1998

(h) Quite well done, with most describing some sort of uncontrollable meltdown or explosive situation.

(i) Many forgot to square c when using Einstein's equation.

MARKING SCHEDULE

Question 1: Rotational Motion (11 marks)

(a) $45 \times 2\pi$ *(must show, 1 mark)*, divide by 60 to get 4.7 *(1 mark)*

(b) $\theta = \omega_i + \frac{1}{2}\alpha t^2$

$= 11.75$

$= 12$ rad

Note that the same answer can be obtained by using the average angular velocity method (ie 0.5 (initial ω plus final ω)). θ = avg $\omega \times t$.

Appropriate formula and substitution *(1 mark)*
Answer *(1 mark)*

(c) $v = r\omega$

$= 0.15 \times 4.7$

$= 0.705$

$= 0.71\ ms^{-1}$

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

(d) Tangential to the point of departure when viewed from directly overhead. *(1 mark)*

(e) (i) Vector drawn towards centre. *(1 mark)*
(ii) Centripetal or centre-directed (not friction). *(1 mark)*

(f) $\omega_f = \omega_i + \alpha.t$

$0 = 4.7 + (-3.0)t$

$t = 1.566$

$= 1.6$ s

Formula and substitution (or any method) *(1 mark)*
Answer *(1 mark)*

Question 2: Torques and Angular Momentum (12 marks)

(a) $\tau = F.r$ *(1 mark)*
Greater diameter (or radius) enables a larger torque to be applied for the same force.
Similar description *(1 mark)*

(b) $\alpha = \frac{\Delta\omega}{\Delta t}$

$= \frac{4.0}{2.0}$

$= 2.0\ rad\ s^{-2}$

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

(c) $\tau = F.r$

$= 0.60 \times 0.15$

$= 0.090$ Nm

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

(d) $\tau = I.\alpha$

$I = \frac{\tau}{\alpha}$

$= \frac{0.090}{2.0}$

$= 0.045\ kg\ m^2$ or $Nm\ s^2$ (not 0.05)

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

(e) $L = I.\omega$

$= 0.045 \times 4.7$

$= 0.2115$

$= 0.21\ kg\ m^2s^{-1}$ or Nm s

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

(f) (i) Angular momentum (not just "momentum"). *(1 mark)*
(ii) Decrease. *(1 mark)*

Question 3: Simple Harmonic Motion (14 marks)

(a) $T = 2\pi\sqrt{\frac{\ell}{g}}$

$\ell = \frac{T^2 g}{4\pi^2}$

$= 1.3 \times 1.3 \times \frac{9.8}{(4 \times \pi \times \pi)}$

$= 0.4195$

$= 0.42$ m

Formula *(1 mark)*
Rearrange or substitute correctly *(1 mark)*
Answer *(1 mark)*

(b) $\omega = \frac{2\pi}{T}$

$= 4.833$

$= 4.8\ rad\ s^{-1}$

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

(c) $v_{max} = r\omega$

$= 0.15 \times 4.8$

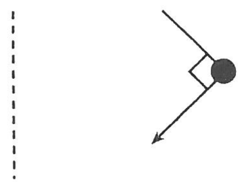
$= 0.72495$

$= 0.72\ ms^{-1}$

Formula and substitution (any method) *(1 mark)*
Answer *(1 mark)*

(d) Maximum velocity occurs at the centre (middle) of the swing, or, directly underneath the pivot ("equilibrium position" not sufficient). *(1 mark)*

(e)

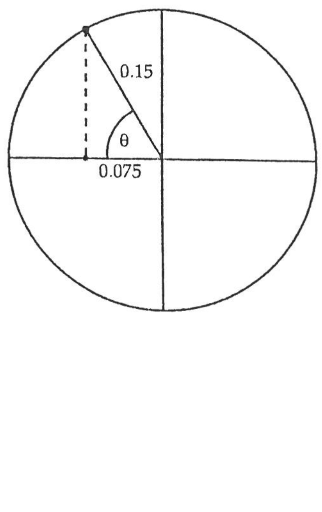


1 mark for an arrow direction close to right angle to pendulum arm.

(f) No *(1 mark)* or "yes, every point along the path is a maximum", ie with description.

(g) Gravitational potential energy and kinetic energy. *(1 mark for both)*

(h)



$\cos\theta = \frac{0.075}{0.15}$

$= 0.5$

$\theta = 60°$ or $= \frac{\pi}{3}$

time $= \frac{60}{360} \times T$

$= 0.21666$

$= 0.22$ s

Showing θ and $\cos\theta$, (or by any other reference circle method) *(1 mark)*
Taking θ as fraction of T *(1 mark)*
Answer *(1 mark)*

Question 4: Gravity (15 marks)

(a) (i) $F = \frac{Gm_1m_2}{r^2}$

$= \frac{6.7 \times 10^{-11} \times 7.0 \times 10^4 \times 2.0 \times 10^4}{20 \times 20}$

$= 2.345 \times 10^{-4}$

$= 2.3 \times 10^{-4}$ N

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

(ii) No *(1 mark)*, this is a tiny force, equivalent to the weight of 23 mg on Earth.
Any similar comparison *(1 mark)*

(b) (i) $a = \frac{v^2}{R}$

$= \frac{1016^2}{3.8 \times 10^8}$

$= 2.716 \times 10^{-3}$

$= 2.7 \times 10^{-3}\ ms^{-2}$

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

(ii) $a = \frac{GM}{R^2}$

$= \frac{6.7 \times 10^{-11} \times 6.0 \times 10^{24}}{\left(3.8 \times 10^8\right)^2}$

$= 2.8 \times 10^{-3}\ ms^{-2}$

or $a \propto \frac{1}{R^2}$

$= 9.8\left(\frac{1}{60}\right)^2$

$= 2.72 \times 10^{-3}\ ms^{-2}$

Either calculation *(1 mark)*
Either answer *(1 mark)*
The centripetal acceleration is produced by the gravitational attraction (and so will be the same).
Explanation *(1 mark)*

(c) (i) $v = \frac{d}{t}$

$= \frac{2\pi R}{T}$

$= 7.272 \times 10^{-5} \times R$

$2\pi R$ (1 mark)
Divide by T (1 mark)

(ii) $F = \frac{GMm}{r^2}$

$= \frac{mv^2}{R}$

$\frac{GM}{R} = v^2$

$v = \sqrt{\frac{GM}{R}}$

Equating the two (1 mark)
Rearrange properly (1 mark)

(iii) $\sqrt{\frac{GM}{R}} = \frac{2\pi R}{T}$

$R^3 = \frac{GMT^2}{4\pi^2}$

$R = 4.2 \times 10^7$ m

Equating the two expressions from (i) and (ii) (1 mark)
Answer (reasonable) (1 mark)

Question 5: Electrons (12 marks)

(a) (i) $P = VI$

$I = \frac{72}{12}$

$= 6.0$ A (1 mark)

(ii) $R = \frac{V}{I}$

$= \frac{12}{6.0}$

$= 2.0\ \Omega$

Formula (1 mark)
Substitution (1 mark)

(b) (i) $R_{parallel}$ = half of 0.5

or $\frac{1}{R_{||}} = \frac{1}{0.5} + \frac{1}{0.5}$

$R_{||} = 0.25\ \Omega$ (1 mark)

$R_{total} = 2.25$

$= 2.3\ \Omega$

Answer (1 mark)

(ii) $I = \frac{V}{R}$

$= \frac{14}{2.3}$

$= 6.087$

or $\frac{14}{2.25} = 6.222$ so answer is 6.1 or 6.2 A.

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

(iii) $V = IR$

$= 6.1 \times 2$

$= 12.2$

or $6.2 \times 2 = 12.4$

so answer is 12 V

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

(c) (i) $V_q = \frac{1}{2}mv^2$

$v = \sqrt{\frac{2Vq}{m}}$

Equating formula (1 mark)
Correct rearrangement (1 mark)

(ii) $v = \sqrt{\frac{2 \times 2.7 \times 10^4 \times 1.6 \times 10^{-19}}{9.1 \times 10^{-31}}}$

$= 9.744 \times 10^7$

$= 9.7 \times 10^7\ ms^{-1}$

Consistent answer (less than speed of light or faster than snail's pace). (1 mark)

Question 6: Capacitors (14 marks)

(a) In any 3.0 s interval the voltage drops to approximately 0.37 (that is, 1/e) of its starting value, ie 12 V drops to 4.4 V in 3.0 s.
Using numbers (1 mark)
Explanation (1 mark)

(b) $\tau = RC$

$3.0 = 22 \times C$

$C = \frac{3.0}{22}$

$= 0.1364$

$= 0.14$ F

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

(c) A larger capacitor stores more charge and so will maintain a current longer when the TV is switched off.
Any similar explanation involving charges and flow of charge (2 marks)

Question 7: Inductance (mean 3.8/14)

Very few candidates showed a thorough understanding of inductance.

(a) Done quite well but too many gave a negative, and so meaningless, answer.
(b) Well done, consequentially from (a).
(c) Very poorly done, and working showed little physical understanding. Attention to detail is required for this type of question, ie 0.27 A was required to be calculated and labelled, as was 12 V. More care is needed with showing asymptotic behaviour in a question like this.
(d) Very poorly done indeed.

Question 8: AC Electricity (mean 5.5/11)

(a) Very well done.
(b) Very poorly done. Rectification was not recognised by many and few noted the peak voltage or the period. The maximum voltage was often written as 230. Full wave, and presumably half wave rectification seems to be a problem area for many candidates.
(c) (i) Done well by some but many missed 2π as part of ω.
(ii) Poorly done by most, who used 45 Ω as the impedance.
(iii) Many candidates saw the r.m.s. symbols and immediately did something with √2.

Question 9: Sound (mean 8.0/14)

(a) Well done, but many candidates used only 2 significant figures here.
(b) Well done in general.
(c) This question was not done well. Work must be set out clearly for markers to follow. Many either did not choose the appropriate sign or performed one of a variety of odd calculations.
(d) Well done, but many forgot to divide by 4.
(e) Satisfactory, but many did not indicate the position of the antinodes or had an antinode indicated too far in from the end of the pipe. Drawing the picture was not enough.
(f) Too many thought that this was about beats or the Doppler effect.
(g) Many got sidetracked here or continued with their Doppler answer from (f).

Question 10: Radio and Light (mean 10.2/16)

(a) Well done by most, although some used the speed of sound instead of the speed of light.
(b) Well done by most.
(c) Very few could get diffraction and interference. Many thought constructive and destructive interference were two separate phenomena. Correct terminology was lacking in many cases.
(d) Even though the formula was given this problem proved difficult for those with poor mathematical skills. Many candidates solved for d, not realising that the x/L was the replacement for sin θ in the regular formula: $n\lambda = d \sin\theta$, where d is the slit separation.
(e) Well done by most, although often by guessing, it would seem.
(f) (i) Well done by some, but ignored by many.
(ii) Many arrived at 1500 m because they were in degree mode on their calculator.
(g) Many did not read the question with sufficient care. A variety of ingenious answers were given, but all were a waste of time if the question had not been read with care.

Question 11: Atoms (mean 5.7/12)

(a) (i) Well done by most candidates.
(ii) A little harder but generally well done by those who attempted it.
(b) Only a few candidates correctly described **n** but most knew what **h** was.
(c) Many had good ideas but confusing expression meant few received all points. Given the importance of the photoelectric effect in modern physics, this is very disappointing.
(d) Little or no understanding appeared here. Most did not notice the polarity of the cell and just wrote down the "stopping voltage" answer they had encountered earlier in class.

Question 12: Nuclear (mean 6.2/12)

(a) Well done.
(b) Well done, but "gamma particle" appeared regularly, and this is of concern.
(c) Well done.
(d) Well done.
(e) Poorly done with "e" the most common error. Half-lives relate to the time constant of the exponential process, and candidates seem unaware of the "time constant" and its power to influence the shape of the time curve of an exponential function.
(f) Very poorly done indeed and obviously not being taught in many schools.
(g) Candidates need to know that a chain reaction happens all the time in a reactor. Many did not understand that this would be a "controlled-power-increase" event and went straight into "meltdown" descriptions. The candidates may not understand that some exponential increases can have a very slow *time constant* and therefore have only small changes in power over reasonable time periods.

(e) Units were poorly done here also. Many candidates were not able to figure out what the unit must be from any formula they used.

(f) (i) Quoting the previous numerical answer was not sufficient here.

(ii) Very well done.

Question 3: Simple Harmonic Motion (mean 8.1/14)

(a) Well done in general but errors often occurred in manipulation of the equation to remove the square root.

(b) Well done by most. It seems that many candidates are not familiar with "show that" type problems as statements lacked a logical sequence.

Candidates must be encouraged not to attempt to "fudge" or shorten their written answers.

(c) Generally well done.

(d) Well done by most, but many stated "equilibrium point" without defining where that might be.

(e) Very few indicated in their figure that acceleration made a right angle to the pendulum arm. Note that the right angle only applies to the two end points, as the acceleration at the midpoint of the swing is the usual centripetal acceleration towards the centre of rotation.

(f) Well done in general.

(g) Specifically *gravitational* potential energy was required here, since there are several sorts of potential energy.

(h) Those who were familiar with the reference circle did well. No marks were given for finding the correct answer by formula. Oddly, many described in detail how the problem might be done but did not actually do it.

Candidates must read the questions.

Question 4: Gravity (mean 5.7/15)

Many candidates did not seem to be prepared at all for this question. It is now back in the prescription and schools were notified early in 1998.

(a) (i) Well done by most but many used $r = 10$ m instead of 20 m. Perhaps if the symbol had been d instead of r this may not have happened. Also, the distance r was often not squared during the calculation.

(ii) Most candidates realised that the force was insignificant but many did not compare it numerically with a common force they knew.

Note: gravity = 9.8 ms^{-2} is *not* a force, but was the most common answer used for comparison.

(b) (i) Poorly done in general. Many calculated F_c and forgot to then convert to acceleration.

(ii) Many simply redid the calculation in part (i) here. Very few could see that the centripetal acceleration was provided by the gravitational attraction, even if they had done the mathematics correctly.

(c) (i) An expression was required with v as the subject, not just with v in it somewhere. Many used πr^2 instead of $2\pi r$.

(ii) Many attempted to equate the two expressions but could not. Clearly the mathematical ability of many candidates was not adequate here.

(iii) Answers like 2 cm or 10^{22} m were not given marks, even if the consequential algebra followed a mistake in parts (i) or (ii).

Candidates must check that their answers are sensible.

Question 5: Electrons (mean 8.7/12)

(a) (i)(ii) Well done by most, but significant figures were a problem.

(b) (i) Poor understanding of what is a simple parallel resistance situation. This is disappointing since it is really form five work.

(ii) Well done in general.

(iii) Well done except some gave answers larger than 14 V.

(c) (i) Most could do this and were able to rearrange properly.

(ii) Many forgot to take the square root, or if (i) had not been done properly, candidates then came up with velocities bigger than the speed of light. Conversely, in some cases the electrons would have taken five years to reach the tube's front screen!

Candidates must check that their answers are sensible.

Question 6: Capacitors (mean 8.9/14)

(a) Generally well done, but many used 67%. Candidates needed to use the graph and explain the answer.

(b) Well done but some used the wrong formula.

(c) Many did not relate their answers to charge/electrons and so lost marks in what was a very easy question.

(d) Well done. One or two significant figures were accepted.

(e) Many added capacitors as if they were in series.

(f) Well done.

(g) Well done but many used the charge they had calculated in (d) instead of that given in the question for the combination.

Candidates must read the question.

(d) $Q = CV$

$= 1.0\times10^{-6}\times100$

$= 1.0\times10^{-4}$ C

Formula and substitution *(1 mark)*

Answer *(1 mark)*

(e) $C_{parallel} = C_1 + C_2 + C_3$

$= 3.0\times10^{-6}$ F

Formula and substitution *(1 mark)*

Answer *(1 mark)*

(f) $V = \frac{Q}{C}$

$= \frac{6.0\times10^{-4}}{3.0\times10^{-6}}$

$= 200$ V

Formula and substitution *(1 mark)*

Answer *(1 mark)*

(g) $E = \frac{1}{2}CV^2$

or $E = \frac{1}{2}QV$

Either formula and substitution *(1 mark)*

To get 0.06 J *(1 mark)*

Question 7: Inductance (10 marks)

(a) $V = \frac{LdI}{dt}$

$410 = L\times\frac{5.0}{0.012}$

$L = 410\times\frac{0.012}{5}$

$= 0.98$ H (no marks if negative)

Formula and substitution *(1 mark)*

Answer *(1 mark)*

(b) $E = \frac{1}{2}LI^2$

$= \frac{1}{2}(0.98)(25)$

$= 12.25$

$= 12$ J

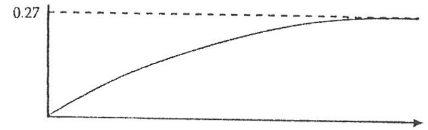
Formula and substitution *(1 mark)*

Answer *(1 mark)*

(c) $I = \frac{V}{R}$

$= \frac{12}{44}$

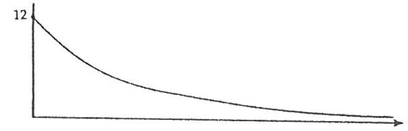
$= 0.27$ A



Asymptote indicated *(1 mark)*

Shape approaching asymptote *(1 mark)*

0.27 A *(1 mark)*



1 mark if 12 V start for the line, 1 mark for shape and nearly-zero asymptotic approach.

(d) $\tau = \frac{L}{R}$

$= \frac{0.22}{44}$

$= 5\times10^{-3}$ s

0.5 s is then about 100 time constants so steady state of zero has essentially been reached.

"zero" for *(1 mark)*

Question 8: AC Electricity (11 marks)

(a) $\frac{V_1}{V_2} = \frac{N_1}{N_2}$

$\frac{230}{12} = \frac{500}{N}$

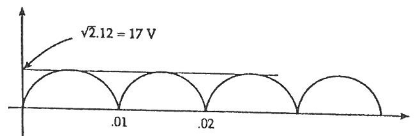
$N = 26.08$ turns

Either 26 or 27 accepted.

Formula and substitution *(1 mark)*

Answer *(1 mark)*

(b)



17 V peak shown *(1 mark)*

Positive (magnitude) sine or cosine with no gaps *(1 mark)*

Correct period of 0.02 s *(1 mark)*

(c) (i) $X_L = \omega L$

$= 2\pi fL$

$= 2 \times \pi \times 50 \times 0.22$

$= 69.115$

$= 69\ \Omega$

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

(ii) $Z = \sqrt{R^2 + X_L{}^2}$

$= \sqrt{45^2 + 69^2}$

$= 82.37$

$= 82\ \Omega$

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

(iii) $I = \frac{V}{Z}$

$= \frac{230}{82}$

$= 2.805$

$= 2.8\ A$

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

Question 9: Sound (14 marks)

(a)

no need for labels

$\ell = \frac{\lambda}{4}$

$\lambda = 4 \times \ell$

$= 4 \times 0.120$

$= 0.480\ m$

(or similar reasoning)
Diagram *(1 mark)*
Reasoning *(1 mark)*

(b) $v = f\lambda$

$f = \frac{v}{\lambda}$

$= \frac{331}{0.480}$

$= 689.58$

$= 690\ Hz$

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

(c) $f' = \frac{f.c}{(c - v)}$

$1010 = \frac{1000. \times 331}{(331 - v)}$

$v = 3.277$

$= 3.28\ ms^{-1}$

Formula and substitution *(1 mark)*
Using minus sign *(1 mark)*
Answer *(1 mark)*

(d) $331 = 1000\lambda$

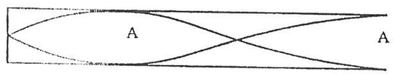
$\ell = \frac{\lambda}{4}$

$= \frac{0.331}{4}$

$0.0828\ m$

Correct ℓ expression *(1 mark)*
Finding λ *(1 mark)*
Answer *(1 mark)*

(e)



Both antinodes labelled (and if drawn, have a correct shape). *(1 mark)*

(f) At Y she hears 690 Hz (maximum volume) and as she walks towards Z volume decreases (as she passes through an area of destructive interference). The pattern may repeat on the way to Z. (Not Doppler effect or beats)
Explanation of interference pattern *(2 marks)*

(g) Echoes (reflections) from walls will disrupt the interference pattern *(1 mark) for similar reasoning.*

Question 10: Radio and Light (16 marks)

(a) $c = v$

$= f\lambda$

$\lambda = \frac{3.0 \times 10^8}{1.2 \times 10^6}$

$= 250\ m$

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

University Entrance, Bursaries and Scholarships
PHYSICS 1998

Marking Schedule and Examination Commentary

GENERAL

The 1998 paper was much the same as in recent years, but it was less contextual, as more emphasis was placed on algebraic manipulation. The paper was straightforward and most candidates were able to finish in the time available. There was no evidence of candidates answering the last questions poorly due to lack of time. In short, the candidates who were well prepared found it easy to achieve good marks.

There were several "show that" questions and these were not answered very well. Logical and clear setting out is required in order to show that the candidate knows how to get to the given answer. Many candidates did not read the questions with sufficient care and wrote answers to incorrect questions that only they perceived.

The allocation of marks for significant figures and units was similar to previous years and in general the units were done well. However, most candidates lost the four marks for significant figures by the end of the paper — more through lack of care than lack of understanding.

Several descriptive responses were required, and these were often done poorly. Questions requiring descriptive sentences need to be practised far more extensively if candidates are to be fully prepared for the University Bursaries examination. Sentence structure and spelling were poor, as well as simple readability of the handwriting. Candidates must ensure that others can read their handwriting easily.

The need for clarity and *single* interpretation is especially true for symbols and numbers. Candidates should be made aware that it is not the job of markers to know whether a sloppy number symbol was intended to be a 5 or 6. Similarly, the habit of some candidates was to write over one number with another number. It is important that answers are very clear so there is no possibility of misinterpretation by markers.

Another area of candidate responsibility is in simple transcription of numbers from written result to the answer box or row. Markers must follow the rule that the last answer is to be considered as the correct one, even when it looks like a simple error in transcription. Powers of ten in answers were often copied incorrectly by candidates.

COMMENTS ON SPECIFIC QUESTIONS

(Note: The mean mark in each case has been obtained from a sample of papers.)

Question 1: Rotational Motion (mean 8 0/11)

(a) Well done by most candidates, but some tried to "fudge" it and did not show the 2π factor.
(b) Well done by most, although some candidates did not incorporate any acceleration into the problem and gained zero marks.
(c) Well done in general with significant figure errors being the only real problem.
(d) Very well done by most, though vertical motion was usually overlooked.
(e) (i) Very well done.
(ii) A few used centrifugal and many used a variety of spellings of centripetal. It is fortunate that marks were not deducted here for spelling. Only a very few gave "friction" which, while strictly true, was not the common force name being sought here.
(f) Well done, but significant figures was a problem here also.

Question 1 was supposed to settle candidates into the examination and it seemed to do that adequately.

Question 2: Torques and Angular Momentum (mean 9.7/12)

(a) Most candidates gave the correct formula, however, many considered that torque was constant and so force decreased. Even if they knew the answer, a clear, descriptive sentence was required here, as well as quoting the correct formula. Many candidates stated confusing sentences because they insisted on referring to torque as just "force"— the same term as they had applied to the F of the torque equation.
(b) Well done, with significant figures the only problem.
(c) Very well done, again with significant figures the only problem.
(d) Units were poorly done in this question. 0.05 was not accepted since it meant a deliberate 1 sf answer rounding.

(f) $1\ \text{eV} = 1.6\times10^{-19}\ \text{J}$

so $2\times10^{8}\ \text{eV} = 2\times\left(1.6\times10^{-11}\right)\ \text{J}$

$= 3.2\times10^{-11}\ \text{J}$

or $3\times10^{-11}\ \text{J}$ (1 sf)

Answer *(1 mark)*

(g) A slow rise or increase in power output, or, slightly more thermal energy produced. Not just "a chain reaction". *(1 mark)*

(h) A rapid/explosive rise in power output; an exponentially-increasing number of disintegrations that can lead to overheating and meltdown; fission events per second increasing too fast for usual control devices to be able to function effectively.

Answer *(1 mark)*
Reasonable explanation *(1 mark)*

(i) $E = mc^2$

$m = \frac{E}{c^2}$

$= \frac{2.0\times10^{14}}{\left(3.0\times10^{8}\right)^2}$

$= 2.2\times10^{-3}\ \text{kg}$

$= 2.2$ grams

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

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PHYSICS

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University Entrance, Bursaries and Scholarships Examination

79 Taranaki Street, Wellington.
PO Box 160, Telephone: 04 802 3000, Fax: 04 802 3113

(b) $\frac{\lambda}{2} = 0.90$ m

$\lambda = 1.8$ m

$f = \frac{v}{\lambda}$

$= \frac{3.0 \times 10^8}{1.8}$

$= 1.666 \times 10^8$

$= 1.7 \times 10^8$ Hz

Correct λ *(1 mark)*
Answer *(1 mark)*
Not formula and substitution.

(c) Diffraction and interference. *(1 mark each)*

(d) $n\lambda = \frac{dX}{L}$

$X = \frac{Ln\lambda}{d}$

$= \frac{1.0 \times 1.0 \times 5.893 \times 10^{-7}}{5.0 \times 10^{-4}}$

$= 1.178 \times 10^{-3}$

$= 1.2 \times 10^{-3}$ m

Formula + rearrange *(1 mark)*
Substitution *(1 mark)*
Answer *(1 mark)*

(e) Spacing would be less, ie lines closer together. *(1 mark)*

(f) (i) $\theta = \frac{1.22\lambda}{d}$

$= \frac{1.22 \times 1.0 \times 10^{-3}}{0.5}$

$= 2.44 \times 10^{-3}$

$= 2.4 \times 10^{-3}$ rad

Substitution *(1 mark)*
Answer *(1 mark)*

(ii) $\tan\theta = \frac{r}{s}$

or $\theta = \frac{r}{s}$

$r = 2.4 \times 10^{-3} \times 3.6 \times 10^7$

$= 8.8 \times 10^4$ m

or 88 km (or 86 400 m)

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

(g) Larger diameter transmitting dish, smaller wavelength signal, more powerful transmitter. *(1 mark each)* for first two answers given.

Question 11: Atoms (12 marks)

(a) (i) $E = hf$ *(1 mark)*

$f = \frac{3.0 \times 10^8}{5.5 \times 10^{-7}}$

$= 5.45 \times 10^{14}$ Hz *(1 mark)*

so $E = 6.626 \times 10^{-34} \times 5.45 \times 10^{14}$

$= 3.6 \times 10^{-19}$ J (or J / photon) *(1 mark)*

(ii) $n = \frac{\text{power}}{\text{energy}}$

$= \frac{1.0 \times 10^3}{3.6 \times 10^{-19}}$

$= 2.77 \times 10^{15}$

$= 2.7$ or 2.8×10^{15}

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

(b) n is positive integer or natural number or energy level or (principal) quantum number or 1, 2, 3 ... *(1 mark)*

h is Planck's constant or 6.626×10^{-34} J s *(1 mark)*

(c) A minimum energy is needed to free each electron; interaction of one photon with one electron; independent of intensity; blue has: a higher frequency, shorter wavelength, higher photon energy than red and so may be above the threshhold frequency of metal.

Frequency related to energy *(1 mark)*
Threshhold/cutoff frequency *(1 mark)*
Excellent description of process *(1 mark)*

(d) Voltage gradient ensures collection of released electrons and so maximises current; electrons are attracted to positive terminal and so efficiency is increased. Candidates must have noticed polarity of cell.

For clear description of both effects *(2 marks)*

Question 12: Nuclear (11 marks)

(a) 36 *(1 mark)*

(b) Gamma ray, high frequency electromagnetic radiation (not gamma particle and not just energy). *(1 mark)*

(c) −1 *(1 mark)*

(d) Electron or e or β *(1 mark)*

(e) c *(1 mark)*