ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme June 2003

GCE

Physics B

Unit PHB5

The Assessment and Qualifications Alliance (AQA) is a company limited by guarantee registered in England and Wales 3644723 and a registered charity number 1073334
Registered address: Addleshaw Booth & Co., Sovereign House, PO Box 8, Sovereign Street, Leeds LS1 1HQ
Kathleen Tattersall: *Director General*

PHB5

Question 1

(a)(i)	(magnetic) flux	Not flux linkage	B1	**1**
(ii)	weber or tesla-metre^2 or Wb or T m^2		B1	**1**
(b)(i)	max d*B*/d*t* determined using tangent drawn at t = 0, 0.5 s or 1.0 s (value should be in range 0.5 to 0.8 (x 10^{-2} T s^{-1}) or coordinates in an equation) (condone powers of 10)		B1	
	Attempt to apply $\Delta(BAN)/t$ e.g. induced emf = 240 x 2.5 x 10^{-4} x dB/dt (ignore powers of 10 here) (any B divided by any t is sufficient evidence e.g. 0.24 s or 1 s)		C1	
	Answer **using correct method** in range 0.30 – 0.50 mV (allow 1, 2 or 3 sf answers)		A1	**3**
(ii)	Graph showing positive and negative values		M0	
	zero emf at approximately correct times (0.20 to 0.26 s and 0.70 to 0.76 s)		A1	
	maximum at correct times **and** correct shape Ignore phase; Must show positive and negative emfs		A1	**2**
(iii)	Pendulum has to be shorter		C1	
	Length reduced to ¼ original length		A1	**2**
(iv)	the (maximum) speed of the magnet increases (condone angular speed)		B1	
	the (maximum) rate of change of flux increases **or** wires/coil cuts flux at a higher rate		B1	**2**
(v)	**ANY 2 from**			
	use a stronger/more powerful magnet		B1	
	use a coil with more turns (allow more coils)		B1	
	(use a coil with) greater area (**Not** magnet with greater area **)**		B1	
	use a soft iron core in the coil		B1	
	use a larger amplitude of oscillation of the magnet		B1	**Max 2**

(vi) output/voltage would be sampled
or
sample at a frequency (much) higher than that of the pendulum B1

changed to digital/binary form
or
processed by an A – D converter B1 **2**

Total 15

Question 2

(a) the radius/diameter of the planet **not** 'size' B1
the mass (or density) of the planet B1 **2**

(b)(i) volume of the granite = $4/3\ \pi\ r^3$
or
radius of the granite = 0.2 km (may be seen in an incorrect equation) B1
200^3 or $4/3\ \pi\ 0.2^3$ **or** $3.35 \times 10^7 m^3$ B1
Mass = density x volume used with any density and their volume
(Volume may be in formula form)
If they use correct volume then either 1.24×10^{11} or 7.37×10^{10} gets the mark) B1
$(3700–2200) \times 3.35 \times 10^7$ **or** $1500 \times 3.35 \times 10^7$ kg
or $(1.24 \times 10^{11} – 7.37 \times 10^{10})$ **or** 5.025×10^{10} **or** 5.03×10^{10} seen
Condone rounding off early leading to 4.6×10^{10} kg B1 **4**

NB
1)the fourth mark is not for 5.0×10^{10} – all working must be shown
2)those who do not show conversion of radius from km to m in the calculation but otherwise correct will get 3

(ii) Gravitation field strength $g = GM/r^2$
or
uses distance of 0.4 km for r C1
Substitution for extra field strength = $6.7 \times 10^{-11} \times 5.0 \times 10^{10}/(0.4 \times 10^3)^2$
Condone r = 0.4 for this mark C1
Correct substitution for the extra field strength with **correct** powers of 10 C1
2.1×10^{-5} N kg^{-1} (condone m s^{-2})
or
1.9×10^{-5} if 4.6×10^{10} carried forward from (i) A1 **4**

(iii) Correct general shape always below original curve B1 **1**

Total 11

	Alternative scheme for different approach to (ii)		
(ii)	Gravitation field strength = GM/r^2 or uses distance of 0.4 km for r	C1	
	Correct substitution for field strength for granite (or soil) $6.7 \times 10^{-11} \times 1.24 \times 10^{11}/(0.4\times10^3)^2$ or $6.7 \times 10^{-11} \times 7.37 \times 10^{10}/(0.4\times10^3)^2$ Condone $r = 0.4$ for this mark	C1	
	Correct substitution for field strength for soil (or granite)	C1	
	2.1×10^{-5} N kg^{-1} (condone m s^{-2})	A1	**4**

Question 3

(a)(i)	zero potential is taken to be at 'infinity' (or a long way from the charge)	B1	
	in this system work has to be done to take a positive charge to infinity/away from Q or energy has to be put in to take a positive charge to infinity/away from Q or positive charge loses PE as it moves from infinity/toward Q or positive charge gains PE as it moves to infinity/away from Q	B1	**2**
	Not the field is such that positive charge is attracted potentials are negative because charge is negative		
(ii)	three radial lines drawn (condone more than three) all toward the charge by eye (−1 for poor quality)	B1	
	at least one arrow shown directed toward the charge	B1	**2**
(b)(i)	$V = q/4\pi\varepsilon_0 r$	C1	
	Correct substitution of any pair of V and r e.g. $10\times(4\pi 8.9 \times 10^{-12} \times 4.0 \times 10^{-2})$ (= 4.47×10^{-11} C)	A1	**2**
(ii)	$E = q/4\pi\varepsilon_0 r^2$ or V/r **(not** V/d**)**	M1	
	250 (251) V m^{-1} (N C^{-1}) (ignore lack of direction indication)	A1	**2**
(c)	energy transferred = Vq or potential difference = 30 V **or** $\frac{Q_1Q_2}{4\pi\varepsilon_0}\left[\frac{1}{r_1}-\frac{1}{r_2}\right]$ **or** $\frac{1.6\times10^{-19}\times4.5\times10^{-11}}{4\pi 8.9\times10^{-12}}\left[\frac{1}{0.01}-\frac{1}{0.04}\right]$ (condone 1/1-1/4)	C1	
	$4.8(3) \times 10^{-18}$ J ecf for their incorrect charge from (b)(i)	A1	**2**

(ii)	(As it moves away) electron loses PE **or** work is done on the electron or the electron is repelled by the negative charge	B1	
	wavelength will decrease	B1	
	plus 2 from		
	as the electron moves away speed will increase	B1	
	as the electron moves away the momentum will increase	B1	
	$\lambda = h/mv$ **or** h/p **or** $\lambda \propto 1/v$ **or** $\lambda \propto 1/mv$	B1	**4**
	At least 3 marks for physics + use of Physics is accurate, the answer is fluent/well argued with few errors in spelling, punctuation and grammar		**2**
	At least 1 mark for physics the use of Physics is accurate, but the answer lacks coherence or spelling, punctuation and grammar are poor		**1**
	the use of Physics is inaccurate, the answer is disjointed, with significant errors in spelling, punctuation and grammar		**0**
			Max 2 **6**

Total 16

Question 4

(a)(i)	1 N per A per m **or** 1 Wb m^{-2} **or** quotes: $B = F/IL$ with terms defined **or** induced $EMF = \Delta BAN/t$ with terms defined **or** a slightly flawed attempt at the definition in statement form	C1	
	It is the flux density (perpendicular to a wire) that produces a force of 1N per m on the wire when the current is 1A **or** $B = F/IL$ **and** 1 T is flux density when F = 1N; I = 1A and L = 1 m **or** induced $EMF = \Delta BAN/t$ and 1 T is the flux change when emf = 1V for A=1 N=1 and t=1 or similar	A1	**2**
(ii)	force on charge due to E field , $F_E = Eq$ **or** Vq/d **and** force due to B field, $F_B = Bqv$ **or** $Eq = Bqv$	B1	
	= Bqv; cancels q **and states explicitly** $v = \frac{E}{B}$ **or** $v = \frac{V}{dB}$	B1	**2**
(iii)	v = 20000/0.14 (seen) **or** 143 x 10^3 m s^{-1}	B1	**1**

(b)(i)	$Bqv = mv^2/r$ or $r = mv/Bq$ (allow e instead of q)	C1	
	mass of ion = $1.7 \times 10^{-27} \times 58$ (may be in equation) **or** (9.86×10^{-26} kg seen)		
	or		
	radius = 0.14 m (may be in equation)	C1	
	Substitutes and arrives at 0.62 to 0.63 T	A1	**3**
(ii)	Calculates new radius (0.145 m) or diameter (0.288 m) using $r \propto m$ or otherwise **allowing ecf**	C1	
	0.010 m (condone 0.01 m) or 0.0096 – 0.0097 m (Allow 0.0079 m or 0.008 m due to use of different sfs for B and v)	A1	**2**
		Total 10	

Question 5

(a)	1	B1	**1**
(b)(i)	$E_k = E_p$ when the protons touch		
	or $E_k = q^2/4\pi\varepsilon_o r$		
	or separation when they touch = 3.0×10^{-15}m		
	or $V = q/4\pi\varepsilon_o r$	C1	
	$E_k = (1.6 \times 10^{-19})^2/4\pi (8.9 \times 10^{-12}) (3.0 \times 10^{-15})$		
	or		
	$E_k = (1.6 \times 10^{-19})^2/4\pi (8.9 \times 10^{-12}) (1.5 \times 10^{-15})$	C1	
	$7.6(1) \times 10^{-14}$J (cao)	A1	**3**
(ii)	incident proton will stop and the stationary proton will move off at velocity/speed of the incident proton		
	or		
	All KE/momentum is transferred to the stationary particle		
	NB not they will not touch	B1	**1**
(iii)	protons travel in the opposite directions or velocity is reversed	M1	
	with initial speeds	A1	
	total momentum before = 0 so momentum after must be 0		
	or		
	provided they have said that speeds are the same		
	total KE is same before and after the collision		
	or		
	the collision is elastic	B1	**3**
(iv)	mention of strong nuclear force		
	or		
	the repulsive force is overcome	C1	
	the strong nuclear force is greater than the electrostatic repulsion		
	or		
	the strong nuclear force is effective when the protons touch	A1	**2**

(c)	$E = mc^2$	C1	
	mass increase = {(2 x 2.2) – (2 x 1.7)} x 10^{-27} kg = 1.0 x 10^{-27} kg **or** calculates initial energy equivalence of 2 protons **or** final energy equivalence of 2 delta + particles	C1	
	8.6 or 9 x 10^{-11} J (i.e. allow 1sf) c.a.o. (NB Adding on the answer to (b)(i) is correct but it has no influence on the answer to 2 sf so its absence is condoned)	A1	**3**
		Total 13	

Question 6

(a)	Escape energy = $\frac{GMm}{r}$ **or** $\frac{GM}{r}$ **or** $\frac{GMm}{r} = \frac{1}{2}mv^2$	B1	
	6.7 x 10^{-11} x 6.0 x 10^{24}/6400 x 10^3 = 63 MJ **or** Calculates escape velocity using $\frac{GMm}{r} = \frac{1}{2}mv^2$ giving 11 200 m s^{-1} **or** recalls escape velocity as 11 000 or 11 200 m s^{-1} **or** Calculates velocity using $80 \times 10^6 = \frac{1}{2}v^2$ giving 12 600 m s^{-1}	B1	
	63 MJ per kg so 80 MJ is more than enough (OWTTE) **or** Calculates the other velocity and draws a conclusion Recall of escape speed and showing escape energy = 63 MJ with conclusion gets last two marks **NB** Arriving at 63 MJ using *mgh* is a physics error and gains no marks. (These candidates get 63 MJ using g = 9.8 m s^{-2} and the radius of the Earth for h)	B1	**3**
(b)	Gases have to be given a velocity/momentum **or** Gas must have an equal and opposite force on it to that on the rocket	B1	
	The gases have kinetic energy	B1	
	or If all KE given to the rocket there is no gas ejected from the exhaust	M1	
	Momentum would not then be conserved	A1	**2**
(c)	fuel has to be provided to move the fuel needed for later parts of the journey **or** to move the fuel itself	B1	

the ratio of payload to original mass that has to be moved is very low.
or
a lot of fuel is needed (for a small payload)(which is expensive)
or
parts of the rocket that containing fuel are discarded on the journey
or
propulsion by burning fuel is inefficient
(or other sensible reason for inefficiency) B1 **2**

Total 7

Question 7

(a)	Superconductors have **no** resistance	B1	
	so **no** heating occurs **or** **no** I^2R losses	B1	**2**
(b)	Magnet moving producing changing magnetic flux	B1	
	I^2R losses/heating of track (due to induced/eddy currents in the (resistive) track)	B1	
	the direction of the induced current oppose the change producing it **or** mention of Lenz's law	B1	
	the induced current is in the magnetic field of the magnet so has a force on it **or** the induced current sets up a field that tries to prevent the magnet moving **or** track behaves like a magnet and attracts the superconducting magnet	B1	
	The faster the motion **or** the greater the rate of change of magnetic flux, the greater the induced currents	B1	
	Faster vehicle leads to greater resistive/power losses **or** Faster vehicle leads to greater magnetic drag forces	B1	
	At least 3 marks for physics + use of Physics is accurate, the answer is fluent/well argued with few errors in spelling, punctuation and grammar		**2**
	At least 1 mark for physics + some incorrect work the use of Physics is accurate, but the answer lacks coherence or spelling, punctuation and grammar are poor		**1**
	the use of Physics is inaccurate, the answer is disjointed, with significant errors in spelling, punctuation and grammar		**0** **8**

Total 10

Question 8

(a)(i)	energy per pulse = 10 000/28 = 360 (357) J	B1	**1**
(ii)	one photon $= hc/\lambda$ **or** hf	C1	
	energy of one photon = 1.86×10^{-19} J **or** $6.6 \times 10^{-34} \times 3 \times 10^{8}/1060 \times 10^{-9}$ (ignore power of 10 for wavelength)	C1	
	1.88 - 1.94×10^{21} (i.e. their (a)(i)/1.86×10^{-19})	A1	**3**
		Total 4	

Question 9

(a)(i)	$v^2 = u^2 + 2as$	C1	
	$a = 48$ m s^{-2} **(**negative answer is a physics error; *u* and *v* wrong way round loses A1 mark)	A1	**2**
(ii)	$v = u + at$ **or** $s = ½(u + v)t$ **or** $s = ut + ½ at^2$	B1	
	$1700 = 48t$ **or** 30 000 = ½ 1700 t or 850t **or** 30 000 = $0.5 \times 48 t^2$ (**N.B.** seen explicitly)	B1	**2**
(b)(i)	PE = *mgh* or $GMm(1/r_1 - 1/r_2)$ **or** KE = ½ mv^2 or one energy change calculated PE 588 000 J; KE 2 890 000 J (using *m* = 2 kg) **or** PE = 294 000 J **or** KE = 1 450 0 00 J (using *m* = 1 kg)	C1	
	Two energy changes calculated correctly using *m* = 1 **or** 2 kg	C1	
	3.5 (3.48) MJ (c.n.a.o.)	A1	**3**
(ii)	Energy supplied = 35 MJ **or** 0.35 MW (using power = 10 kW) but no second mark allowed	C1	
	Efficiency = (9.9% or 0.099 if correct) (5.0% or 0.050 if fuel ignored) Condone 1sf answers in these cases **e.c.f. from (b)(i)** (1.7% if PE only calculated in (i) 8.3% if KE only calculated in (i))	A1	**2**
(c)	Diameter of the mirror needed = 42 m	B1	**1**
(d)(i)	*p/T* = constant	C1	
	$P = 1 \times 10^{5} \times 40\,000/300 = 1.3 \times 10^{7}$ Pa	A1	**2**
(ii)	There will be little or no air/atmosphere (at 30 km height)	M1	
	The system works by air/gas expanding **or** the system works by heating air/gas **or** the thrust will be decreased **or** no thrust **or** no propulsion	A1	

or fewer molecules ejected so rate of change of momentum is lower
(or lower thrust **2**
Allow B1 for problems associated with not capturing energy due to the beam divergence beyond 30km (i.e. considering hydrogen power as a different method of propulsion to overcome this problem)

Total 14