



# **GCSE MARKING SCHEME**

**SCIENCE - PHYSICS**

**SUMMER 2014**

## INTRODUCTION

The marking schemes which follow were those used by WJEC for the Summer 2014 examination in GCSE SCIENCE - PHYSICS. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

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# GCSE Science - Physics 1

## Marking Scheme - Summer 2014

### FOUNDATION TIER

Question			Marking details	Marks
1.	(a)	(i)	[Overhead] cables <b>Don't accept</b> National Grid	1
		(ii)	Step-down [transformer]	1
		(iii)	Step-up [transformer]	1
	(b)	<p><b>Any 2 ×(1) from:</b></p> <ul style="list-style-type: none"> <li>• [More] reliable - <b>Don't accept</b> more efficient</li> <li>• [In case a power station breaks down for] back up</li> <li>• Can react to a changing demand</li> </ul> <p><b>Don't accept</b> a better electricity supply <b>or</b> more power <b>or</b> gives electricity when needed.</p> <p><b>Question total</b></p>	2	
<b>Question total</b>				<b>[5]</b>
2.	(i)		Infra-red (1) Micro[waves] (1) Micro[waves] (1)	3
		(ii)	Radio [waves]	1
	<b>Question total</b>			
3.	(a)	(i)	Same number of <u>lines</u> / four <u>lines</u> (1) <u>Lines</u> at same wavelength / <u>lines</u> at same place (1) <b>Don't accept</b> same colours <b>Award 1 mark</b> for they're both black on the right hand side	2
		(ii)	One has bright/coloured <b>or</b> dark [background] / One has black lines <b>or</b> coloured lines / colours missing in top spectrum are on the bottom spectrum. <b>Don't accept</b> colours in reverse <b>or</b> different colours	1
	(b)	(i)	<u>Lines</u> have moved to red end <b>or</b> wavelength of <u>lines</u> is increased <b>or</b> <u>lines</u> have different wavelengths <b>or</b> <u>lines</u> are red shifted <b>or</b> <u>lines</u> shifted to the right / <u>lines</u> are in different positions	1
		(ii)	<u>Moving away</u> don't accept further away	1
	(c)	No <u>matching lines</u> crossing spectrum [from neon or mercury] / because it <u>only</u> has lines for hydrogen / it only has four <u>lines</u> / it is the hydrogen spectrum. <b>Treat as neutral</b> any reference to not enough lines or double lines.	1	
<b>Question total</b>				<b>[6]</b>

Question			Marking details	Marks
4.	(a)	(i)	Desktop / PC	1
		(ii)	2005	1
		(iii)	Desktop / PC	1
		(iv)	<u>CRT</u> [monitor] (1) <b>Don't accept</b> the green line because <u>biggest drop</u> [in units used or energy consumed] (1) <b>To award both marks both statements must be linked.</b>	2
	(b)	(i)	% efficiency = $\frac{\text{useful energy transfer}}{\text{total energy input}} \times 100$ $= \frac{18}{90} \times 100 = 20[\%]$ (1) for substitution (1) answer Correct answer only gets 2 marks <b>Award 1 mark</b> for 0.2	2
		(ii)	72 [J]	1
		(iii)	(I) Division by 3 (1) [£]1.50 (1) (II) [£]3.00 ( <b>ecf for £4.50 – answer in (b)(iii)(I)</b> ) If answer in (b)(iii)(I) is bigger than £4.50 a negative answer is required.	2 1
<b>Question total</b>			<b>[11]</b>	
5.	(a)	Conduction (1) radiation (1) hot <b>and</b> cold (1) [both in correct order for mark] [ <b>NOT</b> right to left]	3	
	(b)	(i)	46 (1) 70 (1)	2
		(ii)	30 [s]	1
	(c)	(i)	<b>Any 2 ×(1) from:</b> <ul style="list-style-type: none"> <li>• Same diameter <b>or</b> same thickness</li> <li>• Identical drawing pins <b>or</b> same mass of drawing pins</li> <li>• Same flame <b>or</b> same flame temperature <b>or</b> same starting temperature</li> <li>• Same type of wax <b>or</b> same amount of wax</li> <li>• Same distance between pins</li> </ul> <b>(NOT same length / same temperature only / same number of pins)</b>	2
		(ii)	Steel is a poorer <u>conductor</u> / rate of <u>conduction</u> in steel is lower / so <u>heat travels</u> through it slower (1) so time before <u>pins drop off</u> would be longer (1) <b>To award both marks both statements must be linked.</b>	2
<b>Question total</b>			<b>[10]</b>	

Question			Marking details	Marks
6.	(a)	(i)	Alpha / $\alpha$ / helium nucleus	1
		(ii)	1 000 [counts per minute]	1
		(iii)	1 000 [counts per minute]	1
	(b)	(i)	Plots (allow $\pm \frac{1}{2}$ small square division) (2) -1 for each error to a maximum of 2 <u>Smooth curve between 10 and 50 mm</u> allow $\pm \frac{1}{2}$ small square division (1) <b>Don't allow</b> wispy, wobbly, thick, double lines	3
		(ii)	As the thickness increases, the counts per minute (count rate) decreases (1) in smaller and smaller intervals / at a decreasing rate (1) <b>Treat as neutral:</b> in a non-linear way <b>or</b> gradient decreases as the thickness increases <b>ecf</b> from graph <b>Award 2 marks for:</b> every 10 mm the count rate halves	2
		(iii)	(I) 1 000 (1) but not on answer line $\frac{1}{4}$ expressed in any terms <b>or</b> 0.25 (1) <b>Accept</b> 25%	2
	(II)	125 (1) [counts per minute] The count rate halves every 10 mm (1) <b>Accept</b> is a quarter of the 40 mm value <b>or</b> half the 50 mm value <b>Or</b> extrapolated graph (1) value between 50 – 200 (1)	2	
			<b>Question total</b>	<b>[12]</b>
7.	(a)	(i)	<p><b>Indicative content:</b></p> <p>Mass of measuring cylinder (from the first diagram)= 112 g  Mass of measuring cylinder + liquid (from the second diagram)= 172 g  Volume of liquid (from the third diagram) = 75 cm<sup>3</sup>  Mass of liquid = 60 g  density = <math>\frac{\text{mass}}{\text{volume}} = \frac{60}{75} = 0.8 \text{ g/cm}^3</math></p> <p><b>5 – 6 marks</b> The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar.</p> <p><b>3 – 4 marks</b> The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar.</p>	6

Question			Marking details	Marks
			<p><b>1 – 2 marks</b> The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar.</p> <p><b>0 marks</b> The candidate does not make any attempt or give a relevant answer worthy of credit.</p> <p><b>Any 2 ×(1) from:</b></p> <ul style="list-style-type: none"> <li>• Better resolution / more precise / smaller increments / smaller divisions on balance / cylinder</li> <li>• Use a cylinder that measures to the nearest ml</li> <li>• Use a balance that measures to 1 decimal place</li> <li>• Take measurements at eye level</li> <li>• Bigger volume (amount) of liquid</li> <li>• Use a pipette <b>or</b> burette <b>or</b> volumetric flask <b>or</b> syringe</li> <li>• Take repeat readings with different volumes of oil</li> </ul>	2
(b)	(i)	(I)	1.4 MW ( <b>unit with answer</b> for the mark)	1
		(II)	Density is bigger <b>accept</b> density of air is smaller	1
	(ii)		<p>Water flow / tides (<b>NOT</b> waves) is more constant / more regular / more reliable (1) <u>so</u> the power output is more constant (1)</p> <p><b>Alternative:</b> Water turbines are below the water / out of sight (1) <u>so</u> visual / noise pollution is less (1)</p> <p><b>Alternative:</b> Water turbines are <u>smaller</u> (1) <u>so</u> cheaper to build / can be sited more densely / sited in shallow water / less harmful to wildlife (1)</p> <p><b>To award both marks both statements must be linked.</b></p>	2
			<b>Question total</b>	<b>[12]</b>
			<b>Foundation tier paper total</b>	<b>[60]</b>

# GCSE Science - Physics 1

## Marking Scheme - Summer 2014

### HIGHER TIER

Question			Marking details	Marks
1.	(a)	(i)	Alpha / $\alpha$ / helium nucleus	1
		(ii)	1 000 [counts per minute]	1
		(iii)	1 000 [counts per minute]	1
	(b)	(i)	Plots (allow $\pm \frac{1}{2}$ small square division) (2) -1 for each error to a maximum of 2 <u>Smooth curve between 10 and 50 mm</u> allow $\pm \frac{1}{2}$ small square division (1) <b>Don't allow</b> wispy, wobbly, thick, double lines	3
		(ii)	As the thickness increases, the counts per minute (count rate) decreases (1) in smaller and smaller intervals / at a decreasing rate (1) <b>Treat as neutral:</b> in a non-linear way <b>or</b> gradient decreases as the thickness increases <b>ecf</b> from graph <b>Award 2 marks for:</b> every 10 mm the count rate halves	2
		(iii)	(I) 1 000 (1) but not on answer line $\frac{1}{4}$ expressed in any terms <b>or</b> 0.25 (1) <b>Accept</b> 25%	2
	(II) 125 (1) [counts per minute] The count rate halves every 10 mm (1) <b>Accept</b> is a quarter of the 40 mm value <b>or</b> half the 50 mm value <b>Or</b> extrapolated graph (1) value between 50 – 200 (1)	2		
			<b>Question total</b>	<b>[12]</b>
2.	(a)	(i)	<p><b>Indicative content:</b></p> <p>Mass of measuring cylinder (from the first diagram)= 112 g            Mass of measuring cylinder + liquid(from the second diagram)= 172 g            Volume of liquid (from the third diagram) = 75 cm<sup>3</sup>            Mass of liquid = 60 g  <math display="block">\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{60}{75} = 0.8 \text{ g/cm}^3</math></p> <p><b>5 – 6 marks</b> The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar.</p>	6

Question			Marking details	Marks
			<p><b>3 – 4 marks</b> The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar.</p> <p><b>1 – 2 marks</b> The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar.</p> <p><b>0 marks</b> The candidate does not make any attempt or give a relevant answer worthy of credit.</p>	
	(ii)		<p><b>Any 2 ×(1) from:</b></p> <ul style="list-style-type: none"> <li>• Better resolution / more precise / smaller increments / smaller divisions on balance / cylinder</li> <li>• Use a cylinder that measures to the nearest ml</li> <li>• Use a balance that measures to 1 decimal place</li> <li>• Take measurements at eye level</li> <li>• Bigger volume (amount) of liquid</li> <li>• Use a pipette <b>or</b> burette <b>or</b> volumetric flask <b>or</b> syringe</li> <li>• Take repeat readings with different volumes of oil</li> </ul>	2
(b)	(i)	(I)	1.4 MW ( <b>unit with answer</b> for the mark)	1
		(II)	Density is bigger <b>accept</b> density of air is smaller	1
	(ii)		<p>Water flow / tides (<b>NOT</b> waves) is more constant / more regular / more reliable (1) <u>so</u> the power output is more constant (1)</p> <p><b>Alternative:</b> Water turbines are below the water / out of sight (1) <u>so</u> visual / noise pollution is less (1)</p> <p><b>Alternative:</b> Water turbines are <u>smaller</u> (1) <u>so</u> cheaper to build / can be sited more densely / sited in shallow water / less harmful to wildlife (1)</p> <p><b>To award both marks both statements must be linked.</b></p>	2
			<b>Question total</b>	<b>[12]</b>

Question		Marking details	Marks
3.	(a)	<p>Units used = 1.5 ((1) for conversion)  <math>\times (8 \times 14)</math> <b>or</b> 112 (1) = [168]            Cost = units used <math>\times</math> cost per unit  <math>2520 = 168</math> (<b>ecf</b>) <math>\times</math> cost per unit            Cost per unit = <math>\frac{2520}{168}</math> ((1) substitution and manipulation)  <math>= 15</math> [p] ((1) for answer)            Answer of £15 p loses the answer mark</p> <p>N.B.1. Failure to convert 1 500 W to 1.5 kW loses conversion mark and gives an answer of 0.015 p – <b>Award 3 marks</b>            N.B.2. Failure to convert £25.20 to 2520 p gives an answer of 0.15 p - <b>Award 3 marks</b>            N.B.3. Failure to include 8 or 14 loses 2<sup>nd</sup> mark only and gives an answer of 1.875 p (accept 1.88 or 1.9) and 1.071 p (accept 1.1) respectively. <b>Award up to the 3 other marks</b>            N.B.4. Failure to include 1.5 gives an answer of 112 units and a cost of 22.5 p – <b>Award 3 marks</b>            N.B.5. Failure to convert to 1.5 kW and failure to convert to 2 520 p gives an answer of 0.00015 p – <b>Award 2 marks</b></p>	4
	(b)	<p><math>E = P \times t = 1\,500 \times 14 \times 8</math> <b>or</b> 168 000 (1)  <math>60 \times 60</math> <b>or</b> 3 600 (1)            [= 604 800 000 J]            N.B. Award <b>1 mark</b> only for:            28 800, 50 400, 403 200, <math>5.4 \times 10^6</math>, <math>43.2 \times 10^6</math>, <math>75.6 \times 10^6</math>, <math>5.4 \times 10^3</math>,  <math>43.2 \times 10^3</math>, <math>75.6 \times 10^3</math></p>	2
		<b>Question total</b>	<b>[6]</b>

Question			Marking details	Marks
4.	(a)	(i)	Output power = $99\% \times 2 \times 10^9 = 1.98 \times 10^9$ [W]	1
		(ii)	Input Voltage = $\frac{P}{I} = \frac{2 \times 10^9}{4 \times 10^4}$ (1) for substitution $5 \times 10^4$ [V] (1) Output voltage = $8 \times (5 \times 10^4)$ (ecf) = $4 \times 10^5$ [V] (1) Output current = $\frac{1.98 \times 10^9}{4 \times 10^5}$ (ecf on both values) = $4.95 \times 10^3$ [A] (1) for answer <b>Alternative:</b> <b>Award 2 marks for:</b> Output current = Input current $\div 8 = 5 \times 10^3$ [A] <b>Then award another 2 marks for:</b> $5 \times 10^3 \times 99\% = 4.95 \times 10^3$ [A]	4
	(b)	[Step-up] transformer reduces the current <b>or</b> makes the current low[er] / increases the voltage <b>or</b> makes the voltage high[er] (1) to <u>reduce</u> energy / heat losses [in the cables] / increase efficiency (1). <b>To award both marks both statements must be linked.</b> [Step-down] transformers reduce the voltage (1) to a safe[r] level (1). <b>To award both marks both statements must be linked.</b>	4	
			<b>Question total</b>	<b>[9]</b>

Question			Marking details	Marks
5.	(a)	(i)	<p>Straight line / as one increases the other increases at a steady rate / goes up in equal steps (1) through the origin (1).  <b>Award 2 marks for</b> doubling the velocity doubles the distance.</p>	2
		(ii)	<p>Age of universe will be bigger (1). [Value of constant will decrease] meaning the gradient is lower (1). <b>To award both marks both statements must be linked.</b></p>	2
	(b)	<p><math>4 \times 10^8</math> (1) <math>\times 9.5 \times 10^{12} = 3.8 \times 10^{21}</math> [km] (1)            If <math>10^8</math> is omitted <b>award 1 mark for</b> answer of <math>3.8 \times 10^{13}</math></p>	2	
	(c)	<p>Wavelength = <math>(669.4 - 13.1)</math> nm = 656.3 nm (1)            = <math>656.3 \times 10^{-9}</math> m (1) for conversion</p> <p><math>c = f \lambda</math> so <math>f = \frac{c}{\lambda}</math> (1) for manipulation</p> <p><math>= \frac{3 \times 10^8}{656.3 \times 10^{-9}}</math> (1) for substitution</p> <p><math>= 4.571 \times 10^{14}</math> [Hz] (1)</p> <p>N.B.1. If nm is not converted to m then:  <math>\lambda = 656.3(1)</math> and <math>f = \frac{c}{\lambda}</math> (1- manipulation) = <math>\frac{3 \times 10^8}{656.3}</math> (1-substitution)  <math>= 4.571 \times 10^5</math> [Hz] (1) <b>so award 4 marks.</b></p> <p>N.B.2. If 13.1 is <u>added</u> then:  <math>\lambda = 682.5</math> nm(no mark) = <math>682.5 \times 10^{-9}</math> m (1-conversion) and then  <math>f = \frac{c}{\lambda}</math> (1- manipulation) = <math>\frac{3 \times 10^8}{682.5 \times 10^{-9}}</math> (1-substitution)  <math>= 4.396 \times 10^{14}</math> [Hz] (1)            (must apply correct rounding if done) <b>so award 4 marks.</b></p> <p>N.B.3. <u>If no attempt to use 13.1</u> then:  <math>\lambda = 669.4</math> nm(no mark) = <math>669.4 \times 10^{-9}</math> m (1-conversion) and then  <math>f = \frac{c}{\lambda}</math> (1- manipulation) = <math>\frac{3 \times 10^8}{669.4 \times 10^{-9}}</math> (1-substitution)  <math>= 4.482 \times 10^{14}</math> [Hz] <b>so award 3 marks.</b></p>	5	

Question			Marking details	Marks
	(d)	(i)	Gamma [rays] / short wavelength radiation (1) have stretched / increased wavelength / reduced frequency [over time as the Universe expanded] (1) <b>To award both marks both statements must be linked.</b>	2
		(ii)	<b>Any 2 ×(1) from:</b> <ul style="list-style-type: none"> <li>• Because their wavelengths will get longer / waves stretched</li> <li>• Because frequencies decrease</li> <li>• Lower energy of waves</li> </ul> <b>To award both marks both statements must be linked.</b>	2
			<b>Question total</b>	<b>[15]</b>
6.			<b>Indicative content:</b>  A geostationary / geosynchronous satellite orbits the Earth in 24 hours – the same time as the rotation period of the Earth. It therefore stays above the same point on the Earth so that ground satellite dishes do not have to be moved. A minimum of three satellites are needed to relay messages around the world. They relay only microwaves which carry TV, telephone and other signals. Signals can also be relayed along optical fibres which transfer via coded infra-red signals and radio waves can be reflected off the atmosphere.  <b>5 – 6 marks</b> The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar.  <b>3 – 4 marks</b> The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar.  <b>1 – 2 marks</b> The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar.  <b>0 marks</b> The candidate does not make any attempt or give a relevant answer worthy of credit.	6
			<b>Question total</b>	<b>[6]</b>
			<b>Higher tier paper total</b>	<b>[60]</b>

**GCSE Science - Physics 2**  
**Marking Scheme - Summer 2014**  
**FOUNDATION TIER**

Question			Marking details	Marks
1.	(a)	(i)	ammeter (1) series (1)	2
		(ii)	same as	1
		(iii)	variable resistor	1
	(b)	(i)	plots (2) -1 for each error. (allow $\pm \frac{1}{2}$ small square division) line (1) allow $\pm \frac{1}{2}$ small square division. Don't allow wispy, wobbly, thick lines	3
		(ii)	(1-sub of any corresponding values from graph) e.g. $R = \frac{5}{2.5} = 2 \text{ } [\Omega](1) \text{ ecf}$	2
			<b>Question total</b>	<b>[9]</b>
2.	(a)		Ticks in boxes 2, 4 and 6 (3). Lose a mark for any extra tick.	3
	(b)		Momentum = $100 \times 373$ (1-sub) = 37 300 [kg m/s] (1-ans)	2
	(c)		$F = \frac{37300}{42}$ (allow <b>ecf</b> from (b)) (1) = 888.095 [N] ( <b>ecf</b> ) (1) Accept 888 or 888.1 or 890 but not 888.09 (i.e. correct rounding off is required)	2
				<b>Question total</b>
3.	(a)	(i)	4 (half-lives) (1)	1
		(ii)	2 or 120 (allow <b>ecf</b> from (i) above) (1). Hours or minutes (1). <b>Unit must complement the answer.</b> Accept min or h but not m for unit. If the unit is given with the answer, the unit given must agree with it.	2
		(iii)	4 [grams] (allow <b>ecf</b> from (i) above) If answer of 16 in (i) then award <b>no mark</b> here for 64/16	1
	(b)	Emits gamma (1) so it would not ionise [cells] much / radiation can be detected outside of the body / can get out of the body (1) <b>Don't accept</b> doesn't harm. Only gamma passes through the skin <b>award 1 mark only</b> <b>OR</b> Has a short half-life / has a half-life of <u>only</u> 30 mins (1) but doesn't last for long in the body / decays quicker (1). <b>Accept</b> safe after a short time. <b>Don't accept</b> escape quickly. <b>To award both marks both statements must be linked.</b>	2	
				<b>Question total</b>

Question			Marking details	Marks
4.	(a)	(i)	9 [m]	1
		(ii)	2 [s]	1
	(b)	Speed = $\frac{9}{2} = 4.5$ ( <b>ecf</b> on (i) or (ii) above) [m/s] (1-ans)	1	
	(c)	The distances <u>get</u> / are bigger / balls get further apart. <b>Don't accept</b> further away.	1	
	(d)	Distances between the ball positions would be less / the balls would be closer together.	1	
			<b>Question total</b>	<b>[5]</b>
5.	(a)	(i)	Mass is the amount of inertia or material (accept “stuff” (1), whereas weight is the pull <u>of gravity</u> on the car (1). <b>Do not accept</b> that mass is measured in kg, weight is measured in Newtons.	2
		(ii)	weight = $800 \times 10 = 8\,000$ [N] (1-ans)	1
	(b)	(i)	3 000 [N]	1
		(ii)	1 200 [N]	1
	(iii)	$a = \frac{1200(\text{ecf})(\text{ii})}{800}$ (1-sub) = $1.5$ [m/s <sup>2</sup> ] (1-ans)	2	
	(iv)	The [horizontal] forces become balanced (accept match / equal / level out) (1) because the <u>air resistance (or drag)</u> increases [with speed] (1) <b>To award both marks both statements must be linked.</b>	2	
			<b>Question total</b>	<b>[9]</b>
6.	(a)	(i)	0.8 [s]	1
		(ii)	3.2 [s] (allow <b>ecf</b> from (i)) If answer is 3.2 in (i) then <b>don't accept</b> 0.8 as <b>ecf</b> in this part.	1
	(iii)	subs $\frac{15}{3.2(\text{ecf})}$ (1) = 4.69 or 4.7 or 4.6875 [m/s <sup>2</sup> ] (1) Ignore the signs. <b>Don't accept</b> 4.68 or 4.687. A common <b>ecf</b> is $\frac{15}{4.2} = 3.57$ or 3.6	2	
	(iv)	<u>Horizontal</u> line would be longer (1) because the reaction (or thinking) time (or distance) would be longer / would travel further [at constant speed] / slower reactions (1) <b>Don't accept</b> slower reaction time <b>To award both marks both statements must be linked.</b>	2	

Question			Marking details	Marks
		(v)	Less steep graph / sloping line is longer (1) because braking distance (or time) increases / takes longer to stop / smaller deceleration / less friction or grip (1) <b>Don't accept</b> not as fast to mean a greater braking distance. <b>Accept</b> slippery road. <b>To award both marks both statements must be linked.</b>	2
	(b)	(i)	250 <b>and</b> 24 from graph (1) subs $250 \times 24$ (1) = 6000 [J] (1)	3
		(ii)	6000 [J] (ecf)	1
			<b>Question total</b>	<b>[12]</b>
7.	(a)	(i)	38 (1) 2 (1)	2
		(ii)	Neutrons produced [go on to] cause more reactions <b>or</b> collisions <b>or</b> bombards (1), number of neutrons doubles (accept increase / multiply / triple) [each time] (1) Treat reference to fast neutrons as neutral. N.B. reference to 3 neutrons could arise from the equation above. <b>To award both marks both statements must be linked.</b>	2
	(b)		They contain same number of protons / 1 proton (1) but different number of neutrons / 1 neutron and the other has 2 neutrons (1) Reference to electrons loses 1 mark. <b>Don't accept</b> nucleons / mass number / atomic number	2
	(c)		<b>Indicative content:</b>  In fission a heavy element such as [U 235] absorbs a neutron and splits into lighter nuclei [releasing energy]. In fusion, light elements [such as hydrogen isotopes] collide [in high energy collisions and join together] to produce a heavier element, [also releasing energy]. The main problem with nuclear fission is that it produces waste products which are highly radioactive for a long time. The main problem with nuclear fusion is that it requires very high temperatures and pressures which need lots of energy so it is not yet easily contained.  <b>5 – 6 marks</b> The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar.  <b>3 – 4 marks</b> The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar.	6

Question				Marking details	Marks
				<p><b>1 – 2 marks</b> The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar.</p> <p><b>0 marks</b> The candidate does not make any attempt or give a relevant answer worthy of credit.</p>	
				<b>Question total</b>	<b>[12]</b>
				<b>Foundation tier paper total</b>	<b>[60]</b>

GCSE Science - Physics 2

Marking Scheme - Summer 2014

HIGHER TIER

Question			Marking details	Marks
1.	(a)	(i)	0.8 [s]	1
		(ii)	3.2 [s] (allow <b>ecf</b> from (i)) If answer is 3.2 in (i) then <b>don't accept</b> 0.8 as <b>ecf</b> in this part.	1
		(iii)	subs $\frac{15}{3.2(\text{ecf})}$ (1) = 4.69 or 4.7 or 4.6875 [m/s <sup>2</sup> ] (1) Ignore the signs. <b>Don't accept</b> 4.68 or 4.687. A common <b>ecf</b> is $\frac{15}{4.2} = 3.57$ or 3.6	2
		(iv)	<u>Horizontal</u> line would be longer (1) because the reaction (or thinking) time (or distance) would be longer / would travel further [at constant speed] / slower reactions (1) <b>Don't accept</b> slower reaction time <b>To award both marks both statements must be linked.</b>	2
		(v)	Less steep graph / sloping line is longer (1) because braking distance (or time) increases / takes longer to stop / smaller deceleration / less friction or grip (1) <b>Don't accept</b> not as fast to mean a greater braking distance. <b>Accept</b> slippery road. <b>To award both marks both statements must be linked.</b>	2
(b)	(i)	250 <b>and</b> 24 from graph (1) subs $250 \times 24$ (1) = 6000 [J] (1)	3	
	(ii)	6000 [J] ( <b>ecf</b> )	1	
<b>Question total</b>				<b>[12]</b>

Question			Marking details	Marks
2.	(a)	(i)	38 (1) 2 (1)	2
		(ii)	Neutrons produced [go on to] cause more reactions <b>or</b> collisions <b>or</b> bombards (1), number of neutrons doubles (accept increase / multiply / triple) [each time] (1) Treat reference to fast neutrons as neutral. N.B. reference to 3 neutrons could arise from the equation above. <b>To award both marks both statements must be linked.</b>	2
	(b)		They contain same number of protons / 1 proton (1) but different number of neutrons / 1 neutron and the other has 2 neutrons (1) Reference to electrons loses 1 mark. <b>Don't accept</b> nucleons / mass number / atomic number	2
	(c)		<b>Indicative content:</b>  In fission a heavy element such as [U 235] absorbs a neutron and splits into lighter nuclei [releasing energy]. In fusion, light elements [such as hydrogen isotopes] collide [in high energy collisions and join together] to produce a heavier element, [also releasing energy]. The main problem with nuclear fission is that it produces waste products which are highly radioactive for a long time. The main problem with nuclear fusion is that it requires very high temperatures and pressures which need lots of energy so it is not yet easily contained.  <b>5 – 6 marks</b> The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar.  <b>3 – 4 marks</b> The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar.  <b>1 – 2 marks</b> The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar.  <b>0 marks</b> The candidate does not make any attempt or give a relevant answer worthy of credit.	6
<b>Question total</b>				<b>[12]</b>

Question			Marking details	Marks
3.	(a)	(i)	Emits an electron	1
		(ii)	<u>It is the time taken to halve</u> / it takes <u>5 720 years to halve</u> (1) the number of C-14 nuclei (or atoms) / the mass (or amount) of C-14 / the activity / count rate (1) Treat radioactivity as neutral.	2
	(b)	${}^{14}_7\text{N}$ (2) ${}_{-1}^0\text{e}$ (1) beware of missing minus sign	3	
	(c)	(i)	It takes 4 half-lives (1) so time = $4 \times 5\,720 = 22\,880$ [years] (1)	2
		(ii)	100 years is only a [small] fraction or $\frac{1}{57}$ of a half-life (1) so difference in C-14 readings will be small / won't have decayed by very much (1) <b>To award both marks both statements must be linked.</b>	2
	<b>Question total</b>			<b>[10]</b>
4.	(a)	Initially weight is greater than air resistance [so he accelerates] (1) as he <u>goes faster</u> air resistance increases (1) eventually the forces balance (1) <b>To award all 3 marks the third statement written down must be linked to one of the previous two statements.</b>	3	
	(b)	(i)	Change in momentum = $118 \times 373$ (1) = $44\,014$ [kg m/s] (1)	2
		(ii)	Resultant force = $\frac{44014}{42}$ (1) = $1\,048$ [N] (1) <b>ecf</b> from (i) OR use of $F = ma = 118 \times 8.9$ (1) = $1\,050$ [N] (1)	2
	(c)	$W = 118 \times 10 = 1\,180$ N (1) Air resistance = $W -$ resultant force or $1\,180 - 1\,048$ (1) = $132$ [N] (1) <b>ecf</b> from (ii) & on weight <b>N.B. Answer mark awarded only</b> if correct sign present e.g. $118 - 1\,048$ (1) = $-930$ [N]	3	
	(c)	Air resistance force small (1) because in contact with small number of air particles [per second] / so need to go very quickly for air resistance to balance weight / so need to go very quickly to reach terminal velocity (1) <b>To award both marks both statements must be linked.</b>	2	
<b>Question total</b>			<b>[12]</b>	

Question		Marking details	Marks
5.	(a)	<p><b>Indicative content:</b></p> <p>Diagram showing the lamp connected in series with an ammeter, a variable power supply <b>or</b> a power supply with a variable resistor. A voltmeter is connected in parallel across the lamp. A pair of readings is taken from the ammeter and voltmeter. The variable resistor is adjusted [to vary the voltage across the lamp] and another pair of readings is taken. This is repeated. Results are plotted on a graph and the variation in resistance can be determined by how the slope changes <b>OR</b> the resistance of the lamp is calculated for each set of readings by using <math>V=IR</math>.</p> <p><b>5 – 6 marks</b> The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar.</p> <p><b>3 – 4 marks</b> The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar.</p> <p><b>1 – 2 marks</b> The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar.</p> <p><b>0 marks</b> The candidate does not make any attempt or give a relevant answer worthy of credit.</p>	6
	(b)	<p>(i) Scales (at least <math>\frac{1}{2}</math> of each axis used) (1) plots (allow <math>\pm \frac{1}{2}</math> small square division) (1) smooth curve allow <math>\pm \frac{1}{2}</math> small square division (1) allow straight line between 0 and 2 and between 2 and 6 but expect a curve between 6 and 10. <b>Don't allow</b> wispy, wobbly, thick lines</p> <p>(ii) Current from their graph (i.e. 1.6 A) (1), substitution (1), answer = 3.1 [<math>\Omega</math>] (1) <b>ecf</b></p> <p>(iii) <math>R</math> must be increasing (1) Graph becomes less steep / as voltage increases, current increases less and less / an alternative method would be calculating another value of <math>R</math> (1) <b>To award both marks both statements must be linked.</b></p>	3 3 2
		<b>Question total</b>	<b>[14]</b>
		<b>Higher tier paper total</b>	<b>[60]</b>

GCSE Science - Physics 3

Mark Scheme - Summer 2014

FOUNDATION TIER

Question		Marking details	Mark
1.	(a)	circles accept concentric (on its own) or rings. <b>don't accept</b> oval or clockwise	1
	(b)	reverses [direction] accept changes direction / anticlockwise / opposite direction. Treat as neutral references to N & S.	1
	(c)	no magnetic field / field disappears / field stops <b>don't accept</b> less field	1
<b>Question total</b>			<b>[3]</b>
2.	(a)	<p>red super giant <input type="checkbox"/></p> <p>supernova <input type="checkbox"/></p> <p>black hole <input type="checkbox"/></p> <p>main sequence star <input type="checkbox"/></p> <p>3 marks for all correct 2 marks for 2 or 3 correct 1 mark for 1 correct double lines from or to any box earns no credit</p>	3
	(b)	radiation pressure / gas pressure / pressure / force due to fusion	1
	(c)	fusion (1) helium (1) uranium (1) iron (1)	4
<b>Question total</b>			<b>[8]</b>
3.	(a)	(i) steps-down	1
		(ii) 440	1
		(iii) has a changing magnetic field	1
	(b)	<p><b>Any 2 ×(1):</b>  <u>changing</u> magnetic field (1) which links (or cuts) the secondary coil / passes through the secondary coil (1) <u>induces</u> a current or voltage (1)  <b>To award both marks both statements must be linked.</b></p>	2
<b>Question total</b>			<b>[5]</b>

Question		Marking details	Mark
4.	(a)	1	1
	(b)	positron / antiparticle of electron / antielectron	1
	(c)	it is negative (accept different charge or opposite charge) <b>don't accept</b> it is positive	1
	(d)	annihilate / cancel each other out / destroy each other (1) <b>don't accept</b> fuse or neutralise and release energy / creates heat (1) any reference to 2 electrons don't award the 1 <sup>st</sup> mark	2
<b>Question total</b>			<b>[5]</b>
5.	(a)	(i) momentum = $50\,000 \times 6$ (1-sub) = 300 000 [kg m/s] (1-ans)	2
		(ii) mass = $\frac{300000}{4}$ (1-sub) mass = 75 000 [kg](1-ans) <b>ecf from (i)</b>	2
		(iii) mass of B = 25 000 [kg] (1-ans) <b>ecf from (ii)</b>	1
	(b)	(i) loss of momentum = $50\,000 \times 6 - 50\,000 \times 4$ (1-sub) = 100 000 [kg m/s] (1-ans) <b>Accept</b> correct calculation for the momentum gain of B.	2
		(ii) momentum gain = 100 000 [kg m/s] <b>ecf from (b)(i)</b>	1
<b>Question total</b>			<b>[8]</b>
6.	(a)	As time increases, velocity increases ( <b>accept</b> positive correlation) (1) at a uniform rate / uniformly / linearly (1) <b>don't accept</b> at a constant speed N.B. "velocity is directly proportional to time" gets 2 marks	2
	(b)	(i) e.g. $a = \frac{50}{5}$ (Use of paired points for substitution – 1) = 10 [m/s <sup>2</sup> ](1) If paired points chosen should produce an answer of -10 [m/s <sup>2</sup> ] <b>award 1 mark only</b>	2
		(ii) $x = \frac{1}{2}(0 + 40)4$ (1-sub) = 80 [m](1)	2
(c)	Can't ignore air resistance <b>or</b> friction <b>or</b> drag / acceleration isn't constant	1	
<b>Question total</b>			<b>[7]</b>

Question			Marking details	Mark
7.	(a)	(i)	192 (1) 20 (1)	2
		(ii)	Correct points plotted – allow $\pm \frac{1}{2}$ small square division on volume axis (2) -1 for each error. Curve of best fit <b>up to (12,8)</b> allow $\pm \frac{1}{2}$ small square division (1) <b>don't allow</b> wispy, wobbly, thick or point to point lines	3
	(b)	(i)	Volume increases as height increases (1) description of curved relationship e.g. increases at an increasing rate <b>or</b> gradient increases (1) <b>Don't accept</b> non-uniformly / non-linearly / non-proportional	2
		(ii)	[Air] pressure is decreasing	1
		(iii)	Best fit line extrapolated (put tick on graph) (1) Answer consistent with graph (1)	2
	(c)	(i)	[The balloon's volume would] decrease (treat reference to pressure as neutral)	1
		(ii)	As the helium molecules are moving more slowly <b>or</b> have less [kinetic] energy / taking longer between collisions / less force applied in each collision / less collisions <u>per second</u> <b>Don't accept</b> closer together	1
	<b>Question total</b>			<b>[12]</b>
8.	(a)	(i)	Refraction	1
		(ii)	<u>Total internal reflection / TIR</u>	1
	(b)	(i)	Change of speed [at boundary] / change of density <b>Don't accept</b> speeds up or lower density	1
		(ii)	Hits the edge at an angle <u>greater than the critical angle or greater than <math>42^\circ</math></u> (accept between $41^\circ - 45^\circ$ ) (1) must be travelling [from more dense] to less dense medium (1)	2
	(c)	Emergent straight line should be drawn steeper (put tick or cross on the diagram)	1	
	<b>Question total</b>			<b>[6]</b>

Question	Marking details	Mark
9.	<p><b>Indicative content:</b></p> <p>A surface seismic wave travels across the surface of the Earth as opposed to through it. Surface waves usually have larger amplitudes and longer wavelengths than body waves, and they travel more slowly than body waves do. A P wave is a seismic body wave [that shakes the ground back and forth in the same direction and the opposite direction as the direction the wave is moving]/longitudinal wave. An S wave is a seismic body wave [that shakes the ground back and forth perpendicular to the direction the wave is moving]/transverse wave. S waves do not travel through fluids, [so do not exist in Earth's outer core [or molten rock (magma)]]. S waves travel slower than P waves in a solid and, therefore, arrive after the P wave.</p> <p><b>5 – 6 marks</b> The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar.</p> <p><b>3 – 4 marks</b> The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar.</p> <p><b>1 – 2 marks</b> The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar.</p> <p><b>0 marks</b> The candidate does not make any attempt or give a relevant answer worthy of credit.</p> <p><b>Question total</b></p>	6
	<b>Question total</b>	<b>[11]</b>
	<b>Foundation tier paper total</b>	<b>[60]</b>

GCSE Science - Physics 3

Mark Scheme - Summer 2014

HIGHER TIER

Question			Marking details	Mark	
1.	(a)	(i)	192 (1) 20 (1)	2	
		(ii)	Correct points plotted – allow $\pm \frac{1}{2}$ small square division on volume axis (2) -1 for each error. Curve of best fit <b>up to (12,8)</b> (1) allow $\pm \frac{1}{2}$ small square division (1) <b>don't allow</b> wispy, wobbly, thick or point to point lines	3	
	(b)	(i)	Volume increases as height increases (1) description of curved relationship e.g. increases at an increasing rate <b>or</b> gradient increases (1) <b>Don't accept</b> non-uniformly / non-linearly / non-proportional	2	
		(ii)	[Air] pressure is decreasing	1	
		(iii)	Best fit line extrapolated (put tick on graph) (1) Answer consistent with graph (1)	2	
	(c)	(i)	[The balloon's volume would] decrease (treat reference to pressure as neutral)	1	
		(ii)	As the helium molecules are moving more slowly <b>or</b> have less [kinetic] energy / taking longer between collisions / less force applied in each collision / less collisions <u>per second</u> <b>Don't accept</b> closer together	1	
	<b>Question total</b>			<b>[12]</b>	
	2.	(a)	(i)	Refraction	1
			(ii)	<u>Total internal reflection / TIR</u>	1
(b)		(i)	Change of speed [at boundary] / change of density <b>Don't accept</b> speeds up or lower density	1	
		(ii)	Hits the edge at an angle <u>greater than the critical angle or greater than <math>42^\circ</math></u> (accept between $41^\circ - 45^\circ$ ) (1) must be travelling [from more dense] to less dense medium (1)	2	
(c)		Emergent straight line should be drawn steeper (put tick or cross on the diagram)	1		
<b>Question total</b>			<b>[6]</b>		

Question		Marking details	Mark
3.	(a)	<p><b>Indicative content:</b></p> <p>A surface seismic wave travels across the surface of the Earth as opposed to through it. Surface waves usually have larger amplitudes and longer wavelengths than body waves, and they travel more slowly than body waves do. A P wave is a seismic body wave [that shakes the ground back and forth in the same direction and the opposite direction to the direction the wave is moving]/longitudinal wave. An S wave is a seismic body wave [that shakes the ground back and forth perpendicular to the direction the wave is moving]/transverse wave. S waves do not travel through fluids, [so do not exist in Earth's outer core [or molten rock (magma)]. S waves travel slower than P waves in a solid and, therefore, arrive after the P wave.</p> <p><b>5 – 6 marks</b> The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar.</p> <p><b>3 – 4 marks</b> The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar.</p> <p><b>1 – 2 marks</b> The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar.</p> <p><b>0 marks</b> The candidate does not make any attempt or give a relevant answer worthy of credit.</p>	6

Question		Marking details	Mark
	(b) (i)	Describe use of trace to find time delay of 3 mins (1) <b>Accept</b> $5 - 2 = 3$ mins STN2 distance from epicentre = 2 000 [km] (1) <b>ecf</b> from their lag time  e.g. lag time of 2.5 mins (0) distance 1 650 [km] (1) If no description present <b>or</b> indications on the diagrams only <b>award 1 mark</b> maximum.	2
	(ii)	To locate the <b>earthquake</b> candidate stated “draw arcs of the appropriate (scaled) radius from the monitoring stations” <b>or</b> shown calculations that generate answers of 1.8 cm and 4.0 cm ( <b>ecf</b> ) <b>or</b> these arcs <b>shown</b> on the diagram (1) and locate the epicentre where the three circles intersect <b>or</b> point of intersection shown on the diagram (1). Reasonable attempt at finding epicentre with 2 (rough) arcs drawn <b>or</b> scale lines that cross circle given. (1)  N.B. Point only indicated <b>award 1 mark</b> only 1 arc shown for STN3 and point indicated <b>award 2 marks</b> only	3
		<b>Question total</b>	<b>[11]</b>
4.	(a)	Correct substitution into $\frac{V_1}{V_2} = \frac{N_1}{N_2} \rightarrow \frac{132\,000}{V_2} = \frac{154\,000}{50}$ (1)  Rearrangement i.e. $V_2 = \frac{132\,000 \times 50}{154\,000}$ (1) 429 [V] (1) accept 428 [V] or 430 [V] <b>Alternative method:</b> Substitution of 768 turns (1) Rearrangement to give 659 [V] (1) Subtraction of 230 [V] to give 429 [V] (1)	3
	(b) (i)	Increased voltage (1) Because of increased number of [secondary] turns (1) <b>To award both marks both statements must be linked.</b>	2
	(ii)	Failure of electrical equipment / Overheating of equipment / Fire / fuse blows <b>ecf from (i)</b>	1
	(iii)	No effect. (1) Because the ratio of primary to secondary turns for the business remains the same / still connected to B and C (1) <b>Alternative:</b> The businesses lose their supply / the voltage falls to 0 (1) because B joins to C (1). <b>To award both marks both statements must be linked.</b>	2
	(c)	Alternating input current or voltage (1) creates changing magnetic field (1) links (or cuts) with output coil / <u>induces</u> an [alternating] current / <u>induces</u> an [alternating] voltage (1)	3
		<b>Question total</b>	<b>[11]</b>

Question		Marking details	Mark
5.	(i)	Substitution into $v^2 = u^2 + 2ax$ (1) $u = 0$ (1) $v = 10$ m/s (1) <b>Alternative method:</b> $t$ calculated first <b>OR another alternative method:</b> $PE = mgh = 0.2 \times 10 \times 5 = 10$ [J] (1) $\frac{1}{2}mv^2 = 10$ [J] (1) then $v = 10$ [m/s] (1)	3
	(ii)	Recognition that $v^2$ halves i.e. to 50 (1) Therefore new $v = \sqrt{50} = 7[.07]$ [m/s] (1) <b>Alternative method:</b> Initial KE = 10 [J] <b>ecf</b> so rebound KE = 5 [J] (1) Calculation of $v = 7[.07]$ [m/s] (1)	2
	(iii)	Substitution into $x = \frac{1}{2}(u+v)t$ (1) rearrange so $t = \frac{2.5}{3.5(\text{ecf})}$ (1) Answer = 0.7[1] s (1) Award same format of marks if $x = ut + \dots$ is used	3
		<b>Question total</b>	<b>[8]</b>

Question		Marking details	Mark
6.	(a)	${}^2_1\text{H}(1) \quad {}^1_1\text{H}(1)$	2
	(b)	(i) mass of reactants = $(2 \times 3.014932) = 6.029864$ [u] (1) mass of products = $4.00151 \text{ u} + (2 \times 1.00728) = 6.01607$ [u] (1) [mass difference = $0.013794$ u] N.B. for 1 proton: mass of products = $5.00879$ [u] and [mass difference = $1.021074$ u]	2
		(ii) conversion to kg = $0.013794$ (ecf) $\times 1.66 \times 10^{-27} = 2.29 \times 10^{-29}$ kg(1) energy calculation to give answer = $2.06 \times 10^{-12}$ [J] (1) N.B. for 1 proton: conversion to kg = $1.69498 \times 10^{-27}$ kg energy = $1.52548 \times 10^{-10}$ [J]	2
	(c)	<b>Indicative content:</b>  The relationship $E = mc^2$ states the equivalence of mass and energy. Binding energy is the energy equivalent of the mass difference between a whole nucleus and its individual constituent protons and neutrons. As the graph above shows, fusion of light nuclei into heavier nuclei causes an increase in binding energy per nucleon. The product is more stable. In fission heavy nuclei split into lighter nuclei with a higher binding energy per nucleon. The fragments are more stable. In a fusion/fission reaction, the mass difference is converted to energy.  <b>5 – 6 marks</b> The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar.  <b>3 – 4 marks</b> The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar.  <b>1 – 2 marks</b> The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar.  <b>0 marks</b> The candidate does not make any attempt or give a relevant answer worthy of credit.	6
		<b>Question total</b>	<b>[12]</b>
		<b>Higher tier paper total</b>	<b>[60]</b>



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