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.

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

$$^{99}_{43}\text{Tc} \rightarrow {}^{A}_{Z}\text{Ru} + {}^{0}_{-1}\beta + \text{X}$$

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 ($^{99}_{43}\text{Tc}$) nucleus. State an appropriate unit for your answer.

specific charge = ... unit .....

(4 marks)

10

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

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.

$$p + e^- \rightarrow n + \nu_e$$

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.

.....

.....

.....

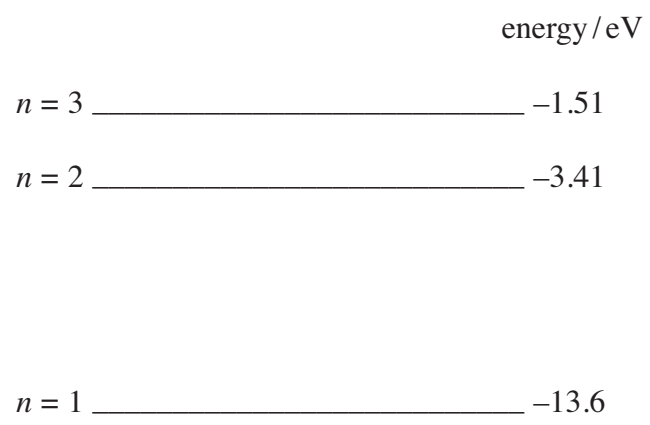
(1 mark)

10

Turn over for the next question

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

Figure 1



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 1.70×10^{-18} 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)

12

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)

5 (c) (i) State the principal property of a superconductor.

.....

.....

(1 mark)

5 (c) (ii) State what is meant by critical temperature.

.....

.....

(1 mark)

5 (c) (iii) Give **one** use of a superconductor.

.....

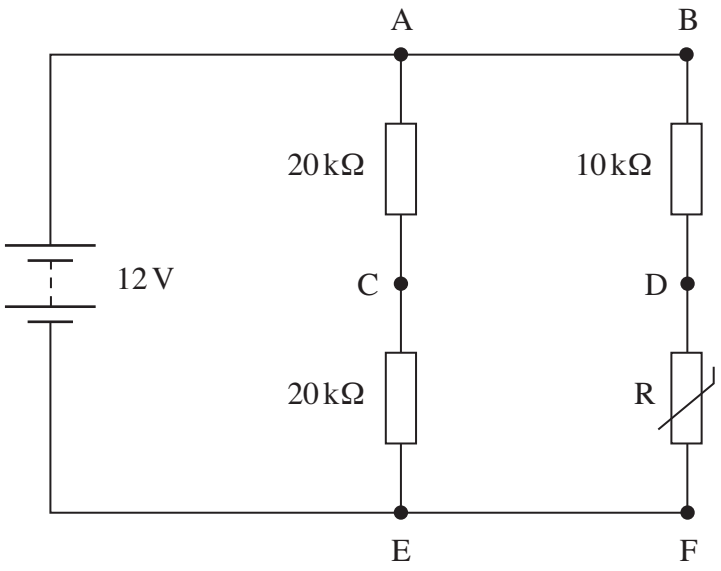
.....

(1 mark)

12

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 kΩ

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

total resistance = ... kΩ
(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)

11

Turn over for the next question

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

7 (a) Calculate the resistance of the wire.

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

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).

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.....

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(2 marks)

8

END OF QUESTIONS

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