Chapter 1: Thermal, nuclear and electrical physics

1.1 SECTION REVIEW

REMEMBERING

1 **a** Solid: fixed shape, fixed volume

b Liquid: no fixed shape, fixed volume

c Gas: no fixed shape, no fixed volume

2 Brownian motion: the random motion of small objects suspended in a fluid as a result of their collision with the particles of the fluid

3 Kinetic energy and potential energy

4 A displacement of the particles from their mean position as determined by their intermolecular forces

UNDERSTANDING

1 Since temperature is directly proportional to the average kinetic energy of the particles in a substance, and increase in temperature of a substance is accompanied by an increase in the average kinetic energy of the particles in that substance.

2 **a** Solid: The particles oscillate around a mean position, but the kinetic energy of the particles is insufficient to overcome the bonding caused by the intermolecular forces

b Liquid: The kinetic energy of the particles is sufficient to allow them to move significantly away from their mean position and ultimately slide past one another.

c Gas: The kinetic energy of the particles is sufficient to allow them to break entirely free from their intermolecular bonds

3 Heat always moves from a hotter object to a colder object, so as the temperature of the objects gets very close to absolute zero, there will no longer be any other object that the energy can move to and so the initial object will not be able to be cooled any further.

1.2 SECTION REVIEW QUESTIONS

REMEMBERING

1 **a** The energy a particle has because of its motion

b The energy a particle has due to its position

c The total sum of the kinetic and potential energies of all of the particles within an object

d A measure of the average kinetic energy of the particles in a substance

e The transfer of thermal energy through a substance or between substances

2 The internal energy of a substance will also increase if the average internal energy is also increasing.

3 The internal energy of a substance decreases if the amount of potential energy stored in its intermolecular bonds decreases.

UNDERSTANDING

4 Chemical energy stored in the coal is transferred to heat energy during combustion; this is then transformed to kinetic and potential energy in the water as it turns to steam. The kinetic energy in the steam is transferred to kinetic energy in the rotating turbines.

5 The potential energy in a bond is at a minimum when its particles are at their mean separation, so an increase or a decrease in this length results in an increase of the potential energy stored.

6 Heat is a transfer of energy between objects, whereas temperature is a measure of the average kinetic energy of the particles in an object.

7 An increase in the internal energy of an object can be due to an increase in the kinetic energy of its particles, an increase in the potential energy stored in its bonds or both. Since temperature is a measure of the average kinetic energy of the particles of an object, it will not increase if the increase in internal energy is due to an increase in an object's potential energy.

APPLYING

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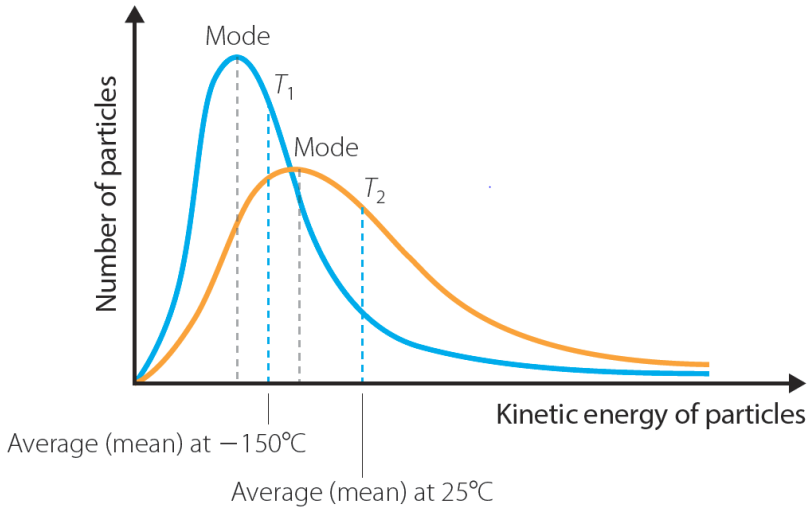

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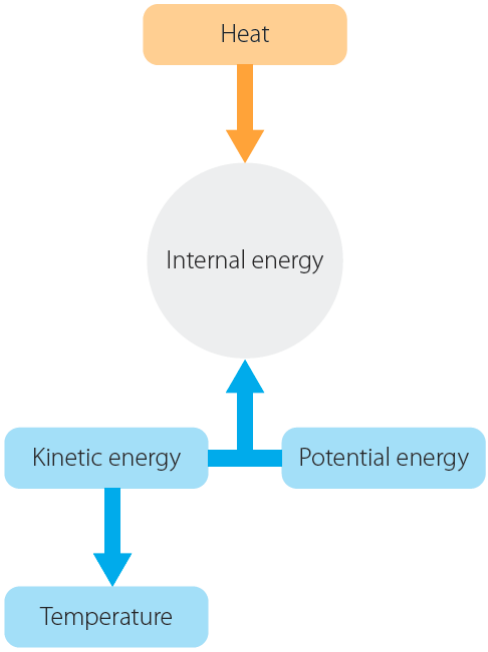

1.3 SECTION REVIEW

REMEMBERING

1 **a** process by which energy is transferred through the collision of atoms

b process by which energy is transferred through the bulk motion of a fluid

c The process of transferring heat energy by electromagnetic radiation.

2 Infrared – Visible – X-Ray

UNDERSTANDING

3 Copper, as with most metals, has many free electrons which can move around the sample unhindered and quickly transport kinetic energy through the sample. Wood has tightly bound electrons that are fixed in place and therefore the transfer of kinetic energy is dependent upon the movement of particles.

4 The water at the top of a body of water is exposed to radiation from the Sun and to conduction with the warmer air, whereas water further down is completely dependent upon the conduction of heat from the upper sections.

5 Heat is transferred from the Sun in the form of radiation until it comes in contact with particles in the atmosphere. Heat from these particles is transferred by either conduction or convection to other particles in the atmosphere until eventually heat is transferred from these particles to the surface of Earth by conduction.

APPLYING

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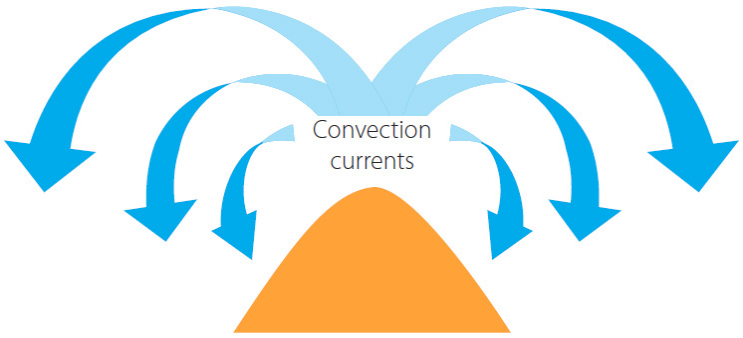

CHAPTER REVIEW QUESTIONS

DETAIL QUESTIONS

1 **a** A physical substance

b The capacity to do work

c The fundamental building block of matter

d A collection of atoms bound together by chemical bonds

e A small portion of matter

f The random motion of small objects suspended in a fluid as result of them being bombarded by the particles of the fluid

g The energy of an object due to its motion

h Energy that is stored in a system due to the configuration and interaction of the bodies within the system

i The sum of the kinetic energy of the particles in a system and the potential energy stored in a system

j A collision between two or more objects in which there is no loss of kinetic energy

k Electrostatic forces of attraction or repulsion between neighbouring particles of a substance

l A measurement of the average kinetic energy of the particles in a substance

m The transfer of thermal energy through a substance or between substances.

n The process by which energy is transferred through the collision of atoms

o The condition that occurs when there are density differences within a fluid; the density differences result in rising and falling currents

p Energy transferred across empty space; the transfer of heat by electromagnetic radiation

2 The large number of particles in any substance together with the fact that they are all constantly moving and colliding with each other means that the motion of any individual particle is impossible to calculate.

CATEGORY QUESTIONS

3 Heat is the transfer of energy between objects, whereas the temperature of an object is a measure of the average kinetic energy of the particles of that object.

4
- All matter is made up of small particles which are in constant motion
- These particles contain kinetic energy due to their motion and potential energy stored in their intermolecular bonds
- Collisions between the particles are perfectly elastic
- The particles obey classical mechanics
- The temperature of an object is proportional to the kinetic energy of its particles

5 Solid: The particles oscillate around a mean position, but the kinetic energy of the particles is insufficient to overcome the bonding caused by intermolecular forces.

Liquid: The kinetic energy of the particles is sufficient to allow them to move significantly away from their mean position and ultimately slide past one another.

Gas: The kinetic energy of the particles is sufficient to allow them to break entirely free from their intermolecular bonds.

6 Different materials have different intermolecular bond strengths that help to keep the particles in place. In a substance with a weaker intermolecular bond strength, an addition of heat would allow the particles to move more freely and therefore collide with more particles, which would spread the heat quickly. A more tightly bound material would impede the freedom of the particles, reducing the amount of collisions and therefore reducing the speed of heat transfer.

7 Different temperatures emit different wavelengths of light. Astronomers are able to estimate the temperature of distant objects by comparing the wavelengths of incoming light to the temperatures that would create them.

ELABORATION QUESTIONS

8 The kinetic particle model explains that heat is the transfer of thermal energy due to either convection, conduction or radiation, while temperature is a measure of the average kinetic energy of the particle in a substance.

9 Even though the total kinetic energy of an object is constant at a fixed temperature, and therefore, so is the average kinetic energy of the particles, the individual kinetic energy of each particle is constantly changing because the particles are constantly undergoing collisions with each other. Therefore, there is no way to know the temperature of an individual particle.

10 If the collisions were not elastic, there would be a loss of kinetic energy during the collisions and therefore the total kinetic energy of the object and the average kinetic energy of the object's particles would decrease over time. This means that the temperature of the object would also decrease with time.

11 The most energetic particles are those that have a kinetic energy above the average kinetic energy of the particles within the substance undergoing cooling. By removing these particles, the scientists are effectively reducing the average kinetic energy of the particles within the object and therefore cooling it down.

EVIDENCE QUESTIONS

12 Caloric was a hypothetical fluid that carried heat from one object to another. The evidence that supported this idea included the fact that heat flows much like a fluid, while the greatest piece of evidence against it is the fact that heat can be transferred through the vacuum of space.

13 The model itself would not be greatly altered as it has been extremely successful in describing the thermodynamic behaviour of objects. The greatest changes would be in the detail that could be used to describe the expected behaviour of heat flow and temperature change of objects as collisions between particles, and the resulting energy changes could be accurately predicted.

14 Einstein's explanation of Brownian motion as being the random motion of particles suspended in fluid due to their collision with smaller particles of the fluid supported the atomic model in that it gave direct evidence of atomic particles.

END-OF-CHAPTER EXAM

1 A

2 C

3 B

4 D

5 B

6 Heat

7 Increasing

8 Internal energy

9 Radiation

10 Thermodynamics

11 The random motion of small objects suspended in a fluid as a result of them being bombarded by the particles of the fluid.

12 The addition of heat will cause an increase in the internal energy of the substance. This could be due to an increase in the total kinetic energy of the substance, which would also cause an increase in the average kinetic energy of the particles of that substance and therefore its temperature, or it could be due to an increase in the potential energy stored in the intermolecular bonds of the substance.

13 The temperature of a substance is directly proportional to the average kinetic energy of the particles of a substance.

14 Heat is the transfer of energy between substances while temperature is a measure of the average kinetic energy of the particles of that substance.

15 the process by which energy is transferred through the collision of atoms

16 When heat is added to a substance, the energy can be transformed into either an increased velocity of the particles or to a change in the distance between particles. An increase in the velocity of the particles would mean an increase in the amount of kinetic energy of the particles, while a change in the distance between the particles would mean an increase in the amount of potential energy stored in the intermolecular bonds.

17 Heat convection occurs due to one area of a fluid being warmer than the rest of the substance. The heat conduction occurring in this region causes the hotter, more energetic particles to move out into the areas containing the cooler, less energetic particles. In this way, heat is transferred throughout the substance.

18 Solid: The particles oscillate around a mean distance, but the kinetic energy of the particles is insufficient to overcome the bonding caused by the intermolecular forces.

Liquid: The kinetic energy of the particles is sufficient to allow them to move away from their mean position and store energy on the form of potential energy. The distance between the particles increases and allows them to slide past one another.

Gas: The kinetic energy of the particles is sufficient to allow them to break entirely free from their intermolecular bonds, which allows the distance between particles to increase greatly.

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