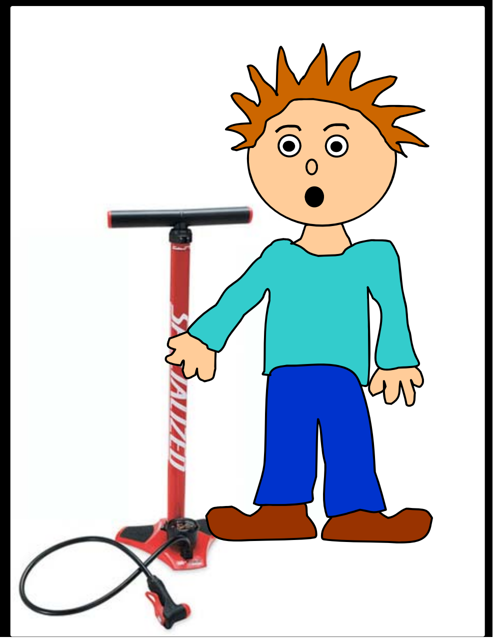
Particle Model of Matter

AQA 2016 Physics topic 3



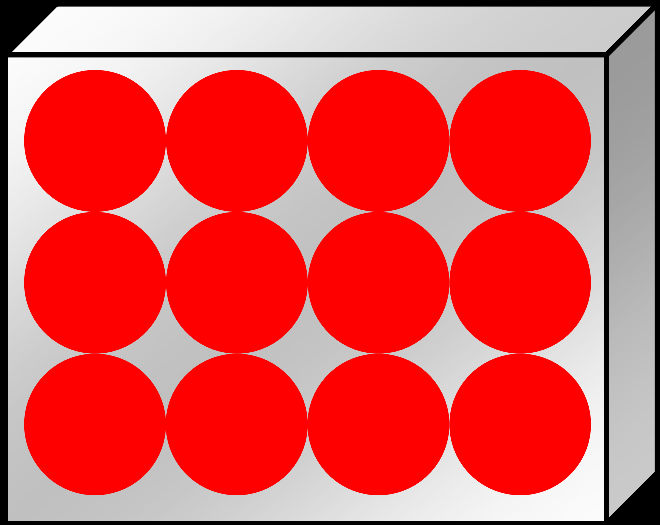
W Richards

The Weald School

3.1 Changes of State and the Particle Model

Particle theory revision

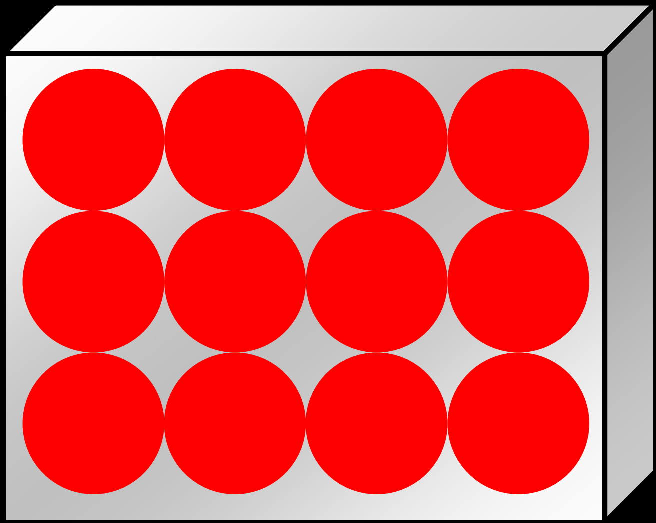
Particle theory is all about explaining the properties of solids, liquids and gases by looking at what the particles do.



SOLIDS

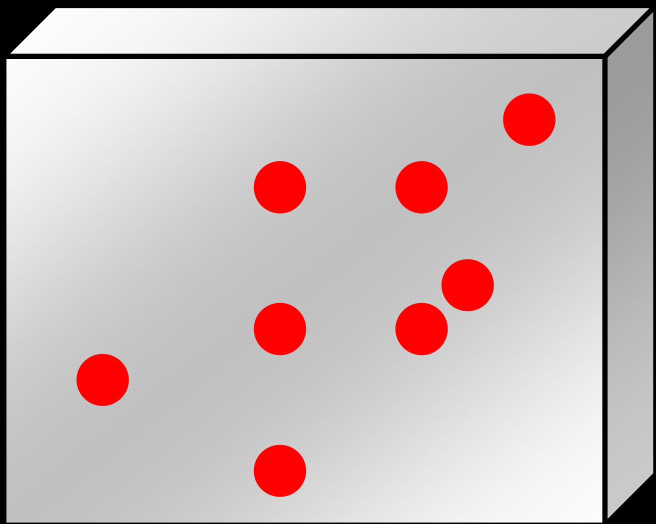
In a solid the particles _______ around a ______ position. There is a _______ force of attraction between each particle and they are very ______ together

Words – strong, close, vibrate, fixed



LIQUIDS

In a liquid the particles are ______ together but can move in any direction. They won't keep a ______ shape like ______ do.



(zoomed out)

GASES

In a gas the particles are very far apart and move ______ in all directions. They often _______ with each other and because they are far apart they can be easily ________.

Words – fixed, collide, quickly, close, squashed, solids

Density

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \qquad \rho = \frac{m}{V}$$

1) What is the density of a piece of wood of volume $2m^3$ and mass 1200kg?

600kg/m^3

2) What is the density of aluminium if $0.5m^3$ has a mass of 1350kg?

2700km/m^3

3) Air only has a density of 1.3kg/m^3. What is the mass of $3m^3$ of air?

3.9kg

4) Carbon dioxide is more dense (2kg/m^3). If you had 0.5kg of carbon dioxide what volume would this be?

$0.25m^3$

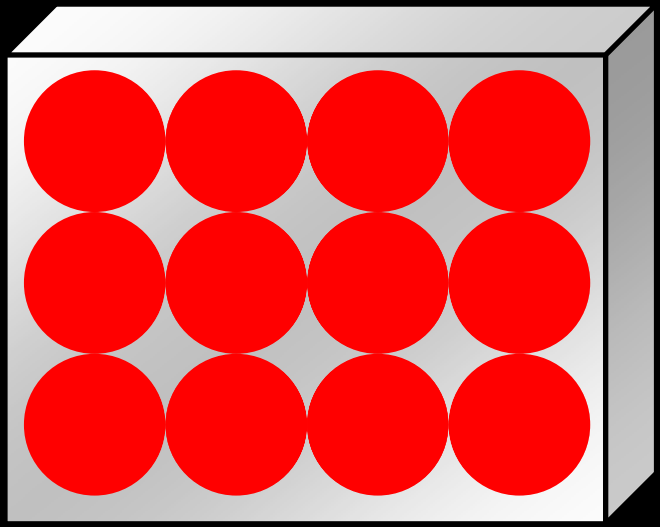
Required Practical - Density

09/01/2020

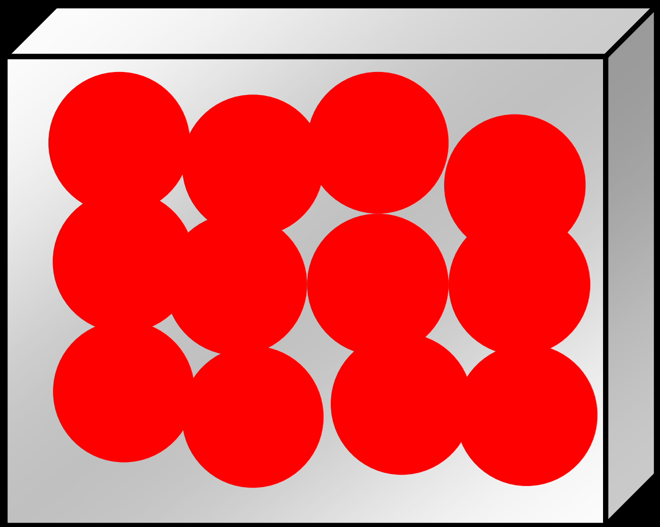
Object	Mass/kg	Volume/m^3	Density/ kg/m^3

Densities in Solids, Liquids and Gases

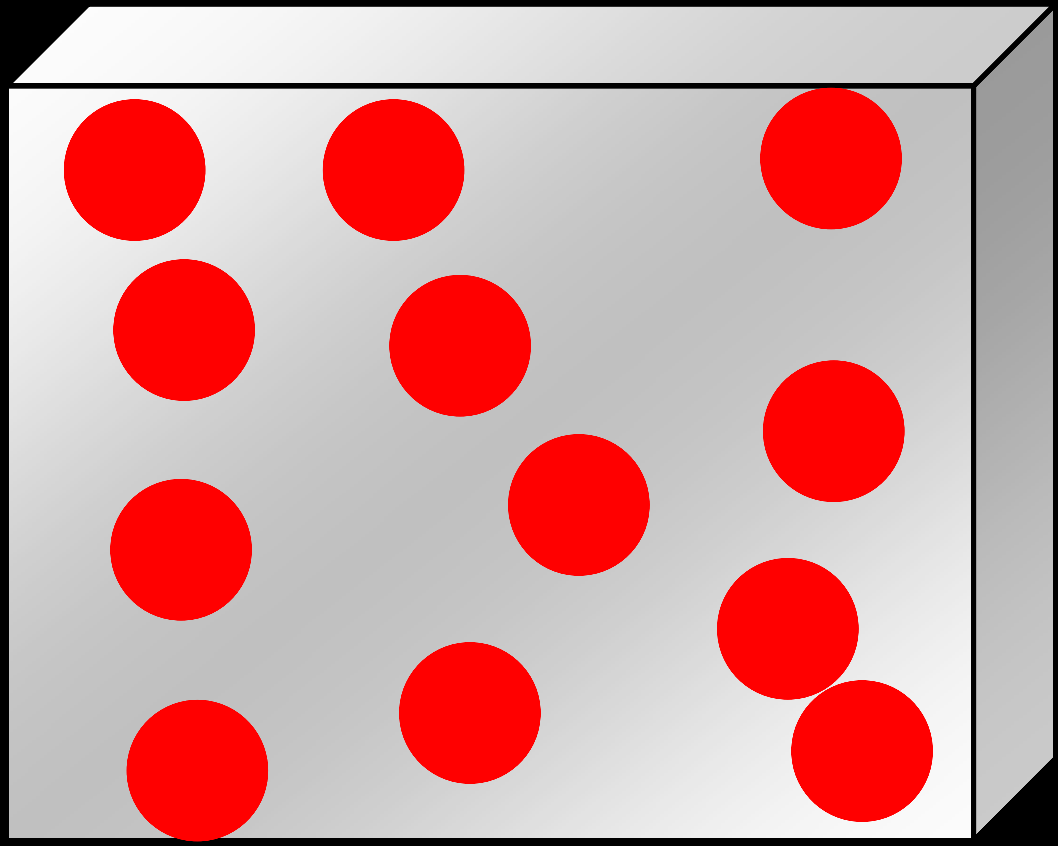
Which one is the most dense and why?



Solid



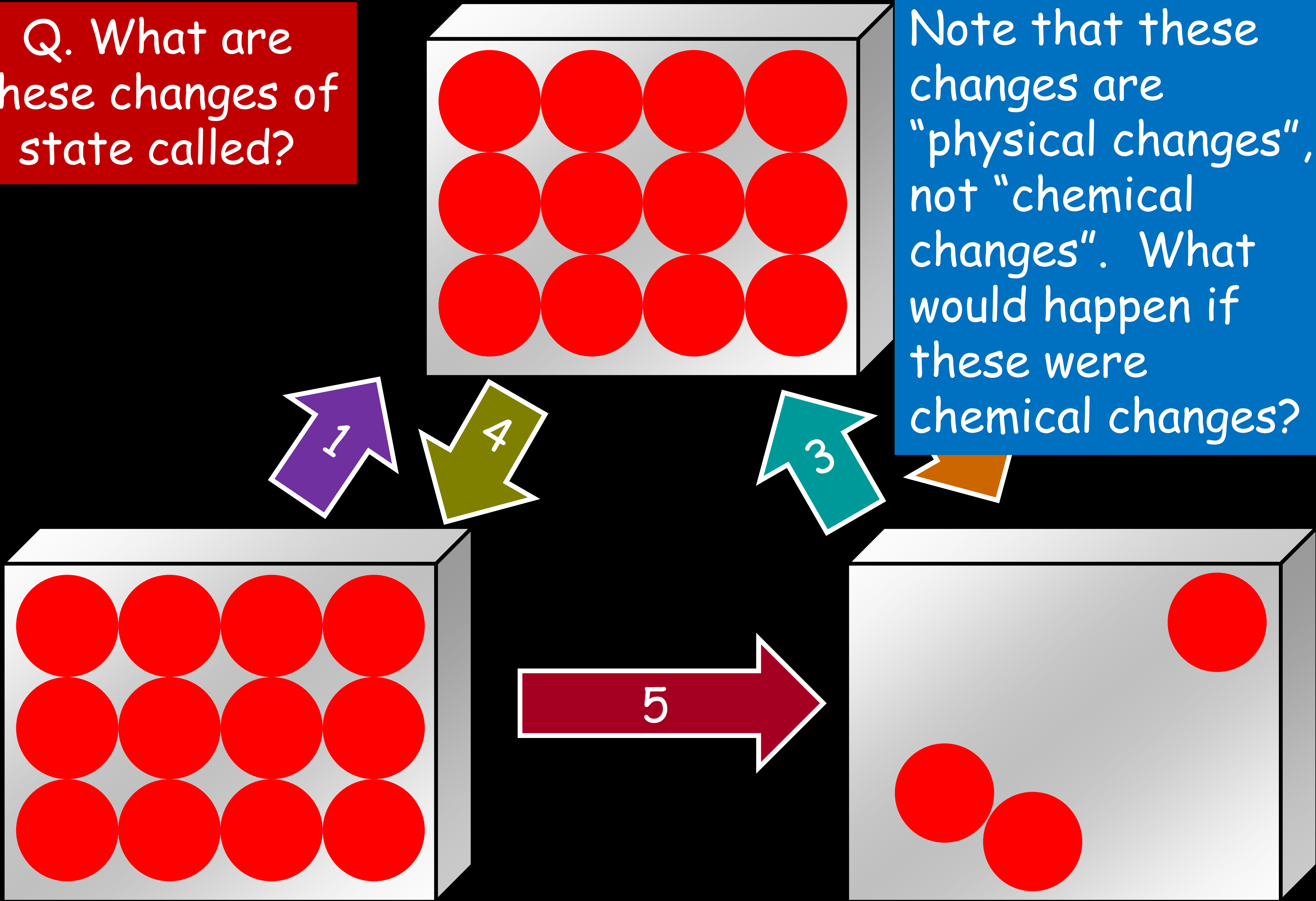
Liquid



Gas

Changes of State

Q. What are these changes of state called?

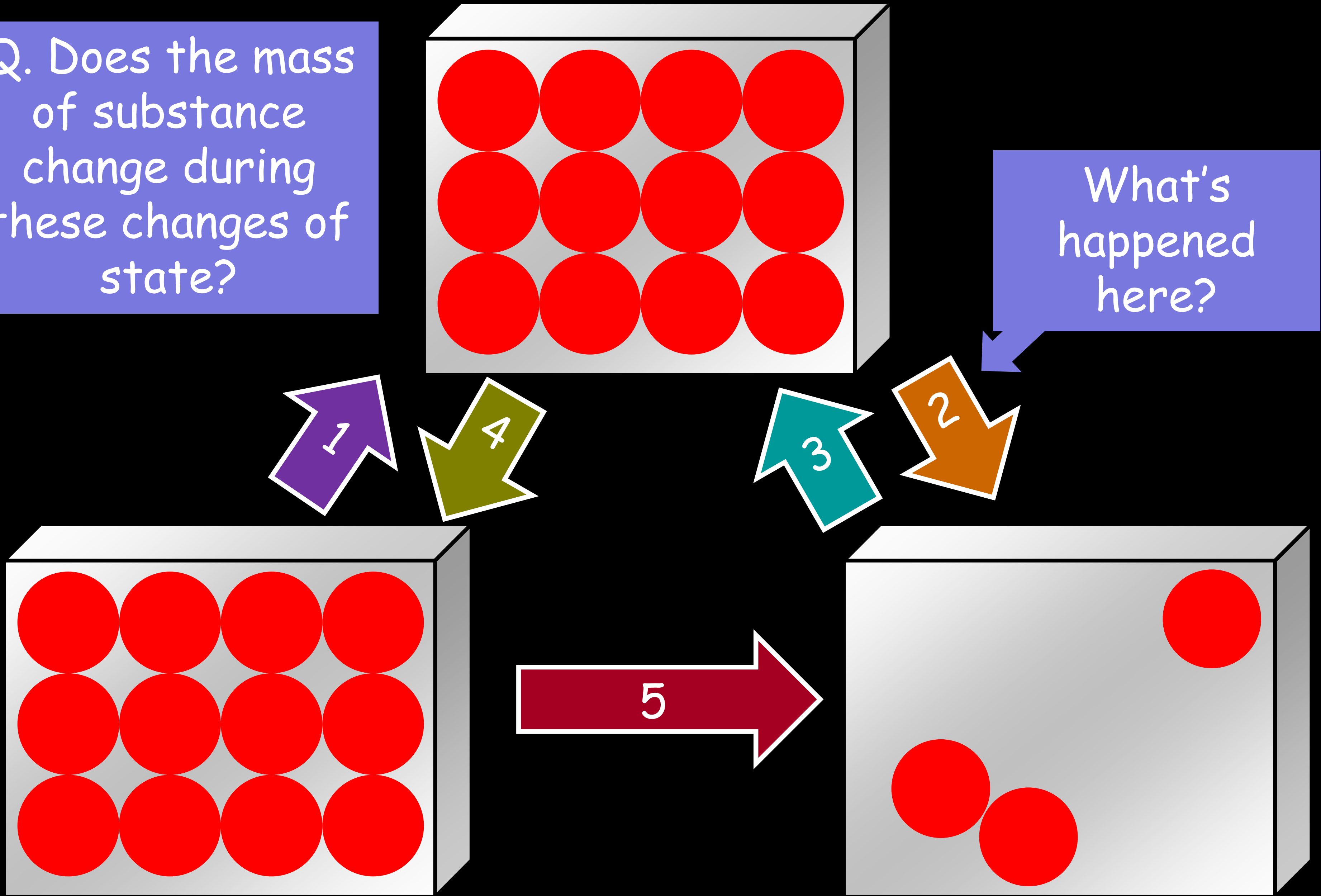


Note that these changes are "physical changes", not "chemical changes". What would happen if these were chemical changes?

09/01/2020

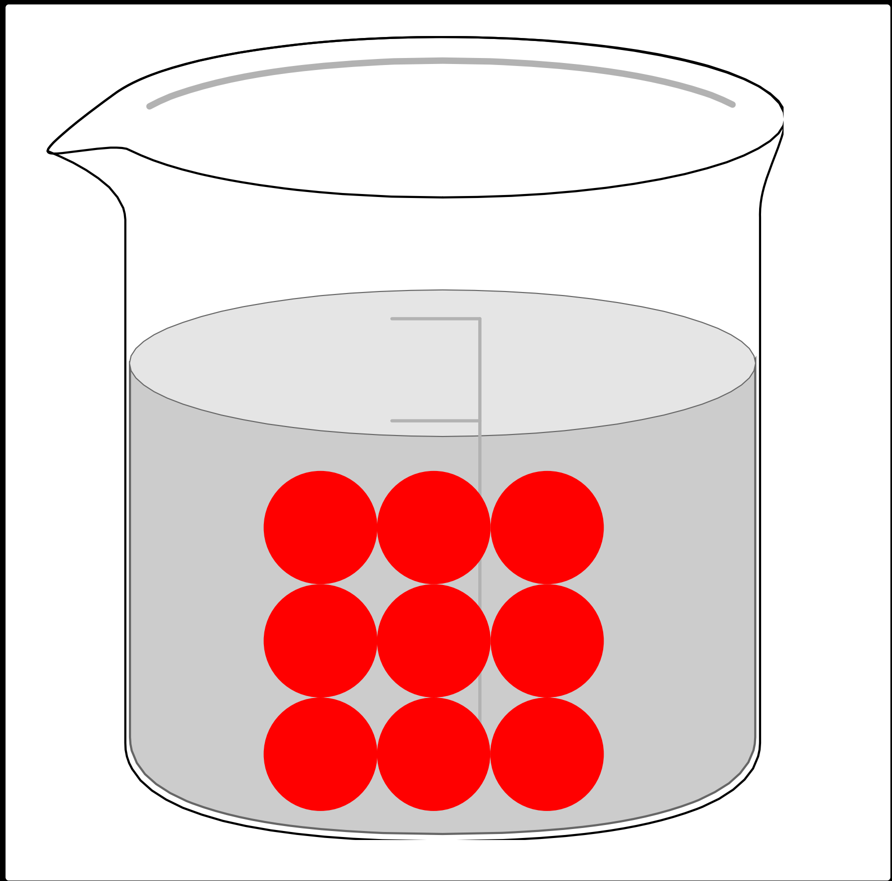
Changes of Mass

Q. Does the mass of substance change during these changes of state?



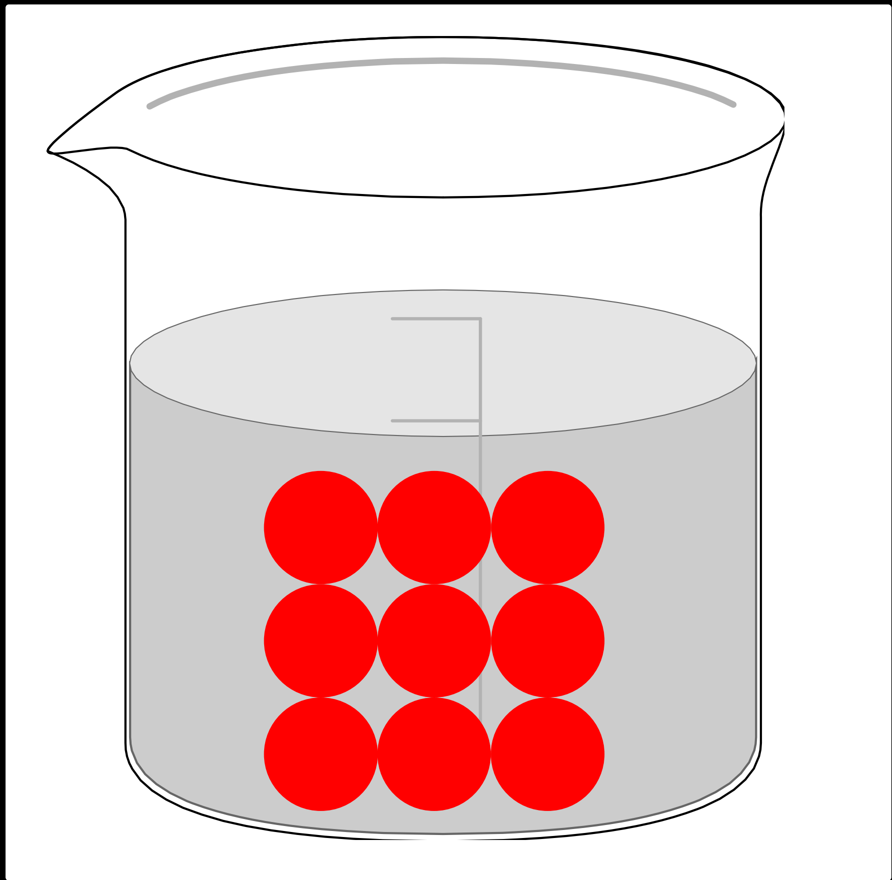
Melting Ice

Ice at a temperature of below 0^oC:



Melting Ice

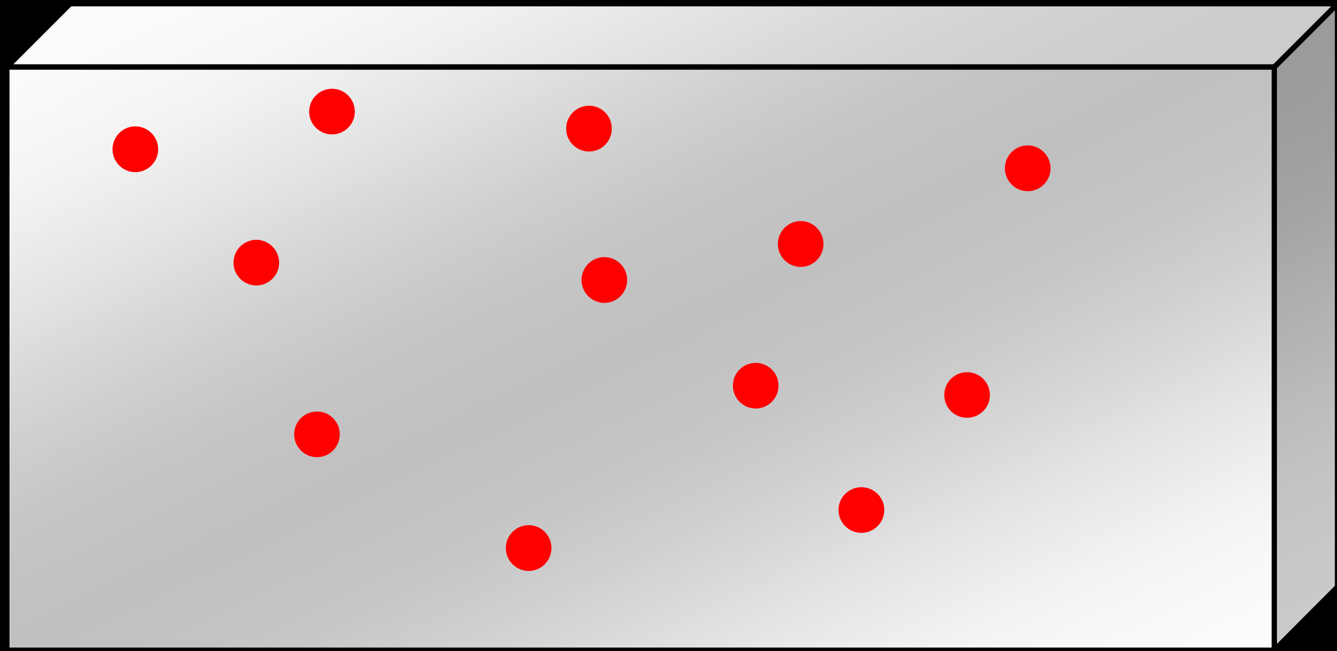
Ice turning into water and then a gas:



3.2 Internal Energy and Energy Transfers

Motion of Gas Particles

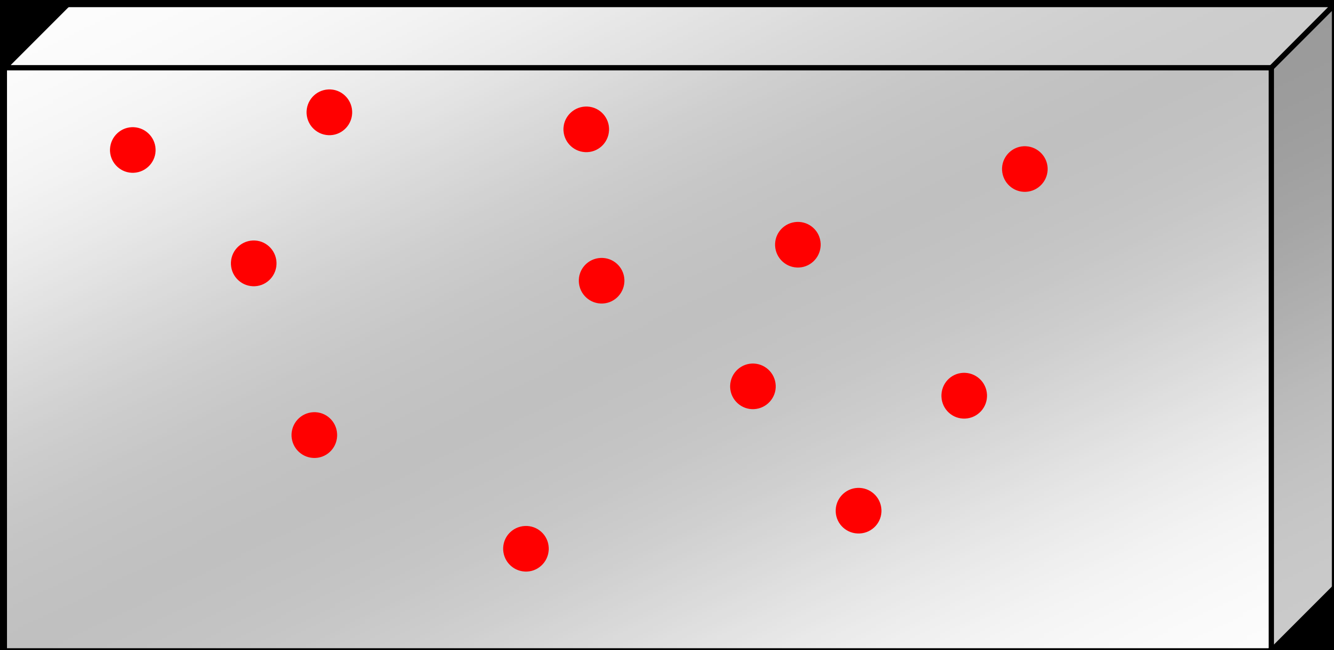
Here are some gas particles doing what gas particles do:



Making a Gas Hotter

Consider increasing the temperature:

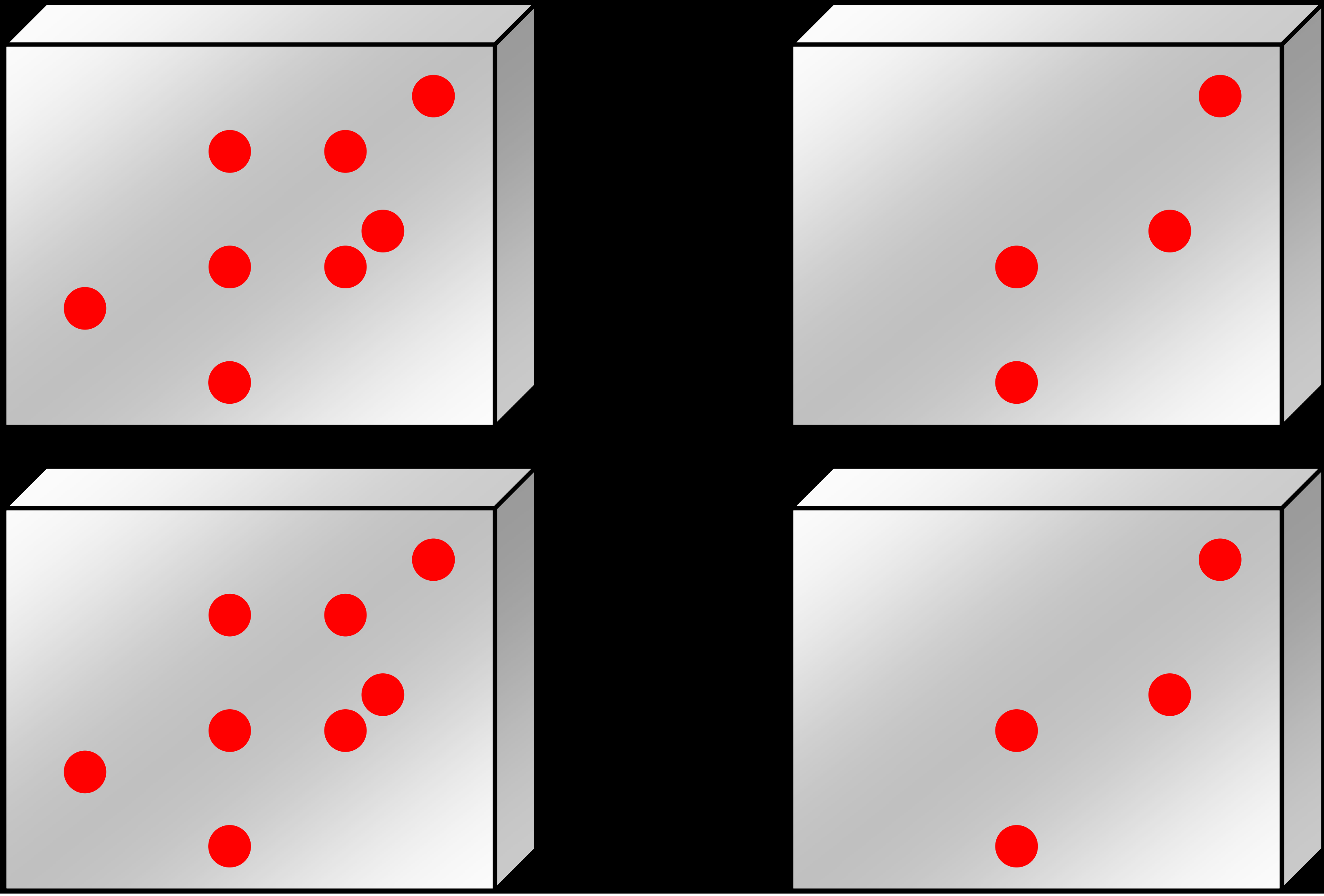
1) What changes did this hotter temperature make to the motion of the particles?
2) How did it affect their spacing?



09/01/2020

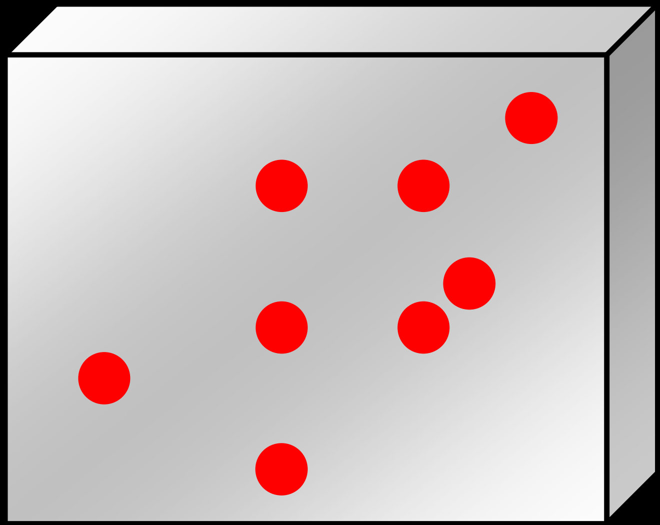
Internal Energy

Which one of these boxes has got the most internal energy? Explain your answer:



Internal Energy

Consider these particles again:



The "internal energy" of the gas is the total amount of _______ energy and potential energy of all of the gas ________ added together.

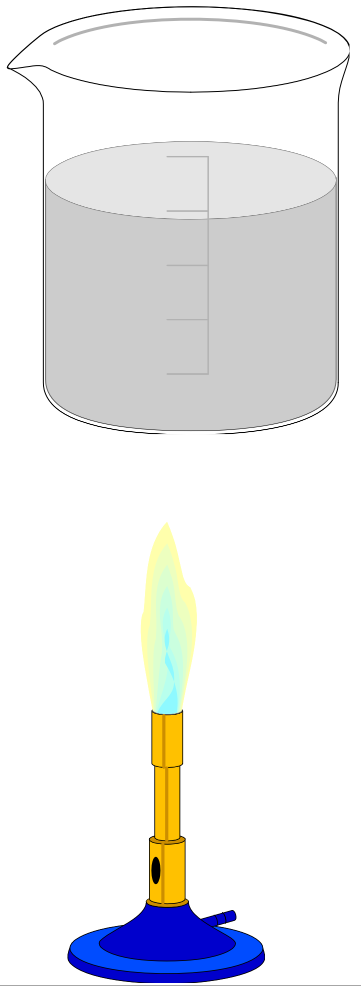
If a substance is heated up it's internal energy ________. This will cause either:

1) An increase in ___________
2) A change of _______

Words – state, temperature, molecules, increases, kinetic

Heating a Liquid up

09/01/2020



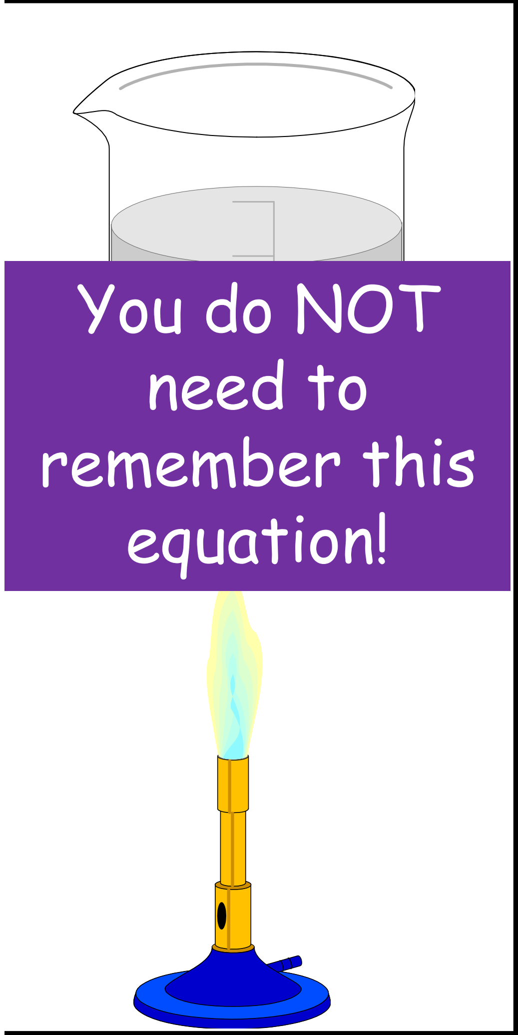
If we heat this beaker up it's fairly clear that the liquid will gain internal energy and get hotter.

Q. What three things does the increase in temperature depend on?

1) The amount of liquid (i.e. the mass)
2) The amount of heat energy going in to the liquid (i.e. how hot the Bunsen is and how long it's on for)
3) The substance being heated – e.g. is it water or cooking oil?

Putting these into an equation…

Let's put the factors from the last slide into an equation:



You do NOT need to remember this equation!

If the rise in temperature depends on the mass of liquid, how much energy it is given and the substance being heated then we can say:

$$\Delta E = mc\Delta\theta$$

Where:

ΔE = amount of heat energy being supplied (in Joules)

m = mass of liquid (in kg)

c = "specific heat capacity" (in J/Kg^{O}C)

$\Delta\theta$ = change in temperature (in ^{O}C)

Definition of Specific Heat Capacity

$$\Delta E = mc\Delta\theta$$

The specific heat capacity can be thought of as the "ability of an object to store heat energy". It's proper definition is:

Definition of SHC: The amount of energy needed to raise the temperature of 1kg of a substance by $1^{O}C$.

Some example questions

1) A beaker filled with 0.1kg of water with specific heat capacity 4200J/(kg.^{0}C) is heated from 20^{0}C to 80^{0}C. Calculate the amount of heat energy gained by the water.

25.2 KJ

2) Another beaker containing 24g of water starts at 50^{0}C. If it loses 2000J of energy what temperature has it dropped to?

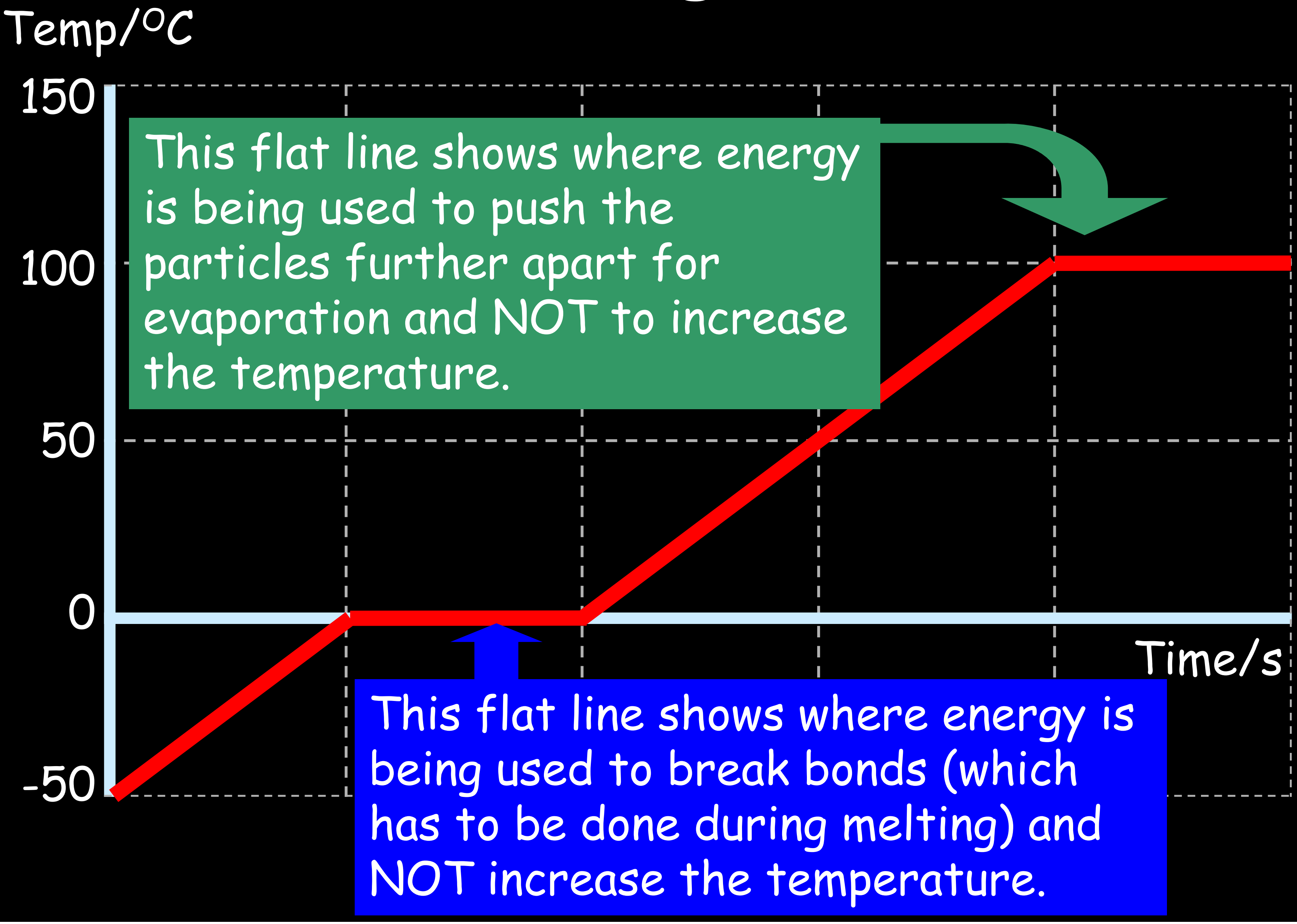
30.2^{0}C

Applying Specific Heat Capacity

1) Night storage heaters often contain blocks of concrete or other materials of high specific heat capacity. Explain how they work.

2) Radiators can either be filled with water or filled with oil. What are the advantages and disadvantages of each?

Heating ice


Temp/°C
150
100
50
0
-50
Time/s
This flat line shows where energy is being used to push the particles further apart for evaporation and NOT to increase the temperature.
This flat line shows where energy is being used to break bonds (which has to be done during melting) and NOT increase the temperature.

Specific Latent Heat

The Specific Latent Heat of a substance is defined as "the amount of heat energy needed to change the state of one kilogram of the substance WITHOUT changing its temperature". Therefore:

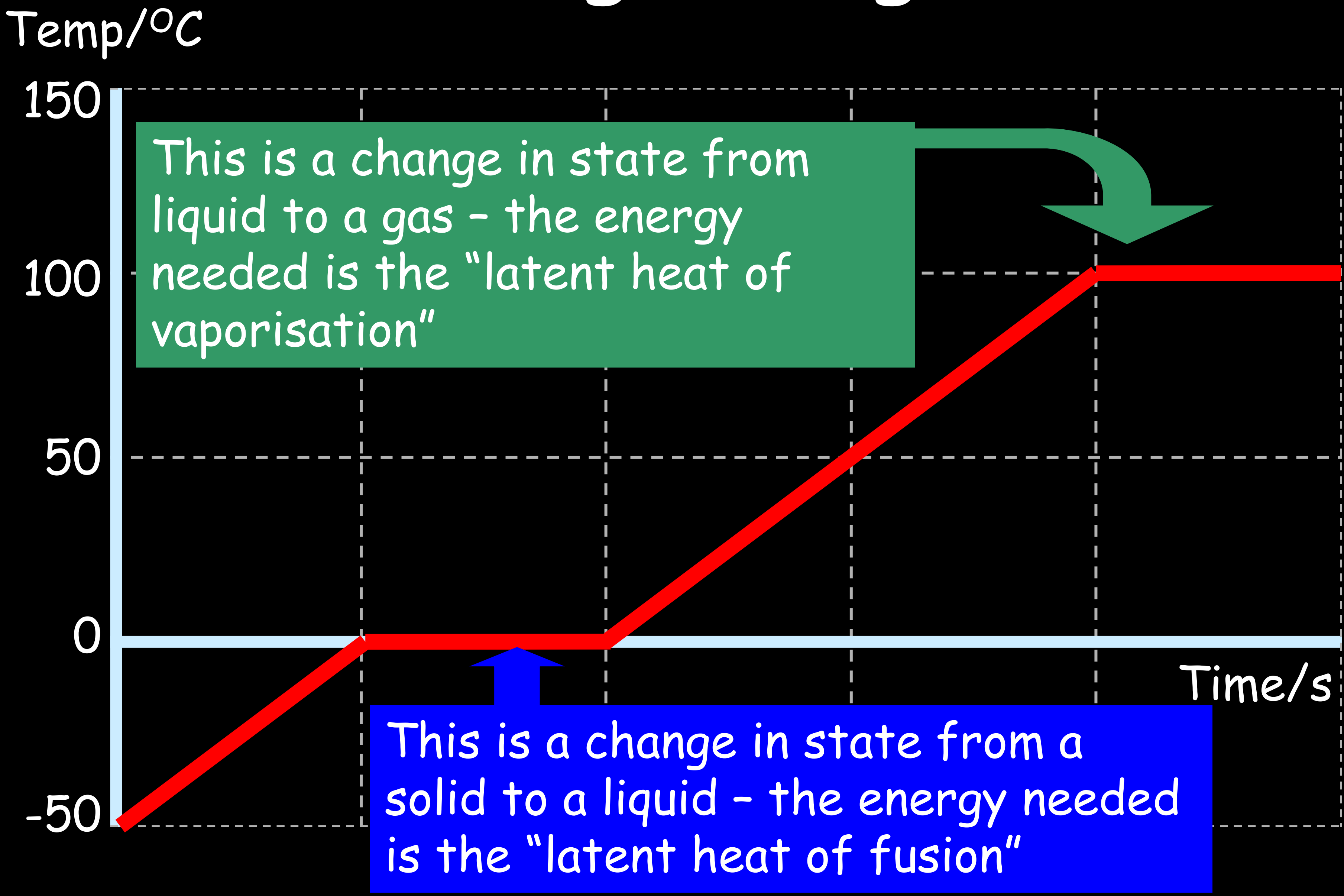
Energy = mass x specific latent heat of fusion

$$E = mL$$

- E is heat energy supplied (in J)
- m is mass (in kilograms)
- L is specific latent heat (in J/kg)

Heating ice again

09/01/2020



Some example questions

1) The latent heat of fusion for water is 334 KJ/kg. How much heat energy would be needed to melt 2kg of ice?

668KJ

2) 0.5kg of ice is supplied with 100KJ of heat energy. Will all of the ice melt?

No – not enough heat energy

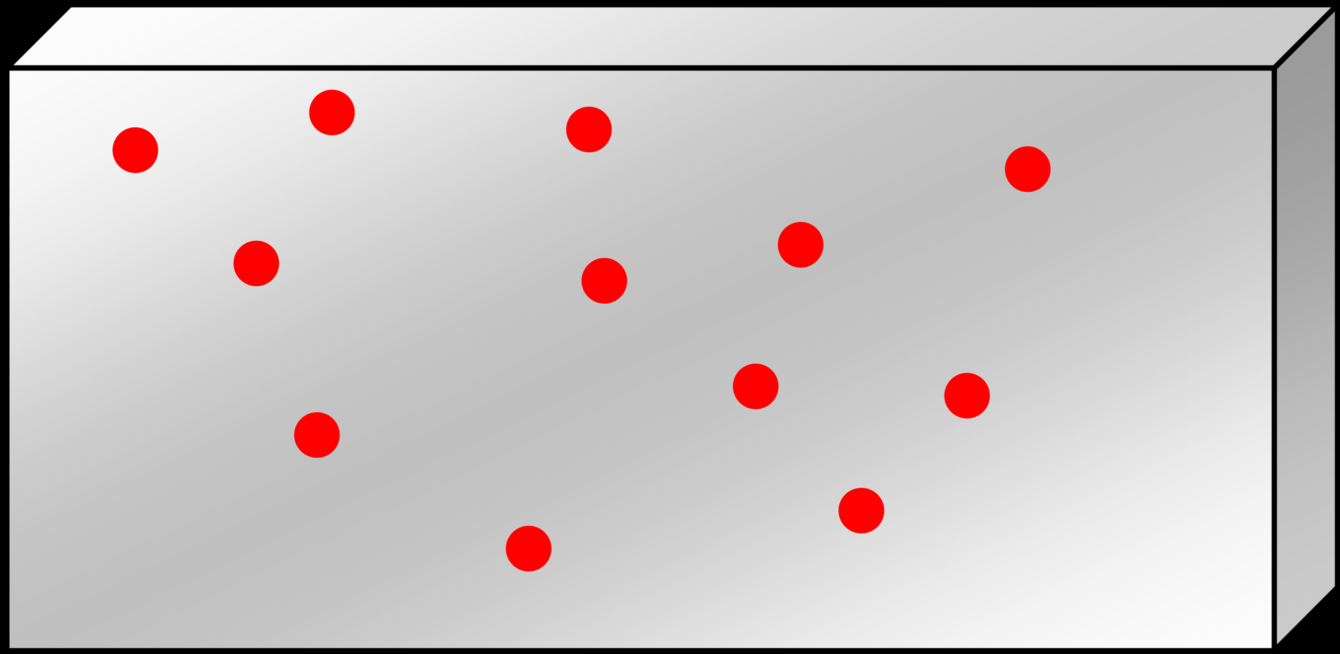
3) Another heater is used to boil off 100g of water. The latent heat of vaporisation is 2260KJ/kg. How much heat energy was supplied to the water?

226KJ

3.3 Particle Model and Pressure

Gas Pressure

Here is our model of particles in a gas again:

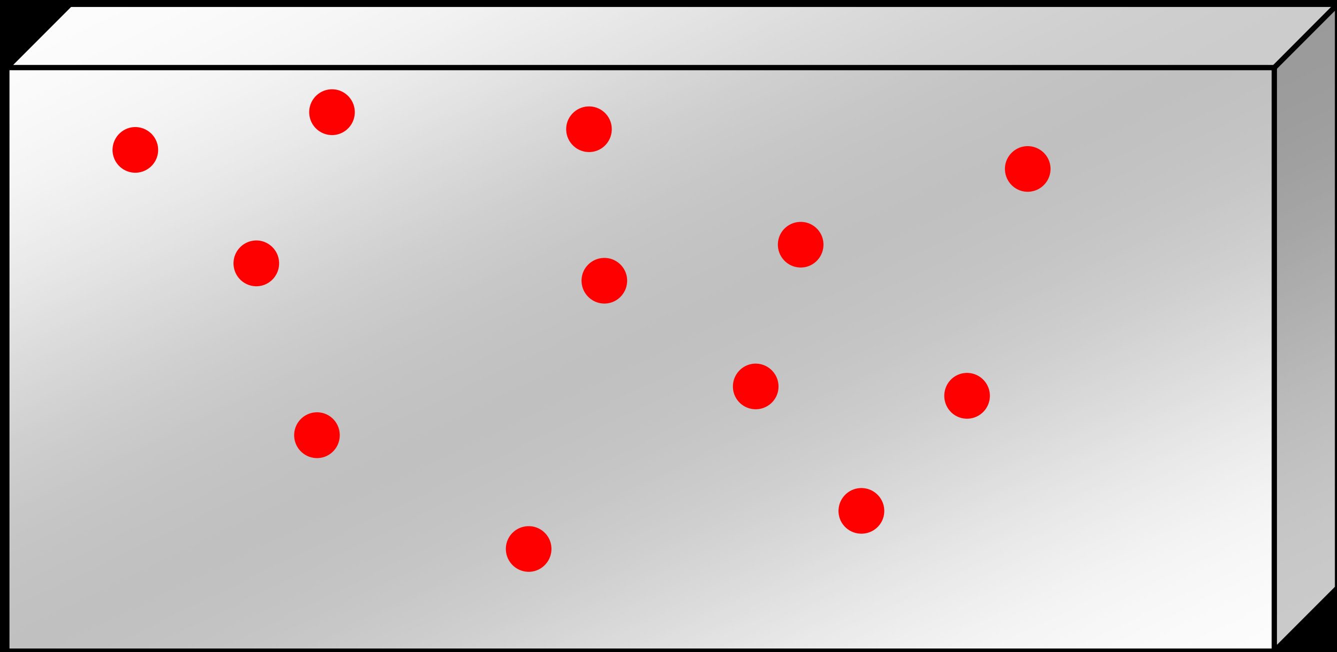


Notice that the particles keep hitting the sides of the container. The total affect of all of these collisions is what we call "pressure".

09/01/2020

Particle Motion in Gases

Q. What happens if we make the gas hotter?

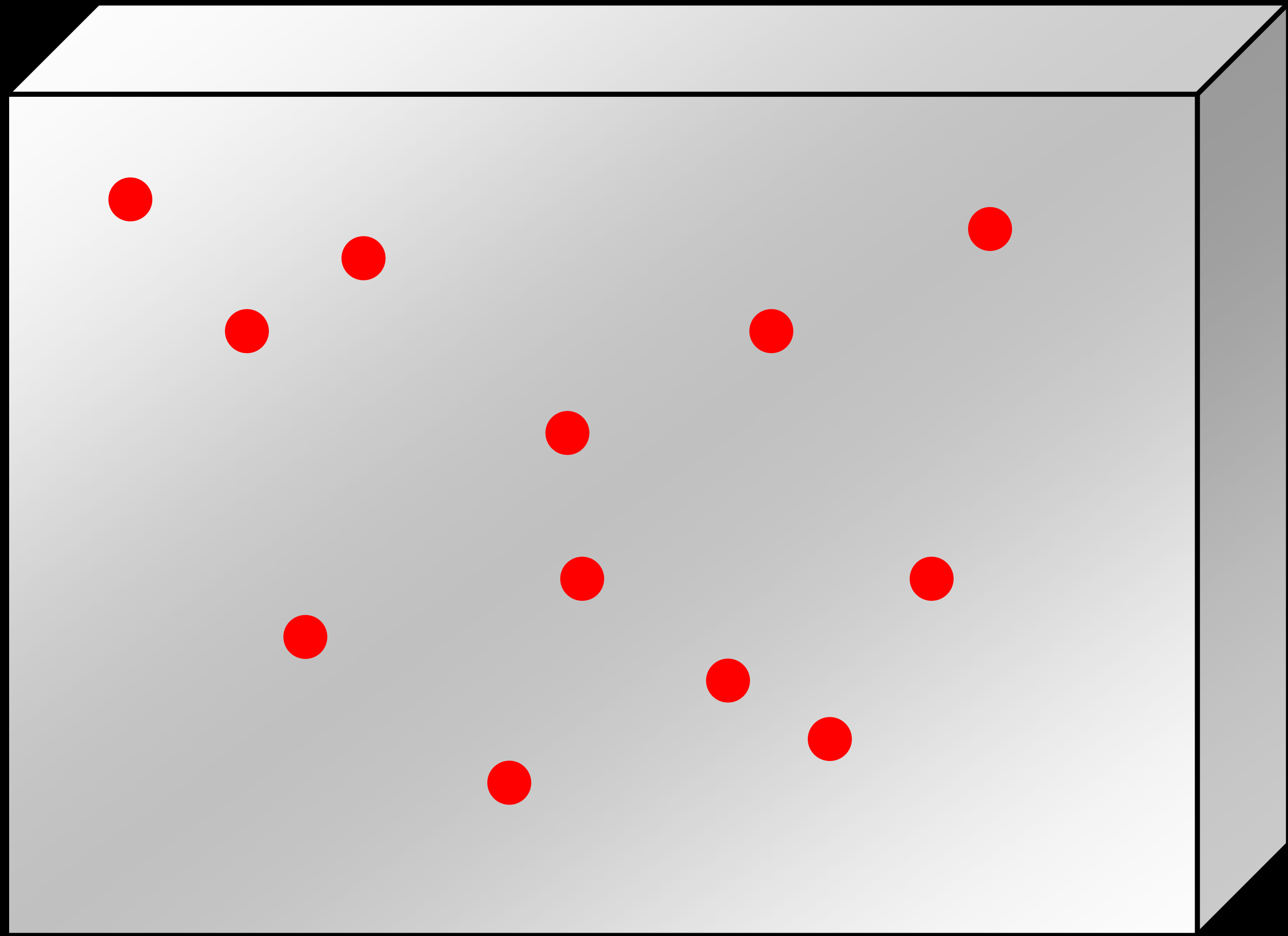


The particles gain ______ energy and move _______. They will collide with the sides of the container ______ often, therefore the pressure is _________. This could cause the container to _______.

Words – expand, more, kinetic, greater, faster

Particle Motion in Gases

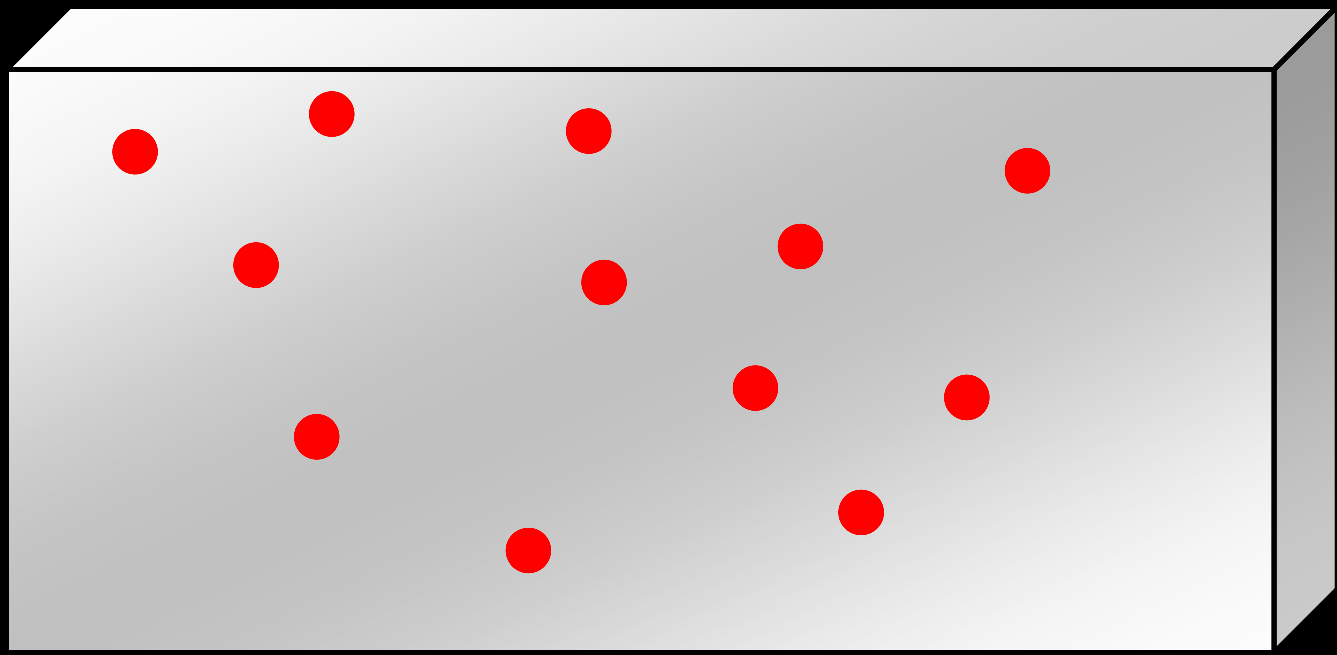
Here's gas pressure in a large container:



Particle Motion in Gases

Consider decreasing the volume:

The particles should collide with the sides of the container ______ often, therefore the pressure is _________.



Pressure and Volume in gases (Physics only)

Pressure	Volume	Pressure x volume

Pressure and Volume in gases (Physics only)

Conclusion

When we multiplied the pressure of a gas by its volume we found that the answer was always __ ________.

In other words, if you DECREASE the volume you ________ the pressure and so on. One goes up, the other goes down!

In other words:

Pressure x volume = constant

Pressure and Volume in gases (Physics only)

Here's another way of expressing the same equation:

Initial Pressure x Initial Volume = Final Press. x Final Vol.

$$P_I V_I = P_F V_F$$

1) A gas has a volume of $3m^3$ at a pressure of $20N/m^2$. What will the pressure be if the volume is reduced to $1.5m^3$?

   $40N/m^2$

2) A gas increases in volume from $10m^3$ to $50m^3$. If the initial pressure was $10,000N/m^2$ what is the new pressure?

   $20KN/m^2$

3) A gas decreases in pressure from 100,000 Pascals to 50,000 Pascals. The final volume was $3m^3$. What was the initial volume?

   $1.5m^3$

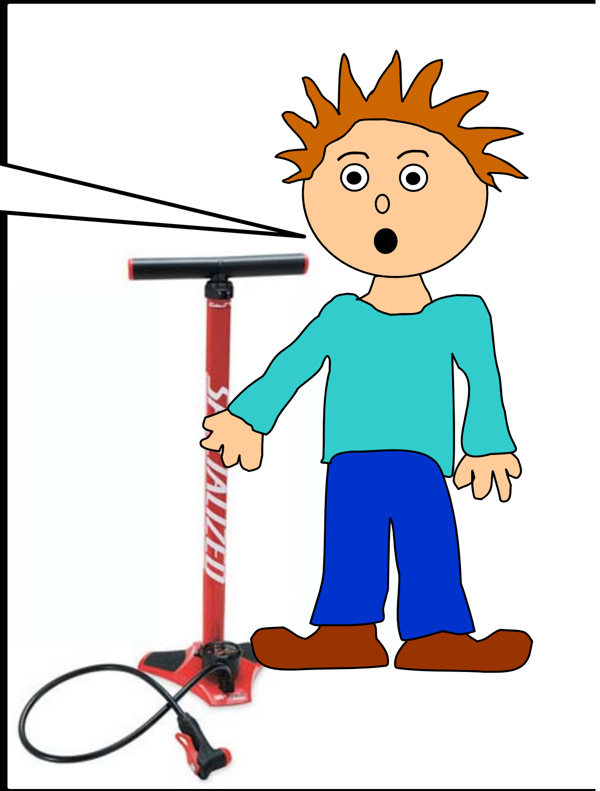
4) The pressure of a gas changes from $100N/m^2$ to $20N/m^2$. What is the ratio for volume change?

   1:5

Increasing Gas Pressure (Physics HT only)

09/01/2020

I'm trying to use this bike pump but it gets really hot when I use it. What's happening?



When the pump is being used there is ______ being done on the enclosed _____. This increases the _______ energy of the gas and, as such, raises its ___________.

Words – gas, work, temperature, internal