

AQA A-LEVEL PHYSICS

PHYSICS



EXAM QUESTION PACK

UNIT 1 OLD SPECIFICATION PAPERS

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Please write clearly in block capitals.

Centre number

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Candidate number

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Surname

Forename(s)

Candidate signature

AS PHYSICS A

Unit 1 Particles, Quantum Phenomena and Electricity

Tuesday 24 May 2016

Morning

Time allowed: 1 hour 15 minutes

Materials

For this paper you must have:

- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator, where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.



J U N 1 6 P H Y A 1 0 1

There are no questions printed on this page

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ANSWER IN THE SPACES PROVIDED**



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

1 The element uranium has an isotope $^{237}_{92}\text{U}$.

1 (a) Explain what is meant by an isotope.

[2 marks]

1 (b) Determine the charge in coulomb of the $^{237}_{92}\text{U}$ nucleus.

[2 marks]

charge = _____ C

1 (c) A positive ion of $^{237}_{92}\text{U}$ has a charge of $+4.80 \times 10^{-19}$ C.

Determine the number of electrons in the ion.

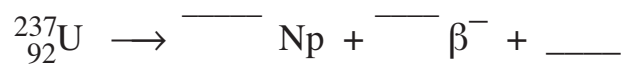
[2 marks]

number of electrons = _____

1 (d) $^{237}_{92}\text{U}$ decays by β^- emission to form an isotope of neptunium (Np).

Complete the equation for this decay.

[3 marks]



2 The positive kaon (K^+) has a strangeness of +1.

2 (a) Which of the following is the quark composition of the positive kaon?
Tick (✓) the correct answer.

[1 mark]

	✓ if correct
$\bar{u}s$	
$uu\bar{s}$	
$u\bar{s}$	
$\bar{d}\bar{d}s$	

2 (b) The equation shows a possible decay of the positive kaon.

$$K^+ \longrightarrow \mu^+ + \nu_\mu$$

2 (b) (i) Show that lepton number is conserved in this decay.

[1 mark]

2 (b) (ii) State a quantity that is not conserved in this decay.

[1 mark]



2 (b) (iii) Complete the following table using ticks to indicate correct classifications for each particle. The first column has been completed for you.

[3 marks]

	Charged	Hadron	Meson	Baryon	Lepton
K^+	✓				
μ^+	✓				
ν_μ					

2 (c) The positive kaon can also decay to form a π^+ and one other particle X.

Deduce the identity of X.

[3 marks]

9

Turn over for the next question

Turn over ►



3 Under certain conditions a photon may be converted into an electron and a positron.

3 (a) State the name of this process.

[1 mark]

3 (b) For the conversion to take place the photon has to have an energy equal to or greater than a certain minimum energy.

3 (b) (i) Explain why there is a minimum energy.

[2 marks]

3 (b) (ii) Show that this minimum energy is about 1 MeV.
Use values from the Data and Formulae Booklet.

[1 mark]

3 (b) (iii) Explain what happens to the excess energy when the photon energy is greater than the minimum energy.

[1 mark]



3 (b) (iv) A photon has an energy of 1.0 MeV.

Calculate the frequency associated with this photon energy.
State an appropriate unit in your answer.

[4 marks]

frequency = _____ unit = _____

9

Turn over for the next question

Turn over ►



4 (a) The mercury atoms in a fluorescent tube are excited and then emit photons in the ultraviolet region of the electromagnetic spectrum.

4 (a) (i) Explain how the mercury atoms become excited.

[3 marks]

4 (a) (ii) Explain how the excited mercury atoms emit photons.

[2 marks]

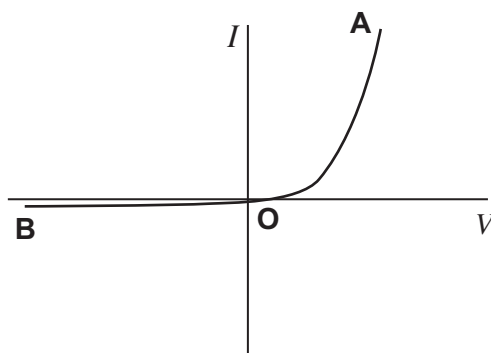
4 (b) Explain how the ultraviolet photons in the tube are converted into photons in the visible part of the electromagnetic spectrum.

[2 marks]



- 5 (a)** The graph in **Figure 1** shows the current–voltage (I – V) characteristic curve for a semiconductor diode.

Figure 1



In order to produce this characteristic a student is given suitable equipment including an ammeter and a voltmeter.

- 5 (a) (i)** Draw a labelled circuit diagram of the apparatus that the student could use to obtain the part of the characteristic from **O** to **A**.

[2 marks]

Question 5 continues on the next page

Turn over ►



- details of how different readings of I and V are obtained
- a consideration of safety precautions when using the diode
- a discussion of the range and number of measurements that need to be taken
- a discussion of the advantages of using a data logger to obtain the measurements.

[6 marks]

[illegible]

Question 5 continues on the next page

- 5 (a) (iii)** Suggest how the circuit you drew in part (a)(i) could be modified to obtain the characteristic from **O** to **B**.

[1 mark]

- 5 (b)** The student wants to find out how the resistance of the diode changes between **O** and **A**.

- 5 (b) (i)** Describe how the student could use the characteristic to determine how the resistance varies as the potential difference (pd) between **O** and **A** increases.

[2 marks]

- 5 (b) (ii)** State how you would expect the resistance of the diode to vary as the pd increases.

[1 mark]



6 An electric oven is connected to a 230 V root mean square (rms) mains supply using a cable of negligible resistance.

6 (a) (i) Calculate the peak-to-peak voltage of the mains supply.

[2 marks]

peak-to-peak voltage = _____ V

6 (a) (ii) The resistance of the heating element in the oven at its working temperature is $12\ \Omega$.

Calculate the power dissipated by the heating element in the oven.
Give your answer to an appropriate number of significant figures.

[3 marks]

power = _____ W

Question 6 continues on the next page

Turn over ►



6 (b) In practice the resistance of the cable connecting the oven to the mains supply is not negligible. Each of the **two** wires connecting the heating element to the mains electricity supply has a length of 3.15 m. Each metre of wire has a resistance of $0.0150\ \Omega$.

6 (b) (i) Explain why the rms voltage across the heating element in the oven will be less than 230 V.

[2 marks]

6 (b) (ii) Calculate the rms voltage across the heating element in the oven when it is at its working temperature.

[3 marks]

rms voltage = _____ V



- 6 (b) (iii)** Calculate the average power wasted in the cable due to the heating effect of the electric current.

[2 marks]

average power = _____ W

- 6 (b) (iv)** State **two** reasons why it is important that the cable has a low resistance.

[2 marks]

1 _____

2 _____

14

Turn over for the next question

Turn over ►



- 7 **Figure 2** shows a circuit that includes an oscilloscope used to find the internal resistance r of a battery.

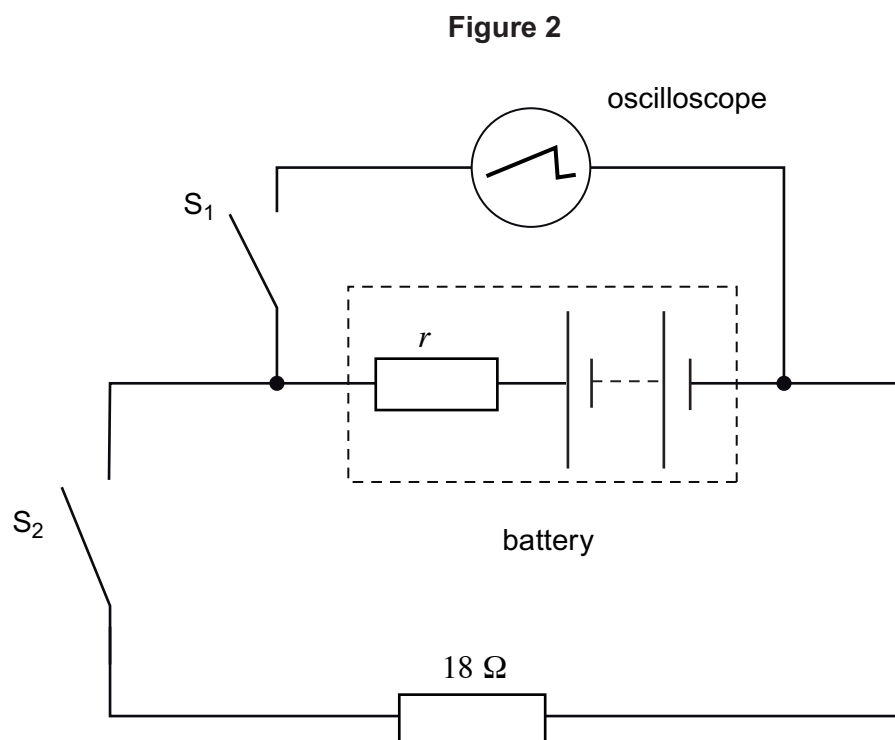
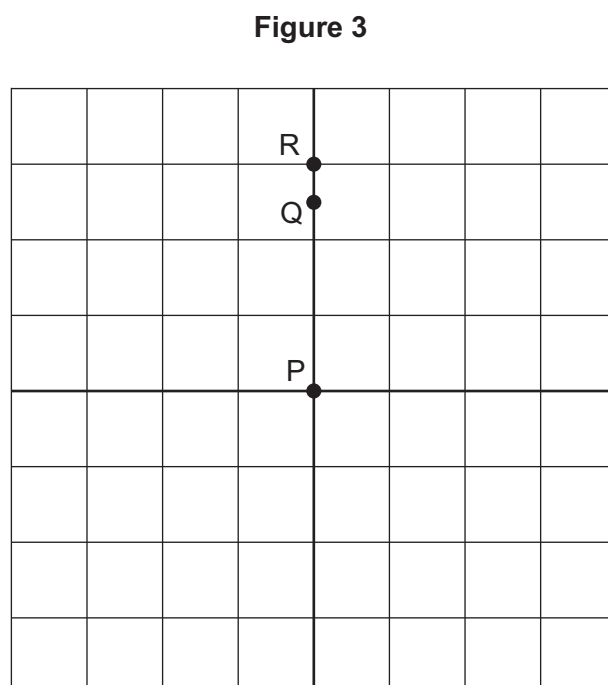


Figure 3 represents the screen of the oscilloscope. With switches S_1 and S_2 open, a bright spot is seen on the screen at P.



The vertical sensitivity of the oscilloscope is set at $2.0\ \text{V}$ per division.



7 (a) Explain why the oscilloscope shows a bright spot rather than a horizontal line. **[1 mark]**

7 (b) When switch S_1 is closed, the spot moves to R.

7 (b) (i) State the electrical property of the battery represented by the deflection PR. **[1 mark]**

7 (b) (ii) Determine the value of the electrical quantity represented by the deflection PR. **[1 mark]**

electrical quantity = _____

7 (c) With switch S_1 kept closed, switch S_2 is also closed. The spot moves to Q.
Explain why the spot moves from R to Q. **[3 marks]**

Question 7 continues on the next page

Turn over ►



7 (d) Calculate the current in the battery when both switches are closed.

[2 marks]

current = _____ A

7 (e) Calculate the internal resistance of the battery.

[2 marks]

internal resistance = _____ Ω

10

END OF QUESTIONS



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AS

Physics

PHYA1 – Particles, Quantum Phenomena and Electricity
Mark scheme

2450
June 2016

Version: 1.0 Final

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

Question	Answers	Additional Comments/Guidance	Mark	ID details
1(a)	(isotopes have) same number of protons✓ different numbers of neutrons✓	allow atomic mass /proton number allow mass number /nucleon number TO where mix up atomic number and mass number	2	
1(b)	$92 \times 1.60 \times 10^{-19}$ ✓ (+) 1.47×10^{-17} (C) ✓ correct power penalise minus sign on answer line	Allow 2 sf answer 1.5×10^{-17} (C) Pay attention to powers on answer line	2	
1(c)	$(4.8 \times 10^{-19} \div 1.60 \times 10^{-19}) = 3$ ✓ (92 – 3 =) 89✓ 95 on answer line 1 mark	or $1.47 \times 10^{-17} - 4.8 \times 10^{-19} (= Q)$ (ecf) $(n = \frac{Q}{e} = \frac{1.47 \times 10^{-17} - 4.8 \times 10^{-19}}{1.6 \times 10^{-19}}) = 89$ (ecf) Integer value for n	2	
1(d)	${}_{92}^{237}\text{U} \rightarrow {}_{93}^{237}\text{Np} + {}_{-1}^0\beta + \overline{\nu}_{(e)}$ ✓✓✓	one mark for: - both numbers correct on Np - both numbers correct on β^- - correct symbol for (electron) antineutrino	3	
Total			9	

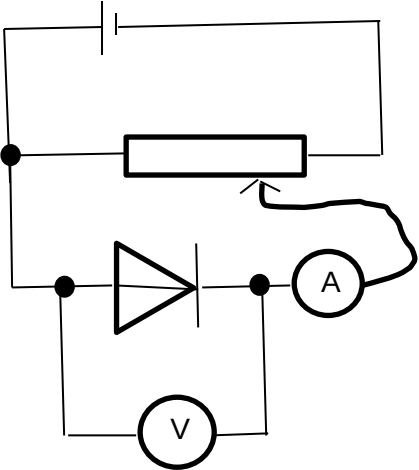
Question	Answers						Additional Comments/Guidance	Mark	ID details		
2(a)							only third box from top ticked Allow crosses in any other box	1			
										$\bar{u}s$	
										$uu\bar{s}$	
										$u\bar{s}$	✓
										$\bar{d}\bar{d}s$	
2(b) (i)	(lepton number of $K^+ = 0$)						need to see $0 \longrightarrow -1 + 1 \checkmark$ (And $0 \longrightarrow 0$) Must be in correct order	1			
	lepton number of $\mu^+ = -1$ lepton number of $\nu_\mu = +1 \checkmark$										
	(hence lepton number zero before and after)										
2(b) (ii)	Strangeness (number)✓						allow <u>rest</u> mass Not meson number	1			
2(b) (iii)		charged	hadron	meson	baryon	lepton	one mark for each correct row ticks in correct boxes only allow crosses in other box(es)	3			
	K^+	(✓)	✓	✓							
	μ^+	(✓)				✓					
	ν_μ					✓					

2(c)	cannot be a lepton (to conserve lepton number)/ cannot be a baryon (to conserve baryon number) / must be a meson cannot have a charge (to conserve charge) ✓ (must be) π^0 ✓	maximum of one mark for either of first marking point can be done by BLQ table for first two marks TO on conservation wrong statements (-1 for each incorrect applied to the first two marking points) allow K^0 as must be a meson allowing strangeness to be conserved	3	
Total			9	

Question	Answers	Additional Comments/Guidance	Mark	ID details
3(a)	pair production✓		1	
3(b) (i)	energy of photon needs to provide at least the <u>rest</u> masses ✓ of the electron <u>and</u> positron / of (both) particles / of particle and antiparticle✓ (allow particles or products) TO on nay suggestion of particles have KE	Or at least the <u>rest</u> energy ✓ Of the electron <u>and</u> positron / of (both) particles of particle and antiparticle✓ Can't score 2nd mark without having scored 1st	2	
3(b) (ii)	minimum energy = $2 \times 0.510999 = 1.021998$ (MeV) ✓ allow detailed argument in reverse 0.5 Mev close to 0.511 MeV	must see working and final answer must be at least 3 sf Or $E=mc^2$ leading to 1.024875 MeV Or $2 \times 5.5 \times 10^{-4} \times 931.5 = 1.02$ MeV	1	
3(b) (iii)	(electron/positron have) kinetic energy✓	thermal energy n/e Momentum n/e	1	
3(b) (iv)	(attempts to convert energy to joules) energy = $1.0 \times 10^6 \times 1.60 \times 10^{-19} = 1.6 \times 10^{-13}$ (J) ✓ (use of $E=hf$) Their energy $\div 6.63 \times 10^{-34} = f$ ✓	Condone power 10 error on MeV conversion to J Must see subject or their f on answer line consistent with working	4	

	$f = 2.4 \times 10^{20} \checkmark \text{ cao}$ Hz (condone s^{-1}) $\checkmark$	Capital H and lower case z (for symbol) Allow word written as Hertz (h lower case)		
Total			9	

Question	Answers	Additional Comments/Guidance	Mark	ID details
4(a) (i)	electrons passing through tube collide with electrons in mercury atom✓ transferring energy / atom gains energy from a collision✓ causing orbital electrons/electrons in mercury atom to move to higher energy level✓	Allow mercury atoms collide with each other Atomic electrons move from ground state	3	
4(a) (ii)	(each) excited electron / atom relaxes to a lower (energy) level✓ emitting a photon of energy <u>equal</u> to the energy difference between the levels✓	allow excited electron / atom de-excites / relaxes Allow excited electron / atom relaxes to ground state Condone moves for relaxes	2	
4(b)	coating absorb (uv) photons (causing excitation) / (uv)photons collide with electrons in the coating (causing excitation) / electrons in coating are excited Atomic <u>electrons</u> de-excite indirectly to previous lower level (and in doing so emit lower energy photons) ✓	allow <u>atoms</u> in coating absorb (uv) photons (causing excitation) Owtte (must convey smaller difference between energy levels in a transition) cascade	2	
Total			7	

Question	Answers	Additional Comments/Guidance	Mark	ID details
5(a) (i)	 correct diode bias for variable supply, must have some attempt to vary pd✓ correct symbols and positions for voltmeter, ammeter: voltmeter in parallel with diode only ammeter in series with diode✓ allow voltmeter across ammeter and diode	Condone variable resistor (condone missing arrow) don't allow thermistor symbol Allow mA symbol instead of A symbol for ammeter Allow symbols for diode without line through triangle and / or with a circle Diode symbol must consist of a triangle and a straight line at nose perpendicular to wiring in circuit. 	2	

5(a) (ii)	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. <i>Candidate explains how to obtain sufficient values of I and V. They mention the need to limit the current through the diode and give an indication of the range and frequency of measurements. They discuss an advantage of using a data logger. voltage does not exceed 1.0V, diode is forward biased</i> Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. <i>Candidate explains how to obtain sufficient values of I and V. includes mention of diode is forward biased or suitable voltage for switch on mentioned or advantage of data logger</i>	Lower band <u>vary pd</u> obtain several readings of I and V or an advantage of using data logger or low level safety and action to minimise risk Middle band vary pd and obtain several readings of I and V, at least 6 different values including an advantage of using data logger or mention of forward bias or mention of switch on voltage (0.6V) or safety Top Band Mention of how to vary pd (seen in viable circuit) obtain several readings of I and V, at least 6 different values (range given where maximum value of pd does not exceed 1.0V) mention of limiting current through diode using protective resistor consider advantage of data logger mention forward bias must include potentiometer for 6 marks must have voltage as independent, no current led arguments in Top band	6	

	Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. vary pd obtain several readings of I and V or an advantage of using data logger or forward biased low level safety may include switch off / avoid overheating type arguments / don't touch The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case. means of controlling pd across diode indication of range and frequency of measurement mention of limiting current to avoid damage to diode a consideration of the advantages of a datalogger e.g. many readings, computer display of results use of potential divider instead of series resistor All signs of quality that could lift mark	Data logger advantages: Not more accurate Not removes human error		
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5 (a) (iii)	reverse connections to the power supply/battery/cell / reverse diode ✓	not switch wires around (need clear link to reversing connections at supply's terminals)	1	
5(b) (i)	divide V by I for a reading from graph or uses $R = \frac{V}{I}$ for a reading from graph ✓ repeat for different values of V and I ✓	Treat gradient = $\frac{1}{R}$ as TO Must score 1 st mark to achieve 2 nd	2	
5(b) (ii)	(Resistance) decreases ✓	Or resistance starts off very high and then becomes much lower	1	
Total			12	

Question	Answers	Additional Comments/Guidance	Mark	ID details
6(a) (i)	$230 \times \sqrt{2} = 325 \text{ (V)} \checkmark$ $(2 \times 325 =) 650 \text{ to } 651 \text{ V} \checkmark$	allow doubling their incorrect peak voltage (162.6×2) by use of $\sqrt{2}$ as an attempt to find peak-to-peak for 1 mark but not just 2×230	2	
6(a) (ii) Must see 6(a) (i)	<i>(use of $P = V^2/R$)</i> $P = 230^2/12 \checkmark$ $P = 4.4 \times 10^3 \text{ (W)} \checkmark \text{ cao}$ 2 sig. figs. Incorrect <u>answer must be supported by working</u> $\checkmark$	Allow their incorrect answer $(a)(i)^2 \div 12$ Or $325^2 \div 12$ as a use of for 1 mark Alternative For first mark $I = \frac{V}{R}$ and $P = VI$ allowing their incorrect answer (a)(i) or 325 as sub for V for 1 mark Answers 8.8 kW (325V) and 35 kW (650V)	3	

6(b) (i)	there is a pd/voltage across the cable ✓ pd/voltage across cooker is 230 V minus this pd/voltage ✓ 2nd mark depends on 1st mark in all	The current is lower due to the resistance of cable / The current is lower as circuit resistance increases ✓ pd across oven is lower <u>since</u> $V = I \times \text{Resistance of element}$ ✓ or Resistance of the cable is in series with element ✓ Voltage splits (in ratio) across these resistances ✓	2	
6(b) (ii)	resistance of cable = $2 \times 3.15 \times 0.0150 = 0.0945$ ✓ $V = \frac{12}{12 + R_{\text{cable}}} \times 230 \checkmark$ =228 V ✓ cao	Allow power 10 error here Or $I = \frac{230}{12 + R_{\text{cable}}}$ and $V = \left(\frac{230}{12 + R_{\text{cable}}} \right) \times 12$ Allow their incorrect R_{cable} correctly substituted for 2nd marking	3	

6(b) (iii)	230 – their (b) (ii) or 19 (A) quoted for current or equivalent seen in equation $(230 / 12.0945)✓$ $(P =) 34.2$ to $42.3(W) ✓$ correct working ecf as $P = (230 - (b)(ii))^2 / \text{their } R_{\text{cable}}$		2	
6(b) (iv)	minimise power loss / maximise efficiency of oven / ensure element gets as hot as possible✓ avoid overheating/fires✓	not just to carry a large current / larger pd across element Either order	2	
Total			14	

Question	Answers	Additional Comments/Guidance	Mark	ID details
7(a)	time base is (switched) off✓ TO for y-input switched off	not affected by x plates because these plates are not switched on	1	
7(b) (i)	emf (of battery)✓	not just terminal pd TO applied for non-emf statements Allow explanation of emf	1	
7(b) (ii)	(emf = $3 \times 2.0 =$) 6.0 V✓	penalise 1 sf	1	
7(c)	Because the pd across the y plates has decreased✓ there is a current (in the battery)✓ there is a pd/voltage across the internal resistance or there are (now) lost volts✓ terminal pd decreases or terminal pd now less than emf or $IR = \varepsilon - Ir$ ✓	MAX 3	3	
7(d)	$V = 2.5 \times 2.0 = 5 \text{ V}$ or (use of $V=IR$) by $I =$ their incorrect voltage $\div 18$ ✓ $I = 0.28 \text{ (A)}$ ✓ cao	Must see I as subject or their working leading to answer line for use of	2	

7(e)	(use of $\mathcal{E}=IR +Ir$) $6.0 = 2.5 \times 2.0 + 0.28 \times r$ or correct rearrangement to make r subject or sets $R_{(r)} = \frac{\mathcal{E}}{0.28} = 21.2 \text{ to } 21.4 \text{ (ohms)}$ with subject seen or $r = \frac{1}{0.28} \checkmark$ $r = 3.4 \text{ to } 3.6 \, \Omega \checkmark$	$r = \frac{\mathcal{E} - IR}{I}$ Ecf for I and V $ecf \text{ ans} = \frac{6 - \text{their } V}{\text{their } I}$	2	
Total			10	

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

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Question	Mark
1	
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7	
TOTAL	



General Certificate of Education
Advanced Subsidiary Examination
June 2015

Physics A

PHYA1

Unit 1 Particles, Quantum Phenomena and Electricity

Tuesday 19 May 2015 9.00 am to 10.15 am

For this paper you must have:

- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Time allowed

- 1 hour 15 minutes

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PHYA1

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

- 1** **Table 1** contains five statements that refer to isotopes and some radium isotopes.

Table 1

	$^{223}_{88}\text{Ra}$	$^{224}_{88}\text{Ra}$	$^{225}_{88}\text{Ra}$	$^{226}_{88}\text{Ra}$
Isotope with the smallest mass number	✓			
Isotope with most neutrons in nucleus				
Isotope with nucleus which has the largest specific charge				
Isotope decays by β^- decay to form $^{225}_{89}\text{Ac}$				
Isotope decays by alpha decay to form $^{220}_{86}\text{Rn}$				

- 1 (a)** Complete **Table 1** by ticking **one** box in each row to identify the appropriate isotope. The first row has been completed for you.

[4 marks]

- 1 (b) (i)** An atom of one of the radium isotopes in **Table 1** is ionised so that it has a charge of $+3.2 \times 10^{-19} \text{ C}$.

State what happens in the process of ionising this radium atom.

[1 mark]

.....
.....

- 1 (b) (ii)** The specific charge of the ion formed is $8.57 \times 10^5 \text{ C kg}^{-1}$.

Deduce which isotope in the table has been ionised. Assume that both the mass of a proton and the mass of a neutron in the nucleus is $1.66 \times 10^{-27} \text{ kg}$.

[3 marks]

isotope = ...



- 2** The equation shows an interaction between a proton and a negative kaon that results in the formation of particle, X.



- 2 (a) (i)** State and explain whether X is a charged particle.

[2 marks]

.....

.....

- 2 (a) (ii)** State and explain whether X is a lepton, baryon or meson.

[2 marks]

.....

.....

- 2 (a) (iii)** State the quark structure of the K^- , K^+ and the K^0 .

[3 marks]

K^-

K^+

K^0

- 2 (a) (iv)** Strangeness is conserved in the interaction.

Determine, explaining your answer, the quark structure of X.

[3 marks]

.....

.....

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3 (a) Baryons, mesons and leptons are affected by particle interactions.

Write an account of these interactions. Your account should:

- include the names of the interactions
- identify the groups of particles that are affected by the interaction
- identify the exchange particles involved in the interaction
- give examples of **two** of the interactions you mention.

The quality of your written communication will be assessed in your answer.

[6 marks]

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3 (b) Draw a labelled Feynman diagram that represents a particle interaction.

[3 marks]

Turn over for the next question

9

Turn over ►



4 Sodium metal has a work function of 2.28 eV. An atom of sodium has an ionisation energy of 5.15 eV.

4 (a) (i) State what is meant by work function.

[2 marks]

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4 (a) (ii) State what is meant by ionisation energy.

[2 marks]

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4 (b) Show that the minimum frequency of electromagnetic radiation needed for a photon to ionise an atom of sodium is about 1.2×10^{15} Hz.

[2 marks]



- 4 (c)** Electromagnetic radiation with the frequency calculated in part (b) is incident on the surface of a piece of sodium.

Calculate the maximum possible kinetic energy of an electron that is emitted when a photon of this radiation is incident on the surface.

Give your answer to an appropriate number of significant figures.

[3 marks]

maximum kinetic energy = ... J

- 4 (d)** Calculate the speed of an electron that has the same de Broglie wavelength as the electromagnetic radiation in part (b).

[3 marks]

speed = ... m s^{-1}

12

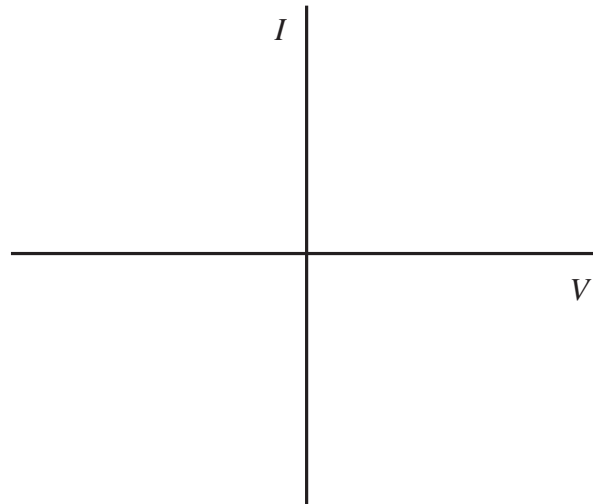
Turn over ►



- 5 (a)** Sketch, on **Figure 1**, the current–voltage (IV) characteristic for a filament lamp for currents up to its working power.

[2 marks]

Figure 1



- 5 (b) (i)** State what happens to the resistance of the filament lamp as the current increases.

[1 mark]

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- 5 (b) (ii)** State and explain whether a filament lamp is an ohmic or non-ohmic conductor up to its working power.

[1 mark]

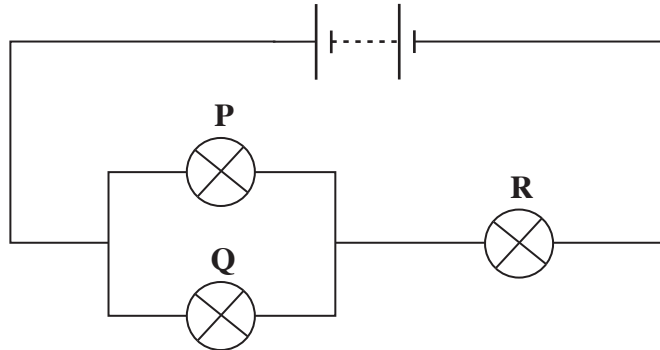
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- 5 (c)** Three identical filament lamps, **P**, **Q** and **R** are connected in the circuit shown in **Figure 2**.

Figure 2



The filament in lamp **Q** melts so that it no longer conducts. Explain why lamp **P** becomes brighter and lamp **R** becomes dimmer.

[2 marks]

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Question 5 continues on the next page

Turn over ►



5 (d) A filament lamp, **X**, is rated at 60 W 230 V. Another type of lamp, **Y**, described as 'energy saving' has the same light intensity output but is rated at 11 W 230 V.

5 (d) (i) Calculate the electrical energy converted by each lamp if both are on for 4 hours a day for a period of 30 days.

[2 marks]

electrical energy converted by **X** = ... J

electrical energy converted by **Y** = ... J

5 (d) (ii) Suggest why the two lamps can have different power ratings but have the same light intensity output.

[2 marks]

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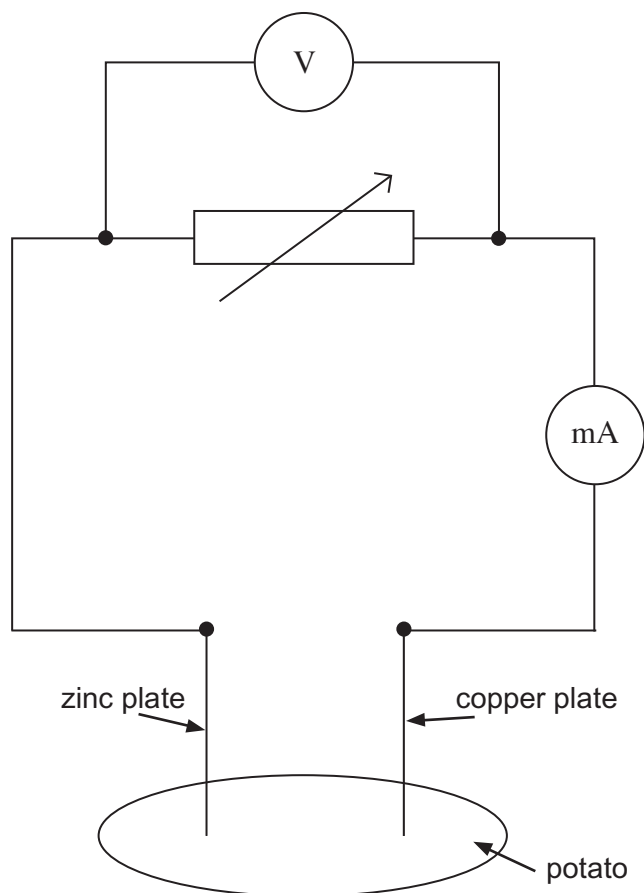
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- 6** A 'potato cell' is formed by inserting a copper plate and a zinc plate into a potato. The circuit shown in **Figure 3** is used in an investigation to determine the electromotive force and internal resistance of the potato cell.

Figure 3



- 6 (a)** State what is meant by electromotive force.

[2 marks]

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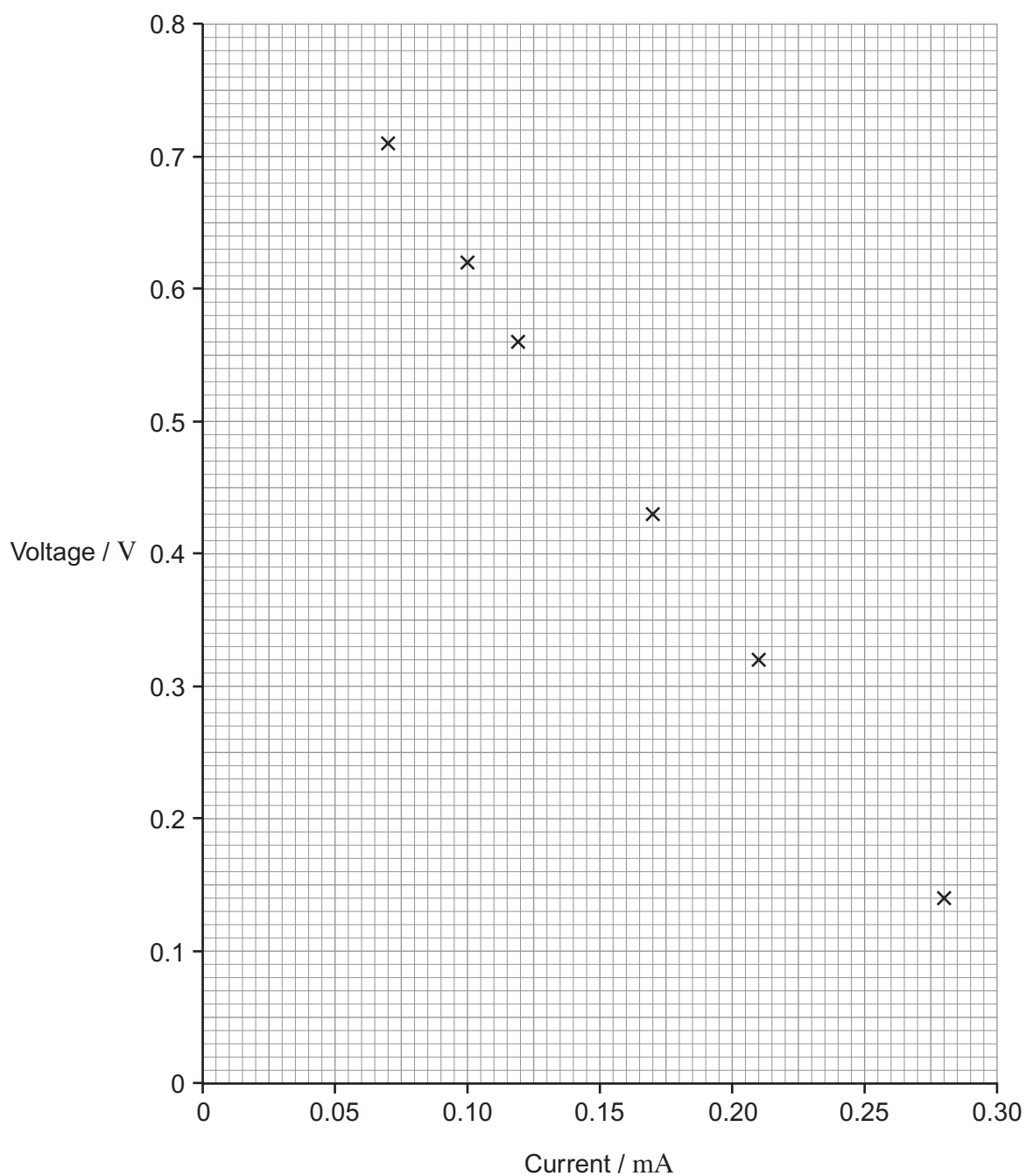
Question 6 continues on the next page

Turn over ►



- 6 (b) The plotted points on **Figure 4** show the data for current and voltage that were obtained in the investigation.

Figure 4



6 (b) (i) Suggest what was done to obtain the data for the plotted points.

[1 mark]

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6 (b) (ii) The electromotive force (emf) of the potato cell is 0.89 V. Explain why the voltages plotted on **Figure 4** are always less than this and why the difference between the emf and the plotted voltage becomes larger with increasing current.

[3 marks]

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6 (b) (iii) Use **Figure 4** to determine the internal resistance of the potato cell.

[3 marks]

internal resistance = ... Ω

Question 6 continues on the next page

Turn over ►



- 6 (c)** A student decides to use two potato cells in series as a power supply for a light emitting diode (LED). In order for the LED to work as required, it needs a voltage of at least 1.6 V and a current of 20 mA.

Explain whether the LED will work as required.

[2 marks]

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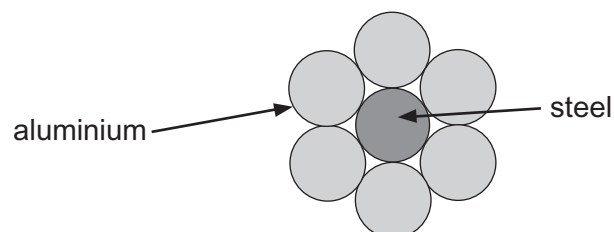
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11



- 7 A cable used in high-voltage power transmission consists of six aluminium wires surrounding a steel wire. A cross-section is shown in **Figure 5**.

Figure 5



The resistance of a length of 1.0 km of the steel wire is $3.3 \, \Omega$. The resistance of a length of 1.0 km of **one** of the aluminium wires is $1.1 \, \Omega$.

- 7 (a) The steel wire has a diameter of 7.4 mm.
Calculate the resistivity of steel. State an appropriate unit.

[4 marks]

resistivity = ... unit

Question 7 continues on the next page

Turn over ►



- 7 (b)** Explain why only a small percentage of the total current in the cable passes through the steel wire.

[3 marks]

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- 7 (c)** The potential difference across a length of 1.0 km of the cable is 75 V.
- Calculate the total power loss for a 1.0 km length of cable.

[3 marks]

Total power loss W

10

END OF QUESTIONS



A-LEVEL

Physics

PHYA1 – Particles, Quantum Phenomena and Electricity
Mark scheme

2450
June 2015

Version V1: Final Mark Scheme

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

Question	Answers	Additional Comments/Guidance	Mark	ID details																														
1a	<table border="1"> <tr> <td></td><td>$^{223}_{88}\text{Ra}$</td><td>$^{224}_{88}\text{Ra}$</td><td>$^{225}_{88}\text{Ra}$</td><td>$^{226}_{88}\text{Ra}$</td></tr> <tr> <td>Isotope with smallest mass number</td><td>(✓)</td><td></td><td></td><td></td></tr> <tr> <td>Isotope with most neutrons in nucleus</td><td></td><td></td><td></td><td>✓</td></tr> <tr> <td>Isotope with nucleus that has highest specific charge</td><td>✓</td><td></td><td></td><td></td></tr> <tr> <td>Isotope that decays by β^- decay to form $^{225}_{89}\text{Ac}$</td><td></td><td></td><td>✓</td><td></td></tr> <tr> <td>Isotope that decays by alpha decay to form $^{220}_{86}\text{Rn}$</td><td></td><td>✓</td><td></td><td></td></tr> </table>		$^{223}_{88}\text{Ra}$	$^{224}_{88}\text{Ra}$	$^{225}_{88}\text{Ra}$	$^{226}_{88}\text{Ra}$	Isotope with smallest mass number	(✓)				Isotope with most neutrons in nucleus				✓	Isotope with nucleus that has highest specific charge	✓				Isotope that decays by β^- decay to form $^{225}_{89}\text{Ac}$			✓		Isotope that decays by alpha decay to form $^{220}_{86}\text{Rn}$		✓			one mark for each correct row (ignore first row as already ticked) allow cross instead of tick and ignore any crossed out ticks if more than one tick in a row then no mark	4	
	$^{223}_{88}\text{Ra}$	$^{224}_{88}\text{Ra}$	$^{225}_{88}\text{Ra}$	$^{226}_{88}\text{Ra}$																														
Isotope with smallest mass number	(✓)																																	
Isotope with most neutrons in nucleus				✓																														
Isotope with nucleus that has highest specific charge	✓																																	
Isotope that decays by β^- decay to form $^{225}_{89}\text{Ac}$			✓																															
Isotope that decays by alpha decay to form $^{220}_{86}\text{Rn}$		✓																																
1bi	the atom has lost <u>two electrons</u> ✓		1																															
1bii	(use of specific charge = charge ÷ mass) mass = $3.2 \times 10^{-19} \div 8.57 \times 10^5 = 3.734 \times 10^{-25}$ (kg) mass number = $3.734 \times 10^{-25} \div 1.66 \times 10^{-27}$ ✓ (= 225) hence $^{225}_{(88)}\text{Ra}$ OR 225✓✓ OR calculate specific charge for each isotope✓ hence $^{225}_{(88)}\text{Ra}$ OR 225✓✓	ignore any reference to electrons first mark for deduction bald correct answer scores 2 marks don't need radium symbol or 88 wrong answer scores zero	3																															

Total			8	

Question	Answers	Additional Comments/Guidance	Mark	ID details
2ai	X must have a <u>negative charge</u> ✓ to conserve charge✓	second mark dependent on first i.e. conserve charge alone scores nothing can gain second mark by showing balanced equation	2	
2aii	X must be a baryon✓ to conserve baryon number✓	here two marks are independent i.e. conserve baryon number alone scores 1 mark can gain second mark by showing balanced equation	2	
2aiii	K^- : $s\bar{u}$ OR strange anti-up ✓ K^+ : $u\bar{s}$ OR up anti-strange✓ K^0 : $d\bar{s}$ OR $s\bar{d}$ OR down anti-strange OR strange anti-down✓	in each case the symbols or words can be in either order must be a bar over anti - quark can be upper case letters e.g. U	3	
2aiv	(strangeness on LHS is -1) strangeness on RHS without X is +2 /strangeness of X is -3 ✓ thus sss OR strangeness on RHS without X is +2 / strangeness of X is -1✓ thus sdd✓✓	correct strangeness without X on RHS is minimum working needed for first mark next two marks awarded for correct quark structure	3	
Total			10	

Question	Answers	Additional Comments/Guidance	Mark	ID details
3a	The student's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The student's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. <i>Student names strong, weak and electromagnetic interactions. Identifies that only hadrons experience the strong interaction but hadrons and leptons experience weak interaction. Charged particles experience electromagnetic interaction. Is able to identify all exchange particles such as gluons, W⁺ and W⁻ and virtual photons. Gives examples of two of the interactions i.e. electrons repelling, electron capture, beta decay.</i> Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of	ignore any reference to gravity ignore any Feynman diagrams electrostatic not allowed as alternative for electromagnetic Properties of interactions - correct exchange particle(W^(+/-)boson/Z₀ boson, (virtual) photon, gluon/pion) NB sign on W not required - correct group of particles affected (strong: baryons and mesons, weak: baryons, mesons and leptons, electromagnetic: charged particles) - example of the interaction Lower band 1 mark – two interactions OR one interaction and one property for that interaction 2 marks – two interactions and one property for one interaction Middle band	6	

	specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.	3 marks - two interactions plus two properties 4 marks – two interactions plus minimum of four properties (e.g. 3 props plus 1 OR 2 props plus 2), if three interactions quoted then properties can be spread between the 3 e.g. one property for each (3) plus one additional Top band 5 marks – 3 interactions plus two properties for each 6 marks – must give first two properties for all three interactions AND correctly state two examples of interactions e.g. electron capture example of weak, strong nuclear responsible for binding protons/neutrons/baryons together		
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	<i>Student names strong, weak and electromagnetic interactions. Identifies that only hadrons experience the strong interaction but hadrons and leptons experience weak interaction. Charged particles experience electromagnetic interaction. Is able to identify some exchange particles such as gluons, W^+ and W^- and virtual photons.</i> Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. <i>Student names strong, weak and electromagnetic interactions.</i>	A table may help: <table><tr><td></td><td>strong</td><td>weak</td><td>EM</td></tr><tr><td>property 1</td><td></td><td></td><td></td></tr><tr><td>property 2</td><td></td><td></td><td></td></tr><tr><td>property 3</td><td></td><td></td><td></td></tr></table>		strong	weak	EM	property 1				property 2				property 3					
	strong	weak	EM																	
property 1																				
property 2																				
property 3																				

	<i>Identifies that only hadrons experience the strong interaction. Identifies one exchange particle.</i> The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case. <i>names of interactions – strong, weak and electromagnetic hadrons experience strong hadrons and leptons experience weak charged particles experience electromagnetic identify exchange particles give examples of various interactions e.g. electron capture</i>			
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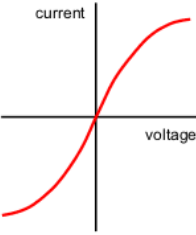
3b	(either weak interaction or electromagnetic or strong interaction) first mark conservation at left hand junction of charge, baryon and lepton number✓ second mark conservation at right hand junction of charge, baryon and lepton number✓ third mark for correct exchange particle✓	if exchange particle not identified but baryon and lepton numbers conserved on both sides – 1 mark ignore orientation of line showing exchange particle or any arrows on exchange particle line when awarding first two marks if arrows on incoming and outgoing interacting particles in wrong direction then lose mark if lines do not meet at a junction lose 1 mark with third mark orientation of exchange particle line must be consistent with exchange particle shown and no arrow required	3	
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		if exchange particle line is horizontal (for weak) then must be a correct arrow arrow overrides slope		
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Total			9	
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Question	Answers	Additional Comments/Guidance	Mark	ID details
4ai	the <u>minimum energy</u> required by an <u>electron</u> ✓ to escape from a (metal) <u>surface</u> ✓	if refer to atom/ionisation zero marks	2	
4aii	the (minimum) energy to remove an electron(from an atom)✓ from the <u>ground state</u> ✓		2	
4b	(use of $hf=eV$) $6.63 \times 10^{-34} \times f = 5.15 \times 1.60 \times 10^{-19}$ ✓ $f = \frac{5.15 \times 1.60 \times 10^{-19}}{6.63 \times 10^{-34}}$ ✓ = 1.24×10^{15} (Hz)	if no working and 1.24×10^{15} (Hz) 1 mark	2	
4c	(use of $hf = E_k + \phi$) $\phi = 2.28 \times 1.60 \times 10^{-19} = 3.648 \times 10^{-19}$ (J) ✓ $E_k = 5.15 \times 1.60 \times 10^{-19} - 3.648 \times 10^{-19} = 4.59 \times 10^{-19}$ J ✓✓	3 sig figs if clearly used 1.2×10^{15} then final answer must be to 2 sig. figs. for last mark to be awarded accept 4.57 in place of 4.59	3	
4d	(use of $c=f\lambda$)	first mark minimum working - determination of wavelength	3	

	$\lambda = \frac{3.0 \times 10^8}{1.24 \times 10^{15}} = 2.42 \times 10^{-7} \checkmark$ $v = h/m\lambda = 6.63 \times 10^{-34} / (9.11 \times 10^{-31} \times 2.42 \times 10^{-7})$ $v = 3010 \text{ m s}^{-1} \checkmark \checkmark$	bald answer gets 2 marks range to 3 sig figs 2900 – 3030		
Total			12	

Question	Answers	Additional Comments/Guidance	Mark	ID details
5a		first mark for linear at origin and decreasing gradient in either quadrant (linear region can be very small) second mark for symmetry plus no dip at end or extended horizontal section at end straight line scores zero	2	
5bi	resistance (of filament lamp) increases✓		1	
5bii	filament lamp is a non-ohmic conductor as current is not (directly) proportional to voltage /resistance is not constant✓	proportionality can be shown using graph	1	
5c	either circuit/total resistance increases✓ (hence) current decreases and pd/voltage across R decreases✓	implication that current is different in different parts of series circuits scores 0 implication that new total current is greater scores zero	2	

	OR resistance of PQ combination increases✓ (hence) greater share of pd/voltage across lamp P✓	voltage flowing loses second mark		
5di	(use of $energy = VIt$) (energy converted by X = $60 \times 120 \times 3600 =$) $2.59 \times 10^7 \text{ J}$ ✓ (energy converted by Y = $11 \times 120 \times 3600 =$) $4.75 \times 10^6 \text{ J}$ ✓	Accept answers to 1 sig. fig.	2	
5dii	in lamps energy is wasted as heat/thermal energy✓ specific lamp considered e.g. in lamp, X/ filament lamp more energy is wasted OR in X/filament lamp less energy is converted to light/luminosity✓		2	

Total			10	
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Question	Answers	Additional Comments/Guidance	Mark	ID details
6a	emf is the work done/ energy transferred by a voltage source/battery/cell ✓ per <u>unit</u> charge✓ OR electrical energy transferred/converted/delivered/produced✓ per <u>unit</u> charge✓ OR pd across terminals when no current flowing/open circuit✓✓	not <u>in</u> battery accept word equation OR symbol equation with symbols defined if done then must explain energy/work in equation for first mark	2	
6bi	by altering the (variable) <u>resistor</u> ✓		1	
6bii	reference to correct internal resistance✓ terminal pd = emf – pd across internal resistance/lost volts✓ pd/lost volts increases as current increases OR as (variable)	e.g. resistance of potato (cell) accept voltage for pd	3	

	resistance decreases greater proportion/share of emf across internal resistance✓			
6biii	draws best fit straight line and attempts to use gradient✓ uses triangle with base at least 6 cm✓ value in range 2600 – 2800 (Ω)✓	stand-alone last mark	3	
6c	total emf is above 1.6 V✓ but will not work as current not high enough/less than 20 mA✓		2	
Total			11	

Question	Answers	Additional Comments/Guidance	Mark	ID details
7a	Use of $\rho=RA/l$ cross sectional area= $\pi \times (3.7 \times 10^{-3})^2 = 4.3 \times 10^{-5} \text{ (m}^2\text{)}✓$ $\rho = \frac{3.3 \times 4.3 \times 10^{-5}}{1000} ✓ = 1.4(2) \times 10^{-7} ✓ \Omega \text{ m}✓$	area : lose first mark if use diameter as radius or fail to convert to m^2 (if both errors still only lose 1 mark) CE area for next two marks but if uses diameter in place of area then lose first two marks if leave length in km lose 2 nd mark but CE for answer UNIT stand-alone 4th mark	4	
7b	(current in) steel wire (is less than the current in an) aluminium wire as it has a higher resistivity/resistance OR aluminium is better conductor✓ the six aluminium wires are in <u>parallel</u> OR <u>total</u> cross-sectional area of aluminium is 6 times greater than steel wire✓ each aluminium wire carries three times as much current as		3	

	the (single) steel wire✓			
7c	resistance of 1 km of 6 Al cables in parallel = $\frac{1.1}{6} = 0.183 \Omega$✓ total resistance of the cable = 0.174Ω✓ power loss per km = 32.3 kW (or 30.7 kW if they ignore the steel)✓ OR power loss in 1 km of steel = 1.70kW✓ power loss in 1 km each of Al cable = 5.11 kW✓ total power loss per km = 32.4 kW (or 30.7 kW if they ignore the steel)✓ OR calculate current in steel wire and aluminium wire (22.7 and 68.2)✓ calculate power loss in aluminium wire and steel wire (1700 and 5115)✓ calculate total power loss ($1700 + 6 \times 5115 = 32,4 \text{ kW}$)✓	if ignored the steel wire then can score first and third mark Accept range 32 kW to 33 kW If ignored steel wire range for third mark is 30 kW to 31 kW if wires treated as series resistors then zero	3	
Total			10	

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										



General Certificate of Education
Advanced Subsidiary Examination
June 2014

Physics A

PHYA1

Unit 1 Particles, Quantum Phenomena and Electricity

Tuesday 20 May 2014

9.00 am to 10.15 am

For this paper you must have:

- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Time allowed

- 1 hour 15 minutes

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	



J U N 1 4 P H Y A 1 0 1

WMP/Jun14/PHYA1/E5

STEMUP.CO.UK

PHYA1

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

1 (a) The positive kaon, K^+ , has a strangeness of +1.

1 (a) (i) What is the quark structure of the K^+ ?

[1 mark]

.....

1 (a) (ii) What is the baryon number of the K^+ ?

[1 mark]

.....

1 (a) (iii) What is the antiparticle of the K^+ ?

[1 mark]

.....

1 (b) The K^+ may decay into a neutrino and an antimuon in the following way.

$$K^+ \rightarrow \nu_\mu + \mu^+$$

1 (b) (i) Complete **Table 1** using ticks and crosses as indicated in the first row.

[3 marks]

Table 1

Classification	K^+	ν_μ	μ^+
lepton	×	✓	✓
charged particle			
hadron			
meson			

1 (b) (ii) In this decay, charge, energy and momentum are conserved.

Give another quantity that is conserved in this decay and one that is not conserved.

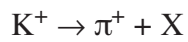
[2 marks]

Conserved

Not conserved



1 (c) Another possible decay of the K^+ is shown in the following equation,



1 (c) (i) Identify X by ticking **one** box from the following list.

[1 mark]

electron	
muon	
negative pion	
neutral pion	
neutrino	
neutron	
positron	

1 (c) (ii) Give **one** reason for your choice in part (c)(i).

[1 mark]

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2 (a) Table 2 contains data for four different nuclei, P, Q, R and S.

Table 2

Nuclei	Number of neutrons	Nucleon number
P	5	11
Q	6	11
R	8	14
S	9	17

2 (a) (i) Which nucleus contains the fewest protons?

[1 mark]

nucleus

2 (a) (ii) Which **two** nuclei are isotopes of the same element?

[1 mark]

nuclei and

2 (a) (iii) State and explain which nucleus has the smallest specific charge.

[2 marks]

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2 (a) (iv) Complete the following equation to represent β^- decay of nucleus R to form nucleus X.

[3 marks]



- 2 (b) (i)** The strong nuclear force is responsible for keeping the protons and neutrons bound in a nucleus.
Describe how the strong nuclear force between two nucleons varies with the separation of the nucleons, quoting suitable values for separation.

[3 marks]

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- 2 (b) (ii)** Another significant interaction acts between the protons in the nucleus of an atom.
Name the interaction and name the exchange particle responsible for the interaction.

[2 marks]

Interaction

Exchange particle

12

Turn over for the next question

Turn over ►



- 3 (a)** What phenomenon can be used to demonstrate the wave properties of electrons?
[1 mark]

.....

- 3 (b)** Calculate the wavelength of electrons travelling at a speed of $2.5 \times 10^5 \text{ m s}^{-1}$.
Give your answer to an appropriate number of significant figures.
[3 marks]

wavelength m

- 3 (c)** Calculate the speed of muons with the same wavelength as these electrons.
mass of muon = $207 \times$ mass of electron
[2 marks]

speed m s^{-1}

Turn to page 8 for the next question



Turn over for the next question

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Turn over ►



4 (a) A fluorescent tube is filled with mercury vapour at low pressure. After mercury atoms have been excited they emit photons.

4 (a) (i) In which part of the electromagnetic spectrum are these photons?

[1 mark]

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4 (a) (ii) What is meant by an excited mercury atom?

[1 mark]

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4 (a) (iii) How do the mercury atoms in the fluorescent tube become excited?

[2 marks]

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4 (a) (iv) Why do the excited mercury atoms emit photons of characteristic frequencies?

[3 marks]

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4 (b) The wavelength of some of the photons emitted by excited mercury atoms is 254 nm.

4 (b) (i) Calculate the frequency of the photons.

[2 marks]

frequency Hz

4 (b) (ii) Calculate the energy of the photons in electron volts (eV).

[2 marks]

energy eV

4 (c) Explain how the coating on the inside of a fluorescent tube emits visible light.

[2 marks]

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13

Turn over for the next question

Turn over ►



- 5 A student investigates how the power dissipated in a variable resistor, Y , varies as the resistance is altered.

Figure 1 shows the circuit the student uses. Y is connected to a battery of emf $\mathcal{E}$ and internal resistance r .

Figure 1

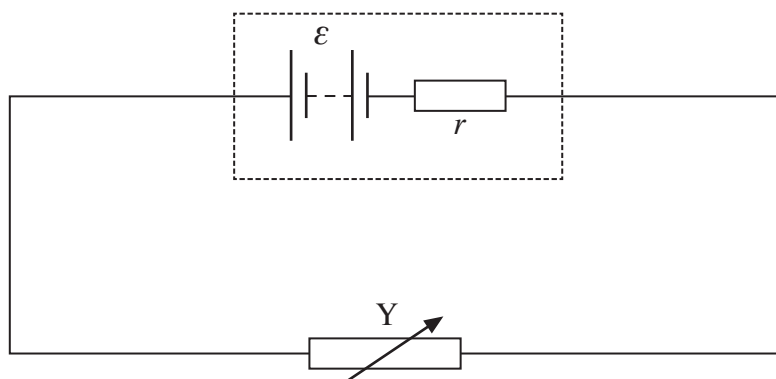
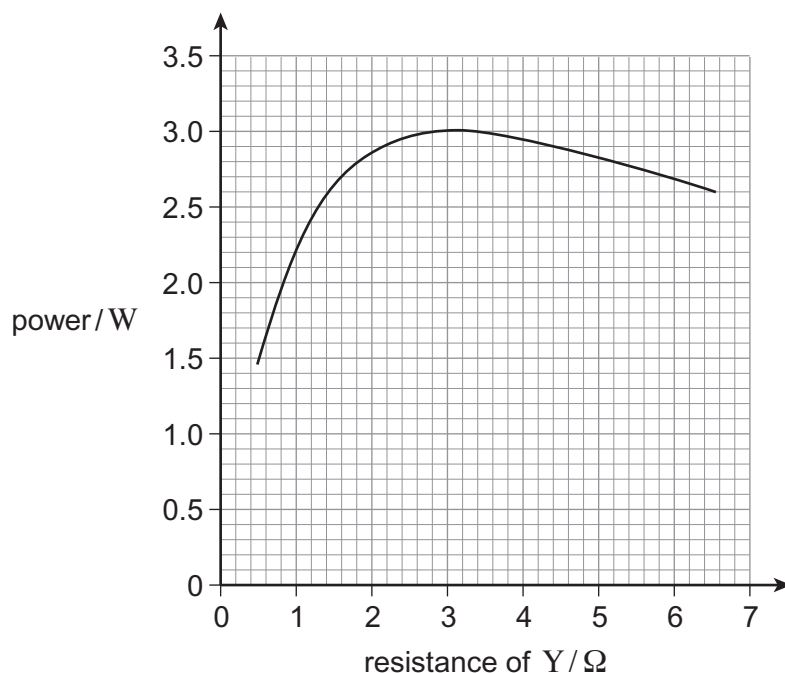


Figure 2 shows the results obtained by the student as the resistance of Y is varied from $0.5\ \Omega$ to $6.5\ \Omega$.

Figure 2



- 5 (a)** Describe how the power dissipated in Y varies as its resistance is increased from $0.5\ \Omega$ to $6.5\ \Omega$.

[2 marks]

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- 5 (b)** The emf of the battery is 6.0 V and the resistance of Y is set at $0.80\ \Omega$.

- 5 (b) (i)** Use data from **Figure 2** to calculate the current through the battery.

[3 marks]

current A

- 5 (b) (ii)** Calculate the voltage across Y.

[2 marks]

voltage V

- 5 (b) (iii)** Calculate the internal resistance of the battery.

[2 marks]

internal resistance Ω

Question 5 continues on the next page

Turn over ►



- 5 (c)** The student repeats the experiment with a battery of the same emf but negligible internal resistance. State and explain how you would now expect the power dissipated in Y to vary as the resistance of Y is increased from $0.5\ \Omega$ to $6.5\ \Omega$.

[3 marks]

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12



6 The critical temperature of tin is -269°C . The resistivity of tin increases as its temperature rises from -269°C .

6 (a) (i) Define resistivity.

[2 marks]

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6 (a) (ii) State the significance of the critical temperature of a material.

[2 marks]

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6 (b) A sample of tin in the form of a cylinder of diameter 1.0 mm and length 4.8 m has a resistance of $0.70\ \Omega$.

Use these data to calculate a value of the resistivity of tin.
State an appropriate unit for your answer.

[4 marks]

resistivity unit

8

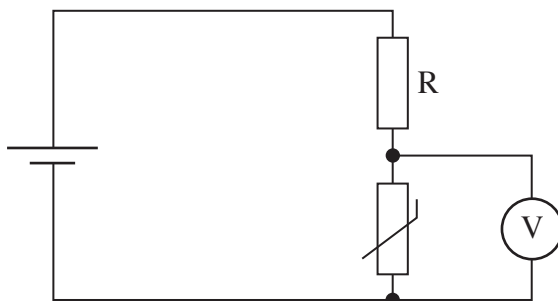
Turn over for the next question

Turn over ►



- 7 A thermistor is to be used as a temperature sensor. In order to find out how the voltage across the thermistor varies with temperature the circuit shown in **Figure 3** is set up.

Figure 3



- 7 (a) Data have to be obtained so that a graph can be plotted to show how the reading on the voltmeter varies with temperature between 0°C and 100°C . Design an experiment, using this circuit, to obtain enough data to plot the graph. Your answer should include:

- details of the measurements taken
- details of how the temperature of the thermistor can be varied
- an explanation of the need for resistor R
- an explanation of how the thermistor can then be used to measure the temperature of a room.

The quality of your written communication will be assessed in your answer.

[6 marks]

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- 7 (b)** The experiment you designed in part (a) is repeated with the voltmeter connected across R instead.
State and explain how the readings on the voltmeter would be different.

[3 marks]

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9

END OF QUESTIONS



There are no questions printed on this page

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A-LEVEL PHYSICS A

PHYA1 – Particles, quantum phenomena and electricity

2450
June 2014

Version: 1.0 Final

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

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COMPONENT NAME: Unit 1 Particles, quantum phenomena and electricity

COMPONENT NUMBER: PHYA1

STATUS: Pre-standardisation

Question	Part	Sub Part	Marking Guidance	Mark		Comments																				
1	a	(i)	$\bar{u}s$ / up and anti-strange✓	1		In any order Bar must only be over s only																				
1	a	(ii)	0 / zero/nothing✓	1																						
1	a	(iii)	K^- / negative kaon / $\bar{u}s$ ✓	1																						
1	b	(i)	<table><tr><td>classification</td><td>K^+</td><td>ν_μ</td><td>μ^+</td></tr><tr><td>lepton</td><td>x</td><td>✓</td><td>✓</td></tr><tr><td>charged particle</td><td>✓</td><td>x</td><td>✓</td></tr><tr><td>hadron</td><td>✓</td><td>x</td><td>x</td></tr><tr><td>meson</td><td>✓</td><td>x</td><td>x</td></tr></table>	classification	K^+	ν_μ	μ^+	lepton	x	✓	✓	charged particle	✓	x	✓	hadron	✓	x	x	meson	✓	x	x	3		1 mark for each correct row
classification	K^+	ν_μ	μ^+																							
lepton	x	✓	✓																							
charged particle	✓	x	✓																							
hadron	✓	x	x																							
meson	✓	x	x																							
1	b	(ii)	conserved: baryon number OR lepton number ✓ not conserved: strangeness/kinetic energy✓	2		Mass in either loses mark																				

1	c	(i)	neutral pion✓	1		Indicated clearly in table in any way e.g. circled or cross. If more than one box used then must be a tick with neutral pion only
1	c	(ii)	must be neutral/no charge/0 charge to obey charge conservation OR cannot be baryon to obey conservation of baryon number OR cannot be lepton to obey conservation of lepton number✓	1		Can show by using equation and appropriate quantum numbers
2	a	(i)	Q/boron/B✓	1		
2	a	(ii)	P and R/ R and P✓	1		
2	a	(iii)	R✓ 6/14 is smallest fraction/0.43 smallest ratio/ 4.13×10^7 C/kg✓	2		Cannot get second mark if not awarded first mark

2	a	(iv)	${}^{14}_6R \rightarrow {}^{14}_7X + {}^0_{-1}e + \overline{\nu}_{(e)}$ ✓✓✓	3		one mark for each correct symbol on rhs ignore –ve sign on e. Can have neutrino with 0,0 on answer lines ignore any subscript on neutrino
2	b	(i)	<u>repulsive</u> below/at 0.5 fm (accept any value less or equal to 1 fm)✓ <u>attractive</u> up to/at 3 fm (accept any value between 0.5 and 10 fm)✓ short range OR becomes zero OR no effect✓	3		Can get marks from labelled graph Don't accept negligible for 3 rd mark
2	b	(ii)	interaction: electromagnetic/em✓ (virtual) photon/ γ ✓	2		
3	a		(electron) diffraction / interference / superposition✓	1		Accept derfraction
3	b		(use of $\lambda=h/mv$) $\lambda=6.63 \times 10^{-34}/(9.11 \times 10^{-31} \times 2.5 \times 10^5)$ ✓ $\lambda=2.9 \times 10^{-9}$ m ✓✓ (2 sig figs.)	3		

3	c		$v=2.5 \times 10^5/207 \checkmark$ $v=1200 \text{ m s}^{-1} \checkmark$ OR use $v=h/m\lambda$ with CE from 3(b)	2		Answer alone gets 2 marks
4	a	(i)	ultraviolet / UV/ UV light/ ultra(-)violet $\checkmark$	1		
4	a	(ii)	<u>electron</u> (in ground state) has moved/in to higher (energy) level/shell/orbital/state OR up level/shell/orbital/state $\checkmark$	1		Ignore reference to photons
4	a	(iii)	(free) electrons collide with orbital electrons/mercury electrons/electrons in atom $\checkmark$ transferring energy $\checkmark$	2		Ignore any reference to photons
4	a	(iv)	(mercury) atoms have discrete/fixed/specific energy levels $\checkmark$ when electrons change levels they lose an exact/fixed/specific/discrete/set amount of energy OR photons emitted with exact/fixed/specific/discrete/set amount of energy $\checkmark$ (leading to photons of) fixed/particular/certain/discrete/specific/unique frequencies $\checkmark$	3		Each mark independent Don't accept characteristic for 3 rd mark
4	b	(i)	(use of $\lambda=c/f$) $f=3 \times 10^8/(254 \times 10^{-9}) \checkmark$ $f=1.18 \times 10^{15} \text{ (Hz)} \checkmark$	2		AE penalty if give answer to 1 sig fig

4	b	(ii)	(use of $E=hf$) $E=6.63 \times 10^{-34} \times 1.18 \times 10^{15} = 7.82 \times 10^{-19} \text{ J} \checkmark$ $E=7.82 \times 10^{-19} / 1.6 \times 10^{-19} \checkmark = 4.9 (4.875) \text{ eV}$	2		CE b(i) Range 4.8 - 5.0 acceptable
4	c		coating <u>absorbs</u> photons/uv light $\checkmark$ and re-emits (photons) of low(er) energy/long(er) wavelength/low(er) frequency $\checkmark$	2		Ignore any description of mechanism
5	a		power increases to a maximum/(up) to 3.0 (2.8 -3.4) Ω / / (up)to 3.0 W $\checkmark$ then decreases $\checkmark$	2		
5	b	(i)	(use of $P=I^2R$) when $R=0.8 \Omega$ power = 1.95 W $\checkmark$ $1.9 = I^2 \times 0.8 \checkmark$ $I = \sqrt{2.375} = 1.5(4) \text{ (A)} \checkmark$	3		Range 1.9 - 2.0 W for power (first mark) Current 1.5 – 1.6 A
5	b	(ii)	(use of $V=IR$) $V=1.54 \times 0.8 \checkmark$ $V=1.2 \text{ V} \checkmark$	2		CE from (i)
5	b	(iii)	(use of $\varepsilon=V+Ir$) $6.0 = 1.2 + 1.54 \times r \checkmark$ $r = (6.0 - 1.2)/1.54 = 3.1 (2.9 - 3.2) (\Omega) \checkmark$	2		CE from (ii)

			use of maximum power theorem (quoted) as alternative method can get both marks i.e. read peak maximum from graph			
5	c		power would decrease (as R increased)✓ pd/voltage across R is now constant/equal to emf✓ and so power proportional to 1/R/ inversely proportional to R OR can quote $P=V^2/R$ but only if scored second mark✓	3		
6	a	(i)	resistivity is defined as $\rho = \frac{RA}{l}$ where R is the resistance of the material of length l✓ and <u>cross-sectional</u> area A✓	2		
6	a	(ii)	<u>below</u> the critical temperature/maximum temperature which resistivity/resistance ✓ is zero/becomes superconductor✓	2		Any reference to negligible/small/very low resistance loses second mark
6	b		$(\text{use of } \rho = \frac{RA}{l})$ $\rho = 0.70 \times \pi \times 0.0005^2 / 4.8 \checkmark = 1.1(5) \times 10^{-7} \text{ (1.1 – 1.2) } \checkmark \checkmark \Omega \text{ m} \checkmark$	4		First mark for substitution R and l Lose 1 mark if diameter used as radius and answer is 4 times too big (4.4 – 4.8) OR if power of ten error

7	a	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. <i>The candidate measures V and temperature. They have a workable method of varying temperature from $0\text{ }^{\circ}\text{C}$ to $100\text{ }^{\circ}\text{C}$. They explain why R is necessary and are able to use the thermistor to measure temperature using a graph and calibration curve.</i> Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. <i>The candidate measures V and temperature. They have a workable method of varying temperature from $0\text{ }^{\circ}\text{C}$ to $100\text{ }^{\circ}\text{C}$. Give some indication of how an unknown temperature is measured.</i> Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and	6	LOWER BAND Measure/record voltage For different temperatures MIDDLE BAND Water bath used Over full range $0 - 100\text{ }^{\circ}\text{C}$ e.g. use ice and Bunsen OR Need for R to form potential divider Use of graph to find
---	---	--	---	--

			may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. <i>The candidate measures V and temperature. They vary the temperature.</i> The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case. measurement of V from the voltmeter use of a thermometer use of water bath use of ice importance of stirring explanation of the need for series resistor plotting of a calibration curve use of calibration curve to determine temperature of room			room temperature TOP BAND 3 out the 4 points in middle band 6 marks only if all 4 points in middle band plus reference to thermometer and some additional e.g. stirring, suggested intervals
7	b		reading changes in opposite way/voltmeter reading would increase as temperature increased ✓ as resistance of thermistor falls/current increases ✓ hence greater share/proportion of pd/voltage across R OR greater current therefore larger pd/voltage across R OR total pd/voltage constant less pd/ voltage across thermistor (at higher temperatures) therefore greater pd/voltage across R ✓	3		

Question	Specification	Topic	Assessment Criteria
1	3.1.1	Classification of Particles	AO1 : 8 AO2 : 2
2	3.1.1	Constituents of the atom	AO1 : 5 AO2 : 7
3	3.1.2	Particle Wave Duality	AO1:1 AO2: 5
4	3.1.2	Energy Levels and Photon emission	AO1 : 9 AO2 : 4
5	3.1.3	Circuits	AO2: 12
6	3.1.3	Thermistor	AO1 : 7 AO3 : 2
7	3.1.3	resistivity	AO1 :4 AO2: 4
		TOTALS	AO1 : 34 AO2 : 34 AO3: 2 TOTAL:70

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	



General Certificate of Education
Advanced Subsidiary Examination
June 2013

Physics A

PHYA1

Unit 1 Particles, Quantum Phenomena and Electricity

Monday 20 May 2013

1.30 pm to 2.45 pm

For this paper you must have:

- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Time allowed

- 1 hour 15 minutes

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.



J U N 1 3 P H Y A 1 0 1

WMP/Jun13/PHYA1

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PHYA1

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

1 An atom of calcium, ${}^{48}_{20}\text{Ca}$, is ionised by removing two electrons.

1 (i) State the number of protons, neutrons and electrons in the ion formed.

protons

neutrons

electrons

(3 marks)

1 (ii) Calculate the charge of the ion.

charge C
(1 mark)

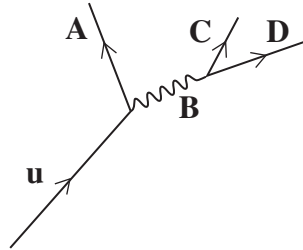
1 (iii) Calculate the specific charge of the ion.

specific charge C kg^{-1}
(2 marks)



- 2 A positron is emitted from a nucleus when a proton changes to a neutron in the nucleus. The Feynman diagram for the quark interaction is shown in **Figure 1**.

Figure 1



- 2 (a) Identify the particles labelled **A**, **B**, **C** and **D** in the diagram.

A

B

C

D

(3 marks)

- 2 (b) (i) State the interaction responsible for this process.

.....
(1 mark)

- 2 (b) (ii) State which letter in **Figure 1** represents an exchange particle.

.....
(1 mark)

- 2 (b) (iii) State **one** difference between this exchange particle and a photon.

.....
(1 mark)

Question 2 continues on the next page

Turn over ►



- 2 (c)** Energy and momentum have to be conserved in this process. State **two** other quantities that need to be conserved and show that they are conserved in the process.

quantity 1

.....

.....

quantity 2

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(4 marks)

10



Write an account of how particles are placed into one or other of these two groups. Your account should include the following:

- The quality of your written communication will be assessed in your answer.

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Turn over ►



3 (b) Every type of particle has a corresponding antiparticle.

3 (b) (i) Give **one** example of a particle and its corresponding antiparticle.

particle

antiparticle
(1 mark)

3 (b) (ii) State **one** difference between this particle and its antiparticle.

.....

.....
(1 mark)



4 When ultraviolet light of frequency 3.0×10^{15} Hz is incident on the surface of a metal, electrons of maximum kinetic energy 1.7×10^{-18} J are emitted.

4 (a) Explain why the emitted electrons have a range of kinetic energies up to a maximum value.

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(3 marks)

4 (b) (i) Show that the work function of the metal is 1.8 eV.

(3 marks)

4 (b) (ii) Calculate the threshold frequency of the metal. Give your answer to an appropriate number of significant figures.

threshold frequency Hz

(3 marks)

Turn over ►



- 4 (c) (i)** State and explain the effect on the emitted electrons of decreasing the frequency of the incident radiation whilst keeping the intensity constant.

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(2 marks)

- 4 (c) (ii)** State and explain the effect on the emitted electrons of doubling the intensity of the incident radiation whilst keeping the frequency constant.

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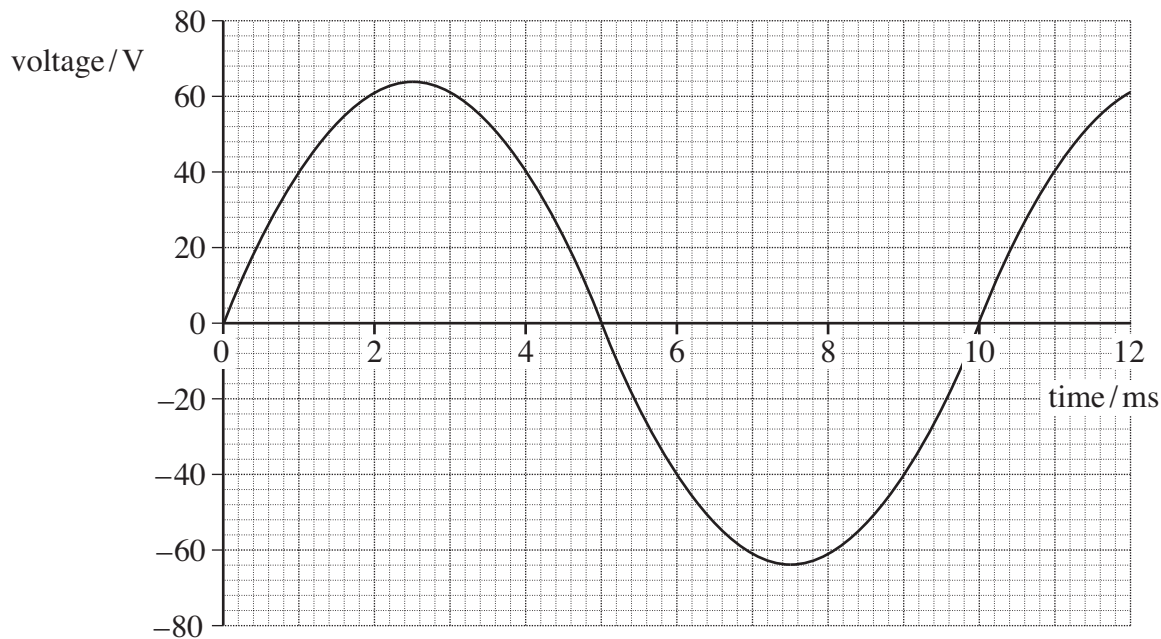
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(2 marks)



- 5** **Figure 2** shows how a sinusoidal alternating voltage varies with time when connected across a resistor, R.

Figure 2



- 5 (a) (i)** State the peak-to-peak voltage.

peak-to-peak voltage V
(1 mark)

- 5 (a) (ii)** State the peak voltage.

peak voltage V
(1 mark)

- 5 (a) (iii)** Calculate the root mean square (rms) value of the alternating voltage.

rms voltage V
(2 marks)

Question 5 continues on the next page

Turn over ►



5 (a) (iv) Calculate the frequency of the alternating voltage. State an appropriate unit.

frequency unit
(3 marks)

5 (b) On **Figure 2** draw a line to show the dc voltage that gives the same rate of energy dissipation in R as produced by the alternating waveform.

(2 marks)

5 (c) An oscilloscope has a screen of eight vertical and ten horizontal divisions. Describe how you would use the oscilloscope to display the alternating waveform in **Figure 2** so that two complete cycles are visible.

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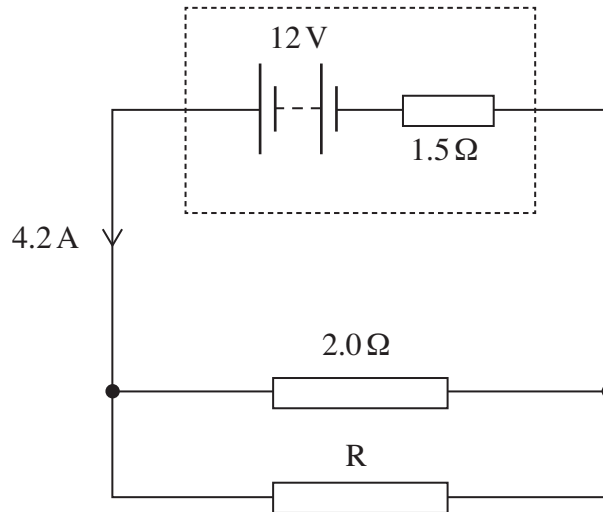
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(3 marks)



- 6** The circuit in **Figure 3** shows a battery of electromotive force (emf) 12 V and internal resistance $1.5\ \Omega$ connected to a $2.0\ \Omega$ resistor in parallel with an unknown resistor, R. The battery supplies a current of 4.2 A.

Figure 3



- 6 (a) (i)** Show that the potential difference (pd) across the internal resistance is 6.3 V.

(1 mark)

- 6 (a) (ii)** Calculate the pd across the $2.0\ \Omega$ resistor.

pd V
(1 mark)

- 6 (a) (iii)** Calculate the current in the $2.0\ \Omega$ resistor.

current A
(1 mark)

- 6 (a) (iv)** Determine the current in R.

current A
(1 mark)

Turn over ►



6 (a) (v) Calculate the resistance of R.

R Ω
(1 mark)

6 (a) (vi) Calculate the total resistance of the circuit.

circuit resistance Ω
(2 marks)

6 (b) The battery converts chemical energy into electrical energy that is then dissipated in the internal resistance and the two external resistors.

6 (b) (i) Using appropriate data values that you have calculated, complete the following table by calculating the rate of energy dissipation in each resistor.

resistor	rate of energy dissipation/W
internal resistance	
2.0Ω	
R	

(3 marks)

6 (b) (ii) Hence show that energy is conserved in the circuit.

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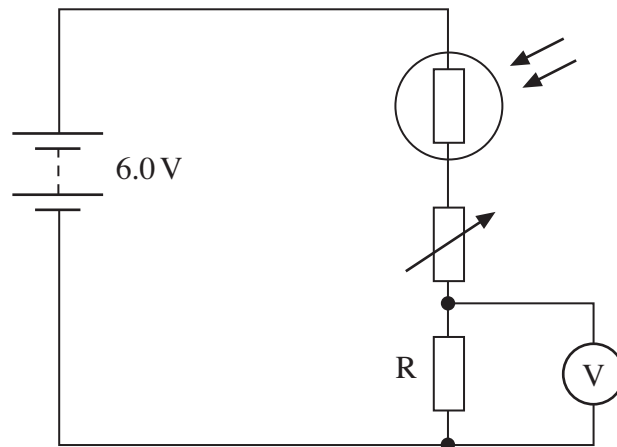
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(2 marks)



- 7 **Figure 4** shows a 6.0 V battery of negligible internal resistance connected in series to a light dependent resistor (LDR), a variable resistor and a fixed resistor, R.

Figure 4



- 7 (a) For a particular light intensity the resistance of the LDR is $50\text{ k}\Omega$. The resistance of R is $5.0\text{ k}\Omega$ and the variable resistor is set to a value of $35\text{ k}\Omega$.

- 7 (a) (i) Calculate the current in the circuit.

current A
(2 marks)

- 7 (a) (ii) Calculate the reading on the voltmeter.

voltmeter reading V
(2 marks)

- 7 (b) State and explain what happens to the reading on the voltmeter if the intensity of the light incident on the LDR increases.

.....

 (2 marks)

Turn over ►



- 7 (c)** For a certain application at a particular light intensity the pd across R needs to be 0.75 V. The resistance of the LDR at this intensity is 5.0 k Ω .

Calculate the required resistance of the variable resistor in this situation.

resistance Ω
(3 marks)

9

END OF QUESTIONS



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General Certificate of Education (A-level)
June 2013

Physics A

PHYA1

(Specification 2450)

**Unit 1: Particles, quantum phenomena and
electricity**

Final

Mark Scheme

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Question	Part	Sub Part	Marking Guidance	Mark	Comments
1	(a)	(i)	protons = 20✓ neutrons = 28✓ electrons = 18✓	3	
1	(a)	(ii)	$2 \times 1.6 \times 10^{-19} = 3.2 \times 10^{-19}$ ✓(C)	1	-ve sign loses mark
1	(a)	(iii)	specific charge = $3.2 \times 10^{-19} / (48 \times 1.67 \times 10^{-27} + 18 \times 9.11 \times 10^{-31})$ ✓ specific charge = 4.0×10^6 C kg ⁻¹ ✓	2	Allow 1.66 Allow CE from (ii) First mark is for mass if miss out electron mass and do not justify lose first mark
2	(a)		A = down✓ B = W ⁺ ✓ C = positron and D = (electron) neutrino✓	3	symbols OK NOT neutron C and D either way round
2	(b)	(i)	weak✓	1	
2	(b)	(ii)	B/W ⁽⁺⁾ ✓	1	
2	(b)	(iii)	W ⁺ /B/exchange particle is charged/γ no charge OR W ⁺ /B/exchange particle has (rest) mass/γ has zero (rest) mass OR photon has <u>infinite</u> range✓	1	exchange particle must be clearly identified don't accept W ⁺ <u>more</u> mass or <u>shorter</u> range
2	(c)		Any two pairs Quantity: lepton number✓ e ⁺ (-1) + ν _e (1) = 0 after same as before✓ Quantity: charge✓ u(+2/3) before 1-d(1/3) = +2/3 after decay✓ Quantity: baryon number✓ proton 1 and neutron 1 (can be shown through quarks) ✓	4	can use p(+1) and e ⁺ (+1)to show charge conserved Each number must be correctly linked to a particle at least once for second mark Strangeness not allowed

3	(a)	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. <i>Candidate gives correct examples of hadrons and leptons. Identifies the differences between hadrons and leptons (hadrons affected by strong nuclear reaction and are made of quarks). Leptons are fundamental and do not experience the strong nuclear reaction. Hadrons are divided into baryons and mesons. Baryons three quarks, mesons quark anti-quark pair. Similarities between groups all experience weak interaction and if charged the electromagnetic interaction. All have rest mass.</i> Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. <i>Candidate gives correct examples of hadrons and leptons. Identifies one difference between hadrons and leptons (e.g. hadrons affected by strong nuclear reaction or are made of quarks). Leptons are fundamental Hadrons are divided into baryons and mesons.</i> Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. <i>Identifies two correct properties of hadrons and leptons.</i>	Lower band 1 or 2 correct facts about hadrons leptons eg Leptons are fundamental/hadrons made of quarks Middle band Only hadrons experience strong nuclear interaction (need this to get in middle band) Hadrons are mesons or baryons Examples of each Top Band Both have rest mass Mention electromagnetic interaction Correct quark structure of mesons and baryons Both hadrons and leptons interact/decay through weak interaction For 6 marks must have last <u>two</u> points
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			The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case. example of hadron and lepton mention of strong interaction mention of quark structure hadrons leptons are fundamental identify baryons and mesons gives quark structure of baryons and mesons similarities e.g. all have rest mass all affected by weak interaction if charged both experience electromagnetic interaction		
3	(b)	(i)	a correct example of particle e.g. electron and correct example of antiparticle e.g. positron✓	1	Allow correct symbols Allow antielectron for positron Also allow pi zero and gamma
3	(b)	(ii)	correct difference e.g. <u>opposite</u> charge/other named quantum number✓	1	must be consistent with (i)
4	(a)		energy of photon is constant/fixed OR energy given to electron is fixed✓ energy required for electron to <u>leave/escape/emit</u> from the <u>surface/metal</u> OR electron has to overcome work function✓ maximum kinetic energy is the energy of photon minus the work function✓ deeper electrons require energy to get to the surface OR have less E_k than surface electrons✓	3 _{max}	mention of energy levels means can only score first mark photoelectric equation alternative for third mark if ϕ and hf defined
4	(b)	(i)	<i>(use of $E = hf$)</i> energy of photon = $6.63 \times 10^{-34} \times 3.0 \times 10^{15} \checkmark = 1.989 \times 10^{-18} \text{ (J)}$ work function = $hf - E_k = 1.989 \times 10^{-18} - 1.7 \times 10^{-18} = 2.89 \times 10^{-19} \checkmark$ work function = $2.89 \times 10^{-19} / 1.6 \times 10^{-19} \checkmark = (1.8 \text{ eV})$	3	hf gets first mark even if in wrong equation
4	b	(ii)	work function = hf_0 $f_0 = 1.8 \times 1.6 \times 10^{-19} / 6.63 \times 10^{-34} \checkmark = 4.3 \times 10^{14} \checkmark \text{ (Hz)} \checkmark \text{ (2 sig figs)}$	3	2 sig . fig stand alone mark Accept 4.4×10^{14}

4	(c)	(i)	decrease the energy of(incident) <u>photons</u> ✓ decrease the <u>maximum</u> kinetic energy of electrons✓ OR decrease the energy of(incident) <u>photons</u> ✓ hence fewer deeper electrons escape✓ OR below <u>threshold frequency</u> ✓ no electrons emitted✓ OR as energy of each <u>photon</u> decreases but intensity is constant (there are more photons/sec)✓ number of emitted electrons(/sec) must increase✓	2	for <u>last two</u> alternatives must get first mark before can qualify for second mark
4	(c)	(ii)	increase in photons cause increase in (emitted) electrons✓ <u>double number</u> of electrons/photons OR reference to rate/per second✓	2	if refer to energy levels/atoms can only award first mark
5	(a)	(i)	128 V✓	1	
5	(a)	(ii)	64 V	1	CE from (i)
5	(a)	(iii)	$V_{\text{rms}} = 64/\sqrt{2}$ ✓=45.3 V✓	2	CE from (ii)
5	(a)	(iv)	frequency = $1/0.01$ ✓= 100✓ Hz✓	3	do not accept kHz for unit mark unless correct for candidate value if use 10 s instead of 10 ms then can score second two marks
5	(b)		horizontal line✓ through $y = 45$ ($44 - 48$) $x = 0$ ✓	2	CE from (a)(iii)+/- half square straight line must extend to at least to 6.0 ms

5	(c)		connect to <u>y-input</u> ✓ adjust/change time base✓ so that each division is 2.0 ms OR 20 ms across screen✓ reference to y-gain/sensitivity✓	3 _{max}	if inappropriate numbers quoted for y gain then lose last mark
6	(a)	(i)	(use of $V=Ir$) $V = 4.2 \times 1.5 = 6.3$ (V)✓	1	
6	(a)	(ii)	$pd = 12 - 6.3 = 5.7$ V✓	1	NO CE from (i)
6	(a)	(iii)	(use of $I = V/R$) $I = 5.7/2.0 = 2.8(5)$ A✓	1	CE from (ii) (a(ii)/2.0) accept 2.8 or 2.9
6	(a)	(iv)	$I = 4.2 - 2.85 = 1.3(5)$ A ✓	1	CE from (iii) (4.2 –(a)(iii)) accept 1.3 or 1.4
6	(a)	(v)	$R = 5.7/1.35 = 4.2$ Ω ✓	1	CE from (iv) (a(ii)/(a)(iv)) Accept range 4.4 to 4.1
6	(a)	(vi)	$\frac{1}{R_{parallel}} = \frac{1}{4.2} + \frac{1}{2.0} = 0.737$ ✓ $R_{parallel} = 1.35$ Ω $R_{total} = 1.35 + 1.5 = 2.85$ Ω ✓ OR $R = 12/4.2$ ✓ $R = 2.85$ Ω ✓	2	CE from (a)(v) second mark for adding internal resistance

6	(b)	(i)	resistor	Rate of energy dissipation (W)	3	CE from answers in (a) but not for first value 2.0: $a(iii)^2 \times 2$ R: $a(iv)^2 \times a(v)$
			1.5 Ω internal resistance	$4.2^2 \times 1.5 = 26.5 \checkmark$		
			2.0 Ω	$2.85^2 \times 2.0 = 16.2$ (15.68 – 16.82) $\checkmark$		
			R	$1.35^2 \times 4.2 = 7.7$ (7.1 – 8.2) $\checkmark$		
6	(b)	(ii)	energy provided by cell per second = $12 \times 4.2 = 50.4$ (W) $\checkmark$ energy dissipated in resistors per second = $26.5 + 16.2 + 7.7 = 50.4 \checkmark$ (hence energy input per second equals energy output)		2	if not equal can score second mark if an appropriate comment
7	(a)	(i)	(use of $I = V/R$) $I = 6.0/(50\,000 + 35\,000 + 5000) \checkmark = 6.7 \times 10^{-5}$ A $\checkmark$		2	first mark for adding resistance values 90 k Ω accept 7×10^{-5} or dotted 6×10^{-5} but not 7.0×10^{-5} and not 6.6×10^{-5}
7	(a)	(ii)	$V = 6.7 \times 10^{-5} \times 5000 \checkmark = 0.33$ (0.33 – 0.35) V $\checkmark$ OR $V = 5/90 \times 6 \checkmark = 0.33$ (V) $\checkmark$		2	CE from (i) BALD answer full credit 0.3 OK and dotted 0.3
7	(b)		resistance of LDR decreases $\checkmark$ reading increase because greater <u>proportion/share</u> of the voltage across R OR higher current $\checkmark$		2	need first mark before can qualify for second
7	(c)		$I = 0.75/5000 = 1.5 \times 10^{-4}$ (A) $\checkmark$ (pd across LDR = 0.75 (V)) pd across variable resistor = $6.0 - 0.75 - 0.75 = 4.5$ (V) $\checkmark$ $R = 4.5/1.5 \times 10^{-4} = 30\,000 \Omega \checkmark$ OR $I = 0.75/5000 = 1.5 \times 10^{-4}$ (A) $\checkmark$ $R_{total} = 6.0/1.5 \times 10^{-4} = 40\,000 \Omega \checkmark$ $R = 40\,000 - 5000 - 5000 = 30\,000 \Omega \checkmark$		3	

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	



General Certificate of Education
Advanced Subsidiary Examination
January 2013

Physics A

PHYA1

Unit 1 Particles, Quantum Phenomena and Electricity

Friday 11 January 2013 1.30 pm to 2.45 pm

For this paper you must have:

- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Time allowed

- 1 hour 15 minutes

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.



J A N 1 3 P H Y A 1 0 1

WMP/Jan13/PHYA1

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PHYA1

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

1 (a) Name the constituent of an atom which

1 (a) (i) has zero charge,

.....
(1 mark)

1 (a) (ii) has the largest specific charge,

.....
(1 mark)

1 (a) (iii) when removed leaves a different isotope of the element.

.....
(1 mark)

1 (b) The equation



represents the decay of technetium-99 by the emission of a β^- particle.

1 (b) (i) Identify the particle X.

.....
(1 mark)

1 (b) (ii) Determine the values of A and Z.

A = ...

Z = ...

(2 marks)

1 (b) (iii) Calculate the specific charge of the technetium-99 (${}_{43}^{99}\text{Tc}$) nucleus. State an appropriate unit for your answer.

specific charge = ... unit
(4 marks)



2 Under certain circumstances it is possible for a photon to be converted into an electron and a positron.

2 (a) State what this process is called.

.....
(1 mark)

2 (b) A photon must have a minimum energy in order to create an electron and a positron.

Calculate the minimum energy of the photon in joules. Give your answer to an appropriate number of significant figures.

minimum energy = ... J
(3 marks)

2 (c) A photon of slightly higher energy than that calculated in part(b) is converted into an electron and a positron.

State what happens to the excess energy.

.....
.....
(1 mark)

2 (d) Describe what is likely to happen to the positron shortly after its creation.

.....
.....
.....
.....
(2 marks)

7

Turn over ►



3 (a) (i) State how many quarks there are in a baryon.

.....
(1 mark)

3 (a) (ii) Hadrons fall into two groups, baryons being one of them.

State the name that is given to the other group of hadrons.

.....
(1 mark)

3 (a) (iii) Give **two** properties of hadrons that distinguish them from leptons.

property 1

.....

property 2

.....
(2 marks)

3 (b) The forces between particles can be explained in terms of exchange particles.

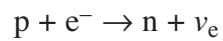
Complete the following table by identifying an exchange particle involved in the interaction.

interaction	exchange particle
electromagnetic	
weak	

(2 marks)



3 (c) The following equation shows electron capture.



3 (c) (i) Draw a Feynman diagram that represents this interaction.

(3 marks)

3 (c) (ii) Explain why, when electron capture occurs, a neutrino rather than an antineutrino is produced.

.....

.....

.....

(1 mark)

10

Turn over for the next question

Turn over ►



- 4 **Figure 1** shows the lowest three energy levels of a hydrogen atom.

Figure 1

	energy / eV
$n = 3$ _____	-1.51
$n = 2$ _____	-3.41
$n = 1$ _____	-13.6

- 4 (a) An electron is incident on a hydrogen atom. As a result an electron in the ground state of the hydrogen atom is excited to the $n = 2$ energy level. The atom then emits a photon of a characteristic frequency.

- 4 (a) (i) Explain why the electron in the ground state becomes excited to the $n = 2$ energy level.

.....

.....

.....

.....

(2 marks)

- 4 (a) (ii) Calculate the frequency of the photon.

frequency = ... Hz
(3 marks)



4 (a) (iii) The initial kinetic energy of the incident electron is $1.70 \times 10^{-18} \text{ J}$.

Calculate its kinetic energy after the collision.

kinetic energy = ... J
(2 marks)

4 (a) (iv) Show that the incident electron cannot excite the electron in the ground state to the $n = 3$ energy level.

(2 marks)

4 (b) When electrons in the ground state of hydrogen atoms are excited to the $n = 3$ energy level, photons of more than one frequency are subsequently released.

4 (b) (i) Explain why different frequencies are possible.

.....
.....

(1 mark)

4 (b) (ii) State and explain how many possible frequencies could be produced.

.....
.....
.....
.....
.....

(2 marks)



5 An experiment can be performed to determine whether a particular component is an ohmic conductor.

5 (a) State what is meant by an ohmic conductor.

.....
(1 mark)

5 (b) (i) Draw a suitable circuit diagram for such an experiment.

(2 marks)

5 (b) (ii) For the circuit diagram you have drawn, describe a suitable experiment. Your account should include details of:

- what measurements you would take
- how you would use your measurements
- how you would reach a conclusion.

The quality of written communication will be assessed in your answer.

.....

.....

.....

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.....

.....



(6 marks)

(1 mark)

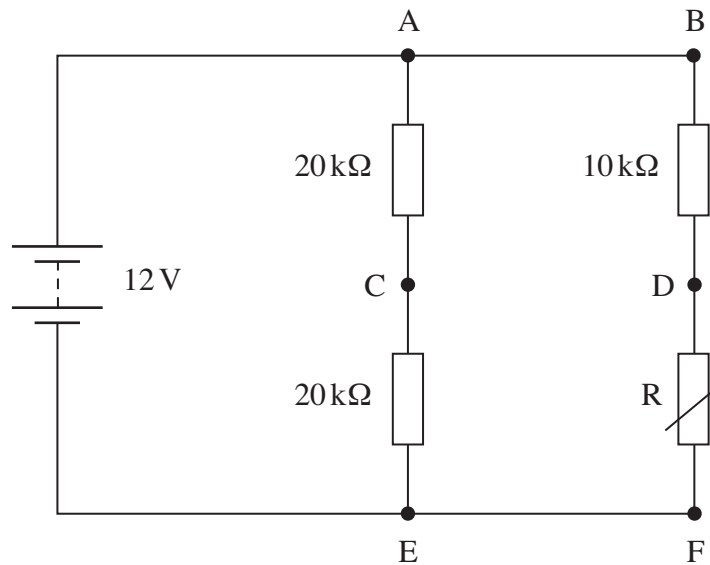
(1 mark)

(1 mark)



- 6** **Figure 2** shows a 12 V battery of negligible internal resistance connected to a combination of three resistors and a thermistor.

Figure 2



- 6 (a)** When the resistance of the thermistor is $5.0\text{ k}\Omega$

- 6 (a) (i)** calculate the total resistance of the circuit,

total resistance = ... $\text{k}\Omega$
(3 marks)

- 6 (a) (ii)** calculate the current in the battery.

current = ... mA
(1 mark)



- 6 (b)** A high-resistance voltmeter is used to measure the potential difference (pd) between points A–C, D–F and C–D in turn. Complete the following table indicating the reading of the voltmeter at each of the three positions.

voltmeter position	pd / V
A–C	
D–F	
C–D	

(3 marks)

- 6 (c)** The thermistor is heated so that its resistance decreases. State and explain the effect this has on the voltmeter reading in the following positions.

- 6 (c) (i)** A–C
-
-
-

(2 marks)

- 6 (c) (ii)** D–F
-
-
-

(2 marks)

Turn over for the next question

Turn over ►



- 7** A copper connecting wire is 0.75 m long and has a cross-sectional area of $1.3 \times 10^{-7} \text{ m}^2$.

- 7 (a)** Calculate the resistance of the wire.

resistivity of copper = $1.7 \times 10^{-7} \Omega \text{ m}$

resistance = ... Ω
(2 marks)

- 7 (b)** A 12 V 25 W lamp is connected to a power supply of negligible internal resistance using two of the connecting wires. The lamp is operating at its rated power.

- 7 (b) (i)** Calculate the current flowing in the lamp.

current = ... A
(1 mark)

- 7 (b) (ii)** Calculate the pd across each of the wires.

pd = ... V
(1 mark)



7 (b) (iii) Calculate the emf (electromotive force) of the power supply.

emf = ... V
(2 marks)

7 (c) The lamp used in part (b) is connected by the same two wires to a power supply of the same emf but whose internal resistance is not negligible.

State and explain what happens to the brightness of the lamp when compared to its brightness in part (b).

.....

.....

.....

.....

.....

.....

(2 marks)

8

END OF QUESTIONS



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General Certificate of Education (A-level)
January 2013

Physics A

PHYA1

(Specification 2450)

**Unit 1: Particles, quantum phenomena and
electricity**

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Instructions to Examiners

- 1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.
- 2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (e.g. relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (i.e. in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	<i>see specific mark scheme</i>	5-6
Modest - Adequate	<i>see specific mark scheme</i>	3-4
Poor - Limited	<i>see specific mark scheme</i>	1-2
The description and/or explanation expected in a good answer should include a coherent account of the following points: <i>see specific mark scheme</i>		

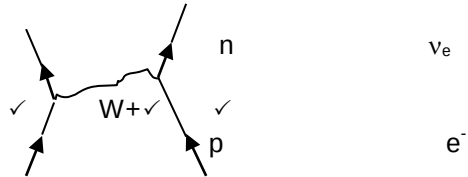
Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

- 3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.
- 4 The use of significant figures is tested **once** on each paper in a designated question or part- question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.
- 5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.

- 6 Knowledge of units is tested on designated questions or parts of questions in each a paper.
On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.
- 7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

1	a	(i)	neutron✓	1	accept symbols symbols e.g. n
1	a	(ii)	electron✓	1	accept symbols
1	a	(iii)	neutron✓	1	accept symbols
1	b	(i)	antineutrino✓	1	$\overline{\nu}_{(e)}$
1	b	(ii)	A=99✓ Z= 44 ✓	2	
1	b	(iii)	specific charge = $43 \times 1.6 \times 10^{-19} \checkmark / 99 \times 1.66 \times 10^{-27} \checkmark$ specific charge = $4.2 \times 10^7 \checkmark \text{ C kg}^{-1} \checkmark$	4	Correct answer no working -1 If include mass of electrons lose 2 and 3 mark

2		(a)	pair production ✓	1	
2		(b)	(energy = 2×rest mass energy) energy = $2 \times 0.510999 = 1.021998$ (MeV)✓ energy = $1.021998 \times 1.60 \times 10^{-13} = 1.64 \times 10^{-13}$ J✓ (3 sig figs✓)	3	If miss out 2 factor can get CE Can use $E=2mc^2$ First mark for full substitution and second mark for answer
2		(c)	kinetic energy (of electron and positron) ✓	1	KE of photon gets zero
2		(d)	(meet an electron and) annihilate✓ (converting into two or more) photons✓ OR gamma rays	2	

3	a	(i)	three✓ OR qq			1										
3	a	(ii)	mesons✓			1										
3	a	(iii)	experience the strong interaction ✓ made up of quarks OR not fundamental✓ (eventually) decay to proton✓			2 _{max}										
3	b		<table><tr><td colspan="2"></td></tr><tr><td>interaction</td><td>exchange particle</td><td rowspan="3"></td></tr><tr><td>electromagnetic</td><td>(virtual)photon✓OR γ</td></tr><tr><td>weak</td><td>W+ or W-or Z⁽⁰⁾ ✓</td></tr></table>					interaction	exchange particle		electromagnetic	(virtual)photon✓OR γ	weak	W+ or W-or Z ⁽⁰⁾ ✓	2	W must have superscript
interaction	exchange particle															
electromagnetic	(virtual)photon✓OR γ															
weak	W+ or W-or Z ⁽⁰⁾ ✓															
3	c	(i)				3	If no arrow on W boson line then must be clearly slanting in correct direction for second mark e must have - superscript If no clear junctions lose second mark If no arrows on sides -1									
3	c	(ii)	lepton number must be conserved ✓ (+1 on lhs must be +1 on rhs)			1										

4	a	(i)	absorbs enough energy (from the incident) electron(by collision) OR incident electron loses energy (to orbital electron) ✓ exact energy/10.1(eV) needed to make the transition/move up to level 2✓	2	For second mark must imply exact energy
4	a	(ii)	(use of $E_2 - E_1 = hf$) -3.41 - - 13.6 = 10.19✓ energy of photon = $10.19 \times 1.6 \times 10^{-19} = 1.63 \times 10^{-18}$ (J) ✓ $6.63 \times 10^{-34} \times f = 1.63 \times 10^{-18}$ $f = 2.46 \times 10^{15}$ (Hz)✓ (accept 2.5 but not 2.4)	3	CE from energy difference but not from energy conversion
4	a	(iii)	$E_k = 1.7 \times 10^{-18} - 1.63 \times 10^{-18} \checkmark = 7.0 \times 10^{-20}$ J✓	2	
4	a	(iv)	energy required is 12.09 eV/ 1.9×10^{-18} ✓ energy of incident electron is only 10.63 eV/energy of electron less than this (1.7×10^{-18} J)✓	2	State and explain must have consistent units i.e. eV or J
4	b	(i)	Electrons return to lower levels by different routes/cascade/not straight to ground state✓	1	
4	b	(ii)	3✓ n= 3 to n=1 or n=3 to n=2 and n=2 to n=1✓	2	no CE from first mark

5	a		a component with constant resistance OR $V \propto I$ ✓	1	
5	b	(i)	circuit using correct symbols with means of varying current/voltage✓ correct voltmeter and ammeter✓	2	ignore symbol for component unless it is a variable resistor

5	b	(ii)	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. <i>Candidate draws an appropriate circuit diagram with correctly positioned ammeter and voltmeters. Candidate has a means of varying the current. Sets current to different values and measures pd. Mentions wide range. Has a sensible way of varying current (e.g. variable resistor/ potential divider). Plots a graph of pd against current. Relates constant gradient to a constant resistance.</i> Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. <i>Candidate draws an appropriate circuit diagram with correctly positioned ammeter and voltmeters. Candidate has a means of varying the current. Varies current and measures pd. Plots a graph of pd against current. Relates constant gradient to a constant resistance.</i> Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. <i>The candidate measures resistance at least twice to see if constant. Has some means of varying current.</i> The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case. method for varying current current varied in regular steps pd and current measure resistance calculated graph drawn significance of gradient of the graph discussed	6	Level 1/2 Take several readings of V and I and plot graph or calculate R Level 3/4 Draw best fit line or state R constant Relate straight line on graph to ohmic conductor Level 5/6 meaning of line through origin reverse current readings suitable range with suggested values
---	---	------	--	---	---

5	c	(i)	a material with zero resistivity/resistance✓	1	not negligible
5	c	(ii)	material becomes superconducting at/below critical temperature✓	1	accept reverse argument
5	c	(iii)	any correct usage e.g. powerful magnets, mri, maglev trains/bullet train/(high power) transmission lines/particle accelerators/LHC✓	1	

6	a	(i)	$1/R_{\text{total}} = 1/(40) \checkmark + 1/(10+5) \checkmark = 0.09167$ $R_{\text{total}} = 10.9 \text{ k}\Omega \checkmark$			3	
6	a	(ii)	$I = 12/10.9\text{k} = 1.1 \text{ mA} \checkmark$			1	
6	b		position	pd/V		3	C.E. for CD
			AC	6.0✓			
			DF	4.0✓			
			CD	2.0✓			
6	c	(i)	AC: no change✓ constant pd across resistors/parallel branches(AE)✓			2	no CE from first mark
6	c	(ii)	DF: decreases✓ as greater proportion of voltage across fixed/10 kΩ resistor✓			2	no CE from first mark

7	a		(use of $\rho=RA/l$) $R=1.7 \times 10^{-7} \times 0.75/1.3 \times 10^{-7} \checkmark$ $R=0.98 \Omega \checkmark$	2	First mark for sub. and rearranging of equation. Bald 0.98 gets both marks Final answer correct to 2 or more sig. figs.
7	b	(i)	(use of $P=VI$) $I=2.08 \text{ A}$	1	
7	b	(ii)	$V=2.08 \times 0.98 = 2.04 \text{ V}$	1	C.E. from (a) and (b)(i)

7	b	(iii)	$\text{emf} = 12 + 2 \times 2.04 = 16.1 \text{ V}$	2	C.E. from (b)(ii) If only use one wire then C.E. for second mark
7	c		lamp would be less bright as energy/power now wasted in internal resistance/battery OR terminal pd less OR current lower (due to greater resistance)	2	No C.E. from first mark

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	



General Certificate of Education
Advanced Subsidiary Examination
June 2012

Physics A

PHYA1

Unit 1 Particles, Quantum Phenomena and Electricity

Thursday 17 May 2012 9.00 am to 10.15 am

For this paper you must have:

- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Time allowed

- 1 hour 15 minutes

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.



JUN12PHYA101

WMP/Jun12/PHYA1

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PHYA1

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

1 (a) The K^- meson has strangeness -1 .

1 (a) (i) State the quark composition of a meson.

.....
(1 mark)

1 (a) (ii) State the baryon number of the K^- meson.

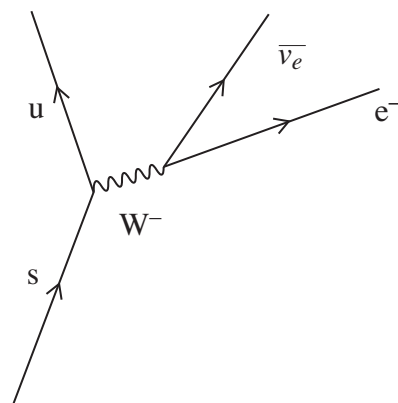
.....
(1 mark)

1 (a) (iii) What is the quark composition of the K^- meson?

.....
.....
(1 mark)

1 (b) **Figure 1** shows a Feynman diagram for a possible decay of the strange quark.

Figure 1



1 (b) (i) Which interaction is responsible for this decay?

.....
(1 mark)

1 (b) (ii) Energy and momentum are conserved when the W^- particle is produced. State **two** other quantities that are also conserved and **one** that is not.

conserved

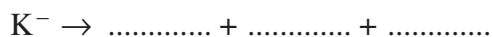
conserved

not conserved

(3 marks)



1 (b) (iii) Complete this equation for the decay of a K^- meson.



(2 marks)

9

2 (a) The nucleus of a particular atom has a *nucleon number* of 14 and a *proton number* of 6.

2 (a) (i) State what is meant by nucleon number and proton number.

nucleon number

.....

.....

proton number

.....

.....

(1 mark)

2 (a) (ii) Calculate the number of neutrons in the nucleus of this atom.

answer = ...

(1 mark)

2 (a) (iii) Calculate the specific charge of the nucleus.

answer = ... $C\,kg^{-1}$

(3 marks)

Question 2 continues on the next page

Turn over ►



2 (b) The specific charge of the nucleus of another isotope of the element is $4.8 \times 10^7 \text{ C kg}^{-1}$.

2 (b) (i) State what is meant by an isotope.

.....

.....

.....

(2 marks)

2 (b) (ii) Calculate the number of neutrons in this isotope.

answer = ...
(3 marks)

10

3 (a) Protons can interact with electrons by gravity and by two other fundamental interactions. In the following table identify these interactions and name the exchange particle involved.

interaction	exchange particle

(2 marks)

3 (b) State the quark composition of a proton.

.....
(1 mark)



3 (c) A change in quark identity is involved in *electron capture*.

3 (c) (i) Explain what is meant by electron capture.

.....

.....

.....

.....

.....

.....

(3 marks)

3 (c) (ii) In the space below draw a Feynman diagram representing electron capture.

(3 marks)

9

Turn over ►



4 (a) When monochromatic light is shone on a clean cadmium surface, electrons with a range of kinetic energies up to a maximum of $3.51 \times 10^{-20} \text{ J}$ are released. The *work function* of cadmium is 4.07 eV .

4 (a) (i) State what is meant by work function.

.....

.....

.....

.....

(2 marks)

4 (a) (ii) Explain why the emitted electrons have a range of kinetic energies up to a maximum value.

.....

.....

.....

.....

.....

.....

(4 marks)

4 (a) (iii) Calculate the frequency of the light. Give your answer to an appropriate number of significant figures.

answer = ... Hz

(4 marks)



- 4 (b)** In order to explain the photoelectric effect the wave model of electromagnetic radiation was replaced by the photon model. Explain what must happen in order for an existing scientific theory to be modified or replaced with a new theory.

.....

.....

.....

(2 marks)

12

Turn over for the next question

Turn over ►



The quality of your written communication will be assessed in your answer.

[illegible]

5 (b) The power supply in part (a) is connected to a 12 V 24 W lamp.

5 (b) (i) Calculate the rms current in the lamp.

answer = ... A
(1 mark)

5 (b) (ii) Calculate the peak current in the lamp.

answer = ... A
(1 mark)

5 (b) (iii) Calculate the peak power of the lamp.

answer = ... W
(2 marks)

10

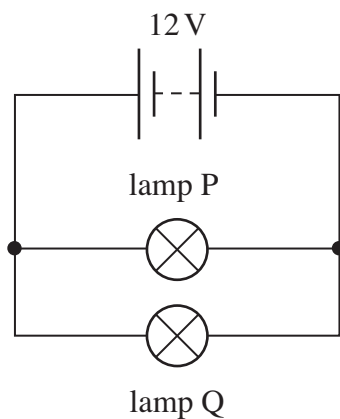
Turn over for the next question

Turn over ►



- 6** A battery of negligible internal resistance is connected to lamp P in parallel with lamp Q as shown in **Figure 2**. The emf of the battery is 12 V.

Figure 2



- 6 (a)** Lamp P is rated at 12 V 36 W and lamp Q is rated at 12 V 6 W.

- 6 (a) (i)** Calculate the current in the battery.

answer = ... A
(2 marks)

- 6 (a) (ii)** Calculate the resistance of P.

answer = ... Ω
(1 mark)



6 (a) (iii) Calculate the resistance of Q.

answer = ... Ω
(1 mark)

6 (b) State and explain the effect on the brightness of the lamps in the circuit shown in **Figure 2** if the battery has a significant internal resistance.

.....

.....

.....

.....

.....

.....

(3 marks)

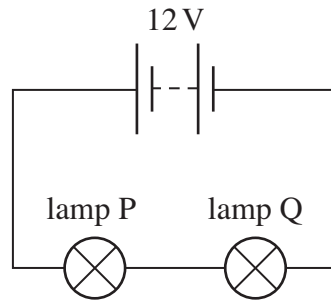
Question 6 continues on the next page

Turn over ►



- 6 (c)** The lamps are now reconnected to the 12 V battery in series as shown in **Figure 3**.

Figure 3



- 6 (c) (i)** Explain why the lamps will not be at their normal brightness in this circuit.

.....

.....

.....

.....

.....

(2 marks)

- 6 (c) (ii)** State and explain which of the lamps will be brighter assuming that the resistance of the lamps does not change significantly with temperature.

.....

.....

.....

.....

(3 marks)

Turn to page 14 for the next question



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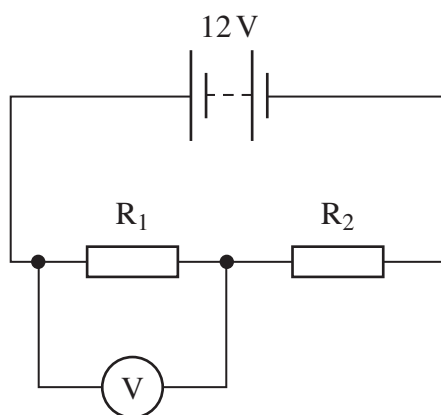
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ANSWER IN THE SPACES PROVIDED**

Turn over ►



- 7 **Figure 4** shows two resistors, R_1 and R_2 , connected in series with a battery of emf 12 V and negligible internal resistance.

Figure 4



- 7 (a) The reading on the voltmeter is 8.0 V and the resistance of R_2 is $60\ \Omega$.
- 7 (a) (i) Calculate the current in the circuit.

answer = ... A
(2 marks)



7 (a) (ii) Calculate the resistance of R_1 .

answer = ... Ω
(1 mark)

7 (a) (iii) Calculate the charge passing through the battery in 2.0 minutes. Give an appropriate unit for your answer.

answer = ... unit = ...
(2 marks)

7 (b) In the circuit shown in **Figure 4** R_2 is replaced with a thermistor. State and explain what will happen to the reading on the voltmeter as the temperature of the thermistor increases.

.....

.....

.....

.....

.....

.....

(3 marks)

END OF QUESTIONS



There are no questions printed on this page

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General Certificate of Education (A-level)
June 2012

Physics A

PHYA1

(Specification 2450)

**Unit 1: Particles, quantum phenomena and
electricity**

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this Mark Scheme are available from: aqa.org.uk

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Instructions to Examiners

- 1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.
- 2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

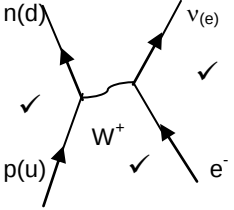
QWC	descriptor	mark range
Good - Excellent	<i>see specific mark scheme</i>	5-6
Modest - Adequate	<i>see specific mark scheme</i>	3-4
Poor - Limited	<i>see specific mark scheme</i>	1-2
The description and/or explanation expected in a good answer should include a coherent account of the following points: <i>see specific mark scheme</i>		

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

- 3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.
- 4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.
- 5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.
- 6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.
- 7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

GCE Physics, Specification A, PHYA1, Particles, Quantum Phenomena and Electricity

1	a	i	quark antiquark pair OR $\overline{q}q$ OR named quark antiquark pair ✓	1						
1	a	ii	0 ✓	1						
1	a	iii	$\overline{u}s$ ✓	1						
1	b	i	Weak ✓ any of the following also score 1 mark: weak interaction weak interaction force weak nuclear weak nuclear interaction weak decay weak force weak nuclear force	1						
1	b	ii	conserved: baryon number, charge, lepton number, spin ✓✓ not conserved: strangeness ✓	3						
1	b	iii	$K^- \rightarrow \pi^0 + e^- + \overline{\nu}_{(e)}$ ✓✓ OR $K^- \rightarrow \pi^0 + \mu^- + \overline{\nu}_{(\mu)}$	2						
2	a	i	nucleon number is the number of protons and neutrons OR mass number proton number is the number of protons OR atomic number✓	1						
2	a	ii	$14 - 6 = 8$ ✓	1						
2	a	iii	specific charge = $6 \times 1.6 \times 10^{-19} \checkmark / (14 \times 1.66 \times 10^{-27} \checkmark)$ specific charge = 4.1×10^7 (C kg ⁻¹) ✓	3						
2	b	i	isotopes are variations of an element that have same proton/atomic number ✓ but different nucleon number OR different number of neutrons ✓	2						
2	b	ii	$4.8 \times 10^7 = 6 \times 1.6 \times 10^{-19} \checkmark / (A \times 1.66 \times 10^{-27})$ $A = 6 \times 1.6 \times 10^{-19} / (4.8 \times 10^7 \times 1.66 \times 10^{-27})$ $A = 12$ ✓ Number of neutrons = $12 - 6$ ✓	3						
3	a		<table><tr><td>interaction</td><td>exchange particle</td></tr><tr><td>weak</td><td>W^+ OR W^- OR Z^0 ✓</td></tr><tr><td>electromagnetic</td><td>photon OR γ ✓</td></tr></table>	interaction	exchange particle	weak	W^+ OR W^- OR Z^0 ✓	electromagnetic	photon OR γ ✓	2
interaction	exchange particle									
weak	W^+ OR W^- OR Z^0 ✓									
electromagnetic	photon OR γ ✓									

3	b		uud ✓	1
3	c	i	an atomic/orbital/shell electron ✓ interacts with a proton in the nucleus (via the weak interaction) ✓ neutron formed or u quark changes to d quark (and neutrino released) ✓	3
3	c	ii		3
4	a	i	<u>minimum energy</u> required ✓ to remove electron from metal (surface) OR cadmium OR the material ✓	2
4	a	ii	photons have energy dependent on frequency OR energy of photons constant ✓ one to one interaction between photon and electron ✓ Max KE = photon energy – work function in words or symbols ✓ more energy required to remove deeper electrons ✓	4
4	a	iii	(use of $hf = \phi + E_{k(max)}$) $6.63 \times 10^{-34} \times f = 4.07 \times 1.60 \times 10^{-19}$ ✓ + 3.51×10^{-20} ✓ $f = 1.04 \times 10^{15}$ (Hz) OR 1.03×10^{15} (Hz) ✓✓ (3 sig figs)	4
4	b		theory makes predictions tested ✓ by repeatable/checked by other scientists/peer reviewed (experiments) OR new evidence that is repeatable/checked by other scientists/peer reviewed ✓	2
5	a		The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. <i>The candidate states that the power supply is connected</i>	max 6

			to the input of the oscilloscope. The time base is switched off and the y gain adjusted until a complete vertical line is seen on the screen. The length of the line is measured and this is converted to peak to peak voltage using the calibration. The peak voltage is divided by root two to get the rms voltage and this is compared with the stated value. The time base is now switched on and adjusted until a minimum of one cycle is seen on the screen. The length of one cycle is measured and this is converted to time using the time base setting. Frequency is the reciprocal of this time. Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. <i>The candidate states that the power supply is connected to the input of the oscilloscope. The y gain adjusted. The length of the line/height of peak is measured. The peak voltage is divided by root two to get the rms voltage. The time base is now switched on and adjusted until a minimum of one cycle is seen on the screen. The length of one cycle is measured and this is converted to time using the time base setting.</i> Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. <i>The candidate states that the power supply is connected to the input of the oscilloscope. The length of the line/height of peak is measured. The time base is now switched on and adjusted until a minimum of one cycle is seen on the screen. The length of one cycle is measured and this is converted to time.</i> The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case. • power supply connected to oscilloscope input • time base initially switched off • y gain adjusted to get as long a line as possible • length of line used to find peak to peak voltage • rms voltage found • time base switched on and adjusted to get several cycles on the screen • use the time base setting to find period • use period to find frequency • compare vales with stated values	
5	b	i	(use of $P = IV$) $I = 24/12 = 2.0 \text{ (A)}$ ✓	1

5	b	ii	peak current = $\sqrt{2} \times 2.0 = 2.8$ (A) ✓	1
5	b	iii	peak power = $\sqrt{2} \times 12 \times \sqrt{2} \times 2.0$ ✓ = 48 (W) ✓	2
6	a	i	(use of $P=VI$) $I = 36/12 + 6/12$ ✓ = 3.5 (A) ✓	2
6	a	ii	(use of $V=IR$) $R = 12/3 = 4$ (Ω) ✓	1
6	a	iii	$R = 12/0.50 = 24$ ✓ (Ω)	1
6	b		terminal pd/voltage across lamp is now less OR current is less ✓ due to lost volts across internal resistance OR due to higher resistance ✓ lamps less bright ✓	3
6	c	i	current through lamps is reduced as resistance is increased or pd across lamps is reduced as voltage is shared ✓ hence power is less OR lamps dimmer ✓	2
6	c	ii	lamp Q is brighter ✓ lamp Q has the <u>higher resistance</u> hence <u>pd/voltage</u> across is greater ✓ current is the same for both ✓ hence power of Q greater ✓	max 3
7	a	i	(use of $V = IR$) $I = (12-8) / 60$ ✓ = 0.067 Or 0.066(A) ✓	2
7	a	ii	(use of $V = IR$) $R = 8/0.067 = 120$ (Ω) ✓	1
7	a	iii	(use of $Q = It$) $Q = 0.067 \times 120 = 8.0$ ✓ C ✓	2
7	b		reading will increase ✓ resistance (of thermistor) decreases (as temperature increases) ✓ current in circuit increase (so pd across R_1 increases) OR correct potential divider argument ✓	3

UMS conversion calculator www.aqa.org.uk/umsconversion

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	



General Certificate of Education
Advanced Subsidiary Examination
January 2012

Physics A

PHYA1

Unit 1 Particles, Quantum Phenomena and Electricity

Thursday 12 January 2012 1.30 pm to 2.45 pm

For this paper you must have:

- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Time allowed

- 1 hour 15 minutes

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.



J A N 1 2 P H Y A 1 0 1

WMP/Jan12/PHYA1

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PHYA1

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

1 (a) The table gives information about some fundamental particles.

Complete the table by filling in the missing information.

particle	quark structure	charge	strangeness	baryon number
	uud		0	
Sigma ⁺	uus	+ 1		
	$\bar{u}\bar{d}$		0	0

(7 marks)

1 (b) Each of the particles in the table has an antiparticle.

1 (b) (i) Give **one** example of a baryon particle **and** its corresponding antiparticle.

particle

antiparticle

(1 mark)

1 (b) (ii) State the quark structure of an antibaryon.

.....

(1 mark)

1 (b) (iii) Give **one** property of an antiparticle that is the same for its corresponding particle and **one** property that is different.

Same

.....

Different

.....

(2 marks)

11



- 2 (a)** State what is meant by the specific charge of a nucleus and give an appropriate unit for this quantity.

.....

.....

.....

.....

unit:
(2 marks)

- 2 (b)** Nucleus X has the same nucleon number as nucleus Y. The specific charge of X is 1.25 times greater than that of Y.

- 2 (b) (i)** Explain, in terms of protons and neutrons, why the specific charge of X is greater than that of Y.

.....

.....

.....

.....

(2 marks)

- 2 (b) (ii)** Nucleus X is $^{10}_5\text{B}$. Deduce the number of protons and the number of neutrons in nucleus Y.

number of protons

number of neutrons

(4 marks)



- 3 (a)** Pair production can occur when a photon interacts with matter. Explain the process of pair production.

.....

.....

.....

.....

(2 marks)

- 3 (b)** Explain why pair production cannot take place if the frequency of the photon is below a certain value.

.....

.....

.....

.....

.....

.....

(3 marks)

- 3 (c)** Energy and momentum are conserved during pair production. State **two** other quantities that must also be conserved.

.....

.....

(2 marks)

7



4 (a) When free electrons collide with atoms in their *ground state*, the atoms can be excited or ionised.

4 (a) (i) State what is meant by ground state.

.....

.....

.....

(1 mark)

4 (a) (ii) Explain the difference between excitation and ionisation.

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(3 marks)

4 (b) An atom can also become excited by the absorption of photons. Explain why only photons of certain frequencies cause excitation in a particular atom.

.....

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.....

.....

(4 marks)

Question 4 continues on the next page

Turn over ►



- 4 (c)** The ionisation energy of hydrogen is 13.6 eV . Calculate the minimum frequency necessary for a photon to cause the ionisation of a hydrogen atom. Give your answer to an appropriate number of significant figures.

answer Hz
(4 marks)

12

- 5 (a)** A student is given a piece of metal wire and asked to investigate how the resistance of the wire changes between a temperature of 0°C and 100°C .
- 5 (a) (i)** Draw a labelled diagram of a suitable arrangement that would enable the student to carry out the experiment.

(3 marks)



The quality of written communication will be assessed in your answer.

[illegible]

Question 5 continues on the next page



- 5 (b)** A certain metal has a *critical temperature* of -268°C (5 K). Explain what is meant by critical temperature.

.....

.....

.....

.....

(2 marks)

11

- 6** **X** and **Y** are two lamps. **X** is rated at 12 V 36 W and **Y** at 4.5 V 2.0 W.

- 6 (a)** Calculate the current in each lamp when it is operated at its correct working voltage.

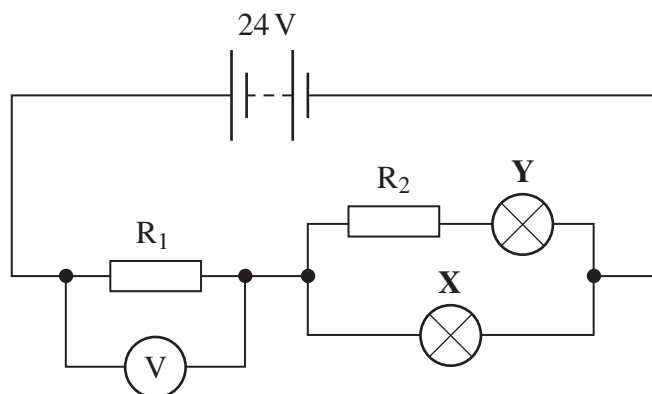
X A

Y A

(2 marks)

- 6 (b)** The two lamps are connected in the circuit shown in **Figure 1**. The battery has an emf of 24 V and negligible internal resistance. The resistors, R_1 and R_2 are chosen so that the lamps are operating at their correct working voltage.

Figure 1



6 (b) (i) Calculate the pd across R_1 .

answer V
(1 mark)

6 (b) (ii) Calculate the current in R_1 .

answer A
(1 mark)

6 (b) (iii) Calculate the resistance of R_1 .

answer Ω
(1 mark)

6 (b) (iv) Calculate the pd across R_2 .

answer V
(1 mark)

6 (b) (v) Calculate the resistance of R_2 .

answer Ω
(1 mark)

Question 6 continues on the next page

Turn over ►



6 (c) The filament of the lamp in **X** breaks and the lamp no longer conducts. It is observed that the voltmeter reading decreases and lamp **Y** glows more brightly.

6 (c) (i) Explain without calculation why the voltmeter reading decreases.

.....

.....

.....

(2 marks)

6 (c) (ii) Explain without calculation why the lamp **Y** glows more brightly.

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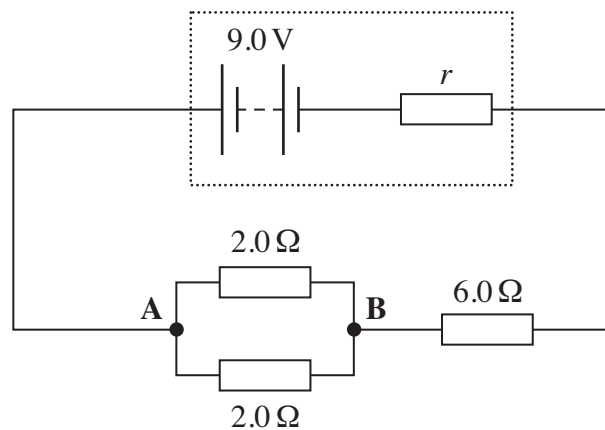
.....

(2 marks)

11

7 A battery of emf 9.0 V and internal resistance, r , is connected in the circuit shown in **Figure 2**.

Figure 2



7 (a) The current in the battery is 1.0 A.

7 (a) (i) Calculate the pd between points **A** and **B** in the circuit.

answer = ... V
(2 marks)

7 (a) (ii) Calculate the internal resistance, r .

answer = ... Ω
(2 marks)

7 (a) (iii) Calculate the **total** energy transformed by the battery in 5.0 minutes.

answer = ... J
(2 marks)

7 (a) (iv) Calculate the percentage of the energy calculated in part (iii) that is dissipated in the battery in 5.0 minutes.

answer %
(2 marks)

Question 7 continues on the next page

Turn over ►



- 7 (b) State and explain **one** reason why it is an advantage for a rechargeable battery to have a low internal resistance.

.....

.....

.....

.....

(2 marks)

10

END OF QUESTIONS





General Certificate of Education (A-level)
January 2012

Physics A

PHYA1

(Specification 2450)

**Unit 1: Particles, quantum phenomena and
electricity**

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

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Instructions to Examiners

- 1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.
- 2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	<i>see specific mark scheme</i>	5-6
Modest - Adequate	<i>see specific mark scheme</i>	3-4
Poor - Limited	<i>see specific mark scheme</i>	1-2
The description and/or explanation expected in a good answer should include a coherent account of the following points: <i>see specific mark scheme</i>		

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

- 3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.
- 4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.
- 5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.
- 6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.
- 7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

GCE Physics, Specification A, PHYA1, Particles, Quantum Phenomena and Electricity

Question 1							
a							7
	particle	quark structure	charge	strangeness	baryon number		
	proton ✓	uud	+ 1 ✓	0	1 ✓		
	sigma ⁺	uus	+ 1	− 1 ✓	1 ✓		
	π^+ ✓	u $\bar{d}$	+ 1 ✓	0	0		
b	i	examples: proton, antiquarks ✓					1
b	ii	consists of 3 antiquarks ✓					1
b	iii	same (rest) mass (energy) ✓ difference eg baryon number/charge ✓					2
		Total					11

Question 2		
a	the ratio of charge to mass of nucleus ✓ $C\text{ kg}^{-1}$ ✓	2
b i	number of protons and neutrons the same or number of neutrons less or mass the same ✓ but more protons therefore greater charge ✓	2
b ii	answers add up to 10 ✓ number of protons = 4 ✓ number of neutrons = $10 - 4 = 6$ ✓ evidence of correct calculation ✓ eg $5q = 1.25 \times ?q$ $? = 4$	4
Total		8

Question 3		
a	photon interacts with (orbital) electron/nucleus/atom ✓ energy of photon used to create particle antiparticle pair ✓ to conserve momentum photon needs to interact with interacting particle ✓	max 2
b	energy of photon depends on frequency ✓ if energy/frequency is below a certain value there is not enough energy ✓ to provide mass/rest energy of particles ✓	3
c	any two ✓✓ eg charge lepton number baryon number strangeness	2
Total		7

Question 4		
a i	when electrons/atoms are in their lowest/minimum energy (state) or most stable (state) they (are in their ground state) ✓	1
a ii	in either case an electron receives (exactly the right amount of) energy ✓ excitation promotes an (orbital) electron to a higher energy/up a level ✓ ionisation occurs (when an electron receives enough energy) to leave the atom ✓	3
b	electrons occupy discrete energy levels ✓ and need to absorb an exact amount of/enough energy to move to a higher level ✓ photons need to have certain frequency to provide this energy or $e = hf$ ✓ energy required is the same for a particular atom or have different energy levels ✓ all energy of photon absorbed ✓ in 1 to 1 interaction or clear a/the photon and an/the electron ✓	max 4
c	energy = $13.6 \times 1.60 \times 10^{-19} = 2.176 \times 10^{-18}$ (J) ✓ $hf = 2.176 \times 10^{-18}$ ✓ $f = 2.176 \times 10^{-18} \div 6.63 \times 10^{-34} = 3.28 \times 10^{15}$ Hz ✓ 3 sfs ✓	4
Total		12

Question 5		
a i	circuit with ammeter and voltmeter correct or ohmmeter ✓ some means of heating eg water bath ✓ thermometer in water bath ✓	3
a ii	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. <i>The candidate states that resistance is measured using an ohmmeter or voltmeter ammeter method. The wire is heated in a beaker of water and the temperature measured with a thermometer. Ice is added to the water and the water is stirred as the water is heated. Details of how resistance is calculated and how results are presented e.g. graph of resistivity against temperature.</i> Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. <i>The candidate states that resistance is measured using an ohmmeter or voltmeter ammeter method. The wire is heated in a beaker of water and the temperature measured with a thermometer. Ice is added to the water. Details of how resistance is calculated.</i> Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. <i>The candidate states that resistance is measured using an ohmmeter or voltmeter ammeter method. The wire is heated in a beaker of water and the temperature measured with a thermometer.</i>	max 6

	The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case. • resistance measured calculated • water bath used • ice added to water • water stirred • temperature measured with thermometer • resistance calculated • graph drawn	
b	the temperature at or below which a material ✓ becomes a superconductor or has zero resistance/resistivity ✓	2
	Total	11

Question 6		
a	(use of $P = VI$) $I = 36/12 = 3.0 \text{ A}$ ✓ $I = 2.0/4.5 = 0.44 \text{ A}$ ✓	2
b i	$\text{pd} = 24 - 12 = 12 \text{ V}$ ✓	1
b ii	$\text{current} = 3.0 + 0.44 = 3.44 \text{ A}$ ✓	1
b iii	$R_1 = 12/3.44 = 3.5 \Omega$ ✓	1
b iv	$\text{pd} = 12 - 4.5 = 7.5 \text{ V}$ ✓	1
b v	$R_2 = 7.5/0.44 = 17 \Omega$ ✓	1
c i	(circuit) resistance increases ✓ current is lower (reducing voltmeter reading) ✓ or correct potential divider argument	2
c ii	pd across Y or current through Y increases ✓ hence power/rate of energy dissipation greater or temperature of lamp increases ✓	2
	Total	11

Question 7		
a	i	(use of $V = IR$) $R_{\text{total}} = 1 \text{ (ohm)} \checkmark$ $V = 1 \times 1 = 1.0 \text{ V} \checkmark$ 2
a	ii	(use of $V = IR$) $R = 9.0/1.0 = 9.0 \Omega \checkmark$ $r = 9.0 - 1.0 - 6.0 = 2.0 \Omega \checkmark$ or use of $(E = I(R + r))$ $9.0 = 1(7 + r) \checkmark$ $r = 9.0 - 7.0 = 2.0 \Omega \checkmark$ 2
a	iii	(use of $W = VIt$) $W = 9.0 \times 1.0 \times 5 \times 60 \checkmark$ $W = 2700 \text{ J} \checkmark$ 2
a	iv	energy dissipated in internal resistance = $1^2 \times 2.0 \times 5 \times 60 = 600 \text{ (J)} \checkmark$ percentage = $100 \times 600/2700 = 22\% \checkmark$ CE from part aii 2
b		internal resistance limits current $\checkmark$ hence can provide higher current $\checkmark$ or energy wasted in internal resistance/battery $\checkmark$ less energy wasted (with lower internal resistance) $\checkmark$ or charges quicker $\checkmark$ as current higher or less energy wasted $\checkmark$ or (lower internal resistance) means higher terminal pd/voltage $\checkmark$ as less pd across internal resistance or mention of lost volts $\checkmark$ max 2
		Total 10
		UMS conversion calculator www.aqa.org.uk/umsconversion

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										



General Certificate of Education
Advanced Subsidiary Examination
June 2011

Physics A

PHYA1

Unit 1 Particles, Quantum Phenomena and Electricity

Tuesday 24 May 2011 9.00 am to 10.15 am

For this paper you must have:

- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet.

Time allowed

- 1 hour 15 minutes

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	



J U N 1 1 P H Y A 1 0 1

WMP/Jun11/PHYA1

STEMUP.CO.UK

PHYA1

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

1 (a) (i) Name two baryons.

.....
(2 marks)

1 (a) (ii) State the quark structure of the pion π^+ .

.....
(1 mark)

1 (b) (i) The K^+ kaon is a strange particle. Give **one** characteristic of a strange particle that makes it different from a particle that is not strange.

.....
.....
(1 mark)

1 (b) (ii) One of the following equations represent a possible decay of the K^+ kaon.

$$K^+ \rightarrow \pi^+ + \pi^0$$

$$K^+ \rightarrow \mu^+ + \bar{\nu}_\mu$$

State, with a reason, which one of these decays is not possible.

.....
.....
(2 marks)

1 (c) Another strange particle, X, decays in the following way:

$$X \rightarrow \pi^- + p$$

1 (c) (i) State what interaction is involved in this decay.

.....
(1 mark)

1 (c) (ii) Show that X must be a neutral particle.

.....
.....
(1 mark)



1 (c) (iii) Deduce whether X is a meson, baryon or lepton, explaining how you arrive at your answer.

.....

.....

.....

.....

(2 marks)

1 (c) (iv) Which particle in this interaction is the most stable?

.....

(1 mark)

11

Turn over for the next question

Turn over ►



2 Alpha decay is a process by which an unstable *isotope* of an element may decay.

2 (i) State what is meant by isotopes.

.....

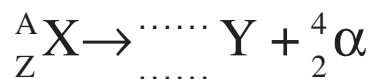
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(2 marks)

2 (ii) Complete this equation for alpha decay.



(2 marks)

2 (iii) Calculate the specific charge of an alpha particle, stating an appropriate unit.

answer = ...

(4 marks)



- 2 (iv)** Explain why the alpha particle, once outside the nucleus, is unaffected by the strong nuclear force.

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(2 marks)

10

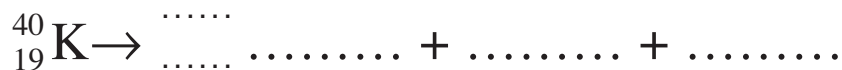
Turn over for the next question

Turn over ►



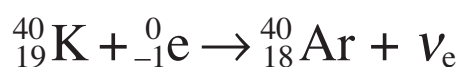
- 3** The isotope of potassium ${}^{40}_{19}\text{K}$ can decay by positron emission to form an isotope of argon, Ar.

- 3 (a)** Complete the following equation which represents this decay.



(4 marks)

- 3 (b)** The following equation represents another possible decay for ${}^{40}_{19}\text{K}$.



- 3 (b) (i)** What is this type of decay called?

.....
(1 mark)

- 3 (b) (ii)** Where does the electron on the left-hand side of the equation come from?

.....
(1 mark)

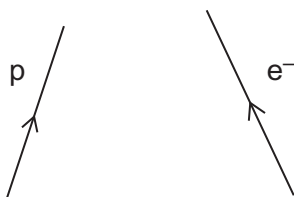
- 3 (b) (iii)** Explain why this reaction has to produce a neutrino rather than an antineutrino.

.....
.....
(1 mark)



3 (b) (iv) Complete the Feynman diagram shown in **Figure 1** that represents this decay.

Figure 1



(3 marks)

10

Turn over for the next question

Turn over ►



- 4 (a)** Line spectra were observed before they could be explained by theory. We now know that photons of characteristic frequency are emitted when the vapour of an element is bombarded by energetic electrons. The spectrum of the light emitted contains lines, each of a definite wavelength.

Explain how

- the bombarding electrons cause the atoms of the vapour to emit photons
- the existence of a spectrum consisting of lines of a definite frequency supports the view that atoms have discrete energy levels.

The quality of your written communication will be assessed in this question.

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(6 marks)



4 (b) The *ionisation energy* of a hydrogen atom is 13.6 eV.

4 (b) (i) State what is meant by the ionisation energy of hydrogen.

.....

.....

(2 marks)

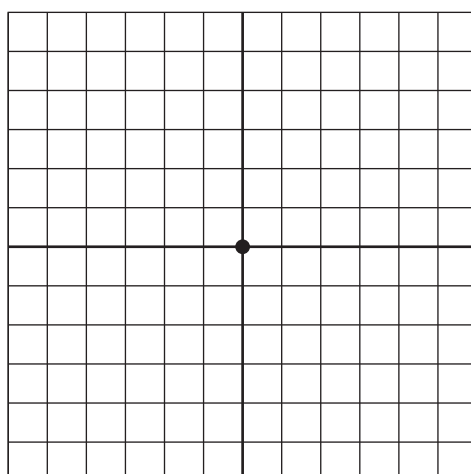
4 (b) (ii) Express the ionisation energy of hydrogen in joules, giving your answer to an appropriate number of significant figures.

answer = ... J
(3 marks)

11

5 An oscilloscope is used to investigate various voltage sources. In order to do this a voltage source is connected to the y-input and the time base is switched off. **Figure 2** shows the screen of the oscilloscope when the y-input is not connected to a voltage source.

Figure 2



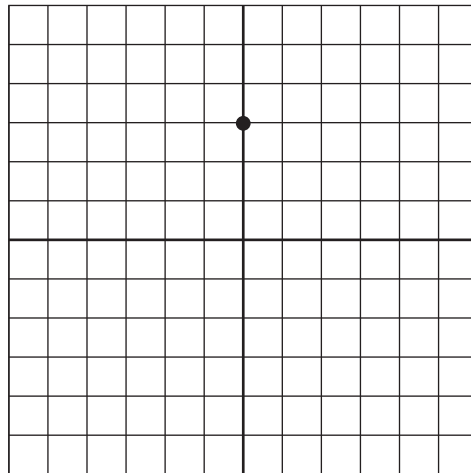
Question 5 continues on the next page

Turn over ►

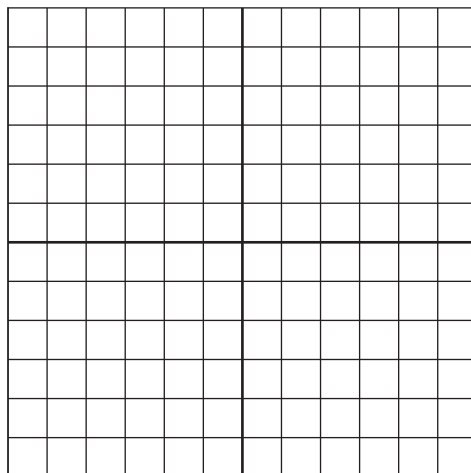


Figure 3 shows the screen when a 1.5 V cell is connected to the y-input.

Figure 3



- 5 (a)** On the grid below show the appearance of the screen if the y-input is connected to a 2.5 V dc supply.

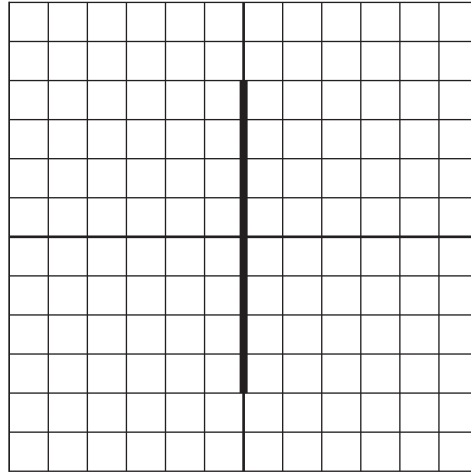


(1 mark)



- 5 (b)** The y-input is now connected to a sinusoidal ac voltage supply and the screen is shown in **Figure 4**.

Figure 4



- 5 (b) (i)** Explain why a vertical line is now seen on the screen.

.....

.....

.....

.....

.....

.....

(2 marks)

- 5 (b) (ii)** Calculate the peak-to-peak voltage of the ac supply.

answer = ... V

(2 marks)

Question 5 continues on the next page

Turn over ►



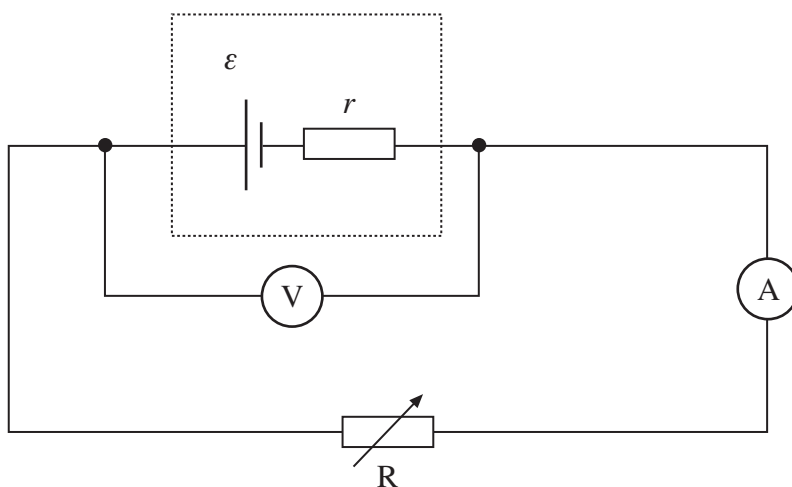
5 (b) (iii) Calculate the root mean square voltage of the supply.

answer = ... V
(2 marks)

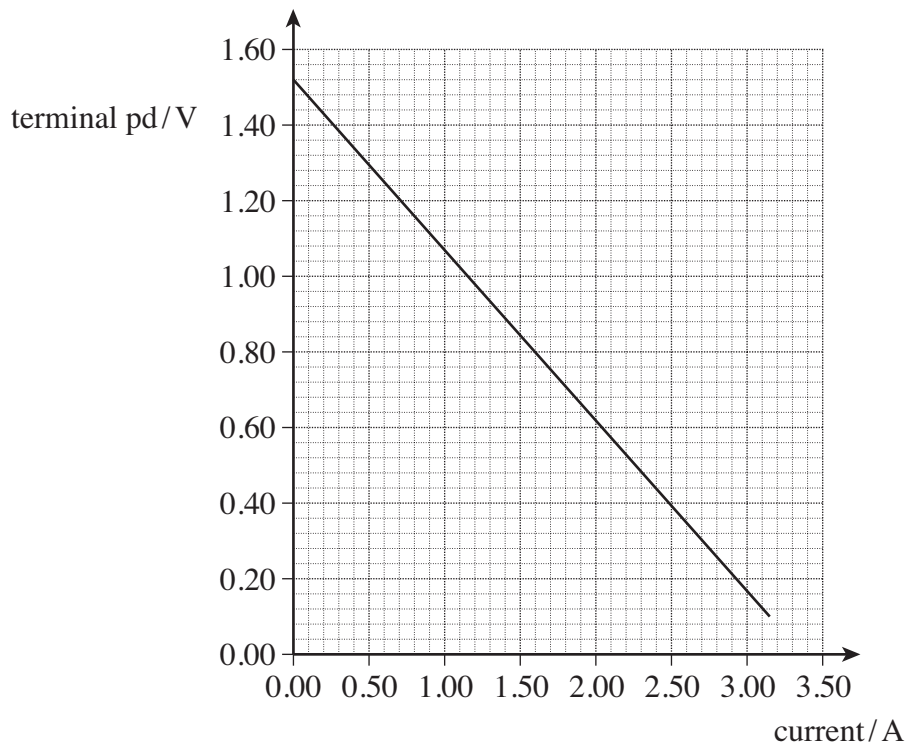
7

- 6 A cell of emf, $\mathcal{E}$, and internal resistance, r , is connected to a variable resistor R . The current through the cell and the terminal pd of the cell are measured as R is decreased. The circuit is shown in **Figure 5**.

Figure 5



The graph below shows the results from the experiment.



- 6 (a)** Explain why the terminal pd decreases as the current increases.

.....

.....

.....

.....

(2 marks)

- 6 (b) (i)** Use the graph to find the emf, $\mathcal{E}$, of the cell.

answer = ... V
(1 mark)

Question 6 continues on the next page

Turn over ►



6 (b) (ii) Use the graph, on page 13, to find the internal resistance, r , of the cell.

answer = ... Ω
(3 marks)

6 (c) Draw a line on the graph, on page 13, that shows the results obtained from a cell with

6 (c) (i) the same emf but double the internal resistance of the first cell labelling your graph **A**
(2 marks)

6 (c) (ii) the same emf but negligible internal resistance labelling your graph **B**.
(1 mark)

6 (d) In the original circuit shown in **Figure 5**, on page 12, the variable resistor is set at a value such that the current through the cell is 0.89 A.

6 (d) (i) Calculate the charge flowing through the cell in 15 s, stating an appropriate unit.

answer = ...
(2 marks)

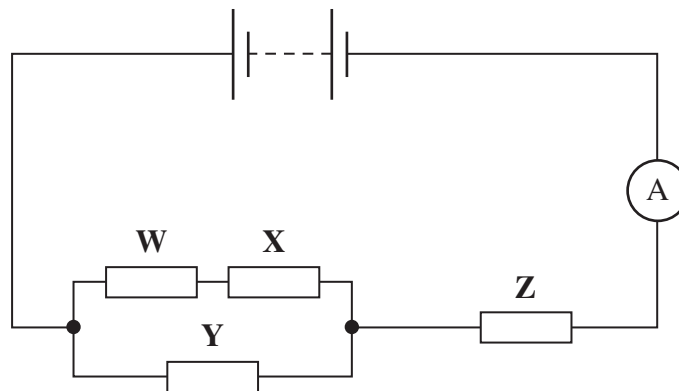


6 (d) (ii) Calculate the energy dissipated in the internal resistance of the cell per second.

answer = ... W
(2 marks)

7 The circuit shown in **Figure 6** shows an arrangement of resistors, **W**, **X**, **Y**, **Z**, connected to a battery of negligible internal resistance.

Figure 6



The emf of the battery is 10 V and the reading on the ammeter is 2.0 A.

7 (a) (i) Calculate the total resistance of the circuit.

answer = ... Ω
(1 mark)

Question 7 continues on the next page

Turn over ►



- 7 (a) (ii) The resistors **W**, **X**, **Y**, and **Z** all have the same resistance. Show that your answer to part (a) (i) is consistent with the resistance of each resistor being $3.0\ \Omega$.

answer = ... Ω
(3 marks)

- 7 (b) (i) Calculate the current through resistor **Y**.

answer = ... A
(2 marks)

- 7 (b) (ii) Calculate the pd across resistor **W**.

answer = ... V
(2 marks)

END OF QUESTIONS





General Certificate of Education (A-level)
June 2011

Physics A

PHYA1

(Specification 2450)

**Unit 1: Particles, quantum phenomena and
electricity**

Final

Mark Scheme

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Instructions to Examiners

- 1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.
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QWC	descriptor	mark range
Good - Excellent	<i>see specific mark scheme</i>	5-6
Modest - Adequate	<i>see specific mark scheme</i>	3-4
Poor - Limited	<i>see specific mark scheme</i>	1-2
The description and/or explanation expected in a good answer should include a coherent account of the following points: <i>see specific mark scheme</i>		

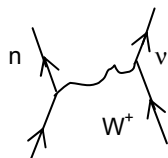
Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

- 3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.
- 4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.
- 5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.
- 6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.
- 7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

GCE Physics, Specification A, PHYA1, Particles, Quantum Phenomena and Electricity

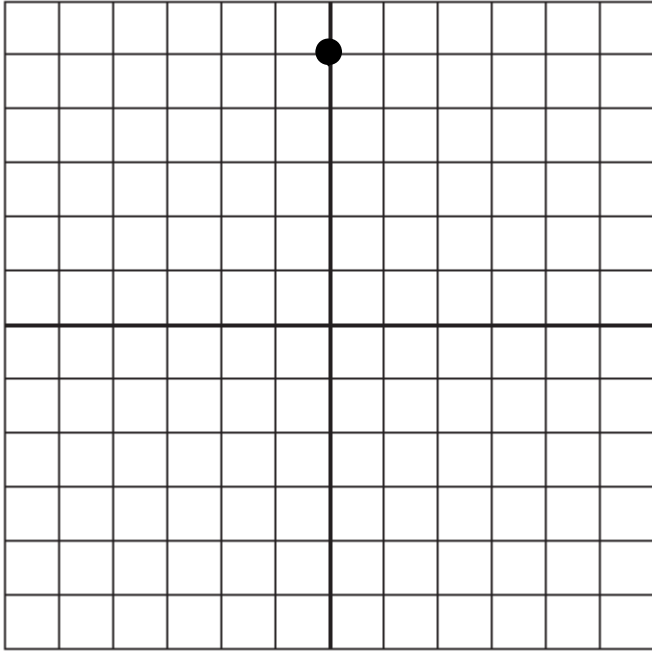
Question 1		
a	i	any two eg proton, neutron ✓✓
a	ii	$u\bar{d}$ ✓
b	i	contains a strange quark or longer half life than expected or decays by weak interaction ✓
b	ii	the second one is not possible ✓ because lepton number is not conserved ✓
c	i	weak (interaction) ✓
c	ii	mention of charge conservation or charge conservation demonstrated by numbers ✓
c	iii	X must be a baryon ✓ baryon number on right hand side is +1 ✓
c	iv	proton/p ✓
		Total
		11

Question 2		
	i	same atomic number/number of protons ✓ different mass/nucleon number/different number of neutrons ✓
	ii	${}^A_ZX \rightarrow {}^{A-4}_{Z-2}Y + {}^4_2\alpha$ ✓✓
	iii	$\frac{q}{m} = \frac{2 \times 1.6 \times 10^{-19}}{4 \times 1.67 \times 10^{-27}}$ ✓✓ $\frac{q}{m} = 4.8 \times 10^7 \text{ C kg}^{-1}$ ✓✓
	iv	strong nuclear force is short range ✓ no effect at distances larger 3 fm (except any distance less than 10 fm) ✓
		Total
		10

Question 3			
a	${}^{40}_{19}\text{K} \rightarrow {}^{40}_{18}\text{Ar} + {}^0_1\text{e} + \nu_e$ ✓✓✓✓ (accept + for 1 and e^+ or β^+)	4	
b	i	electron/K capture ✓	
b	ii	(inner) shell (of atom) ✓	
b	iii	conservation of lepton number ✓	
b	iv	 n ✓ ν ✓ W^+ ✓	3
		Total	
		10	

Question 4		
a	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. The candidate provides a comprehensive and coherent description which includes a clear explanation of constant energy level differences and how electrons can be excited by electron collisions. The link between the energy of a photon and its frequency should be clear. The description should include a clear explanation of the reason atoms of a given element emit photons of a characteristic frequency or there is a clear link between constant energy differences and photon frequency/wavelength (eg $E=hf$). The candidate should relate the energy difference between levels to the energy of emitted photons and state the energy difference is fixed/constant. Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. The candidate provides an explanation of energy levels and how excitation takes place by electron collision with atomic/orbital electrons. The candidate explains how an orbital/atomic electron loses energy by emitting a photon.	max 6

		Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. Some mention of energy levels and the idea of excitation of electron. Talk about excitation of atom instead of electron limits the mark to 1. Incorrect, inappropriate or no response: 0 marks No answer or answer refers to unrelated, incorrect or inappropriate physics. The explanation expected in a competent answer should include a coherent account of the significance of discrete energy levels and how the bombardment of atoms by electrons can lead to excitation and the subsequent emission of photons of a characteristic frequency. electrons bombard atoms of vapour and give energy to electrons in atom electrons move to a higher energy level electrons are excited excited electrons move down to lower energy levels losing energy by emitting photons photons have energy hf photons of characteristic frequencies emitted from atoms of a particular element this is because atoms have discrete energy levels which are associated with particular energy values	
b	i	energy required to (completely) remove an electron from atom/hydrogen ✓ ground state/lowest energy level ✓	2
b	ii	$13.6 \times 1.6 \times 10^{-19} \checkmark = 2.18 \times 10^{-18} \text{ (J)} \checkmark$ 3 sfs ✓	3
		Total	11

Question 5		
a		1
b i	the voltage reverse/changes direction/sign ✓ this makes the spot move up and down or correct explanation of lack of horizontal movement ✓	2
b ii	length of line = 8 divisions peak to peak = $8 \times 0.5 = 4.0 \text{ V}$ ✓✓	2
b iii	(peak = 2.0 V) rms = $2.0/\sqrt{2}$ ✓ = 1.4 V ✓	2
Total		7

Question 6		
a	mention of pd across internal resistance or energy loss in internal resistance or $\text{emf} > V$ ✓ pd across internal resistance/lost volts increases with current or correct use of equation to demonstrate ✓	2
b	i	$y - \text{intercept } 1.52 \text{ V } (\pm 0.01 \text{ V})$ ✓
b	ii	identifies gradient as r or use of equation ✓ substitution to find gradient or substitution in equation ✓ $r = 0.45 \pm 0.02 \Omega$ ✓
c	i	same intercept ✓ double gradient (must go through 1.25, 0.40 ± 1.5 squares) ✓
c	ii	same intercept horizontal line ✓
d	i	(use of $Q = It$) $Q = 0.89 \times 15 = 13$ ✓ C ✓
d	ii	use of $P = I^2 r$ ✓ $P = 0.89^2 \times 0.45$ $P = 0.36 \text{ W}$ ✓
Total		13

Question 7		
a	i	(use of $R = V/I$) $R = 10/2.0 = 5.0 \Omega$ ✓
a	ii	$\frac{1}{R} = \frac{1}{3} + \frac{1}{3+3} = \frac{3}{6}$ ✓ $R = 2 (\Omega)$ ✓ $R_{\text{total}} = 2 + 3$ ✓ (= 5Ω)
b	i	voltage across Y = $10.0 - 2.0 \times 3.0 = 4.0 \text{ V}$ ✓ current in Y = $4.0/3.0 = 1.3 \text{ A}$ ✓
b	ii	current through W = 0.67 A ✓ voltage = $0.67 \times 3 = 2.0 \text{ V}$ ✓ (or $4.0/2$ ✓ = 2.0 V ✓)
Total		8

UMS conversion calculator www.aqa.org.uk/umsconversion	
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ERRATUM NOTICE



General Certificate of Education
January 2011

PHYSICS A

Unit 1 Particles, Quantum Phenomena and Electricity

PHYA1

Wednesday 12 January 2011 9.00 am to 10.15 am

Instructions to Invigilators

Before the start of the examination please ask candidates to amend their question papers as follows.
(Please read out this message twice to ensure understanding.)

Turn to page 2, Question 1(b)

In the question under the figure, cross out the fourth word, 'laws' and insert the word 'law'.

ERRATUM NOTICE



General Certificate of Secondary Education
January 2011

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Unit 1 Particles, Quantum Phenomena and Electricity

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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										



General Certificate of Education
Advanced Subsidiary Examination
January 2011

Physics A

PHYA1

Unit 1 Particles, Quantum Phenomena and Electricity

Wednesday 12 January 2011 9.00 am to 10.15 am

For this paper you must have:

- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet.

Time allowed

- 1 hour 15 minutes

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	



J A N 1 1 P H Y A 1 0 1

WMP/Jan11/PHYA1

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PHYA1

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

1 Sub-atomic particles can either be hadrons or leptons.

1 (a) (i) State **one difference** between these two groups of particles.

.....
(1 mark)

1 (a) (ii) Give an example of a non-strange hadron and an example of a lepton.

hadron

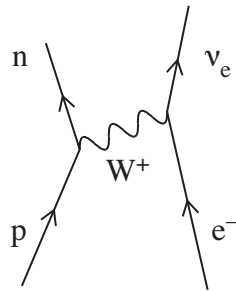
lepton
(2 marks)

1 (a) (iii) Hadrons can be further divided into two groups. Name these two groups **and** state a difference between them.

.....
.....
.....
.....
(3 marks)

1 (b) The Feynman Diagram in **Figure 1** represents an interaction known as electron capture.

Figure 1



1 (b) State a conservation laws obeyed in this interaction. Show how the property mentioned in the law is conserved.

.....
.....
.....
.....
(2 marks)



2 A neutral atom of a radium isotope may be represented by ${}^{228}_{88}\text{Ra}$.

2 (a) (i) Name the constituents of this atom and state how many of each are present.

.....

.....

.....

(3 marks)

2 (a) (ii) Which constituent of an atom has the largest specific charge?

.....

(1 mark)

2 (a) (iii) This isotope of radium decays by β^- decay to form an element with symbol, Ac.
Write down an equation that represents this decay.

(4 marks)

2 (b) ${}^A_Z\text{Ra}$ is a neutral atom of a different isotope of radium. State a possible value for A and for Z.

A:

Z:

(2 marks)

10

Turn over for the next question

Turn over ►



3 Under certain circumstances, a photon moving through a material can interact with the nucleus of an atom of the material to produce an electron and a positron.

3 (i) What is the name of this process?

.....
(1 mark)

3 (ii) Give one reason why the photon could not produce a single electron instead of an electron and a positron.

.....
.....
.....
.....
(2 marks)

3 (iii) Make use of the Data and Formulae booklet to show that the minimum energy of the photon required for this process is 1.02 MeV.

(1 mark)

3 (iv) Photons whose wavelength exceeds a certain value will not cause this process. Calculate the maximum wavelength for the process to occur stating your answer to an appropriate number of significant figures.

answer = ... m
(4 marks)



- 3 (v) Explain what will happen to the positron produced by the interaction.

.....

.....

.....

.....

(2 marks)

10

Turn over for the next question

Turn over ►



The quality of your written communication will be assessed in this question.

This image shows a single page of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

- 4 (b) (i) An alpha particle of mass 6.6×10^{-27} kg has a kinetic energy of 9.6×10^{-13} J.
Show that the speed of the alpha particle is 1.7×10^7 m s⁻¹.

(3 marks)

- 4 (b) (ii) Calculate the momentum of the alpha particle, stating an appropriate unit.

answer = ...

(3 marks)

- 4 (b) (iii) Calculate the de Broglie wavelength of the alpha particle.

answer = ... m

(2 marks)

Turn over for the next question

Turn over ►



5 Domestic users in the United Kingdom are supplied with mains electricity at a *root mean square voltage* of 230 V.

5 (a) State what is meant by root mean square voltage.

.....

.....

.....

(1 mark)

5 (b) (i) Calculate the peak value of the supply voltage.

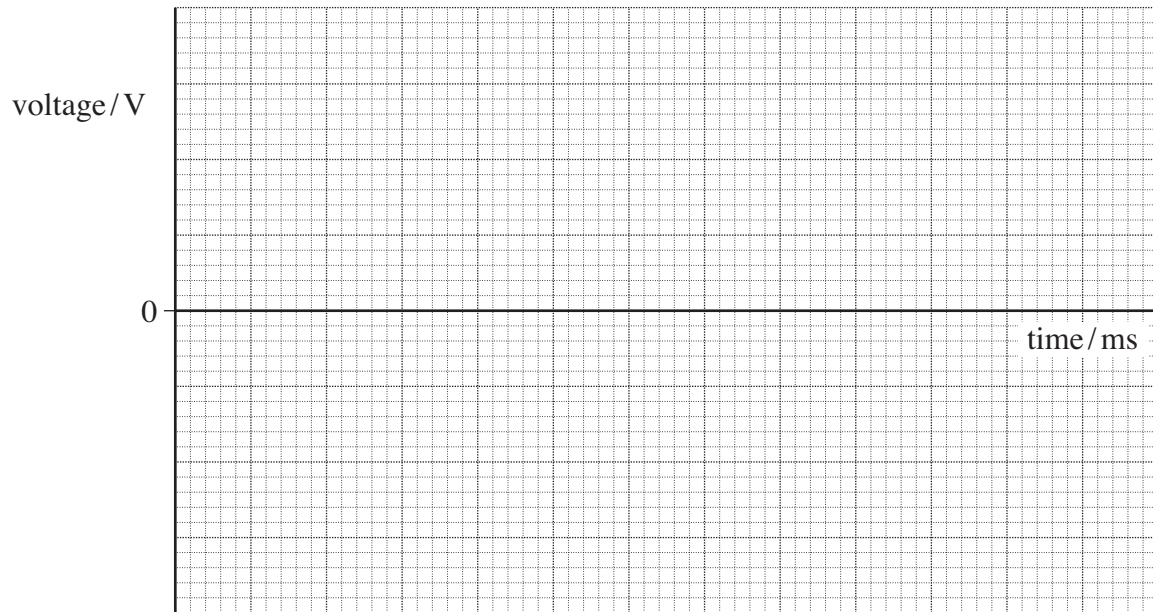
answer = ... V
(2 marks)

5 (b) (ii) Calculate the average power dissipated in a lamp connected to the mains supply when the rms current is 0.26 A.

answer = ... W
(1 mark)



- 5 (c)** The frequency of the voltage supply is 50 Hz. On the axes below draw the waveform of the supplied voltage labelling the axes with appropriate values.



(4 marks)

8

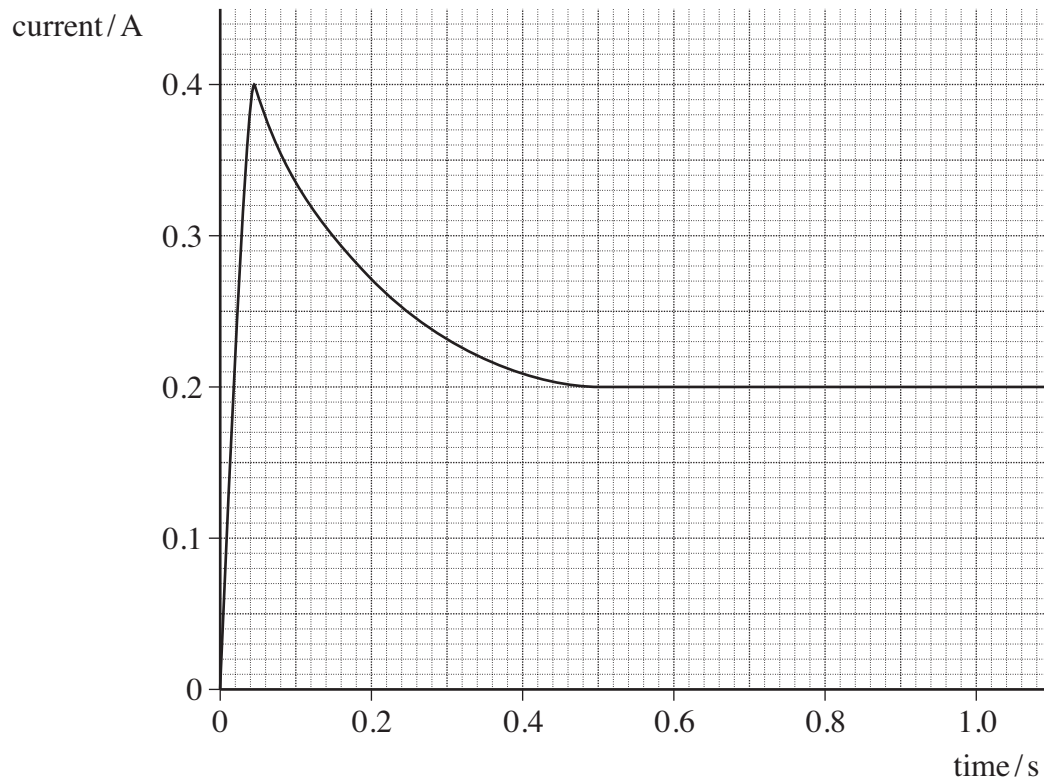
Turn over for the next question

Turn over ►



- 6 When a filament lamp is switched on it takes 0.50 seconds for the filament to reach its normal operating temperature. The way in which the current changes during the first second after switching on is shown on the graph in **Figure 2**.

Figure 2



- 6 (a) Use the graph to determine the maximum current through the lamp.

answer = ... A
(1 mark)



6 (b) Assuming that the lamp is connected to a 12 V dc supply of a negligible internal resistance,

6 (b) (i) Calculate the resistance of the lamp when it has reached its normal operating temperature,

answer = ... Ω
(1 mark)

6 (b) (ii) Calculate the power of the lamp when it has reached its normal operating temperature.

answer = ... W
(1 mark)

6 (c) Explain why the current through the lamp decreases between 0.05 s and 0.50 s.

.....

 (2 marks)

Question 6 continues on the next page

Turn over ►



6 (d) State and explain the change, if any, to the final current through the lamp if it is connected to the same supply with another similar lamp

6 (d) (i) in series,

.....

.....

.....

.....

(2 marks)

6 (d) (ii) in parallel.

.....

.....

.....

.....

(2 marks)

6 (e) State and explain why a filament lamp is most likely to fail as it is switched on.

.....

.....

.....

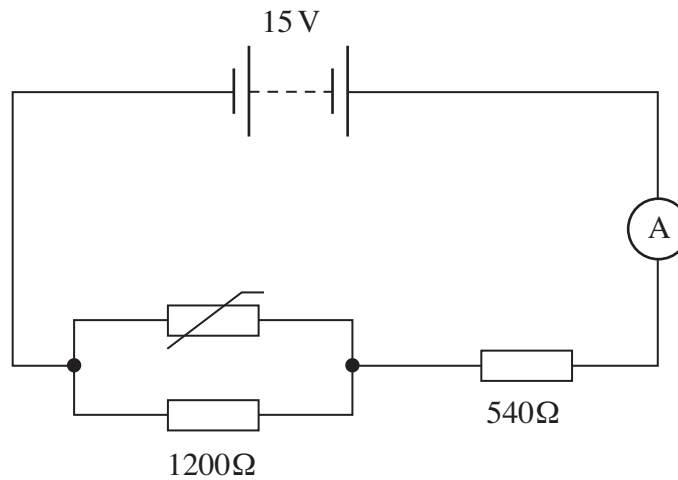
.....

(2 marks)



- 7 The circuit shown in **Figure 3** shows a thermistor connected in a circuit with two resistors, an ammeter and a battery of emf 15 V and negligible internal resistance.

Figure 3



- 7 (a) When the thermistor is at a certain temperature the current through the ammeter is 10.0 mA.
- 7 (a) (i) Calculate the pd across the 540Ω resistor.

answer = ... V
(1 mark)

- 7 (a) (ii) Calculate the pd across the 1200Ω resistor.

answer = ... V
(1 mark)

Question 7 continues on the next page

Turn over ►



7 (a) (iii) Calculate the resistance of the parallel combination of the resistor and the thermistor.

answer = ... Ω
(2 marks)

7 (a) (iv) Calculate the resistance of the thermistor.

answer = ... Ω
(2 marks)

7 (b) The temperature of the thermistor is increased so that its resistance decreases.
State and explain what happens to the pd across the $1200\ \Omega$ resistor.

.....

.....

.....

.....

(3 marks)

END OF QUESTIONS



There are no questions printed on this page

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General Certificate of Education (A-level)
January 2011

Physics A

PHYA1

(Specification 2450)

**Unit 1: Particles, quantum phenomena and
electricity**

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this Mark Scheme are available from: aqa.org.uk

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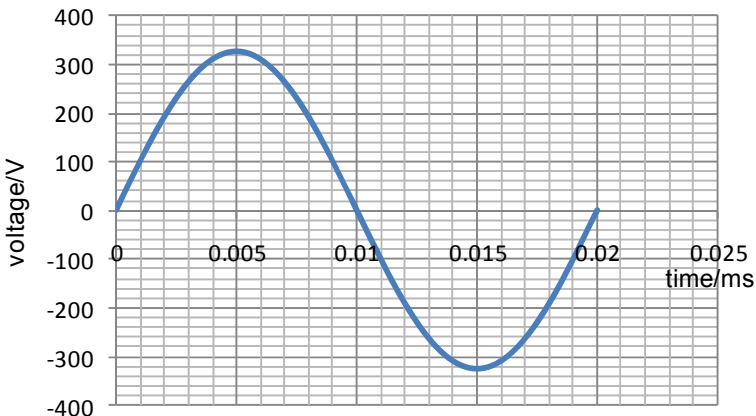
Question 1		
(a) (i)	leptons do not experience the strong interaction but hadrons do or hadrons not fundamental/made of quarks and leptons are not ✓	1
(a) (ii)	hadron eg proton, neutron, pion ✓ lepton eg electron, neutrino ✓	2
(a) (iii)	baryons ✓ mesons ✓ baryons made from three quarks (or 3 antiquarks), mesons a quark, antiquark pair or baryons, baryon number is +1 or –1 mesons 0 ✓	3
(b)	baryon number, lepton number, charge, strangeness, energy or momentum ✓ demonstration of conservation (before and after considered and number appropriate to particle quoted) ✓	2
Total		8

Question 2		
(a) (i)	88 protons ✓ 140 neutrons ✓ 88 electrons ✓	3
(a) (ii)	electron ✓	1
(a) (iii)	${}_{88}^{228}\text{Ra} \rightarrow {}_{89}^{228}\text{Ac} + {}_{-1}^0\text{e} + \bar{\nu}_e$ ✓✓✓✓	4
(b)	228 ± 10 ✓ 88 ✓	2
Total		10

Question 3		
(i)	pair production ✓	1
(ii)	conservation law stated (charge or lepton number) ✓ shown to be true eg lepton number $+1-1 = 0$ ✓	2
(iii)	energy = 2×0.510 (ignore sfs) ✓	1
(iv)	$E = (1.02 \times 1.6 \times 10^{-13}) = 1.63 \times 10^{-13}$ ✓ $1.63 \times 10^{-3} = 6.63 \times 10^{-34} \times 3.00 \times 10^8/\lambda$ ✓ $\lambda = 6.63 \times 10^{-34} \times 3.00 \times 10^8/1.63 \times 10^{-13} = 1.22 \times 10^{-12}\text{m}$ ✓ 3 significant figures ✓	4
(v)	will encounter an electron and the two particles will annihilate ✓ releasing (two high energy/gamma) photons/quanta ✓	2
Total		10

Question 4		
(a)	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of the three levels according to the following criteria. High Level (good to excellent) 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. The candidate provides a comprehensive and coherent description which includes a clear explanation of threshold frequency and why this cannot be explained by the wave theory. The description should include a clear explanation of the photon model of light and this should be linked to the observations such as threshold frequency, the lack of time delay or mentions 1 to 1 interaction, the could not be explained by the wave model. Intermediate Level (modest to adequate) 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. The candidate provides an explanation of threshold frequency and work function. The candidate explains the photon model of light and how this can provide an explanation of threshold frequency, eg relates energy of photon to frequency or talks about packets of energy. Low Level (poor to limited) 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may only be partly appropriate. States what is meant by photoelectric effect. Knowledge of photons/packets of energy. The explanation expected in a competent answer should include a coherent account of the significance of threshold frequency and how this supports the particle nature of electromagnetic waves. • threshold frequency minimum frequency for emission of electrons • if frequency below the threshold frequency, no emission even if intensity increased • because the energy of the photon is less than the work function • wave theory can not explain this as energy of wave increases with intensity • light travels as photons • photons have energy that depends on frequency • if frequency is above threshold photon have enough energy • mention of lack of time delay	max 6

(b)	(i)	use of $E_k = \frac{1}{2}mv^2$ $\frac{1}{2} \times 6.6 \times 10^{-27} \checkmark \times v^2 = 9.6 \times 10^{-13} \checkmark$ $v^2 = 2.91 \times 10^{-14}$ (or $v = \sqrt{2.91 \times 10^{-14}} \checkmark$) ($v = 1.7 \times 10^7 \text{ ms}^{-1}$)	3
(b)	(ii)	(use of $p = mv$) $p = 6.6 \times 10^{-27} \times 1.7 \times 10^7 \checkmark$ $p = 1.1 \times 10^{-19} \checkmark \text{ kg ms}^{-1}/\text{Ns} \checkmark$	3
(b)	(iii)	(use of $\lambda = \frac{h}{mv}$) $\lambda = 6.63 \times 10^{-34}/1.1 \times 10^{-19} \checkmark$ $\lambda = 5.9 \times 10^{-15} \text{ m} \checkmark$ ($6.03 \times 10^{-15} \text{ m}$)	2
Total			14

Question 5		
(a)	the square root of the mean of the squares of all the values of the voltage in one cycle ✓ or the equivalent dc/steady/constant voltage that produces the same heating effect/power ✓	1
(b) (i)	peak voltage = $230 \times \sqrt{2}$ ✓ peak voltage = 325 V (or 324 V) ✓	2
(b) (ii)	average power = $230 \times 0.26 = 60 \text{ W}$ ✓	1
(c)	 shape and symmetrical with consistent values of x at $y = 0$ and consistent y_{max} (must be at least one cycle) ✓ appropriate scale y-axis ✓ correct peak values (to within one 2 mm square) ✓ correct period (accept 0.02 or 20) ✓	4
Total		8

Question 6		
(a)	current = 0.40 A ✓	1
(b) (i)	resistance = $12/0.2 = 60\ \Omega$ ✓	1
(b) (ii)	power = $12 \times 0.2 = 2.4\text{ W}$ ✓	1
(c)	resistance of filament increases or more collisions/scattering ✓ as temperature of filament increase or filament gets hot/heats (until reaches thermal equilibrium) ✓	2
(d) (i)	voltage of supply now shared by lamps or resistance increased ✓ hence current reduced ✓	2
(d) (ii)	current through the lamps unchanged/stays the same ✓ as both connected directly to the supply or correct resistance argument ✓	2
(e)	resistance of lamps will be lower when first switched on ✓ hence initial current will be larger ✓ sudden rapid change in temperature ✓	max 2
Total		11

Question 7		
(a)	(i)	voltage = $0.01 \times 540 = 5.4 \text{ V}$ ✓ 1
(a)	(ii)	voltage = $15 - 5.4 = 9.6 \text{ V}$ ✓ 1
(a)	(iii)	(use of resistance = voltage/current) resistance = $9.6/0.01$ ✓ = 960Ω ✓ or $R_T = 15/0.01 = 1500 \Omega$ ✓ $R = 150 - 590 = 960 \Omega$ ✓ or potential divider ratio ✓✓ 2
(a)	(iv)	(use of $1/R = 1/R_1 + 1/R_2$) $1/960 = 1/200 + 1/R_2$ ✓ $1/R_2 = 1/960 - 1/1200$ $R_2 = 4800 \Omega$ ✓ 2
(b)		(voltage of supply constant) (circuit resistance decreases) (supply) current increases or potential divider argument ✓ hence pd across 540Ω resistor increases ✓ hence pd across 1200Ω decreases ✓ or resistance in parallel combination decreases ✓ pd across parallel resistors decreases ✓ pd across 1200Ω decreases ✓ 3
		Total 9

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										



General Certificate of Education
Advanced Subsidiary Examination
June 2010

Physics A

PHYA1

Unit 1 Particles, Quantum Phenomena and Electricity

Thursday 27 May 2010 1.30 pm to 2.45 pm

For this paper you must have:

- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet.

Time allowed

- 1 hour 15 minutes

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	



J U N 1 0 P H A Y 1 0 1

WMP/Jun10/PHYA1

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PHYA1

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

1 A ${}_{11}^{22}\text{Na}$ nucleus decays, forming a new nucleus, by releasing a β^+ particle and one other particle which is difficult to detect.

1 (a) Name the particle which is difficult to detect.

answer = ...
(1 mark)

1 (b) Write down the proton number and the nucleon number of the new nucleus.

proton number

nucleon number
(2 marks)

1 (c) Name the baryon and each of the leptons formed as a result of this decay.

baryon

lepton

lepton
(3 marks)

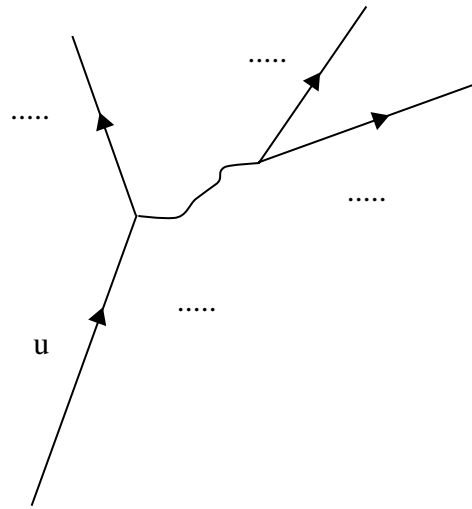
1 (d) Give the quark structure for a neutron and a proton.

neutron

proton
(1 mark)



1 (e) Complete the following Feynman diagram so that it represents β^+ decay.



(3 marks)

10

Turn over for the next question

Turn over ►



- 2 (a)** Describe how the strong nuclear force between two nucleons varies with the separation of the nucleons quoting suitable values for separation.

.....

.....

.....

.....

.....

.....

(3 marks)

- 2 (b)** An unstable nucleus can decay by the emission of an *alpha particle*.

- 2 (b) (i)** State the nature of an alpha particle.

.....

.....

(1 mark)

- 2 (b) (ii)** Complete the equation below to represent the emission of an α particle by a $^{238}_{92}\text{U}$ nucleus.



(2 marks)



2 (c) $^{238}_{92}\text{U}$ decays in stages by emitting α particles and β^- particles, eventually forming $^{206}_{82}\text{Pb}$, a stable *isotope* of lead.

2 (c) (i) State what is meant by isotopes.

.....

.....

(2 marks)

2 (c) (ii) If there are eight alpha decays involved in the sequence of decays from $^{238}_{92}\text{U}$ to $^{206}_{82}\text{Pb}$ deduce how many β^- decays are involved.

answer = ...

(3 marks)

11

Turn over for the next question

Turn over ►



3 When a clean metal surface in a vacuum is irradiated with ultraviolet radiation of a certain frequency, electrons are emitted from the metal.

3 (a) (i) Explain why the kinetic energy of the emitted electrons has a maximum value.

.....

.....

.....

.....

(2 marks)

3 (a) (ii) Explain with reference to the work function why, if the frequency of the radiation is below a certain value, electrons are not emitted.

.....

.....

.....

.....

(2 marks)

3 (a) (iii) State a unit for work function.

.....

(1 mark)

3 (b) Light energy is incident on each square millimetre of the surface at a rate of $3.0 \times 10^{-10} \text{ J s}^{-1}$. The frequency of the light is $1.5 \times 10^{15} \text{ Hz}$.

3 (b) (i) Calculate the energy of an incident photon.

answer = ... J
(2 marks)



- 3 (b) (ii)** Calculate the number of photons incident per second on each square millimetre of the metal surface.

answer = ...
(2 marks)

- 3 (c)** In the wave theory model of light, electrons on the surface of a metal absorb energy from a small area of the surface.

- 3 (c) (i)** The light striking the surface delivers energy to this small area at a rate of $3.0 \times 10^{-22} \text{ J s}^{-1}$.
The minimum energy required to liberate the electron is $6.8 \times 10^{-19} \text{ J}$.
Calculate the minimum time it would take an electron to absorb this amount of energy.

answer = ... s
(1 mark)

- 3 (c) (ii)** In practice the time delay calculated in part c (i) does not occur. Explain how this experimental evidence was used to develop the particle model for the behaviour of light.

.....

.....

.....

.....

(2 marks)



4 Electrons exhibit *wave properties*.

4 (a) What phenomenon can be used to demonstrate the wave properties of electrons? Details of any apparatus used are not required.

.....
.....

(1 mark)

4 (b) Calculate the de Broglie wavelength of electrons travelling at a speed of $4.50 \times 10^5 \text{ m s}^{-1}$.

answer = ... m
(2 marks)

4 (c) The muon has a mass equal to 207 times the mass of an electron.
Calculate the speed of muons with the same de Broglie wavelength as the electrons in part (b).

answer = ... m s^{-1}
(3 marks)



- 5 (a)** A student wishes to investigate how the resistance of a thermistor changes with temperature.
- 5 (a) (i)** Draw a labelled diagram of a suitable circuit that would enable the student to measure the resistance of the thermistor.

(2 marks)

- 5 (a) (ii)** Describe the procedure the student would follow in order to obtain accurate and reliable measurements of the resistance of the thermistor at different temperatures.

The quality of your written communication will be assessed in this question.

.....

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(6 marks)

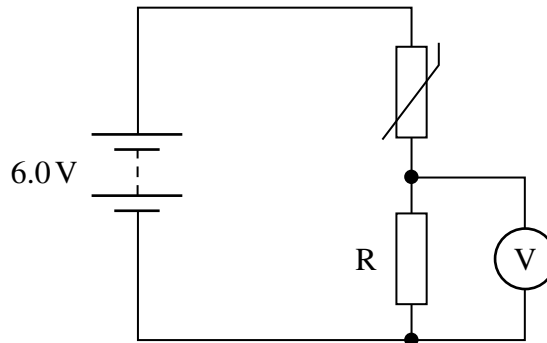
Question 5 continues on the next page

Turn over ►



- 5 (b)** **Figure 1** shows a thermistor connected in series with a resistor, R , and battery of emf 6.0 V and negligible internal resistance.

Figure 1



When the temperature is 50°C the resistance of the thermistor is $1.2\text{ k}\Omega$. The voltmeter connected across R reads 1.6 V .

- 5 (b) (i)** Calculate the pd across the thermistor.

answer = ... V
(1 mark)

- 5 (b) (ii)** Calculate the current in the circuit.

answer = ... A
(1 mark)



- 5 (b) (iii)** Calculate the resistance of R quoting your answer to an appropriate number of significant figures.

answer = ... Ω
(2 marks)

- 5 (c)** State and explain the effect on the voltmeter reading if the internal resistance of the battery in the circuit in part (b) was not negligible.

.....

.....

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.....

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.....

(2 marks)

14

Turn over for the next question

Turn over ►



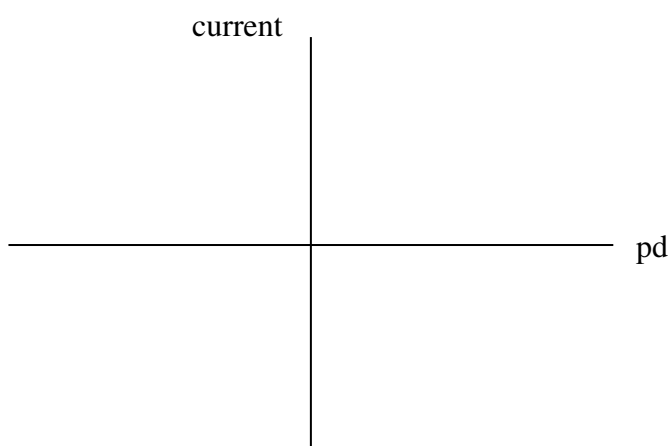
- 6 (a)** A semiconducting diode is an example of a *non-ohmic* component. State what is meant by a non-ohmic component.

.....

 (1 mark)

- 6 (b)** A filament lamp is also an example of a non-ohmic component.

- 6 (b) (i)** Sketch on the axes below the current-voltage characteristic for a filament lamp.



(2 marks)

- 6 (b) (ii)** State, with reference to the current-voltage characteristic you have drawn, how the resistance of the lamp changes as the pd across its terminals changes.

.....

 (1 mark)

- 6 (c)** A filament lamp has a power rating of 36 W when there is a pd across its terminals of 12 V.

- 6 (c) (i)** Calculate the resistance of the filament when the pd across its terminals is 12 V.

answer = ... Ω
 (2 marks)



- 6 (c) (ii)** A student predicts that if the pd across the bulb is reduced to 6.0 V the power rating of the bulb would be 9.0 W. State and explain how in practice the power rating will be slightly different from this value.

.....

.....

.....

.....

.....

.....

(3 marks)

9

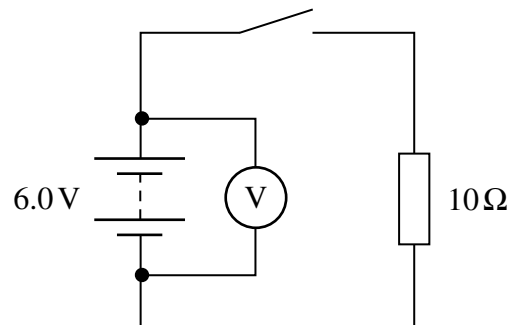
Turn over for the next question

Turn over ►



- 7 A battery is connected to a $10\ \Omega$ resistor as shown in **Figure 2**. The emf (electromotive force) of the battery is $6.0\ \text{V}$.

Figure 2



- 7 (a) (i) Define the emf of a battery.

.....

.....

(1 mark)

- 7 (a) (ii) When the switch is open the voltmeter reads $6.0\ \text{V}$ and when it is closed it reads $5.8\ \text{V}$. Explain why the readings are different.

.....

.....

.....

.....

.....

(2 marks)

7 (b) Calculate the internal resistance of the battery.

answer = ... Ω
(3 marks)

7 (c) State and explain why it is important for car batteries to have a very low internal resistance.

.....

.....

.....

.....

.....

.....

(2 marks)

8

END OF QUESTIONS



There are no questions printed on this page

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**General Certificate of Education
June 2010**

Physics A PHYA1

Particles, Quantum Phenomena and Electricity

Unit 1

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this Mark Scheme are available to download from the AQA Website: www.aqa.org.uk

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Instructions to Examiners

- 1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.
- 2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	<i>see specific mark scheme</i>	5-6
Modest - Adequate	<i>see specific mark scheme</i>	3-4
Poor - Limited	<i>see specific mark scheme</i>	1-2
The description and/or explanation expected in a good answer should include a coherent account of the following points: <i>see specific mark scheme</i>		

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

- 3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.
- 4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.
- 5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.
- 6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.
- 7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

GCE Physics, Specification A, PHYA1, Particles, Quantum Phenomena and Electricity

Question 1		
(a)	neutrino ✓	1
(b)	proton number = 10 ✓ nucleon number = 22 ✓	2
(c)	baryon = neutron ✓ lepton = positron ✓ lepton = neutrino ✓	3
(d)	ddu and uud ✓	1
(e)	-1 for each error	3
Total		10

Question 2		
(a)	repulsive then attractive ✓ short range (if distance quoted must be of order fm) ✓ correct distance for cross over (accept range 0.1 – 1.0 fm) ✓	3
(b) (i)	a helium nucleus (accept 2p and 2n) ✓	1
(b) (ii)	$({}_{92}^{238}\text{U}) \rightarrow ({}_{90}^{234}\text{Th}) + ({}_{2}^{4}\text{He})$ ✓	2
(c) (i)	same atomic number/proton number ✓ different number of neutrons/nucleons ✓	2
(c) (ii)	evidence of subtraction of mass number or atomic number ✓ (thus atomic number decreases to) 76 ✓ (atomic number of lead is 82 therefore) 6 (82 – 76) beta decays ✓	3
Total		11

Question 3		
(a) (i)	hf is energy available/received or same energy from photons ✓ energy required to remove the electron varies (hence kinetic energy of electrons will vary) ✓	2
(a) (ii)	(work function is the) minimum energy needed to release an electron ✓ (or not enough energy to release electron) below a certain frequency energy of photon is less than work function or energy of photon correctly related to f ✓	2
(a) (iii)	joule ✓ (accept eV)	1
(b) (i)	(use of $E = hf$) energy = $6.63 \times 10^{-34} \times 1.5 \times 10^{15}$ ✓ energy = 9.9×10^{-19} (J) ✓	2
(b) (ii)	number of photons per second = $3.0 \times 10^{-10}/9.9 \times 10^{-19}$ ✓ number of photons per second = 3.0×10^8 ✓	2
(c) (i)	(time taken = $6.8 \times 10^{-19}/3 \times 10^{-22}$) time taken = 2.3×10^3 s ✓	1
(c) (ii)	light travels as particles/ photons ✓ (or has a particle(like) nature) (which transfer) energy in discrete packets ✓ or 1 to 1 interaction or theory rejected/modified (in light of validated evidence)	2
Total		12

Question 4		
(a)	(electron) diffraction/interference/superposition ✓	1
(b)	(use of $\lambda = h/mv$) $\lambda = 6.63 \times 10^{-34}/(9.11 \times 10^{-31} \times 4.50 \times 10^5)$ ✓ $\lambda = 1.6 \times 10^{-9}$ (m) ✓	2
(c)	$207 \times 9.11 \times 10^{-31}$ ✓ $\times v = 6.63 \times 10^{-34}/1.6 \times 10^{-7}$ ✓ $v = 2200$ (2170) (m s ⁻¹) ✓	3
Total		6

Question 5		
(a) (i)	working circuit including power supply and thermistor (correct symbol) ✓ voltmeter and ammeter or ohm meter ✓	2
(a) (ii)	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. The candidate states that the thermistor is connected in a suitable circuit with voltmeter and ammeter or ohmmeter. The candidate gives details of how the thermistor is heated in a beaker of water or a water bath and a thermometer is used to measure the temperature at small regular intervals. The candidate states that the resistance is found at various temperatures either directly with an ohmmeter or by dividing voltage by current. The candidate may mention that the water must be stirred to ensure that the thermistor is at the temperature measured by the thermometer. The candidate may give some indication of the range of temperatures to be used. The candidate may refer to repetition of whole experiment. The candidate may plot a graph of resistance against temperature. The candidate may use a digital thermometer. Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. The candidate states that the thermistor is connected in a suitable circuit with voltmeter and ammeter or ohmmeter. The candidate gives details of how the thermistor is heated in a beaker of water and a thermometer is used to measure the temperature. The candidate states that the resistance is found at various temperatures either directly with an ohmmeter or by dividing voltage by current. Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. The candidate changes temperature at least once and measures V and I or R. The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case.	max 6

(b)	(i)	pd = $6.0 - 1.6 = 4.4$ (V) ✓	1
(b)	(ii)	current = $4.4/1200 = 3.7 \times 10^{-3}$ (A) ✓ (not 3.6)	1
(b)	(iii)	resistance = $1.6/3.7 \times 10^{-3} = 440$ or 430 (Ω) ✓ 2 sfs ✓	2
(c)		less current now flows or terminal pd/voltage lower ✓ (or voltage across cell/external circuit is lower) (hence) pd/voltage across resistor will decrease ✓	2
Total			14

Question 6			
(a)		a non-ohmic conductor does not have a constant resistance ✓	1
(b)	(i)	curve of decreasing gradient with increasing V ✓ attempt to make graph symmetric in two opposite quadrants ✓	2
(b)	(ii)	resistance increases as pd increases/current increases ✓	1
(c)	(i)	(use of $P = V^2/R$) $36 = 144/R$ ✓ $R = 4.0$ (Ω) ✓	2
(c)	(ii)	reference to temperature change ✓ (resulting in) a lower resistance ✓ (hence) power rating would be greater ✓	3
Total			9

Question 7			
(a)	(i)	work (done)/energy (supplied) per unit charge (by battery) ✓ (or pd across terminals when no current passing through cell or open circuit)	1
(a)	(ii)	when switch is closed a current flows (through the battery) ✓ hence a pd/lost volts develops across the internal resistance ✓	2
(b)		(use of $\varepsilon = V + Ir$) $I = 5.8/10 = 0.58$ (A) ✓ $6.0 = 5.8 + 0.58r$ ✓ $r = 0.2/0.58 = 0.34$ (Ω) ✓	3
(c)		need large current/power to start the car ✓ (or current too low) internal resistance limits the current/wastes power(or energy)/reduces terminal pd/increases lost volts ✓	2
Total			8

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										



General Certificate of Education
Advanced Subsidiary Examination
January 2010

Physics A

PHYA1

Unit 1 Particles, Quantum Phenomena and Electricity

Wednesday 13 January 2010 9.00 am to 10.15 am

For this paper you must have:

- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet.

Time allowed

- 1 hour 15 minutes

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	



J A N 1 0 P H Y A 1 0 1

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PHYA1

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

- 1** (a) *Hadrons* are a group of particles composed of quarks. Hadrons can either be baryons or mesons.

- 1** (a) (i) What property defines a hadron?

.....
(1 mark)

- 1** (a) (ii) What is the quark structure of a baryon?

.....
(1 mark)

- 1** (a) (iii) What is the quark structure of a meson?

.....
(1 mark)

- 1** (b) State **one** similarity and **one** difference between a particle and its antiparticle.

similarity

.....

difference

.....

(2 marks)

- 1** (c) Complete the table below which lists properties of the antiproton.

	charge/C	baryon number	quark structure
antiproton			

(2 marks)



- 1 (d) The K^- is an example of a meson with strangeness -1 . The K^- decays in the following way:

$$K^- \rightarrow \mu^- + \bar{\nu}_\mu$$

- 1 (d) (i) State, with a reason, what interaction is responsible for this decay.

.....

.....

.....

.....

(2 marks)

- 1 (d) (ii) State **two** properties, other than energy and momentum, that are conserved in this decay.

.....

.....

.....

.....

(2 marks)

11

Turn over for the next question

Turn over ►



2 (a) A fluorescent tube is filled with mercury vapour at low pressure. In order to emit electromagnetic radiation the mercury atoms must first be *excited*.

2 (a) (i) What is meant by an excited atom?

.....
.....
(1 mark)

2 (a) (ii) Describe the process by which mercury atoms become excited in a fluorescent tube.

.....
.....
.....
.....
.....
.....
(3 marks)

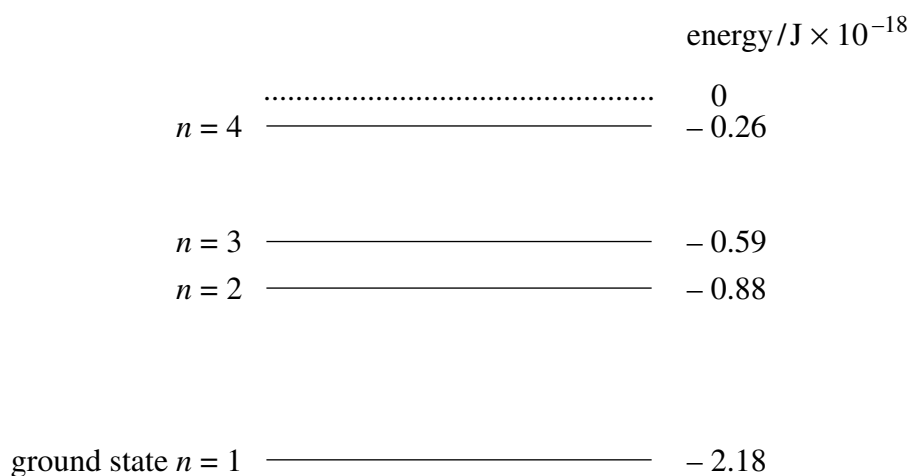
2 (a) (iii) What is the purpose of the coating on the inside surface of the glass in a fluorescent tube?

.....
.....
.....
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.....
.....
(3 marks)



- 2 (b) The lowest energy levels of a mercury atom are shown in **Figure 1**. The diagram is **not** to scale.

Figure 1



- 2 (b) (i) Calculate the frequency of an emitted photon due to the transition level $n = 4$ to level $n = 3$.

answer = ... Hz
(3 marks)

- 2 (b) (ii) Draw an arrow on the **Figure 1** to show a transition which emits a photon of a longer wavelength than that emitted in the transition from level $n = 4$ to level $n = 3$.

(2 marks)

12

Turn over for the next question

Turn over ►



3 (a) An unstable nucleus, ${}^A_Z\text{X}$, can decay by emitting a β^- particle.

3 (a) (i) What part of the atom is the same as a β^- particle?

.....
(1 mark)

3 (a) (ii) State the changes, if any, in A and Z when X decays.

change in A

change in Z
(2 marks)

3 (b) In the process of β^- decay an *anti-neutrino* is also released.

3 (b) (i) Give an equation for this decay.

.....
(1 mark)

3 (b) (ii) State and explain which conservation law may be used to show that it is an *anti-neutrino* rather than a *neutrino* that is released.

.....
.....
.....
.....
(2 marks)

3 (b) (iii) What must be done to validate the predictions of an unconfirmed scientific theory?

.....
.....
.....
.....
(2 marks)

Turn to page 8 for the next question



Turn over for the next question

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ANSWER IN THE SPACES PROVIDED**

Turn over ►



4 (a) Experiments based on the photoelectric effect support the particle nature of light. In such experiments light is directed at a metal surface.

4 (a) (i) State what is meant by the threshold frequency of the incident light.

.....
.....
(1 mark)

4 (a) (ii) Explain why the photoelectric effect is **not** observed below the threshold frequency.

.....
.....
.....
.....
(2 marks)

4 (b) Monochromatic light of wavelength 5.40×10^{-7} m is incident on a metal surface which has a work function of 1.40×10^{-19} J.

4 (b) (i) Calculate the energy of a single photon of this light.

answer = ... J
(2 marks)

4 (b) (ii) Calculate the maximum kinetic energy of an electron emitted from the surface.

answer = ... J
(2 marks)



4 (b) (iii) Calculate the maximum speed of the emitted electron.

answer = ... m s^{-1}
(2 marks)

4 (b) (iv) Calculate the de Broglie wavelength of the fastest electrons.

answer = ... m
(2 marks)

Turn over for the next question

Turn over ►



- 5 (a) A sample of conducting putty is rolled into a cylinder which is 6.0×10^{-2} m long and has a radius of 1.2×10^{-2} m.

resistivity of the putty = $4.0 \times 10^{-3} \Omega\text{m}$.

- 5 (a) (i) Calculate the resistance between the ends of the cylinder of conducting putty. Your answer should be given to an appropriate number of significant figures.

answer = ... Ω
(4 marks)

- 5 (a) (ii) The putty is now reshaped into a cylinder with half the radius and a length which is four times as great. Determine how many times greater the resistance now is.

.....
.....
.....
.....
.....
.....
(2 marks)



- 5 (b) Given the original cylinder of the conducting putty described in part (a), describe how you would use a voltmeter, ammeter and other standard laboratory equipment to determine a value for the resistivity of the putty.

Your description should include

- a labelled circuit diagram,
- details of the measurements you would make,
- an account of how you would use your measurements to determine the result,
- details of how to improve the precision of your measurements.

The quality of your written communication will be assessed in this question.

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(8 marks)

Turn over for the next question

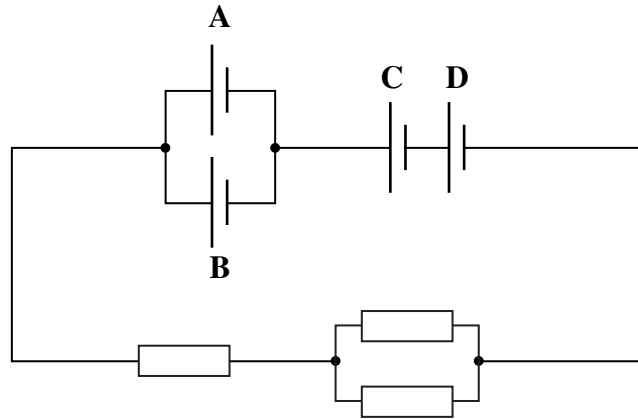
14

Turn over ►



- 6** The circuit in **Figure 2** contains four identical new cells, **A**, **B**, **C** and **D**, each of emf 1.5 V and negligible internal resistance.

Figure 2



- 6** (a) The resistance of each resistor is $4.0\ \Omega$.
- 6** (a) (i) Calculate the total resistance of the circuit.

answer = ... Ω
(1 mark)

- 6** (a) (ii) Calculate the total emf of the combination of cells.

answer = ... V
(1 mark)



- 6** (a) (iii) Calculate the current passing through cell A.

answer = ... A
(2 marks)

- 6** (a) (iv) Calculate the charge passing through cell A in five minutes, stating an appropriate unit.

answer = ...
(2 marks)

- 6** (b) Each of the cells can provide the same amount of electrical energy before going flat. State and explain which two cells in this circuit you would expect to go flat first.

.....

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(3 marks)

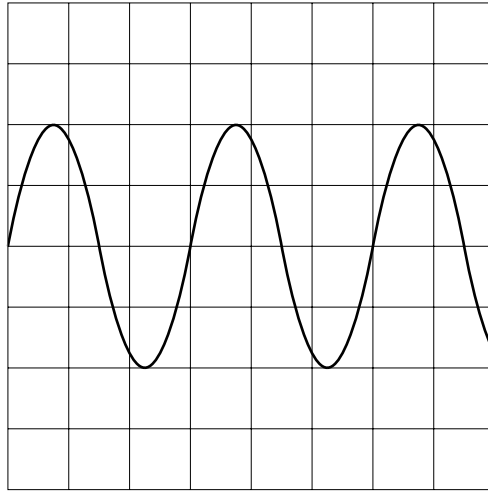
Turn over for the next question

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- 7 An alternating current (ac) source is connected to a resistor to form a complete circuit. The trace obtained on an oscilloscope connected across the resistor is shown in **Figure 3**.

Figure 3



The oscilloscope settings are: Y gain 5.0 V per division
time base 2.0 ms per division.

- 7 (a) (i) Calculate the peak voltage of the ac source.

answer = ... V
(1 mark)

- 7 (a) (ii) Calculate the rms voltage.

answer = ... V
(1 mark)

- 7 (a) (iii) Calculate the time period of the ac signal.

answer = ... ms
(1 mark)



7 (a) (iv) Calculate the frequency of the ac signal.

answer = ... Hz
(2 marks)

5

END OF QUESTIONS



There are no questions printed on this page

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General Certificate of Education

Physics 1451

Specification A

PHYA1 Particles, Quantum Phenomena and Electricity

Mark Scheme

2010 examination - January series

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Instructions to Examiners

- 1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.
- 2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	<i>see specific mark scheme</i>	5-6
Modest - Adequate	<i>see specific mark scheme</i>	3-4
Poor - Limited	<i>see specific mark scheme</i>	1-2
The description and/or explanation expected in a good answer should include a coherent account of the following points: <i>see specific mark scheme</i>		

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

- 3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.
- 4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.
- 5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.
- 6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.
- 7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

GCE Physics, Specification A, PHYA1, Particles, Quantum Phenomena and Electricity

Question 1											
(a)	(i)	particles that experience the strong (nuclear) force/interaction ✓	1								
(a)	(ii)	particles composed of three quarks ✓	1								
(a)	(iii)	particles composed of a quark and an antiquark ✓	1								
(b)		similarity: but the same (rest) mass or rest energy ✓ difference: opposite quantum states eg charge ✓	2								
(c)		<table><tr><td></td><td>charge/C</td><td>baryon number</td><td>quark structure</td></tr><tr><td>antiproton</td><td>-1.6×10^{-19}</td><td>-1</td><td>$\overline{u}\overline{u}\overline{d}$</td></tr></table> -1 for each error		charge/C	baryon number	quark structure	antiproton	-1.6×10^{-19}	-1	$\overline{u}\overline{u}\overline{d}$	2
	charge/C	baryon number	quark structure								
antiproton	-1.6×10^{-19}	-1	$\overline{u}\overline{u}\overline{d}$								
(d)	(i)	weak interaction ✓ strange not conserved or there is a change/decay of quark (flavour) ✓	2								
(d)	(ii)	any two eg charge baryon number (muon) lepton number	2								
Total			11								

Question 2		
(a) (i)	an electron/atom is at a higher level than the ground state ✓ or electron jumped/moved up to another/higher level	1
(a) (ii)	electrons (or electric current) flow through the tube ✓ and collide with orbiting/atomic electrons or mercury atoms ✓ raising the electrons to a higher level (in the mercury atoms) ✓	3
(a) (iii)	photons emitted from mercury atoms are in the ultra violet (spectrum) or high energy photons ✓ these photons are absorbed by the powder or powder changes frequency/wavelength ✓ and the powder emits photons in the visible spectrum ✓ incident photons have a variety of different wavelengths ✓	max 3
(b) (i)	(use of $E = hf$) $-0.26 \times 10^{-18} - 0.59 \times 10^{-18} \checkmark = 6.63 \times 10^{-34} \times f \checkmark$ $f = 0.33 \times 10^{-18} / (6.63 \times 10^{-34}) = 5.0 \times 10^{14} \text{ (Hz)} \checkmark$	3
(b) (ii)	one arrow between $n=3$ and $n=2$ ✓ in correct direction ✓	2
Total		12

Question 3		
(a)	(i)	an electron ✓ 1
(a)	(ii)	change in $A = 0$ ✓ change in $Z = +1$ ✓ 2
(b)	(i)	${}^A_ZX \rightarrow {}^A_{Z+1}Y + {}^0_{-1}e + \bar{\nu}_e$ ✓ or $n \rightarrow p + e^- + \bar{\nu}_e$ or $d \rightarrow u + e^- + \bar{\nu}_e$ 1
(b)	(ii)	lepton number must be conserved ✓ lepton number before decay equals zero hence after decay lepton number of electrons cancels with lepton number of anti-neutrino or zero on both sides ✓ 2
(b)	(iii)	hypothesis needs to be tested by experiment ✓ experiment must be repeatable ✓ or hypothesis rejected 2
Total		8

Question 4		
(a)	(i)	below a certain frequency (called the threshold frequency) no electrons emitted ✓ or minimum frequency for electrons to overcome work function 1
(a)	(ii)	(light travels as photons) energy of a photon depends on frequency ✓ below threshold frequency (photon) does not have enough energy to liberate an electron ✓ or reference to work function eg a photon does not have enough energy (to allow the electron) to overcome the work function 2
(b)	(i)	(use of $E = hc/\lambda$) $E = 6.63 \times 10^{-34} \times 3.00 \times 10^8 / 5.40 \times 10^{-7}$ ✓ $E = 3.68 \times 10^{-19}$ (J) ✓ 2
(b)	(ii)	(use of $hf = E_k + \phi$) $3.68 \times 10^{-19} = E_k + 1.40 \times 10^{-19}$ ✓ $E_k = 2.28 \times 10^{-19}$ (J) ✓ 2

(b)	(iii)	(use of $E_k = mv^2/2$) $2.28 \times 10^{-19} = 1/2 \times 9.11 \times 10^{-31} \times v^2 \checkmark$ $v^2 = 2 \times 2.28 \times 10^{-19} / 9.11 \times 10^{-31} = 5.0 \times 10^{11}$ $v = 7.1 \times 10^5 (\text{ms}^{-1}) \checkmark$	2
(b)	(iv)	(use of $\lambda = h/mv$) $\lambda = 6.63 \times 10^{-34} / (9.11 \times 10^{-31} \times 7.1 \times 10^5) \checkmark$ $\lambda = 1.03 \times 10^{-9} (\text{m}) \checkmark$	2
Total			11

Question 5			
(a)	(i)	(use of $R = \rho l/A$) $R = 4.0 \times 10^{-3} \times 0.060 \checkmark / (\pi \times 0.012^2) \checkmark$ $R = 0.53 \text{ } (\Omega) \checkmark$ 2 significant figures $\checkmark$	4
(a)	(ii)	halving the diameter will increase resistance by factor of 4 or increasing the length by a factor of 4 will increase resistance by factor of 4 $\checkmark$ (hence) resistance will be 16 times greater $\checkmark$	2

(b)	the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication	
	circuit must include:	2
	voltmeter and ammeter connected correctly ✓	
	power supply with means of varying current ✓	
QWC	descriptor	mark range
	(i) Uses accurately appropriate grammar, spelling, punctuation and legibility.	
	(ii) Uses the most appropriate form and style of writing to give an explanation or to present an argument in a well structured piece of extended writing.	
good - excellent	[may include bullet points and/or formulae or equations]	5 - 6
	An excellent candidate will have a working circuit diagram with correct description of measurements (including range of results) and processing.	
	An excellent candidate uses a range of results and finds a mean value or uses a graphical method, eg I - V characteristics. They also mention precision eg use of vernier callipers.	
	(i) Only a few errors.	
	(ii) Some structure to answer, style acceptable, arguments or explanations partially supported by evidence or examples.	
modest - adequate	An adequate candidate will have a working circuit and a description with only a few errors, eg do not consider precision. They have not taken a range of results and fail to realise that the diameter needs to be measured in several places.	3 - 4
	(i) Several significant errors.	
	(ii) Answer lacking structure, arguments not supported by evidence and contains limited information.	
poor - limited	Several significant errors, eg important measurement missed, incorrect circuit, no awareness of how to calculate resistivity.	1 - 2
incorrect, inappropriate or no response		0
	The explanation expected in a good answer should include a coherent account of the procedure and include most of the following points.	
	• length with a ruler	
	• thickness/diameter with vernier callipers/micrometer	
	• measure voltage	
	• measure current	
	• calculate resistance	
	• use of graph, eg I - V or resistance against length	
	• use of diameter to calculate cross-sectional area	
	• mention of precision, eg vernier callipers or full scale readings for V and I	
	• flat metal electrodes at each end to improve connection	
	Total	14

Question 6		
(a)	(i)	6.0 (Ω) ✓
(a)	(ii)	4.5 (V) ✓
(a)	(iii)	(use of $I = V/R$) $I = 4.5/6.0 = 0.75$ (A) ✓ current through cell A = $0.75/2 = 0.375$ (A) ✓
(a)	(iv)	charge = $0.375 \times 300 = 112$ ✓ C ✓
(b)		cells C and D will go flat first or A and B last longer ✓ current/charge passing through cells C and D (per second) is double/more than that passing through A or B ✓ energy given to charge passing through cells per second is double or more than in cells C and D ✓ or in terms of power
		Total
		9

Question 7		
	(i)	10.0 (V) ✓
	(ii)	$V_{\text{rms}} = 10.0/\sqrt{2} = 7.1$ (V) ✓
	(iii)	time period = $3 \times 2 = 6$ (ms) ✓
	(iv)	frequency = $1/0.006$ or $1/6$ ✓ frequency = 167 ✓ (Hz)
		Total
		5