Rewarding Learning

ADVANCED
General Certificate of Education
January 2014

Physics

Assessment Unit A2 1

assessing

Momentum, Thermal Physics, Circular Motion, Oscillations and Atomic and Nuclear Physics

[AY211]

MONDAY 20 JANUARY, AFTERNOON

MARK SCHEME

Subject-specific Instructions

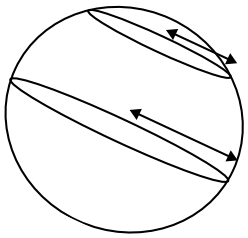
In numerical problems, the marks for the intermediate steps shown in the mark scheme are for the benefit of candidates who do not obtain the final correct answer. A correct answer and unit, if obtained from a valid starting-point, gets full credit, even if all the intermediate steps are not shown. It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

Note that this "correct answer" rule does not apply for 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 subsequent stages of questions that are consistent with an earlier incorrect numerical answer, and are based on 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)**	To conserve momentum [1] total momentum is zero [1]			[2]	
	(b)	**(i)** $7.26 \times 8.15 = 1.47 \times 13.32 + 7.26 \times v$ subs	[1]			
		$5.45\ m\ s^{-1}$	[1]	[2]		
		(ii) 1. Kinetic energy is not conserved	[1]			
		2. ke before = 241 J	[1]			
		ke after = 238 J e.c.f.(i)	[1]	[3]		7
2	**(a)**	Ideal gas the internal energy is all kinetic	[1]			
		Real gas internal energy is potential and kinetic	[1]	[2]		
	(b)	Correct subs into 3/2 kT	[1]			
		3.52×10^{-23} J	[1]	[2]		
	(c)	**(i)** Gradient = $\frac{P}{< c^2 >}$	[1]			
		$\frac{Nm}{3V}$	[1]	[2]		
		(ii) Process to find m: $\frac{44.01(\times 10^{-3})}{6.02 \times 10^{23}}$				
		or finds $m = 7.31 \times 10^{-26}$ (kg) or 10^{-23}(g)	[1]			
		Chooses points from line and subs or calculates gradient	[1]			
		Changes V to m^3 correctly	[1]			
		$N = 5 \times 10^{21}$	[1]	[4]		10
		SE: 8.5×10^{-3} $\frac{3}{4}$; apply 10^n penalty once only				
3	**(a)**	**(i)** Power supply in series with ammeter and heater	[1]			
		Voltmeter across heater	[1]	[2]		
		All symbols correct – penalty [–1]				
		(ii) Change in temperature is lower than it should be/heat energy has been added without giving time for it to reach thermometer and cause a change in temperature	[1]			
		$c = \frac{Q}{m\Delta\theta}$ therefore smaller temp rise gives higher c value	[1]			
		Highest temperature reached after the heater is turned off should be recorded	[1]	[3]		
	(b)	Water: Q = 100(4.184)(1.36) or 569 J	[1]			
		Metal: 569 = 15 × c × 73.64 e.c.f. Q	[1]			
		515 J kg^{-1} $°C^{-1}$	[1]	[3]		8

						AVAILABLE MARKS
4	**(a)**	Uses correct equation $\omega = \frac{2\pi}{T}$	[1]			
		Uses correct equation for $v = r\omega$	[1]			
		$\omega_F = 2.51 \quad \omega_E = 7.27 \times 10^{-5}$	[1]			
		$v_F = 1.01 \quad v_E = 465$ e.c.f. ω	[1]	[4]		
		[–1] if units not consistent with values				
	(b)	**(i)** (v depends on radius) and radius is much bigger		[1]		
		(ii) The radius of the circle will depend on where on the Earth the object is placed	[1]			
		Correct illustration on diagram, e.g.	[1]	[2]		7
						
5	**(a)**	**(i)** Time for 1 complete orbit or revolution		[1]		
		(ii) Time for 1 complete oscillation		[1]		
		(iii) Circular motion – F acts towards the centre of the circle	[1]			
		SHM – F acts towards equilibrium position	[1]			
		Circular motion – F is constant	[1]			
		SHM – F varies depending on position of object	[1]	[4]		
		Definition of SHM only [1]/[4]				
	(b)	Amplitude decreases	[1]			
		Period stays constant	[1]			
		Speed decreases because oscillator must cover less distance in the same time	[1]	[3]		9
6	**(a)**	Calculate r (= 4.59×10^{-15})	[1]			
		Calculate V e.c.f. r (4.05×10^{-43})	[1]			
		Calculate m, consistent with r	[1]			
		Calculate ρ e.c.f. V and m	[1]	[4]		
		(If A ≠ 56 a qualification may get [1])				
	(b)	$7872\,kg\,m^{-3}$		[1]		
	(c)	Iron atoms are mostly empty space/All the mass is concentrated in the nucleus		[1]		6

					AVAILABLE MARKS
7	**(a)**	Number of undecayed nuclei/number of radioactive nuclei		[1]	
	(b)	**(i)** 151, 77		[1]	
		(ii) Points correctly plotted	[1]		
		Smooth curve drawn, starting at 250	[1]	[2]	
		(iii) At least 2 sets of correct values used and averaged	[1]		
		4.0–4.4 [1 d.p.]		[1]	[2]
		(iv) 0.693/their **(iii)**		[1]	
		(v) Compares with probability of 1/6		[1]	8
8	**(a)**	subs into $E = mc^2$	[1]		
		2.9×10^{-14} kg	[1]	[2]	
	(b)	In nuclear reactions the mass of the nuclei before nuclear reaction is greater than the mass after	[1]		
		Missing mass = energy	[1]	[2]	
	(c)	Curve correct shape	[1]		
		Peak in correct place (60, 9)	[1]		
		Fusion to left of peak and fission to RHS	[1]		
		Curve ends ~ 240 and no lower than ~6 MeV	[1]	[4]	8
9	**(a)**	Each fission produces more than 1 neutron	[1]		
		Each neutron produced can cause a fission	[1]		
		Runaway or avalanche chain reaction	[1]	[3]	
	(b)	**(i)** Control rods absorb neutrons	[1]		
		Max absorption when control rods inserted fully	[1]	[2]	
		(ii) e.g. Reactor shielding/concrete	[1]		
		absorbs *neutrons*	[1]	[2]	
	(c)	Extremely high cost of decommissioning		[1]	8

					AVAILABLE MARKS
10	$\binom{2}{1}$ Deuterium + $\binom{3}{1}$ Tritium → $\binom{4}{2}$ Helium + $\binom{1}{0}$ n $\left(+ 17.6 \text{ MeV}\right)$		[1]		
	Advantages: • No (long term storage) issues with (radioactive or CO_2) waste products • Fuel is readily available in seawater • Higher energy yield per kg • Safety comment if qualified Any **two**		[2]		
	Problems: • To overcome the electrostatic repulsion between nuclei, they need to have sufficient kinetic energy • Temperatures of the order of 10^8 or 10^9 K are required • Confinement necessary (time or density) Any **two**		[2]		
	Methods to overcome difficulties: • Inertial confinement • Magnetic confinement Either		[1]	[6]	
	Quality of written communication **2 marks** The candidate expresses ideas clearly and fluently, through well-linked sentences and paragraphs. Arguments are generally relevant and well-structured. There are few errors of grammar, punctuation and spelling. **1 mark** The candidate expresses ideas clearly, if not always fluently. There are some errors in grammar, punctuation and spelling, but not such as to suggest weakness in these areas. **0 marks** The candidate expresses ideas satisfactorily, but without precision. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling are sufficiently intrusive to disrupt the understanding of the passage.		[2]		8
11	**(a)** Base units of P correct kg m^{-1} s^{-2}		[1]		
	kg m^{-1} s^{-1}		[1]	[2]	
	(b) **(i)** Volume recorded from the measuring cylinder		[1]		
	Volume/60		[1]	[2]	
	(ii) Graph will be a straight line through the origin		[1]		
	Gradient of graph = $\frac{\pi r^4 P}{8\eta}$ if law is correct		[1]	[2]	
	(c) **(i)** L = 0.35 m		[1]		
	Q = 1.86–1.88 × 10^{-4} $m^3 s^{-1}$		[1]	[2]	
	(ii) Uses large triangle		[1]		
	6.25–6.35 × 10^{-5}		[1]		
	Units: m^4 s^{-1}		[1]	[3]	11
			Total		**90**