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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.

Excellence

TOTAL 22

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QUESTION ONE: MILK TANKS

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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.

following principal conservation energy

This is due to conduction. Because steel is a therma conductor, when his hand touched the tank the heat from his hand heats up particles in the steel causing them to vibrate, as they vibrate they knock into other particles causing them to vibrate and so on. Thus the heat energy from his hand is converted into kinetic energy ~~the particles to vibrate~~. Since the tank takes his heat energy ~~(principal of conservation of energy)~~, he feels cold.

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(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.

This is because of conduction. As the steel receives heat from radiation from the sun, the particles (from the tank) convert the heat energy into to kinetic, causing them to vibrate, as they vibrate they bump into other particles such as the shaded ones, (causing them to) ~~and they~~ vibrate (thus) causing the heat to spread throughout the whole ~~metal~~ body. This is only possible as the tanks made of metal meaning it's a thermal conductor, a thermal insulator prevents the vibrations meaning it wouldn't spread if it was made of plastic, wood etc.

a

(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**.

$Q = mc\Delta T$, $Q = 680\text{kg} \times 510\text{Jkg}^{-1}\text{°C}^{-1} \times (28-19)\text{°C}$

$= 3121200\text{ J} = 3121.2\text{ kj}$

Heat energy: 3121.2 KJ

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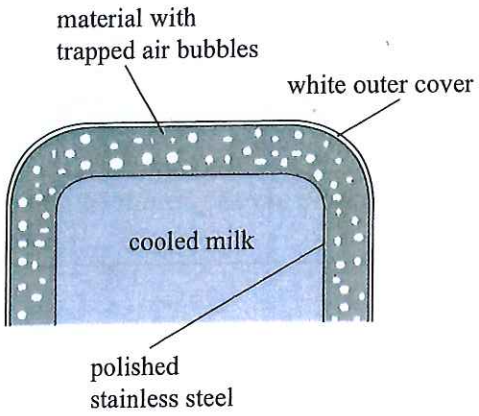
(d) Milk collected from cows on a dairy farm is rapidly cooled and stored until it is transported to a processing factory. The diagram shows an insulated stainless steel tank used to store milk. The tank is initially wrapped using an insulating material with **air bubbles** trapped in it. It is then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

The white cover prevents/reduces radiation. This is because light colours reflect radiation/heat, so by having a white outer cover, the milk is kept cool as most of the heat from outside/the sun is reflected.

e.g.

Trapped air bubble material cover:

This is used to prevent conduction. Air is a thermal insulator and so is material trapping it. This means that heat is not transfered to the milk because the insulators prevent the vibration of particles caused by heat. Thus preventing conduction.

Polished stainless steel inner:

Steel is shiny, meaning it will reflect radiation as shiny materials are the most effective at reflecting heat/radiation. By having the polished stainless steel tank, any heat that seeps through the previous layers is reflected back out, keeping from reaching the milk, thus the milk remains cool.

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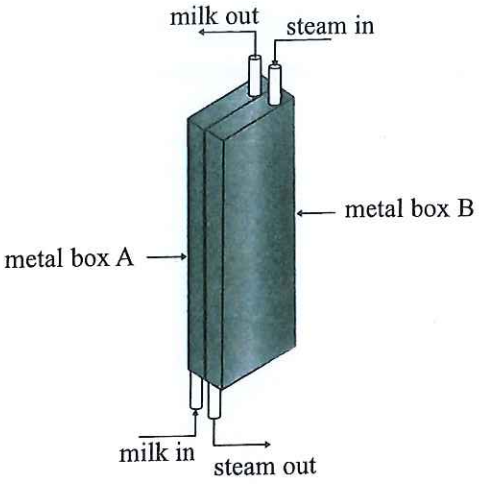
QUESTION TWO: MILK PROCESSING

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
(slightly spaced)	

a

(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.

Metal Box B absorbs the heat from the steam via conduction, the steam particles vibrate slower and are closer to each other now as their ~~metal~~ heat energy is transfered to the metal box. The particles in Box B would be vibrating due to the heat energy and would bump into the particles of ~~of~~ Box A causing them to vibrate (transfering the heat energy). The particles in Box A would then bump into the particles in the milk, heating it up as they vibrate. This is only possible because: milk, metal and steam are thermal conductors

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(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.

The milk particles would spread out more, causing the milk to become less dense

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(ii) Explain why this occurs.

The ~~with~~ milk particles take the heat energy from the metal particles via bumping into each other. This would cause them to vibrate / vibrate faster causing them to spead out ~~as their~~. Causing a less dense milk

M

(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}.

1g = 0.001kg $Q = mL$

$Q = 0.001kg \times 2300000\ J\,kg^{-1} = 2300\ J$

(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 $kg^{-1}\,°C^{-1}$. 8g = 0.008kg

Calculate the increase in temperature of the milk.

$2300J \times 0.85 = 1955\ J$, $Q = mC\Delta T$, $T = \frac{Q}{mC\Delta}$

$T = \frac{1955}{0.008kg \times 3900\ J\,kg^{-1}°C^{-1}} = \frac{1955J}{31.2\ J°C^{-1}} = 62.66 = 62.7°C$

E

Increase in temperature: 62.7°C

(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.

Radiation, because the plate is hotter than it's ~~see~~ surroundings it will radiate heat, causing the atmosphere / surroundings to heat up ever so slightly. Convection as well, the air would carry & the heat as air would be less dense near the plate causing it to take some heat and rise, cooling down as the further it travels and drops picking up more heat and

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QUESTION THREE: IN A CAFÉ

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 is the amount of energy required for ~~a~~ 1kg of a substance to change states. In this case ~~it~~ when the steam condenses, 2300000 Jkg^{-1} (latent heat) is ~~required~~ lost to change steam from a gas to liquid per 1 kg

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.

The lid ~~prevents~~ reduces heat loss by preventing convection of the coffee's heat with the open air. Convection currents occur when there is heat below a free-to-move substance such as air. The heat causes the substance to rise as it becomes less dense due to the heat energy/vibrations. It cools down and drops due to it becoming dense again and heats back up continuing the cycle of siphoning heat. The lid stops this from happening with the air being the "substance" and the coffee being the "heat". Convection currents will still occur in the coffee and there'll still be conduction and radiation causing heat loss but the lid significantly reduces this loss.

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

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(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.

$Q = mL$, $20g = 0.02kg$, $Q = 0.02kg \times 2300000 Jkg^{-1} = 46000 J$

$P = E/T$, $T = E/P$, $T = \frac{46000 J}{1100 W} = 41.8 s$

Time: 41.8 seconds

(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.

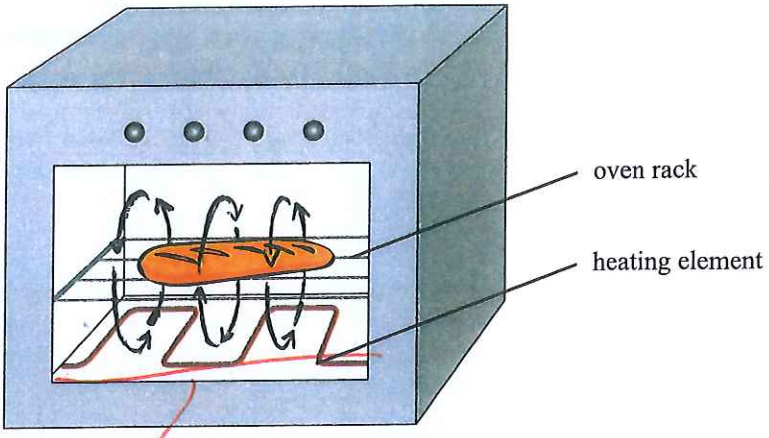
Explain your answer.

200g of steam at 100°C has more energy. Even though they both have the same mass and temperature steam has more energy as it has absorbed, 2300000 × 0.1 = 230000 J of energy to evaporate, becoming steam while the water hasn't / is still in the process of absorbing this amount of energy meaning steam has more energy.

e

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.

Air moves like this because of convection, As the air heats up it becomes less dense due to heat energy → kinetic energy / vibrations. As it rises it cools down, becoming denser causing it to drop and reheat again continuing the cycle of convection currents. The air in the middle revolves oppositely to the sides because of the orientation of the heating element. The element pertrudes towards the front causing air here to rise ~~over~~ while the at the sides the air at the back rises due to the element being at the back.

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

QUESTION NUMBER

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Annotated Exemplars

Excellence exemplar for 90939 2015		Total score	22
Q	**Grade score**	**Annotation**	
1	E7	(a) **Merit** Clear description of heat transfer from hand to tank and linkage between heat transfer and conductive properties of steel. (b) **Achieved.** Clear description of heat transfer by radiation (from Sun to empty tank) and clear description of heat transfer by conduction (within the body of the tank) (c) **Merit.** Correct calculation of the heat energy gain using the information given and correct conversion to kJ. (d) **Excellence.** Two full and correct explanations of how heat transfer is reduced have been given.	
2	E7	(a) **Achieved.** Correct diagrams for both steam particles and metal particles in solid form are given. (b) **Merit.** A description of conduction is given and an explanation of the metal particles vibrating and transferring the energy. (c)(i) and (ii) **Merit.** There is a clear description of the particles getting further apart and a clear explanation that this is because they are vibrating faster. (d) **Excellence.** There has been a valid method to show the energy released is the value given and a correct calculation of the temperature increase and an explanation of the heat transfer method.	
3	E8	(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) **Excellence.** Arrows have correctly been drawn to indicate convection currents, a correct explanation regarding the change in density of the hot and cold air has been given and an understanding that this process is cyclical. .	