Government of **Western Australia**
Curriculum Council

WACE

43628

PHYSICS

Stage 3

WACE Examination 2010

Marking Key

Marking keys are an explicit statement about what the examiner expects of candidates when they respond to a question. They are essential to fair assessment because their proper construction underpins reliability and validity.

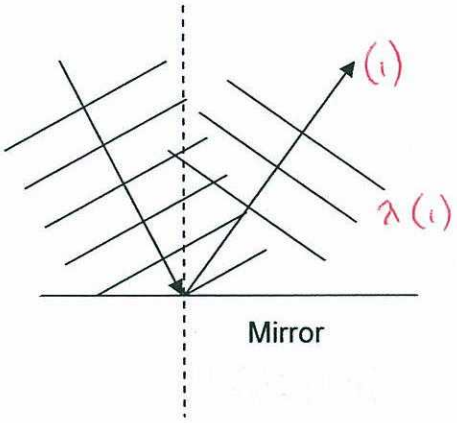
When examiners design an examination, they develop provisional marking keys that can be reviewed at markers' meetings and modified as necessary in the light of candidate responses.

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

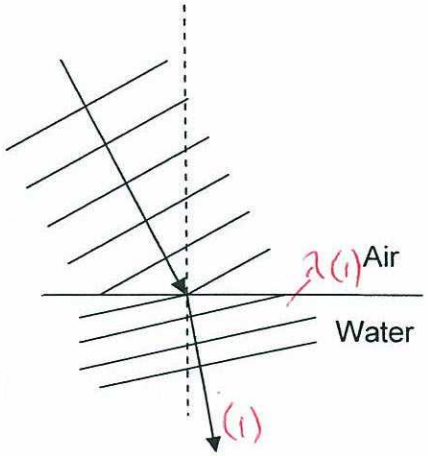
Question 1 **(4 marks)**

The diagrams below show wavefronts of light incident on two different surfaces. In diagram (a) the wavefronts are incident on a mirror. In diagram (b) the wavefronts are incident on an air-water interface. In both diagrams a dotted line at 90° to the surface has been drawn. Complete the diagrams showing how the wavefronts behave as they interact with the surface. In both cases you should draw four wavefronts. The direction of travel of the wavefronts is included.

(a)

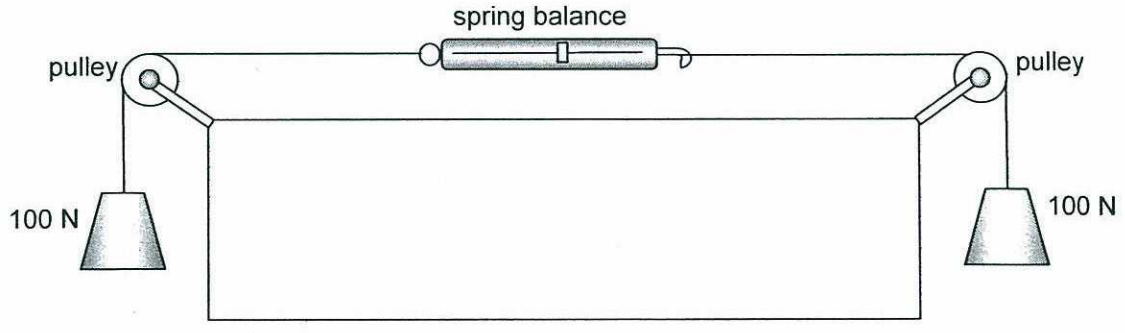


(b)



Description	Marks
Reflection reflected wavelength same as incident wavelength (1) angle of reflection (roughly) equal to angle of incidence. (1)	1-2
Refraction, direction of wavefront in correct direction (1) wavelength of refracted wavefront less than the incident wavelength. (1)	1
Direction of **wavefronts** must be shown.	1
	Total 4

Question 2 **(3 marks)**



(a) What is the reading on the spring balance? Circle your answer. (1 mark)

Description	Marks
100 N	1
	Total 1

(b) Choose **one** of the answers that you **rejected** and give your reason. (2 marks)

Description	Marks
If zero then the weight would stay in position without any string being required, if 200 N then the block would accelerate (only one required). Reason must explain the selected choice. (2)	1-2
	Total 2

Zero - no tension in string ✓

Question 3 **(3 marks)**

Use Table 1 to determine the values of the charge and strangeness quantum numbers for the particles in Table 2.

Table 2: Properties of some sub-atomic particles

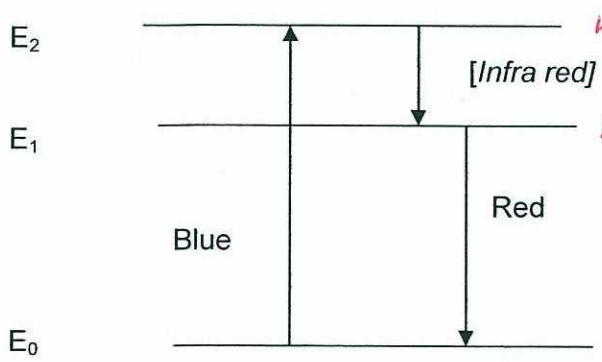
Particle	Quark composition	Charge, Q	Strangeness, S
Lambda	up, down, strange	**0**	**-1**
Xi	up, strange, strange	**0**	**-2**
Sigma minus	down , down strange	**-1**	**-1**

(1) Both correct.
(1)
(1)

Description	Marks
Charge column entered correctly.	1
Strangeness column entered correctly.	1-2
	Total 3

Question 4 **(5 marks)**

(a) Draw an energy level diagram showing possible electron transitions taking place in the atoms of the fluorescent protein that could give rise to the observed phenomena. (2 marks)



Description	Marks
Lines drawn and spacing appropriate.	1
Arrows appropriate, emission/absorption.	1
	Total 2

(b) Calculate the energy in joules of a photon of blue light and a photon of red light. Blue light has wavelength of 400 nm and red light 700 nm. Use the energy values to label the transitions in the diagram you drew in part (a). (3 marks)

Description	Marks
Use $E = hc/\lambda$ then wavelengths are red = 7×10^{-7} m and blue = 4×10^{-7} m	1
E (red) = 3×2 rt $\times 10^{-19}$ J or 1.8 eV 2.84×10^{-19} J	1
E (blue) = 5×10^{-19} J or 3.1 eV and label on diagram. 4.97×10^{-19} J	1
	Total 3

Correct diagram label - 1 mark.

Question 5 **(5 marks)**

(a) The plates are separated by 0.025 m and the voltage difference between the plates is 1000 V. Calculate the electric field intensity. (2 marks)

Description	Marks
$E = \frac{1000}{0.025} = 40\,000$ V .m^{-1} (1) (1)	1–2
	Total 2

(b) If the force required to cause a black spot on the paper (i.e. so the drop goes onto the page, not into the gutter) is 10^{-8} N, calculate the charge on each drop. (3 marks)

Description	Marks
$F = Q.E$ $10^{-8} = Q \times 40\,000$ (1) $Q = 2.5 \times 10^{-13}$ C (1)	1–2
Negatively charged	1
	Total 3

Question 6 **(4 marks)**

Until about 50 years ago, astronomers used visible light to observe the Universe. They now use a variety of types of electromagnetic radiation to make their observations. With reference to the properties of electromagnetic radiation, explain the potential advantages to an astronomer of studying the Universe using:

(a) radio waves

(b) X-rays

Description	Marks
• Radio waves have long wavelengths (~1 m) compared to visible; (1) • tend to pass through gas and dust that obscure visible sources; (1) • typical radio sources include our galactic core; pulsars; neutron stars; quasars.	1-2
• X rays have short wavelengths (~ 1 nm) compared to visible; (1) • usually associated with high energy sources (1) • such as: material falling into black holes; supernovae; material falling from one star to another more massive one; active galactic centres.	1-2
	Total 4

Question 7 **(4 marks)**

Estimate the torque, exerted by the wind blowing on the sails, that would just begin to tip the *BMW Oracle* as shown. The sail has a mass of 3.5×10^3 kg, the central hull 1.0×10^3 kg and each outrigger 0.5×10^3 kg.

Description	Marks
Torque = Force (weight]) × perpendicular distance.	1
Understand max torque is when assume angle of tilt is zero ie weight and wind direction perpendicular.	1
Take moments about left hand hull, Torque = $(1.0 + 3.5) \times 9.8 \times 10^3 \times 14 + 0.5 \times 10^3 \times 9.8 \times 28$ (1) $= 6.3 \times 10^5 + 1.35 \times 10^5$ $= 8 \times 10^5$ Nm (allow $g = 10$ m s^{-2}) (1)	1-2
	Total 4

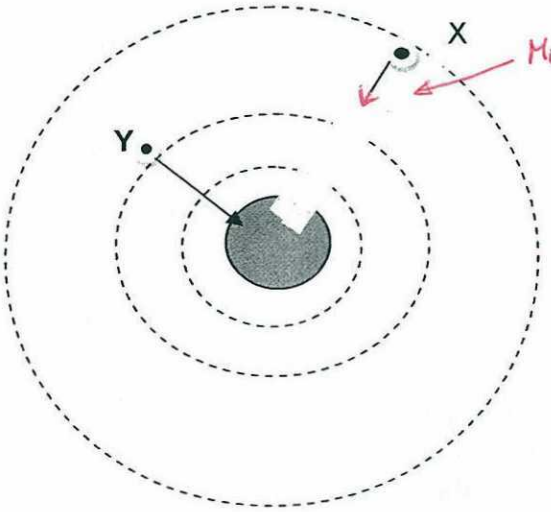
Question 8 **(5 marks)**

This question is about the gravitational field around an asteroid. The asteroid is spherical and of uniform density. The diagram below shows lines of equal gravitational field strength as dashed lines. There is a constant difference in the value of the field strength between each line.

(a) Describe what the diagram shows about the gravitational field strength as the distance from the asteroid increases. (1 mark)

Description	Marks
the field strength is inversely proportional to the distance apart $g \propto \frac{1}{r^2}$ Decreasing with increasing distance (1)	1
	Total 1

(b) Draw the gravitational field at points X and Y. (2 marks)



Description	Marks
arrows point to centre of asteroid (1) arrow length X < length Y (1)	1-2
	Total 2

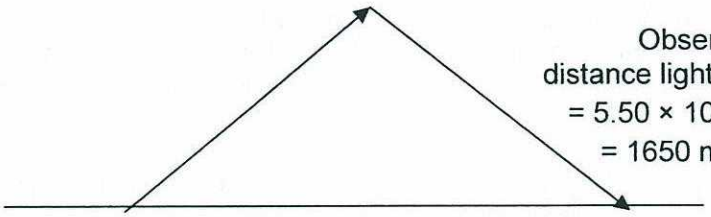
(c) The asteroid has a radius of 1.25×10^5 m. If the gravitational field strength on its surface is 0.194 N kg^{-1}, calculate the mass of the asteroid. (2 marks)

Description	Marks
$g=G\frac{m}{r^2}$ $\therefore m=\frac{gr^2}{G}$ $m=\frac{0.194\times(1.25\times10^5)^2}{6.67\times10^{-11}}$ (1) $m=4.54\times10^{19}$ kg (1)	1–2
	Total 2

Question 9 **(4 marks)**

Explain why Observer B measures a longer time than Observer A, using a labelled diagram to aid your explanation. Calculations are not required.

Obs A
$3 \times 10^8 = \frac{2 \times 500}{\text{Time}}$
Time = 3.30×10^{-6} s



Observer B
distance light beam travels
$= 5.50 \times 10^{-6} \times 3 \times 10^8$
= 1650 m (further)
(2)

Description	Marks
Observer A and Observer B are not in the same reference frame Observer A moves with the pulse of light and mirrors, Observer B watches them move past him. For both observers the speed of light remains constant. (1)	1
Light path drawn correctly (2)	2
Observer B will watch the light trace the path shown on the diagram above. He observes the light trace the path of a right angled triangle, which is longer distance so he measures a longer time. (1)	1
	Total 4

Question 10 **(4 marks)**

The magnet falling through the plastic tube travelled much faster than the magnet falling through the aluminium tube.

Explain, clearly indicating the physics principles involved. (4 marks)

Description	Marks
Current induced in the aluminium tube due to changing magnetic flux.	1
Motion produces a magnetic field in the aluminium tube **only**.	1
This field acts to OPPOSE the motion of the magnet falling so the magnet travels more slowly.	1-2
	Total 4

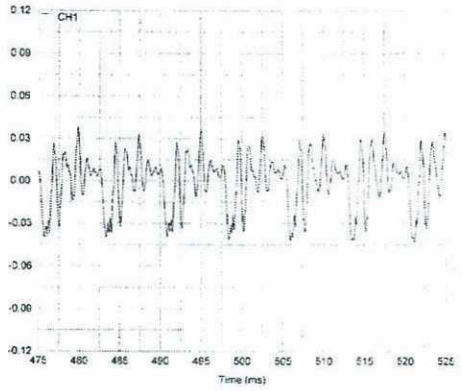
Question 11 **(5 marks)**

Find the value of the shunt resistor R.

Description	Marks
Current through shunt = 1.50- 0.005 = 1.495 A	1
Demonstrate understand voltage across shunt and meter are identical.	1
V =IR	1
Therefore 1.495 × R = 0.005 × 5	1
R = 1.67 × 10^{-2} Ω	1
	Total 5

Question 12 **(4 marks)**

The graph below shows the trace of a sound displayed on a cathode ray oscilloscope (CRO). The horizontal (*x*) axis is time and the vertical (*y*) axis is amplitude.



(a) Is the above trace noise or a musical note? Explain your reasoning. (2 marks)

Description	Marks
Musical note (1)	1
There is a pattern in the waveform. (1)	1
	Total 2

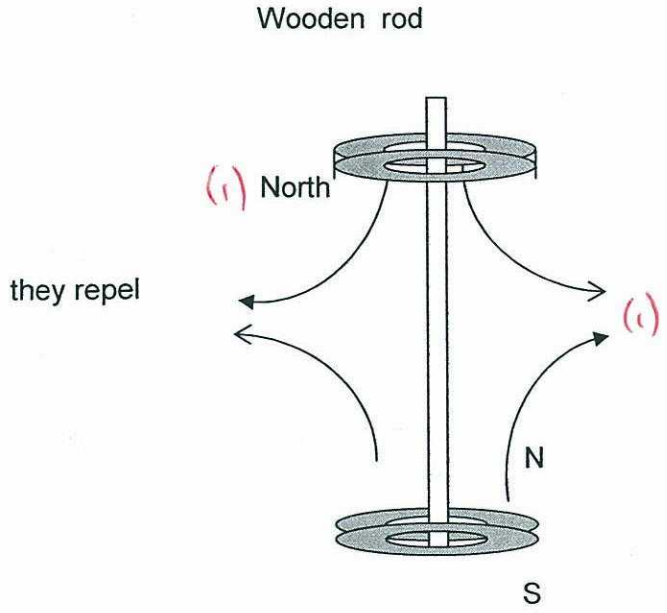
(b) Describe the effect on the trace if the sound wave was **louder.** (2 marks)

(i) Effect on the shape of the trace:
(ii) Effect on the amplitude of the trace:

Description	Marks
The trace is identical in shape (1) but larger amplitude. (1)	1 1
	Total 2

Question 13 **(4 marks)**

Below is a diagram of a wooden rod on which are two powerful magnets, one of which is 'floating' above the other.



(a) Indicate the North pole of the floating magnet and draw the magnetic field lines between the magnets. (2 marks)

Description	Marks
North pole clearly marked on top magnet. Lines between poles show field lines repelling and so diverge (could have labels and arrows reversed).	1
Arrows on field lines N → S.	1
	Total 2

(b) Explain why the top magnet 'floats'. (2 marks)

Description	Marks
Two equal sized and opposite forces;	1
forces are magnetic repulsion and gravitational attraction.	1
	Total 2

End of Section One

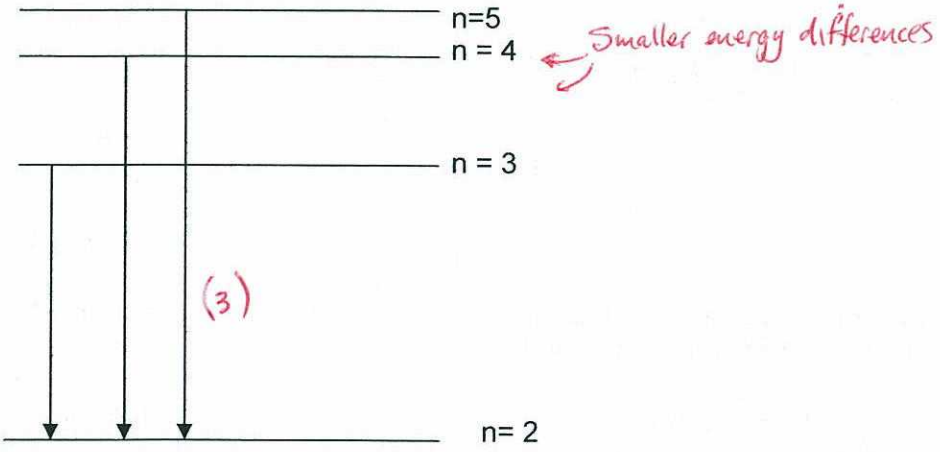
Section Two: Extended answer **50% (90 Marks)**

Question 14 **(11 marks)**

There are three lines in the emission spectrum of hydrogen that occur in the visible part of the electromagnetic spectrum. These involve transitions to the n = 2 energy level.

The three lines have the wavelengths; 6.60×10^{-7} m, 4.90×10^{-7} m and 4.40×10^{-7} m.

(a) Draw an energy level diagram to illustrate the transitions from the n = 3, 4, 5 levels to the n = 2 level. Label the levels n = 2, 3, 4, 5. (4 marks)



Description	Marks
One mark for each line with correct arrow	1–3
While it is not essential that the energy level diagram be drawn to scale there should be some indication that candidates appreciate that as n increases the energy difference between levels gets smaller. Allow if this is obvious	1
	Total 4

(b) Which value of wavelength from the list above corresponds to the transition with the largest energy difference? Explain your answer. (2 marks)

Description	Marks
From $E=\frac{hc}{\lambda}$, largest E corresponds to lowest λ, (1)	1
So $\lambda = 4.40 \times 10^{-7}$ m. (1)	1
	Total 2

(c) The n = 2 level has an energy of -3.4 eV. The photon with wavelength 4.9×10^{-7} m corresponds to the transition between the n = 4 and n = 2 energy levels. Calculate the energy of the n = 4 energy level in eV. (3 marks)

Description	Marks
E of photon = $hc/\lambda = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{4.9 \times 10^{-7} \times 1.6 \times 10^{-19}}$ (1) = 2.53 eV (1)	1-2
$E_{n=4}$ = -3.4 ev + 2.5 eV = -0.9 eV (1)	1
	Total 3

(d) Calculate the wavelength of the n = 4 to n = 2 transition in hydrogen that would be observed by an astronomer studying the galaxy 8C. (2 marks)

Description	Marks
Rearrange equation above: $\lambda_{observed} = (z+1) \times \lambda_{earth}$ (1)	1
$\lambda_{obs} = (4.25+1) \times 4.9 \times 10^{-7}$ m = 2.6×10^{-6} m (1)	1
	Total 2

Question 15 **(12 marks)**

(a) Explain the principle of operation of this metal detector. In your answer, explain why the coil has to be moved whilst locating metal objects. (4 marks)

Description	Marks
Field produced in primary coil due to battery and coil	1
This field sweeps over the metal object so the field exposed to the object is changing.	1
This changing magnetic field in the object induces a voltage in the object and this produces a field in the secondary.	1
The current in the secondary flows through the buzzer producing a sound.	1
	Total 4

(b) What type of metal can the detector find? Circle the correct answer. (1 mark)

copper and tin iron and steel any metal

Description	Marks
Any metal	1
	Total 1

(c) Use the following data to **estimate** the voltage in the secondary buzzer circuit. (5 marks)

Magnetic field strength within primary coil = 0.0500 ~~Wb~~ T

Number of turns in secondary coil = 10

Time of sweep = 0.5 s

Can be $\Delta\phi = 0.0500$ Wb ⇒ no need to estimate A. ∴ 2 possible answers.

Description	Marks
Students may interpret the magnetic field information as either field strength or as enclosed flux. $\text{emf} = -N\frac{\Delta\Phi}{t}$ ← $\Delta\phi$ should be between 0 and 0.05 Wb. $= -N\frac{A\Delta B}{t}$ Radius of the coil seems about 5 cm or 0.05 m (plus or minus 1 cm) so $A = \pi\times(0.05)^2 = 0.008\ m^2$ (1) if done. $\text{emf} = -10\left(\frac{0.008\times0.05}{0.5}\right)$ V = 0.008 V (accept 0.005 to 0.011 V) or $\text{emf} = -N\frac{\Delta\Phi}{t}$ ← show $\Delta\phi$ is between 0 and 0.05 Wb. $= -10\frac{0.05}{.5}$ V = 1 V 2 marks only Must justify: will be much less than 0.05 T. • Flux change – (1) • Time for sweep. – (1) • Area – (1)	1-5
	Total 5

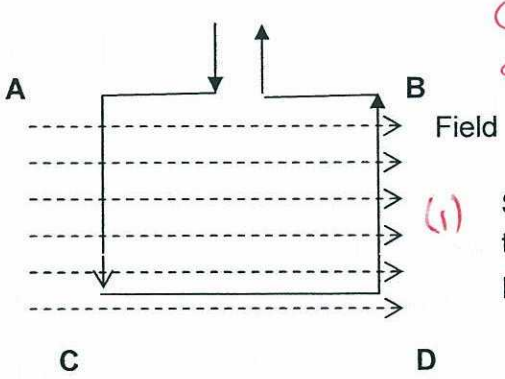
(d) How would the sound change if the metal detector was held stationary near a nail? Give a brief reason for your answer. (2 marks)

Description	Marks
No sound, because no induced voltage. (1) (1)	1–2
	Total 2

Question 16 **(13 marks)**

(a) When a current flows in the rectangular coil a force is produced on each side of the coil that interacts with one magnetic field. Explain the reason for this force and comment on its direction. You must draw a diagram to illustrate your explanation. (2 marks)

Description	Marks
Interaction of the field due to the wire and the field due to the permanent magnet.	1
Direction at right angles to both the current and the field. Diagram is essential (see below). (1)	1
It is in a different direction on each side of the coil (that is why it rotates).	1
	Total 3



Can show direction of rotation as well.

(1) Show force on AC is out of the page and on BD into page

(b) The coil has a length of 0.100 m and a width of 0.0800 m and has 50.0 turns. There is a current of 4.00 A in the coil and it is in a uniform magnetic field of 0.0100 T.

(i) Calculate the force on one of the long sides of the coil. (4 marks)

Description	Marks
Appropriate formula $F = BI\ell n$ (n = 1 mark)	1
Substitute $F = 0.01 \times 4 \times 0.1 \times 50$	1
$= 0.200$ N	1
Zero answer - must state long side is parallel to the field (1) **Total**	**4**

(ii) Hence determine the torque acting on the coil. (3 marks)

Description	Marks
Appropriate formula $T = 2$ (F × separation)	1
Subs $T = 2 (0.200 \times 0.0400)]$	1
$= 1.60 \times 10^{-2}$ N m	1
Total	**3**

(c) Why will the coil rotate? (3 marks) 2

Description	Marks
An unbalanced torque will cause rotation. (2)	1-2
	Total 3 2

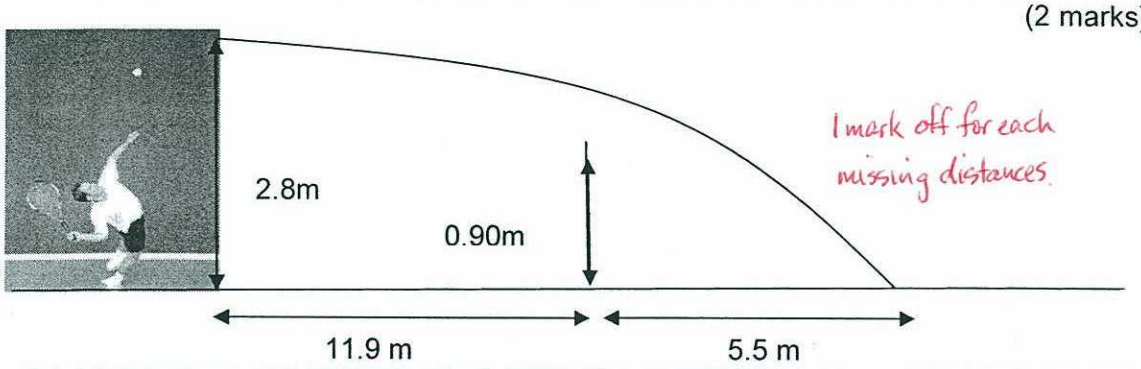
(d) The loosely coiled spring provides a torque that opposes the coil's rotation. When the coil is stationary, with a current flowing in it, state the relationship between the torque acting on the coil because of the magnetic field, and the torque provided by the spring. (1 mark)

Description	Marks
Equal size and opposite in direction.	1
	Total 1

Question 17 **(11 marks)**

While serving a tennis ball, a tennis player aims to hit the ball horizontally so that it lands in the opponent's court 5.50 m from the net. The height of the net is 0.900 m, the distance between the serve point and the net is 11.9 m and the ball is hit from a height of 2.80 m. Ignore air resistance.

(a) Draw a diagram to illustrate the path of the ball with all relevant distances labelled. (2 marks)



Description	Marks
All 4 distances recorded correctly, deduct marks for missing measurements.	1–2
	Total 2

(b) Calculate the time taken for the tennis ball to reach the net and the minimum initial speed that the tennis ball would need to just clear the net. (3 marks)

Description	Marks
Resolve vertically (2.8-0.9) $= 0 + 4.9\ t^2$	1
Time to reach net = 0.62 s	1
Speed = 11.9/ 0.62 = 19.1 m s^{-1}	1
	Total 3

(c) Calculate the length of time the ball is in the air. (3 marks)

Description	Marks
Resolve vertically, $s = ut + 4.9\ t^2$	1
$2.8 = 0 + 4.9\ t^2$	1
Time = 0.76 s	1
	Total 3

(d) Calculate the distance from the net that the ball will land on the opponent's side of the court. If you were unable to determine an answer in part (c) you should assume that the time of flight is 0.900 s and if you were unable to determine an answer to part (a) you should assume that the minimum initial speed is 20.0 m s^{-1}. (3 marks)

Description	Marks
Horizontal velocity remains unchanged at 19.1 m s^{-1}	1
Resolve horizontally $s = ut + 0$ = 19.1 × 0.76 = 14.4 m	1
Distance = 14.4 m from where it is hit , from net is 2.54 m	1
	Total 3

If use 19.2 m s^{-1} and 0.90 s then distance is 17.28 m - 11.9 m = 5.38 m (3 marks)

If use 20 m s^{-1} and 0.690 s then distance is 18.0 m -11.9 = 6.1 m (3 marks)

Question 18 **(14 marks)**

(a) Calculate the current in each of the ammeters A1, A2 and A4. (3 marks)

Description	Marks
A2 = 2 × 0.096 = 0.192 A (1) (since resistance path has half the resistance of G3, G4)	1
A4 = A1= A 2 + A3 =0.192 + 0.096 = 0.288 A	1–2
(1) (1) **Total**	**3**

(b) Calculate the resistance of each light globe. (3 marks)

Description	Marks
Calculation of networks total resistance as 5R/3 (2)	2
~~Recall current thru" G2 is 0.192 A so current in A1 is 0.288 A~~	
Sub 24 = 0.288 5R/3 to give R = 50 Ω	1
Total	**3**

(c) Which light globe will be the brightest? Justify your answer. (2 marks)

Description	Marks
G1	1
Reason , splits after G1 so current reduces.	1
Total	**2**

(d) Calculate the total power consumed by all four light globes. If you were unable to determine an answer to part (a) you should assume the current in ammeter A4 is 0.300 A. (2 marks)

Description	Marks
Power G1 = $(0.288)^2$ × 50 = 4.15 W G2 = $(0.192)^2$ × 50 = 1.84 W G3 = G4 = $(0.096)^2$ × 50 = 0.46 W	1-2
Total is 4.15 +1.84 +0.46 + 0.46 = 6.91 W	
Or P=I.V = 0.288 × 24 =6.91 W	
(1) (1) **Total**	**2**

If use 0.30A then solutions are G1 = $(0.30)^2$ × 50 = 4.50W G3 = G4 = 0.46 W, as before
G2 = $(0.204)^2$ × 50 = 2.08 W total = 7.50 W (2 marks)

$P = VI = (24.0)(0.300) = 7.2$ W.

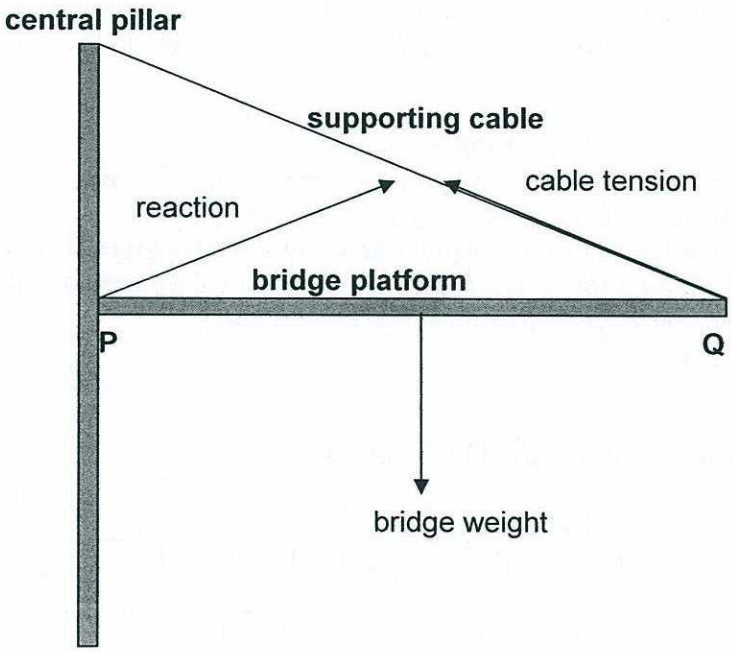
(e) If globe G3 is broken, describe how the brightness of each of the light globes G1 and G2 changes. Give a reason in each case. (4 marks)

Description	Marks
If G3 is broken then circuit resistance is 2R (100 Ω) instead of 5R/3 so current is reduced in G1 to 0.24 A.	2.
Current in G2 is increased from 0.192 A to 0.24 A so G2 is BRIGHTER. (1)	1-2
Current in G1 is reduced from 0.288 A to 0.24 A so G1 is DULLER. (1)	1-2
NB: calculations are not required but it is difficult to work out the answers without them.	
Total	**4**

Question 19 **(9 marks)**

(a) The section of bridge platform labelled PQ on the diagram below is in equilibrium even though three forces act on it. Draw and label these three forces on the diagram. (3 marks)

Description	Marks
Each vector drawn with arrow to indicate direction. No labels - 1 mark only	3
~~All three vectors intersect at one point.~~	0
Total	**3**



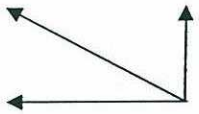
(b) Calculate the angle Φ. (1 mark)

Description	Marks
Calculate angle Φ tan Φ = 17.5/35 Φ = 26.5°	1
Total	**1**

(c) By taking moments about a suitable point calculate the vertical component of the tension. (3 marks)

Description	Marks
Take moments about point A (1) (1) $(50 \times 10 \times 1000 \times 9.8) + (420 \times 17.5 \times 1000 \times 9.8) = T_V \times 35$	1-2
$T_v = 76.9 \times 10^6 / 35 = 2.19 \times 10^6$ N (1)	1
Total	**3**

(d) Using the vertical component from (c), determine the tension in the cable. If you could not calculate the vertical component, use 4.20×10^6 N. (2 marks)

Description	Marks
$\sin 26.5° = T_v / T$ $T = \frac{2.19 \times 10^6}{\sin 26.5°}$ (1) 	1
$T = 4.9 \times 10^6$ N (1)	1
Total	**2**

Question 20 **(11 marks)**

(a) Apart from the phenomenon of vibrating air columns, describe one example where resonance may be observed. Explain how resonance occurs in the example that you have chosen. (3 marks)

Description	Marks
There are many appropriate examples: a ringing wine glass, the Tacoma Narrows Bridge, the Millennium Bridge, microwave oven, etc.	1
Explanation should include the following: object has a natural frequency of (1) oscillation when it is driven by a force with the same frequency then the size of the oscillation massively increases and resonance is observed.	2
(1)	**Total 3**

(b) Calculate the wavelength of sound in the cylinder. (2 marks)

Description	Marks
Nodes are separated by ½ λ, so ½ λ = 49 cm -17 cm = 32 cm (1)	1
So λ = 64 cm (1)	1
Can use $4 \times 17 = 68$ cm (Ignores end effect). (1)	**Total 2**

Average of 2 - 2 marks.

(c) Calculate the frequency being emitted by the loudspeaker. (2 marks)

Description	Marks
$v = f \times \lambda$, $f = v/\lambda = 346$ m s^{-1} / 0.64 m (1)	1
f = = 540 Hz (1)	1
	Total 2

(d) The diagrams below show very simple versions of a flute and a clarinet.

(i) The ratio of the first three frequencies heard in the flute $f_1:f_2:f_3$ is 1:2:3. Determine the ratio of the first three frequencies heard in the clarinet. (1 mark)

Description	Marks
1:3:5 (1)	1
	Total 1

(ii) Using your knowledge of vibrations in air columns, explain the differences between the frequencies heard in the flute and those in the clarinet. (3 marks)

Description	Marks
The flute is an example of a pipe open at BOTH ends – the note is generated by blowing over the top of the instrument. (1)	1-3
The clarinet is an example of a pipe that is CLOSED at one end – the mouth is placed over the end to generate the note so it closes the pipe. (1)	
An open end of an air column reflects a sound wave with a change of phase, a closed end reflects with no change of phase. Standing waves in a closed pipe have a node at one end and an antinode at the other, so only odd numbered harmonics are possible. (1)	
	Total 3

Question 21 **(9 marks)**

(a) The radius of the orbit of Venus around the Sun is 1.08×10^{11} m.

(i) Derive an expression that relates the orbital period of Venus to the orbital radius of Venus and the mass of the Sun. (3 marks)

Description	Marks
$F_c = F_g$ $\frac{M_{Venus} \cdot v^2}{r} = G \frac{M_{Sun} \times M_{Venus}}{r^2}$ (1) Where $v = \frac{s}{t} = \frac{2\pi r}{T}$ So $v^2 = \frac{4\pi^2 r^2}{T^2}$ (1) $\frac{M_{Venus} \cdot \frac{4\pi^2 r^2}{T^2}}{r} = G \frac{M_{Sun} \times M_{Venus}}{r^2}$ $\frac{4\pi^2 r^2}{T^2} = G \frac{M_{Sun}}{r}$ $T^2 = \frac{4\pi^2 r^3}{GM_{Sun}}$ (1) If answer only ⇒ ZERO.	1-3
	Total 3

(ii) Calculate the time in Earth days for Venus to orbit the Sun. (3 marks)

Description	Marks
$T^2 = \frac{4\pi^2 r^3}{GM_{Sun}}$ $T^2 = \frac{4\pi^2(1.08 \times 10^{11})^3}{(6.67 \times 10^{-11})(1.99 \times 10^{30})}$ (1) $T^2 = \frac{4.973 \times 10^{34}}{1.327 \times 10^{20}}$ $T = \sqrt{\frac{4.973}{1.327}} \times 10^7 s$ $= 1.936 \times 10^7$ s (1) = 224 days (1)	1-3
	Total 3

(b) By measuring the time difference for A to occur at different locations on Earth (Tahiti and California) astronomers were able to measure the solar parallax angle Φ as shown in the diagram below which is not to scale. From this the Earth to Sun distance was calculated in 1769 to an amazing accuracy.

Calculate the Earth – Sun distance in kilometres if the solar parallax angle $\Phi = 0.00250°$. (3 marks)

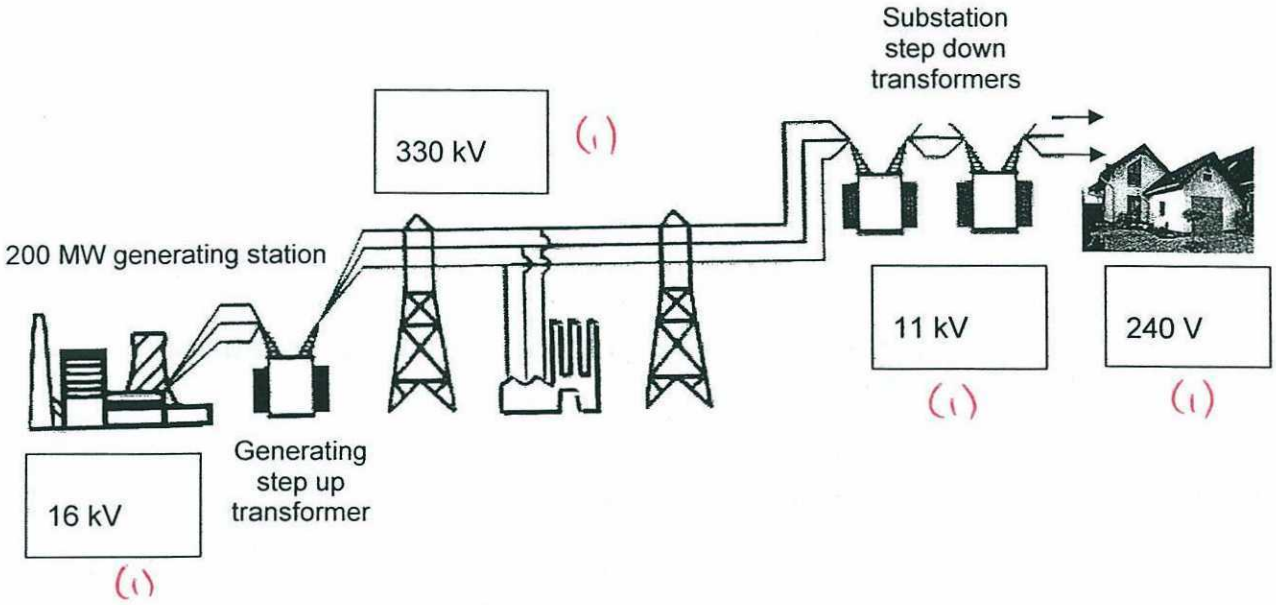
Description	Marks
$\tan \phi = \frac{6.38 \times 10^6}{E-S}$ (1)	1
So $E-S = \frac{6.38 \times 10^6}{\tan 0.0025}$ (1) = 146 million km (1.46×10^{11} m) (1)	1-2
	Total 3

Section Three: Comprehension and data analysis. **20% (36 Marks)**

Question 22 **(16 marks)**

Generation and Transmission of Electricity

(a) On the diagram below show the voltages at the different stages of the transmission. (4 marks)



Description	Marks
Each error subtract 1 mark (minimum mark of zero)	1–4
	Total 4

(b) Explain why the generator is designed to produce alternating current and not direct current. (2 marks)

(1) Description	Marks
Key idea is that a transformer works on AC and not DC and transformers are required throughout the transmission process.	1–2
Must have changing flux - must be AC. (1)	**Total 2**

(c) Calculate the current generated in one of the 200 MW generators. (2 marks)

Description	Marks
$P = I.V$ $200 \times 10^6 = 16 \times 10^3 \times I$ (1)	1
$I = \frac{200 \times 10^6}{16 \times 10^3} = 1.25 \times 10^4$ A (1)	1
	Total 2

(d) Explain why the voltage is increased to 330 kV before it is distributed to users. (2 marks)

Description	Marks
Key idea is that if high voltage is used then the same power can be transmitted at a lower current (1)	1-2
If the transmission current is reduced then the losses $I^2 R$ are reduced significantly (1)	
	Total 2

(e) Calculate the turns ratio of a transformer being used to increase the voltage from a 60 MW generator to 330 kV. (2 marks)

Description	Marks
Recall $\frac{V_s}{V_p} = \frac{N_s}{N_p}$	1
Substitute 330 kV / 11.8 kV = Turns ratio= 28 (1:28) (1) (1)	1
	Total 2

(f) Suggest a possible difference between the 60 MW and the 200 MW generators that would result in a difference in output voltage. (1 mark)

Description	Marks
Either more turns on the coil or a stronger magnetic field. Not different rotation frequency. Either (1)	1
	Total 1

Question 23 **(23 marks)**

(a) What provides the centripetal force that acts on the charged particle? (1 mark)

Description	Marks
The magnetic force	1
	Total 1

(b) Operation of the cyclotron is based on the principle that frequency of revolution is independent of the speed of charged particles and the radius of the circular path. Use the equations given in the Formulae and Constants Sheet to show that frequency, f is given by $f = \frac{qB}{2\pi m}$. (4 marks)

Description	Marks
$v = 2\pi r / t = 2 \pi r f$ $f = \frac{v}{2\pi r}$ (1)	1
$\frac{mv^2}{r} = q v B$ (1) $r = \frac{m v}{Bq}$ $\frac{v}{r} = \frac{B q}{m}$ (1)	1-2
combine: $f = \frac{B q}{2\pi m}$ (1)	1
	Total 4

(c) Suppose a cyclotron with a dee radius of 53.0 cm is tuned to accelerate protons at an oscillator frequency of 12.0 MHz. Calculate the strength of the magnetic field needed to accelerate deuterons with the same frequency. (3 marks)

Description	Marks
$f = \frac{qB}{2\pi m}$ Rearrange formula – 1 mark. $B = \frac{2\pi (12 \times 10^6 \text{ Hz})(3.34 \times 10^{-27} \text{ kg})}{(1.60 \times 10^{-19} \text{ C})}$ (1) $= 1.6 \text{ T}$ (1)	1-3
	Total 3

(d) A conventional cyclotron begins to fail beyond a proton energy of 50 MeV.
(i) Explain why is this so. (2 marks)

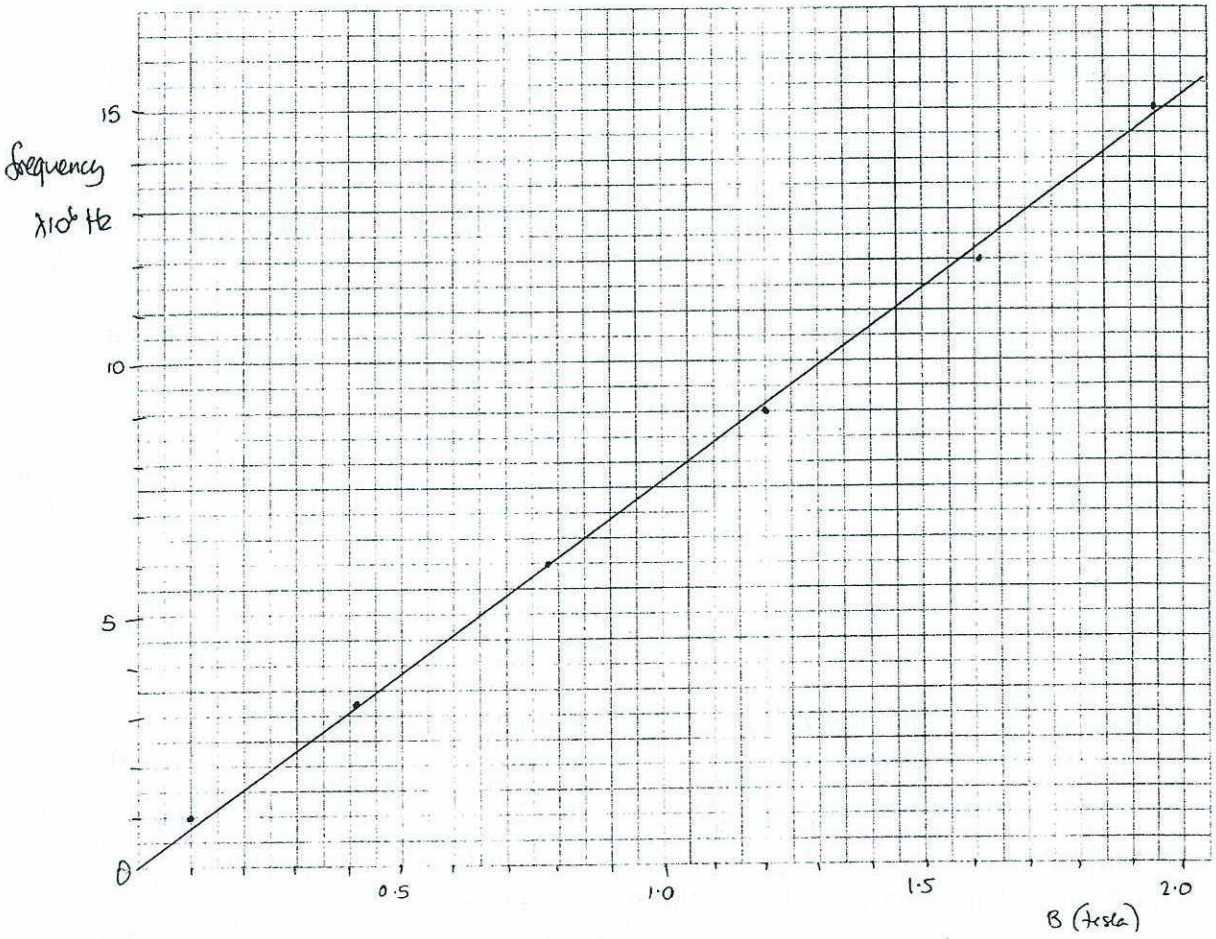
Description (1)	Marks
At higher energies the speed of the charged particle is relativistic (approaching the speed of light) and its mass cannot be considered as constant	1-2
(1)	**Total 2**

(ii) At what electron energy will the same cyclotron begin to fail? (2 marks)

Description	Marks
Assume 0.1c is the limiting electron velocity. Then limiting energy is given by $E_k = {}^1/_2(9.11\times10^{-31})(3\times10^7)^2$ (1) $E_k = 40.95\times10^{-17}$J (1) $E_k = \frac{40.95\times10^{-17}}{1.6\times10^{-19}}$eV =2.56 keV Mass ratio. $\frac{m_e}{m_p}$ = 27.3 keV.	1-2
	Total 2

(e) An unknown particle was tested and gave the following values of high voltage oscillator frequency and the corresponding magnetic field:

(i) Using the graph paper on the next page, plot a straight line graph with magnetic field on the *x*-axis and frequency on the *y*-axis. (3 marks)



Description	Marks
Points plotted, axes labelled, line of best fit drawn. (1) (1) (1)	1–3
	Total 3

(ii) Calculate the gradient of this graph. (3 marks)

Use points from table, – no marks!

Description	Marks
Gradient calculated from graph line Value about 7.6×10^6 C kg^{-1} (accept 7.3×10^6 C kg^{-1} to 7.9×10^6 C kg^{-1}).	1–3
	Total 3

(1) (1)-unit. large space on line – (1).

(iii) Use the gradient to find the ratio $\frac{\text{charge on the particle}}{\text{mass of particle}}$ for the unknown particle. (3 marks)

(If you could not complete (ii), use a gradient of magnitude 2.9×10^{10}.)

(1) Description (1)	Marks
q/ m from experiment = $2\pi f/B = 2\pi \times$ gradient = 4.8×10^7 C kg^{-1} (1) (accept 4.5×10^7 C kg^{-1} to 5.0×10^7 C kg^{-1}). Or if using gradient = 2.9×10^{10} q/ m from experiment = $2\pi f/B = 2\pi \times$ gradient = 1.8×10^{11} C kg^{-1}	1–3
	Total 3

(iv) Circle the unknown particle involved and justify your selection. (2 marks)

(I) electron (II) proton (III) neutron (IV) deuteron (1)

Description	Marks
deuteron q/m of deuteron from supplied data = $\frac{1.6 \times 10^{-19}}{3.34 \times 10^{-27}} = 4.79 \times 10^7$ C kg^{-1} (1) Or if using gradient = 2.9×10^{10}, **electron** q/m of electron from supplied data = $\frac{1.6 \times 10^{-19}}{9.91 \times 10^{-31}} = 1.76 \times 10^{11}$ C kg^{-1}	1–2
	Total 2

ACKNOWLEDGEMENTS

Question 7 The West. (2010, February 4). BMW Oracle [Photograph of catamaran]. *The West Australian*, p. 59.

Question 21 Adapted from: Transit of Venus on June 8th, 2004. (2004) Sky Watch. Retrived March, 2010, from www.sky-watch.com/transit.html.

Question 23 Adapted from: Wikipedia. (2008). *Electricity distribution* [diagram of power transmission]. Retrieved March, 2010, from http://en.wikipedia.org/wiki/Electricity_distribution.