8 Figure 23 shows an electric car connected to a battery charger.

(Source: © Danil Roudenko/123RF)

Figure 23

The car has a rechargeable battery to drive its motor.

The rechargeable battery provides a potential difference of 330 V and can store up to 64 MJ.

It takes 8 hours for the battery to receive a full charge.

Assume that the charging process is 100% efficient.

(a) Calculate the total charge that flows while the battery is being charged.

(3)

(b) Calculate the average charging current.

(3)

current = ... A

*(c) The battery charger shown in Figure 23 is connected to the 230 V a.c. domestic mains supply.

The output voltage of the charger is 335 V and it provides a d.c. charging current. Charging stops if the charging current exceeds 15 A.

Explain how electrical components in the charger can be connected together to give this type of output.

(6)

.....

.....

.....

.....

.....

.....

.....

(Total for Question 8 = 12 marks)

Question number	Answer	Additional guidance	Mark
8(a)	Rearrangement of equation (1) $Q = \frac{E}{V}$ Substitution including change of unit (1) 64 MJ = 64 000 000 J $Q = \frac{64\,000\,000}{330}$ Answer and unit (1) Q = 190 000 (C)	allow answers that round to 190 000, e.g. 193 939 if the calculation is worked throughout without changing MJ to J, then maximum of 2 marks unless unit matches quantity	**(3)**

Question number	Answer	Additional guidance	Mark
8(b)	Rearrangement (1) $I = \frac{Q}{t}$ Conversions and substitution (1) 190 (kC) = 190 000 (C) 8 hours = 8 × 3600 (s) = 28 800 (s) $I = \frac{190000}{28800}$ Evaluation (1) = 6.6 (A)	ecf from (a) (6.5972) if 193 939 used then accept 6.7	**(3)**

Question number	Indicative content	Mark
*8(c)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 (6 marks)** • the sequence of events is voltage change, conversion to direct current, followed by current limiting • the battery is the load in the secondary circuit, not a store of energy for the primary circuit • a transformer is needed to increase (or step up) the voltage • so a diode is needed to change a.c. to d.c. • the charging current can be limited to 15 A using a fuse (or circuit breaker) • a circuit breaker may be preferable to a fuse, since a fuse would need to be replaced after use • the transformer primary coil is connected between the live and neutral in the primary circuit • the diode is connected in the secondary circuit of the transformer • the battery(which is to be charged), diode, fuse and secondary coil should be connected in series in the secondary circuit	**(6)**

Level	Mark	Descriptor
	0	No awardable content.
Level 1	1–2	• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
Level 2	3–4	• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5–6	• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)