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Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 1 Physics, Earth and Space Science 2024

92047 Demonstrate understanding of a physical system using energy concepts

Credits: Five

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of a physical system using energy concepts.	Explain a physical system using energy concepts.	Analyse a physical system using energy concepts.

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.

Pull out Resource Booklet 92047R from the centre of this booklet.

Show ALL working.

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 2–12 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area. This area will be cut off when the booklet is marked.

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

Excellence

TOTAL 21

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QUESTION ONE: ENERGY CHANGES

Janet drops a tennis ball from the top of a building.

(a) Describe the energy changes (transfer) that take place as the ball falls down.

As the ball falls down from the top of the building to the Earth's surface, the gravitational potential energy of the ball is converted to kinetic energy as it falls, Some of which is wasted on heat and sound energy.

(b) The mass of the tennis ball is 0.0585 kg. The tennis ball falls through a height of 14.7 m.

Show that the gravitational potential energy the ball loses as it falls to the ground is 8.6 J.

Gravitational Potential Energy lost by the ball

$E_p = mg\Delta h \quad = 0.0585 \times 10 \times 14.7$

$E_p = 8.5995$ Joules $= 8.6$ Joules

(c) Calculate the speed with which the ball hits the ground.

As the ball falls its E_p is converted into E_K, wherefore $E_p = E_K$

Speed at which the ball hits the ground

$\sqrt{\frac{2E_K}{m}} = v \quad \sqrt{\frac{2 \times 8.6}{0.0585}} = 17.146 \text{ ms}^{-1}$

$V = 17.15 \text{ ms}^{-1}$

(d) In reality, the speed of the ball when it hits the ground is not the same as what was calculated in part (c) above.

Explain the reason for this difference, including a statement whether the speed was more or less than what was calculated above.

When the ball hits the ground, the speed is less than that calculated above in part (c). The reason for this is that friction/air resistance is slowing the ball down, decreasing its speed as it falls towards the surface of the Earth.

(e) Janet's friend Maya retrieves the ball from the ground and runs up two flights of stairs, covering a total height of 15 m. Maya has a mass of 48 kg and she takes 34.2 seconds to reach the top.

Calculate the power.

- Begin your answer by describing the meaning of power and how it relates to Maya running up the stairs.
- State any assumptions you make.
- Include a unit with your answer.

Power is the rate at which work is done, and it can be determined by the Joules of energy that an object has, and the time taken (in seconds) for the object to create that power. This relates to Maya running up the stairs as she is using her energy to do work over a specific period of time. We are assuming that the mass is including Maya's mass and the mass of the ball.

Force used to run up 2 flights of Stairs

$F = mg$

$F = 48 \times 10$

$F = 480$ N (Newtons)

work done by Maya

$W = Fd$

$W = 480 \times 15$

$W = 7200$ J (Joules)

Power that Maya uses to reach top of the building

$\Delta E = Pt$

$P = \Delta E / t$

$P = 7200 / 34.2$

$P = 210.526$ W

$P = 210.53$ W (watts)

QUESTION TWO: THERMAL ENERGY

Oliver wants to be able to keep his water cool the whole day while he is at school. Firstly, he tries freezing a bottle of water to take to school. Over the day, Oliver finds that it takes a long time for the ice to melt. Once the ice has melted, the water gets to room temperature quite quickly.

The specific heat capacity of water = $4200\ \text{J kg}^{-1}$
The latent heat of fusion = $334\,000\ \text{J kg}^{-1}$
Mass of water in the bottle = 0.750 kg (750 mL)

(a) What does the term 'latent heat of fusion' mean?

The term 'latent heat of fusion' is referring to the Joules of energy required per kg of the substance to undergo a change of phase/state from a solid to a liquid or a liquid to a solid without a change in temperature of the substance.

(b) Calculate the heat energy required for 0.750 kg of water to change state from solid to liquid.

Thermal Energy required for water to change state from solid to liquid

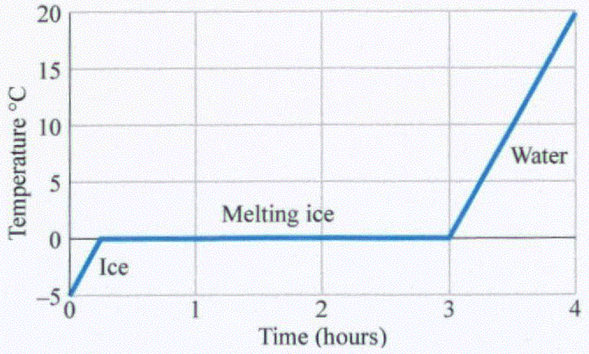
$E = mL \quad = 0.750 \times 334000$

$= 250500$ Joules $= 250.5$ kJ

(c) The temperature against time graph below shows what happens to ice when taken out of the freezer.

Use the information provided opposite and the graph below to describe the reason why it takes a longer time for the ice to completely melt, and a much shorter time for the melted water to get to room temperature.

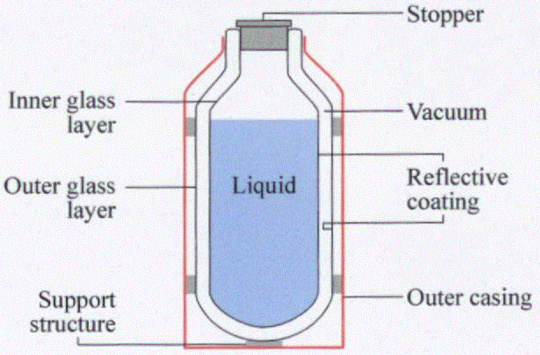
Temperature against time graph for ice left outside



By analysing the information/graph provided, we can see that it takes over 3 hours for the ice to completely melt, and only one hour for the water to reach room temperature. The reason for this is that it takes a lot of thermal energy to break the bonds of the particles in solids, so that it can turn into a liquid.

(d) Oliver next decides to try using a Thermos that holds the same volume of water as his earlier bottle. The Thermos flask is also known as a vacuum flask. It is a double-walled glass vessel that is designed to minimise heat transfer by keeping hot things hot, and cold things cold.

Describe TWO key features of a Thermos that reduce heat transfer, and explain the type of heat transfer each feature is designed to reduce.



1. The reflective coating on the Thermos is designed to reduce the effects of radiation. The Thermos is designed so that the thermal energy from the liquid will reflect off the coating and serve its purpose by keeping the liquid hot or cold.

2. The stopper on the Thermos is designed to reduce the effects of convection. When a liquid is heated or cooled, the particles gain or lose thermal energy. The stopper is designed to prevent this thermal energy from escaping the Thermos, serving its purpose and keeping

(e) Oliver decides to test his Thermos, and finds that at the start of the day, the temperature of the water is 5 °C. Five hours later, he finds the temperature has risen to 12 °C.

Show that the average rate of thermal energy absorption of the water in the Thermos over the five hours is approximately 1.2 W.

Thermal energy of the water in the Thermos

~~E = mcΔT~~ E (thermal) = mcΔT

E = 0.750 x 4200 x 7

E = 22050 Joules

Average rate of thermal energy absorption of water over five hours

ΔE = pt

p = ΔE/t

~~p = 22050/~~ t = 60 x 60 x 5 = 18000 Seconds

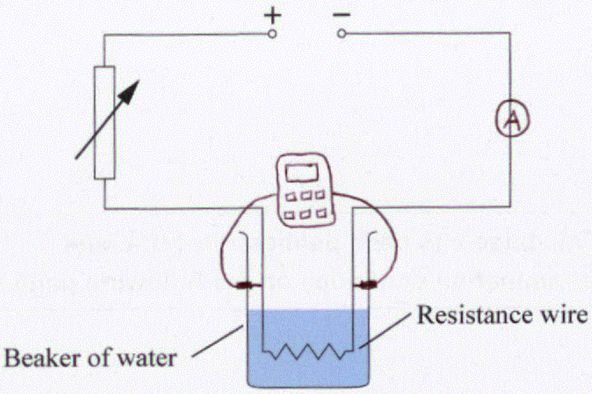
p = 22050/18000

p = 1.225 W

p = 1.2 watts

QUESTION THREE: ELECTRICITY

Tane is studying the relationship between current, voltage, and resistance. He uses a power supply, a variable resistor, and a piece of resistance wire submerged in a beaker of water. He connects the components as follows:

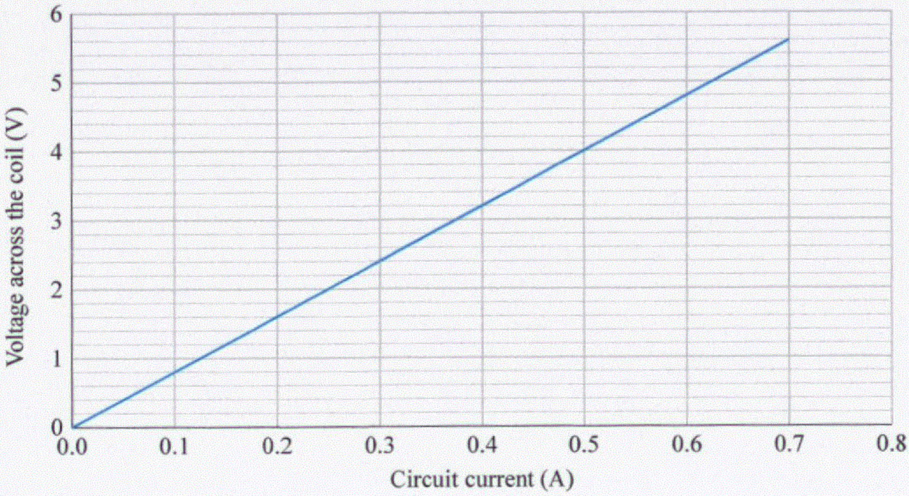


(a) In the above diagram, include an ammeter to measure the circuit current and a voltmeter to measure the voltage across the coil of wire.

(b) The following graph shows the relationship between voltage and current.

Using information from the graph, calculate the resistance of the coil and include an appropriate unit.

Show your working clearly.



Resistance of the coil

$V = IR$

$R = V / I$

$R = 5.6 / 0.7 = 8\ \Omega$

$R = 8.0\ \Omega$ (ohms)

(c) Give a reason why the wire is submerged in water during the experiment.

During the experiment, the coil of resistance wire is submerged in water so that the resistance wire doesn't get ~~[illegible]~~ too much current flowing through it at one time, which will prevent the wire from getting too hot and exploding, breaking the circuit.

(d) Using the data from the graph, what is the maximum rate of electrical potential energy being used?

Include units with your answer.

Maximum rate of electrical potential energy being used

$P = VI$

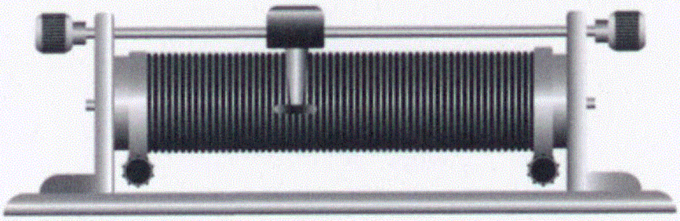
$P = 5.6 \times 0.7$

$P = 3.92$ w (watts)

The maximum rate of electrical potential energy being used is 3.92 watts of power.

Question Three continues on the following page.

(e) One of the components in the circuit is a variable resistor.



https://stock.adobe.com/nz/search?k=%22variable%20resistor%22

Explain how the variable resistor is used, and analyse the effect it has on both the current and the voltage for components in the circuit, as the resistance is increased.

The variable resistor in the circuit is used to slow down the flow of electrons in the circuit, also known as current. If you slide the resistor to the left side of the metal bar, this decreases the resistance, allowing the electrons to move quickly around the coiled wire until they get to the other side of the variable resistor, where they carry on through the circuit and come back around to repeat the process again. However, if you slide the resistor to the right side of the metal bar, it increases the resistance, forcing the flow of electrons to decrease and move slowly around the coiled wire.

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

QUESTION NUMBER

Pg 5 Question 2 D: Serving its purpose and keeping the drink either hot or cold.

Pg 10 Question 3 E: As the resistance in the circuit is increased, the current ~~decr~~ decreases, meaning that the components in the circuit will have less current ~~f~~ flowing through them in a specific time period. For example, if there was a bulb in the circuit, and there was a decrease in current, the bulb would become dimmer because there is no longer the same number of electrons flowing through the bulb in a specific time period. An increase in resistance in the circuit will ~~cau~~ cause the voltage in the circuit to decrease. The voltage in a circuit is the power supply which pushes the current around the circuit. If there was an increase in resistance there would be a decrease in the voltage available for the components in a specific time period.

Pg 5 Question 2 C: However, the particles in liquids are moving around a little more freely, and it doesn't take very much thermal energy to increase the temperature of water.

Pg 3 Question 1 E: we are also assuming that the work done by Maya to climb to the top of the building is equal to the Joules of energy used to climb to the top of the building.

Excellence

Subject: Physics, Earth and Space Science

Standard: 92047

Total score: 21

Q	Grade score	Marker commentary
One	7	Correct description of energy loss, and correct calculation of the speed that the ball would hit the ground. The loss of energy due to friction of air particles hitting the surface of the ball is not given. Correct definition of power and has mentioned an assumption, along with correct calculation of work done and power.
Two	7	Correct definition of latent heat, which includes no change in temperature. Correct calculation of latent heat. Explanation of the graph does not include the idea that the latent heat value is greater than the specific heat value. Candidate has linked the coating with radiation, and the stopper with convection, but has not adequately explained these. Candidate has correctly calculated the energy and the power for the Thermos heating up.
Three	7	In the first diagram this candidate has not labelled the voltmeter. An explanation of why you would keep the resistance wire under water is given. The calculation of power is correct, with the correct unit. This candidate has explained what happens to the current when the variable resistor is adjusted, but there is no discussion around the voltages in this circuit.