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NZQA

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Level 1 Physics, 2015

90939 Demonstrate understanding of aspects of heat

9.30 a.m. Thursday 19 November 2015
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 space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–9 in the correct order and that none of these pages is blank.

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

Merit

TOTAL 14

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QUESTION ONE: MILK TANKS

Dairy farmers store milk in a tank made from stainless steel like the one shown in the photograph.

(a) When a farmer touches an empty stainless steel milk tank with his bare hand, his hand feels cold.

Use physics ideas to explain why his hand feels cold when he touches the tank with his bare hand.

The tank will have a lower temperature than the farmers hand, so when the farmer places his bare hand on the tank, the ~~table~~ tank will ~~fel~~ feel cold as he is transferring heat energy from his hand to the tank.

a

(b) On a sunny day, even though the sunlight falls on only one half of the empty stainless steel tank, the other half also becomes hot.

Use a **heat transfer** method to explain how the heat energy from the **Sun** reaches the tank, and how the **whole** metal body of the tank heats up.

Heat ~~always transfers~~ will be received by the tank from the Sun via radiation of heat from the sun. The whole tank will become warmer because heat energy will always be transfered from hot to cold objects, so the side of the tank receiving heat will then transfer this heat to the other side of the tank until they are both of equal temperatures

(c) An empty tank has a mass of 680 kg. The specific heat capacity of stainless steel is 510 J kg^{-1} $°C^{-1}$. During the day, the tank heats up from 19°C to 28°C.

Calculate the amount of heat energy absorbed by the tank.

Write down your answer in **kilojoules**.

$Q = mc\Delta T$

$= 680 \times 510 \times 9°$

$= 3121200$

Heat energy: 3,121,200 J

a

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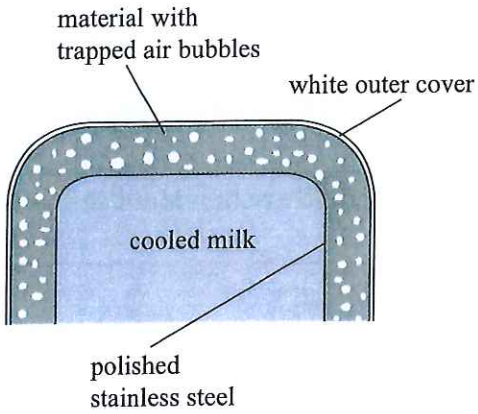
(d) Milk collected from cows on a dairy farm is rapidly cooled and stored until it is transported to a processing factory. The diagram shows an insulated stainless steel tank used to store milk. The tank is initially wrapped using an insulating material with **air bubbles** trapped in it. It is then covered with a **white** waterproof material.

The sketch below shows three main design features of an insulated milk tank.



Explain, in terms of heat transfer, how the design features labelled in the diagram help to keep the milk cool.

White outer cover:

White is not a good conductor of heat energy, but is a better insulator of heat energy. This white outer cover will absorb some heat energy via radiation, but not a large amount.

Trapped air bubble material cover:

The air bubble material will slow down/prevent the transfer of heat energy. Some energy will be transfered through the air bubble material via conduction, but a large amount of this will be prevented due to the air inside the air bubbles not conducting heat very well via conduction, and the lack of space and the sealing off of the air prevents convection currents from being created.

Polished stainless steel inner:

Stainless steel has a silver colouring, which is a very good reflector of heat energy. This stainless steel inner will reflect any heat energy it receives via conduction back to the air bubble material, preventing heat from being transferred to the milk via conduction and prevents the creation of a convection current.

M

A3

QUESTION TWO: MILK PROCESSING

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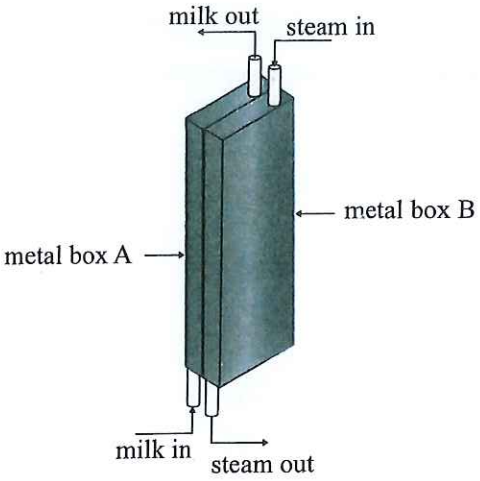
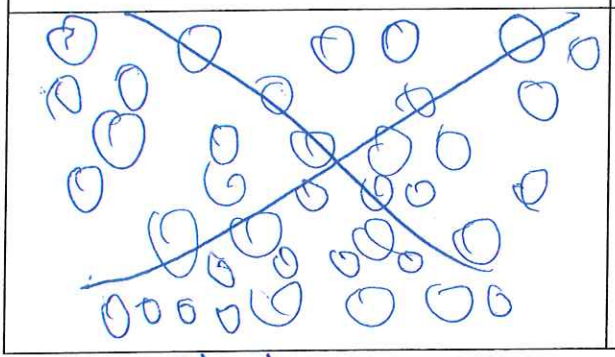
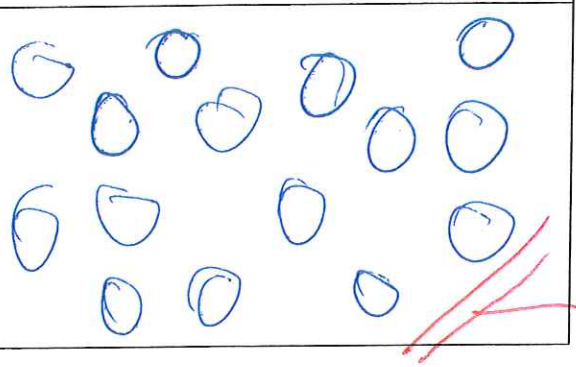
In a milk processing factory the milk is heated to a specific temperature for a very short time. This is done by using a plate heat exchange system. It consists of a series of a very thin metal boxes placed **touching** each other. The diagram shows a pair of metal boxes used in a plate heat exchange system. Cold milk is continuously passed through box A, while steam continuously passes through box B.



(a) In the space given below, draw diagrams to show the arrangement of particles in the hot metal of box B and in the steam.

Particle arrangement in the HOT metal of box B	Particle arrangement in steam
	

Top

Bottom

a

See back

(b) Using a heat transfer method, explain how the heat travels from the metal box B to the cold milk in the metal box A.

Via ~~the~~ conduction and ~~convection~~ convection, heat energy will be transferred from Box B to Box A. The particles in the steam in box B will collide with the sides of the Box, giving the box heat energy. These colder particles will sink to the bottom and out, and will allow any remaining hot particles to move back up, creating a convection current. This energy now in Box B will be transferred ~~to~~ to Box a, because heat travels from hot to cold. The heat energy will then be transferred to the milk in Box A, heating up the milk as it passes through Box A.

a

(c) As the milk passes through the metal box A, its temperature quickly increases whilst still staying in a liquid state.

(i) Describe how the distance between the milk particles changes during heating.

As the particles in the milk gain more thermal energy, they will begin to move further apart from each other.

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(ii) Explain why this occurs.

As the temperatures of the particles increase, the kinetic energy of the particles will increase, causing the particles to move at a faster speed. As the particles gain more thermal energy & move faster, the bonds holding these particles will begin to break, allowing these particles to move further apart, which causes the particles to be less dense.

a

(d) (i) During the heat transfer process, some of the steam at 100°C condenses to water at 100°C.

Show that the energy released to the surroundings when 1.0 g of steam at 100°C condenses to water at 100°C is 2300 J.

Latent heat of fusion of steam is 2 300 000 J kg^{-1}.

$Q = mL$

$= 0.001_g \times 2{,}300{,}000\ J\,kg^{-1}$

$= 2300\ J$

(ii) When 1.0 g of steam condenses to water, 2300 J of energy is released to the surroundings. 8.0 g of milk absorbs 85% of the energy released. The specific heat capacity of milk is 3900 J $kg^{-1}\,°C^{-1}$.

Calculate the increase in temperature of the milk.

$2300 \times 0.85 = 1955$

$Q = mc\Delta T$

$\Delta T = \frac{Q}{mc}$

$= \frac{1955}{0.08 \times 3900}$

$\Delta T = 6.27°C$ (2dp)

Increase in temperature: 6.27°C (2dp)

a

(iii) Some of the heat from the plate heat exchange system is lost to the surroundings.

Using one heat transfer method, explain how the heat energy is lost to the surroundings.

As the Boxes Heat up, they will become hotter than the surrounding particles. Because heat travels from Hot to cold objects, the boxes will begin to transfer heat to their surroundings until they become of an equal temperature. ~~Because~~ Because these boxes are constantly gaining heat, they will continue to radiate heat, causing a loss of heat energy.

A4

QUESTION THREE: IN A CAFÉ

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When making a coffee in a café, milk is heated by passing steam into a jug of milk. When steam passes through the milk, some steam condenses to water.

Latent heat of fusion of steam is 2 300 000 J kg^{-1}.

(a) Use the given context above to explain the meaning of "latent heat of fusion of steam is 2 300 000 J kg^{-1}".

http://democafedonpaco.cadimo.com/wp-content/gallery/preparation-tips/steaming-milk-for-a-cappuccino.jpg

"Latent heat of fusion of steam is 2,300,000 J kg^{-1}" means that in order for 1 kg of steam to condense from steam into a liquid, 1 kg 2,300,000 J of energy is required to be released

a

(b) In the café, take-away coffee is normally served in a paper cup with a lid.

Use one heat transfer method to explain how the lid **reduces** the loss of heat to the surroundings.

Inside the cup, a convection current is created within the fluid, as the hotter coffee will rise to the top of the cup, and the colder coffee sinks to the bottom of the cup. The lid reduces the loss of heat energy, as if there were ~~not~~ no lid, more heat energy ~~wat~~ would escape ~~in the for~~ via radiation and in the form of steam. Having the lid on top of the cup reduces this loss of heat, as the energy is trapped inside the cup, and can only escape via a small hole at the top of the ~~cup~~ cup. This allows the coffee to slowly cool down without wasting heat energy.

http://www.dreamstime.com/illustration/takeaway-coffee-cup.html

m

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(c) (i) The power output of the coffee machine is 1100 W.

Latent heat of vaporisation of water is 2 300 000 J kg^{-1}.

Calculate the time taken to convert 20 g of water at 100°C into steam at 100°C.

E = mL

E = 0.02 × 2300000

E = 46000 J

P = E/t

t = E/P

= 46000/1100

t = 41.82s

Time: 41.82s (2dp)

(ii) The temperature of the boiling water and the steam is 100°C.

State whether 200 g of boiling water at 100°C or 200 g of steam at 100°C has more energy.

Explain your answer.

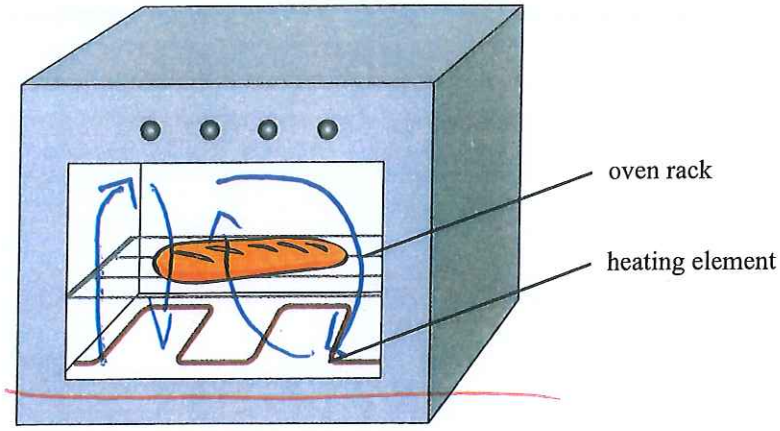
200g of steam at 100°C has more energy than 200g of boiling water at 100°C. This is because the steam has gained more heat energy during its conversion from water to steam. Because the Latent heat of vaporisation of water is 2300000 J kg^{-1}, 200g of steam at 100°C will have 460,000 J of energy more than 200g of boiling water at 100°C.

e

2300000 × 0.2 = 460000 J

Question Three continues on the following page.

(d) The diagram below shows a breadstick being heated in an oven in the café.



(i) On the diagram, draw arrows to show the direction of movement of air **inside** the oven.

(ii) Explain why the air moves in the direction shown by your diagram.

As the air particles in the oven gain more heat energy, they become less dense and rise to the top of the oven. The cooler, denser particles will sink to the bottom of the element where they will gain heat energy from the element, and rise to the top of the element, creating a convection current.

a

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E7

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

QUESTION NUMBER

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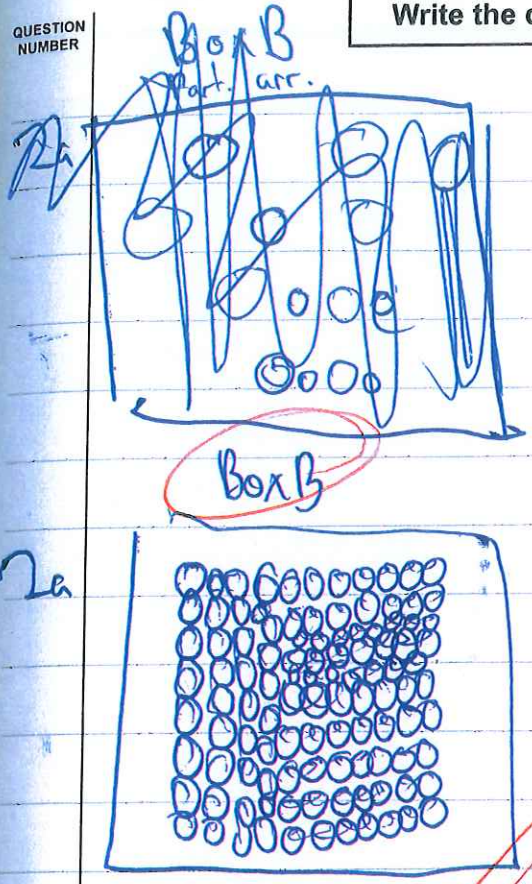

Annotated Exemplars

Merit exemplar for 90939 2015		Total score	14
Q	**Grade score**	**Annotation**	
1	A3	(a) **Achieved.** Clear description of heat transfer from hand to tank but no linkage between heat transfer and conductive properties of steel. (b) **Not Achieved.** Clear description of heat transfer by radiation (from Sun to empty tank) but no clear description of heat transfer by conduction (within the body of the tank) (c) **Achieved.** Correct calculation of the heat energy gain using the information given but no attempt to convert to kJ. (d) **Merit.** One clear explanation of how heat transfer is reduced has been given.	
2	A4	(a) **Achieved.** Correct diagrams for both steam particles and metal particles in solid form are given. (b) **Achieved.** A description of conduction is given but no explanation of the metal particles vibrating and transferring the energy. (c)(i) and (ii) **Achieved.** There is a clear description of the particles getting further apart but no clear explanation that this is because they are vibrating more (d) **Achieved.** There has been a valid method to show the energy released is the value given.	
3	E7	(a) **Achieved.** There is a correct description of latent heat. (b) **Merit.** One valid heat transfer method, and how it has been prevented, has been explained. (c) **Excellence.** The time taken using the information given has been correctly calculated and there is a correct explanation why steam has more energy than water. (d) **Achieved.** Arrows have correctly been drawn to indicate convection currents.	