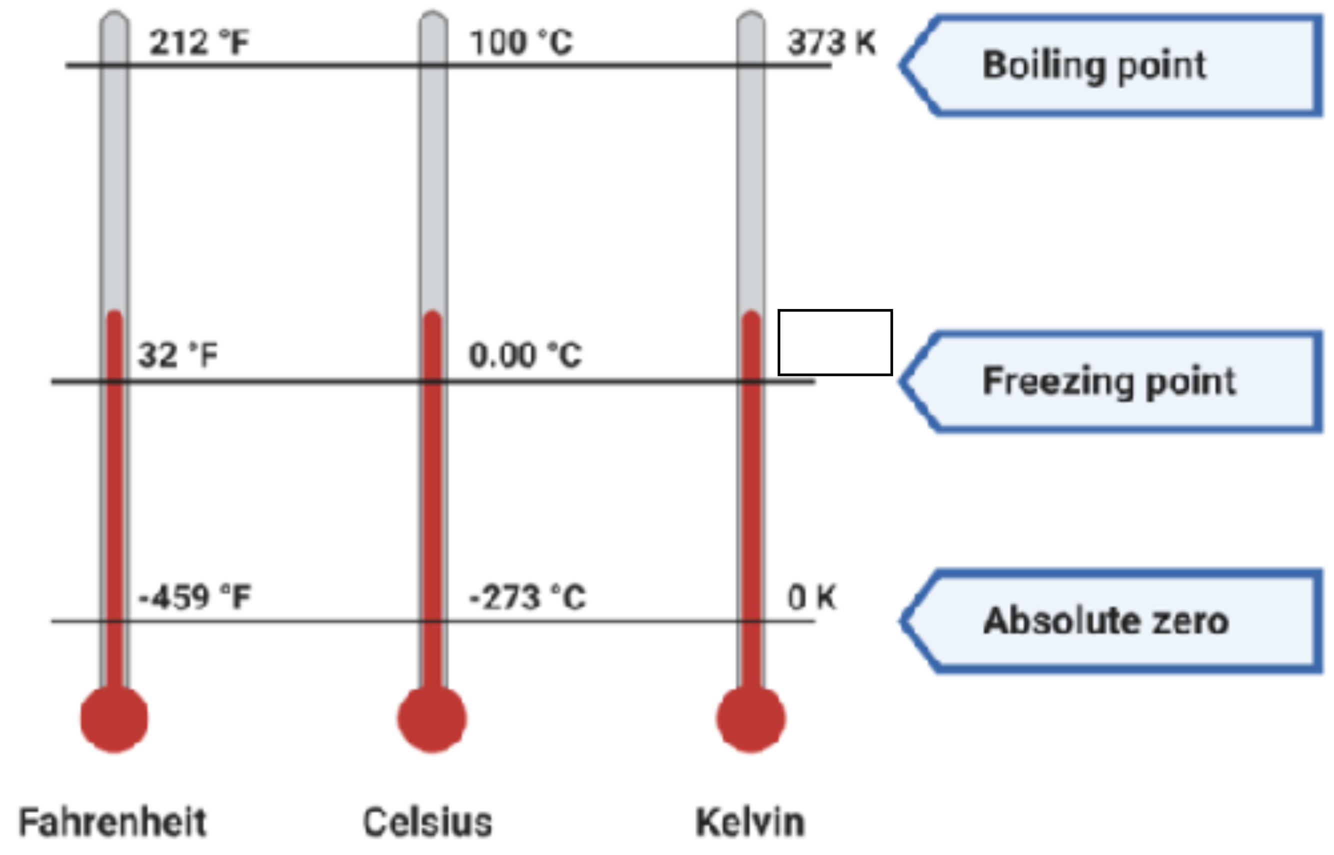
Today's lesson will cover the following spec points:

Describe the relationship between the motion of particles and temperature, including the idea that there is a lowest possible temperature (–273°C), known as absolute zero, where the particles have least kinetic energy

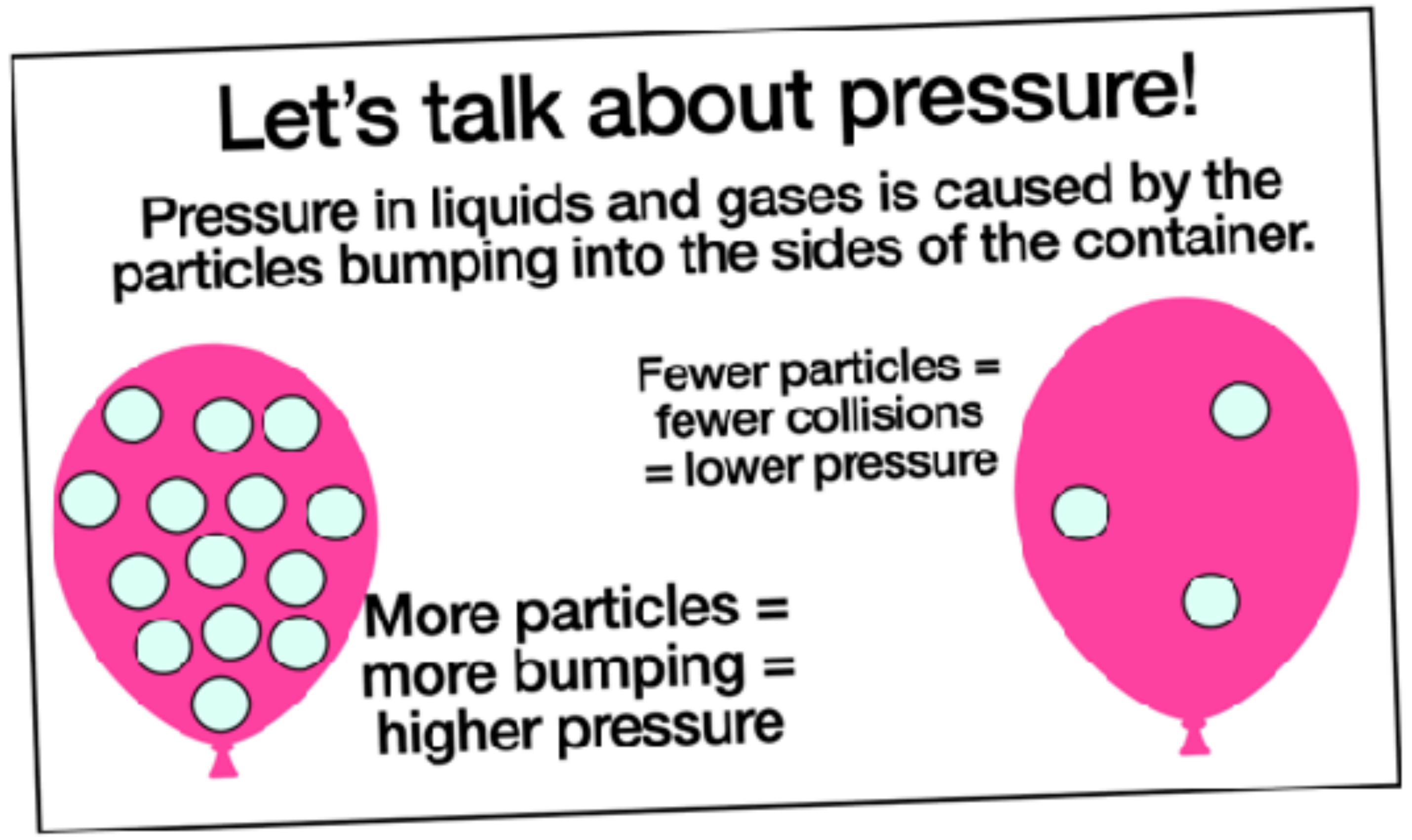
Convert temperatures between kelvin and degrees Celsius; recall and use the equation T (in K) = θ (in °C) + 273

Recall and use the equation pV = constant for a fixed mass of gas at constant temperature, including a graphical representation of this relationship

Use the relationship between the pressure and volume of a fixed mass of gas at constant temperature: p1V1 = p2V2



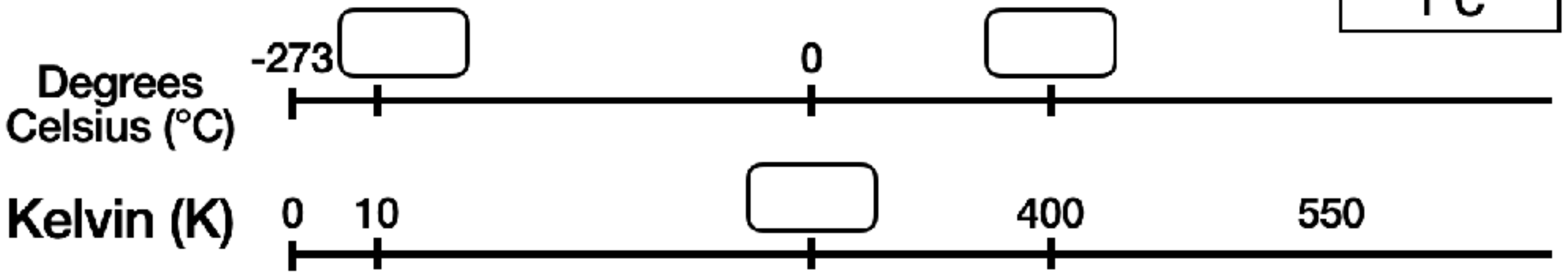
I was trying to teach pressure in the all-ages lesson, and lashed out this slide. What silly mistake have I made?!



To join in bring:
Calculator! Bowl of very hot water, bowl of very cold water (iced if you like). Narrow-necked glass bottle (no lid required), small cup warm water, washing up liquid

Can you fill out any/all of the gaps on this number line? I'll give you the equation in a minute.

1K is the same size division as 1°C



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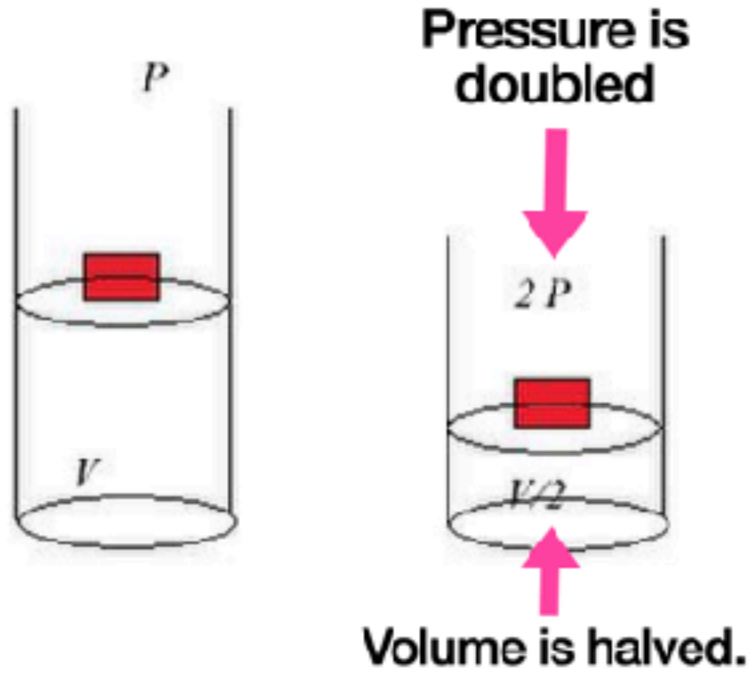
In an *ideal gas*:

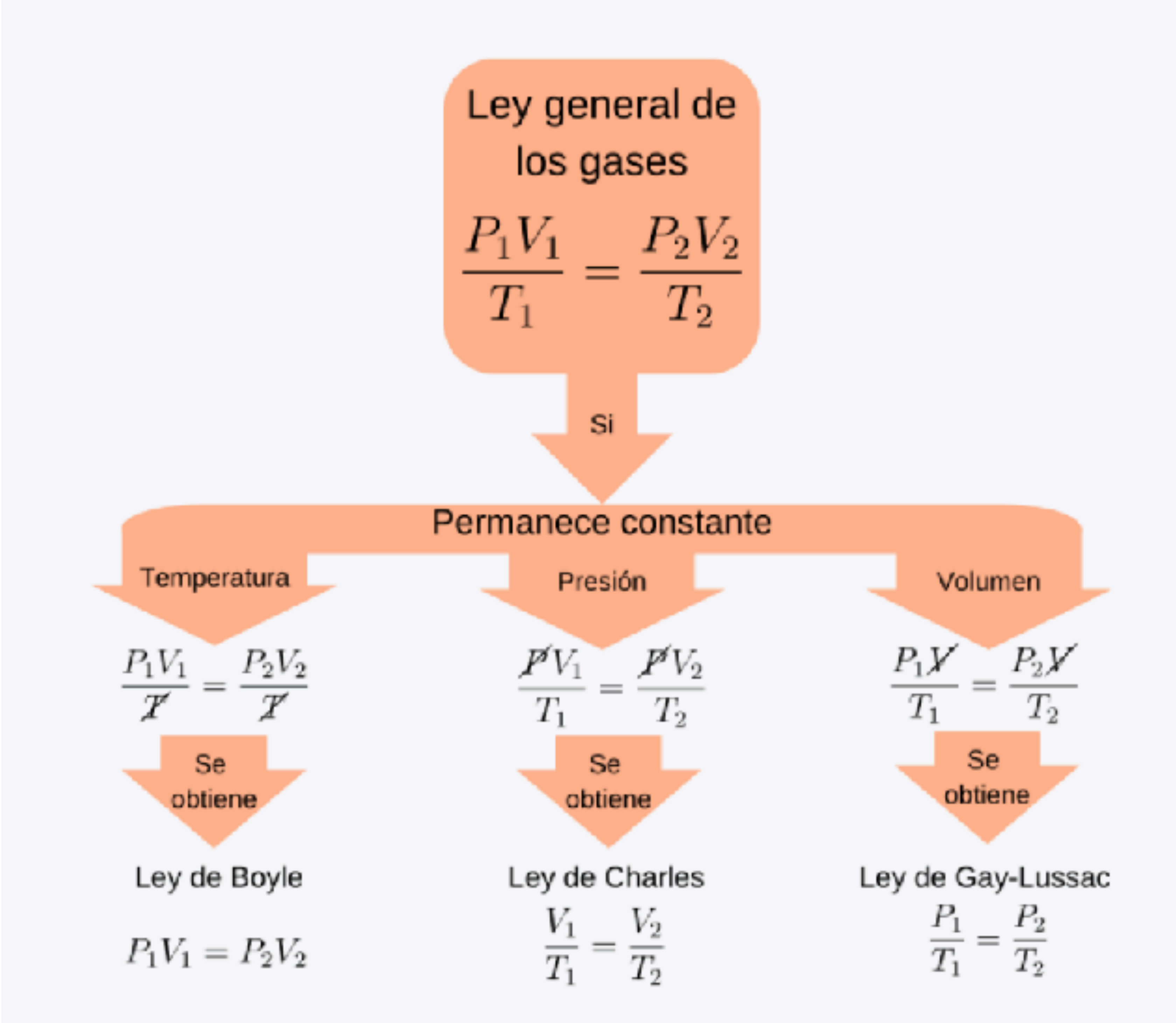
Pressure x volume = constant

Because when this goes up

This goes down

So if you have air particles in a cylinder and squish them, the pressure x volume at the beginning is the same as the pressure x volume at the end.

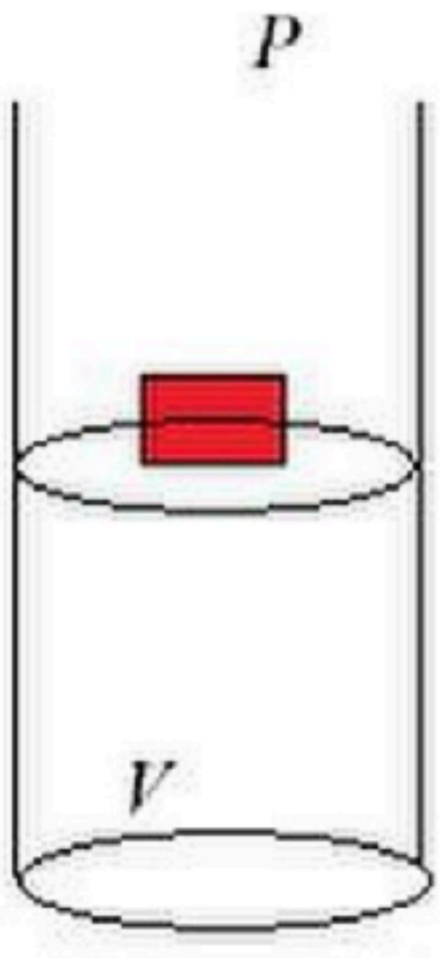




In other, (freaky physics words): $p_1V_1 = p_2V_2$ *

1) A gas has a volume of 40cm³ and a pressure of 10 000 Pa. If it is compressed to a volume of 20cm³. What is the new pressure?

2) The gas is compressed further to a volume of 18cm³. what is the new pressure?



3) A gas with a volume of 1m³ at a pressure of 100kPa until it is at a pressure of 0.75kPa. What is the new volume of the gas?

*There's another equation like this for pressure and temperature; I'll give you some questions in the 'homework' pdf in my Facebook group.

Diagram (in Spanish, but I feel like it's not the words making it confusing anyway?) showing the Ideal Gas Law, and how the Boyle, Charles, and Gay-Lussac equations come out of it. You need to be able to use the Boyle and the Charles one for an IGCSE exam, but at the time of writing (Jan 2024) they give you it. You don't have to use the equation at the top. Just thought some of you might like to see the details! Image: Dione Murrieta via wikimedia commons. License: https://creativecommons.org/licenses/by/4.0/