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QUALIFY FOR THE FUTURE WORLD
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Level 1 Physics, 2016

90939 Demonstrate understanding of aspects of heat

2.00 p.m. Tuesday 15 November 2016
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.

Useful information for calculation questions is available in the Resource Booklet.

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 2–12 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 23

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QUESTION ONE: COOLING YOUR DRINK

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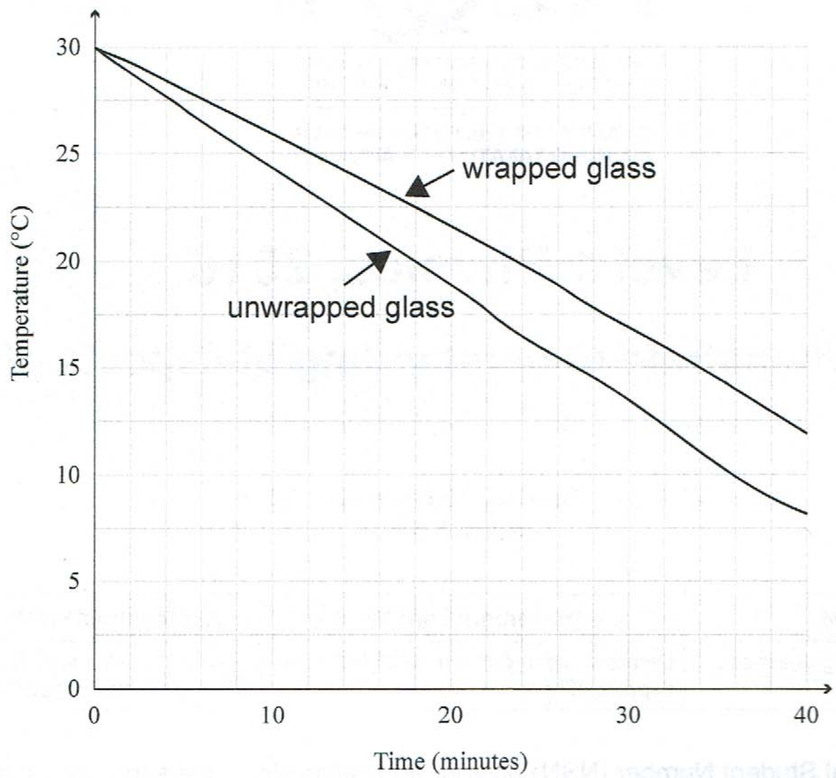
Bill and Ted want to find a fast way to cool down their drinking water in summer. Bill told Ted that if you wrap tissue paper around a drink and then put it in the freezer, it will cool down faster.

They decided to test this theory, so they got two identical glass bottles, and filled each glass bottle with 600 g of water. Bill and Ted then screwed on the caps and wrapped one with tissue paper. Both bottles were placed in the freezer and the results are shown in the graph below.



(a) From the graph it can be seen that both bottles lost heat energy. State where the heat energy was lost to.

The heat energy is lost to the surroundings (the air in the freezer).//

(b) Both bottles were placed on the bottom of the freezer without touching each other.

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Explain, in terms of heat transfer methods, how the unwrapped bottle lost heat energy AND why this bottle would cool faster than the wrapped bottle.

· The unwrapped bottle will lose energy by conduction and convection. It conducts heat away into the bottom of the freezer. It also sets up a convection current because it heats up the air around it, causing the air to expand and rise. The cooler, denser air sinks. This transfers heat to the surroundings.
· The tissue paper in the wrapped bottle acts as an insulator, slowing down the heat transfer and so making the water cool more slowly

(c) The power rating of the freezer is 0.2 kW.

Calculate the time in **minutes** for 600 g of water at 0°C to freeze into ice at 0°C.

$Q = mL$

$= 0.6\,kg \times 330\,000\,J\,kg^{-1}$

$= 198\,000\,J$

$= 198\,kJ$

$t = \frac{E}{P}$

$= \frac{198}{0.2}$

$= 990\,s$

$= 16.5\,min$

Time: 16.5 min

(d) Bill suggested to Ted that they could try a different freezer that had a power rating of **0.4 kW**.

Explain how doubling the power rating of the freezer would affect the time taken for the 600 g of water at 0°C to freeze into ice at 0°C.

- The amount of heat needed to be released to freeze the water stays the same.
- Since $t = \frac{E}{P}$, with ~~th~~ a constant E (heat needing to be released), and double P (power of the freezer), the time taken will be halved.

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E8

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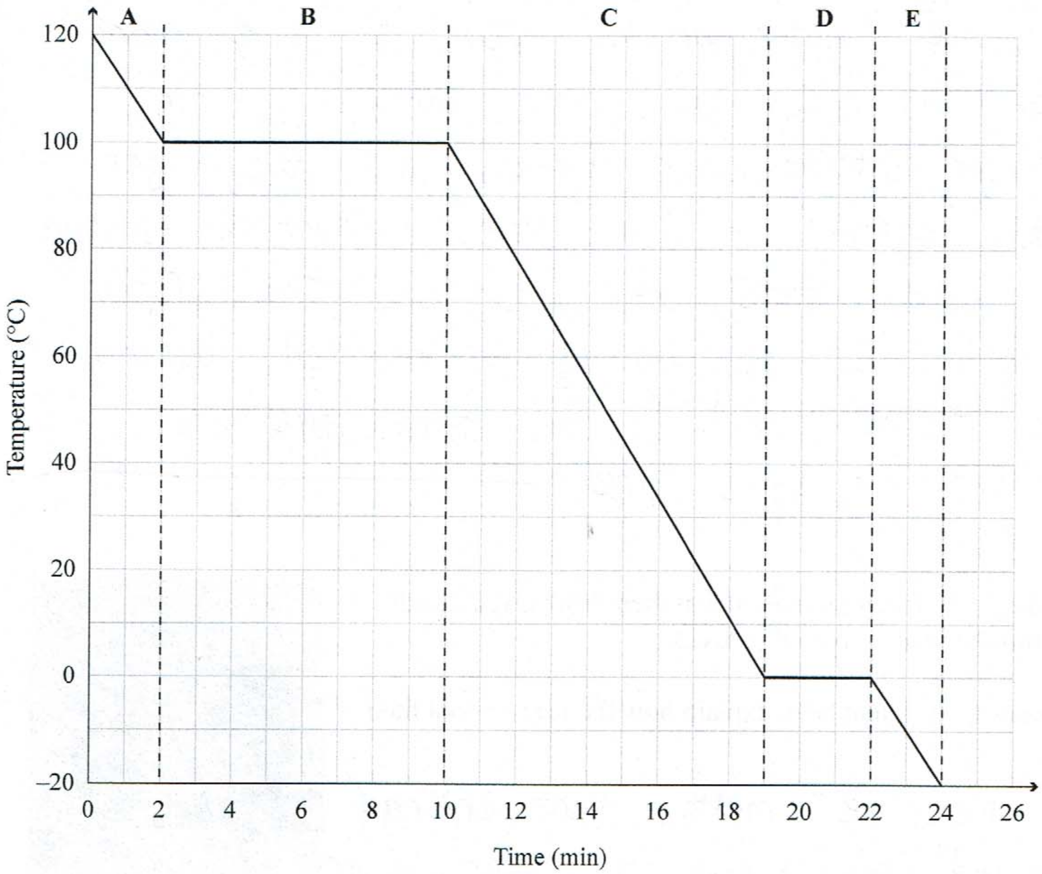
QUESTION TWO: COLD DRINK

Bill and Ted want to learn more about how to cool down their drinks. They look at a graph of cooling water to help them understand the process of cooling.



(a) Use the graph above to give the names of the:

(i) phases (states of matter) of sections A, C and E

Section A: gas Section C: liquid Section E: Solid

(ii) processes occurring during sections B and D.

Section B: condensation Section D: freezing

(b) (i) Give the definition of latent heat.

Latent heat is the amount of heat needed to be absorbed/released by a substance to be able to change state.

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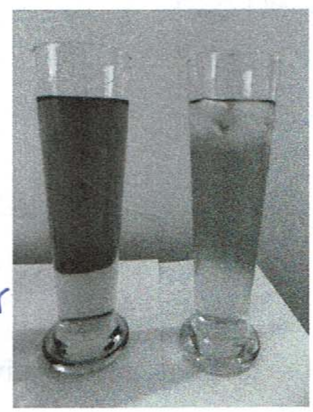
(ii) The graph on the previous page shows that the temperature is constant in Section D.

Explain, in terms of particle motion, what has happened to the water during Section D.

As the temperature of the water ~~reaches~~ decreases ~~0°C~~, the water particles start to move more slowly. At 0°C, the water particles form stronger intermolecular forces, and they get held together in a lattice structure, forming the solid state of water (ice). This process takes time, as energy is released during this process, and so the temperature stays constant for some time.

(c) Instead of using the freezer to cool down their drinks, Ted decides to put ice into their water to cool it down.



Using the concept of latent heat, explain how the ice can cool their drinks.

- When the ice melts, heat energy is needed to break the intermolecular forces between the molecules, and so allow them to flow freely over one another. This heat energy is absorbed from the surroundings.
- Because the ice absorbs heat, the drinks must release heat, and this decreases the temperature of the drinks, thus cooling them down.

(d) Ted then puts some ice into a glass of water.

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Calculate the total amount of energy required to change 65 g of ice at –5°C into 65 g of water at 8°C.

Start by calculating the energy required to raise the temperature of the ice from –5°C to 0°C.

$Q_{-5°C \text{ to } 0°C} = mc\Delta T$

$= 0.065\text{kg} \times 2100\ \text{J kg}^{-1}\ °C^{-1} \times 5°C$

$= 682.5\text{J}$

$Q_{\text{melting}} = mL$

$= 0.065\text{kg} \times 330\,000\text{J kg}^{-1}$

$= 21450\text{J}$

$Q_{0°C \text{ to } 8°C} = mc\Delta T$

$= 0.065\text{kg} \times 4200\ \text{J kg}^{-1} C^{-1} \times 8\ °C$

$= 2184\text{J}$

$Q_{\text{Total}} = 682.5\text{J} + 21450\text{J} + 2184\text{J}$

$= 24\,316.5\text{J}$

Total energy: 24 316.5 J

E7

QUESTION THREE: STAY COOL

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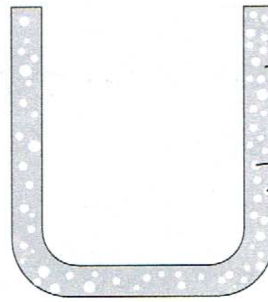
Now that Bill and Ted have cooled their water, they want to keep it cool. They have decided to invest in a bottle holder called a Koozie. A Koozie is usually made from foam rubber that will fit over a bottle. Foam rubber is a material that has been created to have air pockets inside it.



(a) Describe how the foam material of the Koozie helps to keep the drink cool.

The foam is a bad conductor of heat, because it traps air, which is a bad conductor of heat. Because the air is trapped, it cannot transfer heat by convection.

(b) Bill and Ted find that their drinking water is still warming up.

State and explain any modification that could be done to the Koozie to help reduce the rate of heat energy transfer.

- The outside of the Koozie should be lined with silver foil, to reflect away any incoming radiation. Radiation can be absorbed by the ~~Koozie,~~ koozie or the water, leading to it heating up. The ~~Koo~~ silver foil will prevent heating by radiation.

- A lid should be placed on the bottle to stop the air from warming the water in the bottle by convection.

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(c) Bill noticed that water had **condensed** on the outside of the water bottle.

Calculate the mass of the water that condensed if 12 000 J of energy was released during the condensation process.

Give your answer in **grams**.

$Q = mL$

$m = \frac{Q}{L}$

$= \frac{12\,000}{2\,300\,000}$

$= 0.005217\ldots$ kg

$= 5.22$ g (2dp)

Mass: 5.22 g

(d) In their research they found that in some countries people tend to drink hot drinks to try to increase their sweating to therefore lower their body temperature.

(i) Explain how drinking a hot drink could lower a person's body temperature.

· When the person drinks a hot drink, ~~their~~ they start to sweat more. ~~This means~~ when the sweat evaporates, it requires a large amount of latent heat of vaporisation (~~2 300 000~~ 2 300 000 J kg^{-1}) This heat energy is absorbed from the water's surroundings, including the person that released the sweat. This means that the person has released heat to the sweat and so the body temperature of the person decreases.

There is more space for your answer on the following page.

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(ii) Explain why drinking a hot drink in high humidity would be less effective at lowering the body temperature of a person than drinking a hot drink in low humidity.

· In high humidity, there is already alot of water vapour in the ~~air. There is~~ air. There is a maximum amount of water vapour that the air can hold; meaning that in high humidity less excess water can evaporate than at a lower humidity. This means that thee water evaporates more slowly, and the rate of heat loss is slower and so this technique is less effective.

~~Continued next page~~ Continued (pg. 11)

E8

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

QUESTION NUMBER | ASSESSOR'S USE ONLY

3dii - ~~Also, when there is high humidity, some excess water vapour in the air may condense onto the person's body, releasing heat and thus making the person even hotter.~~

Drinking a hot drink in high humidity may even be counter-productive as the heat gained from the drink may be greater than the heat lost through evaporation of sweat, and so the body temperature may increase instead of decrease.

Annotated Exemplars

Excellence exemplar for 90939 2016		Total score	23
Q	**Grade score**	**Annotation**	
1	E8	(a) **Achieved.** This response provides evidence towards Achievement by providing a description of where heat energy was lost to. (b) **Merit.** There is a description of heat transfer by conduction, a description of tissue paper acting as an insulator/poor conductor and a complete explanation of the heat transfer. (c) **Excellence.** This paragraph provides a full answer as there is a complete set of correct calculations including units. (d) **Merit.** There is a clear description and calculation of the time taken being halved and a statement that the amount of energy needed to be transferred is the same.	
2	E7	(a) **Achieved.** Names of processes correct. (b) (i) and (ii) **Merit.** Latent Heat incorrectly defined – it is required or given out for a change of state – but there is a correct explanation of particle motion when water freezes. (c) (i) and (ii) **Achieved.** There is a partial explanation, using the concept of latent heat, of how ice can cool drinks. (d) **Excellence.** There are correct calculations showing the three energy processes adding together for the total energy required and correct units.	
3	E8	(a) **Achieved.** This response provides evidence towards Achievement by providing a description correct description of the bad conducting properties of the trapped air. (b) **Merit.** This response provides evidence towards Merit by providing an explanation of a reasonable modification. (c) **Merit.** There is a correct calculation and a correctly converted final answer from kg to g. (d) (i) and (ii) **Excellence.** There is a full explanation of how sweat lowers a person's body temperature and the effect of changing the humidity level.	