Version 3

General Certificate of Education (A-level)
January 2013

Physics B **PHYB4**

(Specification 2455)

Post-Standardisation

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this Mark Scheme are available from: aqa.org.uk

Set and published by the Assessment and Qualifications Alliance.

The Assessment and Qualifications Alliance (AQA) is a company limited by guarantee registered in England and Wales (company number 3644723) and a registered charity (registered charity number 1073334).
Registered address: AQA, Devas Street, Manchester M15 6EX.

1	a		zero potential at infinity (a long way away)	B1	2	
			energy input needed to move to infinity (from the point) work done by the field moving object from infinity potential energy falls as object moves from infinity	B1		

1	b		Any pair of coordinates read correctly	C1	3	±1/2 square
			Use of E_p or $V = (-)\dfrac{GM}{r}$	C1		Rearrange for *M*
			6.4 (±0.5) × 10^{23} kg	A1		

1	c		Reads correct potential at surface of Mars = -12.6 (MJ)	C1	3	or reads radius of mars correctly(3.5 x10^6)
			equates to ½ v^2 (condone power of 10 in MJ)	C1		use of $v=\sqrt{(2GM/r)}$ with wrong radius
			5000 ± *20* m s^{-1} (condone 1sf e.g. 5 km s^{-1})	A1		e.c.f. value of *M* from 1(b) may be outside range for other method 6.2 x 10^{-9}x √their *M*

1	d		Attempts 1 calculation of *Vr*	B1	3	Many values give 4.2…. so allow mark is for reading and using correct coordinates but allow minor differences in readings Ignore powers of 10 but consistent
			Two correct calculation of *Vr*	B1		
			Three correct calculations with conclusion	B1		

2	a		$F = \dfrac{GM(m)}{r^2}$ used	C1	4	Allow *g* = instead of *F=*
			mass difference = (4/3) π 600^3 4700 =4.2×10^{12} (kg)	C1		Allow for one mass calculated correctly(allow correct substitution) i.e mass of ore body or mass of displaced 'earth' (6.5 x 10^{12} or 2.3 x 10^{12})
			correct answer 0.00058 N kg^{-1}	A1		
			correct conversion of their N kg^{-1} to gal *their N kg^{-1} x 10^2 gal* (58 m gal or 5.8 x 10^{-2} gal if answer correct)	B1		

2	b	i	Attempt to manipulate formula to give T^2	B1	3	
			correct manipulation to $g = \frac{4\pi^2 L}{T^2}$	B1		
			correct conclusion identifying $(4\pi^2)L$ constant for a given pendulum	B1		

2	b	ii	Attempt to find fractional uncertainty in T (= 0.000004)	B1	3	Attempt to calculate g for T = 25.0001 or 24.9999,
			double the uncertainty	B1		Correct *g* for24.9999 or 25.0001
			Detectable change = 0.000008 × 9.81 (0.000078 N Kg^{-1})	B1		Subtracts 9.81 to find answer allow 1 sf
						OR
						Uses gT^2 = constant (6131.25) or uses ratios
						Correct *g* for 24.9999 or 25.0001
						Subtracts 9.81 to find answer allow 1 sf

2	b	iii	Use of equation to deduce L = 150 m	B1	2	Allow if done in (2(b)(ii)
			concludes that length will be impracticably/too long	B1		Condone loose terminology here: too big/large
			Or			Allow any 2 in coherent answer
			Mentions that damping effects and the long time period	B1		
			Oscillations may die away too quickly to allow measurement of T			
			Or			
			Need to make measurements over a long time to detect the change in time period	B1		
			so survey would a take long time	B1		

2	b	iv	Quote formula for a mass-spring system	B1	2	
			Identifies that period is independent of *g* *Or g* is not in the formula for period of a mass spring system) Or depends only *M* and *k*	B1		

3	a	i	*Attempt to use* volume = mass/density (1.4/810 seen)	C1	2	Condone 0.028
			0.00173 m^3	A1		

3	a	ii	quantity of gas = 1.4/0.028 mol or temperature =298 K used	C1	3	Allow 1.4/28
			use of $pV = nRT$	C1		
			Correct answer 1.24 m^3	A1		

3	b		momentum is conserved	B1	3	
			gas ejected (backwards) so its momentum changes/it is given momentum or force needed to produce change in momentum	B1		ejected gas has momentum OWTTE
			equal and opposite <u>change</u> in momentum of the astronaut equal and opposite force on the astronaut	B1		NB not momentum of astronaut = momentum of gas

3	c	i	Use of $F=ma$ 3.56/151 seen	C1	2	
			0.024 m s^{-2}	A1		

3	c	ii	Use of rocket equation	C1	3	Allow 1 for direct use of conservation of momentum 329
			$3.05 = v_o \ln \frac{151}{149.6}$	C1		
			327 (330) m s^{-1}	A1		

3	c	iii	Time for which rocket accelerates given by final $v = at$ (t = 3.05/ 0.024) ecf from (c)(i)	C1	3	or $Ma = 3.56 = (dm/dt)\ v$
			t = 127 - 129 s ecf	A1		or 151 x c(i) = (dm/dt) x c(ii)(ecf)
			1.4/their time 0.011 (kg)	B1		0.011 (kg) ecf

3	d		gas does work as it expands/W is negative	B1	3	
			ΔU is negative (allow temperature of gas falls)	B1		
			Q = 0/ No thermal energy input or output	B1		

4	a		Use of cos 20 or sin 70 or F(horizontal) = 30/1.3 = 23.1	C1	2	
			24.6 (N)			

4	b	i	angular acceleration = T/I	C1	5	
			30/240 = 0.125 rad s^{-2}	A1		
			$\theta = 180°$ or π seen	B1		
			$\omega^2 = 2\times 0.125 \times \pi$ or $\omega^2 = 2\alpha\theta$	B1		Allow substitution with their α and θ=180
			0.886 (2 or more sf)	B1		

4	b	ii	Use of conservation of angular momentum *or* use of $T = 2\pi/\omega$	C1	4	variations for use of 0.89 and reasonable rounding errors allowed
			Initial angular momentum 240 $\times$ 0.9 (allow 212 to 216) (kg m^2 s^{-1})	C1		
			Final angular speed = 0.76 rad s^{-1}	A1		
			8.3 s Allow ecf from incorrect ω (likely to be 7.0 s or 7.1 s allow 1 sf)	B1		

4	b	iii	Energy =½ $I\omega^2$	C1	3	
			Calculation of one energy correctly 97J or 82 J	C1		Allow 115 J from ½ (240+45) x 0.9^2
			Calculates both correctly and subtracts (15J)	A1		

4	b	iv	Collision is inelastic or Energy converted into heat/internal energy when child jumps o or work done against friction at contact point when child jumps on	B1	**1**	

4	c	i	acceleration is (rate of change)of velocity	B1	3	
			velocity is a vector or has (magnitude and) direction	B1		
			direction of (linear motion) is changing	B1		
			or			
			acceleration = force/mass	B1		
			there is a force on the child toward the centre of the roundabout	B1		Mention of centripetal force/acceleration
			Some discussion of how the force arises(friction or holding on)	B1		

4	c	ii	Mention of Newton's third law or equivalent statement	B1	2	Equal and opposite force on child and roundabout
			application to the situation (applying force to the object he is on)	B1		
			or			
			Child is part of the system	B1		
			Is not providing an external torque force	B1		

5	a	i	Air or (other transmitting) body is in contact with the crystal	B1	2	ANY 2 condone air resistance
			The vibrational energy of the crystal energy becomes energy of the ultrasound wave	B1		Not losses as waves travels through the body
			as energy converted energy in to vibrational energy of the particles in the body	B1		
			Energy losses due to friction between atoms inside the crystal			

5	a	ii	appreciates energy proportional to amplitude^2	C1	3	
			75% loss	A1		
			Average energy loss per mm = 3% or divides their percentage energy loss by 25(likely answer 1%)	B1		2% for those who forget to square

5	b		High frequency means short wavelength	B1	**2**	ANY 2
			high resolution /higher quality image	B1		Not just better but condone clearer
			objects of the order of magnitude of wavelength can be seen owtte			

5	c		use of $v = f\lambda$	C1	2	
			100 µm 1(.0) $\times 10^{-4}$ m	A1		

5	d		Use of $T = 1/f$	C1	3	
			Time between pulses = 1 ms	C1		
			Number of ultrasound oscillations in 1 ms = 15000	A1		

5	e		**Usual QOWC marking**		6	
			Points which should occur:			**5/6** will address each section 6 should have no omissions and be well written 5 will omit detail in **A or C or have** faults in communication **3/4** will 4 will have acceptable communication skills and • address **A** thoroughly and be inadequate elsewhere • address **A** and **C** but omit detail 3 will have very poor communication but satisfy the two bullets above. **1/2** will give a brief superficial response low in factual content and is likely to show very poor communication
			A Pulse sent though body			
			Reflection at tumour			
			Detect time between transmitted and received pulse			
			Distant below surface of body = vt/2			
			B Cannot detect difference between similar density tissue			
			Reflections too weak Reflections at interface			
			C Use ex CT MRI scanners Some detail on how these are better e.g. no reliance on reflection of waves			

6	a		sketch correct general shape including characteristic lines a minimum wavelength (no-zero)and a peak	C1	3	
			Correct lower wavelength shown on axes or Characteristic wavelengths in correct positions	C1		
			Completely correct – no second intercept	A1		

6	b		Use of $E=hc/\lambda$ or attempt using $eV = hf$	C1	3	
			$1.6 \times 10^{19} \times V = 6.6 \times 10^{-34} \times 3 \times 10^{8} /(0.035 \times 10^{-9})$	C1		allow any wavelength and condone power of 10 in wavelength
			35 .4 kV	A1		

6	c		Incident electrons excites/removes electrons in, or ionises the target atoms	B1	4	
			photons emitted	B1		
			Electrons relax(fall) into lower energy state(ground state)	B1		Not just changing levels
			Inner energy levels transitions /large energy drops/high energy photons give rise to X rays	B1		

6	d	i	x-ray power = 40 W or X-ray power = 1560 W	C1	2	Allow 2400 J for 1 mark
			Energy wasted per minute = 93600 (94000)J	A1		

6	d	ii	Large amount of energy becomes internal energy of the target/raises temperature of the target	B1	**3**	condone ‘heat’
			Unless energy removed target would melt/or needs cooling system	B1		
			either rotating anode or liquid /air cooling system	B1		

6	e		ANY Three			
			improves quality of image/reduces blurring	B1	**3**	
			X ray photons scattered <u>when passing thought the body</u>	B1		
			lead grid absorbs (some)scattered X-rays so	B1		
			only those travelling in straight line get to the plate	B1		