

Kinetic and molecular model of matter: Part 1 - Answers

1. Using appropriate key words, explain why liquids cannot be compressed. **[2 marks]**

Liquids cannot be compressed because the particles in a liquid are already in contact with each other [1] and so there are no spaces between them which makes it impossible to compress/push/move them closer together [1].

2. Describe the movement of particles in a solid. **[2 marks]**

Particles in a solid vibrate [1] about a fixed position [1].

3. Describe Brownian motion and how this can be demonstrated in a school laboratory, for example by using smoke particles in air. **[3 marks]**

Brownian motion is erratic / random [1] movement of particles in a fluid / liquids and gases [1], as a result of continuous bombardment from molecules of the surrounding medium (such as air, or water) [1].

4. Relate the properties of solids, liquids and gases to the forces and distances between molecules and to the motion of the molecules. **[6 marks]**

Solids - particles are close / very close to each other in a fixed arrangement [1] but they are able to vibrate about a fixed position [1].

Liquids - particles are close to each other but are free to move around each other / they are not in a fixed arrangement [1] which allows liquids to fill the shape of their container / allows liquids to flow [1].

Gases - particles are far apart from each other [1] and move with random / rapid motion as they collide with each other / the walls of the container.

5. Describe how and why the molecular arrangement of water molecules in ice is different to most other molecules, and why this results in ice being less dense than the water it is placed in (demonstrated by the fact that ice floats in water). **[2 marks]**

When liquid water turns to ice, the water molecules end up slightly further apart [1] compared to their arrangement in the liquid. Since the mass is the same, but the volume is bigger, and density = mass/volume, this results in the ice having a lower density than the water, hence why it floats [1].

Kinetic and molecular model of matter: Part 2 - Answers

1. Describe the difference between boiling and evaporation. **[2 marks]**

Boiling is when a liquid reaches its boiling point and turns into a gas.

Evaporation is when molecules in a liquid gain enough (kinetic) energy to escape from the surface of the liquid [1] (and this can happen at any temperature).

2. When a nurse uses a cotton swab to rub alcohol over the skin before administering an injection, the skin often feels cold in that localised area. Explain why. **[2 marks]**

Thermal/heat energy from the body [1] is used to evaporate the alcohol [1] (and so the skin feels colder as the heat energy leaves the surface of the body)

3. A balloon has a volume of 200cm^3 and a pressure of 40Pa . What would the new pressure be if the volume was changed to 150cm^3 and what assumption are you making during this change? **[3 marks]**

$$pV = \text{constant or } P_1V_1 = P_2V_2 \text{ [1]}$$

$$200 \times 40 = 150 \times P_2$$

$$P_2 = 8000 / 150 = \mathbf{53.3 \text{ Pa}} \text{ [1]}$$

Assumptions: either that the temperature stays constant [1] or that the number of gas molecules remains constant [1].

4. Describe three factors which affect the rate of evaporation from the surface of a liquid, and explain how each factor makes a difference. **[6 marks]**

The higher the temperature, the greater the rate of evaporation [1] as more of the molecules will have enough energy to evaporate per unit time [1]

The drier the surrounding air, the greater the rate of evaporation [1] as the difference in concentration between the molecules in the liquid and the surrounding atmosphere will be greater [1].

The more movement of the air molecules above the surface of the liquid [1] the greater the rate of evaporation as drier air will replace the more humid air above the surface of the liquid [1].

The larger the surface area of the liquid [1], the greater the rate of evaporation as more of the molecules will be at the top of the surface / in contact with the air [1].

5. Describe what is meant by the expression $pV = \text{constant}$ and what assumption is being made when using this rule. **[2 marks]**

Pressure x volume of a gas gives a constant value so if one increases the other must decrease [1] or they are inversely proportional to each other [1]. The assumption being made is that there is no change in temperature during these changes [1].

Thermal properties and temperature: Part 1 - Answers

1. Identify and explain some of the everyday applications and consequences of thermal expansion, using a named example in your answer. **[2 marks]**

Any sensible applications i.e. a car tyre, bicycle tyre, hot air balloon etc [1] and how thermal expansion affects the named example stated [1].

2. Describe and explain the how a liquid-in-glass thermometer is made, and what the basic principles are in the design, structure and action of these thermometers. **[6 marks]**

A glass tube is made with a hollow centre and a bulb at the base [1]. This bulb is then filled with a liquid and the tube is sealed [1]. The thermometer is then placed in a mixture of ice and water so the 0 degree Celsius point can be marked at the position the liquid rises to [1]. The thermometer is then placed in boiling water so the 100 degree Celsius point can be marked at the position the liquid rises to [1]. The space in between these two points can then be divided into 100 equal parts to mark out each degree Celsius [1]. These thermometers are useful for day to day use such as measuring the temperature of a room, the surroundings or of a liquid within this range [1].

3. In the context of a liquid-in-glass thermometer, describe and explain the terms sensitivity, range and linearity by correctly using them in sentences. **[3 marks]**

Sensitivity is the ability to distinguish between two temperatures (i.e. a standard liquid-in-glass thermometer has a sensitivity of 1 degree Celsius) [1].

Range is the difference between the maximum and minimum temperature a thermometer can measure [1].

Linearity is when the divisions / gaps in the scale of the thermometer are at evenly spaced temperatures (i.e. like in a standard liquid-in-glass thermometer) [1].

4. Compare the thermal expansion of melting a 200g block of a solid metal, compared to evaporating a 200g liquid of the same metal. **[2 marks]**

The thermal expansion when a solid turns into a liquid is much smaller [1] than the thermal expansion when the same liquid turns into a gas [1].

5. Explain why we have so many different types of thermometers, such as liquid-in-glass thermometers, digital thermometers, infrared thermometers and so on. **[3 marks]**

Each of these thermometers may have a different range, level of precision or sensitivity and this will affect its use [1]. For example, a typical liquid-in-glass thermometer can measure between 0 degrees Celsius and 100 degrees Celsius but only at 1 degree intervals [1] whereas a digital thermometer used in a hospital may have a smaller range (i.e. 30 degrees to 50 degrees) but a greater sensitivity (such as one decimal place, which is useful when trying to identify different grades of fever) [1]. Accept any other sensible comparison between the different types of thermometers.

Thermal properties and temperature: Part 2 - Answers

1. Water with a mass of 800g is heated from 20°C to 40°C. The specific heat capacity of water is 4120 J/kg/°C. Calculate the energy required to raise the temperature of water by this amount. **[2 marks]**

$E = \text{mass} \times \text{specific heat capacity} \times \text{change in temperature}$

$$E = 0.8 \times 4120 \times (40-20) \text{ [1]}$$

$E = 65,920 \text{ J [1]}$ *Note: correct answers and unit required for the final mark. Accept 66,000 J and 66kJ for the final mark.*

2. What is meant by specific heat capacity and how is this different to thermal capacity (without the word specific) ? **[1 mark]**

Specific heat capacity is the energy required to raise 1kg of a substance by 1 degree Celsius whereas the thermal capacity (of an object) is the energy required to raise the temperature of the entire object (say a chair, a table, a block of metal, etc) by 1 degree Celsius [1].

3. What is meant by specific heat capacity and how is this different to specific latent heat? **[1 mark]**

Specific heat capacity is the energy required to raise 1kg of a substance by 1 degree Celsius (without a change in state) whereas the specific latent heat is the energy required to change the state of 1kg of a substance (without a change in temperature).

4. Describe a practical way to find the specific heat capacity of water. **[6 marks]**

Measure the mass of an empty beaker [1]. Collect a fixed mass of water (i.e. 200g) by pouring water into the beaker while it is still on the balance / scales (the mass of the water can be found by subtracting the mass of the empty beaker from the mass of the water and beaker together) [1]. Measure the initial temperature of the water using a thermometer [1]. Use an electric (immersion) heater to heat the water for a fixed amount of time (i.e. five minutes) [1]. Find the change in temperature using the thermometer by subtracting the initial temperature from the final temperature [1]. Use the formula $\text{energy} = \text{power} \times \text{time}$ to find the energy provided to the water, and then the formula $\text{specific heat capacity} = \text{energy} \div (\text{mass of water} \times \text{change in temperature})$ to find the specific heat capacity of water [1].

5. What is the difference between latent heat of fusion and latent heat of vaporisation? Sketch a graph of an ice cube being heated over time at a constant rate and label the key features of this graph. **[4 marks]**

Latent heat of fusion is energy required to change 1kg of a substance from solid to liquid [1] whereas latent heat of vaporisation is the energy required to change 1kg of a substance from liquid to gas [1]. Graph correctly sketched for all states of matter (solid to liquid to gas) [1]. Horizontal line for LHV should be longer than the LHF line [1].

Thermal processes - Answers

1. Compare the structure and properties of a good insulator compared to a good conductor. **[2 marks]**

A good (thermal) insulator does not allow heat energy to pass through it, for example by having air, empty spaces or a vacuum within it. [1]

A good (thermal) conductor allows heat energy to pass through it, for example by having particles close together to pass on the energy (i.e. as in a solid metal) [1].

2. Describe two different real-life examples of convection in action. **[3 marks] + [3 marks] = [6 marks]**

1: The water cycle [1] is powered by thermal energy from the sun causing water from rivers/lakes/seas/oceans to evaporate (into water vapour) [1] before cooling and condensing (back into a liquid) and falling as rain [1].

2: In a pan/kettle etc of hot/boiling water [1] thermal energy from the base of the pan/kettle heats the water and causes it to rise to the top [1] before cooling down again and sinking back to the bottom of the pan/kettle [1].

Accept any other sensible examples [1] with correct descriptions of convection for the second and third marks.

3. How does radiation differ to both conduction and convection? **[2 marks]**

Radiation travels as an electromagnetic/infrared wave [1] and can pass through a vacuum / does not require particles [1] (whereas conduction and convection both rely on particles and therefore cannot take place in a vacuum / empty space etc)

4. Describe the effects of dark, light, smooth, rough, shiny and dull surfaces on incident infrared radiation. Give at least two real-life examples of this in action. **[6 marks]**

Dark / rough / dull (or matt) surfaces are good absorbers and emitters of infrared radiation [1] but poor reflectors [1].

Light / smooth / shiny surfaces are poor absorbers and emitters of infrared radiation [1] but good reflectors [1].

Accept any two real life examples, such as aluminium foil reflecting heat back towards food, or black radiators in cars drawing heat away from hot engines etc.

5. Use each of the following words in a short paragraph about light waves to show how they are all different: transmitted, reflected, refraction, absorbed, emitted. **[5 marks]**

A light wave passing through glass can pass through the glass (this is transmitted) [1], bounce off the glass (this is reflected) [1], enter and remain in the glass (this is absorbed) [1] and later pass back out again from the surface of the glass (this is emitted) or change direction as it passes through (this is refracted).

Thermal Physics Practicals and Calculations - Answers

1. Describe how you would find the specific heat capacity of a liquid such as water using standard laboratory equipment. Clearly state all equipment used and all measurements taken. Explain how you will make your data reliable. **[6 marks]**

Measure the mass of an empty beaker, and then the same beaker with a fixed mass of water (i.e. 200g) by pouring water into the beaker while it is still on the balance / scales (the mass of the water can be found by subtracting the mass of the empty beaker from the mass of the water and beaker together) [1]. Measure the initial temperature of the water using a thermometer [1]. Use an electric (immersion) heater to heat the water for a fixed amount of time (i.e. five minutes) [1]. Find the change in temperature using the thermometer by subtracting the initial temperature from the final temperature [1]. Use the formula energy = power x time to find the energy provided to the water, and then the formula specific heat capacity = energy divided by (mass of water x change in temperature) to find the specific heat capacity of water [1]. Repeat three times and take an average / insulate the beaker [1] to make it more reliable.

2. Describe how you would find the specific heat capacity of a solid block such as aluminium using standard laboratory equipment. Clearly state all equipment used and all measurements taken. Explain how you will make your data reliable. **[6 marks]**

Take a solid block (such as aluminium) containing two holes - one for an electric (immersion) heater and one for a thermometer [1]. Measure the initial temperature of the block [1]. Heat the block for a fixed amount of time such as 5 minutes and then use the equation energy = power x time to calculate the energy supplied to the block [1]. Note the final temperature of the block and subtract the original to find the change in temperature [1]. Use the formula specific heat capacity = energy / (mass x change in temperature) to find the specific heat capacity of the material. To make the data reliable, repeat this process three times and take an average, or insulate the block with a material such as polystyrene [1].

3. If water has a specific heat capacity of 4120 J/kg/°C, how much energy will it take to raise 250ml of water from 20°C to 80°C? **[3 marks]**

$E = \text{mass} \times \text{specific heat capacity} \times \text{change in temperature}$ [1]; $E = 0.250 \text{ kg} \times 4120 \times (80 - 20) = 61, 800 \text{ J}$ (accept 61.8 kJ or 62 kJ) [1]

Note that 250ml of water is 250g of water since water has a density of 1 g/cm³ and 1ml is also 1cm³. This is then 0.250 kg when used in the formula. [1]

4. If you use a kettle which is only 60% efficient, how much energy does the kettle use in total to heat the water in question 3? **[3 marks]**

61, 800 J = 60% [1] therefore 1030 J = 1% [1] and so 1030 x 100% = **103, 000 J** [1]