RECOGNISING ACHIEVEMENT

Mark Scheme 2825/04
January 2002

ADVICE TO EXAMINERS ON THE ANNOTATION OF SCRIPTS

1. Please ensure that you use the **final** version of the Mark Scheme. You are advised to destroy all draft versions.

2. Please mark all post-standardisation scripts in red ink. A tick (✓) should be used for each answer judged worthy of a mark. Ticks should be placed as close as possible to the point in the answer where the mark has been awarded. The number of ticks should be the same as the number of marks awarded. If two (or more) responses are required for one mark, use only one tick. Half marks (½) should never be used.

3. The following annotations may be used when marking. No comments should be written on scripts unless they relate directly to the mark scheme. Remember that scripts may be returned to Centres.

   x = incorrect response (errors may also be underlined)
   ^ = omission mark
   bod = benefit of the doubt (where professional judgement has been used)
   ecf = error carried forward (in consequential marking)
   con = contradiction (in cases where candidates contradict themselves in the same response)
   sf = error in the number of significant figures

4. The marks awarded for each part question should be indicated in the margin provided on the right hand side of the page. The mark total for each question should be ringed at the end of the question, on the right hand side. These totals should be added up to give the final total on the front of the paper.

5. In cases where candidates are required to give a specific number of answers, (e.g. 'give three reasons'), mark the first answer(s) given up to the total number required. Strike through the remainder. In specific cases where this rule cannot be applied, the exact procedure to be used is given in the mark scheme.

6. Correct answers to calculations should gain full credit even if no working is shown, unless otherwise indicated in the mark scheme. (An instruction on the paper to 'Show your working' is to help candidates, who may then gain partial credit even if their final answer is not correct.)

7. Strike through all blank spaces and/or pages in order to give a clear indication that the whole of the script has been considered.

8. An element of professional judgement is required in the marking of any written paper, and candidates may not use the exact words that appear in the mark scheme. If the science is correct and answers the question, then the mark(s) should normally be credited. If you are in doubt about the validity of any answer, contact your Team Leader/Principal Examiner for guidance.

Abbreviations, annotations and conventions used in the Mark Scheme	/	= alternative and acceptable answers for the same marking point
	;	= separates marking points
	NOT	= answers which are not worthy of credit
	( )	= words which are not essential to gain credit
	___	= (underlining) key words which **must** be used to gain credit
	ecf	= error carried forward
	AW	= alternative wording
	ora	= or reverse argument

Question	Expected Answers	Marks	
1. (a)	radius of 1 nucleon/proton/neutron/H nucleus	1	[1]
(b)(i)	$r = 3.8 \times 10^{-15}$ m	1	
(ii)	$r_0 = r / A^{1/3} = 3.8 \times 10^{-15} / 20^{1/3}$ $= 1.4 \times 10^{-15}$ m	1	[2]
(c)	$\rho = m/V = m_0 / (\frac{4}{3}\pi r_0^3)$	1	
	$= 1.67 \times 10^{-27} / (\frac{4}{3}\pi [1.4 \times 10^{-15}]^3)$	1	
	$= 1.5 \times 10^{17}$ kg m^{-3} unit penalty	1	[3]
	(allow $1.4\text{-}1.5 \times 10^5$ from ecf)		
(d)	answer to **(c)** is much greater than 70 kg m^{-3}	1	
	mass of atom ≅ mass of nucleus	1	
	so volume of atom >> volume of nucleus	1	
	conclusion eg most of atom is empty space / filled with low density electron (wave)	1	[4]
(e)(i)	$V \propto A$ or $V = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi (r_0 A^{1/3})^3 = \frac{4}{3}\pi r_0^3 A$	1	
(ii)	separation of nuclei constant/always the same	1	[2]
2. (a)	both decelerate (as they approach each other) (1) both come to rest (1) then accelerate away (from each other) (1) final speeds equal initial speeds or equivalent (1) acceleration varies with separation (1) any three	3	[3]
(b)	as protons approach, k.e. changes to p.e.	1	
	when they are at rest, all energy is potential	1	
	as they recede, p.e. changes to k.e.	1	[3]
(c)(i)	$E_p = (1.6 \times 10^{-19})^2 / (4\pi \times 8.85 \times 10^{-12} \times 2.0 \times 10^{-15})$	1	
	$= 1.15 \times 10^{-13}$ J	1	
(ii)	two protons have 1.15×10^{-13} J, so each proton has 5.8×10^{-14} J	1	[3]

(d)(i)	k.e. of particles/protons increases with temperature	1	[1]
(ii)	$5.8 \times 10^{-14} = 2 \times 10^{-23} T$ $T = 2.9 \times 10^{9}$ K	1 1	[2]
3 (a)	mass = 1.67×10^{-27} kg charge = -1.6×10^{-19} C	1 1	[2]
(b)	Method 1 Only a small proportion of energy is available to create new particles because products carry away large amount of k.e. Method 2 Only small proportion of particles collide because large gaps between particles, so can easily miss.	1 1 1 1	[4]
(c)(i)	rest mass = $2 \times 1.67 \times 10^{-27} = 3.34 \times 10^{-27}$ kg so energy equivalent = Δmc^2 = $3.34 \times 10^{-27} \times (3 \times 10^{8})^2$ = 3.0×10^{-10} J	1 1 1	
(ii)	$E = 2hf$ $3 \times 10^{-10} = 2 \times 6.63 \times 10^{-34} f$ $f = 2.3 \times 10^{23}$ Hz unit penalty	1 1	
(iii)	circumstance: proton and antiproton are at rest/moving with negligible speed initially	1	[6]

4 (a)

	baryon	hadron	lepton	neutrino
neutron	✓	✓		

1 [1]

(b)

	baryon number	charge	strangeness
proton	1	+1	0
neutron	1	0	0
up quark	1/3	(+)2/3	0
down quark	1/3	-1/3	0

one mark per line correctly completed 3 [3]

(c)(i)	quarks: up + down + down (or udd)	1	
(ii)	baryon number: 1/3 + 1/3 + 1/3 = 1	1	
1.	charge: +2/3 - 1/3 -/1/3 = 0	1	
2.	strangeness: 0 + 0 + 0 = 0	1	[4]
3.			
(d)(i)	^1_0n -> ^1_1p + $^0_{-1}e$ + $^0_0\nu$ (+ *bar above 'ν' symbol*)	2	
(ii)	no change to up and one down quark or by implication	1	
	one down quark changes to up quark + electron + antineutrino	1	[4]
5 (a)(i)	absorbed neutron causes/initiates/precipitates the reaction	1	
	fission means splitting	1	
(ii)	(neutron) with k.e./ speed ≈ k.e./ speed of surrounding molecules / in equilibrium with s. m.	1	[3]
(b)(i)	uranium-236 $^{236}_{92}U$	1	
(ii)	fissile nucleus has many more neutrons than protons (144:92)	1	
	stable, smaller nuclei have neutron/proton ratio nearer to 1.0	1	[3]
(c)(i)	$^{239}_{94}Pu$ -> $^{235}_{92}U$ + ^4_2He	2	
(ii)	<u>*either*</u>		
	$N = N_0(½)^n$	1	
	$N/N_0 = (½)^{1/24}$	1	
	= 0.972	1	
	so decayed percentage = 2.8 % (or 3 %)	1	
	<u>*or*</u>		
	$N = N_0 e^{-\lambda t}$		
	where λ = 0.6931 / 24 000 = 2.89×10^{-5} y^{-1}		
	= 0.6931 / (24 000 x 365 x 24 x 3 600)		
	= 9.16×10^{-13} s^{-1}		
	$\ln(N/N_0) = -\lambda t$ = $-2.89 \times 10^{-5} \times 1000$ = -2.89×10^{-2}		
	so N/N_0 = 0.97 and decayed proportion = 3 %		
	(alternatively, λt = $9.16 \times 10^{-13} \times 1\,000 \times 365 \times 24 \times 3\,600$		
	= -2.89×10^{-2} etc.)		[6]
6 (a)	total energy = 1.5 + 46 x 0.5 = 24.5 MeV		
	allow 1.5 + 47 x 0.5 = 25.0 MeV	1	[1]
(b)	Protons always pass from positive to negative cylinder	1	
	detail: positive charge on proton attracted towards negative cylinder/ repelled from positive cylinder	1	[2]
(c)	electric field is zero	1	[1]
(d)	k.e. = $½mv^2$	1	
	$1.5 \times 10^6 \times 1.6 \times 10^{-19} = ½ \times 1.67 \times 10^{-27} v^2$	1	
	$v = 1.70 \times 10^7$ m s^{-1}		[2]

(e)	$T = 1/f$ $= 1/(80 \times 10^6)$ (= 1.25×10^{-8} s) $l = vt$ $= 1.7 \times 10^7 \times (1.25/2) \times 10^{-8}$ = 0.106 m	1 1 1	 [3]
(f)	proton accelerates (between cylinders) and so travels further in the same time	1	[1]
7 (a)	cable has resistance hence there is a pd across cable (itself) this is not available to user (energy dissipated in cable could get 1/2 of last two marks)	1 1 1	
(b)	air emerging from aerogenerator is moving (1) hence it has ke/eddies (1) work/energy used against friction (1) (ohmic) heating in generator (1) any 2	 2	
(c)(i)	$m = \pi R^2 l \rho$ $= \pi (0.75)^2 \times 8 \times 1.3$ (= 18.4 kg)	1 1	
(ii)	ke $= ½ m v^2$ $= ½ \times 18 \times 8^2 = 576$ J (allow 588 J from $½ \times 18.4 \times 8^2$)	1 1	
(iii)	average power output = (40/100) x 576 = 230 W (allow 235 W from 0.4 x 588)	1	
(d)	$W = Pt$ $7\times10^6 = 230t$ $t = 3.0(4)\times10^4$ s (= 8.45 h) (allow 2.98×10^4 from $7\times10^6 = 235t$)	1 1	
(e)(i)	chemical (not potential or electrical)	1	
(ii)	energy dissipated/wasted as heat inside battery/wires	1	
(f) (i)	$E = Pt$ $= 160 \times 40 \times 3600 = 2.3 \times 10^7$ J	1 1	
(ii)	total stored energy $= 2.3 \times 10^7 \times 100/80$ $= 2.88 \times 10^7$ J	1 1	
(iii)	no. of batteries $= 2.88 \times 10^7 / (7 \times 10^6)$ (= 4.1) ie 5	1 1	