Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED
General Certificate of Education
January 2010

Physics

Assessment Unit A2 3A

assessing

Module 6: Particle Physics

[A2Y31]

WEDNESDAY 3 FEBRUARY, AFTERNOON

A2Y31

TIME

1 hour.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all five** questions.
Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 50.
Quality of written communication will be assessed in question **5(b)**.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.
You may use an electronic calculator.
Question **5** contributes to the synoptic assessment requirement of the Specification.
You are advised to spend about 40 minutes in answering questions **1–4**, and about 20 minutes in answering question **5**.

For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
Total Marks	

If you need the values of physical constants to answer any questions in this paper, they may be found on the Data and Formulae Sheet.

Examiner Only	
Marks	Remark

Answer **all five** questions

1 The radius r of a nucleus is given by **Equation 1.1**.

$$r = r_0 A^{\frac{1}{3}}$$ **Equation 1.1**

(a) (i) What do the symbols r_0 and A represent in **Equation 1.1**?

r_0 = ______________________________ [1]

A = ______________________________ [1]

(ii) When using **Equation 1.1**, what shape is the nucleus assumed to have?

______________________________ [1]

(b) (i) State the number of protons and neutrons in the nucleus of the lead isotope $^{206}_{82}\text{Pb}$.

Number of protons ___________

Number of neutrons ___________ [2]

(ii) The value of r_0 in **Equation 1.1** is 1.20 fm. Find the radius of a $^{206}_{82}\text{Pb}$ nucleus.

Radius = ___________ m [2]

Examiner Only	
Marks	Remark

2 **(a)** **Equation 2.1** represents a nuclear fusion reaction.

$$^{3}_{1}H + ^{2}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$$ **Equation 2.1**

Use the information below to calculate the energy released in this reaction.
Give your answer in MeV.

Nuclear masses:	$^{4}_{2}He$	4.00150 u
	$^{3}_{1}H$	3.01550 u
	$^{2}_{1}H$	2.01355 u
Neutron mass:	$^{1}_{0}n$	1.00867 u

Energy = _______________ MeV [4]

(b) **(i)** Explain why it is difficult to achieve fusion reactions.

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____

____ [2]

(ii) State **two** advantages that fusion reactors would have over current fission reactors, if they could be made to work successfully.

1. ____

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2. ____

____ [2]

3 **(a)** **(i)** Draw a labelled diagram of a synchrotron.

[2]

(ii) Describe the principle of operation of the synchrotron.

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____ [3]

Examiner Only	
Marks	Remark

(b) The annihilation of an electron and a positron may produce a pair of identical photons.

(i) Use Einstein's mass–energy relation to calculate the frequency of each photon.

Frequency = ____________ Hz [2]

(ii) Explain why, if the Law of Conservation of Momentum is to be obeyed, a pair of photons must be produced.

____

____

____ [2]

Examiner Only	
Marks	Remark

4 Hadrons can be classified as either baryons or mesons.

Examiner Only	
Marks	Remark

(a) **(i)** State the baryon number of each of the following:

Particle	Baryon Number
Baryon	
Antiparticle of a baryon	
Meson	
Antiparticle of a meson	

[2]

(ii) There are six different types of quark.
Name these.

1. ____________________________

2. ____________________________

3. ____________________________

4. ____________________________

5. ____________________________

6. ____________________________ [2]

(b) In terms of quark structure, describe the difference between baryons and mesons.

____

____

____ [2]

Examiner Only	
Marks	Remark

5 Television Tubes

In cathode ray tubes, such as those used in colour television sets, electrons are accelerated through a potential difference of as much as 25 kV. The electrons strike a fluorescent screen. When the electrons strike the screen, some of their energy may be converted to X-rays. Because of the nature of the screen material, the spectrum of the emitted X-rays is continuous only. The X-rays are absorbed by the glass of the screen.

(a) Describe the physical processes occurring for X-rays to be produced in a television tube. In your account, refer to the energy changes which take place, starting with the electrons in the metal cathode and finishing with the production of the X-rays.

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____ [5]

(b) With the aid of an electron energy-level diagram, explain how the electrons striking the fluorescent screen generate a visible emission.

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____ [6]

Quality of written communication [1]

Examiner Only	
Marks	Remark

(c) **(i)** Calculate the gain in kinetic energy of an electron that is accelerated through a potential difference of 25 kV.

Energy gain = ____________ J [1]

(ii) Explain why the X-rays produced in the tube have a certain minimum wavelength.

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____ [2]

(iii) Calculate the minimum wavelength of X-rays produced in the tube.

Wavelength = ____________ m [3]

(d) On the axes of **Fig. 5.1**, sketch the graph of intensity against wavelength for the emitted X-rays.

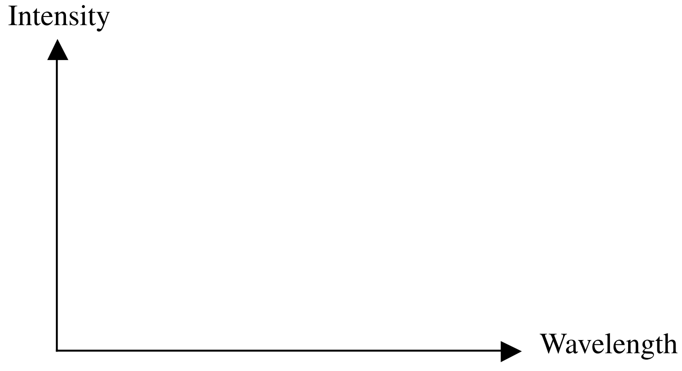

Fig. 5.1 [2]

THIS IS THE END OF THE QUESTION PAPER

GCE Physics (Advanced Subsidiary and Advanced)

Data and Formulae Sheet

Values of constants

speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
permeability of a vacuum	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
permittivity of a vacuum	$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$ $\left(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\ \mathrm{F^{-1}\,m}\right)$
elementary charge	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
unified atomic mass unit	$1\ \mathrm{u} = 1.66 \times 10^{-27}\ \mathrm{kg}$
mass of electron	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
mass of proton	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
molar gas constant	$R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall on the Earth's surface	$g = 9.81\ \mathrm{m\,s^{-2}}$
electron volt	$1\ \mathrm{eV} = 1.60 \times 10^{-19}\ \mathrm{J}$

A2Y31INS

USEFUL FORMULAE

The following equations may be useful in answering some of the questions in the examination:

Mechanics

Momentum-impulse relation	$mv - mu = Ft$ for a constant force
Power	$P = Fv$
Conservation of energy	$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = Fs$ for a constant force

Simple harmonic motion

Displacement	$x = x_0 \cos \omega t$ or $x = x_0 \sin \omega t$
Velocity	$v = \pm\omega\sqrt{x_0{}^2 - x^2}$
Simple pendulum	$T = 2\pi\sqrt{l/g}$
Loaded helical spring	$T = 2\pi\sqrt{m/k}$

Medical physics

Sound intensity level/dB	$= 10\ \lg_{10}(I/I_0)$
Sound intensity difference/dB	$= 10\ \lg_{10}(I_2/I_1)$
Resolving power	$\sin\theta = \lambda/D$

Waves

Two-slit interference	$\lambda = ay/d$
Diffraction grating	$d \sin\theta = n\lambda$

Light

Lens formula	$1/u + 1/v = 1/f$

Stress and Strain

Hooke's law	$F = kx$
Strain energy	$E = <F> x$ ($= \frac{1}{2}Fx = \frac{1}{2}kx^2$ if Hooke's law is obeyed)

Electricity

Potential divider	$V_{out} = R_1V_{in}/(R_1 + R_2)$

Thermal physics

Average kinetic energy of a molecule	$\frac{1}{2}m<c^2> = \frac{3}{2}kT$
Kinetic theory	$pV = \frac{1}{3}Nm<c^2>$

Capacitors

Capacitors in series	$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$
Capacitors in parallel	$C = C_1 + C_2 + C_3$
Time constant	$\tau = RC$

Electromagnetism

Magnetic flux density due to current in

(i) long straight solenoid	$B = \frac{\mu_0 NI}{l}$
(ii) long straight conductor	$B = \frac{\mu_0 I}{2\pi a}$

Alternating currents

A.c. generator	$E = E_0 \sin \omega t$ $= BAN\omega \sin \omega t$

Particles and photons

Radioactive decay	$A = \lambda N$, $A = A_0 e^{-\lambda t}$
Half life	$t_{\frac{1}{2}} = 0.693/\lambda$
Photoelectric effect	$\frac{1}{2}mv^2_{max} = hf - hf_0$
de Broglie equation	$\lambda = h/p$

Particle Physics

Nuclear radius	$r = r_0 A^{\frac{1}{3}}$