Trial WACE Examination: Paper 1

Question/Answer Booklet

PHYSICS
Stage 3

Please place your student identification label in this box

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 Constants Sheet

To be provided by the candidate
Standard items: pens, pencils, eraser, correction fluid/tape, ruler, highlighters

Special items: a blue or black pen, non-programmable calculators satisfying the conditions set by the School Curriculum and Standards Authority for this course, drawing templates, drawing compass and 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 notes or other items of a non-personal nature in the examination room. 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 response	13	13	50	54	30
Section Two: Problem-solving	8	8	90	90	50
Section Three: Comprehension	2	2	40	36	20
			Total	**180**	**100**

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2012.* Sitting this examination implies that you agree to abide by these rules.

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

3. Working and reasoning should be shown clearly when calculating or estimating answers.

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

5. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
   - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
   - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Section One: Short response **30% (54 Marks)**

This section has **13** questions. Answer **all** questions. Write your answers in the spaces provided. Use only a blue or black pen. Diagrams may be completed in pencil.

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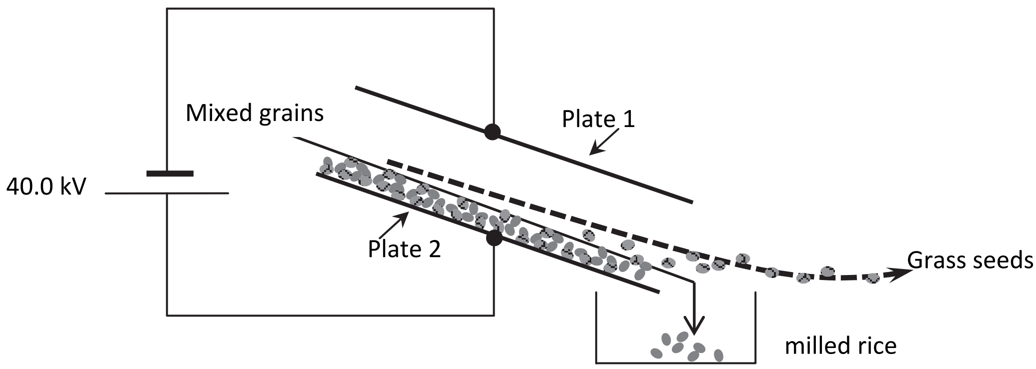
Suggested working time: 50 minutes.

Question 1 **(5 marks)**

Unwanted grass seeds can be separated from milled rice via the use of electric fields. The mixed grains are passed through an intense electric field. This field is produced by a 40.0 kV potential difference across two iron plates, placed 10.0 cm apart. The milled rice husks slide down Plate 2 into a collection bin, whereas the unwanted grass seeds follow a curved path and are separated as shown below.



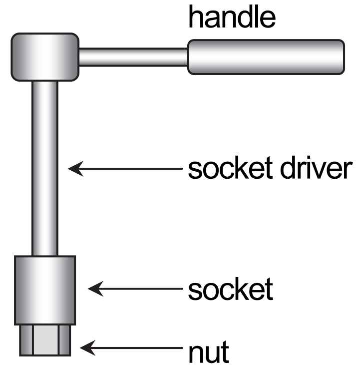
(a) What type of charge must exist on the grass seeds? Explain. (1 mark)

(b) A particular grass seed has become charged due to the loss of 3.55×10^5 electrons. What force is exerted on this grass seed by the electric field? (4 marks)

Question 2 **(4 marks)**

A mechanic uses a spanner shown in the diagram. She finds the nut is very tight and decides she needs more torque. Explain the effect on the torque she can produce if she makes the following changes.

(a) Increasing the length of the socket driver. (2 marks)



(b) Increasing the length of the handle. (2 marks)

Question 3 **(3 marks)**

Quarks are the fundamental particles of which hadrons are composed. Two types of quark are the **up quark** (charge +2/3) and **down quark** (charge -1/3). All quarks have a baryon number of 1/3. Anti-quarks have the opposite charge of their corresponding quark as well as an opposite baryon number.

Rho-minus mesons are sub atomic particles that consist of an anti-up quark and a down quark. Determine the charge and baryon number for a rho-minus meson. (3 marks)

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Section Two: Problem-solving 50% (90 Marks)

This section has **8** questions. Answer **all** questions. Write your answers in the spaces provided. Use only a blue or black pen. Diagrams may be completed in pencil.

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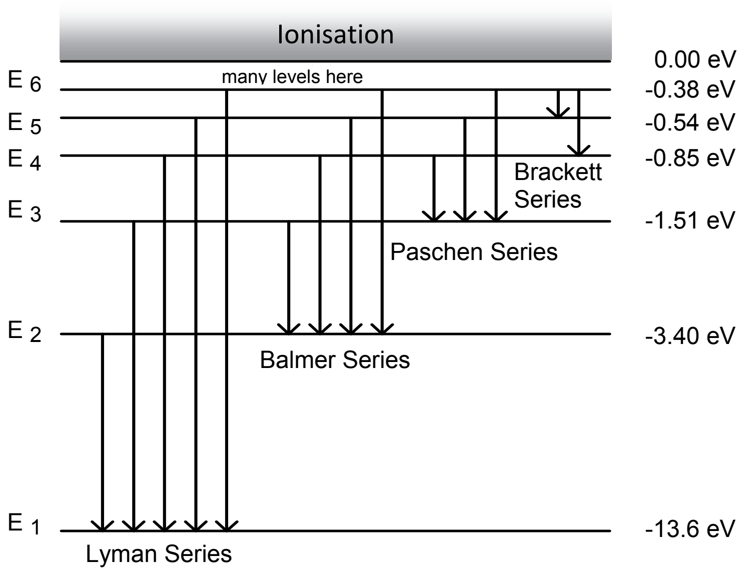
Suggested working time: 90 minutes.

Question 14 (11 marks)

The diagram below shows the energy levels for hydrogen based on the Bohr model for the hydrogen atom.



(a) Will the electron transitions drawn on this diagram produce an absorption or emission spectrum? Explain your answer. (2 marks)

(b) A line in the emission spectrum of hydrogen has a wavelength of 486 nm. To which series does it belong? Show working. (2 marks)

(c) To what part of the electromagnetic spectrum does the Balmer series belong? Justify your answer. (4 marks)

(d) What is the ionization energy for hydrogen atoms? Explain your answer. (3 marks)

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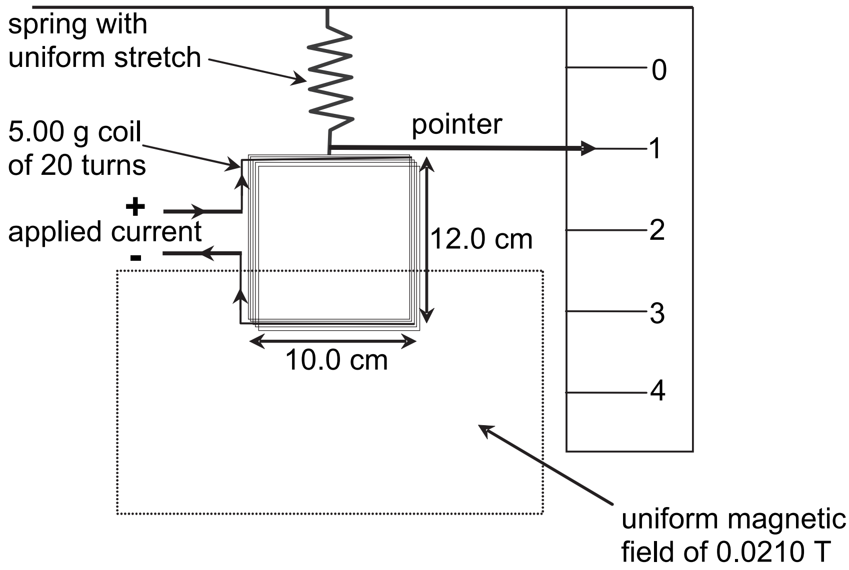
Question 15 **(13 marks)**

A student made a simple experimental ammeter using a 5.00 g rectangular coil consisting of 20.0 turns. The coil was attached to a uniformly stretchy spring and hung vertically with the lower half of the spring surrounded by a uniform magnetic field.



(a) Draw in the space marked by the dotted lines in the diagram, the orientation of the magnetic field that would be required to cause the coil to move downwards. (2 marks)

(b) With the ammeter positioned horizontally and no current flowing in the coil, the pointer reads 0.00 units. When positioned vertically with no current flowing in the coil, the pointer reads 1.00 units. What causes the coil to register on the scale even though there is no current flowing? (2 marks)

(c) What would be the reading on the scale if there was a current of 0.300 A flowing through the coil in the direction shown in the diagram? (4 marks)

(d) If the meter was incorrectly connected and the current was made to flow in the opposite direction to that shown in the diagram, what size current would cause the pointer to register zero on the scale? (3 marks)

(e) Would the ammeter operate if the entire coil was placed into the magnetic field? Explain your answer. (2 marks)

Section Three: Comprehension 20% (36 Marks)

This section has **two** questions. Answer **both** questions. Write your answers in the spaces provided. Use only a blue or black pen. Diagrams may be completed in pencil.

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Suggested working time: 40 minutes.

Question 23 (20 marks)

Mass Spectrometry In Drug Analysis

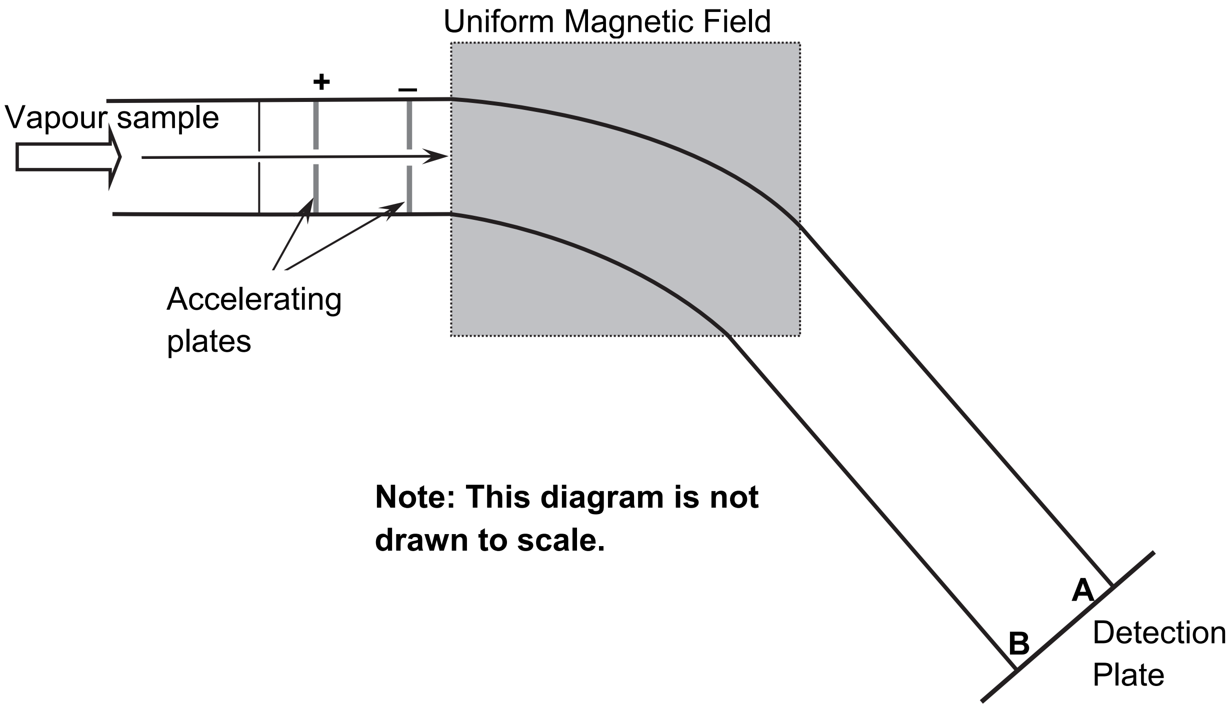
The use of illicit drugs in sport has become a huge issue for sporting organisations. From Olympic Games competitions to large local sports events, sports administrators are constantly working with the medical authorities to develop testing regimes that will both identify “drug cheats” and discourage “clean” athletes from using performance enhancing substances.

One analytical method used to detect chemicals in urine/blood samples is mass spectrometry (MS). The samples taken from athletes are broken down into very small parts within a vapour. This vapour is then ionized into charged molecular fragments (ions). These are accelerated to high speeds by a 10 kV electric field.

After accelerating, the ions move through a long evacuated tube surrounded by a uniform magnetic field (see diagram). **The fast moving ions are then deflected by the magnetic field according to their mass to charge ratio** towards a detector plate where they are recorded. The images created on the deflector plate are distinct for various charged molecular fragments and as such, they leave a “molecular fingerprint” on the detector plates.

Over many years of testing, authorities have compiled many fingerprints of illicit drugs. If a particular sample shows the same image on a detection plate as known drugs, the athlete is said to have returned a “positive result”. The testers then repeat the process for a second “B” sample taken from the athlete to confirm the first test.
Although very accurate, the mass spectrometer test cannot uncover all drugs in the system. Authorities are constantly developing new tests but unfortunately, drug developers are also working hard on new drugs and evasive “masking” chemicals.

The diagram below shows the basic components of a mass spectrometer.



(a) The vapour is bombarded by electrons prior to entering the acceleration zone to produce positive ions. Why are negative ions unsuitable for use in this spectrometer? (2 marks)

(b) On the diagram, show the direction of the uniform magnetic field that will cause the particles to deviate around the curved part of the tube. (2 marks)

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(c) The magnetic force creates the necessary centripetal force that allows the ions to follow a curved deflection path within the uniform magnetic field. Derive an expression that represents the mass to charge ratio of an ion travelling at constant speed in the magnetic field. (5 marks)

(d) Justify and elaborate on the statement from the third paragraph, "*The fast moving ions are then deflected by the magnetic field according to their mass to charge ratio*". (4 marks)

(e) A sodium ion Na^+ has a relative mass of 23 and a charge of 1+ while a potassium ion K^+, has a relative mass of 39 and a charge of 1+. In a particular analysis both of these ions are produced in the MS unit and are accelerated into the uniform magnetic field at approximately the same speed and at right angles to the field. One of these ions strikes the detection plate at A and the other at B (see the diagram). Which of the ions strikes at A? Justify your answer. (4 marks)

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Physics Stage 3 Trial WACE Examination 1: Solutions

These written solutions are extensive and detailed. This is for the students' benefit and does not necessarily indicate what is required for full marks. The extent of the answer should be guided by the directions in the examination paper, the question itself, the mark allocation and the space provided for the response.

Section One: Short response

Question 1

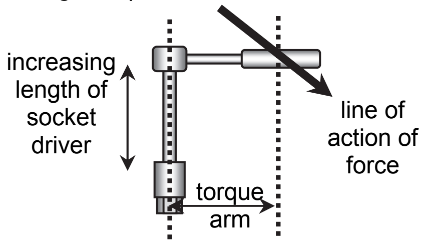
(a) Plate 1 is attached to the negative terminal of the high voltage DC power supply. The grass seeds are attracted upwards towards Plate 1, therefore they have a positive charge as opposite charges attract.

(b) $E = \frac{V}{d} = \frac{4.00x10^4}{0.100} = 4.00x10^5\ V\ m^{-1}$

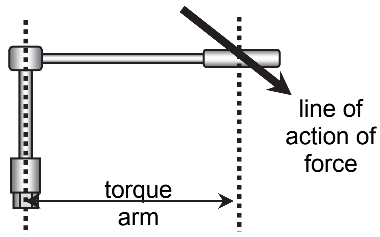
The charge on the grass seed = 3.55 x 10^5 x 1.60 x 10^{-19} = 5.68 x 10^{-14} C

$F = Eq = 4.00x10^5 x5.68x10^{-14} = 2.27x10^{-8}$ *N towards the negative plate*

Question 2



(a) The magnitude of the torque depends upon the size of the force and the length of the torque arm, τ = F r. The force is unchanged and the length of the torque arm (ie the perpendicular distance from the line of action of the force to the pivot point) is also unchanged, thus torque is unchanged.



(b) Torque increases since increasing the length of the handle increases the length of the torque arm (ie the perpendicular distance from the line of action of the force to the pivot point).

Question 3

The charge of an **anti**-up quark is –2/3 (ie opposite to that of an up quark) and a down quark has a charge of -1/3 thus the Rho-minus mesons have a charge of -1. The baryon number of an anti-up quark is -1/3 (ie opposite to that of an up quark) while a down quark has a baryon number of 1/3 so the Rho-minus mesons have a baryon number of 0.

Section Two: Problem-solving

Question 14

(a) These transitions produce an emission spectrum. It shows electrons that have been excited to higher energy levels returning to lower energy levels. As electrons do this their excess energy is emitted as an emission spectrum.

(b) A wavelength of 486 nm = 486 x 10^{-9} m. This corresponds to the visible part of the spectrum. (See data sheet.)

(c) $E_3 - E_2 = (3.40 - 1.51)x1.60x10^{-19} = 3.02x10^{-19}\ J$

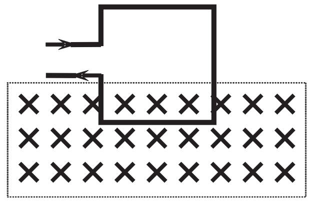
$f = \frac{E}{h} = \frac{3.02x10^{-19}}{6.63x10^{-34}} = 4.56x10^{14}\ Hz$

$E_6 - E_2 = (3.40 - 0.38)x1.60x10^{-19} = 4.83x10^{-19}\ J$

$f = \frac{E}{h} = \frac{4.83x10^{-19}}{6.63x10^{-34}} = 7.29x10^{14}\ Hz$

The range of frequencies for the Balmer series is between 4.56 x 10^{14} Hz and 7.29 x 10^{14} Hz. This corresponds to the visible part of the electromagnetic spectrum.

Question 15



(a) B is into the page. See diagram at right.

(b) The weight of the coil (*$5.00 \times 10^{-3} \times 9.8$ N*) causes the spring to stretch giving the 1.00 scale reading.

(c) With no current flowing the weight of the coil alone produces a 1.00 unit reading:

$i.e.\quad a\ force\ \ of\ \ mg = 5.00x10^{-3}x9.80 = 4.90x10^{-2}\ N = 1.00\ units$

with a current flowing in the coil: $F = nBI\ell = 20x0.0210x0.300x0.100 = 1.26x10^{-2}\ N$

so the number of units is: $\frac{0.0126}{0.0490} = 0.257\ units \quad \therefore\ scale\ reading = 0.257 + 1.00 = 1.26\ units$

(d) The upward force required to balance the weight of the spring is 0.0490 N up.

thus $\quad I = \frac{F}{nB\ell} = \frac{0.0490}{20x0.0210x0.100} = 1.17\ A$

(e) The pointer would not move as the force on the top half of the coil would be upwards with an equal but downwards force on the lower part of the coil. The net force on the coil would be zero and it won't move.

Section Three: Comprehension

Question 23

(a) The negative ions will not be accelerated towards the negative plate and into the magnetic field. Instead these ions would be attracted by the positive plate and would not pass through it. If any did move into the magnetic field region they would be deflected away from the detection plate.

(b) B is out of the page.

(c) For an ion travelling in the uniform magnetic field the centripetal force is provided by the electrical force:

$$F_c = F_m \quad ie \quad \frac{mv^2}{r} = qvB \quad thus \quad \frac{m}{q} = \frac{rB}{v}$$

(d) The force exerted on the fast moving ions is due to their motion perpendicular to a uniform magnetic field. This force causes the ions to move in a circular path. As shown in question part (c) $\frac{m}{q} = \frac{rB}{v}$. The ratio $\frac{m}{q}$ is the mass to charge ratio for the ion. As can be seen, for a given value of ion velocity (v) the radius (r) increases as the mass to charge ratio, ($\frac{m}{q}$) increases, ie radius (r) increases as mass (m) increases and decreases as charge (q) increases.

(e) The comparative mass to charge ratios for these ions is: Na^+, 23/1 (ie 23) and K^+, 39/1 (ie 39). Using the relationship from (c) at the same speed (v) in the same magnetic field (B), the Na^+ has the smallest mass to charge ratio ($\frac{m}{q}$) so it has the smallest radius (r) and so strikes the detector plate at B.

(f) $E = 3.05x1.6x10^{-19} = 4.88x10^{-19}\ J$

$also\ E_k = \frac{1}{2}mV^2 \quad thus \quad V^2 = \frac{2E_k}{m} = \frac{2x4.88x10^{-19}}{1.67x10^{-27}} = 5.84x10^8\ m^2s^{-2}\ \ ie\ V = 2.42x10^4\ ms^{-1}$