Name: ______________________________ (   )   Class: _____

華僑中學
HWA CHONG INSTITUTION
Sample Paper B

PHYSICS
Paper 2

Level: Secondary Three
Duration: 1 hour 45 min

Do not open this booklet until you are told to do so.

INSTRUCTIONS TO CANDIDATES

Write your name, index number and class on the top of this page.

Answer the questions in **Section A and B** in the spaces provided. All workings must be shown.

In **Section B**, for **Question 8** answer '**EITHER**' or '**OR**'.

INFORMATION FOR CANDIDATES

In **Sections A and B** the intended marks for each question or part of a question are given in brackets [ ]. Any working should be done in the space provided.

When necessary, take g to be 10 m s^{-2} or 10 N kg^{-1}

SECTION A (40 MARKS)

1) In Oishi Sushi restaurant, after customers had placed their orders via a touch screen menu, shortly after, automated carriers would transport the ordered food from the kitchen to them via high speed tracks. After the customers had removed the food from the carriers, they would press a button located at their booths to send the carriers back to the kitchen. Fig. 1.1 shows two such empty carriers **A** and **B** on separate tracks at booths 1 and 2 respectively. Both carriers were at rest and directly below the booth buttons.

Image source: http://www.canstockphoto.com/illustration/shinkansen.html

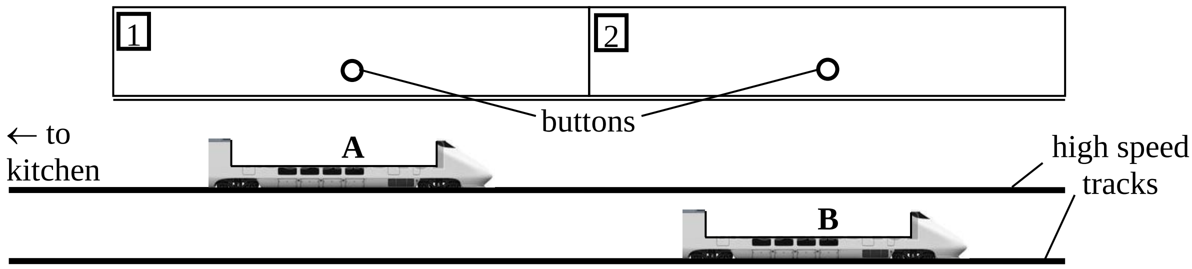

Fig. 1.1

Fig. 1.2 represents the motion of carriers **A** and **B** over a period of 25 seconds.

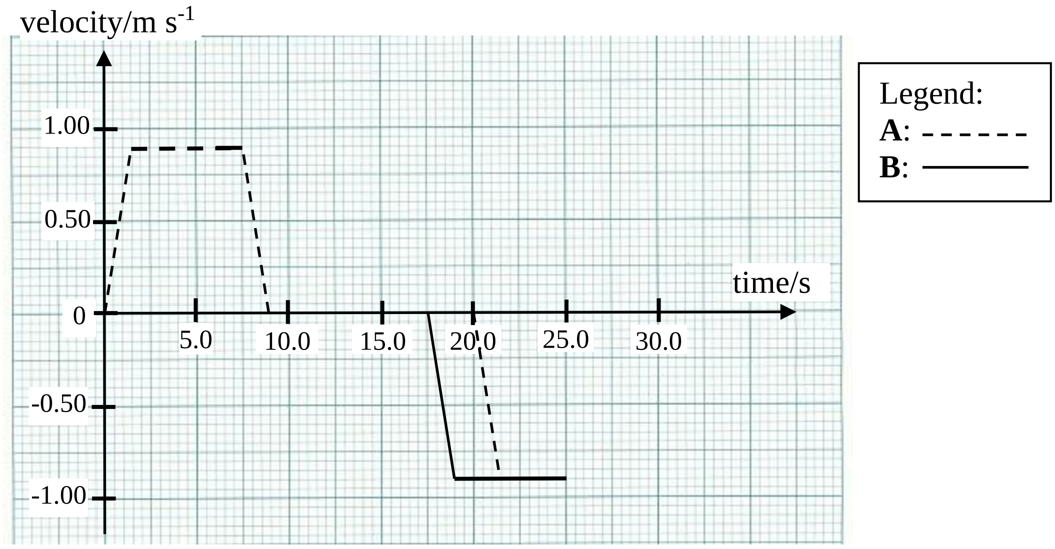

Fig. 1.2

At t = 0 s, carrier **A** was at the kitchen whereas carrier **B** was at booth 2.

(a) Describe the resultant force acting on carrier **A** for its journey from the kitchen to booth 1. [3]

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(b) Carrier **A** was transporting a bowl of soup from the kitchen to booth 1. On Fig. 1.3, sketch the soup level if carrier **A** had

(i) moved with constant velocity, [1]

(ii) suddenly accelerated from rest. [1]

(i) (ii)

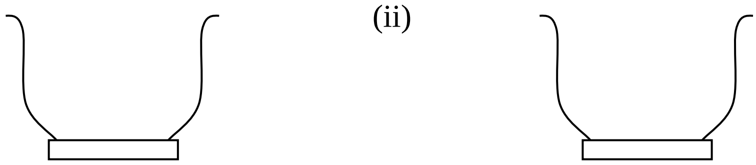

Fig. 1.3

(c) Both carriers were at rest at booths 1 and 2 during a common time range from t_1 s to t_2 s. State the values of t_1 and t_2. [1]

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(d) Given carrier **B** left booth 2 and was directly below carrier **A** just when it was about to leave booth 1,

(i) calculate the distance between the two booth buttons. [2]

(ii) determine the magnitude and direction of carrier B's initial acceleration. [2]

2) Fig. 2.1 shows a scale diagram of the paths of light rays from an object point **P** passing through a thin converging lens **L** of focal point **F**.

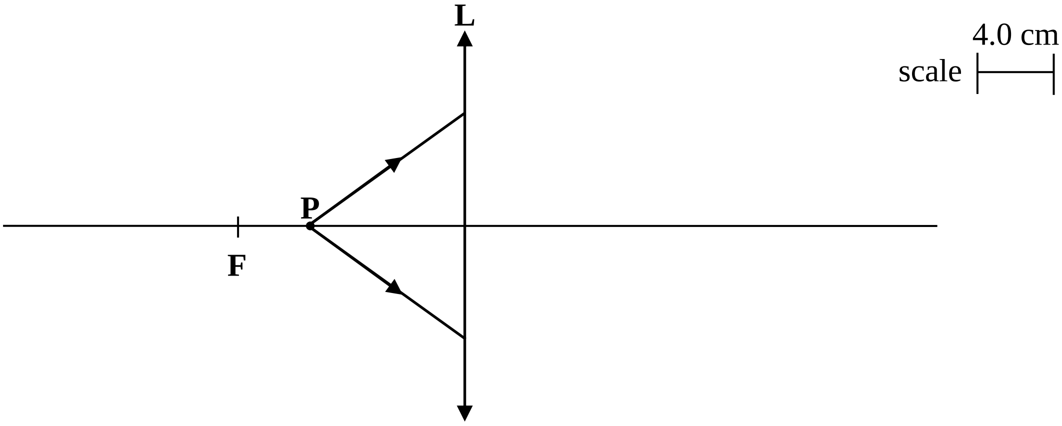

Fig. 2.1

(a) Given the image is 24.0 cm from the lens, on Fig. 2.1, mark out the position of the image and label it **I**. [1]

(b) On Fig. 2.1, complete the path of the two rays to show how the image **I** is produced by the lens. Show any construction lines clearly. [2]

(c) Explain, in terms of light rays, if image **I** is a real image or virtual image. [2]

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3) Fig. 3.1 shows a cycle pump connected to an airtight glass flask and a pressure gauge.

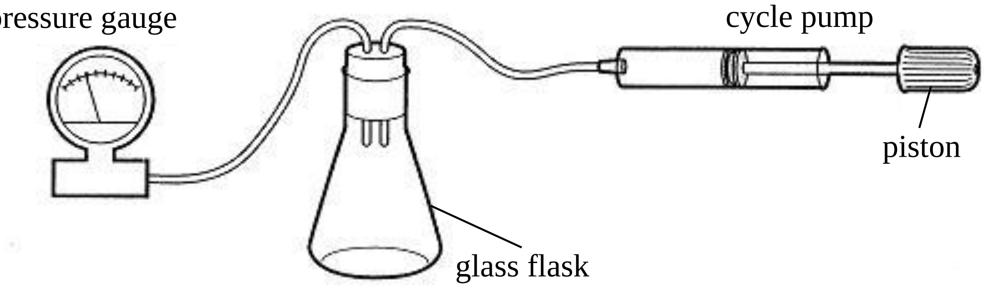

Fig. 3.1

(a) State the change in the reading on the pressure gauge when the piston of the cycle pump was pushed in slowly. [1]

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(b) Using the kinetic model of matter, explain how the pressure change in (a) occurred. [3]

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(c) Describe another method to bring about the same pressure change in (a) other than pushing in the piston of the cycle pump. [1]

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4) Fig. 4.1 shows a trapezoidal rough wooden block **PQRS**. A hand exerted a constant force of magnitude f along **PQ** on a brick of mass 1.2 kg to slide it continuously at constant speed from **P** to **Q.** Subsequently, the brick is moved from **Q** to **R** and pushed off the edge of side **R** so that it dropped vertically to the ground as shown.

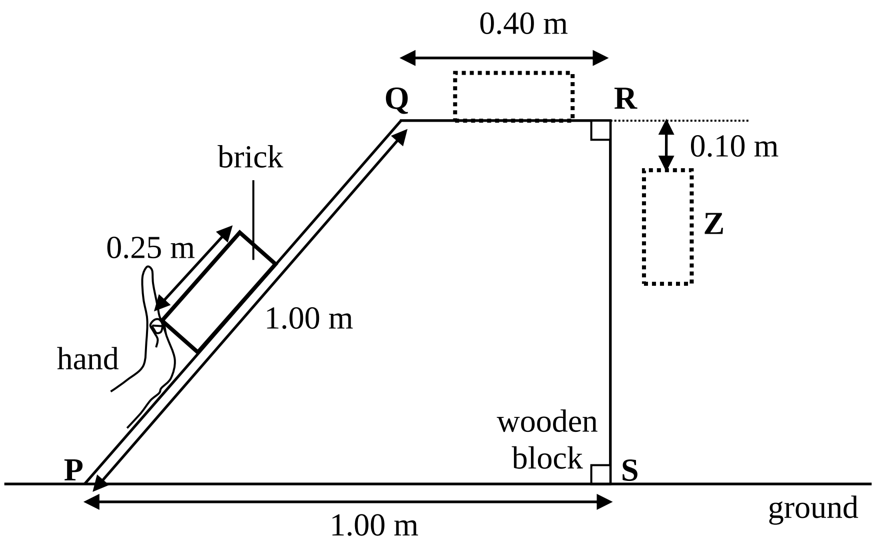

Fig. 4.1

(a) State a pair of action-reaction forces involving the brick as it moves from **P** to **Q**. [1]

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(b) Calculate

(i) the work done against gravity to move the block from **P** to **Q**. [2]

(ii) the magnitude of constant force f if work done against friction was 2.4 J as it moved from **P** to **Q**. [2]

(c) When the block was at position **Z** as shown in Fig. 4.1, its velocity was 2.0 m s^{-1}.

(i) If the block was falling freely, calculate the time taken to reach the ground from position **Z**. [3]

(ii) Explain, in terms of forces acting on the block, how the time calculated in (c)(i) would differ if air resistance were present as it fell to the ground. [2]

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5) Fig. 5.1 shows the displacement-time graph of a particle of a visible light wave of wavelength λ.

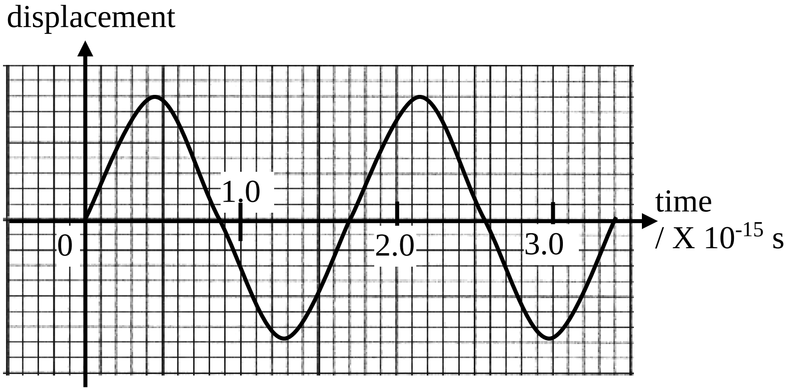

Fig. 5.1

colour	wavelength / nm
violet	380 – 450
blue	450 – 495
green	495 – 570
yellow	570 – 590
orange	590 – 620
red	620 – 750

Fig. 5.2

(a) (i) Calculate the frequency of this wave. [1]

(ii) Given the speed of light in air is 3.0×10^8 m s^{-1}, determine λ, the wavelength of this wave. [2]

(b) A light ray of wavelength λ is incident on a glass prism as shown in Fig. 5.3.

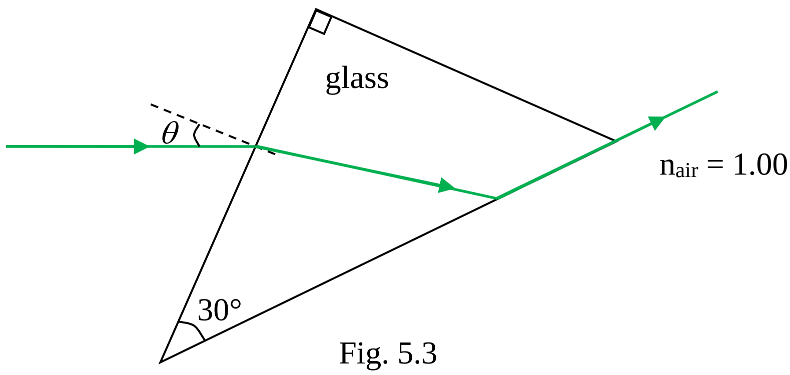

Fig. 5.3

(i) If the absolute refractive index of the glass prism for this light is 1.47, calculate the critical angle for this light passing from glass into air. [2]

(ii) Using your answer from (b)(i), calculate the value of the angle θ. [2]

(iii) Using information from Fig. 5.2, state and explain the change in the absolute refractive index of glass if the light ray of wavelength λ is replaced by a ray of red light directed along the same path with an angle of incidence of θ. [3]

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SECTION B (30 Marks)

Answer question Q6, Q7 and either Q8A or Q8B in this section

6) In the quest to harness alternative sources of energy, solar energy is one of the most popular option. Solar cells or photovoltaic (PV) cells are used to convert light energy from the sun into electrical energy. Currently, the semiconducting materials used in PV cells are either crystalline silicon wafers or thin, good light-absorbing films deposited on coated glass or stainless steel sheets.

Image source:
http://www.engineering.com/SustainableEngineering/RenewableEnergyEngineering/SolarEnergyEngineering/Photovoltaics/tabid/3890/Default.aspx

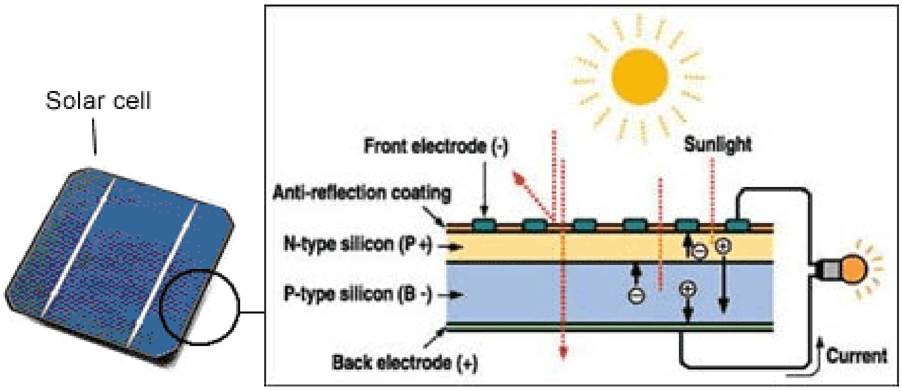

Fig. 6.1

Fig. 6.1 shows a PV cell made up of two layers of chemically treated crystalline silicon (which is the N-type silicon and the P-type silicon) bonded together. When sufficient light energy falls on the cell, the positive and negative charges move across the boundary of the layers to create a voltage difference between the front and the back of the cell.

Typically, the voltage, V, provided by a PV cell is about 0.5 V and the maximum current, I, which can be drawn is about 3 A. By soldering 36 PV cells in series for example, the result is a PV module which provides a voltage of 18 V and delivers a maximum power output, P, of 54 W, given power, $P = VI$.

In recent years, there has been more research done on "Black silicon" or crystalline silicon PV cells that have been treated so that they appear to be black on the surface in hope that this technology would increase the efficiency of the PV cell.

(a) Suggest a reason why treating the silicon PV cells black would possibly increase its efficiency. [1]

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(b) (i) A crystalline PV module combines 40 PV cells of 0.5 V, 3 A in series. Calculate the maximum power output, in W, delivered by this PV module. [2]

(ii) 10 such PV modules in (b)(i) are mounted in a PV array. If a household has 2 such PV arrays to support its daily consumption of energy which is 31.6 kW h (kilowatt hour) on average, calculate the estimated percentage of energy provided by the array system when it had received approximately 5.0 hours of strong sunlight on a sunny day. [3]

(c) Fig. 6.2 shows the micrometer screw gauge readings to measure the thickness of a crystalline silicon PV cell.

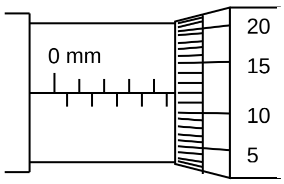

Fig. 6.2

(i) State the measured thickness of the cell in Fig 6.2. [1]

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(ii) Calculate the thickness of a thin film PV cell which is 90 times less thinner than the crystalline silicon PV cell shown in Fig. 6.2. Express your answer in microns given that 1 micron is equal to 1 micrometre. [2]

(iii) What can the engineer do to obtain a more accurate reading for the thickness of the cell? [1]

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7) Fig. 7.1 shows a girl of mass 32 kg who was about to sit on a swing's seat of mass 2 kg. Fig. 7.2 shows the side view of the girl at the instant she lifts both her feet off the ground during her swinging motion. Position **X** is the highest point of her entire motion and at **X**, she was momentarily at rest.

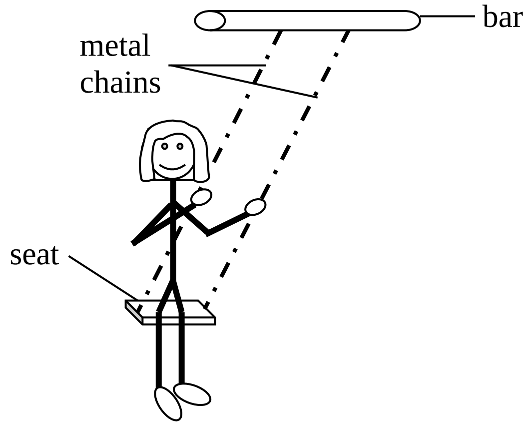

Fig. 7.1

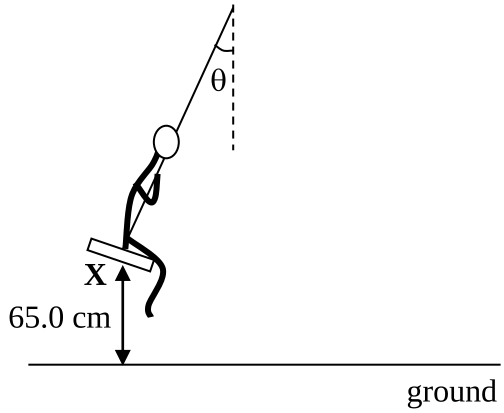

Fig. 7.2

Assume the metal chains are always taut during her motion and neglect air resistance.

(a) Calculate the speed of the swing's seat at the lowest point of its motion, which is 40.0 cm vertically above the ground. [2]

(b) On Fig. 7.3, sketch and label the velocity-time graph of the swing's seat for one complete oscillation given that at t = 0 s, it is at position **X**. Take the left to right direction as the positive direction. [2]

Fig. 7.3

(c) By considering the girl and the swing's seat as one body, Fig. 7.4 shows the free-body diagram of the body at position **X**.

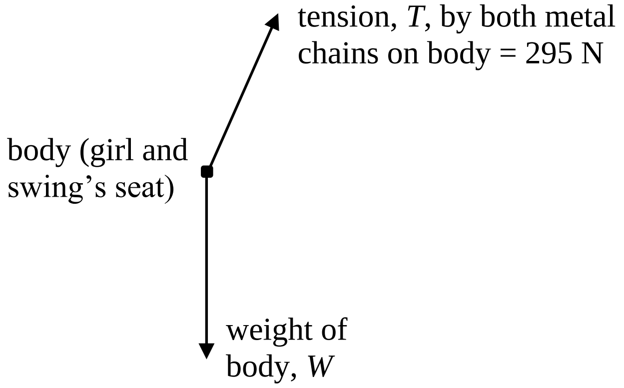

Fig. 7.4

Determine the weight of the body, *W*. [1]

(d) Given the resultant force at position **X** for Fig. 7.4 acts perpendicularly to the tension *T*.

By drawing a scale diagram or otherwise (support with an appropriate illustration), determine

(i) the magnitude of the resultant force at position **X**, [3]

(ii) the value of angle θ. [1]

(e) Describe the change in the magnitude of the resultant force as the swing moved from position **X** to the lowest point of its motion. [1]

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EITHER

8A) Fig. 8A.1 shows the parts of a 1500 W electric kettle.

Image source: http://www.remodelista.com/files/styles/733_0s/public/Electric-Tea-Kettle-Breville.jpg

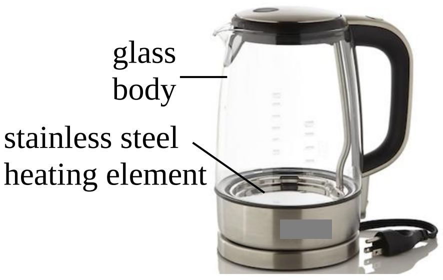

Fig. 8A.1

material	stainless steel	borosilicate glass
density / g cm^{-3}	8.0	2.2
specific heat capacity / J kg^{-1} K^{-1}	500	830
linear thermal expansion coefficient / $\mu m\ m^{-1}\ K^{-1}$	16.9	3.25
thermal conductivity / W m^{-1} K^{-1}	15.9	1.14

Fig. 8A.2

Fig. 8A.2 shows the properties of the two materials used to make the kettle.

(a) The electric kettle has a borosilicate glass body with a stainless steel heating element.

Using information from Fig. 8A.2, state and explain each of the following,

(i) **two** advantages of using borosilicate glass as the body
(ii) **one** advantage of using stainless steel as the heating element

for the kettle shown in Fig. 8A.1. [3]

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(b) It is observed that at the base of the kettle, a gap is purposely left between the stainless steel heating element and the glass body. This gap is usually covered up by a silicone ring which is a flexible and rubberlike plastic material.

Using information from Fig. 8A.2, explain why the gap is necessary. [2]

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(c) Given that the specific heat capacity of water = 4200 J kg^{-1} K^{-1} and the specific latent heat of vaporisation of water = 2.3 X 10^6 J kg^{-1}.

(i) Calculate the amount of energy needed to raise the temperature of 1.5 kg of water from 30.0 ^oC to 100.0 ^oC. [2]

(ii) The kettle switches off automatically 1.0 minute after the water has reached its boiling point. Calculate the mass of water boiled away in this time. [3]

OR

8B) Fig. 8B.1 shows an experimental setup which can be used as a thermometer. The narrow tube which emerges from the top of the flask shows the water level at the room temperature of 28.0 ^{o}C. Fig. 8B.2 shows the height of the water level above point **X** of the flask, *h*, when it was immersed in a trough of water at different temperatures, *T*.

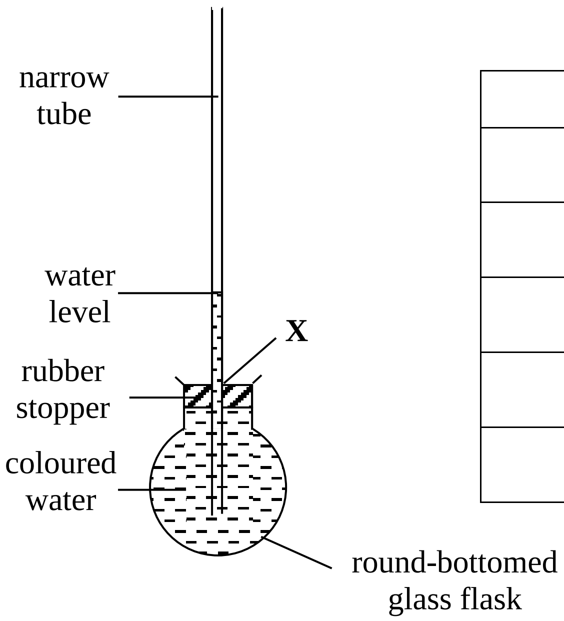

Fig. 8B.1

h / cm	*T* / ^{o}C
12.5	20.0
	28.0
17.5	40.0
20.5	52.0
22.5	60.0

Fig. 8B.2

(a) (i) State the thermometric property when the setup in Fig. 8B.1 was used as a thermometer. [1]

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(ii) Name a suitable apparatus which can be used to measure the thermometric property stated in (a)(i). [1]

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(b) (i) Complete the table in Fig. 8B.2. [1]

(ii) State the assumption made for the computation in (b)(i). [1]

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(c) From room temperature, the round-bottomed glass flask was fully immersed in a trough of water at 15.0 ^{o}C. The measurement of *h* was taken when the water level was steady.

(i) Why was it necessary to measure *h* only when the water level was steady? [1]

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(ii) State the process by which thermal energy was transferred through the glass flask. [1]

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(iii) Explain, in molecular terms, how the process in (c)(ii) transferred thermal energy through the glass flask. [3]

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(d) The round-bottomed flask was partially filled with air and the same coloured water as shown in Fig. 8B.3.

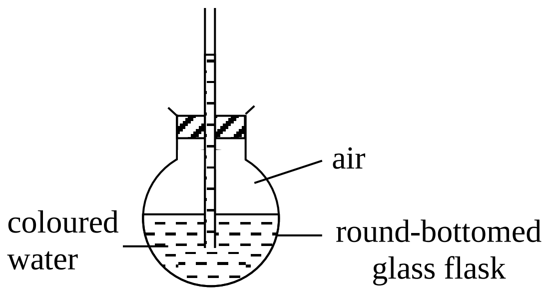

Fig. 8B.3

Given all other equipment and conditions remain the same, state one change in the characteristic of this new thermometer. [1]

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