Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

For Examiner's Use

General Certificate of Education
June 2007
Advanced Level Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

PHYSICS (SPECIFICATION B) **PHB6/2**
Unit 6 Exercise 2

Monday 21 May 2007 1.30 pm to 3.00 pm

For this paper you must have:
- a calculator
- a ruler.

Time allowed: 1 hour 30 minutes

For Examiner's Use			
Question	Mark	Question	Mark
1		PHB6 /1	
2			
Total (Column 1)			
Total (Column 2)			
TOTAL			
Examiner's Initials			

Instructions
- Use blue or black ink or ball-point pen.
- Answer **all** questions.
- *Formulae Sheets* are provided on pages 3 and 4. Detach this perforated page at the start of the examination.
- There are two questions in this paper.
  45 minutes are allowed for Question 1 and 45 minutes for Question 2.
- Show all your working. Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The maximum mark for this paper is 39.
- Four of these marks will be awarded for using good English, organising information clearly and using specialist vocabulary where appropriate.
- The marks for questions are shown in brackets.
- Questions 1(e) and 2(e) should be answered in continuous prose. In these questions you may be marked on your ability to use good English, to organise information clearly and to use specialist vocabulary where appropriate.

Advice
- Before commencing the first part of any question, read the question through completely.
- Ensure that **all** measurements taken, including repeated readings, gradients, derived quantities, etc., are recorded to an appropriate number of significant figures with due regard to the accuracy of measurement.
- If an experiment does not operate correctly, you should request assistance from the Supervisor. The Supervisor will give the minimum help necessary to make the experiment operate and will report the action taken to the Examiner. If the fault is due to your inability to make the experiment operate, a deduction of marks will be made, but it will be possible for you to complete the remainder of the question and gain marks for the later parts of that question.

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Answer **all** questions in the spaces provided.

1 **Read this question carefully before you begin. Ask your supervisor to provide the hot water for the experiment only when you are ready to take readings.**

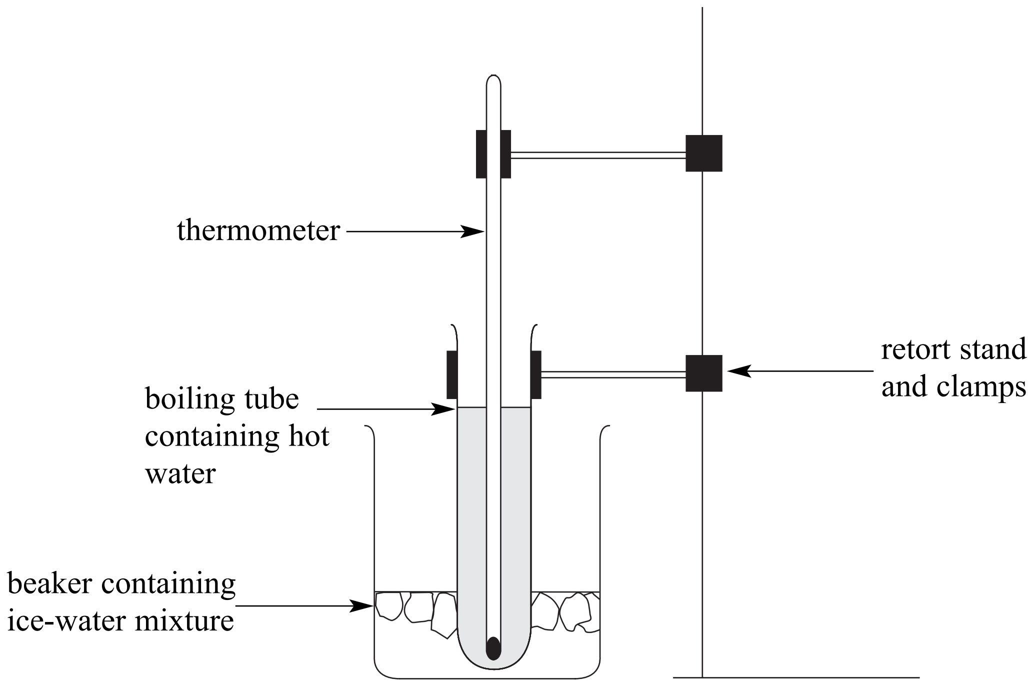
This question is about the way in which a hot body can be cooled by melting ice.

You will be provided with about 0.04 kg of water at a temperature of about 70 °C in a boiling tube mounted in a beaker containing an ice-water mixture at 0 °C.

When you are ready to begin, ask your supervisor for your hot water.

Figure 1 shows how the arrangement should look whilst you take readings.

Figure 1



(a) Start the stopclock and take readings of the temperature every 15 s for 2 minutes. **You are not required to repeat the readings.**

Time/s	Temperature/°C

(1 mark)

Detach this perforated page at the start of the examination.

Foundation Physics Mechanics Formulae

moment of force $= Fd$

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

$s = \frac{1}{2}(u + v)t$

for a spring, $F = k\Delta l$

energy stored in a spring $= \frac{1}{2}F\Delta l = \frac{1}{2}k(\Delta l)^2$

$T = \frac{1}{f}$

Foundation Physics Electricity Formulae

$I = nAvq$

terminal p.d. $= E - Ir$

in series circuit, $R = R_1 + R_2 + R_3 + ...$

in parallel circuit, $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$

output voltage across $R_1 = \left(\frac{R_1}{R_1 + R_2}\right) \times$ input voltage

Waves and Nuclear Physics Formulae

fringe spacing $= \frac{\lambda D}{d}$

single slit diffraction minimum $\sin\theta = \frac{\lambda}{b}$

diffraction grating $n\lambda = d\sin\theta$

Doppler shift $\frac{\Delta f}{f} = \frac{v}{c}$ for $v << c$

Hubble law $v = Hd$

radioactive decay $A = \lambda N$

Properties of Quarks

Type of quark	Charge	Baryon number
up u	$+\frac{2}{3}e$	$+\frac{1}{3}$
down d	$-\frac{1}{3}e$	$+\frac{1}{3}$
$\overline{u}$	$-\frac{2}{3}e$	$-\frac{1}{3}$
$\overline{d}$	$+\frac{1}{3}e$	$-\frac{1}{3}$

Lepton Numbers

Particle	Lepton number L		
	L_e	L_μ	L_τ
e^-	1		
e^+	−1		
ν_e	1		
$\overline{\nu}_e$	−1		
μ^-		1	
μ^+		−1	
ν_μ		1	
$\overline{\nu}_\mu$		−1	
τ^-			1
τ^+			−1
ν_τ			1
$\overline{\nu}_\tau$			−1

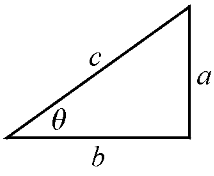
Geometrical and Trigonometrical Relationships

circumference of circle $= 2\pi r$

area of a circle $= \pi r^2$

surface area of sphere $= 4\pi r^2$

volume of sphere $= \frac{4}{3}\pi r^3$



$\sin\theta = \frac{a}{c}$

$\cos\theta = \frac{b}{c}$

$\tan\theta = \frac{a}{b}$

$c^2 = a^2 + b^2$

Detach this perforated page at the start of the examination.

Circular Motion and Oscillations

$$v = r\omega$$

$$a = -(2\pi f)^2 x$$

$$x = A \cos 2\pi ft$$

$$\text{maximum } a = (2\pi f)^2 A$$

$$\text{maximum } v = 2\pi f A$$

$$\text{for a mass-spring system, } T = 2\pi\sqrt{\frac{m}{k}}$$

$$\text{for a simple pendulum, } T = 2\pi\sqrt{\frac{l}{g}}$$

Fields and their Applications

$$\text{uniform electric field strength, } E = \frac{V}{d} = \frac{F}{Q}$$

$$\text{for a radial field, } E = \frac{kQ}{r^2}$$

$$k = \frac{1}{4\pi\varepsilon_0}$$

$$g = \frac{F}{m}$$

$$g = \frac{GM}{r^2}$$

$$\text{for point masses, } \Delta E_p = GM_1M_2\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$\text{for point charges, } \Delta E_p = kQ_1Q_2\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$\text{for a straight wire, } F = BIl$$

$$\text{for a moving charge, } F = BQv$$

$$\phi = BA$$

$$\text{induced emf} = \frac{\Delta(N\phi)}{t}$$

$$E = mc^2$$

Temperature and Molecular Kinetic Theory

$$T/\text{K} = \frac{(pV)_T}{(pV)_{tr}} \times 273.16$$

$$pV = \tfrac{1}{3} Nm\langle c^2\rangle$$

$$\text{energy of a molecule} = \tfrac{3}{2} kT$$

Heating and Working

$$\Delta U = Q + W$$

$$Q = mc\Delta\theta$$

$$Q = ml$$

$$P = Fv$$

$$\text{efficiency} = \frac{\text{useful power output}}{\text{power input}}$$

$$\text{work done on gas} = p\Delta V$$

$$\text{work done on a solid} = \tfrac{1}{2} F\Delta l$$

$$\text{stress} = \frac{F}{A}$$

$$\text{strain} = \frac{\Delta l}{l}$$

$$\text{Young modulus} = \frac{\text{stress}}{\text{strain}}$$

Capacitance and Exponential Change

$$\text{in series, } \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\text{in parallel, } C = C_1 + \mathrm{C}_2$$

$$\text{energy stored by capacitor} = \tfrac{1}{2} QV$$

$$\text{parallel plate capacitance, } C = \frac{\varepsilon_0\varepsilon_r A}{d}$$

$$Q = Q_0 \mathrm{e}^{-t/RC}$$

$$\text{time constant} = RC$$

$$\text{time to halve} = 0.69\, RC$$

$$N = N_0 \mathrm{e}^{-\lambda t}$$

$$A = A_0 \mathrm{e}^{-\lambda t}$$

$$\text{half-life, } t_{\frac{1}{2}} = \frac{0.69}{\lambda}$$

Momentum and Quantum Phenomena

$$Ft = \Delta(mv)$$

$$E = hf$$

$$hf = \boldsymbol{\Phi} + E_{\text{k(max)}}$$

$$hf = E_2 - E_1$$

$$\lambda = \frac{h}{mv}$$

(b) It is suggested that under certain conditions the temperature of the water falls exponentially with time.

(i) Describe a technique that can be used to test this suggestion.

(ii) Use the proposed technique to test whether your data obey the suggestion that the temperature falls exponentially with time.

(iii) State your conclusion clearly.

(4 marks)

(c) You were provided with 40 ± 5 g of hot water. Assume that all the energy required to melt the ice in the beaker was supplied by the cooling water in the boiling tube.

Calculate the mass of ice that melted during your experiment from the moment you began timing until you took the last reading. Set out the steps in your calculation clearly.

specific heat capacity of water = $(4.2 \pm 0.1) \times 10^3\ \text{J kg}^{-1}\ \text{K}^{-1}$
specific latent heat of melting of ice = $(3.4 \pm 0.1) \times 10^5\ \text{J kg}^{-1}$

(3 marks)

Question 1 continues on the next page

(d) (i) Estimate the absolute uncertainty in one of your temperature readings.

(ii) Estimate the absolute uncertainty in the temperature difference between the first and last readings from your table in part (a).

(iii) Estimate the percentage uncertainty in your answer to part (c).

(4 marks)

(e) Suggest changes to this experiment that will allow the estimate of the mass of ice melted by the hot water to be improved. In your answer, you should consider changes to the apparatus, the experimental method and the analysis.

Two of the 8 marks are available for the quality of your written communication.

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(8 marks)

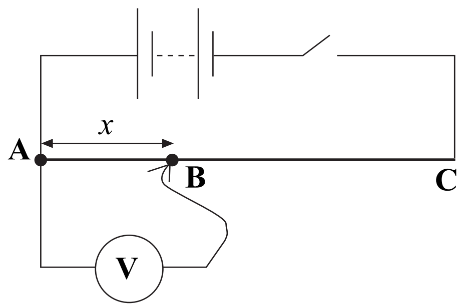
20

Turn over for the next question

Turn over for the next question

2 **Figure 2** shows a diagram of the circuit that has been set up for you. The connection between the voltmeter and the wire **AC** is made using a lead terminating in a crocodile clip.

Figure 2



Switch on the circuit.

(a) (i) Take and record readings that will enable you to sketch a graph of the potential difference V_{AB} against x where V_{AB} is the potential difference between points **A** and **B** and x is the length of wire between **A** and **B**.

Switch off the circuit when you have finished making measurements.

(ii) Without plotting points, sketch a graph to show the relationship between V_{AB} and x.

(5 marks)

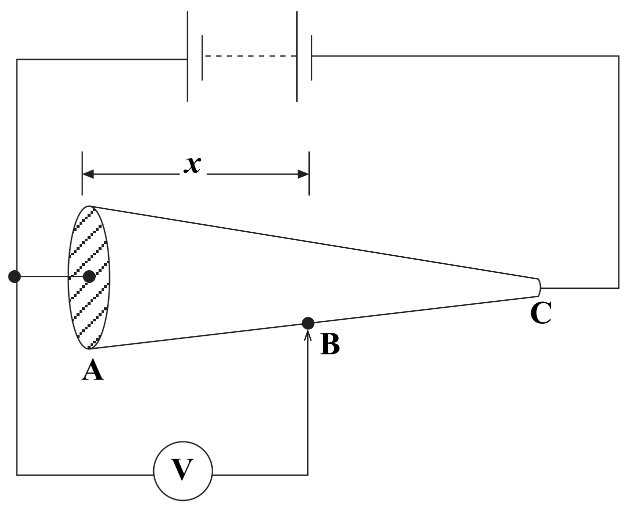
(b) Your wire has a uniform cross-sectional area of $1.7 \times 10^{-7}\ \text{m}^2$ and a resistivity of $4.5 \times 10^{-7}\ \Omega\,\text{m}$.

Calculate the resistance of 0.010 m of the wire.

(2 marks)

(c) You are now to consider what would happen if the uniform wire in part (a) were to be replaced with a tapered wire of circular cross-section as shown in **Figure 3**.

Figure 3



(i) Draw another line on your sketch in part (a) (ii) to show the new relationship you would expect between V_{AB} and x. Label this line clearly **TAPER**. You should assume in your answer that the power supply has **no** internal resistance.

(ii) Explain why this second line has the shape you have drawn.

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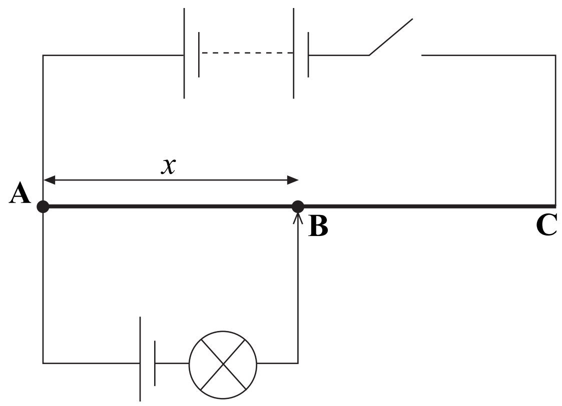
(4 marks)

Question 2 continues on the next page

(d) Now remove the voltmeter from the circuit by disconnecting the lead at **A**.

You have also been supplied with a 1.5 V cell and a light bulb that have already been connected together. Do not attempt to separate the cell and bulb. Connect the free lead attached to the cell to point **A**. **Figure 4** shows the circuit diagram for the final arrangement.

Figure 4



Switch the circuit on before you begin to take readings.

Make a connection to the wire with the crocodile clip near the middle of the wire (the exact position does not matter). The bulb should not light at this position.

(i) **Reduce** x in steps of about 0.05 m until the bulb just begins to glow.

Record the value of x between 0 and 0.5 m at which the bulb just begins to glow.

(ii) Return the clip to the middle of the wire and this time **increase** x in steps of about 0.05 m until the bulb just begins to glow.

Record the value of x between 0.5 m and 1.0 m at which the bulb just begins to glow.

(1 mark)

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MARGIN
BLANK

Switch the circuit off.

(e) Explain why the bulb does not light when the connection is made in the centre of the wire. Go on to explain the behaviour of the circuit as the connection is moved from one end of the wire to the other.

Two of the 7 marks are available for the quality of your written communication.

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(7 marks)

19

END OF QUESTIONS

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