Advanced Extension Award

Physics

Summer 2006

Mark Scheme

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NORTHERN IRELAND GENERAL CERTIFICATE OF SECONDARY EDUCATION (GCSE) AND NORTHERN IRELAND GENERAL CERTIFICATE OF EDUCATION (GCE)

MARK SCHEMES (2006)

Foreword

Introduction

Mark Schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes teachers and students will be able to see what examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather with rewarding students for what they do know.

The Purpose of Mark Schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of 16- and 18-year-old students in schools and colleges. The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes therefore are regarded as a part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. What is published represents this final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example, where there is no absolute correct response – all teachers will be familiar with making such judgements.

The Council hopes that the mark schemes will be viewed and used in a constructive way as a further support to the teaching and learning processes.

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THURSDAY 29 JUNE, AFTERNOON

MARK SCHEME

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Mark Scheme

Subject-specific Instructions

In numerical problems, the marks for intermediate steps shown in the mark-scheme are for the benefit of candidates who do not obtain the correct final answer. A correct answer and unit, if obtained from a valid starting-point, gets full credit, even if all the intermediate steps are not shown. It is not necessary to quote correct units for intermediate numerical quantities.

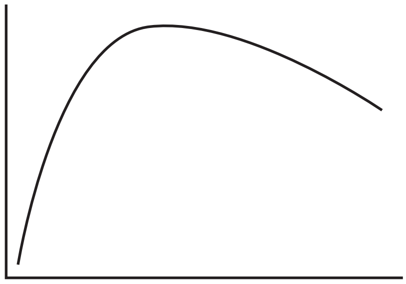
Note that this "correct answer" rule does not apply to formal proofs and derivations, which must be valid in all stages to obtain full credit.

Do not reward wrong physics. No credit is given for consistent substitution of numerical data, or subsequent arithmetic, in a physically incorrect equation. However, answers to later parts of questions that are consistent with an earlier incorrect numerical answer, and are based on a physically correct equation, must gain full credit. Designate this by writing **ECF** (Error Carried Forward) by your text marks.

The normal penalty for an arithmetical and/or unit error is to lose the mark(s) for the answer/unit line. Substitution errors lose both the substitution and answer marks, but 10^n errors (e.g. writing 550 nm as 550×10^{-6} m) count only as arithmetical slips and lose the answer mark.

				AVAILABLE MARKS
1 (a) (i)	e.g. $^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{1}H + ^{1}_{1}H$	LHS showing collision of two or more deuterium **only**	1	
	$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He + ^{1}_{0}n$	production of neutrons	1	
	$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$	production of alpha particles (last equation alone gets 2)	1	3

(ii) (mean) b.e. per nucleon



nucleon number

graph with correct axes 1

inverted curve (even labelled mass defect) 0/1

Following marks independent of graphical equation:

Obtain all b.e. per nucleon values on l.h.s. of equation 1

Convert to total binding energies 1

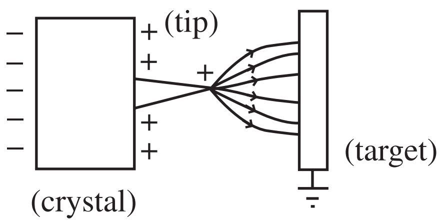
Repeat for r.h.s. of equation 1

difference (r.h.s. total binding energy) – (l.h.s. total binding energy) = energy generated 1 | 5

(iii) Uranium energy release is by **fission** or division 1

Uranium nucleus divides into nuclei of smaller nucleon number/ smaller/lighter nuclei 1 | 2

(b) Diagram



crystal, tip, target with tip facing target 1

polarities (tip or side of crystal with, earthed target) 1

field pattern: lines (at least 3)

closer near tip and going to target (only score if tip facing target) 1

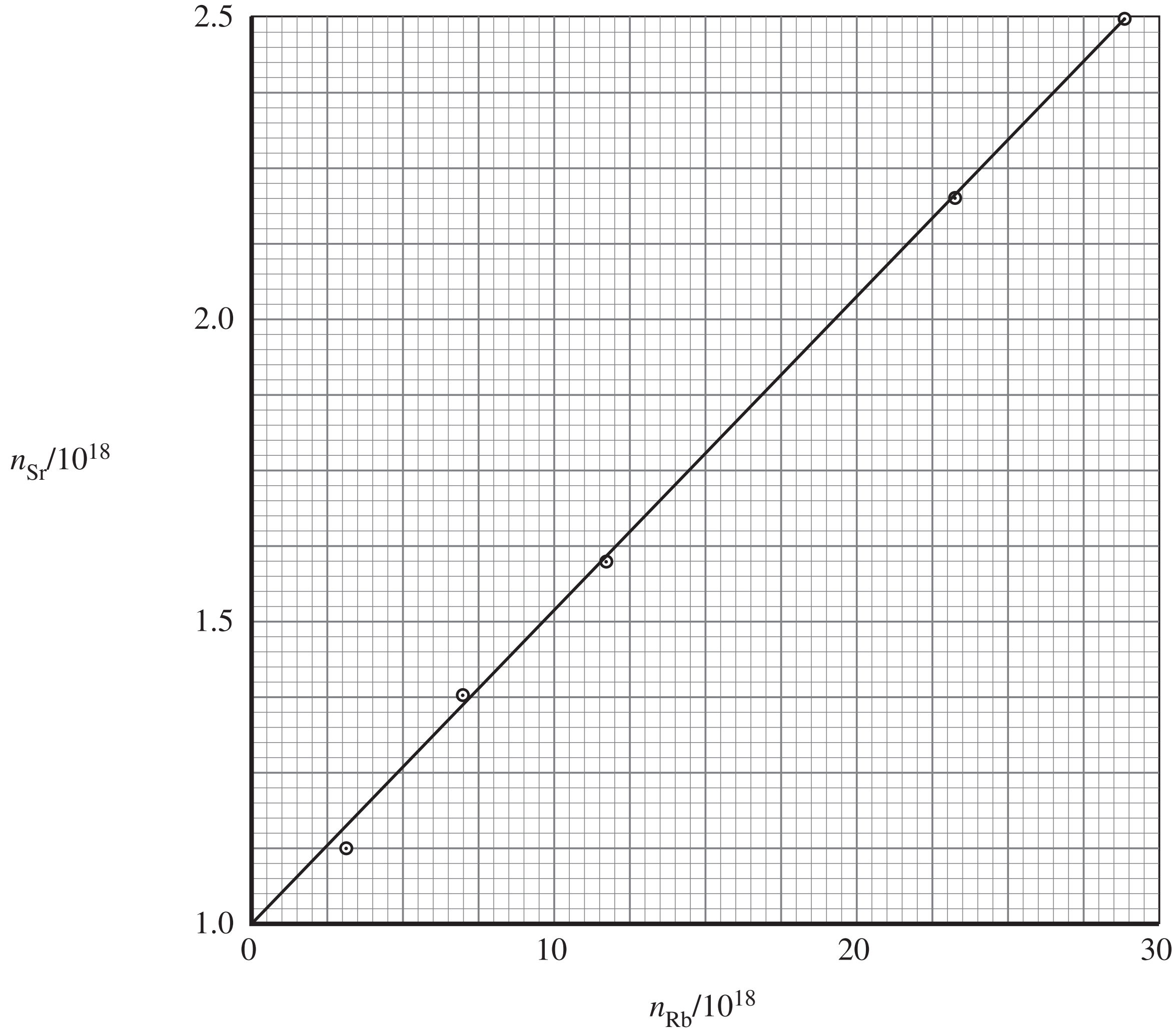
Motion:

Deuterium ions **accelerate** (**along field lines** towards target) 1

greatest acceleration near tip *or* **where lines are closest** 1 | 5

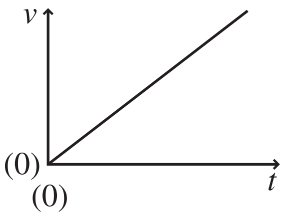
		AVAILABLE MARKS
(c) Device consumes more energy than it produces (hence acts as neutron generator rather than energy generator)	1	
● Pyroelectric crystal: potential charge depends on change of temperature or hotter means more charge		
● Greater charge/potential, more ionisation or greater accelerating field		
● so the greater the temperature change, the more fusion there is or more neutrons produced		
● comment on safety because of neutron production		
Any **three** from 4		4
(d) Fusion normally at high temperature		
or magnetic containment problems	1	
Nuclei repel	1	
High energy needed to overcome	1	
Here, (kinetic) energy supplied by (acceleration in) field	1	4
	Total	**23**

				AVAILABLE MARKS
2	**(a)**	(If n_0 = number of Rb nuclei at $t = 0$)		
		$n_{Rb} = n_0 e^{-\lambda t}$	1	
		$n_{Sr} = n_0 - n_{Rb}$	1	
		so $n_{Sr} = n_{Rb} e^{\lambda t} - n_{Rb}$	1	3
		(hence result)		
	(b)	**(i)** (Eqn 2.1 suggests graph of n_{Sr} against n_{Rb} should be)		
		straight line	1	
		through origin	1	
		provided that $(e^{\lambda t} - 1)$ **or** t is same for all samples **or** all formed at same time **or** t constant	1	3
		(ii) Graph: axes	1	
		points	1	
		best straight line	1	
		Reason: recognise intercept	1	
		some Sr to start with or from source other than Rb decay	1	5
		or may have started while still molten		
		(iii) Identifies gradient as $(e^{\lambda t} - 1)$	1	
		Obtains gradient (their value (~ 0.0517))	1	
		Value of t ($= 1.11 \times 10^{17}$ s) = $\mathbf{3.5 \times 10^9}$ **year**	1	3
		(in range 3.4×10^9 to 3.6×10^9)		
			Total	**14**


2.5
2.0
1.5
1.0
$n_{Sr}/10^{18}$
0
10
20
30
$n_{Rb}/10^{18}$

AVAILABLE MARKS

3 **(a)** Graph (unlabelled axes, 0) 1



$F = ma$ *or* $F = \mathrm{d}(mv)/\mathrm{d}t$

$W = Fd$ both equations 1

$F = m \times$ gradient of graph **or** $F = m \times \frac{v}{t}$ **or** gradient = acceleration 1

$W = Fx$ area under graph **or** $F\frac{vt}{2}$ **or** correct integral **or** distance = area 1

Hence energy $= W = m \times (v/t) \times \frac{1}{2}vt = (\frac{1}{2}mv^2)$ 1 | 5

(b) **(i)** Charging capacitor: small charges transferred from one plate to the other (cause an increase in p.d. between plates) 1

Work done at p.d. V is $V\Delta q$ 1

V proportional to q **or** straight line graph 1

Area of triangle under **V**, ***q*** graph involves $\frac{1}{2}$ (**not** q, V graph max. $\frac{3}{4}$) 1 | 4
or equivalent explanation

(ii) Close S_1:

$Q_1 = C_1V_0$ or 4.02×10^{-4} C any use of $Q = CV$ 1

$E_1 = \frac{1}{2}C_1V_0^2$ or 1.206×10^{-3} J any use of $E = \frac{1}{2}CV^2$ **or** $\frac{1}{2}qV$ 1

Open S_1, close S_2:

Charge conserved (say q_1 on C_1 and q_2 on C_2) and same p.d. across C_1 and C_2 (say V_1)

$q_1 + q_2 = Q_1$ charge conserved 1

$q_1 = C_1V_1$ and $q2 = C_2V_1$ same p.d. 1

i.e. $(C_1 + C_2)V_1 = Q_1 = C_1V_0$

so $V_1 = (C_1V_0)/(C_1 + C_2)$ or $V_1 =$ **4.517** V 1

Total energy $= \frac{1}{2}(C_1 + C_2)V_1^2$ or 9.08×10^{-4} J 1

Energy in spark $= 12.06 \times 10^{-4} - 9.08 \times 10^{-4} =$ **2.98×10^{-4} J** 1

Indep. mark: Over-estimate because of heat/energy loss **in wires/circuit** 1 | 8

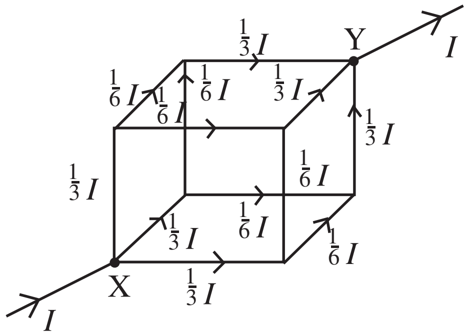
Total | **17**

			AVAILABLE MARKS
4 **(a)** Wavelength in range 600 nm – 700 nm (633 nm)		1	
Power in range 0.25 mW – 2.5 mW		1	
Energy of one photon = hc/λ		1	
Power = number of photons per unit time × energy of each		1	
Rate = e.g. $(0.50 \times 10^{-3} \times 633 \times 10^{-9})/(6.63 \times 10^{-34} \times 3.0 \times 10^{8})$	subs	1	
Rate **in range 7.5 × 10^{14} s^{-1} to 8 × 10^{15} s^{-1}**		1	6
Error in wavelength or power could score 4/6; (Error in wavelength and power could score 3/6)			
(b) **(i)** Atmospheric pressure at Earth's surface = (total weight of molecules)/(surface area of Earth)		1	
total weight of molecules = total number of molecules × weight of each		1	
$N = [1 \times 10^{5} \times 4\pi(6 \times 10^{6})^{2}]/(5 \times 10^{-26} \times 10)$	subs	1	
Number of molecules = **9 × 10^{43}** No s.f. penalty		1	4
(Use of $pV = nRT$ max. 2/4 involves estimating height of atmosphere and temperature, leading to $10^{42} – 10^{46}$)			
(ii) Height of atmosphere in range 5 km to 500 km		1	
$g = GM/r^2$ or g proportional to $1/r^2$		1	
If $g = 10\ m\ s^{-2}$ at Earth's surface, will be			
$[6.0 \times 10^{6}/6.1 \times 10^{6}]^{2} \times 10$ at e.g. 100 km	subs	1	
g at top of atmosphere in range 10 $m\ s^{-2}$ to 9 $m\ s^{-2}$		1	
Conclusion: **constant** (to within 10%) (not indep.)		1	5
		Total	**15**

					AVAILABLE MARKS
5	**(a)**	$Bev = mv^2/r$		1,1	
		$p = mv = Ber$	algebra	1	3
	(b)	**(i)** $E = (–)(\Delta\Phi/\Delta t$		1	
		$W = Ee = e\Delta\Phi/\Delta t$ (includes n(no. of terms) – 1 once only)		1	2
		(ii) If tangential force on electron is F, $W = F.2\pi r$			1
		(iii) $F = (–)(e/2\pi r)(\Delta\Phi/\Delta t)$ **or** e.c.f. from **(i)**, **(ii)**			1
		(iv) Force = rate of change of momentum		1	
		i.e. $F = er(\Delta B/\Delta t)$		1	2
		(v) From **(iii)** and **(iv)** $(–)(e/2\pi r)(\Delta\Phi/\Delta t) = er(\Delta B/\Delta t)$ (allow e.c.f. up to here)		1	
		$\boldsymbol{\Delta\Phi = 2\pi r^2\,\Delta B}$ this answer only		1	2
			Total		**11**
6	**(a)**	Reasoning: total resistance of parallel connection always less than that of either component		1	
		Hence 1.0 Ω resistor cannot be the single parallel component of R_{AB}, R_{CD} or R_{DA} but must be Q_2:$\boldsymbol{Q = 1.0\ \Omega}$		1	
		and 2.0 Ω resistor cannot be the single parallel component of R_{CD} or R_{DA}: $\boldsymbol{P = 2.0\ \Omega}$		1	
		One parallel equation, e.g. $1/R_{AD} = 1/S + 1/(R + 1 + 2)$		1	
		and $10 = 1 + 2 + R + S$, leads to $\boldsymbol{S = 3.0\ \Omega}$		1	5
		and hence $\boldsymbol{R = 4.0\ \Omega}$			
		or			
		by solution of three parallel equations in turn: first equation		1	
		second equation		1	
		sum or resistances and first R value		1	
		second R value		1	
		third and fourth R values		1	

AVAILABLE MARKS

(b) e.g.



Analyse for currents 1/3 I values (1), 1/6 I values (1) — 1

Realise 3 parallel connections from each corner, 6 in middle — 1
or addition of voltages
$\frac{1}{3}IR + \frac{1}{6}IR + \frac{1}{3}IR = IR\ 10r$

$R_{tot} = R/3 + R/6 + R/3$ — series addition — 1

$\boldsymbol{R_{tot} = 5R/6}$ — 1 — 5

Total — **10**

7 Physics examples likely to be radioactive decay, discharge of capacitors

For each, name situation (e.g. radioactivity) — 1

Description e.g. gets less with time (rate of decay proportional to number of radioactive nuclei) — 1

Second situation e.g. discharge of capacitor — 1

description

What exponential decay is $\frac{dn}{dt} \alpha n$ **or** $n = n_0 e^{-ct}$ — 1

Grand National:

assume probability of falling at a fence is constant — 1

then rate of change of number of horses still running proportional to number still in the race before each fence

or $dN/dt = -kN$

or $N = N_0 e^{-kt}$ — 1 — 8

Why exponential may not be good: e.g. too few horses, not all the same, fences not the same, horses tire etc. — 1

Quality of written communication

Correct standard (i.e. physics not over-weighted), holds interest, well structured (e.g. **title**) — 1

Technical features: spelling, punctuation, grammar — 1 — 2

Total — **10**