Semester Two Examination 2016

Question/Answer Booklet

CORPUS CHRISTI COLLEGE

SEQUERE DOMINUM

PHYSICS

12 ATAR

Student Number: In Figures | | | | | | | | | |

In words _____

_____

Time allowed for this paper

Reading time before commencing work: Ten minutes
Working time for paper: Three hours

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet/Formulae and Data Booklet

To be provided by the candidate

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction tape/fluid, eraser, ruler and highlighters

Special items: non-programmable calculators approved for use in this examination, drawing templates, drawing compass and a protractor

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised material. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Short answers	14	14	50	54	30
Section Two: Problem-solving	7	7	90	90	50
Section Three: Comprehension	16	16	40	36	20
				Total	100

Instructions to candidates

1. The rules for the conduct of the Western Australian Certi cate of Education ATAR course examinations are detailed in the *Year 12 Information Handbook 2016*. Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer booklet.

3. When calculating or estimating answers, show all your working clearly. Your working should be in sufficient detail to allow your answers to be checked readily and for marks to be awarded for reasoning.

   In calculations, give final answers to three significant figures and include appropriate units where applicable.

   In estimates, give final answers to a maximum of two significant figures and include appropriate units where applicable.

4. You must be careful to con ne your answers to the specific questions asked and to follow any instructions that are specific to a particular question.

5. Additional working space pages at the end of this Question/Answer booklet are for planning or continuing an answer. If you use these pages, indicate at the original answer, the page number it is planned/continued on and write the question number being planned/continued on the additional working space page.

6. The Formulae and Data booklet is not to be handed in with your Question/Answer booklet.

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Additional Data

PARTICLE PHYSICS

Rest energy values

class	*name*	*symbol*	*rest energy /MeV*
photon	photon	γ	0
lepton	neutrino	ν_e	0
		ν_μ	0
	electron	$e^{\pm}$	0.510999
	muon	$\mu^{\pm}$	105.659
mesons	π meson	$\pi^{\pm}$	139.576
		π^0	134.972
	K meson	$K^{\pm}$	493.821
		K^0	497.762
baryons	proton	p	938.257
	neutron	n	939.551

Properties of quarks
antiquarks have opposite signs

type	*charge*	*baryon number*	*strangeness*
u	$+\frac{2}{3}e$	$+\frac{1}{3}$	0
d	$-\frac{1}{3}e$	$+\frac{1}{3}$	0
s	$-\frac{1}{3}e$	$+\frac{1}{3}$	-1

Properties of leptons

	lepton number
particles: e^-, ν_e; μ^-, ν_μ	+1
antiparticles: e^+, $\overline{\nu_e}$; μ^+, $\overline{\nu_\mu}$	–1

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Section One. Short responses. **30% (54 Marks)**

Attempt **ALL FOURTEEN** (14) questions in this section. Marks for each question are clearly identified.

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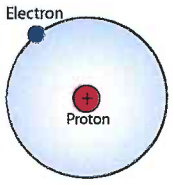
1. The distance between the proton and the electron in the ground state of the hydrogen atom is defined as the Bohr radius. Given that the Bohr radius can be measured as r = 5.29 x 10^{-11} metres, what is the force experienced by the electron as it orbits in the atom? **[4 marks]**



$F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$ $q_1 = q_2 = 1.6 \times 10^{-19}\,C$.

$F = \frac{(9\times10^9)(1.6\times10^{-19})^2}{(5.29\times10^{-11})^2} = \frac{2.31\times10^{-28}}{2.80\times10^{-21}}$ (4)

$\therefore F = 8.25\times10^{-8}\,N$ TOWARDS PROTON.

2. Consider the decay equation shown here showing hadron interactions. Show that charge, baryon number and strangeness are all conserved. **[3 marks]**

$K^0 + p \rightarrow K^+ + n$

$(d\bar{s}) + (uud) \rightarrow (u\bar{s}) + (udd)$

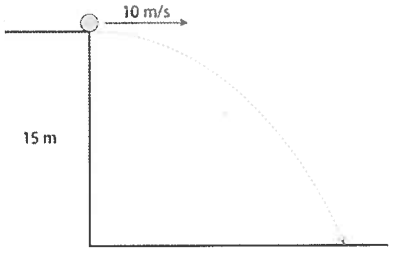
Charge $(-\frac{1}{3}+\frac{1}{3})(+\frac{2}{3}+\frac{2}{3}-\frac{1}{3}) \rightarrow (\frac{2}{3}+\frac{1}{3})(\frac{2}{3}-\frac{1}{3}-\frac{1}{3}) = \frac{1}{3}$.

Baryon number $(\frac{1}{3}\,\frac{1}{3})(\frac{1}{3}\,\frac{1}{3}\,\frac{1}{3}) \rightarrow (\frac{1}{3}\,\frac{1}{3})(\frac{1}{3}\,\frac{1}{3}\,\frac{1}{3}) = \frac{1}{3}$ (3)

Strangeness $(0\,+1)(000) \rightarrow (0\,+1)(000) = +1$.

(7)

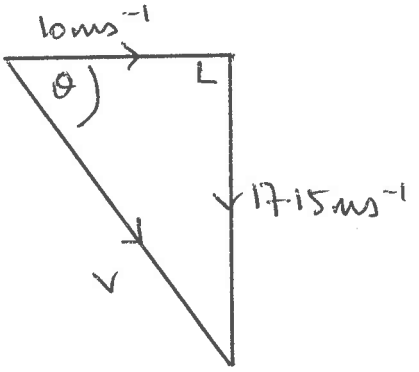
3. A football is kicked horizontally from the edge of a cliff into a river below with a speed of 10 ms^{-1}, as shown here. Calculate the **velocity** with which the ball enters the water. **[5 marks]**



$s = ut + \frac{1}{2}gt^2 \quad (u = 0)$.

$t^2 = \frac{2s}{g} = \frac{30}{9.8} = 3.06$; $t = 1.75$ secs ✓

$v_v = u_v + gt = 0 + (9.8)(1.75) = 17.15\ ms^{-1}$ ✓



$V^2 = (10)^2 + (17.15)^2$

$V = 20.2\ ms^{-1}$ ✓

$\tan\theta = \frac{17.5}{10} = 1.75$

$\therefore \theta = 60.3°$ ✓

$\therefore V = 20.2\ ms^{-1}$, 60.3° BELOW HORZ. ✓

(5)

4. Find the De Broglie wavelength, **in nm**, of an electron of rest mass 0.511 MeV, traveling at a velocity of 3.00×10^{-5} ms^{-1}. **[2 marks]**

$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{6.63 \times 10^{-34}}{(9.11 \times 10^{-31})(3 \times 10^5)}$

$= \frac{6.63 \times 10^{-34}}{2.73 \times 10^{-25}}$ ✓

$= 2.43 \times 10^{-9}\ m$

$= 2.43\ nm.$ ✓

(2)

(7)

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5. A light source of wavelength 45.0 nm strikes a metal whose work function is 4.0 eV.

a) What is the maximum kinetic energy of the emitted photoelectrons? **[3 marks]**

$f = \frac{c}{\lambda} = \frac{3 \times 10^8}{45 \times 10^{-9}} = 6.67 \times 10^{15}$ Hz. ✓ (3)

$E_K = hf - \phi$ (DATA SHEET). ✓

$= (6.63 \times 10^{-34})(6.67 \times 10^{15}) - (4)(1.6 \times 10^{-19})$

$= (4.42 \times 10^{-18}) - (6.4 \times 10^{-19})$

$= 3.78 \times 10^{-18}$ J. ✓

b) The intensity of the light being used is doubled. How will this affect the numbers of photoelectrons emitted, the photocurrent produced and the energy of the kinetic energy photoelectrons emitted? **[3 marks]**

Number of photoelectrons	• INCREASE # OF PHOTOELECTRONS EMITTED. ✓
Photocurrent	• INCREASE THE PHOTOCURRENT PRODUCED. ✓ (3)
Kinetic energy	• NO CHG IN E_K. ✓

(6)

6. In 2012 the Hot-Wheels toy company executed a car stunt where a typical family car successfully performed an inverted loop on a specially designed, 6 storey loop.

At the top of the loop the car is just in contact with the road. **Estimate** the minimum velocity, *v*, required to keep the car in contact with the road at this point. **[4 marks]**

EST HEIGHT : 18 - 21 M ✓

$v^2 = rg$ ✓

(FOR $r = 9m$) . (OR) (FOR $r = 10.5m$)

$v^2 = (9)(9.8)$ ✓ $v^2 = (10.5)(9.8)$ ✓

$= 8.82$ $= 102.9$

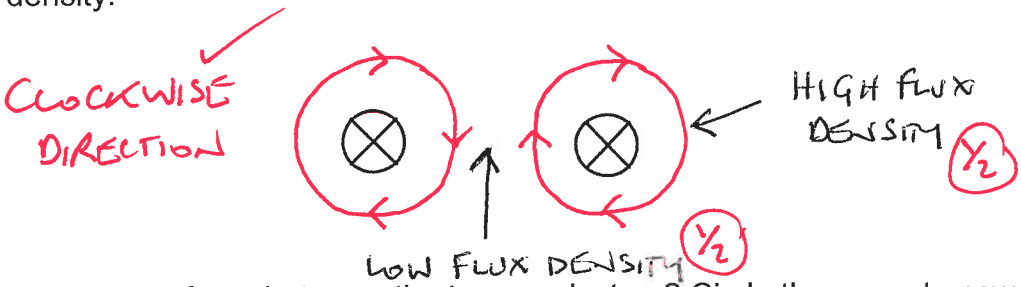
✓ ✓

$\therefore v = 9.39 ms^{-1}$. $\therefore v = 10.14 ms^{-1}$.

4

7. Two current carrying conductors are shown in the diagram below.

b) Sketch the resultant magnetic field and clearly label any areas of high or low flux density. **[2 marks]**



2

c) Is there any force between the two conductors? Circle the correct answer below. **[1 mark]**

There is a force of repulsion | *There is no force* | *There is a force of attraction* ✓

1

7

8. The large hadron collider (LHC) is a particle collider located on the Swiss/French border. A large magnetic field, created using superconducting solenoids, keeps hadrons circling around a 27 kilometre circumference at speeds approaching the speed of light. Calculate the magnetic field strength required to keep a proton circulating inside the solenoids- traveling at 5×10^5 ms^{-1}. **[4 marks]**

$$r = \frac{C}{2\pi} = \frac{27,000}{6.28} = 4.3 \times 10^3 \, m$$

$$B = \frac{mv}{qr} = \frac{(1.67 \times 10^{-27})(5 \times 10^5)}{(1.6 \times 10^{-19})(4.3 \times 10^3)}$$

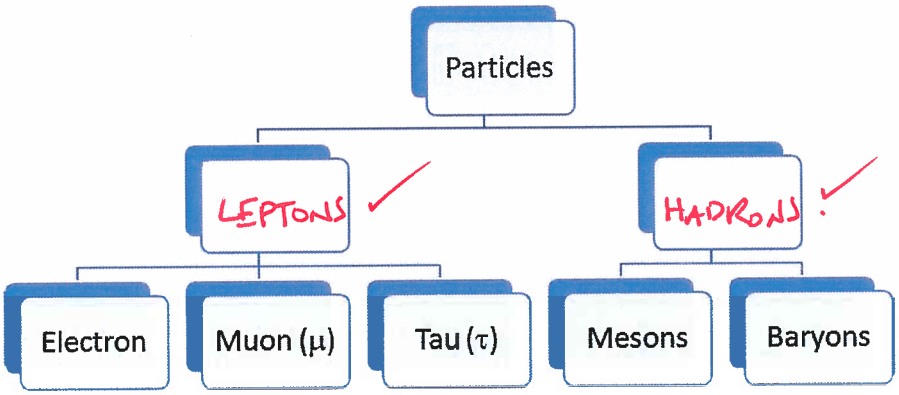
$$= \frac{8.35 \times 10^{-22}}{6.88 \times 10^{-16}}$$

$$\therefore B = 1.21 \, \mu T$$

4

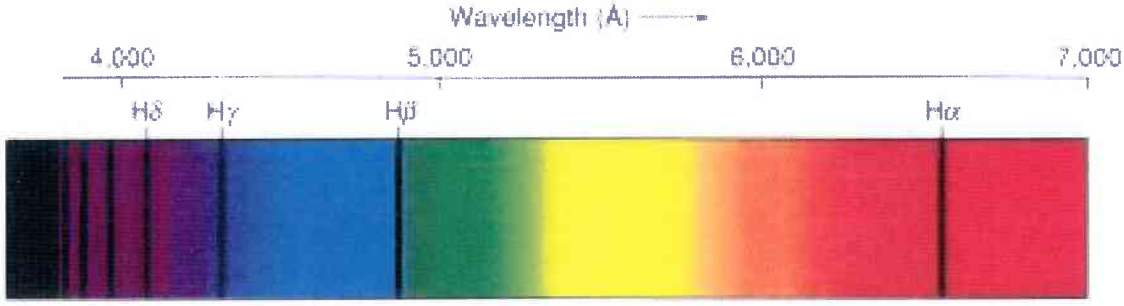
9. Consider the classification table (below) for elementary particles. Write the missing headings in the spaces provided. **[2 marks]**

2



6

10. The visible part of the solar spectrum shows numerous thin dark lines appearing on the continuous spectrum as shown here:

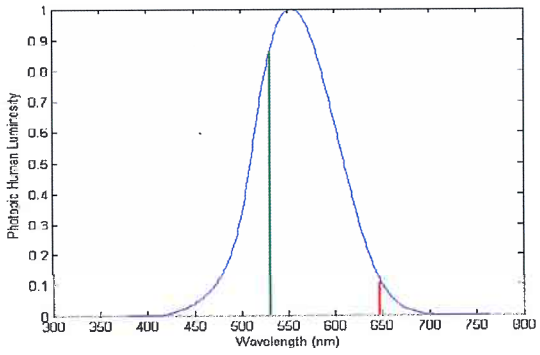


Explain what these lines are and how they are produced. **[3 marks]**

- FRAUNHOFFER LINES ✓
- ABSORPTION OF PHOTONS ✓ CORRESPONDING TO TRANSITIONS IN ELEMENTS IN THE UPPER ATMOSPHERE OF SUN OR EARTH. ✓

3

11. The diagram shows the typical human visual response for a green laser pointer (GLP). The wavelength of the GLP line is at 532nm and the 650nm wavelength of a typical red laser pointer is also shown. Given that the GLP operates with a power of 110W, calculate the number of photons emitted in 10 seconds. **[4 marks]**



$GLP(\lambda) = 532\,nm$.

$$E = \frac{hc}{\lambda} = \frac{(6.63\times10^{-34})(3\times10^{8})}{(532\times10^{-9})} \checkmark$$

$$= 3.74\times10^{-19}\,J. \checkmark$$

4

$$\#\ PHOTONS = \frac{110}{(3.74\times10^{-19})} = 2.94\times10^{20} \checkmark \text{ PER SEC.}$$

$\therefore$ TOT # PHOTONS $= 2.94\times10^{21}$ ✓.

7

12. A pion is a subatomic particle consisting of a quark and an antiquark. What is the speed of a pion if its average lifetime is measured to be 4.10×10^{-8} seconds? At rest, its average lifetime is 2.60×10^{-8} seconds. **[5 marks]**

$$t = \frac{t_0}{\sqrt{1 - v^2/c^2}} \quad \text{[FROM DATA SHEET]} \qquad t = 4.10 \times 10^{-8}\ s. \quad \checkmark$$

$$t_0 = 2.60 \times 10^{-8}\ s.$$

$$\therefore \quad (4.10 \times 10^{-8}) = \frac{(2.60 \times 10^{-8})}{\sqrt{1 - v^2/c^2}} \quad \checkmark$$

$$(4.10 \times 10^{-8})\left(\sqrt{1 - v^2/c^2}\right) = (2.60 \times 10^{-8}).$$

$$(4.10 \times 10^{-8})^2 (1 - v^2/c^2) = (2.60 \times 10^{-8})^2 \quad \checkmark$$

$$(1.681 \times 10^{-15}) - (4.10 \times 10^{-8})\left(\frac{v^2}{c^2}\right) = 6.76 \times 10^{-16}.$$

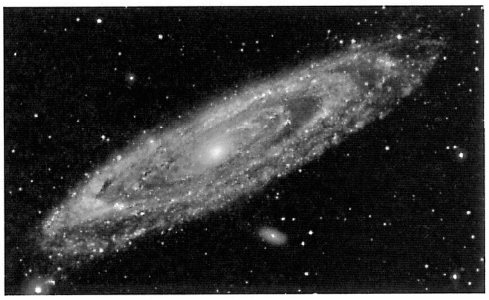
$$-(1.868 \times 10^{-32})\, v^2 = (6.76 \times 10^{-16}) - (1.681 \times 10^{-15})$$

$$\therefore \quad v^2 = \frac{(1.005 \times 10^{-15})}{(1.868 \times 10^{-32})} = 5.38 \times 10^{16} \quad \checkmark$$

$$\therefore \quad \underline{v = 2.3 \times 10^{8}\ ms^{-1} \quad (0.77c)} \quad \checkmark$$

(5)

13. The 355nm spectral line of an element is found to be 366nm in the light coming from the galaxy shown here.



a) Is this a red shift, or a blue shift? **[1 mark]**

REDSHIFT. ✓ (1)

b) Is the galaxy receding, or moving towards us? **[1 mark]** (1)

RECEDING. ✓

c) Calculate the velocity of the galaxy. **[2 marks]**

$$z = \frac{\Delta\lambda}{\lambda} = \frac{366 - 355}{355} = \frac{11}{355}$$

$$= 0.031. \checkmark$$

$$z = \frac{v}{c} \quad \therefore \quad v = zc = (0.031)(3\times10^8)$$

$$= 9.30 \times 10^6 \text{ ms}^{-1} \checkmark$$

(2)

d) Use a Hubble Constant of $H_o = 71 \text{kms}^{-1}\text{Mpc}^{-1}$ to determine the distance to the galaxy in lightyears. **[2 marks]**

$$v = 9.30\times10^6 \text{ ms}^{-1} = 9300 \text{ kms}^{-1}$$

(2)

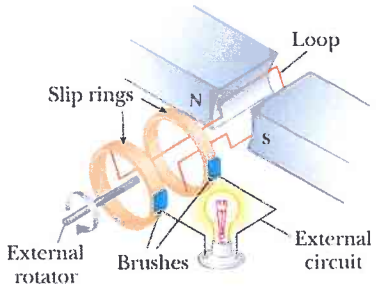
$$v = H_o d \quad \therefore \quad d = \frac{v}{H_o} = \frac{9300}{71} = \checkmark 131 \text{ Mpc.}$$

$$\therefore \quad d = (131)(3.26\times10^6)$$

$$= 4.27 \times 10^8 \checkmark \text{Lyrs.}$$

(6)

14. An armature of an AC generator rotates in a field of strength 0.20T. The area of the armature is 5.0×10^{-2} m^2. As the coil rotates from the vertical to the horizontal in 20ms, the maximum voltage required is 150 volts. How many loops should the coil contain to achieve this? **[3 marks]**



$$EMF = -n\frac{d\Phi}{dt}.$$ ✓

$$\therefore \quad 150 = n\frac{BA}{t} = n\frac{(0.2)(5\times10^{-2})}{(20\times10^{-3})}$$ (3)

$$\therefore \quad 150 = n(0.5)$$ ✓

$$\therefore \quad n = 300 \text{ TURNS}.$$ ✓

(3)