University Entrance, Bursaries and Scholarships Examination
PHYSICS 2002

Marking Schedule and Examination Commentary

General Comments

The 2002 paper was similar in style to recent years but was more challenging than the 2001 paper. Only the most able candidates scored more than 130 marks. Most questions had the more challenging parts towards the end and only the most able candidates were able to successfully answer these parts. As in previous years, the paper was based on contextual algebraic and descriptive questions. Nearly all candidates appeared to finish the paper in the allocated time, apparently with sufficient time to check their answers.

'Show that' questions have been well answered. Candidates seemed to have been clearly instructed on how to gain full marks in this type of question. This was most pleasing.

Candidates were very proficient at using formulae and solving straightforward problems. Their mathematical skills were sufficient for the level of problems posed. It was clear that most candidates were well prepared in this aspect of physics. However, candidates' ability to explain physics concepts and phenomena was extremely disappointing.

This paper included more 'explain' questions than in previous years. They were handled very poorly by all but the most able candidates. Candidates need to be given a considerable amount of practice at answering this type of question. Candidates need to read the question very carefully and use simple, clear English to communicate physics concepts.

Most candidates were well prepared to answer questions from all four sections of the prescription. It was clear that a large number of candidates had been extremely well taught. The mechanics and waves sections of the prescription were well understood by most candidates but electricity, electromagnetism and atomic physics were poorly understood. The following is a list of areas of concern:

- the concept of resonance
- the concept of diffraction
- kinetic energy in SHM
- the concept of change in momentum
- the vector nature of momentum
- applications of Newton's Laws of Motion
- the concepts of potential difference, current, resistance, power and back emf
- the concept of mutual inductance
- the concept and calculation of impedance
- the concept of binding energy
- the Bohr atom.

Units were handled well by most candidates this year and a considerable number gained full marks. Angular momentum was the only unit consistently poorly done. Significant figures were also handled better this year. This year's paper was more straight-forward in this respect but candidates do seem to be improving in this area.

The general presentation of responses from candidates was much improved this year. Some candidates still need to be reminded that they should be trying to produce a clear, tidy script which is easy to read. The use of pencil and/or correction fluid was still widespread. A number of candidates submitted scripts entirely in pencil. Candidates are strongly advised not to use pencil and/or correction fluid.

Comments on Specific Questions

Note: the mean mark in each case has been obtained from a sample of papers and is unscaled.

Question One: Tobie and The Shower
(mean 8.8/14)

As in earlier years, Question One was designed to be reasonably straightforward in order to settle candidates into the examination.

(a) Well done by almost all candidates.

(b) Well done by most candidates. Some candidates were unable to show that wavelength was a function of length.

(c) Well done by most candidates. A reasonable proportion had problems with the significant figures.

(d) Well done.

(e) Well done.

(f) Poorly done. Very few candidates were able to define resonance.

(g) Very poorly done. This was a difficult question which required candidates to visualise the three-dimensional nature of the shower box.

Question Two: The Concert Hall (mean 6.7/14)

(a) Well done.

(b) Generally well done, but a number of candidates had difficulty defining *diffraction*. Confusion with *refraction* was common.

(c) Poorly done. The vast majority of candidates failed to acknowledge the wave nature of light and say why it did not noticeably diffract. The role of relative gap size in diffraction is not well understood.

(d) Most candidates were familiar with the Doppler Effect. Identifying the increase in wavelength was less well done.

(e) Well done by most. Candidates showed a high level of mathematical skills in this question.

(f) Reasonably well done. Candidates who recognised that a kinematic formula needed to be applied scored well.

Question Three: Ganymede (mean 7.4/11)

(a) Well done.

(b) Well done by most candidates. A reasonable proportion had problems with the significant figures.

(c) Although this question was generally attempted well by the majority of the candidates, there was a significant proportion that simply defined the difference between vector and scalar quantities.

(d) Well done by most candidates.

(e) Reasonably well done. Despite being told to equate the two forces, too many candidates did not know which equations to use. Those that did start correctly usually managed to gain full marks.

(f) Reasonably well done. The most common errors involved omitting exponents during the substitution. A small proportion of candidates had problems with the significant figures.

Question Four: The Internal Combustion Engine (mean 9.2/16)

(a) Well done.

(b) Well done by most candidates. A small proportion had problems with the significant figures.

(c) Generally well answered. Some candidates used the formulae $v = -A\omega\sin\omega t$ or $v = A\omega\cos\omega t$ and failed to recognise that $\cos\omega t$ or $\sin\omega t = 1$ at maximum.

(d) Poorly done. Most candidates were able to calculate the maximum energy and the period but very few knew how to plot the graph. Very few recognised that a sine squared graph was required. There were many different shapes drawn, the most popular being the 'McDonald's Arches'.

(e) Generally well answered.

(f) Generally well answered. Many candidates did not show sufficient working to gain two marks for this question. Some appeared to have worked backwards from the equation given.

(g) Generally well answered, although a significant number of candidates lost marks through simple mathematical errors. Many had problems with the significant figures.

Question Five: The Snooker Game (mean 11.5/21)

(a) Well done.

(b) Most candidates calculated the answer but failed to show that the initial momentum was zero.

(c) Well done.

(d) Well done by most candidates.

(e) Well done by most candidates, especially those who gained full marks in part (d).

(f) Very poorly done. Only the most able candidates could successfully answer this question. The vector nature of momentum was poorly understood by most candidates.

(g) Very few candidates gained two marks. A large number understood that friction was involved but did not identify that a torque was created.

(h) Generally well done but a large number of candidates used 'sec' for the unit of time.

(i) Poorly done. A large group of candidates had no idea how to calculate the gradient. Most candidates did not supply the appropriate unit for the gradient.

(j) Poorly done. Many candidates discussed SHM and damping! A number could not explain why the ball did not bounce as high.

(k) Generally well done, but a significant number of students confused the situation with that of a constant velocity situation and subsequently calculated the answer to be 2.50 m.

Question Six: The Zoo Trip (mean 4.8/9)

(a) Well done.

(b) Well done.

(c) Generally well done. About half of candidates got full marks for this question. A large number appeared to work backwards to get the correct working.

(d) Very poorly done. Only about 10% of candidates gained any marks at all. A large number did not attempt the question. The most common answer was 44.1 N.

Question Seven: The Electron Microscope (mean 2.1/7)

Very few candidates scored full marks for this question. Well over 20% of all candidates scored zero and a large number did not attempt the question.

(a) Very poorly done. The concept of potential difference was not understood by the vast majority of candidates.

(b) Generally well done. Most candidates scored one mark but failed to show where their answer came from.

(c) Poorly done. This question was answered disappointingly, given that a similar question was asked a few years ago. Many candidates considered the situation to be analogous to a parallel plate capacitor! A large number of candidates calculated values for the answer greater than the speed of light. This is of great concern – candidates need to check the 'sense' of their answers.

Question Eight: The Contact Timer (mean 8.3/16)

(a) Well done.

(b) Well done.

(c) Poorly done. Most candidates used the current from part (b) in attempting to calculate the new resistance. Very few candidates used the idea of ratios.

(d) Well done.

(e) Generally well done. A number of candidates used charge Q instead of capacitance C in the time constant formula. A considerable number had problems with the significant figures.

(f) Very poorly done. A number of candidates simply used the formula to explain the phenomenon. This gained zero marks. Very few candidates could explain the situation by using correct physical principles. Statements were made such as: 'voltage flows', 'current slows down if resistance increases', 'it is harder for current to flow if resistance increases', 'resistance blocks current'. These statements were common and are of considerable concern.

(g) Generally well done. A number incorrectly used 63%.

(h) A very difficult question designed to challenge top candidates. This question was poorly done by the weaker candidates but some of the better candidates were able to work through to a correct solution. A number used the approach that recognised the nature of the exponential curve and set up a geometric series and calculated the number of time constants needed. A very clever approach.

Question Nine: The Transformer (mean 4.2/9)

Many candidates scored full marks for this question but a larger group scored zero, often by omitting the entire question.

(a) Generally well done.

(b) Reasonably well done but carelessness in transcribing figures was a problem for a considerable group of candidates.

(c) Poorly done. Only the better candidates used conservation of power and therefore most candidates scored zero. A considerable number had problems with the significant figures.

(d) Generally well done. Most candidates lost a mark as they used the self-inductance formula rather than the mutual inductance formula. It appears that the topic of mutual inductance may not be taught in every school.

(e) Reasonably well done. A number of candidates lost marks by being too vague in their responses.

Question Ten: Inductors (mean 5.0/12)

Candidates continue to struggle with AC electricity. This question was poorly done. A number of candidates showed a very real lack of solid understanding of current, voltage, power, impedance and back emf.

(a) Well done.

(b) Generally well done, but some candidates were confused about the correct unit for reactance. A considerable number had problems with the significant figures.

(c) Poorly done. Few candidates knew how to calculate the impedance. A large group of candidates scored zero for this question.

(d) Poorly done. Very few candidates connected brightness to power. A large group simply stated that nothing changed. This is poor examination technique as the question is worth two marks and a reasonably detailed explanation was required for full marks.

(e) Well done by those who had successfully completed part (d).

(f) (i) Well done.

(ii) Poorly done. Most candidates attempted to explain the decrease in brightness by using back emf. Very few were able to do this successfully. There appeared to be a real lack of understanding of back emf. A number of candidates wrote 'a current set up to oppose the forward current'. The candidates who attempted to argue on the basis of increased impedance struggled to successfully link the necessary concepts together.

Question Eleven: Nuclear Physics (mean 5.7/10)

(a) Well done.

(b) Generally well done. Some exotic particles were mentioned here. A number of candidates gave the symbol rather than the name.

(c) Reasonably well done. About 40% of candidates scored zero for this question. Most of the other candidates scored full marks. A large number did not realise that a mass deficit was needed in order to calculate the energy released.

(d) Generally well done. Two was a common answer.

(e) Reasonably well done. A number of candidates did not realise that the released neutrons were then able to react with other uranium atoms. Many stated that the neutrons would react with the barium and/or krypton atoms.

(f) Very poorly done. Only about 10% of candidates managed to score marks. The concept of binding energy was a complete mystery to virtually all candidates. A number discussed the binding energy of iron. Careful reading of the question was required.

Question Twelve: The Bohr Atom (mean 4.2/13)

This question was poorly done. The last two parts of this question were challenging but there was a considerable number of straightforward questions. Over 10% of all candidates scored zero for this question, with a large number not attempting the question at all. It appears that more teaching time needs to be dedicated to this part of the prescription.

(a) Reasonably well done. A number of candidates gave very vague answers. A considerable number included zero in their list of possible n values.

(b) Poorly done. Most candidates struggled to define 'quantised'.

(c) Poorly done. Nearly all candidates lost the first mark as they believed the third excited state was $n = 3$. Most managed to correctly follow through to gain one mark. A considerable number had difficulty stating the correct unit for angular momentum.

(d) Reasonably well done. A number of candidates used the wrong constant or incorrectly multiplied by the charge on the electron. A number had problems with the significant figures.

(e) Well done.

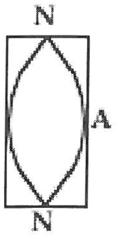
(f) Very poorly done. This was a difficult question designed to challenge the best candidates. Most candidates did not identify the transition required.

(g) Very poorly done. About 10% of all candidates gained full marks. A challenging question designed for the best candidates.

MARKING SCHEDULE

QUESTION ONE: TOBIE AND THE SHOWER (14 marks)

(a)



(1 mark) for both nodes

(1 mark) for the antinode

(b) $L = \lambda/2$ (1 mark)

$L = 2.50$ m (1 mark)

($\lambda = 5.00$ m)

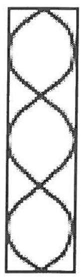
(c) $v = f\lambda$

$f = v/\lambda$

$= 335/5.00$ (1 mark)

frequency = 67.0 Hz (1 mark)

(d)



(1 mark) for node at each end

(1 mark) for 3 fundamentals as shown in 1(a)

(e) $v = f\lambda$ (wavelength =5/3 m)

$f = v/\lambda$

$= (335/5.00) \times 3$ (1 mark)

frequency = 201 Hz (1 mark)

(f) Driving frequency = natural frequency (1 mark)

Creating maximum amplitude (1 mark)

(g) Additional resonance comes from the standing wave in the horizontal direction ($\lambda = 2$ m). (2 marks)

QUESTION TWO: THE CONCERT HALL (14 marks)

(a) $v = f\,\lambda$

$\lambda = v/f$ (1 mark)

$= 335/220$ (1 mark)

($= 1.52$ m)

(b) Bending of waves/light/sound (1 mark)

Around an obstacle or through a gap (1 mark)

(c) Sound wave bends (due to diffraction) around entrance, enabling Lee to hear her. (1 mark)

Obstacle >> λ_{light} or obstacle $\approx \lambda_{sound}$ (1 mark)

Light does not diffract enough (to see Tobie) but the sound does. (1 mark)

(d) Wavelength increases which causes the frequency heard to decrease. (2 marks)

Doppler Effect mentioned = 1 mark

(e)

$$f' = f_o \frac{v_w}{v_w + v_s}$$

substitution f', f_o, v_w (1 mark) for correct formula or substitution

$$v_s = \frac{1120}{1080} \times 335 - 335$$

or appropriate working (1 mark)

Speed of cellphone = 12.4 m s^{-1} (1 mark)

(f) $v^2 = v_i^2 + 2ad$

$12.4^2 = 0^2 + 2 \times 9.8 \times d$ (1 mark)

distance fallen = 7.85 m (1 mark)

QUESTION THREE: GANYMEDE (11 marks)

(a) $60 \times 60 \times 24 \times 7.15$ (1 mark)

$(= 6.18 \times 10^5 \text{ s})$

(b)
$$v = \frac{2\pi R}{T}$$
$$= \frac{2 \times \pi \times 1.07 \times 10^9}{6.18 \times 10^5}$$ (1 mark)

linear speed $= 1.09 \times 10^4 \text{ m s}^{-1}$ (1 mark)

(c) Direction changes (1 mark)

(d) (1 mark)
$$a = \frac{v^2}{r}$$
$$= \frac{(1.09 \times 10^4)^2}{1.07 \times 10^9}$$

$(= 0.111 \text{ m s}^{-2})$ (1 mark)

(e)
$$\frac{GMm}{R^2} = \frac{mv^2}{R}$$ (1 mark)

$$v = \frac{2\pi R}{T}$$ (1 mark)

correct intermediate working leading to

$$\frac{GM}{R} = \frac{4\pi^2 R^2}{T^2} (= v^2)$$ (1 mark)

(f)
$$M = \frac{4\pi^2 R^3}{T^2 G}$$
$$= \frac{4\pi^2 (1.07 \times 10^9)^3}{(6.18 \times 10^5)^2 \times 6.67 \times 10^{-11}}$$ (1 mark)

mass of Jupiter $= 1.90 \times 10^{27}$ kg (1 mark)

QUESTION FOUR: THE INTERNAL COMBUSTION ENGINE (16 marks)

(a) $(4.00 \times 10^3 \times 2\pi)/60$ (1 mark) for $\times 2\pi$

$(= 419 \text{ rad s}^{-1})$ (1 mark) for /60

(b) $\omega = 2\pi f$

$f = 4.00 \times 10^3/60$ (1 mark)

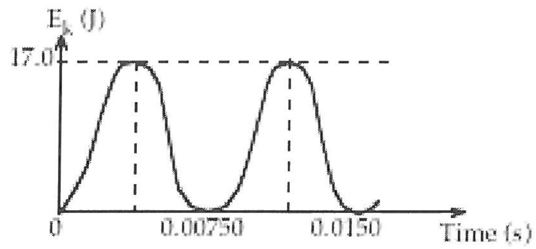
frequency = 66.7 Hz (1 mark)

(c) $v = A\omega$

$= 2.50 \times 10^{-2} \times 419$ (1 mark)

maximum velocity = 10.5 m s^{-1} (1 mark)

(d)



(1 mark) for 17.0J

(2 marks) for shape

(1 mark) indication of period

(e) $ma\ (= -m\omega^2 A)$

$= 0.31 \times (419)^2 \times 0.025$ (1 mark)

maximum force = 1360 N (1 mark)

or energy argument

(f) $\frac{1}{2}mv^2 = \frac{1}{2}kx^2$ (1 mark)

$v^2 = kx^2/m$ (intermediate step) (1 mark)

(g) $v = \sqrt{\frac{kx^2}{m}}$

$= \sqrt{\frac{3 \times 10^6 \times (2.16 \times 10^{-2})^2}{1.25 \times 10^3}}$ (1 mark)

$= 1.06 \text{ m s}^{-1}$

$= 106 \text{ cm s}^{-1}$ (1 mark)

QUESTION FIVE: THE SNOOKER GAME (21 marks)

(a) $E_k = \frac{1}{2} mv^2$ (1 mark)

$= \frac{1}{2} \times 0.173 \times 2.1^2$

(= 0.381 J) (1 mark)

(b) Change in momentum = $p_f - p_i$

$= mv_f - 0$

$= 0.173 \times 2.10$ (1 mark) (no indication of change then zero)

change in momentum = 0.363 kg m s^{-1} (1 mark)

(c) $F\Delta t = \Delta p$

$$F = \frac{\Delta p}{\Delta t}$$

$$= \frac{0.363}{0.300}$$ (1 mark)

average force = 1.21 N (1 mark)

(d) mvCosϑ or appropriate working (1 mark)

$= 0.173 \times 1.5 \times \text{Cos } 30$ (1 mark)

(= 0.225 kg m s^{-1})

(e) mvSinϑ or appropriate working

$= 1.5 \times 0.173 \text{ Sin } 30$ (1 mark)

= 0.130 kg m s^{-1} (1 mark)

(f) Momentum of white in y direction = initial – (d)(above)

= 0.3633 – 0.2247

= 0.1386 kg m s^{-1}

Momentum of white in x direction = (e) above

= 0.12975 kg m s^{-1} (1 mark)

$$p_{white} = \sqrt{(0.12975)^2 + (0.1386)^2}$$
$$= 0.189855 \text{ kg m s}^{-1}$$

$$v_{white} = \frac{p_{white}}{m}$$ (1 mark)
$$= \frac{0.189855}{0.173}$$

or any other valid method (2 marks)

speed = 1.10 m s^{-1} (1 mark)

(g) Friction (1 mark)

creates a torque (1 mark)

(h) time = 0.5 seconds (1 mark) (no sig fig)

(i) gradient = –10 m s^{-2} (1 mark) (no sig fig)

(j) Loss of (kinetic) energy in the collision (bounce) (1 mark)

doesn't bounce as high (therefore less time) (1 mark)

(k) $\frac{1}{2}$ × slope × time^2 or area under graph

= $\frac{1}{2}$ × 0.5 × 5.0 (1 mark)

height = 1.25 m (1 mark) (no sig fig)

or energy argument

QUESTION SIX: THE ZOO TRIP (9 marks)

(a) F = mg (1 mark)

= 9.00 × 9.80 (1 mark)

(= 88.2 N)

(b) Upwards (1 mark)

(c) Indication of unbalanced force = 4.50 × 9.80 = 44.1 N (1 mark)

Indication of total mass = 22.5 kg (1 mark)

Indication of derived *a* (1 mark)

$$= \frac{4.50 \times 9.80}{22.50}$$

($a = 1.96 \text{ m s}^{-2}$)

(d) Indication of resultant force of 8.82 N (4.5 × 1.96) (1 mark)

Indication of idea of sum of forces = ma (1 mark)

$T_2 = 35.3$ N (1 mark)

$$4.50 \times 9.8 - T_2 = 4.5 \times 1.96$$
$$44.1 - T_2 = 8.82$$
$$T_2 = 35.3 \text{ N}$$

QUESTION SEVEN: THE ELECTRON MICROSCOPE (7 marks)

(a) Difference in (electrical potential) energy per coulomb (1 mark)

between 2 points (1 mark)

(b)

$$I = \frac{Q}{t}$$

$$= 1.2 \times 10^{-8}\,\text{A}$$

$Q = 1.2 \times 10^{-8}$ C in one second (1 mark)

charge on one electron = 1.6×10^{-19} C

Number of electrons flowing =

$$\frac{1.2 \times 10^{-8}}{1.6 \times 10^{-19}}$$ (1 mark)

(= 7.5×10^{10})

(c) Calculate eV = $1.60 \times 10^{-19} \times 5.00 \times 10^{3} = 8.00 \times 10^{-16}$ J (1 mark)

$\frac{1}{2}mv^2$ = energy from part (1) (1 mark)

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

$$= \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 5000}{9.11 \times 10^{-31}}}$$

speed = 4.19×10^{7} m s^{-1} (1 mark) (no mark awarded for speeds > speed of light)

QUESTION EIGHT: THE CONTACT TIMER (16 marks)

(a) $R = R_1 + R_2$

$= 1.30 \times 10^3 + 1.00 \times 10^3$

total resistance $= 2.30 \times 10^3\ \Omega$ (1 mark) (2 or 3 sig fig)

(b) $V = IR$

$I = \frac{V}{R}$ (1 mark)

$= \frac{15.0}{2.30 \times 10^3}$ (1 mark)

$(= 6.52 \times 10^{-3}\ A)$

(c) Recognise voltage ratio 10:5 (total 15 V)

or resistor ratio 2:1 (1 mark)

$V = \frac{V_0 R}{R_T}$

$= 10$

$= \frac{15 \times R}{(R + 1300)}$

$R = 2.60 \times 10^3\ \Omega$ (1 mark) (2 or 3 sig fig)

(d) $Q = CV$ (1 mark)

$= 10 \times 1 \times 10^{-7}$ (1 mark)

$(= 1 \times 10^{-6}\ C)$

(e) $\tau = RC$

$= 5 \times 10^3 \times 1 \times 10^{-7}$ (1 mark)

time constant $= 5.00 \times 10^{-4}\ s$ (1 mark)

(f) Increased R therefore decreased I in circuit (1 mark)

Less current therefore longer time to discharge (1 mark)

(g) 37% of 10 V (1 mark)

voltage = 3.70 V (1 mark) (no sig fig)

(h)

$$V = V_o e^{-\frac{t}{\tau}}$$ (1 mark)

$$2 = 10e^{-\frac{t}{(5.00\times10^{-4})}}$$

$$\ell nV = \ell n\left(V_o e^{-\frac{t}{\tau}}\right)$$ (1 mark)

$$(\ell n10 - \ell n2)\tau = t$$

Contact time = 8.05×10^{-4} s (1 mark)

QUESTION NINE: THE TRANSFORMER

(9 marks)

(a) Step up (1 mark)

(b)

$$\frac{N_P}{N_s} = \frac{V_P}{V_s}$$

$$= \frac{240 \times 10\,000}{(1.20 \times 10^4)}$$ (1 mark)

number of turns = 200 (1 mark) (no sig fig)

(c)

$$I_p V_p = I_s V_s$$

$$I_p = \frac{I_s V_s}{V_p}$$

$$= \frac{(1.10 \times 10^{-3} \times 1.20 \times 10^4)}{240}$$ (1 mark)

current = 0.0550 A (1 mark)

(d)

$$V_s = -M\frac{\Delta I_P}{\Delta t}$$

$$= -0.215 \times \frac{1.00}{0.0210}$$ (1 mark) (lost mark if used L instead of M)

induced emf = 10.2 V (1 mark)

(e) Increase the rate of change of current in primary or turn switch on faster or get the current to change faster.

Reduce number of primary coils. (2 marks)

Increase number of secondary coils.

Put in an iron core.

1 mark awarded for laminate core without explanation; change the ratio of coils; different core (without explanation).

QUESTION TEN: INDUCTORS (12 marks)

(a) $\omega = 2\pi f$ (1 mark)

$= 2 \times \pi \times 50$

$\left(= 314 \text{ rad s}^{-1}\right)$

(b) $X_L = \omega L$

$= 2\pi \times 50.0 \times 0.190$ (1 mark)

reactance = 59.7 Ω (1 mark)

(c) $Z = \sqrt{R_T^2 + X_L^2}$ *or* words/vectors etc (1 mark) for impedance method

$= \sqrt{33^2 + 59.7^2}$

= 68.2 ohms (1 mark)

$I = \frac{V}{Z}$

$= \frac{20}{68.2}$

current = 0.293 A (1 mark)

(d) 12.0 Ω (1 mark)

(e) No change in power (for same brightness) (1 mark)

same current and same voltage (1 mark)

(f) (i) Decrease (1 mark)

(f) (ii) Impedance increases so current drops (1 mark)

Impedance increased so voltage across bulb drops (1 mark)

or

A back emf is produced in the inductor which opposes the (applied) current, reducing the power/brightness

QUESTION ELEVEN: NUCLEAR PHYSICS (10 marks)

(a)	$a = 1$	(1 mark)
	$b = 0$	(1 mark)
(b)	Particle X = neutron	(1 mark)
(c)	$\Delta m = 3.52 \times 10^{-3}$ amu $(=5.84(32) \times 10^{-30}$ kg)	(1 mark) for Δm
	$E=\Delta m \times 1.66 \times 10^{-27} \times c^2$	(1 mark)
	Energy $= 5.26 \times 10^{-13}$ J	(1 mark)
(d)	$k = 3$	(1 mark)
(e)	Three neutrons producing three more reactions	(1 mark)
	or $k > 1$ produces more than one reaction	
(f)	Products have higher binding energy	(1 mark)
	Difference between binding energy of products and reactants, therefore energy released	(1 mark)

QUESTION TWELVE: THE BOHR ATOM

(13 marks)

(a) 1, 2, 3, … (natural numbers) (1 mark)

(b) Discrete values (1 mark)

(c) $L = \frac{nh}{2\pi}$

Third excited state is n=4 (1 mark)

angular momentum = 4.22×10^{-34} J s or kg m^2 s^{-1} (1 mark)

(d) $\frac{2.18 \times 10^{-18}}{1.6 \times 10^{-19}}$ (1 mark)

= 13.6 eV

(1 mark)

(e) $\frac{-hcR}{n^2}$ (1 mark)

$= \frac{\left(6.63 \times 10^{-34} \times 3 \times 10^{8} \times 1.097 \times 10^{7}\right)}{9}$

$\left(= 2.42 \times 10^{-19}\ \text{J}\right)$

(1 mark)

(f) n = 2 to n = 1 transition (1 mark)

$\frac{1}{\lambda} = 1.097 \times 10^{7}\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$ (1 mark) for formula and integer substitution

$\lambda = 1.22 \times 10^{-7}$ m (1 mark) (3 or 4 sig fig)

or

an energy argument involving $\frac{-hcR}{n^2}$

(g) The reference point for zero (potential) energy is an infinite distance from the nucleus. (2 marks)

or

An ionised electron has zero energy so any electron closer must have negative energy.