New Zealand Qualifications Authority
Mana Tohu Matauranga o Aotearoa

University Entrance and Bursaries Examination, incorporating The National Bank of New Zealand Ltd Scholarships

No. 262

Marking Schedule and Examination Commentary 1995

PHYSICS

NEW ZEALAND QUALIFICATIONS AUTHORITY

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University Entrance and Bursaries Examination, incorporating The National Bank of New Zealand Ltd Scholarships – PHYSICS 1995

Marking Schedule and Examination Commentary

GENERAL

The 1995 paper continued the style of the previous few years in that the questions were contextual, and candidates were expected to express their knowledge of physics concepts both mathematically and descriptively. The question that required students to find mistakes in a written experimental report was discontinued as the time needed to do it was not reflected in the marks which could be gained.

There was evidence that many students found the paper long and were unable to do justice to questions later in the paper.

Although there were scripts in which the logic of a solution was communicated clearly and succinctly both from a mathematical and descriptive aspect, these were sufficiently rare for it to be clear that this skill is not always being emphasised. Answers to 'explain' questions were in **all** cases expected to contain **both** a statement of what happened and a physical reason for why it happened. However, in far too many cases, candidates lost marks because although they made a perfectly correct statement, they failed to go on to explain the physics concept on which the statement was based.

Many candidates did not realise that 'explain the difference' is not covered by 'it changes' or 'it alters' but demands the specific way in which the change is made.

Many descriptive answers were long and convoluted and it was difficult at times for markers to sort the 'wheat from the chaff'. When answering descriptive questions students should be encouraged to use physics language (eg. 'force' rather than 'blow') and be concise. A significant number of candidates did not read the questions carefully and their answers, although correct in themselves, were not what was asked for.

Questions requiring descriptive answers need to be practised far more extensively if candidates are to do justice to themselves in the examination.

Many candidates repeatedly failed to show any knowledge of how to express a mathematical answer to an appropriate number of significant figures, indicating that this skill is not widely emphasised. Although the instructions given in the answer booklet clearly stated that appropriate interpretation of significant figures was required, markers found it frustrating having to deduct marks because candidates had clearly not been taught this skill. Candidates must clearly understand that the number of significant figures in the given data is the guide to the number of significant figures required in the answer.

On the positive side, very few candidates lost marks through failing to give a unit with their answers and so it is pleasing to see that this skill is obviously now being well taught. Marks which were lost in this respect were almost always because the wrong unit was given.

SPECIFIC QUESTIONS

(Note: The average mark given for each question has been obtained from a sample of papers)

Question 1: A Head-On Collision (mean 9/13)

(a) Generally well done. The most common error was to use a non-zero final momentum. Candidates must realise that when a direction is asked for it must relate to the question. A direction of 'to the right' was not marked correct.
(b) Well done.
(c) Generally well done, but many candidates left too many significant figures in the answer.
(d) Many did not recognise that **initial** meant immediately after the collision and talked about passengers flying through the windscreen. Some candidates thought that there would be an **extra** force as the passenger hit the dashboard.
(e) Generally well done.
(f) Many candidates did not **compare** the forces but simply stated them. The best answers gave an indication that the sudden application of the force was an important aspect.

Question 2: A Glancing Collision (mean $9^1/_2$/19)

(a) Poorly done. Very few candidates recognised that the vectors represented momentum. Of those who did, some confused total momentum with change in momentum.
(b) Candidates found it difficult to reduce the situation to an unbalanced force not acting through the centre of mass, hence causing a torque.
(c) Many candidates realised that mass distribution was the key factor, but few went on to clearly explain how a change in mass distribution affects rotational inertia.
(d) Only the most able candidates used the radius of the model rather than the wheel. Too many significant figures in the answer was also a common error.
(e) (i) Mostly well done but some drew the vector acting through the centre of mass of the wheel.
(ii) Well done.
(f) The calculation was generally well done but many lost marks because a wrong unit was given. There are still some candidates writing rad/s^2.
(g) Generally well done although some rather lengthy methods were used.
(h) Most candidates correctly identified heat as being the energy produced but then many lost a mark by not explaining that the change was due to friction.

Question 3: Stopping Distances (mean 6/10)

(a) Most candidates were able to identify the variables but some got them the wrong way around.

(b) Fair test concept seemed reasonably well understood. Some had difficulty distinguishing between what was the variable and what was the action to be taken to control it. Others had some very impractical ways of controlling the variable such as using new tyres for every test!
(c) Most identified that reaction time was the main source of error but very few went on to say how the error would affect the measurement of the stopping distance.
(d) Most recognised that a graph would have to be plotted (although a few decided that the more familiar distance / time graph would be more appropriate), but many went on to describe what should be done to **determine** a relationship rather than describe how they would expect the graph to **confirm** the relationship.

Question 4: SHM of an Electron (mean 7½/14)

(a) Well done.
(b) 3% of amplitude very well done but only the best candidates recognised the absolute uncertainty should be quoted to 1 significant figure.
(c) No problem for those who knew about uncertainties.
(d) Well done.
(e) Many candidates stated that as the displacement increases the force decreases, failing to recognise that it is the direction which is the key factor.
(f) Well done.
(g) Well done.
(h) Most candidates did not draw a reference circle. Many assumed that because the electron had travelled one eighth the distance of a full cycle, the angle turned by the magnet was 45°. Many other candidates used the end position as the starting point and did a cosine calculation.

Question 5: The Didgeridoo (mean 10½/17)

(a) Well done, but some diagrams were very poorly drawn.
(b) Many candidates fell into the trap and wrote transverse, clearly misunderstanding the transverse representation of a longitudinal wave.
(c) Calculation done very well but only the best candidates gave the answer to the required significant figures. The most common answer was 3 m.
(d) Well done.
(e) Calculation mostly well done but again only the best candidates gave the answer to the required 3 significant figures.
(f) Generally well done although many candidates did not make the full comparison; their answer showing no causal understanding of longer wavelength.
(g) Well done.
(h) Many candidates used the word 'note' instead of pitch or frequency.
(i) Real confusion here, especially with v'. Many candidates stated 'apparent speed' without any reference to what the speed was relative to, while others stated the speed relative to the observer.

Question 6: Diffraction (mean 6/15)

(a) Well done.
(b) Poorly done. Most candidates did not label their diagrams, making it difficult to decide which fringes were bright and which were dark. Very few candidates seemed to be aware of the difference between double slit and multiple slit interference. Many candidates drew diagrams which indicated they had never actually seen an interference pattern.
(c) (i) Most candidates knew that a spectrum was involved, but many were unable to show the arrangement of spectra both sides of a central maximum and even fewer recognised that the central maximum was white.
(ii) Many candidates were unclear about the essential features of a diffraction grating.
(iii) Calculation was generally handled well, the most common errors being the confusion between slit separation and lines per metre, and not converting lines per centimetre into lines per metre.
(d) Few candidates saw this as a diffraction situation. Many attempted to interpret it in terms of earthquake waves travelling through the earth! Students need to be exposed to practical applications of diffraction outside the laboratory.

Question 7: Recharging a Car Battery (mean 4/15)

(a) Only the best candidates recognised that energy was being **used** by both the battery and the internal resistance.
(b) Well done, but many candidates need to become more skilled in setting out a mathematical proof in a logical way.
(c) Many candidates failed to recognise that this was a 'power' problem. Of those who did, most used the wrong voltage.
(d) Many candidates recognised that the current would decrease but only the best were able to give a valid explanation. A significant number of candidates thought that it was decreasing internal resistance rather than the increasing voltage which was the key factor in this situation.
(e) (i) Well done.
(ii) Some candidates were able to follow up the previous calculation with the required subtraction.
(iii) Only the best candidates recognised the significance of the equal voltages.
(f) Very few candidates managed this question even though the given information had been carefully chosen to make the Kirchoff calculation straightforward.

Question 8: 'High Tech' Capacitors (mean 8½/12)

(a) (i) Well done although the spelling of farad was often most creative!
(ii) Well done.
(b) Mostly well done, but a significant number of candidates correctly selected the formula then forgot to square the voltage! Others used the wrong voltage value.

(c) Mostly well done, the most common error being not to extend the line beyond the second plotted point.
(d) Some candidates did not read the time accurately enough or misread the scale.
(e) Well done.
(f) Well done.

Question 9: A Loudspeaker Circuit (mean 9½/21)

(a) Most got the shape if not the direction of the magnetic field. Some did not show the field inside the coil.
(b) All sorts of vague and woolly explanations which did not include the two key points that a changing current will create a changing magnetic field and that the resulting change in flux linkage will cause an induced voltage.
(c) Many answers were probably guesses.
(d) Many candidates worked backwards from information given later on in the question and were not given the mark. Again significant figures proved a problem for most.
(e) Direction was almost always correct but many candidates lost a mark because they were careless in drawing the length of the vector.
(f) Well done.
(g) A surprising number of candidates put ohms.
(h) A common error was inductance = capacitance.
(i) For a straight recall question it was surprising how many candidates got this wrong.
(j) Most recognised that the current increased, few gave a good explanation of why.
(k) A disappointingly high number of candidates assumed the value to be proved and got into all sorts of trouble because they no longer had an unknown in the equation.
(l) Most candidates thought that a variable capacitor should be used so as to give resonance at all audible frequencies! Very few candidates realised that the resonant frequency had to be outside the audible range.

Question 10: Fluorescent Lights (mean 4/9)

(a) Candidates were familiar with the formula E = hf but some did not realise that the frequency had first to be calculated, and used the given value of λ. Powers of 10 were mostly handled well.
(b) The most common errors were 'photons', 'energy differences' and 'spectral lines'.
(c) Most candidates found this difficult. Many gave the impression that they understood what was happening but expressed themselves so badly that it was impossible to isolate the required key points. A common error was to attribute the discreteness of the lines to the fact that there was only one electron.
(d) Mostly well done. Some candidates appeared to have memorised the wavelength of red light and actually calculated values for the frequency!

Question 11: The Sun (mean 6½/15)

(a) (i) 'Fussion' was probably the most popular answer; designed perhaps to cover both options!
(ii) Most candidates linked high temperature to high energy (speed) but only a few went on to explain that the need for high energy is to overcome electrostatic repulsion.
(b) (i) Many candidates were unable to quote the law of conservation of mass / energy, relying on a statement of $E = mc^2$ to imply this.
(ii) Very poorly done. Few candidates had any idea of the relativistic increase of mass with speed.
(c) Many candidates knew what approach should be made but lost themselves in the maze of millions.
(d) Generally well done but many candidates missed the point of (iii) which was that water is an abundant, cheap supply.

MARKING SCHEDULE

The following formulae may be of use to you:

$$\Delta p = Ft \qquad \omega = \omega_o + \alpha t$$
$$\theta = \omega_o t + \tfrac{1}{2}\alpha t^2 \qquad \omega^2 = \omega_o^2 + 2\alpha\theta$$
$$v = r\omega \qquad y = A\sin(\omega t + \phi)$$
$$d = r\theta \qquad v = A\omega\cos(\omega t + \phi)$$
$$a = r\alpha \qquad a = -A\omega^2\sin(\omega t + \phi)$$
$$n\lambda = d\sin\theta$$
$$n\lambda = \frac{dx}{L} \qquad E = \tfrac{1}{2}CV^2$$
$$X_L = \omega L \qquad X_C = \frac{1}{\omega C}$$

Question 1: A Head-On Collision (13 marks)

(a) $\Delta p = m\Delta v$
$= (950 + 85 + 65) \times (6.9 - 0)$
$= 7590$
$= 7600$ kg m s^{-1}
away from the tree (opposite to car's motion)

Formula and substitution	*(1 mark)*
Answer and unit	*(1 mark)*
Direction	*(1 mark)*

(b) F = ma
$= (950 + 85 + 65) \times 55$
$= 60500$
$= 61000$ N

Formula and substitution *(1 mark)*
Answer and unit *(1 mark)*

(c) $\Delta p = Ft$

$\Rightarrow t = \dfrac{\Delta p}{F}$

$= \dfrac{7590}{60500}$

$= 0.125$
$= 0.13$ s

Formula and substitution *(1 mark)*
Answer (2 or 3 sf) and unit *(1 mark)*

(d) The force would have been less *(1 mark)*
because the mass of any unbelted occupants would not have been stopped by the force. *(1 mark)*

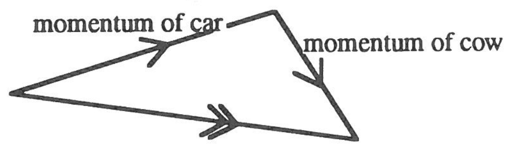
(e) $F = ma$
$= 13 \times 55$
$= 715$
$= 720$ N

Formula and substitution *(1 mark)*
Answer and unit *(1 mark)*

(f) It is unlikely that the passenger would keep hold of the child *(1 mark)*
because the force required to do so would be equivalent to having to suddenly lift one's own weight. *(1 mark)*

Question 2: A Glancing Collision (19 marks)

(a)



Each vector *(3 marks)*
Each vector represents the correct quantity *(1 mark)*

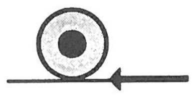
(b) The direction of the force *(1 mark)*
does not act through the centre of mass. *(1 mark)*

(c) The mass of the wheel is **not** all concentrated at the rim. *(1 mark)*
Its rotational inertia is less than it would be if the mass were all concentrated at the rim. Therefore for the model and the wheel to have the same rotational inertia the radius of the model must be smaller. *(1 mark)*

(d) $I = 25 \times 0.25^2$
$= 1.56$
$= 1.6$ kg m s^{-1}

Correct radius *(1 mark)*
Answer (2 or 3 sf) and unit *(1 mark)*

(e) (i)



Correct direction and placement *(1 mark)*

(ii) Friction *(1 mark)*

(f) $\omega = \omega_0 + \alpha t$

$\Rightarrow \alpha = \dfrac{|72 - 86|}{0.85}$

$= 16.47$
$= 16$ rad s^{-2}

Correct formula *(1 mark)*
Substitution and answer *(1 mark)*
Unit *(1 mark)*

(g) $v = r\omega$
$= 0.29 \times 72$
OR $v = v_i + r\alpha t$

Formula *(1 mark)*
Substitution *(1 mark)*

(h) Linear kinetic energy is changed to heat *(1 mark)*
by friction. *(1 mark)*

Question 3: Stopping Distances (10 marks)

(a) The independent variable is speed *(1 mark)*
The dependent variable is (stopping) distance *(1 mark)*

(b)

Variable *(1 mark)* any two	**Control by:** *(1 mark)* any two
Mass	Always have the same people in the car
Brake pressure	Same driver/press as hard as possible each time
Road surface	Same bit of air strip in same weather conditions
Tyre condition	Careful not to skid/minimum number of trials
Reaction time	Same driver/repeat and average

(4 marks)

(c) Main inaccuracy is due to the reaction time of the driver *(1 mark)*
and would make the stopping distances too long. *(1 mark)*

(d) Graph stopping distance against speed. *(1 mark)*
A straight line graph would indicate a proportional relationship. *(1 mark)*

Question 4: SHM of an Electron (14 marks)

(a) $v = A\omega$

$$\Rightarrow A = \frac{2.4\times10^{-4}}{314}$$
$$= 7.6433\times10^{-7}$$
$$= 7.6\times10^{-7}\text{ m}$$

Formula and substitution *(1 mark)*
Answer and unit *(1 mark)*

(b) $\Delta A = 0.03\times7.6\times10^{-7}$
$= 0.2\times10^{-7}\text{ m}$

3% of amplitude *(1 mark)*
Answer to 1sf *(1 mark)*

(c) $a = (A\pm3\%)\times(\omega\pm1\%)^2$
$= A\omega^2 \pm (3\% + 2\times1\%)$
$\Rightarrow \Delta a = \pm5\%$

$2\times1\%$ *(1 mark)*
$+3\%$ *(1 mark)*

(d)

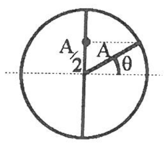
Both marked *(2 marks)*
If one marked *(1 mark)*

(e) The force acts in the opposite direction to the displacement / The force is a restoring force. *(1 mark)*

(f) The force is proportional to the displacement. *(1 mark)*

(g) $\omega = 2\pi f$ *(1 mark)*

(h)



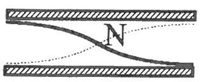
(1 mark)

$$\sin\theta = \frac{A/2}{A} = 0.5$$ *(1 mark)*

$\Rightarrow \theta = 30°$ *(1 mark)*

Question 5: The Didgeridoo (17 marks)

(a)



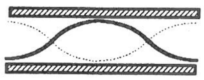
Wave shape *(1 mark)*
Node marked *(1 mark)*

(b) Longitudinal *(1 mark)*

(c) $\frac{1}{2}\lambda = 1.50$
$\Rightarrow \lambda = 3.00\text{ m}$

½ wave fits into pipe *(1 mark)*
Answer (2 or 3 sf) and unit *(1 mark)*

(d)



Wave shape *(1 mark)*

(e) $v = f\lambda$

$$\Rightarrow f = \frac{v}{\lambda}$$
$$= \frac{335}{1.5}$$
$$= 223\text{ Hz}$$

Correct wavelength *(1 mark)*
Formula and substitution *(1 mark)*
Answer to 3sf *(1 mark)*

(f) Second pipe *(1 mark)*
because a lower pitch means a longer wavelength and so a longer pipe. *(1 mark)*

(g) Beats would be heard *(1 mark)*
at a frequency of 4 per second. *(1 mark)*

(h) The pitch of the note *(1 mark)*
would change from high to low. *(1 mark)*

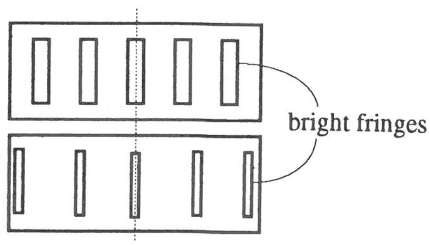
(i) v represents the speed of sound in air. *(1 mark)*
v' represents the speed of sound relative to the truck. *(1 mark)*

Question 6: Diffraction (15 marks)

(a) Monochromatic means one colour *(2 marks)*

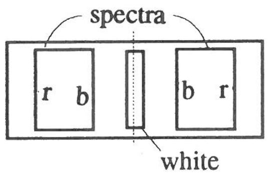
(b) (i)

(ii)



Evenly spaced *(1 mark)*
Further apart in (ii) *(1 mark)*
Bright centre in both *(1 mark)*
Brighter or sharper in (ii) *(1 mark)*

(c) (i)



White centre	*(1 mark)*
Spectra both sides	*(1 mark)*
Blue and red marked correctly	*(1 mark)*

(ii) Narrow slits (*1 mark*)
closely spaced (*1 mark*)

(iii)
$$n\lambda = d\sin\theta$$
$$\Rightarrow \sin\theta = (6000 \times 100) \times 700 \times 10^{-9}$$
$$\Rightarrow \theta = 25°$$

Lines per cm changed to lines per m	*(1 mark)*
Answer	*(1 mark)*

(d) *Recognition that diffraction is the key principle* (*1 mark*)
The longer wavelength of the sea diffracts more than the shorter wavelength of the gulls cries. (*1 mark*)

Question 7: Recharging a Car Battery (15 marks)

(a) Energy is being supplied to both the battery and the internal resistance (*1 mark*)
and so the voltages add. (*1 mark*)

(b)
$$V = IR$$
$$\Rightarrow 12.6 - 10.8 = 2.0\,R$$
$$\Rightarrow R = 0.90\ \Omega$$

Correct voltage	*(1 mark)*
Internal resistance not included	*(1 mark)*

(c)
$$P = IV$$
$$= 2.0 \times 10.6$$
$$= 21.2$$
$$= 21\ J$$

Recognition that this is a power problem	*(1 mark)*
Substitution	*(1 mark)*
Answer and unit	*(1 mark)*

(d) The current reduces (*1 mark*)
because the total voltage in the circuit reduces. (*1 mark*)

(e) (i)
$$V = IR$$
$$= 2.0 \times 0.90$$
$$= 1.8\ V$$

Answer and unit (*1 mark*)

(ii) $V_{PQ} = 12.6 - 1.8\ V$
Correct subtraction (*1 mark*)

(iii) The voltage across PQ is equal to the voltage of the original battery. (*1 mark*)

(f)
$$0 = 10.9 - 10.8 - 0.080 \times I$$
$$\Rightarrow I = 1.25$$
$$= 1.3\ A$$

Net voltage correct	*(1 mark)*
Correct resistance value used	*(1 mark)*
Answer and unit	*(1 mark)*

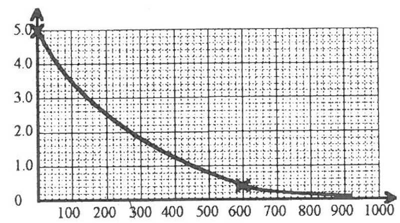
Question 8: 'High Tech' Capacitors (12 marks)

(a)(i) farad (*1 mark*)
(ii) capacitance (*1 mark*)

(b)
$$E = \tfrac{1}{2}CV^2$$
$$= \tfrac{1}{2} \times 0.47 \times 5.0^2$$
$$= 5.875$$
$$= 5.9\ J$$

Correct voltage used	*(1 mark)*
Formula and substitution	*(1 mark)*
Answer and unit	*(1 mark)*

(c) Voltage (V)



Time (s)

Top point	*(1 mark)*
Bottom point	*(1 mark)*
Exponential curve	*(1 mark)*

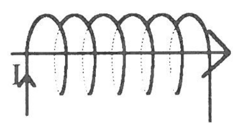
(d) *Time as read from graph at 3.0 V (± 5 s)* (*1 mark*)

(e) There would be more time (*1 mark*)
because the time constant will increase. (*1 mark*)

(f) *Capacitors connected in parallel.* (*1 mark*)

Question 9: A Loudspeaker Circuit (21 marks)

(a)



Straight inside coil	*(1 mark)*
to the right	*(1 mark)*

(b) Changing current causes changing magnetic field strength. (*1 mark*)

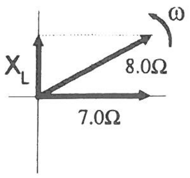
Resulting change in flux linkage causes an induced voltage. (*1 mark*)

(c) Same direction. *(1 mark)*

(d) $\omega = 2\pi f$
$= 2\pi \times 1.00 \times 10^3$
$= 6.28 \times 10^3$ rad s^{-1}

Formula and substitution *(1 mark)*
Answer to 3 sf *(1 mark)*

(e)



Upwards *(1 mark)*
Correct length (± 1 mm) *(1 mark)*

(f) $X_L = \omega L$

$\Rightarrow L = \dfrac{3.9}{6.28 \times 10^3}$

Formula *(1 mark)*
Substitution *(1 mark)*

(g) Henry *(1 mark)*

(h) Inductive reactance = capacitive reactance (or voltages) *(1 mark)*

(i) They are in phase. *(1 mark)*

(j) Current increases *(1 mark)*
because the impedance decreases. *(1 mark)*

(k)
$$\omega L = \frac{1}{\omega C}$$
$$\Rightarrow \omega^2 = \frac{1}{LC}$$
$$\Rightarrow f = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$$
$$= \frac{1}{2\pi}\sqrt{\frac{1}{6.2 \times 10^{-4} \times 1.0 \times 10^{-4}}}$$

Successful rearrangement of the formula to find f (2 marks)
Substitution *(1 mark)*

(l) The resonant frequency needs to be outside the audible range. *(1 mark)*
The capacitance would need to be increased or decreased to achieve this. *(1 mark)*

Question 10: Fluorescent Lights (9 marks)

(a) $E = hf,\ f = \frac{}{v} = 1.364 \times 10^{15}$

$E = 6.63 \times 10^{-34} \times 1.364 \times 10^{15}$
$= 9.0 \times 10^{-19}$ J

Frequency calculation *(1 mark)*
Formula and substitution *(1 mark)*
Answer and unit *(1 mark)*

(b) Energy states (levels) *(1 mark)*

(c) Statement must clearly imply that:
Electron energy jumps are downwards *(1 mark)*
Electron energy jumps are discrete *(1 mark)*
Each jump results in a single frequency *(1 mark)*

(d) L = 3 *(1 mark)*
Frequency of red light is lower than other colours. *(1 mark)*

Question 11: The Sun (15 marks)

(a)(i) Fusion *(1 mark)*

(ii) Hydrogen nuclei must have very high energy *(1 mark)*
to overcome the repulsive force. *(1 mark)*

(b)(i) Some of the mass is released as energy *(1 mark)*
in accordance with conservation of mass/energy. *(1 mark)*

(ii) The mass of the particle increases *(1 mark)*
when the speed increases. *(1 mark)*

(c)
$E = \Delta mc^2$
$\Delta m = (564 - 560) \times 10^9$ kg
$\Rightarrow E = 4.0 \times 10^9 \times (3.00 \times 10^8)^2$
$= 3.6 \times 10^{26}$ Js^{-1}
$= 3.6 \times 10^{20}$ MW

Δm identified *(1 mark)*
Formula and substitution *(1 mark)*
Powers of 10 handled correctly *(1 mark)*
Answer *(1 mark)*

(d)(i) Atomic number is 0 *(1 mark)*
Mass number is 1 *(1 mark)*

(ii) Particle is a neutron *(1 mark)*

(iii) Sea water is cheap / plentiful / renewable etc *(1 mark)*