



GCSE MARKING SCHEME

SCIENCE - PHYSICS

SUMMER 2010

INTRODUCTION

The marking schemes which follow were those used by WJEC for the Summer 2010 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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Physics 1 – Foundation Tier

F	H	Answer / Explanatory Notes	Marks Available
1.	(i) (ii)	<p>$C \rightarrow A \rightarrow D \rightarrow B$ All correct (3); 2 or 3 correct (2); 1 correct (1)</p> <p>A [or stable]</p>	3 1 4
2.	(i) (ii) (iii)	<p>Helium / He[Capital H, small e] (1)</p> <p>fusion (1)</p> <p>red (1)</p>	3 3
3.	(a) (b)	<p>(i) <u>decreases</u></p> <p>(ii) <u>increases</u></p> <p>Wavespeed = $[3 \times 0.2 =] 0.6$ [m/s] (ans)</p>	1 1 1 3
4.	(a) (b) I	<p>(i) Loft insulation yearly saving = £100 (1) Total Cost = £1600 (1)</p> <p>(ii) £1000 no e.c.f.</p> <p>(i) Contains <u>air</u> which is a <u>poor conductor</u> / insulator</p> <p>(ii) Air cannot move / trapped within the insulation [so no convection possible] – accept “not enough space for particles to move about” – not can’t escape</p> <p>Any 1x (1) valid point from each of</p> <ul style="list-style-type: none"> • environmental reasons, e.g. global warming / CO₂ emissions, waste disposal – or just “for the environment” • resources e.g. fossil fuel depletion 	2 1 1 1 2 7
5.	(i) (ii) (iii) (iv)	<p>Windy location / 40% of European wind energy</p> <p>The average wind speed is less than 5 m/s [accept : too low] – or equiv.</p> <p>Windier location [or wind speed > 5 m/s](1)</p> <p>Long distance to connect [or not connected] to grid (1)</p> <p>£1500 ÷ £300 / year / 5 years (working or ans)</p> <p>[accept correct working even with wrong answer but not £300 ÷ £1500 = 5]</p>	1 1 2 1 5

F H		Answer / Explanatory Notes	Marks Available
6.	(a)	System of linked cables [accept wires / power lines – not just pylons or transformers] (1) connecting users / homes / businesses / factories to power stations / distributing electricity [or power](1)	2
	(b)	(i) 25 GW (ii) 15 GW	1 1
	I	(i) Suitable time given, a time between 12 am – 6 am [must include am] – not just “late at night” but accept 4 am onwards. demand at its lowest low [or equivalent, even “not many people using electricity”] (ii) Water can flow [almost] instantly – or equiv. [accept “no start up time <u>for burning fuels</u> ”]	1 1 1
			7
7.	(a)	(i) Units used = 320 kWh (ii) Cost = £38.40 or 3840 p [accept £38.40p] ecf (1) with correct unit (1)	1 2
	(b)	(i) Unit conversion → 0.5 [hr] (1) Units used = 3 × time[accept 30] (1) [= 1.5 kWh] [3 × 30 → (1); 3 × 30 / 60 → (2); 3 × 0.5 → (2); 0.5 anywhere → (1)] (ii) Less water used – or equiv [not “don’t boil the kettle fully”]	2 1
			6
8.	(a)	(i) Microwaves (ii) Radio [or UHF] (iii) Infra red [accept visible / light]	1 1 1
	(b)	Any 2 × (1) of <ul style="list-style-type: none"> • Satellite in same position <u>above the earth</u> / <u>in the sky</u> ✓ [not: does not move] • because orbit time is the same as the Earth’s rotation time [accept 24 hours] ✓ • geosynchronous / geostationary orbit ✓ 	2
			5
9.	(i)	Plots ± ½ square (2) [-1 per error, minimum 0] Smooth curve not hairy between the points [ignore origin to 1 st point and above highest point](1) – allow e.c.f for suitable line for misplotted points	3
	(ii)	Not straight / it’s a curve [If they’ve drawn a straight line not through the origin accept “not through origin” Accept good description in terms of data]	1
	(iii)	No – there is no pattern [however expressed] [accept – no rule]	1
			5

F H		Answer / Explanatory Notes	Marks Available
10. (a)		Equation: [%] Efficiency = $\frac{\text{Useful energy [input]}}{\text{[total] energy input}} \times 100$ Calculation: % Efficiency = $\frac{400}{1000} (1) \text{ [or } 0.4] \times 100 = 40\% (1 - \text{ans})$	1 2
(b)		Wasted energy = 100 J (1) Useful energy = 900 J (1) [e.c.f.]	2 5

Physics 1 – Higher Tier

F H	Answer / Explanatory Notes	Marks Available
1. (a)	(i) Microwaves (ii) Radio [or UHF] (iii) Infra red [accept visible / light]	1 1 1
(b)	Any 2 × (1) of <ul style="list-style-type: none"> • Satellite in same position <u>above the earth</u> / <u>in the sky</u> ✓ [not: does not move] • because orbit time is the same as the Earth's rotation time [accept 24 hours] ✓ • geosynchronous / geostationary orbit ✓ 	2 5
2. (a)	(i) Mercury / Venus / Mars / Pluto (ii) Jupiter	1
(b)	(i) Plots ± ½ square (2) [-1 per error, minimum 0] Smooth curve not hairy between the points [ignore origin to 1 st point and above highest point](1) – allow e.c.f for suitable line for misplotted points (ii) Not straight / it's a curve [If they've drawn a straight line not through the origin accept "not through origin" Accept good description in terms of data]	3 1
(iii)	No – there is no pattern [however expressed] [accept – no rule]	1 5
3. (a)	Equation: [%] Efficiency = $\frac{\text{Useful energy [input]}}{\text{[total] energy input}} \times 100$	1
(b)	Calculation: % Efficiency = $\frac{400}{1000}(1)$ [or 0.4] × 100 = 40% (1 - ans)	2
(b)	Wasted energy = 100 J (1) Useful energy = 900 J (1) [e.c.f.]	2 5
4 (a)	[As the water becomes shallower] the wavelength decreases (1) and the amplitude increases (1) [or equiv]. [They both increase → (1)]	2
(b)	(i) [0.2] waves / cycles [pass any point] per / every second [accept 1 wave every 5 seconds]	1
(ii)	wavelength = $\frac{\text{wave speed}}{\text{frequency}}$	1
(iii)	wavelength = $\frac{0.6}{0.2}(1 - \text{subst}) = 3$ [m] (1 - ans)	2
		6

F H		Answer / Explanatory Notes	Marks Available
5	<p>(a)</p> <p>Any 3 × (1) sensible points relating to</p> <ul style="list-style-type: none"> • commissioning / decommissioning costs • energy source availability / cost / lifetime / sustainability • transport • environmental impact <p>Maximum of 1 mark per bullet point</p> <p>(b)</p> <p>(i) Reference to variable wind speed</p> <p>(ii) Currency conversion [12 p → £0.12 or £384 → 38400 p] (1) Substitution to find number of units: e.g. £384 = units used × £0.12 (1) Number of units used = 3200 [kWh] (1) Substitution to find time: 3200 (ecf) = 2.5 × time / Time = 1280 hours (1) [NB 12.8 → (3); 128 →(2)]</p>	<p>3</p> <p>1</p> <p>4</p> <p>8</p>	
6	<p>(a)</p> <p>(i) Any 2 × (1) from:</p> <ul style="list-style-type: none"> • Increase / high voltage ✓ • decrease in / small current ✓ • less heating ✓ <p>(ii) Conversion: $1.9 \times 10^4 \text{ kW} \rightarrow 1.9 \times 10^7 \text{ W}$ or $3.8 \times 10^5 \text{ V} \rightarrow 380 \text{ kV}$ (1) Subst e.g. $1.9 \times 10^4 \text{ kW} = 3.8 \times 10^5 \text{ V} \times I$ (1) manip: $\therefore I = \frac{1.9 \times 10^4 \text{ kW}}{3.8 \times 10^5 \text{ V}}$ (1) Current = 50 A [NB No answer mark]</p> <p>(b)</p> <p>(i) Any 3 × (1) from:</p> <ul style="list-style-type: none"> • [Metal is a good] conductor ✓ • [Black surface is] a good radiator / emitter [good absorber – s.i.f.] ✓ • [Fins] have big surface area ✓ • Convection between fins ✓ <p>(ii) Equation : Energy transfer = Power × time Power loss = $0.1 \times 10^4 \text{ kW}$ (1) × 1000 (1) × 60 (1) Energy loss = 60 000 000 J / 60 000 kJ / 60 MJ</p>	<p>2</p> <p>3</p> <p>3</p> <p>1</p> <p>3</p> <p>12</p>	

F H	Answer / Explanatory Notes	Marks Available
7 (a)	<p>It was thought that <u>chemical energy</u> [or fuel or named source of chemical] was the source of the Sun's output (1) This energy supply <u>should not last this long</u> [or equiv.] (1)</p>	2
(b)	<p>The fraction / proportion / quantity of heavy elements [or helium or elements heavier than helium] is increasing [or converse e.g. fraction of light elements or hydrogen reduced](1) Result of <u>nuclear fusion</u> in stars (1) in which [nuclei of] light elements join to produce heavier nuclei. [or hydrogen to helium] (1)</p>	3
(c)	<p>The radiation from distant galaxies shows a red shift / increased wavelength (1) showing that the galaxies are moving away from our galaxy / the universe has expanded since the radiation was emitted [not: galaxies expanding](1)</p>	2
		7

Physics 2 – Foundation Tier

Question Foundation Tier		Details	Mark Available
1.	(a)	(i) Blue (ii) Earth [or ground]	1 1
	(b)	If the current is too high /goes higher than 5 A (1) the fuse melts / breaks [accepts “blows”] / breaks the circuit / stops the current (1)	2
			4
2.	(a)	3000 N + 5000 N = 8000 N (ans)	1
	(b)	1200 N circled / indicated [more than 1 circled →0]	1
	(c) <u>at an increasing speed</u> (1) <u>driving force</u> (1) ...	2
			4
3.	(a)	(i) 3000 + 2000 + 1400 (1) = 6400 W (working or answer) (ii) 6.4 kW (ec.f.)	1 1
	(b)	Current = $\frac{6400(\text{e.c.f.})}{230}$ (1 subs) = 27.8 / 28 A (1 ans)	2
			4
4.	(a)	(i) 50% + 10% +20% = 80% (ans) (ii) The fraction from nuclear power is tiny / <u>only</u> 1% / small / much less than from natural sources / nearly all radiation from non-power station sources [or equiv]	1 1
	(b)	<u>Radon</u> varies geographically [or equiv] / depends on <u>type</u> of rocks [accept: could be higher nearer to power stations / reprocessing plants]	1
			3

Question Foundation tier		Details	Mark Available
5.	(a)	Time = $\frac{12}{20}$ (1 subs) = 0.6 s (1 ans)	2
	(b)	Alcohol: increases , increases / no change (1) Lower speed:decreases, decreases (1) wet road: no change increases (1) [accept equivalent wording, e.g. gets more, as appropriate]	3 5
6.	(i)	10 000 circled (1)	2
	(ii)	15 000 circled (1)	2
7.	(a)	Work done = 2450 + 350 [= 2800 J] (working or answer)	1
	(b)	Force = $\frac{2800(\text{e.c.f.})}{3.5}$ (1 subs) = 800 N (1 ans)	2 3
8.	(a)	(i) radiation damages <u>cells</u> / DNA / causes mutations / ionizes	1
		(ii) radiation is [very] penetrative / has to be contained or monitored / long time to become inactive / long half life [“buried” needs to be qualified, e.g. deep].	1
	(b)	(i) 100 cpm (ii) 200 cpm (iii) Aluminium / it absorbs[or stops] alpha (1) and beta (1) [Or “ <u>only</u> (1) gamma passes through” → (1)]	1 1 2 6
9.	(a)	<u>live</u>	1
	(b)	(i) A and B (1) [if C identified → 0] (ii) C (only) (1) [if A and/or B identified → 0]	2 3

Question Foundation tier		Details	Mark Available
10.	(a)	Resistance = $\frac{6}{1.2}$ (1 subs) = 5 Ω (1 ans)	2
	(b)	(i) Increases (1) [or w.t.t.e]	3
		(ii) Decreases (1) [or w.t.t.e.]	
	(iii) Stays the same (1) [or w.t.t.e.]	5	
11.	(a)	Acceleration to 30 m/s followed by constant speed shown (1) Change to constant speed at 40 s (1) [allow graph beyond 60s]	2
	(b)	(i) Acceleration = $\frac{\text{change in speed}}{\text{time}}$	1
		(ii) Acceleration = $\frac{30-20}{20}$ (1 subs) = 0.5 m/s ² (1 ans) [allow e.c.f. from graph]	2
		5	
12.	(i)	High dose [to tumour / cancer] (1) limits damage / low dose to surrounding / healthy cells (1)	2
	(ii)	[heavy] shielding [however expressed] / remote control	1
	(iii)	Any 2 \times (1) from: <ul style="list-style-type: none"> • less dangerous to administer ✓ • less damage to healthy cells / patient ✓ • lower overall dose ✓ • located in / dose directly to the tumour / destroys tumour from inside ✓ • uses a short $\frac{1}{2}$ life source ✓ 	2
	(iv)	Heat / energy from the radiation	1
		6	

Physics 2 – Higher Tier

Question Higher tier	Details	Mark Available
1.	<p>(a) Resistance = $\frac{6}{1.2}$ (1 subs) = 5 Ω (1 ans)</p> <p>(b) (i) Increases (1) [or w.t.t.e] (ii) Decreases (1) [or w.t.t.e] (iii) Stays the same (1) [or w.t.t.e]</p>	<p>2</p> <p>3</p> <p>5</p>
2.	<p>(a) Acceleration to 30 m/s followed by constant speed shown (1) Change to constant speed at 40 s (1) [allow graph beyond 60s]</p> <p>(b) (i) Acceleration = $\frac{\text{change in speed}}{\text{time}}$ (ii) Acceleration = $\frac{30-20}{20}$ (1 subs) = 0.5 m/s² (1 ans) [allow e.c.f. from graph]</p> <p>(c) (i) Moving at constant speed / acceleration = 0 (1) Resultant force is zero (1) [Forces balanced / equal and opp.] (ii) Resultant force = 2400 \times 0.5 (e.c.f) = 1200 N (1 ans)</p> <p>(d) Any 2 \times (1) from: <ul style="list-style-type: none"> • 0 – 20 s: (0, 0) \rightarrow (0, 20) \checkmark • 20 – 40 s: (>2400, 20) \rightarrow (0, 40) \checkmark • 40 – 60 s: (0, 40) \rightarrow (0, 60) \checkmark </p>	<p>2</p> <p>1</p> <p>2</p> <p>1</p> <p>2</p> <p>10</p>
3.	<p>(i) High dose [to tumour / cancer] (1) limits damage / low dose to surrounding / healthy cells (1)</p> <p>(ii) [heavy] shielding [however expressed] / remote control</p> <p>(iii) Any 2 \times (1) from: <ul style="list-style-type: none"> • less dangerous to administer \checkmark • less damage to healthy cells / patient \checkmark • lower overall dose \checkmark • located in / dose directly to the tumour / destroys tumour from inside \checkmark • uses a short $\frac{1}{2}$ life source \checkmark </p> <p>(iv) Heat / energy from the radiation</p>	<p>2</p> <p>1</p> <p>2</p> <p>1</p> <p>6</p>

Question Higher tier		Details	Mark Available
4.	(a)	Fuses are always on the live side	1
	(b)	S ₁ on the A line (1) S ₂ on the horizontal line between B & C (1) Both switches on the live side (1)	3 4
5.	(a)	Equation: Power = current × voltage	1
		Conversion kW → W (1) [2 × 1000 = 2000 W] [at any stage]	
	Subs / manip (1) $\left[I = \frac{2000}{230} \right]$	3	
	Ans (1) I = 8.7 A [accept 9 A]		
(b)	(i)	Compares [accept: measures] current in live and neutral leads [or equiv] (1) Difference detected causes rcd to break circuit / using an electromagnetic switch (1)	2
	(ii)	More sensitive / triggered by v small current difference (1) Very fast acting (1)	2 8
6.	(a)	850 – 50 = 800 cpm (ans)	1
	(b)	Table completed: 800, 400, 200, 100, 50 and suitable scales to use the bulk of grid (1) Plots ± ½ minor division (1) Line (1)	3
	(c)	(i) Reading from candidate's graph (1) [likely range 250 – 310] Detector reading = 300 + 50 = 350 cpm (1) [i.e. + 50]	2
	(ii)	Detector reads 125 cpm (1) Spilled material gives 125 – 50 = 75 cpm (1) Line at 75 cpm gives 35 days (1)	3 9

Question Higher tier		Details	Mark Available
7.	(a)	(i) $mgh = 937.5 \text{ J}$ $30 \times 10 \times h = 937.5$ $h = \frac{937.5}{300} \text{ (1 subs/manip) } = 3.125 \text{ m (1 ans)}$	2
		(ii) Energy lost = $\frac{60}{100} \times 937.5 = 562.5 \text{ J (1)}$ KE of child = $937.5 - 562.5 = 375 \text{ J (1)}$ $\left[\text{or } \frac{40}{100} \times 937.5 \text{ (1) ans (1)} \right]$	2
		(iii) $\frac{1}{2} mv^2 = 375 \text{ (e.c.f)}$ $\frac{1}{2} \times 30 \times v^2 = 375 \text{ (1) (subs)}$ $v = 5 \text{ m/s (1) (ans)}$	2
	(b)	Work has to be done (1) to overcome friction between the slide and the child (1)	2
			8

Physics 3 – Foundation Tier

F - tier		Answer / Explanatory Notes	Marks Available
1.	(a)	Electron (1), nucleus (1), neutron (1) labelled	3
	(b)	(i) 7 (ii) 3	1 1
			5
2.	(a)	(i) D (ii) B	1 1
	(b)	(iii) Move faster (1) stronger magnetic field (1) / stronger magnets/ move magnets closer not thicker wire not more turns no marks for “coil”	2
			4
3.	(a)	refraction	1
	(b)	decreases (1) decreases (1)	2
	(c)	... <u>transverse</u> (1) <u>are at 90°</u> to (1)	2
			5
4.	(a)	Faster (than S wave)	1
	(b)	it is liquid / there is a liquid layer / (outer) core is liquid	1
	(c)	P is longitudinal or S is transverse	1
			3
5.	(a)	(i) Hydrogen (1) (ii) neutron (1) (iii) fusion (1)	3
	(b)	Any 2 × (1) from <ul style="list-style-type: none"> • high temperature needed ✓ / that would melt container/ [or equiv.] ✓ / high energy needed • high pressure needed ✓ / needs to be strong for containment • particles need to overcome the repulsive force ✓ 	2
			5

F - tier		Answer / Explanatory Notes	Marks Available
6.	(a)	0.6 s	1
	(b)	1.8 s	1
	(c)	$\frac{6(1)}{1.2(1)}$ Answer 5 m/s ² (1)	3
	(d)	velocity	1
	(e)	1500 × 4 (1) = 6000 (1) 1 mark for 4 appearing	2
			8
7.	(a)	U captures (slow-moving) neutrons (1) and splits (1) /produces 2 nuclei(1)	2
	(b)	²³⁵ ₉₂ U can only capture slow-moving neutrons/slow enough to react / more chance of capture /equiv.	1
	(c)	increase in energy (1) more <u>neutrons</u> available to produce fission [or equiv.] (1)	2
			5
8.	(a)	Pitch/frequency too high/outside our range of hearing/very high pitch/ Hz too high	1
	(b)	depth = 1500 × 3 (subst – 1) = 4500 m (ans – 1) division by 2 at any stage (1)	3
	(c)	(industrial) cleaning / fault finding/searching for oil Accept man made use including sonar Not ultrasound imaging on its own	1
			5
9.	(a)	91/92 m	1
	(b)	20 (1) – 14 = 6 m (1)	2
	(c)	The 2-second rule gives a stopping distance that is smaller than the Highway Code data [or equiv.] Any reference to time ×	1
	(d)	the line is curved [or equiv. e.g. using data from the line to show that doubling speed doesn't just double the stopping distance]	1
			5

F - tier		Answer / Explanatory Notes	Marks Available
10.	(a)	Coil B (1) It steps down / output voltage smaller than input (1)	2
	(b)	magnetic field must change	1
	(c)	direct magnetic field into secondary / make field stronger / traps the field	1
	(d)	magnetic field inside the secondary is <u>changing</u>	1
			5

Physics 3 – Higher Tier

H - tier	Answer / Explanatory Notes	Marks Available
1.	<p>(a) frequency too high</p> <p>(b) depth = 1500×3 (subst – 1) = 4500 m (ans – 1) division by 2 at any stage (1)</p> <p>(c) industrial cleaning / fault finding</p> <p>(d) Wavelength = $1500/50000$ [1 for manip of eqⁿ or numbers, 1 for subst] = 0.03 [Ans 1]</p>	<p>1</p> <p>3</p> <p>1</p> <p>3</p> <p>8</p>
2.	<p>(a) 92 m</p> <p>(b) $20(1) - 14 = 6$ m (1)</p> <p>(c) The 2-second rule gives a stopping distance that is smaller than the Highway Code data [or equiv.]</p> <p>(d) the line is curved [or equiv. e.g. using data from the line to show that doubling speed doesn't just double the stopping distance]</p>	<p>1</p> <p>2</p> <p>1</p> <p>1</p> <p>5</p>
3.	<p>(a) Coil B (1) It steps down / output voltage smaller than input (1)</p> <p>(b) magnetic field [accept "it"] must change [direction] / alternate [to get induced voltage]</p> <p>(c) direct magnetic field into secondary / make field stronger</p> <p>(d) magnetic field inside the secondary is changing</p> <p>(e) $\frac{V_1}{V_2} = \frac{N_1}{N_2}$ (1) $\frac{230}{5} = \frac{9200}{N_2}$ (1) [subst or manipulation]; $N_2 = 200$ (1) [ans] NB 46 or $\frac{1}{46}$ gets one mark</p>	<p>2</p> <p>1</p> <p>1</p> <p>1</p> <p>3</p> <p>8</p>

H - tier		Answer / Explanatory Notes	Marks Available
4.	(a)	chain reaction	1
	(b)	56 (for the atomic no. of Ba) (1) 90 (for mass no. of Kr) (1)	2
	(c)	(i) slows down (fast) neutrons	1
		(ii) boron [steel] rods raised in / lifted from the reactor / add more fuel/or uranium / increase the number of successful collisions / absorb fewer neutrons	1
	(d)	availability of fuel (1) waste material not / less <u>radioactive</u> (1) more energy available from fusion than fission (1)	3
			8
5.	(a)	its final velocity is negative	1
	(b)	(i) 0.2 s	1
		(ii) - 20 m/s [negative sign not needed]	1
	(iii)	$F = \frac{1200 \times [-]20}{0.2}$ (e.c.f.) from (i) & (ii) (1- subst) = 120 000 N (1) or $F = \frac{18000 \pm 6000}{0.2}$ -(1) Ans 120,000N (1)	2
	(c)	distance travelled = area under graph Distance = 0.5×5 (1) $\times 1.8$ (1:use of time 1.8–1.85 s) = 4.5 m (1) [NB 1.85 s → 4.625 m] Or $x = \frac{1}{2}(u+v)t$ = $\frac{5}{2}$ (1) $\times 1.8$ (1) = 4.5	3
	(d)	air bag or seat belt (1) / crumple zone increased time to stop (1) / increase distance to stop / absorbs some of the impact energy	2
			11

H - tier		Answer / Explanatory Notes	Marks Available
6.	(a)	Negatively charged / electrons (1) are contained in a sea of positive charge (1) – in writing or labelled on diagram Labelled diagram (1)	3 6
	(b)	Arrowed line from inner orbital to outer (1) Radiation [accept wave drawn] emitted between the two orbitals (1) Arrowed line back to inner orbital (1) [Information can be on diagram and / or as written explanation]	
7.	i)	.. to control / change (1) ...the magnetic field strength (1) / electromagnets are more powerful than permanent / permanent magnets lose their strength	4 4
	ii)	.. to increase the voltage from the generator (1) More lines cut (1)	
	iii)	to create radial field / so lines are at 90° to coils (1) voltage is always a maximum (1) Must gain 1 mark from each of the 3 parts	



WJEC
245 Western Avenue
Cardiff CF5 2YX
Tel No 029 2026 5000
Fax 029 2057 5994
E-mail: exams@wjec.co.uk
website: www.wjec.co.uk