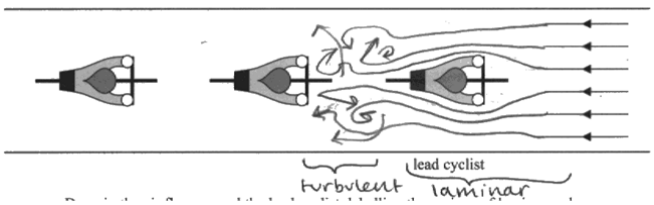
Question Number	Answer	Mark
1 (a)	A statement which implies only certain energies are allowed e.g. Allowed/possible energy of atom/electron (in an atom) Discrete energy of an atom/electron One of the energies of the atom/electron Energy an atom/electron can have	**1**
(b)	Photon is a (discrete) package/packet/quantum of (electromagnetic) energy/particle of light	**1**
(c)	(energy of) E_2 – (energy of)E_1	**1**
(d)	See $E = h c / \lambda$ **OR** use of $v = f\lambda$ Substitution into $E = h c / \lambda$ **OR** use of $E = hf$ $E = 3.14 \times 10^{-19}$ J or 1.96 eV **Example of answer** $E = (6.63 \times 10^{-34}$ Js $\times 3 \times 10^{8}) \div 6.33 \times 10^{-7}$ m $E = 3.14 \times 10^{-19}$ J	**1** **1** **1**
	Total for question	**6**

Question Number	Answer		Mark
2 (a)(i)	Laminar alone to handlebar (at least from front wheel and 4 lines) and some turbulant behind (laminar: continuous lines, not crossing, not bending sharply, no eddies) A region of laminar and turbulent correctly labelled for candidates drawing  	**(1)** **(1)**	**2**
2 (a)(ii)	Velocity of the lead cyclist relative to the air is greater (than that of the 2nd cyclist) **Or** air flow around the bicycle is greater for lead cyclist **Or** lead cyclist has increased the speed of the air More (air) resistance/drag on lead cyclist (Allow opposite for 2nd cyclist)	**(1)** **(1)**	**2**
2(b)	4 × force required (allow air resistance, drag, cyclist's force, friction etc) See or used $P = Fd/t$ **Or** $P \propto v$ **Or** $P = Fv$ Power = $8P$ <u>Example of calculation</u> Power = (force × distance) /time $P = (kv^2 \times d)/t$ New power $P_{faster} = (k(2v)^2 \times 2d)/t$ $P_{faster} = 8\ (kv^2 \times d)/t = 8P$	**(1)** **(1)** **(1)**	**3**
2(c)(i)	30 (°C) as the drag is lower **Or** 30 (°C) because cyclist can travel faster for the same drag (accept high/largest instead of 30 (°C))	**(1)**	**1**
2(c)(ii)	Use of work done = force × distance Difference in work done at these temperature = 8800 J (accept Nm) (accept 9000 J as 4 km is to 1 sf) <u>Example of calculation</u> Difference in work done = (66.4 N – 64.2 N) × 4 000 m Difference in work done = 265600 − 256800 = 8800 J	**(1)** **(1)**	**2**
	Total for question		**10**

Question Number	Answer		Mark
3(a)	Wind exerts a force/push(on the blades) blades move (through a distance in the direction of the force) **Or** Energy is transferred From kinetic energy of wind to (KE of) the blades	**(1)** **(1)** **(1)** **(1)**	**2**
3(b)(i)	Use of volume = area x length Volume = 270 000 (m^3) Example of calculation Volume per second = 6 000 m^2 × 9 m = 54 000 m^3 Total volume in 5 seconds = 54 000 m^3 × 5 s = 270 000 (m^3)	**(1)** **(1)**	**2**
3(b(ii)	Use of mass = density x volume Mass = 324 000 kg (ecf) Example of calculation Mass = 1.2 kg m^{-3} × 270 000 m^3 = 324 000 kg	**(1)** **(1)**	**2**
3(b)(iii)	Use of $E_k = 1/2\ mv^2$ E_k =1.3 x 10^7 J (ecf) Example of calculation E_k = ½ × 324 000 kg × (9 m s^{-1})^2 = 13 122 000 J	**(1)** **(1)**	**2**
3(b)(iv)	**Use of either** Energy from wind over 5 second period = 59 % x E_k **Or** KE divided by 5(s) Power = 1.5 MW [Range of correct answers 1.5 MW to 1.8MW] Example of calculation Energy from the wind in 5 seconds = 0.59 × 13 100 000 J = 7 741 980 J Power = energy/second = 7 741 980 J/5 s = 1.548 MW	 **(1)** **(1)**	**2**
3(c)	Would need to stop wind entirely/Wind or air still moving/Wind or air still has KE/Not all the air hits the blades	**(1)**	**1**
3(d)	**Max 2** • Wind doesn't always blow/if there is no wind they don't work/ wind speeds are variable/ need minimum amount of wind to generate the electricity/need a large amount of wind/can't be used in very high winds • Only 59 % max efficiency • Low power output/Need a lot of turbines/ Need a lot of space	**(1)** **(1)** **(1)**	**2**
	Total for question		**13**

Question Number	Answer	Mark
4 (a)	Show that the work done by the horse in turning the wheel once was about 20 000 J. Use of distance = 2 π r **(1)** Use of work = force x distance **(1)** Correct answer (19 000 (J) to at least 2 sf) **(1) [no ue]** (If force x 3.7 m used, allow second mark only) (If force x distance for 144 turns used, allow 1st and 2nd marks) *Example of calculation* x = 2 x π x 3.7 m = 23.2 m $W = F\Delta x$ =800 N x 23.2 m = 18 600 J ('Reverse show that' starting from 20 000J – max 2)	**(3)**
4 (b)	Calculate the average power of the horse Recall power is rate at which work is done (accept formula or substituted values) **(1)** Substitute for 144 turns **(1)** Correct answer (740 W) **(1)** If using P = Fv: Recall P = Fv **(1)** Use of v = s/t for 144 turns **(1)** Correct answer **(1)** *Example of calculation* Power = work done / time = 144 x 18 600 J / 60 x 60 s = 744 W (accept any dimensionally correct unit – ignore later units if W used as well) (use of 20 000 J gives 800 W)	**(3)**
	Total for question	**6**

Question Number	Answer	Mark
5 a	Describe how you could measure *g* **QWC – Work must be clear and organised in a logical manner using technical wording where appropriate** Max 6 marks state sufficient quantities to be measured (e.g. *s* and *t* OR *v*, *u* and t OR *u, v* and *s*)) (1) relevant apparatus (includes ruler and timer/data logger/ light gates) (1) describe how a distance is measured (1) describe how a speed or time is measured (1) further detail of measurement of speed or time (1) vary for described quantities and plot appropriate graph (1) state how result calculated (1)	**Max 6**
5b	repeat and mean (one mark max for any relevant quantity/result) (1) Precaution – a precaution relating to experimental procedure (1)	**1**
	Total for question	**7**