AQA
6.3 Particle Theory

© R Ashbee 2017

Density

All matter is made of atoms and molecules. We can use the term “particles” to include atoms and molecules.

Density is a measure of how heavy a certain volume of a material is. Iron is more dense than wood and wood is more dense than air. The equation for density is:

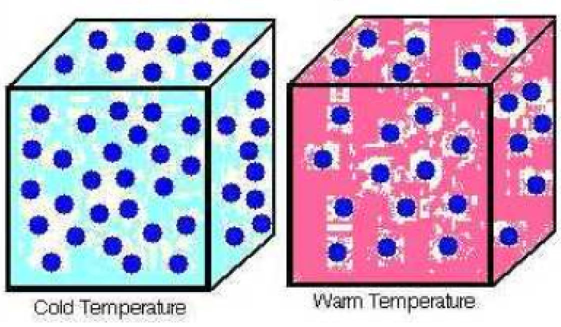
$$\rho = \frac{m}{V} \qquad \text{density} = \frac{\text{mass}}{\text{volume}}$$

density, ρ, in kilograms per metre cubed, kg/m^3

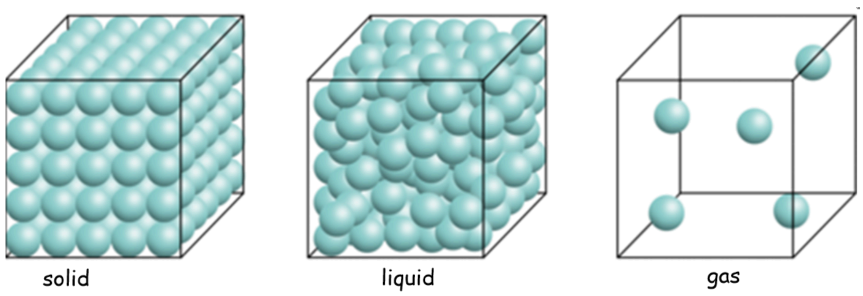
mass, m, in kilograms, kg

volume, V, in metres cubed, m^3

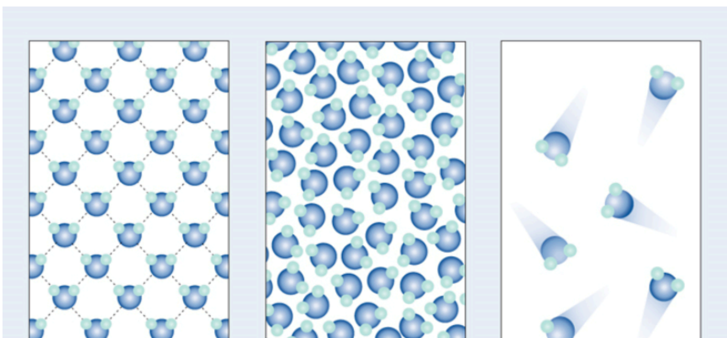
Most materials become less dense as they are heated. Heating gives particles more kinetic energy, and as they move faster particles become further apart from each other, effectively decreasing the density of the material as a higher proportion of it is empty space.



Different states of a material have different densities because of particle arrangement:



Most materials are most dense when they are in a solid form. For example, solid iron is more dense than liquid iron, and liquid iron is more dense than gaseous iron. The main exception to this rule is water, which because it has unusually shaped molecules, actually forms a less dense crystal when it is in solid state (frozen) than when it is a liquid:

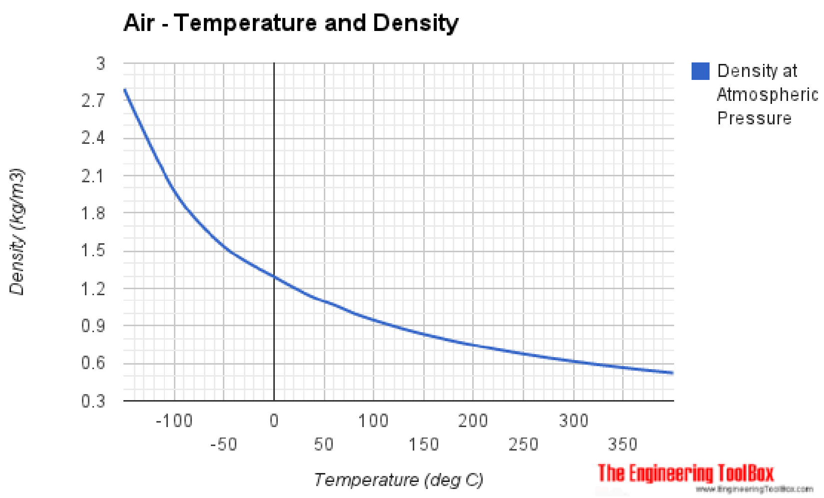


Questions:

1. What is the formula for density?
2. Draw the particle arrangements for solids, liquids and gases.
3. Describe the particle arrangements for solids, liquids and gases.
4. Explain why most materials are more dense in their solid form.
5. Explain why heating a block of metal causes it to become less dense.
6. Calculate the density of a block of metal with mass 1.2kg and volume 0.3m^3.
7. If a volume of 5.6m^3 a liquid has mass 6.9kg, find its density.
8. If the density of aluminium is 2,712kg/m^3, find the volume of 13,800kg.
9. Calculate the volume of 240,000kg of barium if the density of barium is 3594kg/m^3.
10. What mass of germanium takes up 4570m^3 of space if the density of germanium is 5323kg/m^3?
11. If the density of manganese is 7440kg/m^3, find the mass of 35,000 m^3.

Extension:

1. Find the number of particles in the box labelled "solid" on the previous page.
2. Estimate the number of particles in the cube labelled "liquid" above.
3. The graph shows how the density of air varies with temperature.

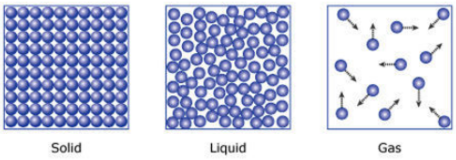


   a. Describe the relationship between temperature and density for air.
   b. Find the density of air at -50^{o}C.
   c. What is the mass of 5m^3 of air at 150^{o}C?

© R Ashbee 2017

d. What is the volume of 15kg of air at 50°C?

Answers:

1. What is the formula for density? $\rho = \frac{m}{V}$ density = mass/ volume
2. 

3. Solid: particles are in a regular arrangement and have a fixed position. Small spaces between particles. Particles touch.
   Liquid: particles touch but no fixed position and slide past each other.
   Gas: Large spaces between particles. Particles move around quickly.
4. Because there is less empty space between the particles.
5. Heating gives the particles more kinetic energy so that they move more. This increased movement leads to increased space between the particles.
6. 4kg/m^3
7. 1.23kg/m^3
8. 5.09m^3
9. 66.78m^3.
10. 24,326,110kg
11. 260,400,000kg

Extension:

1. 150
2. Any number between 60 and 125
   3.
   a. The higher the temperature the lower the density
   b. 1.55kg/m^3
   c. 4.25kg
   d. 13.64m^3

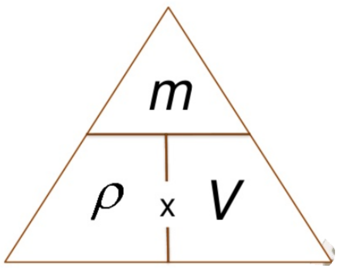
Intervention Questions

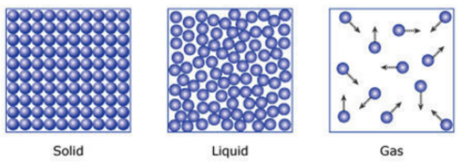
1. Draw the formula triangle for density.
2. Draw the particle arrangements for solids, liquids and gases.

© R Ashbee 2017

3. Describe the particle arrangements for solids, liquids and gases.
4. Explain why most materials are least dense in their gaseous form.
5. Explain why cooling a block of metal causes it to become more dense.
6. Calculate the density of a block of metal with mass 3.2kg and volume $0.12m^3$.
7. If a volume of $7.6m^3$ a liquid has mass 9.9kg, find its density.
8. If the density of aluminium is $2,712kg/m^3$, find the volume of 67,800kg.
9. Calculate the volume of 18,000kg of barium if the density of barium is $3,594kg/m^3$.
10. What mass of germanium takes up $18,780m^3$ of space if the density of germanium is $5323kg/m^3$?
11. If the density of manganese is $7440kg/m^3$, find the mass of $28,000\ m^3$.

Intervention Answers

1. 

2. 

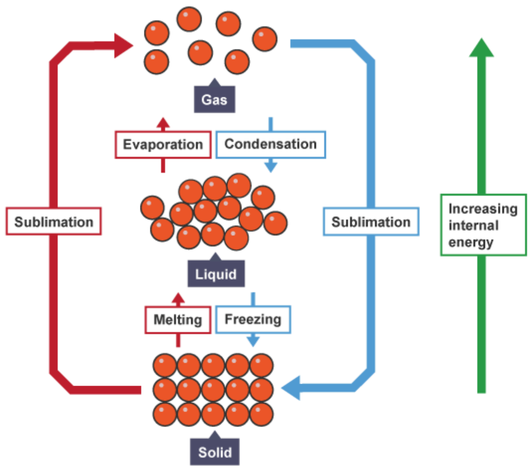
3. Solid: particles are in a regular arrangement and have a fixed position. Small spaces between particles. Particles touch.
   Liquid: particles touch but no fixed position and slide past each other.
   Gas: Large spaces between particles. Particles move around quickly.
4. A gas has the largest empty spaces between particles
5. Cooling removes heat energy from the material, causing the particles to have less kinetic energy. They therefore move around more slowly and the empty spaces between them get smaller.
6. $26.67kg/m^3$
7. $1.30kg/m^3$
8. $25m^3$
9. $5.01m^3$
10. 99,965,940kg
11. 208320000kg

© R Ashbee 2017

© R Ashbee 2017

Changes of State

There are three main states of matter: solid, liquid and gas. A substance can be in the solid, the liquid or the gaseous state depending on the energy its particles have. For example, oxygen is a gas at room temperature but if we remove energy from its particles by cooling it, it will condense into a liquid and then freeze into a solid. Different substances do this at different temperatures.



Mass is conserved when a substance changes state. If you start with 1kg of oxygen gas and cool it, you will have 1kg of liquid oxygen.

Changes of state are physical changes as opposed to chemical changes. An example of a chemical change is combustion. Combustion is a chemical change because chemical bonds are broken and formed during the change. It is impossible to reverse combustion and recover the original properties of the reactants. In a physical change such as melting or freezing however, no chemical bonds are broken or formed. Rather, intermolecular forces are overcome or experienced as particles are moved further or closer together as a result of their kinetic energy. If the process is reversed then the properties of the material are identical to those before the state change.

Questions:

1. State the three main states of matter.
2. Copy and complete the table:

State change	**From __ to __**	**Add or remove energy?**	**What happens to particle movement?**	**What happens to intermolecular forces?**
Melting	From solid to liquid			
Freezing		Remove		
Boiling			Increases	
Condensing				Enabled

3. What does it mean when we say “mass is conserved” in a state change?

© R Ashbee 2017

4. Grace has 2.5kg of ice and melts it in a sealed container. What is the mass of the water when she has finished?
5. Define a physical change.

Extension:

1. Anish boils 18g of water and collects the gas but 12% of the water remains in the beaker as droplets. What is the mass of the collected gas?
2. Is photosynthesis a chemical or physical change? Explain your answer.
3. What is "sublimation"?
4. Which of the following is not a physical change: sublimation; burning; evaporating
5. An ice cube is dropped on the floor and first melts, then evaporates. Write a paragraph from the point of view of a water particle in the ice cube.
6. A liquid is poured into a tray and then frozen. Noah thinks the mass of the frozen solid will be greater than the mass of the liquid. Ajay thinks the masses will be the same. Who is right? Explain your answer.

Answers:

1. Solid, liquid, gas
2. :

State change	**From __ to __**	**Add or remove energy?**	**What happens to particle movement?**	**What happens to intermolecular forces?**
Melting	From solid to liquid	add	increase	overcome
Freezing	Liquid to solid	Remove	decreases	enabled
Boiling	Liquid to gas	add	Increases	Overcome
Condensing	Gas to liquid	remove	Decreases	Enabled

3. The mass at the start is equal to the mass at the end
4. 2.5kg
5. A change in which no chemical bonds are broken or formed: intermolecular forces are overcome or enabled.

© R Ashbee 2017

Extension:

1. 15.84g
2. Chemical as chemical bonds are broken and formed. It is impossible to reverse the change and obtain the same properties as before the change.
3. When a solid turns into a gas or vice versa
4. Burning
5. Teacher to mark
6. The masses will be the same as mass is conserved in physical changes

Intervention Questions:

1. Name the three states of matter
2. Copy and complete:

State change	From __ to __	Increase or decrease temperature?	What happens to particle movement?	What happens to intermolecular forces?
Boiling				
Condensing				
Freezing				
Melting				

3. Why do we say “mass is conserved” in a physical change?
4. Grace has 3.6kg of ice and melts it in a sealed container. What is the mass of the water when she has finished?
5. Define a physical change.

Intervention Answers:

1. Solid, liquid and gas
2.

State change	From __ to __	Increase or decrease temperature?	What happens to particle movement?	What happens to intermolecular forces?
Boiling	Liquid to gas	increase	increase	overcome
Condensing	Gas to liquid	decrease	decrease	Enabled

© R Ashbee 2017

Freezing	Liquid to solid	decrease	decrease	Enabled
Melting	Solid to liquid	increase	increase	overcome

3. Because the mass before the change is the same as the mass after the change
4. 3.6kg
5. A change in which no chemical bonds are broken or formed: intermolecular forces are overcome or enabled.

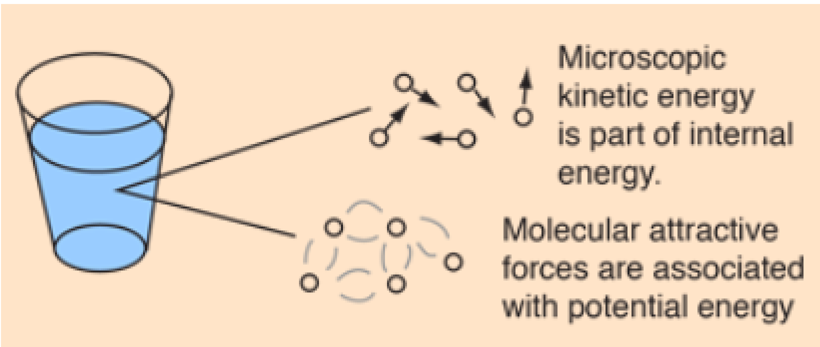
© R Ashbee 2017

Internal Energy

"Absolute zero" is the temperature at which particles (atoms and molecules) have no kinetic energy and do not move at all. Absolute zero is -273.15^{o}C.

At all temperatures higher than absolute zero, particles have kinetic energy and move. Their motion depends on how much energy they have and the state of matter they are in. The particles also have potential energy. When a liquid turns into a solid, heat energy is given out – this is called latent heat. So the fact that a liquid can be turned into a solid means the particles in a liquid have potential energy. Another way of saying this is that particles in, for example, a liquid have had work done on them for them to change state from a solid: an object that has had work done on it has potential energy.

The sum of the total kinetic and potential energies of all the particles in an object is the **internal energy** of that object.



When we heat an object we increase its internal energy. This either increases the temperature of the object (because of specific heat capacity -) or changes the state up (because of latent heat).

<u>Questions:</u>

1. What is "internal energy"?
2. How can we increase an object's internal energy?
3. What two things can happen when we increase an object's internal energy?

<u>Extension:</u>

1. Heating an object can increase its temperature. State three things that the increase in temperature depends on.
2. Jade says that "thermal energy is just one version of kinetic energy". Explain what she means by this.

<u>Answers:</u>

1. Total of kinetic and potential energy of the particles in an object
2. Heat it

© R Ashbee 2017

3. Increase temperature or change state up

Extension:

1. Amount of heat energy, mass of object, specific heat capacity of material
2. Thermal energy is the energy an object has because of the motion of its particles i.e. their kinetic energy.

Intervention Questions:

1. Define “internal energy”
2. How can we decrease an object’s internal energy?
3. What two things can happen when we decrease an object’s internal energy?

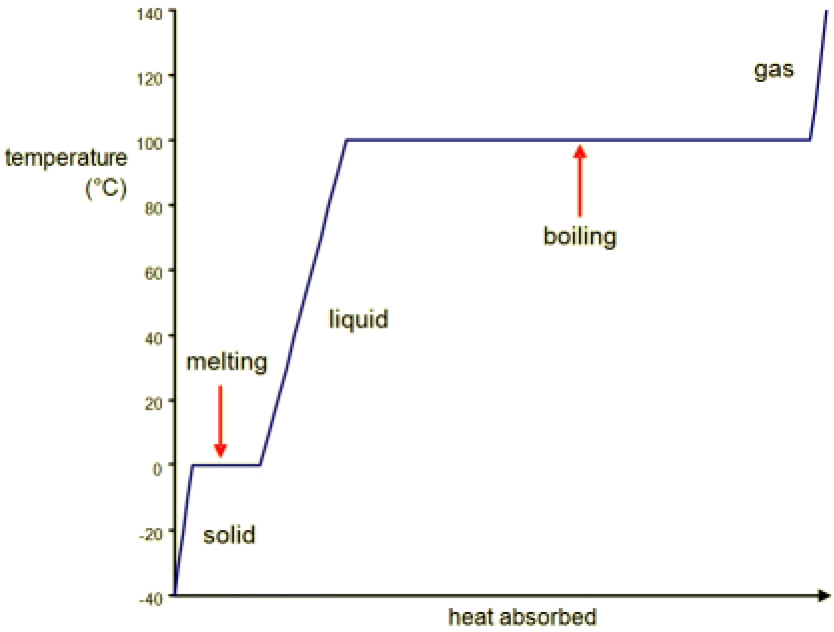
Intervention Answers:

1. Total of kinetic and potential energy of the particles in an object
2. Cool it
3. Decrease temperature or change state down

© R Ashbee 2017

6323 Specific Latent Heat

The graph shows the temperature changes when ice is heated:



In section 6.1.1.3 we looked at specific heat capacity. Specific heat capacity is related to the principle that if you add heat energy to a material, its temperature will rise. There are some special cases where this does not apply: during changes of state. The graph shows how the temperature of water changes as heat energy is added to it. The water starts off at -40°C (ice) and its temperature increases until it reaches 0°C. Here it remains constant while more energy is added to it. This is melting: the heat energy that is being added is being used to overcome the intermolecular forces of attraction that hold the water particles in their solid arrangement. So the heat energy cannot be used to increase the temperature. After the right amount of energy has been added, all the intermolecular forces have been overcome and the ice has fully melted into liquid water. So the temperature increases again as more heat energy is added. A similar thing happens at the next state change: boiling.

The energy used in the state change is called **latent heat**.

The specific latent heat of a material is the energy absorbed or released when 1kg of the material changes state without a change in temperature.

The energy supplied for the state change does increase the internal energy of the material but it doesn't increase the temperature. This is because the particles do not move faster (gain kinetic energy) but because they are changing their arrangement to a higher state they are gaining potential energy.

© R Ashbee 2017

Energy required for change of state = mass x specific latent heat

This formula is on the physics equation sheet.

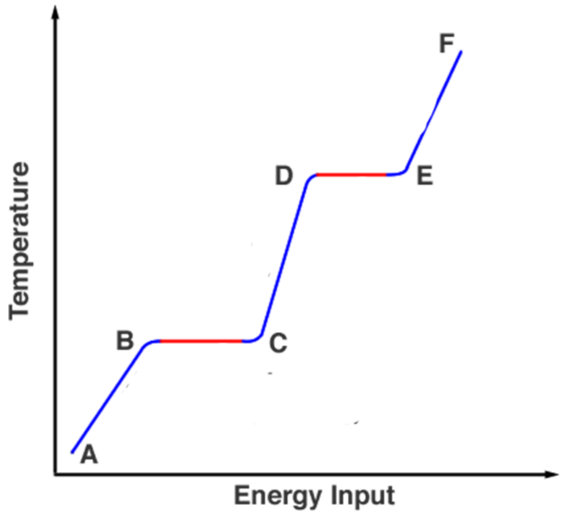
Specific latent heat of fusion = energy needed for melting

Specific latent heat of vaporisation = energy needed for boiling

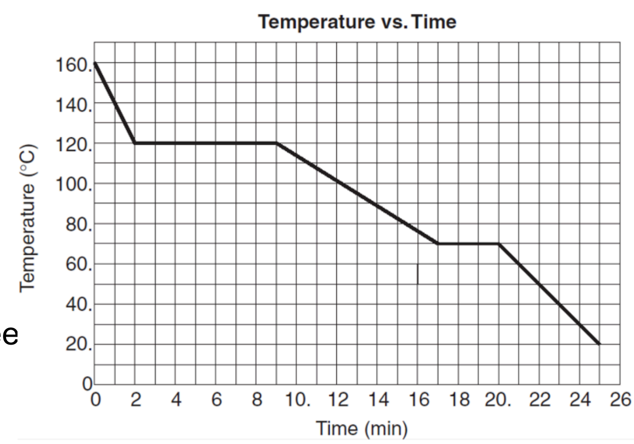
__Questions:__

1. Define specific latent heat.

2. Copy the graph and explain what is happening at stages A-B; B-C; C-D; D-E, E-F. Use the following words: solid, liquid, gas, state change, melting, boiling, particles, internal energy, kinetic energy, potential energy, latent heat of fusion, latent heat of vaporisation.



3. Calculate the energy needed to melt 0.49kg of aluminium . The specific latent heat of fusion of aluminium is 399,000 J/kg.
4. If the specific latent heat of vaporisation of aluminium is 10,500,000 J/kg, find the energy needed to vapourise 0.49kg of aluminium.
5. Find the specific latent heat of fusion of element Y if 405,000J of energy are used to melt 0.6kg of the element.
6. What is the specific latent heat of vaporisation of element Z if 2,670J of energy are needed to boil 0.51kg of the element?
7. What mass of lead can be melted using 58,000J of energy? The specific latent heat of fusion of lead is 25,000 J/kg.
8. What mass of helium can be boiled using 84,000J of energy? The specific latent heat of vaporisation of helium is 21,000J/kg.
9. Explain the difference between specific heat capacity and specific latent heat. Do not just write the definitions.
10. A gas was cooled and its temperature recorded over time. The graph shows the results: Explain what is happening at each stage in the graph. Use the words solid,



© R Ashbee

liquid, gas, state change, melting, boiling, particles, internal energy, kinetic energy, potential energy, latent heat of fusion, latent heat of vaporisation.

Extension:

1. Plot the points to show the change in temperature for element X as it is heated. Label the stages and draw a particle diagram for each one.

2. The specific latent heat of fusion for element X is 40J/kg, yet this is not shown on the graph. Suggest a reason for this discrepancy.

Energy input (J)	**Temperatur**
0	-60
50	-40
100	-20
150	-20
200	-20
250	+5
300	+30
350	+30
400	+30
450	+30
500	+50

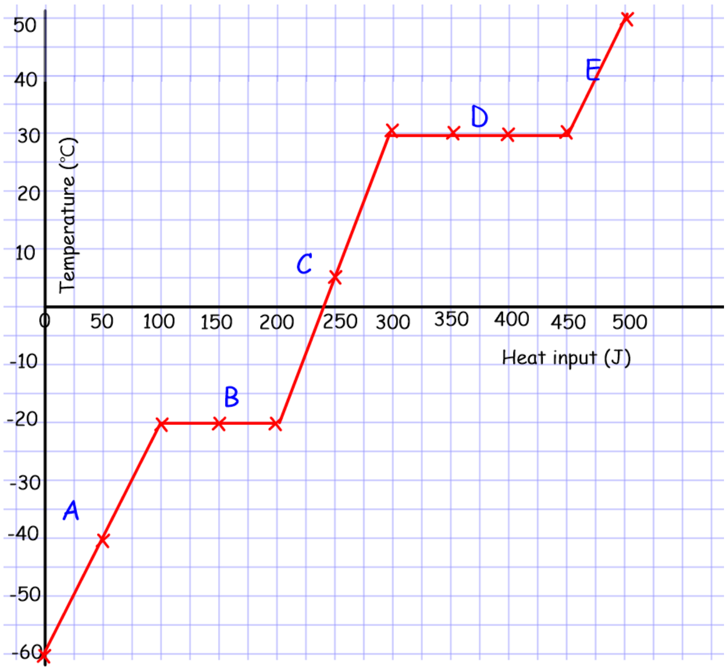
Answers:

1. The specific latent heat of a material is the energy absorbed or released when 1kg of the material changes state without a change in temperature.
2. A-B: Solid is being heated. The particles gain kinetic energy so the solid's temperature increases. B-C: The solid is melting. Latent heat of fusion is being used to change the state. The particles' potential energy increases but not their kinetic energy so the temperature remains constant until all the inter-molecular forces have been overcome. C-D: The material has now all melted and is a liquid. Its temperature rises as heat energy is added due to the increased kinetic energy of the particles. D-E: the liquid is boiling. Latent heat of vaporisation is used for this state change. The particles gain potential energy but not kinetic energy. The internal energy of the material increases but not the temperature. The heat energy added is being used to overcome intermolecular forces that hold the particles in liquid arrangement. E-F: The material has now all vaporised and its temperature rises as heat energy is added as the particles gain kinetic energy.
3. 195,510J.
4. 5,145,000J
5. 675,000J/kg
6. 5235.29J/kg
7. 2.32kg
8. 4kg
9. Specific heat capacity applies where there is no state change but a temperature change, whereas specific latent heat applies where there is no temperature change but a state change.
10. Between 0-2 mins the gas is decreasing in temperature as its particles lose kinetic energy. Between 2-9 minutes the gas is condensing. There is no

© R Ashbee 2017

temperature change as energy is being lost in the potential energy of the particles as they arrange in a liquid state. This is the latent heat of vapourisation. Between 9-17 minutes the liquid temperature cools as energy leaves the system. 17-20 minutes is freezing. The latet heat of fusion leaves the system but this does not cause a temperature change as it is the potential energy of the particles that is reduced, as they arrange themselves in a solid state rather than slow down. 20-25 minutes shows the solid cooling in temperature as its particles lose kinetic energy.

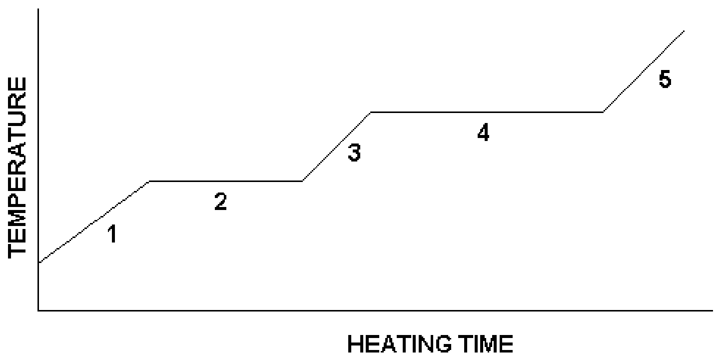
Extension:



1.
2. On the graph, 100J of energy is used for fusion. This could be because some energy is used to heat the container.

Intervention Questions:

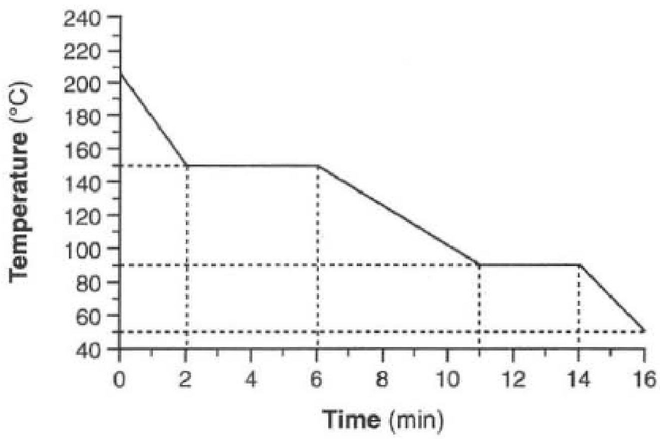
1. Define specific latent heat
2. Copy the graph and explain what is happening at stages 1, 2, 3, 4, and 5. Use the following words: solid, liquid, gas, state change, melting, boiling, particles, internal energy, kinetic



© R Ashbee 2017

energy, potential energy, latent heat of fusion, latent heat of vaporisation.

3. Calculate the energy needed to melt 0.23kg of aluminium . The specific latent heat of fusion of aluminium is 399,000 J/kg.
4. If the specific latent heat of vaporisation of aluminium is 10,500,000 J/kg, find the energy needed to vapourise 0.23kg of aluminium.
5. Find the specific latent heat of fusion of element Y if 325,000J of energy are used to heat 0.4kg of the element.
6. What is the specific latent heat of vaporisation of element Z if 2,890J of energy are needed to boil 0.31kg of the element?
7. What mass of lead can be melted using 136,000J of energy? The specific latent heat of fusion of lead is 25,000 J/kg.
8. What mass of helium can be boiled using 16,000J of energy? The specific latent heat of vaporisation of helium is 21,000J/kg.
9. Draw a Venn diagram for specific heat capacity and specific latent heat. Include the terms: state change; temperature change; unique to the material; per kg, per °C; cooling; heating; internal energy; kinetic energy, intermolecular forces, particle arrangement, potential energy.
10. A gas was cooled and its temperature recorded over time. The graph shows the results: Explain what is happening at each stage in the graph. Use the words solid, liquid, gas, freezing, condensing, particles, internal energy, kinetic energy, potential energy, surroundings, latent heat of fusion, latent heat of vaporisation.



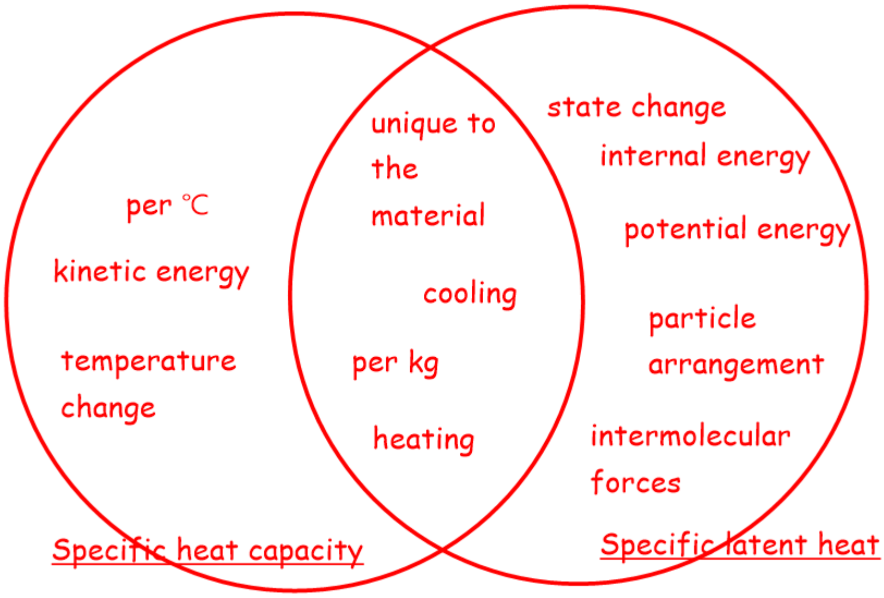
Intervention Answers:

1. The specific latent heat of a material is the energy absorbed or released when 1kg of the material changes state without a change in temperature.
2. At 1 the material is a solid and is being heated. Its temperature rises as its particles gain kinetic energy. At 2 the solid is melting, its particles gain potential energy as their intermolecular forces are overcome, but they do not gain kinetic energy. Therefore the temperature does not increase even though heat energy is being added. The energy used at this stage is the latent heat of fusion. At 3 the material has melted and is now a liquid. As heat energy is added its temperature increases as its particles gain kinetic energy. At 4 the

© R Ashbee 2017

liquid is boiling. The heat energy that is added is used to overcome intermolecular forces and so the temperature does not rise as the particles do not gain kinetic energy. The energy used at this stage is the latenet heat of vaporisation. At 5 the material has boiled and is now a gas, as more heat energy is added its temperature increases as its particles gain kinetic energy. Copy the graph and explain what is happening at stages 1, 2, 3, 4, and 5.

3. 91,770J
4. 2,425,000J
5. 812,500J/kg
6. 9,322.58J/kg
7. 5.44kg
8. 0.76kg



9.
10. Between 0-2 minutes the gas is decreasing in temperature as it loses heat energy to the surroundings. Its particles lose kinetic energy. From 2-6 minutes the gas is condensing. The energy that is lost to the surroundings is the latent heat of vaporisation. The particles don't lose kinetic energy but they lose potential energy as their arrangement changes into that of a liquid. From 6 – 11 minutes the liquid decreases in temperature as its particles lose kinetic energy. From 11- 14 minutes the energy that is lost to the surroundings comes from the potential energy rather than the kinetic energy of the particles. This energy is the latent heat of fusion. The particles change their arrangement as the material freezes. From 14 – 16 minutes the solid decreases in temperature as its particles decrease in kinetic energy.

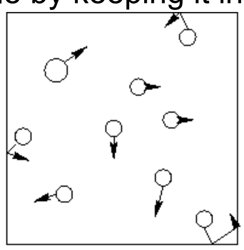
© R Ashbee 2017

Gas Pressure

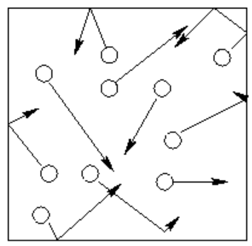
The particles of a gas are in constant random motion. The temperature of a gas is determined by the average kinetic energy of the particles.

All gases exert a pressure on the walls of their container. This is caused by the particles colliding with the container walls.

If the volume of a gas is kept the same, for example by keeping it in a sealed container of constant size, and the temperature is increased, for example by holding the container over a heat source, then the gas pressure will increase. This is due to the particles gaining kinetic energy and therefore colliding with the container walls more frequently and with greater force. If you took a sealed can with a gas, e.g. water vapour, and heated it, the increasing pressure would cause it to explode.



Cool gas, fewer and less energetic collisions

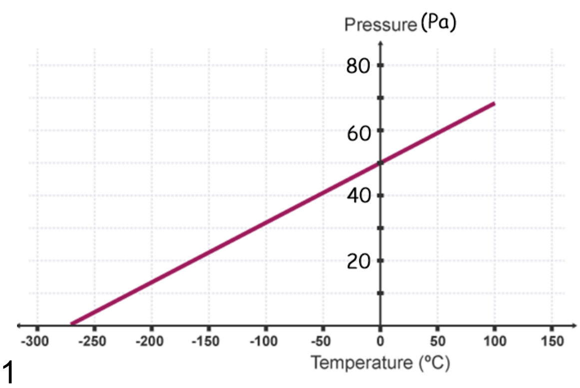


Hot gas, more and more energetic collision

The explanation of phenomena using the motion of particles is known as kinetic theory. When we examine the relationship between two variables, such as temperature and pressure, we keep all other variables, such as volume, fixed (constant) so that the relationship is clear to see.

Questions:

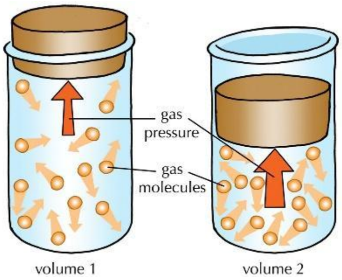
1. What is temperature a measure of?
2. What causes gas pressure? Copy the diagram that shows this and label it with: gas particle, container wall, collision
3. At a constant volume, what is the relationship between a gas' pressure and temperature?
4. Use kinetic theory to explain why the relationship is as you have described. Use the words kinetic energy, collisions, frequent, forceful, pressure.
5. In the diagram above for "hot gas", why are the arrows bigger? Copy the diagram for cool and hot gas.
6. Why can heating a sealed container cause it to explode? Use the words kinetic energy, collisions, frequent, forceful, pressure.
7. What is the relationship between temperature and pressure at constant volume?
8. The graph shows how pressure varies with temperature for a gas, X. Copy the graph and use it to support your answer to (7).



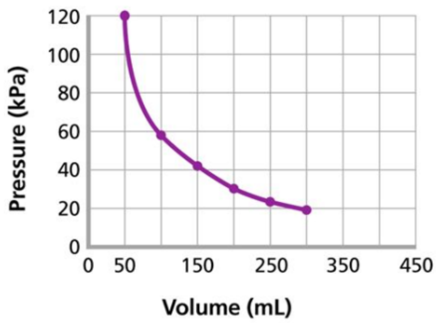
© R Ashbee 201

Extension:

1. If you kept the mass of a gas the same but decreased its volume, what would happen to its pressure? Copy the diagram and describe and explain what would happen.



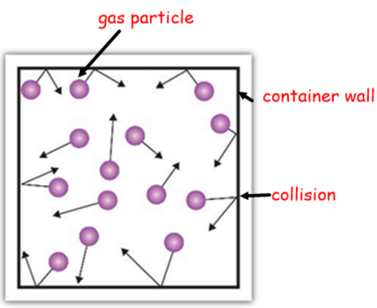
2. The graph shows how pressure of a gas varies with volume at constant temperature. Write a quantitative description of the relationship between pressure and volume and give evidence from the graph. Use kinetic theory to explain why this relationship exists.



3. Sketch a graph to show the relationship between temperature and volume of a gas at constant pressure. Use kinetic theory to explain why this relationship is as it is. Consider the frequency of collisions but not their force.

Answers:

1. Average kinetic energy of particles
2. Particles' collisions with the walls of the container



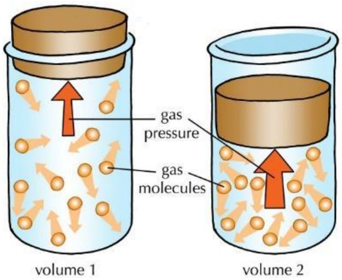
3. The higher the temperature, the higher the pressure
4. When you increase a gas' temperature you are giving the particles more kinetic energy. They move faster and therefore have more frequent and more forceful collisions. These collisions are what cause the gas pressure.

© R Ashbee 2017

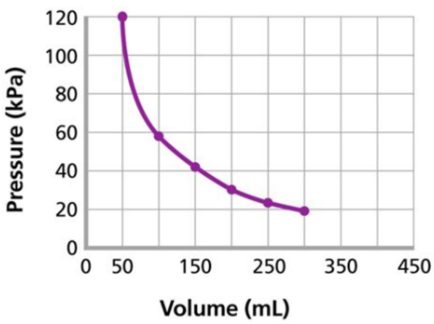
5. The particles are moving faster as they have more kinetic energy
6. Heating causes the gas particles to move faster as they have more kinetic energy. This leads to more frequent and more forceful collisions between the particles and the walls of the container. This leads to increased gas pressure, which eventually forces the container apart.
7. The higher the temperature, the higher the pressure.
8. E.g.: As you can see on the graph, when the temperature is -200^{o}C the pressure is 10Pa, and when we increase the temperature to 100^{o}C the pressure increases to 30Pa.

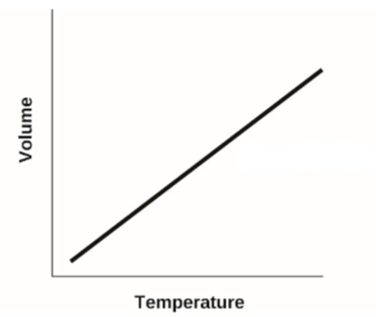
Extension:

1. The pressure would increase because now the same number of particles are in a smaller space (volume). The distance between the container walls is shorter so collisions between particles and container walls will be more frequent, meaning higher pressure.



2. Pressure is inversely proportional to volume. That is to say, when you double the volume, the pressure halves. For example, when the volume is 50 mL the pressure is 120kPa. When the volume doubles to 100mL the pressure halves to 60kPa. When the volume doubles , the distance between the container walls is longer so collisions between particles and container walls will be half as frequent, meaning half the pressure.



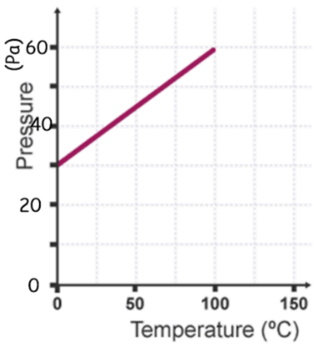


3. An increased temperature means faster-moving particles as they have more kinetic energy. In order for the pressure on the walls of the container to be the same, we must have the same frequency of collisions, i.e. the same time between each collision. Since time = distance/speed, if speed increases then distance must increase in order to maintain a constant time. A greater distance between container walls means a bigger volume.

© R Ashbee 2017

Intervention Questions:

1. Define temperature in terms of particle motion.
2. Explain why a gas exerts a pressure on the walls of its container
3. If you increase the temperature of a gas, what happens to its pressure? Assume constant volume.
4. Rachel wrote an explanation of the relationship in (3) using kinetic theory, but she made three mistakes. Write out the correct version of her explanation: “The higher the temperature the higher the pressure. This is because in a gas at a higher temperature the particles have less kinetic energy. This means they move faster and so have less frequent and less forceful collisions with the container walls.”
5. In the diagram above for “cool gas”, why are the arrows smaller?
6. If we put a balloon filled with air into a freezer, it collapses. Explain why using the words temperature, kinetic energy, collisions, frequent, forceful, pressure.
7. If we keep the volume of a gas the same, how does pressure vary with temperature?
8. The graph shows how pressure varies with temperature for a gas, Y. Copy the graph and use it to support your answer to (7).



Intervention Answers:

1. Temperature is a measure of the average kinetic energy of the particles.
2. The particles of a gas are in constant random motion and so collide with the walls of the container. These collisions cause a gas’ pressure.
3. The higher the temperature the higher the pressure (at constant volume).
4. “The higher the temperature the higher the pressure. This is because in a gas at a higher temperature the particles have *more* kinetic energy. This means they move faster and so have *more* frequent and *more* forceful collisions with the container walls.”
5. The particles are moving at a lower speed as they have less kinetic energy.
6. When the balloon is put in the freezer, the temperature of the air in the balloon decreases. This means the gas particles have less kinetic energy and move more slowly, causing less frequent and less forceful collisions with the walls of the balloon. This reduces the gas pressure inside the balloon, causing it to collapse.
7. If we keep the volume of a gas the same, how does pressure vary with temperature? The higher the temperature the higher the pressure.
8. E.g.:When the temperature is 0°C, the pressure is 30Pa, and when the temperature increases to 50°C, the pressure increases to 45Pa.

© R Ashbee 2017

© R Ashbee 2017