| Centre Number | | | | | | Candidate Number | | | | |
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| For Examiner's Use | |
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| Examiner's Initials | |
| Question | Mark |
| 1 | |
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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.

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?

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*(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)*

*Areas outside the box will not be scanned for marking*

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

$$K^- \longrightarrow \mu^- + \overline{\nu_u}$$

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

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*(2 marks)*

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

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*(2 marks)*

11

**Turn over for the next question**

**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?

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*(1 mark)*

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

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*(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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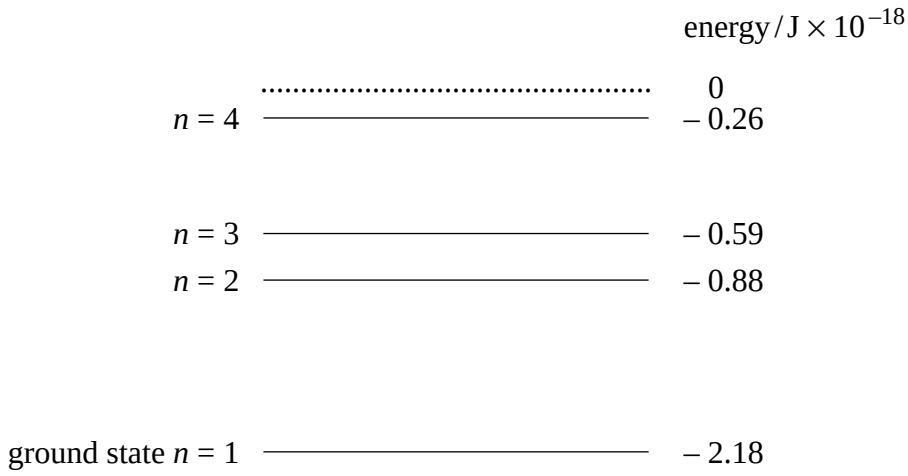
*(3 marks)*

**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**

**3** (a) An unstable nucleus, ${}^{A}_{Z}\mathrm{X}$, can decay by emitting a $\beta^-$ particle.

**3** (a) (i) What part of the atom is the same as a $\beta^-$ 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 $\beta^-$ decay an *anti-neutrino* is also released.

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

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*(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.

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*(2 marks)*

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

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*(2 marks)*

**Turn to page 8 for the next question**

**8**

**Turn over for the next question**

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

**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.

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*(1 mark)*

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

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*(2 marks)*

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

**11**

**Turn over for the next question**

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

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*(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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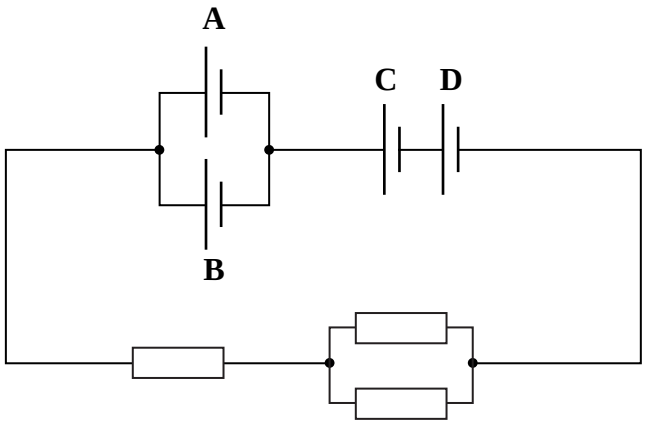
*(8 marks)*

**14**

**Turn over for the next question**

**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 Ω.

**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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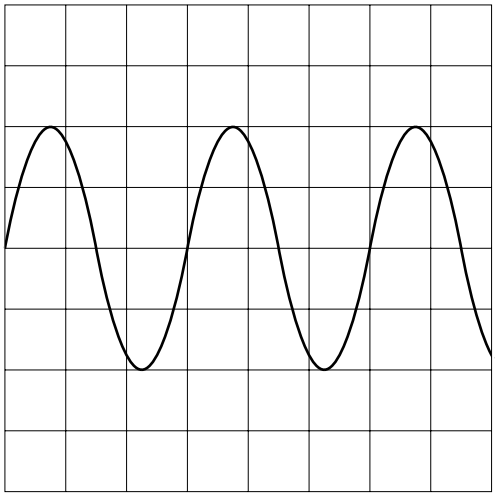
*(3 marks)*

**9**

**Turn over for the next question**

**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**

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