Centre No.						Paper Reference	Surname	Other names
Candidate No.						6 7 3 5 / 2 B	Signature	

Edexcel GCE

Physics

Advanced Level

Unit Test PHY5 Practical Test
Group 2

Wednesday 20 May 2009 – Morning

Time: 1 hour 30 minutes

Supervisor's Comments

For Examiner's use only

For Team Leader's use only

Question numbers	Leave blank
A	
B	
C	
Total	

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, other names and signature.

PHY5 consists of questions A, B and C. Each question is allowed 20 minutes plus 5 minutes writing-up time. There is a further 15 minutes for writing-up at the end. The Supervisor will tell you which experiment to attempt first.

Write all your results, calculations and answers in the spaces provided in this question booklet.

In calculations you should show all the steps in your working, giving your answer at each stage.

Information for Candidates

The marks for individual questions and the parts of questions are shown in round brackets.

The total mark for this paper is 48.

The list of data, formulae and relationships is printed at the end of this booklet.

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Question 2A

1. On the burette there are three pieces of tape labelled H, M and L. The upper edges of these are used to mark the level of water in the burette. There is a beaker under the capillary tube to collect the outflow. This arrangement should not be disturbed.

(a) (i) Measure the height of the capillary tube outlet above the bench.

....

Measure the height from the bench to the top of tape H.

....

Hence calculate the height h_0 of the top of tape H above the capillary outlet.

....

Make further measurements to find the heights **above the capillary outlet** of the tops of the other two pieces of tape on the burette; make sure you measure to the upper edge of the tape each time. Let these two heights be h_1 and h_2, where h_1 is the larger.

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Calculate the ratios h_1/h_0 and h_2/h_1.

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(3)

(ii) Check that the burette is filled above tape H.

Open the tap on the burette and measure the time t_1 for the water to fall from the upper edge of tape H to the upper edge of tape M. Close the tap.

....

Add a few cm^3 of water from the top-up beaker to the burette to take the level above tape M.

Measure the time t_2 for the water to fall from the upper edge of tape M to the upper edge of tape L. Close the tap.

....

Refill the burette above tape H and repeat your readings for t_1 and t_2.

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(3)

Leave blank

(iii) Estimate the uncertainty in your average values for t_1 and t_2. Hence comment on the suggestion that t_1 and t_2 might be the same.

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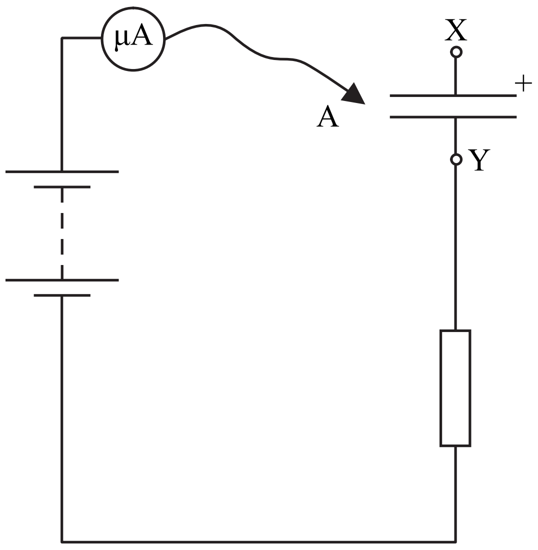
(2)

(b) (i) The circuit shown below has been set up for you. Identify the points labelled A, X and Y.



Connect point A to point Y. Record the current I_0.

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Disconnect A from Y.

QUESTION 2A CONTINUES ON THE NEXT PAGE

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You are now to take measurements to record the current after 15.0 s and 30.0 s from the start as the capacitor charges through the resistor.

First discharge the capacitor. Do this by connecting point X to point Y for a short time using the spare lead.

Disconnect the spare lead from X and Y. Connect A to X and start the stopwatch. Record the current I_1 at 15.0 s and I_2 at 30.0 s.

	I_1	I_2	I_0 / I_1	I_1 / I_2
Mean values				

Calculate the ratios I_0 / I_1 and I_1 / I_2 and complete the table.

....

....

(6)

(ii) Calculate the percentage difference between the two ratios. Comment on the suggestion that these ratios have the same value.

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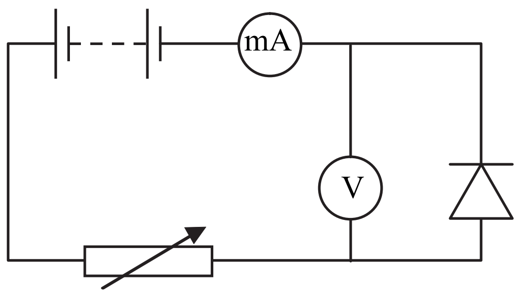
(2)

Q2A

(Total 16 marks)

Question 2B

A diode and a thermometer have been placed in a boiling tube containing water. The diode is connected to the electrical circuit shown below. You are to measure the current in the diode at **constant voltage** as you vary the temperature of the diode. You will do this by heating the water in the boiling tube and keeping the voltage constant by adjusting the variable resistor.



(a) Connect the battery and adjust the variable resistor until the ammeter reading I is close to 4 mA. Record below the voltmeter reading V and the ammeter reading I.

I = ...

V = ...

Record the temperature θ of the diode as shown on the thermometer.

θ = ...

Transfer your readings of I and θ to the table on the following page.

By heating the boiling tube gently you will raise θ. You will need to adjust the variable resistor to return the reading on the voltmeter to V as recorded above. You are to measure and record I and θ as θ increases, keeping V constant.

Describe two precautions that you will need to take to ensure that your readings are as accurate as possible.

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(3)

QUESTION 2B CONTINUES ON THE NEXT PAGE

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(b) Take five further readings of the current I in the diode as you raise the temperature θ by about 50 °C. Record all your readings for I and θ below. **Ensure that you adjust the variable resistor such that the reading on the voltmeter is V each time you take your readings**.

Disconnect the battery after you have taken your readings and move the Bunsen burner from under the boiling tube.

θ / °C	I / mA	T / K	ln(I / mA)

(6)

(c) It is suggested that I and T are related by the equation

$$I = I_0 e^{bT}$$

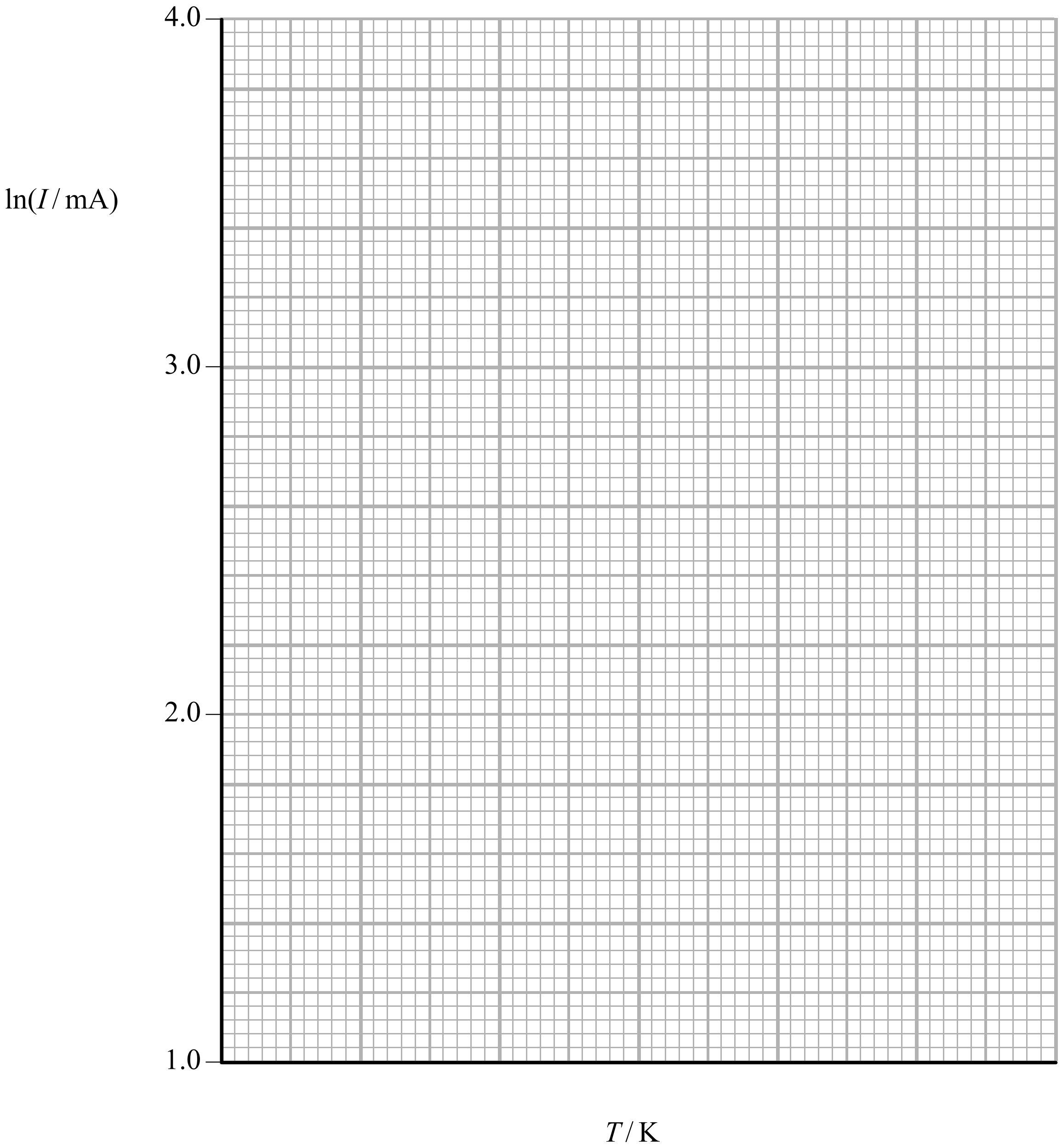
and hence

$$\ln I = bT + \ln I_0$$

where I_0 and b are constants and T is the temperature of the diode in kelvin.

Add values of T and $\ln I$ to your table and then plot a graph of $\ln I$ against T on the grid opposite.

(3)



QUESTION 2B CONTINUES ON THE NEXT PAGE

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(d) (i) Use the gradient of your graph to find a value for the constant *b*.

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(ii) Explain how you would use your graph to find a value for I_0.

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What is the physical significance of I_0?

....

(4) **Q2B**

(Total 16 marks)

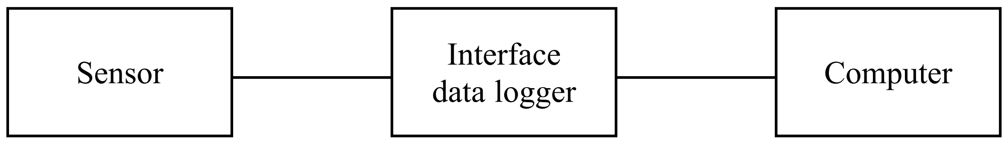
Leave blank

Question 2C

You are to plan an experiment on a sample of gas using computer technology to capture the data. You will then analyse a set of data from a similar experiment.

(a) A calibrated syringe is filled with the gas at atmospheric pressure. The pressure of the gas is monitored by a pressure sensor attached to the end of the syringe. This sensor measures the difference between the pressure of the gas and atmospheric pressure. The output from this sensor is sent to a computer to record the data.

The block diagram for measuring and recording the pressure sensor is shown below:



The method is to vary the volume of the gas whilst keeping the temperature constant. The computer records the sensor reading. The volume of the gas is read from the scale on the syringe and the values are entered manually using the keyboard.

What must be done to avoid a systematic error in the pressure of the gas?

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....

Suggest two experimental precautions that you would take to ensure that the data are accurate.

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Suggest an advantage of using computer technology for this experiment.

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(5)

QUESTION 2C CONTINUES ON THE NEXT PAGE

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(b) By considering the Ideal Gas Equation

$$pV = nRT$$

explain why a graph of p against $1/V$ will be a straight line through the origin.

....

....

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....

Write down the expression for the gradient of such a graph.

....

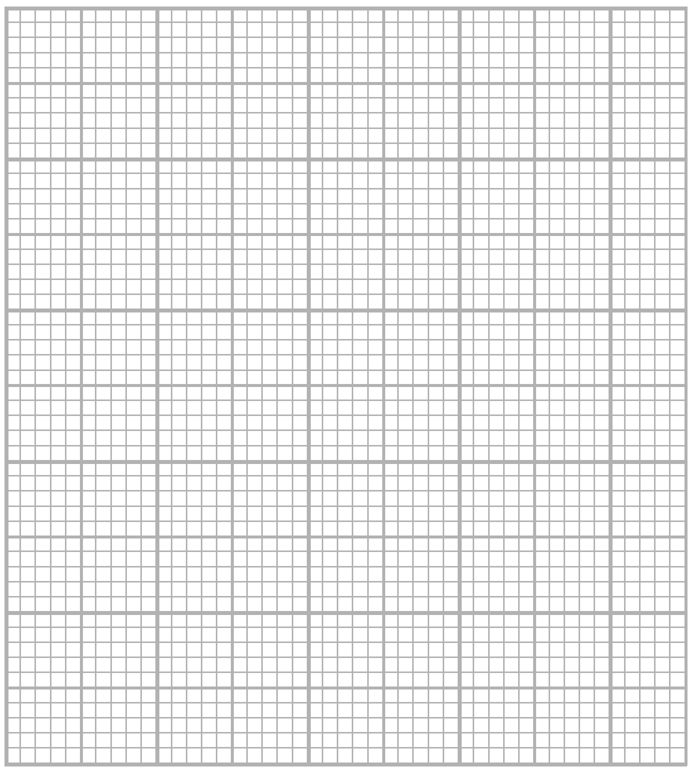
(3)

(c) In such an experiment the following data were recorded.

p / kPa	V / cm^3	
101	60.0	
112	54.0	
120	50.2	
135	45.0	
150	40.2	
167	36.5	
179	34.0	
190	32.0	
200	29.9	

Plot a graph of p against $1/V$ on the grid opposite. Use the additional column for any processed data.

Leave blank



(4)

(d) Determine the gradient of your graph.

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....

Given that the temperature of the room is 25 °C, calculate the number of moles of gas in the container.

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(4)

Q2C

(Total 16 marks)

TOTAL FOR PAPER: 48 MARKS

END

List of data, formulae and relationships

Data

Speed of light in vacuum	$c = 3.00 \times 10^8 \text{ m s}^{-1}$	
Gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$	
Acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$	(close to the Earth)
Gravitational field strength	$g = 9.81 \text{ N kg}^{-1}$	(close to the Earth)
Elementary (proton) charge	$e = 1.60 \times 10^{-19} \text{ C}$	
Electronic mass	$m_e = 9.11 \times 10^{-31} \text{ kg}$	
Electronvolt	$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$	
Planck constant	$h = 6.62 \times 10^{-34} \text{ J s}$	
Unified atomic mass unit	$\text{u} = 1.66 \times 10^{-27} \text{ kg}$	
Molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$	
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$	
Coulomb law constant	$k = 1/4\pi\varepsilon_0$ $= 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$	
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ N A}^{-2}$	

Rectilinear motion

For uniformly accelerated motion:

$$v = u + at$$

$$x = ut + \tfrac{1}{2}at^2$$

$$v^2 = u^2 + 2ax$$

Forces and moments

Moment of F about O = $F \times$ (Perpendicular distance from F to O)

Sum of clockwise moments about any point in a plane = Sum of anticlockwise moments about that point

Dynamics

Force $\quad F = m\dfrac{\Delta v}{\Delta t} = \dfrac{\Delta p}{\Delta t}$

Impulse $\quad F\Delta t = \Delta p$

Mechanical energy

Power $\quad P = Fv$

Radioactive decay and the nuclear atom

Activity $\quad A = \lambda N \quad$ (Decay constant λ)

Half-life $\quad \lambda t_{\frac{1}{2}} = 0.69$

Electrical current and potential difference

Electric current	$I = nAQv$	
Electric power	$P = I^2R$	

Electrical circuits

Terminal potential difference	$V = \mathcal{E} - Ir$	(E.m.f. $\mathcal{E}$; Internal resistance r)
Circuit e.m.f.	$\Sigma\mathcal{E} = \Sigma IR$	
Resistors in series	$R = R_1 + R_2 + R_3$	
Resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$	

Heating matter

Change of state:	energy transfer $= l\Delta m$	(Specific latent heat or specific enthalpy change l)
Heating and cooling:	energy transfer $= mc\Delta T$	(Specific heat capacity c; Temperature change ΔT)
Celsius temperature	$\theta/°\mathrm{C} = T/\mathrm{K} - 273$	

Kinetic theory of matter

Temperature and energy	$T \propto$ Average kinetic energy of molecules	
Kinetic theory	$p = \frac{1}{3}\rho\langle c^2\rangle$	

Conservation of energy

Change of internal energy	$\Delta U = \Delta Q + \Delta W$	(Energy transferred thermally ΔQ; Work done on body ΔW)
Efficiency of energy transfer	$= \frac{\text{Useful output}}{\text{Input}}$	
Heat engine maximum efficiency	$= \frac{T_1 - T_2}{T_1}$	

Circular motion and oscillations

Angular speed	$\omega = \frac{\Delta\theta}{\Delta t} = \frac{v}{r}$	(Radius of circular path r)
Centripetal acceleration	$a = \frac{v^2}{r}$	
Period	$T = \frac{1}{f} = \frac{2\pi}{\omega}$	(Frequency f)

Simple harmonic motion:

displacement $x = x_0 \cos 2\pi ft$

maximum speed $= 2\pi fx_0$

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

For a simple pendulum	$T = 2\pi\sqrt{\frac{l}{g}}$	
For a mass on a spring	$T = 2\pi\sqrt{\frac{m}{k}}$	(Spring constant k)

Waves

Intensity	$I = \dfrac{P}{4\pi r^2}$	(Distance from point source r; Power of source P)

Superposition of waves

Two slit interference	$\lambda = \dfrac{xs}{D}$	(Wavelength λ; Slit separation s; Fringe width x; Slits to screen distance D)

Quantum phenomena

Photon model	$E = hf$	(Planck constant h)
Maximum energy of photoelectrons	$= hf - \varphi$	(Work function φ)
Energy levels	$hf = E_1 - E_2$	
de Broglie wavelength	$\lambda = \dfrac{h}{p}$	

Observing the Universe

Doppler shift	$\dfrac{\Delta f}{f} = \dfrac{\Delta\lambda}{\lambda} \approx \dfrac{v}{c}$	
Hubble law	$v = Hd$	(Hubble constant H)

Gravitational fields

Gravitational field strength	$g = F/m$	
for radial field	$g = Gm/r^2$, numerically	(Gravitational constant G)

Electric fields

Electrical field strength	$E = F/Q$	
for radial field	$E = kQ/r^2$	(Coulomb law constant k)
for uniform field	$E = V/d$	
For an electron in a vacuum tube	$e\Delta V = \Delta(\frac{1}{2}m_e v^2)$	

Capacitance

Energy stored	$W = \frac{1}{2}CV^2$	
Capacitors in parallel	$C = C_1 + C_2 + C_3$	
Capacitors in series	$\dfrac{1}{C} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \dfrac{1}{C_3}$	
Time constant for capacitor discharge	$= RC$	

Magnetic fields

Force on a wire	$F = BIl$	
Magnetic flux density (Magnetic field strength)		
in a long solenoid	$B = \mu_0 nI$	(Permeability of free space μ_0)
near a long wire	$B = \mu_0 I/2\pi r$	
Magnetic flux	$\Phi = BA$	
E.m.f. induced in a coil	$\varepsilon = -\dfrac{N\Delta\Phi}{\Delta t}$	(Number of turns N)

Accelerators

Mass-energy	$\Delta E = c^2 \Delta m$
Force on a moving charge	$F = BQv$

Analogies in physics

Capacitor discharge	$Q = Q_0 e^{-t/RC}$
	$\dfrac{t_{\frac{1}{2}}}{RC} = \ln 2$
Radioactive decay	$N = N_0 e^{-\lambda t}$
	$\lambda t_{\frac{1}{2}} = \ln 2$

Experimental physics

$$\text{Percentage uncertainty} = \frac{\text{Estimated uncertainty} \times 100\%}{\text{Average value}}$$

Mathematics

$$\sin(90° - \theta) = \cos\theta$$

$$\ln(x^n) = n \ln x$$

$$\ln(e^{kx}) = kx$$

Equation of a straight line	$y = mx + c$	
Surface area	cylinder $= 2\pi rh + 2\pi r^2$	
	sphere $= 4\pi r^2$	
Volume	cylinder $= \pi r^2 h$	
	sphere $= \frac{4}{3}\pi r^3$	
For small angles:	$\sin\theta \approx \tan\theta \approx \theta$	(in radians)
	$\cos\theta \approx 1$	

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