Name: ________________ Class: ___________

VICTORIA JUNIOR COLLEGE
2007 JC2 PRELIMINARY EXAMINATION

PHYSICS **9745**
Higher 2
Paper 2

18/9/2007 **2 pm – 3.15 pm**
TUESDAY **(1 hour 15 mins)**

This paper consists of 5 short structured questions and 1 data analysis question. Attempt all questions. Write your answers in the spaces provided for each question.

The intended marks for each question or part question are given in brackets [ ].

N.B. You will hand in the whole question set issued to you at the end of the examination. Do not separate the question set into parts.

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For marker's use	
Q1	
Q2	
Q3	
Q4	
Q5	
Q6 (data)	
s.f	
unit	
Total (60)	
Percentage	

This question set consists of a total of 13 printed pages.

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Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$\mu_o = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$\varepsilon_o = 8.85 \times 10^{-12}$ F m^{-1} $(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary of charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant,	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	$g = 9.81$ m s^{-2}

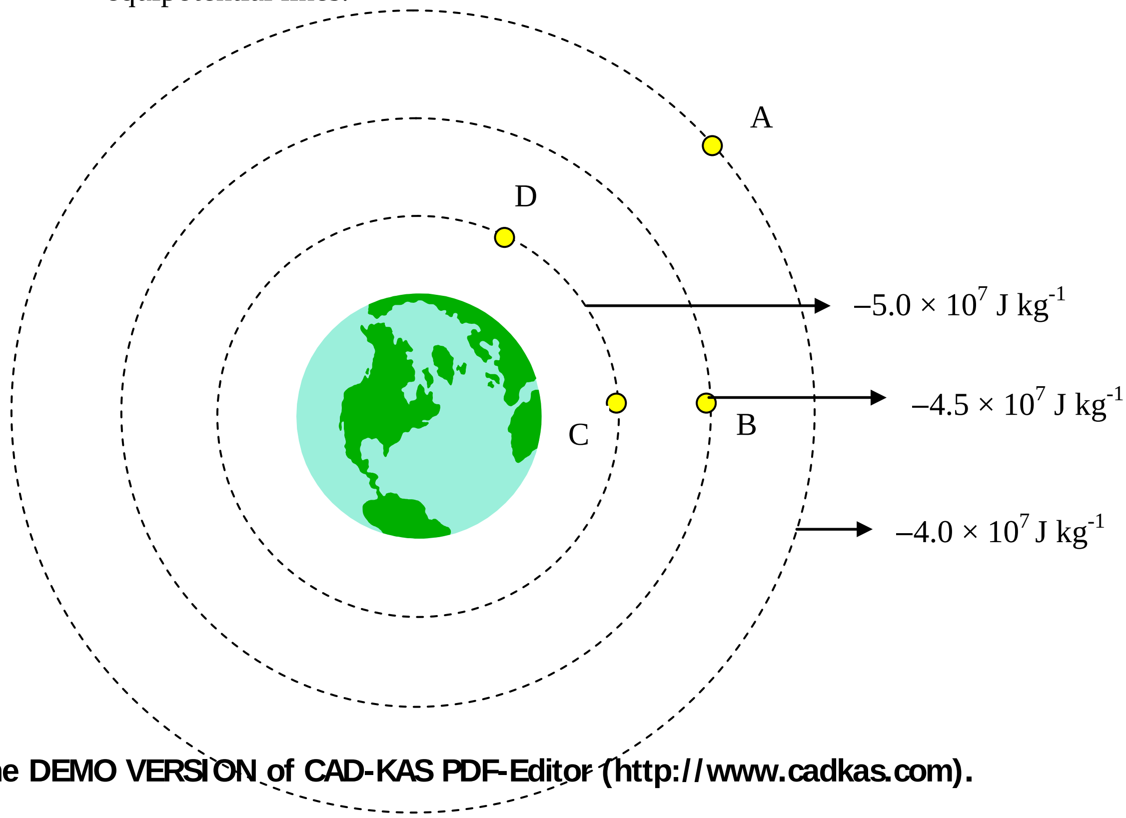
Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2} at^2$ $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure,	$p = \rho gh$
gravitational potential,	$\phi = -\frac{Gm}{r}$
displacement of particle in s.h.m.	$x = x_o \sin \omega t$
velocity of particle in s.h.m.,	$v = v_o \cos \omega t$ $= \pm\omega\sqrt{(x_o^2 - x^2)}$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = Q/4\pi\varepsilon_o r$
alternating current/voltage,	$x = x_o \sin \omega t$
transmission coefficient,	$T = \exp(-2kd)$ where $k = \sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	$x = x_o \exp(-\lambda t)$
decay constant,	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

http://www.etuition.net78.net

Attempt All Questions

1 In the diagram below, the dashed lines enclosing the Earth represents equipotential lines. The gravitational potential is as shown for each of the equipotential lines.



(a) At which point (or points) is the gravitational potential the highest? Explain your answer. [2]

(b) Calculate the work done by the gravitational field in bringing a space-craft of mass 5000 kg

(i) from A to C [2]

(ii) from C to D [1]

(c) The equipotential lines, which are given for every interval of 0.5×10^7 J kg^{-1} are not equally spaced. Explain why. [1]

(d) Calculate the distance BC along the same radial line from the centre of the Earth outwards, given that the mass of the Earth is 6.0×10^{24} kg. [2]

2 Using a rope, a bucket of water is swung in a vertical circle of radius 0.950 m. The mass of the water and bucket is 3.25 kg. At the top of the circle, the speed of the bucket is 3.23 m s^{-1} and the bucket is upside down at this instant.

(a) What is the tension in the rope tied to the bucket at the top of the circle? [3]

(b) Explain qualitatively why the water in the bucket does not fall out. [2]

(c) What is the magnitude and direction of the force acting on the water by the bucket when it is at the top? Take the mass of water to be 2.25 kg. [3]

3 A proton and an alpha particle are both initially at rest and separated by a distance of 1.0×10^{-9} m. Due to their mutual repulsion, they move apart.

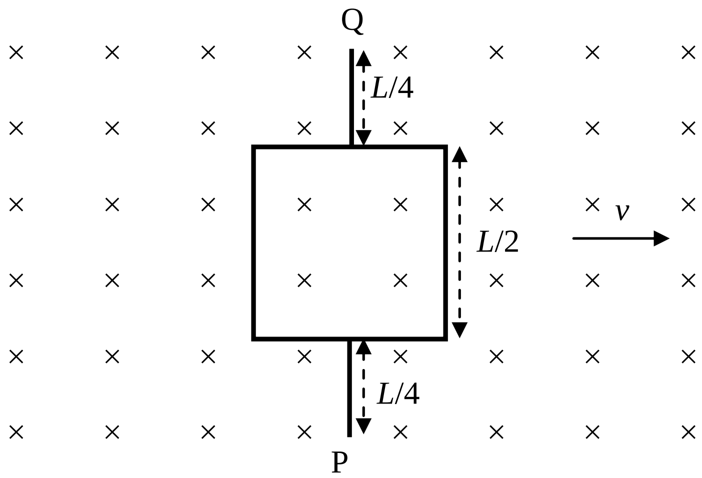
(a) Calculate the initial electric potential energy of this two-particle system. [2]

(b) When the proton has reached a speed of 2.0×10^{4} m s^{-1}, what is the speed of the alpha particle? [2]

(c) What is the total kinetic energy of the system of these two particles at this point? [2]

(d) How far apart are the two particles at this point? [2]

4 (a) Find the induced emf between the ends of a wire structure (see below) that is placed in a plane perpendicular to a magnetic field B, and travelling to the right with uniform velocity v.



Specify the end with the higher potential.

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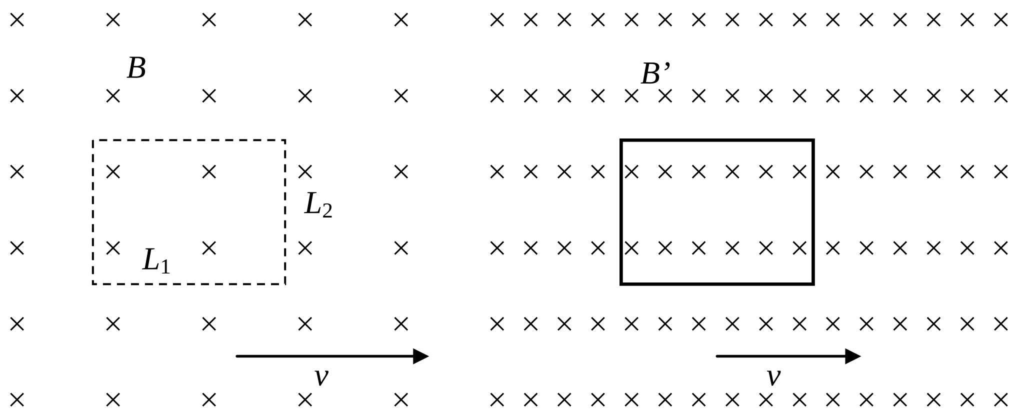
____ [3]

(b) A rectangular metal wire loop has resistance R and dimensions L_1 and L_2 . An external agency causes the loop to move through fields B and B' at constant velocity.



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(i) As the coil is crossing the boundary between the two fields, a current flows around the loop. Explain why this is so, and indicate its direction. [2]

(ii) Derive an expression for the current. [2]

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(iii) Explain why there is no current flow in the coil when the coil is totally immersed in the magnetic field *B'* and moving perpendicularly to the *B'* field. [1]

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5 (a) Explain the term *mass excess*. [2]

(b) A country at a particular time is using 40 000 MW of electrical power. Given that 1 kg of coal can produce 20 MJ of electrical energy, find

(i) the mass of coal burnt per second. [2]

(ii) the mass equivalence of the electrical power of 40 000 MW being produced in one second. [2]

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(iii) If electrical power is produced only at an efficiency of 20 %, how much **more** coal needs to be burnt per second? [2]

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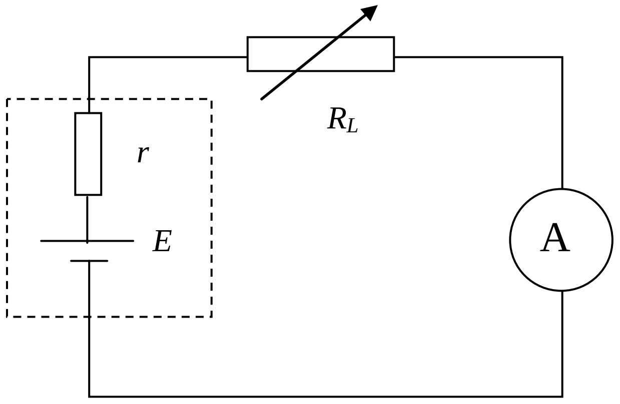

Figure 1

The figure above shows an ammeter of negligible resistance used in conjunction with a variable load resistor of resistance R_L in order to find the electromotive force E and the internal resistance r of a cell. The following values of current I are obtained for different values of R_L :

R_L / Ω	I /A
2.00	0.590
3.00	0.420
4.00	0.330
5.00	0.270
6.00	0.230

(a) (i) By plotting a suitable graph, determine the values of E and r.

[6]

Records and calculations:

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Calculations:

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(ii) From the answers in (a)(i), deduce the value of R_L for it to dissipate the maximum power. What is then the current flowing in the circuit?

[3]

(b) (i) Many metals and alloys have resistance which increases with temperature. Suggest why this is so in terms of electron flow through the specimens.

[3]

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(ii)

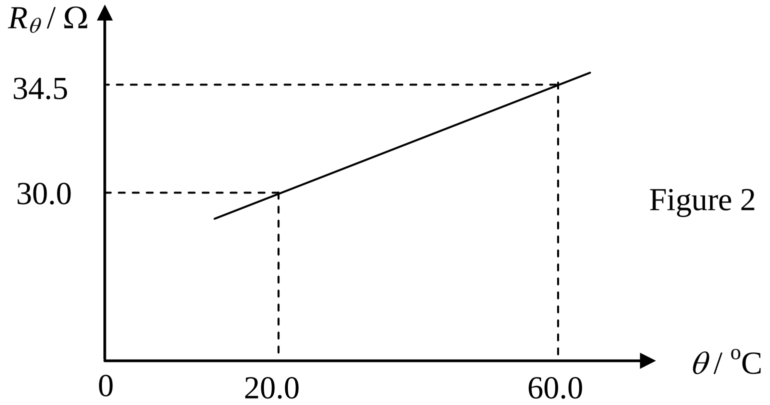

Figure 2

A certain metal coil has resistance that varies with temperature according to the graph shown above. We can define a quantity α such that

$$\alpha = \frac{R_\theta - R_0}{R_0\theta}$$

where R_θ and R_0 are resistances at temperature θ and 0 °C respectively.

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1. Determine α for this metal. [3]

2. At what value of R_θ in figure 2 will the graph cut the vertical axis? [2]

3. Some semiconductors have a negative value for α. What does this predict about the semiconductor resistance as temperature rises? [1]

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(c) The resistance of a certain conducting loop at low temperatures is given below:

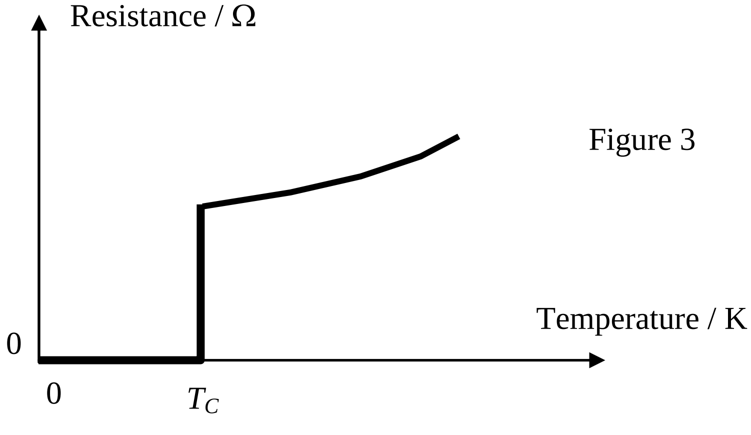

Figure 3

A current is induced in the loop at a temperature below T_C. Explain why the current can flow in the loop for months on end. [2]

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