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Level 1 Physics 2021

90939 Demonstrate understanding of aspects of heat

Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of aspects of heat.	Demonstrate in-depth understanding of aspects of heat.	Demonstrate comprehensive understanding of aspects of heat.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

Make sure that you have Resource Sheet L1–PHYSR.

In your answers use clear numerical working, words, and/or diagrams as required.

Numerical answers should be given with an appropriate SI unit.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–8 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area (▨). This area may be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

QUESTION ONE: KEEPING COOL

(a) State the three types of heat transfer.

(1) _____

(2) _____

(3) _____

Masdar City in Abu Dhabi is being developed as one of the world's most sustainable cities.

Source: https://urbanutopiasnet.files.wordpress.com/2018/10/incubator-building.jpg?w=720

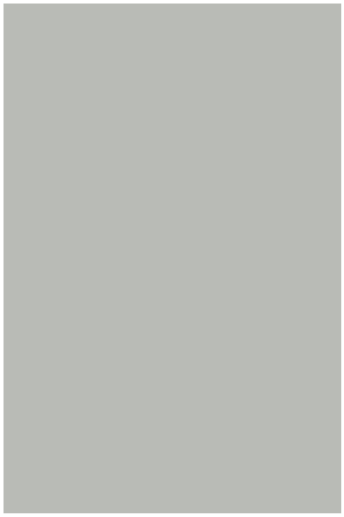
(b) The roof and windows of the building above have a highly reflective coating.

Explain how this helps to keep the inside of the building cool on a bright day.

(c) An office room at 20.5 °C contains 85.8 kg of air. (The specific heat capacity of dry air is 1006 J kg^{-1} $°C^{-1}$.) The sunlight entering through its windows corresponds to an energy influx of 422 W.

Calculate how long it takes to heat the air in the room up to 25.0 °C.

(d) Some buildings have an outer cladding of terracotta. Terracotta is a light ceramic made from clay. It has a highly porous structure, meaning that it contains a lot of empty space that is filled with air.



Source: https://www.ecocladding.com/sites/default/files/Alpha%20Vci_29b.jpg

Explain how the terracotta cladding helps keep the inside of the building cool.

In your answer, you should

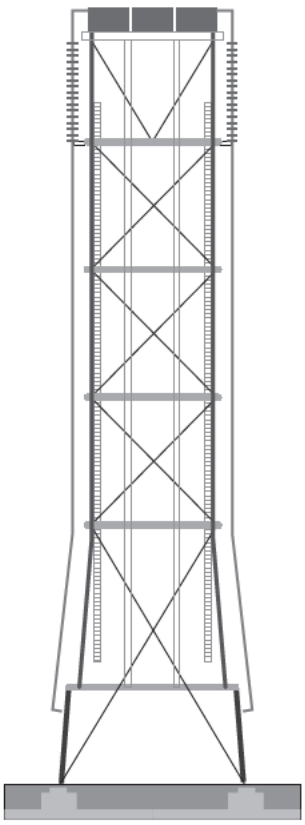
- state the name of the heat-transfer mechanism through the terracotta tiles
- describe, in terms of kinetic theory, how this mechanism allows heat to be transferred through a terracotta tile
- explain why the air-filled porous structure prevents heat from being transferred and helps keep the inside of the building cool.

QUESTION TWO: HOT AND COLD

Masdar City's wind towers are tall, cylindrical structures that allow vertical movement of air through them. They help to keep a lower temperature at ground level by enabling convection currents of air.

(a) On the diagram below right, draw and label the convection currents of warm air.

Source: https://i.pinimg.com/originals/4b/77/90/4b7790d9723a5ae1232bea915347d963.jpg

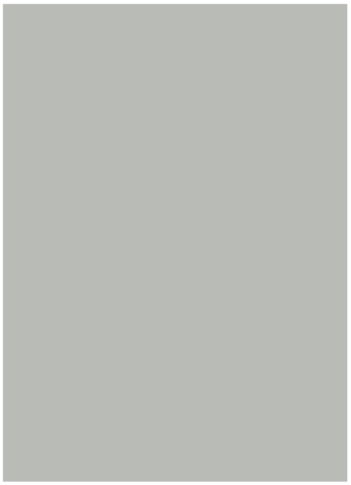


(b) Explain the movement of warm air in the wind tower using kinetic theory.

(c) Masdar City's wind towers are equipped with sensors that can measure wind speed and direction at the top of the tower. Mist jets humidify the air to achieve a further cooling effect at ground level.

Explain, in terms of the specific heat capacities of dry air (1006 J kg^{-1} $°C^{-1}$) and humid air (1884 J kg $°C^{-1}$), why humidifying the air helps to keep the air temperature at ground level cooler.

(d) Abu Dhabi has very hot days and cool nights. Buildings and other structures, such as bridges and road ramps, are therefore fitted with 'expansion joints' as shown in the picture.



Source: https://educalingo.com/en/dic-en/expansion-joint

Explain how an expansion joint allows structures to withstand temperature changes.

In your answer, you should

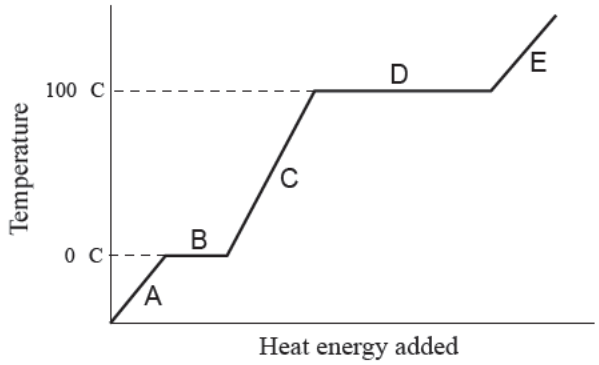
- define 'thermal expansion'
- explain, in terms of kinetic theory, why thermal expansion occurs
- explain how an expansion joint helps to minimise stress due to thermal expansion of the material.

QUESTION THREE: DESALINATION

Source: https://i.pinimg.com/originals/61/18/e5/6118e5fb8d9b155e1321413d3b75ce67.jpg

Masdar City's freshwater supply relies on powerful desalinators that remove the salt from ocean water. This process requires the salt water to be heated, so uses a lot of energy.

(a) Label the phase changes in the heating curve of water below.



(b) As the salt water is heated at a constant rate, its temperature rises to 100 °C and then stays constant at that temperature until all the water is evaporated.

Explain, in terms of kinetic theory, why the temperature of the boiling water does not increase above 100 °C, although it is being heated.

(c) The desalinator receives solar energy at a rate of 3 800 W. The desalinator is operating at 65% efficiency, and it continues to heat the boiling salt water for 40 min (2 400 s).

Calculate the mass of the salt water that would be evaporated during this time.

Start by showing that the energy put into the salt water corresponds to 5 928 000 J.

(d) The desalinator recovers the (pure) water by condensation of the steam that results from evaporation of the salt water. Condensation of steam to water releases energy. This energy can be fed back into the process by using it to heat up the incoming salt water.

Explain why and how this increases the efficiency of the desalination process.

In your answer, you should

- explain, in terms of kinetic theory, why the condensation of steam releases energy
- explain how starting with warmer salt water reduces the energy required for the desalination process.

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

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