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90939

NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 1 Physics, 2014

90939 Demonstrate understanding of aspects of heat

2.00 pm Tuesday 25 November 2014
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 2–10 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: THE THERMOS FLASK DESIGN

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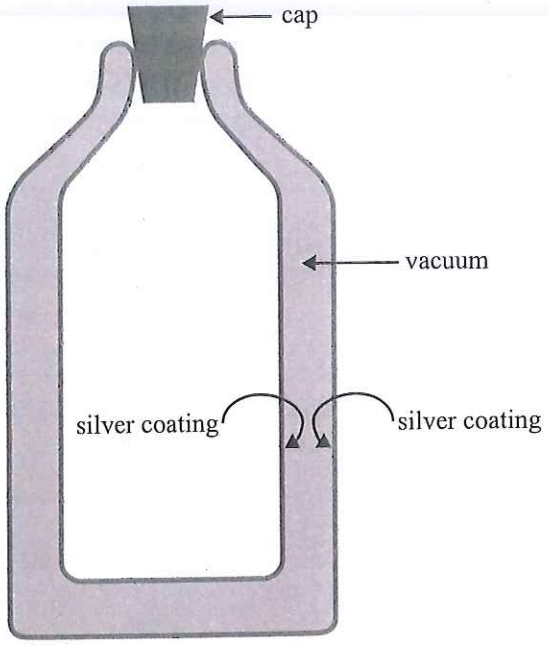

The diagram shows a thermos flask used for keeping hot liquids hot. It consists of two glass containers, placed one inside the other and sealed together at their necks. The air between the walls of the two glass containers is removed to create a vacuum. The inner and the outer glass layers are silvered, and the cap is made of thick plastic.

(a) Explain the purpose of removing the air from between the walls of the two glass containers.

A vacuum is a space which contains no particles. The air (particles) is removed to prevent heat loss via conduction (particle to particle heat transfer) and convection (heat transfer in fluids) as no particles are present to aid the heat transfer. M

(b) Explain why the inner and the outer walls of the thermos flask are silvered.

The walls are silvered to prevent heat loss via radiation (heat transfer in vacuums). The silver coating is highly reflective and so any emitted radiation (from the contents) is reflected back toward the contents thus stopping any heat transfer (to outside) via radiation. M

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(c) The thermos flask can also be used to keep cold things cold. To test the effectiveness of a thermos flask, the flask is initially cooled to 0°C and then 1.2 kg of ice at 0°C is placed inside the flask and the cap is replaced. The flask and its contents are left undisturbed. It is found that after exactly 11.6 hours, all of the ice inside the flask is melted to water at 0°C.

The latent heat of fusion of ice is 3.36×10^5 J kg^{-1}.

(i) Calculate the average rate at which the contents gain heat from the surroundings, in joules per second.

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

$= \frac{(3.36 \times 10^5) \times 1.2}{(11 \times 60 \times 60) + (0.6 \times 60 \times 60)}$ $= \frac{403200}{39600 + 2160}$

$= \frac{403200}{41760}$ $= 9.655 \text{ J s}^{-1}$

$= 9.7 \text{ J s}^{-1}$

Rate of heat gain: 9.7 J s^{-1}

(ii) After all the ice has melted, the thermos flask and its contents are left for a certain time. It is found that the **rate** of heat gain gradually decreases.

Explain why this is so.

As the contents come to have a similar (close to) amount of heat energy as the surroundings the rate of heat gain will decrease until the levels of heat energy are even. Thus no more heat energy can be gained from the surroundings. ~~The rate can be regulated to the right~~

e

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(d) (i) Some hot water is placed in an **empty** thermos flask.

Explain why it is essential for the top of the flask to be closed for the liquid to remain hot over a long period of time.

The lid prevents heat loss/transfer via convection. The lid seals the contents in removing any air flow around the contents which is vital for convection currents to form. When heated, water becomes less dense and rises. Cooler, more dense water then takes its place also gaining heat energy, thus forming a cycle-like current. The lid is also made from plastic which is an insulator (poor conductor) thus removing heat loss via conduction.

(ii) In reality, the hot water in the thermos flask will lose heat over a 24-hour period, even if the top of the flask is closed.

Explain why this happens.

None of the listed methods are completely effective. Some radiation will escape, some of the waters energy will be conducted away by the metal body and so some (small proportion of the energy is lost. Over a period of time, the with energy lost, the water cools and so has lost heat energy.

e

E8

QUESTION TWO: HEATING WATER

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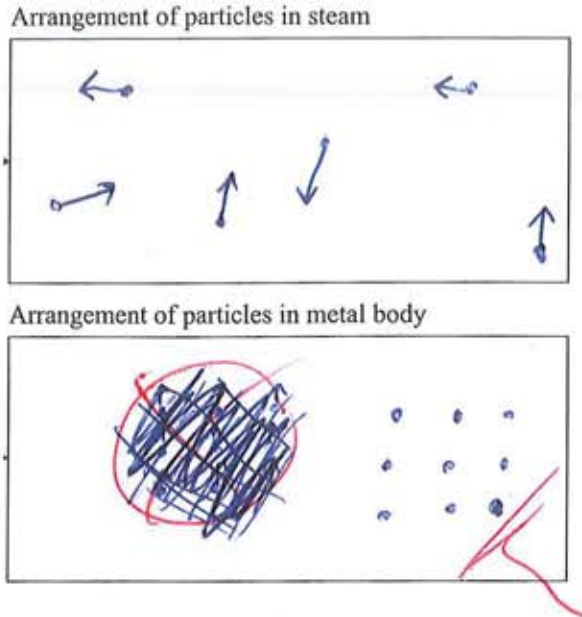

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http://motivationnation.wordpress.com/2007/11/25/212-degrees/

9

(a) The photograph above shows water being heated in a container. As the water boils, steam is produced.

In the spaces given above, draw diagrams to show how the particles are arranged in:

(i) steam

(ii) the metal body of the gas burner.

(b) (i) The metal body of the gas burner is made from iron. When the metal body heats up, it expands.

In terms of the arrangement of particles in the metal body, explain why the metal body expands during heating.

In a solid the particles are close together and strongly bonded together also. As heat energy is gained (heats up) the particles electrons begin to move faster and faster, forcing particles away from each other and thus expanding the metal body.

(ii) Explain why heat energy is needed to convert boiling water at 100°C to steam at 100°C, even though the temperature remains constant during the change of phase.

e p3

The heat energy used to change the phase of a substance is latent heat (in this case latent heat of vaporisation) This large amount of energy goes into breaking the inter molecular bonds that hold the substance together. ✓

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(c) Particles in water are in liquid state, and particles in steam are in gaseous state.

(i) State one similarity between the behaviour of the particles in liquid state and in gaseous state.

In both liquids and gasses the particles/molecules are free to move about each other thus taking the shape of the containing unit.

(ii) State one difference between the particles in liquid state and in gaseous state.

In gases, the particle movement is completely free and individual/random, Each particle moves by itself whilst in a liquid this cannot occur.

M

(d) A liquid is heated with a 150 W electric heater. When the liquid reaches the boiling point, only 85% of the power supplied is absorbed by the liquid to keep it boiling, and the rest is lost to the surroundings.

Calculate the value of the **latent heat of vaporisation** of the liquid, given that 0.0075 kg of the liquid has evaporated in 35 s.

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

$E = pxt = (0.85 \times 150) \times 35$

$= 4462.5$

$Q = mL$

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

$= \frac{4462.5}{0.0075}$

$= 595000\ J\,kg^{-1}$

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Latent heat of vaporisation: $595000\ J\,kg^{-1}$

$\rightarrow 595\ kJ\,kg^{-1}$

E8

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The examination continues on the following page.

QUESTION THREE: SOLAR HEATING

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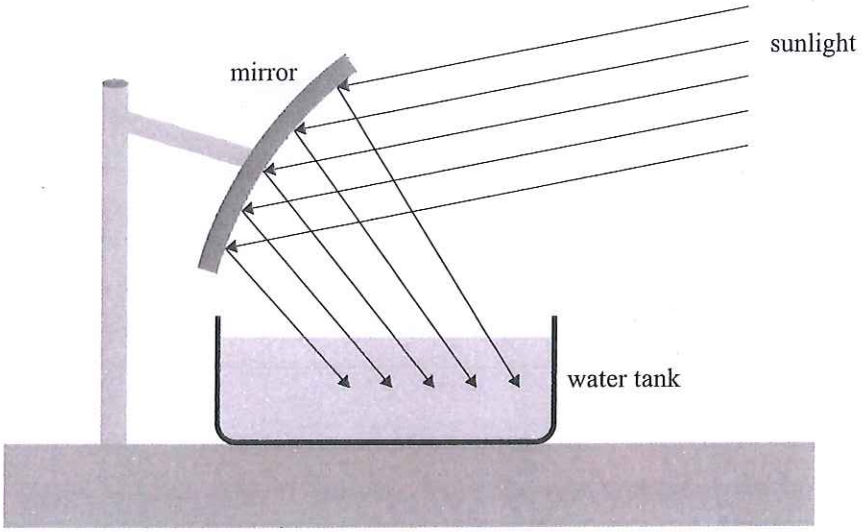
A curved mirror is used to heat water. The mirror focuses the heat energy from the Sun onto a small metal tank containing water, as shown in the diagram below. The mirror is made from a thin sheet of polished stainless steel and it is arranged so that all of the reflected energy is focussed onto the water and the tank.



(a) Name and describe the method of heat transfer from the Sun to the mirror in the above set-up.

Name: Radiation

Description: Energy is transfered in the form of waves (infrared) and so can also be used in a vacuum. (Eg the Sun to the Earth through space) // m

(b) Not all the energy incident on the mirror is actually used to heat the water.

Give TWO reasons why this is so.

Reason 1: Some of the energy is conducted away by the metal tank and thus less energy held by the water. m

Reason 2: Due to the tanks being open topped, the water is open to the air and so some of the water's gained energy is lost to the surrounding air via convection. //

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(c) On a particular day, the average amount of energy received from the Sun at the mirror is 630 joules per square metre per second. The area of the mirror is 1.5 m^2.

Specific heat capacity of water is 4200 J kg^{-1} $(°C)^{-1}$.

Calculate the minimum time taken to raise the temperature of 5.0 kg of water from 26°C to 90°C.

Assume that the entire heat energy incident on the mirror is used to heat the water.

Energy s^{-1} = 1.5 × 630 = 945 J s^{-1}

Energy required to heat water = $mc\Delta T$ = 5 × 4200 × 64 = 1344000 J required.

Time required (minimum) = $\frac{E_{total}}{E\ s^{-1}} = \frac{1344000}{945}$

= 1422.2 s

= 23 min 42.2 s

Minimum time: 23 min 42.2 s

e

(d) State and explain TWO modifications to the set-up shown in the previous page that would increase the efficiency of heating of the water in the tank.

The tank should have a lid to prevent any air circulation (or convection) over the water, as this flow sets up a convection current that removes heat energy from the water and into the surrounding air. The tank should also be made from an insulator / insulating material such as plastic (yeat insulator) as this lowers the likelyhood of heat loss via conduction as the tank would not be able to receive as much energy from the water. Another modification would be the colour of the tank itself. If the tank was darker in colour, more radiation would be absorbed

e

E7

(continued on over leaf)

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

QUESTION NUMBER

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3d as darker colours absorb radiation more easily than lighter ones. This colour change would be highly effective on the proposed lid as this is the focal point from the mirror.

SEEN

Excellence exemplar for 90939 2014		Total score	23
Q	**Grade score**	**Annotation**	
1	E8	(a) **Merit.** Preventing both methods of heat transfer (conduction and convection) are described and explained. (b) **Merit.** Reflection is correctly described and an explanation of why silver is used as the mirror is provided. (c) **Excellence.** There is a full calculation for the rate of heat energy gain and an explanation of why the rate of heat gain decreases. (d) **Excellence.** There is mention of Physics ideas used to explain heat loss (convection) but a limited explanation.	
2	E8	(a) **Achievement.** Correct diagrams for steam particles and metal particles in solid form. (b) **Excellence.** There are full explanations for both the effect of latent heat of vaporisation and for expansion. (c) **Merit.** There is one valid similarity between the particles in liquid and gaseous state and one valid difference. (d) **Excellence.** There is a full calculation to calculate the latent heat of vaporisation including correct units using the information given.	
3	E7	(a) **Merit.** Has correctly identified radiation as the method of heat transfer from the Sun and there is a coherent description of radiation. (b) **Merit.** There are two valid reasons for loss of energy stated; but for Excellence, both should be fully explained. (c) **Excellence.** There has been a valid method used to calculate the time taken. (d) **Excellence.** Two valid modifications are stated, both with valid explanations.	