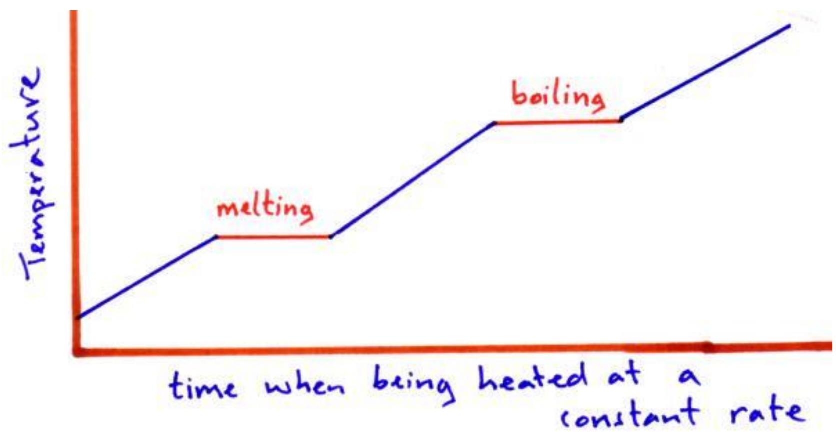
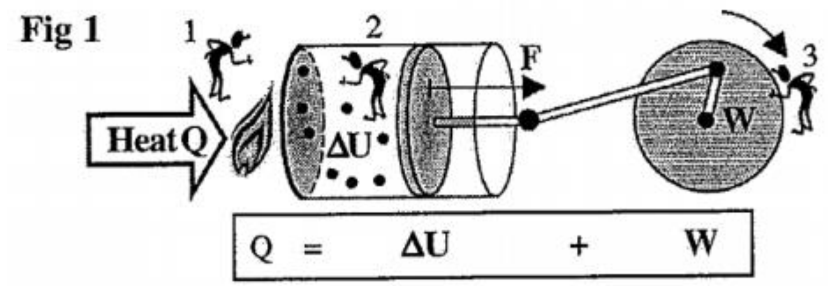
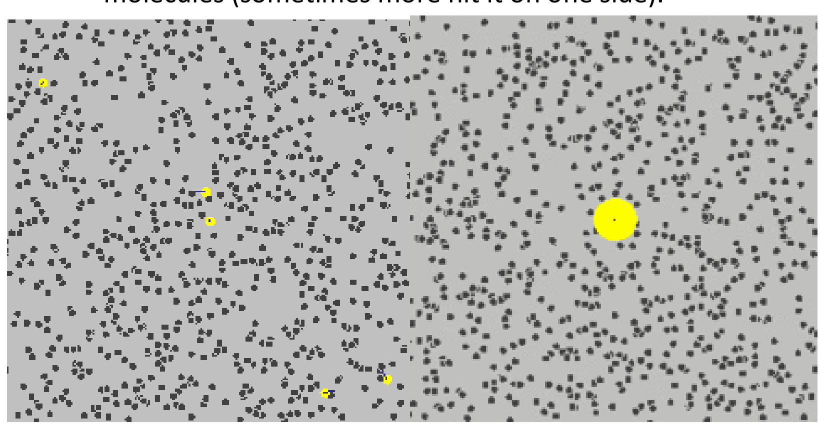
U6 - Thermal Physics

What is Specific Heat Capacity?	The energy required to raise the temperature of 1 kg of a substance by 1 K.
What is Specific Latent Heat?	The energy required to change the state of 1 kg of material without changing temperature. *As the energy is going into breaking bonds, not changing temperature.*
What are the 2 types of latent heat?	 ● Solid to liquid - latent heat of fusion. ● Liquid to gas - latent heat of vaporisation. *Interestingly enough, sublimation is going straight from solid to gas which is how you can smell soap.*
What is the internal energy of a system?	Sum of kinetic and potential energies (i.e., stored in bonds). *This thermal kinetic energy is the sum of the energies of all the particles moving in different directions. An object as a whole won't move. Whereas mechanical kinetic energy is where all the particles are moving in the same direction.*
What's the difference between heat and temperature?	● Heat (Q) is a type of energy measured in J. ● Temperature is how fast particles are vibrating.

What is the 1st Law of Thermodynamics with an example?	● The internal energy of a system equals the heat added to it minus the work done by the system: $$\Delta U = \Delta Q - \Delta W$$ ● Example:  If 100 J of heat enters the gas and 70 J is given to gas molecules then 30 J must appear as work done.
What is the difference between evaporation and boiling?	● Evaporation is going from liquid to gas. ● Boiling is the maximum temperature a liquid can stay as a liquid.
What is Brownian Motion, what can demonstrate it and why?	● The random motion of particles. ● Smoke particles. ● They're light enough to have their motion determined by air molecules (sometimes more hit it on one side).  *On the left, a gas molecule undergoing Brownian Motion. On the right, a dust particle moving through gas.*
What did Brownian Motion show the existence of?	Molecules and atoms which more randomly.
What is Boyle's Law? (with its graph and justification)	● Pressure x Volume = constant for a constant temperature

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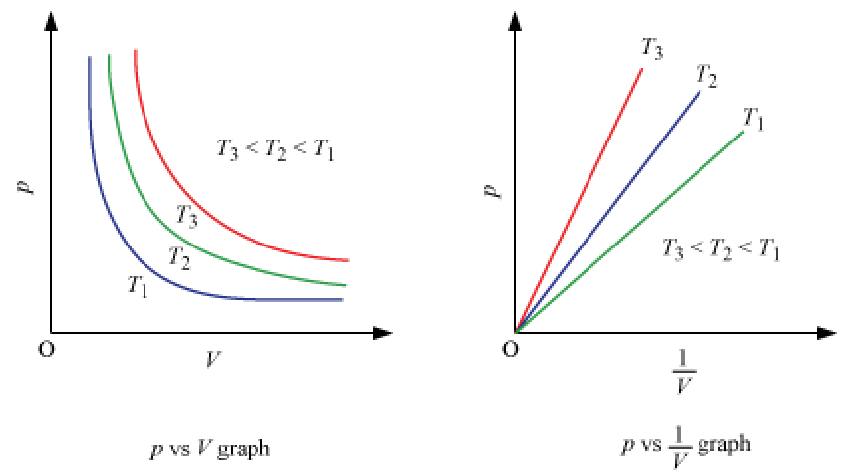
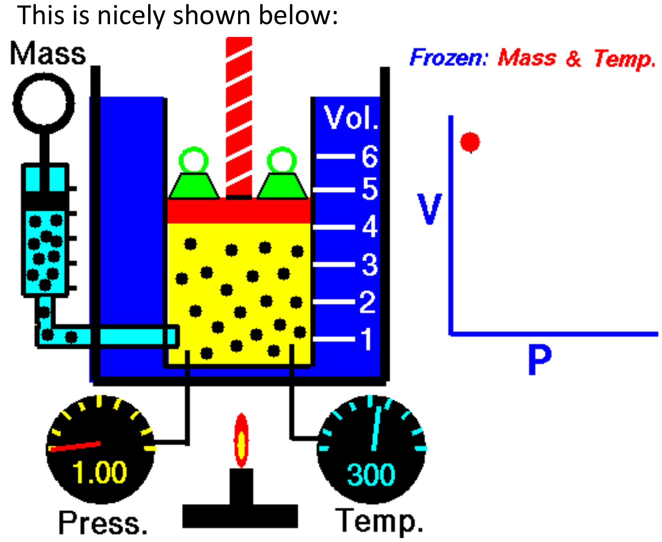


Left: the higher temperature is further from the origin since PV = nRT and increasing T increases constant and thus stretch. Right: nRT is the gradient and increasing T leads to steeper gradient.

This is since reducing volume means molecules travel less distance between impacts as walls ∴ more impacts / second ∴ greater force as the speed is constant since temperature is constant.
This is nicely shown below:



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<tr><td>Define isothermic</td><td>Constant temperature.</td></tr>
<tr><td>Define isobaric</td><td>Constant pressure (as ba for barometers).</td></tr>
<tr><td>Define adiabatic</td><td>Energy being transferred without loss to surroundings.</td></tr>
<tr><td>When does Boyle’s Law cease to work and why?</td><td>At very high pressures as molecules are so close together that their net volume becomes a larger fraction of volume of container.</td></tr>
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<td>Why is Charles' Law? (with a graph for different pressures and justification)</td>
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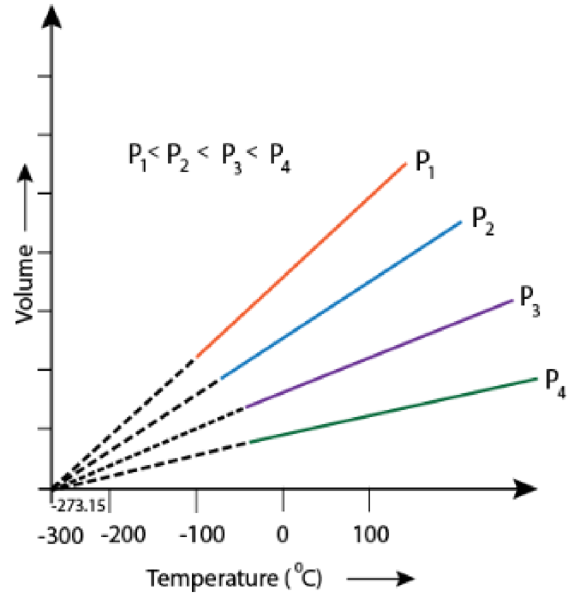
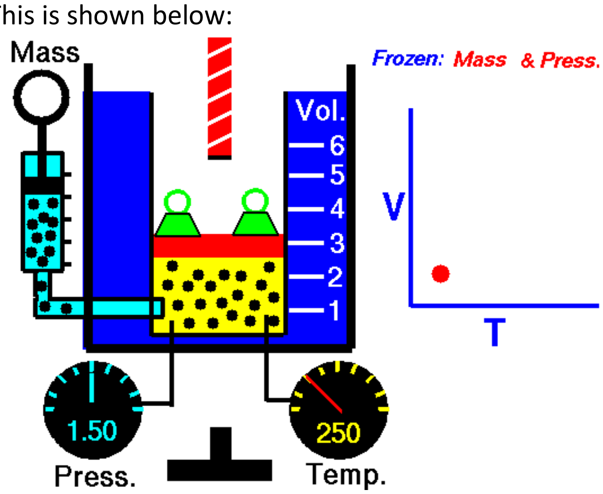
- Volume ∝ Temperature for a constant pressure.



The smaller gradient means greater pressure since V/T = Nk/P.

- As temperature increases, particles gain kinetic energy. Since they must have frequency of collisions with the wall to keep pressure constant, the volume must increase.
- This is shown below:



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<td>Draw the graph of temperature against pressure under Charles' Law</td>
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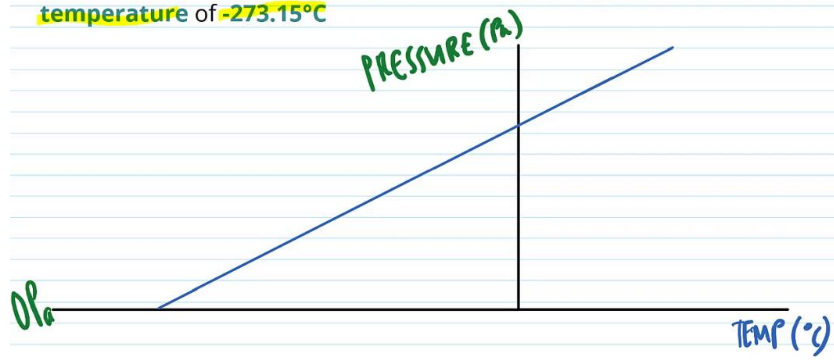
• We will find that the **extended line** crosses **0Pa** of **pressure** at a **temperature** of **-273.15°C**



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<td>What is the Pressure Law? (with a graph and justification)</td>
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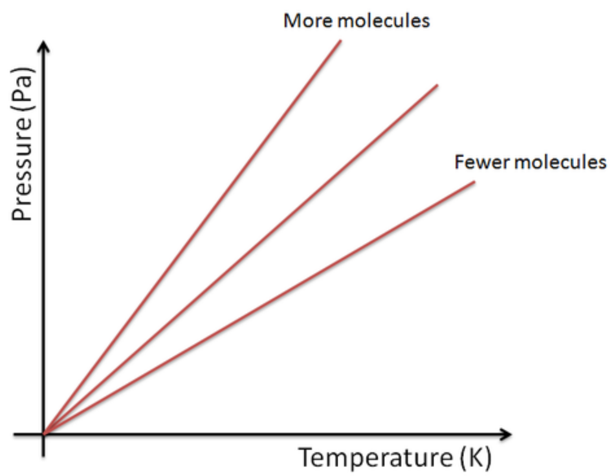
- Pressure ∝ Temperature for constant volume.



*Since P = Nk/v * T, steeper gradient means more molecules.*

- If you fix the volume and increase the temperature, the particles have more kinetic energy and thus move faster, have more frequent collisions with the walls increasing pressure.

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<td>What are the 2 forms of the Ideal Gas Equation and how are they relate?</td>
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$$\boxed{PV = nRT = Nk_BT}$$

since...

$$\boxed{k_B = \frac{R}{N_A}} \quad \boxed{n = \frac{N}{N_A}}$$

Where...

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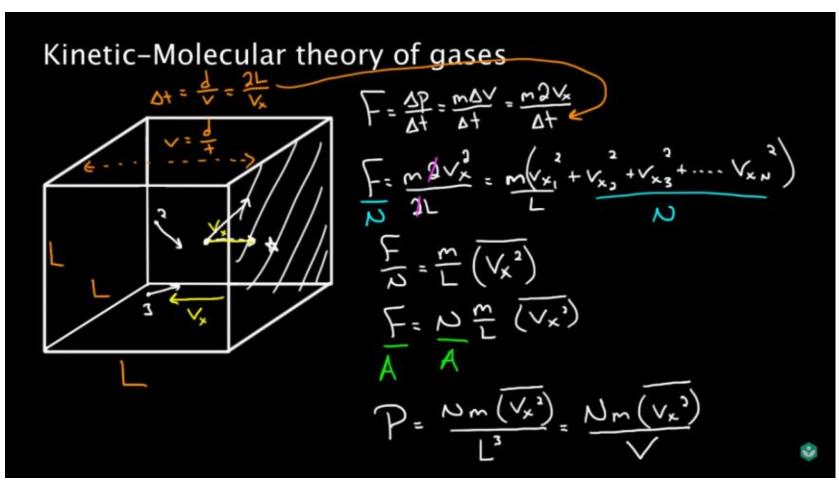
	● P = pressure (Pa) ● V = volume (m^3) ● T = temperature (K) ● n = number of moles ● N = number of molecules ● R = universal gas constant = 8.3145 $Jmol^{-1}K^{-1}$ ● k_B = Boltzmann's constant = 1.38×10^{-23} JK^{-1} ● N_A = Avagadro's number = 6.023×10^{23} mol^{-1} *This is formed by combining all 3 gas laws to form a constant of PV ∝ T which becomes PV ∝ NT as with more molecules, we have greater pressure and then we introduce a constant. This constant is good for proportionality questions.*
What assumptions are made in the molecular kinetic theory?	● R - random motion. ● A - no attraction between particles. ● V - particles have negligible volume compared to container. ● E - elastic collisions so E_k is conserved. ● D - duration of collisions << time between them.
How can you calculate RMS velocity?	$$c_{rms} = \left[\frac{(c_1^2 + c_2^2 + \ldots + c_N^2)}{N}\right]^{1/2}$$ *We call this the average speed. The average **<u>VELOCITY</u>** is zero since we have equal number of molecules travelling in opposite directions.*
Derive the relationship between K_E and temperature $\frac{1}{2}m(c_{rms})^2 = \frac{3}{2}kT = \frac{3RT}{2N_A}$	

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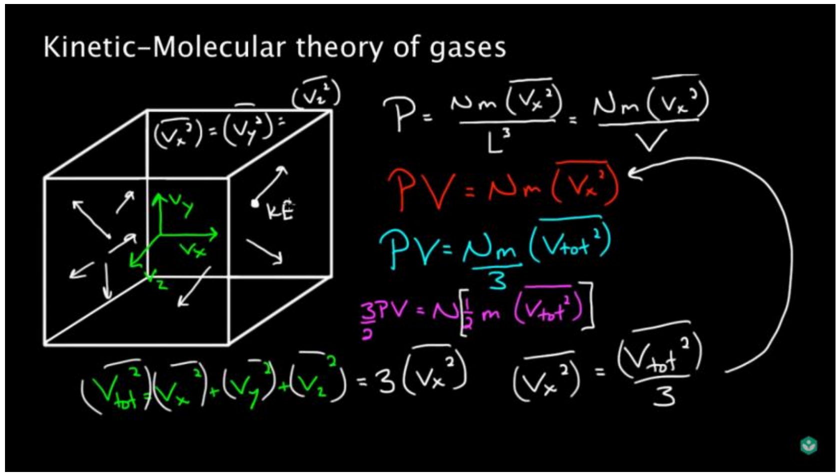
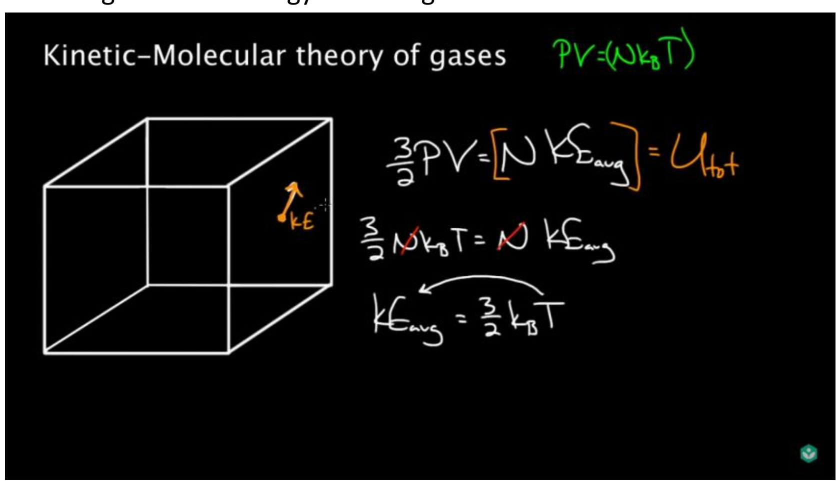
Consider a box of side length L. We can calculate the force by considering the change in momentum when it hits the wall and the time between collisions (since this is the change in momentum / s). Then we add all the velocities and divide by the number of molecules. Convert this into pressure.



Now, we know that the v_x^2 is ⅓ v_{tot}^2 or c_{rms}^2 by using Pythagoras in 3D. We can get kinetic energy on the right.



Using the ideal gas equation on the right, we can finally related kinetic energy to temperature.
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<td>What is the work done on a gas and when can this be seen?</td>
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- W = P x ΔV
  - Work Done = Pressure x Change in Volume

- Heat a balloon and it will expand, remove the heat source and it will contract as heat is lost to the surroundings.
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<td>What is Avogadro’s Law? (with example)</td>
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- Volume Gas ∝ Number Moles of Gas at constant pressure and temperature. Independent of gas itself.
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	• Eg, if there are 2 moles of O_2 in 50cm^3 of oxygen gas, then there will be 2 moles of N_2 in 50cm^3 of nitrogen gas and 2 moles of CO_2 in 50 cm^3 of carbon dioxide gas at the same temperature and pressure.