T5-2 *[122 marks]*

1. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

2. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

3. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

4. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

5. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

6.

[1 mark]

Markscheme

A

Examiners report

The vast majority of candidates understood, correctly, that the radius had to be larger – but many chose B, incorrectly thinking that the radius, rather than the cross-sectional area, changes proportionately with the length for two wires of common resistance.

7.

[1 mark]

Markscheme

C

Examiners report

Most candidates chose A – an intuitive guess, but an incorrect one. When X breaks then the resistance in the circuit increases hence Z will be dimmer. Hence only C or D could be correct. And since Y has half the battery voltage across it, rather than a third previously, it has increased in brightness.

8.

[1 mark]

Markscheme

C

Examiners report

9.

[1 mark]

Markscheme

D

Examiners report

10.

[1 mark]

Markscheme

B

Examiners report

11.

[1 mark]

Markscheme

D

Examiners report

The majority of candidates chose the number of electrons flowing past a point in a given time as the definition of the ampere when the correct answer is in terms of a force between parallel currents.

12. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

13. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

14. *[1 mark]*

Markscheme

C

Examiners report

This question dealt with electric potential, a topic that is not part of the SL syllabus. The question was therefore deleted. The examination team apologizes for the logistical error of including this HL question in the SL paper as well.

15. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

16a. *[2 marks]*

Markscheme

$V = \frac{1.9 \times 10^{-18}}{1.6 \times 10^{-19}}$;

=12V;

Examiners report

However, this part was done well.

16b. *[8 marks]*

Markscheme

(i) ratio potential difference/voltage (across resistor) to current (in resistor) / $\frac{V}{I}$
with symbols defined;

(ii) some of the power/energy delivered by a cell is used/dissipated in driving the current though the cell itself;
the power loss can be equated to I^2r where r represents the (internal) resistance of the cell;
*To award **[2]** the resistance must be put into some context.*
*Award **[1 max]** for e.g. it is the resistance of the cell itself.*

(iii) pd across $R = \frac{1.44\times10^{-18}}{1.6\times10^{-19}} = 9.00\text{V}$;
pd across internal resistance=12.0-9.00(=3.00V);
current in circuit=$\left(\frac{3.00}{5.00} =\right) 0.600\text{A}$;
$R = \frac{9.00}{0.600}$;
(=15.0Ω)

(iv) 7.20 W;

Examiners report

(i) Many have now learnt the definition of resistance that this syllabus requires. Some still continue however to provide (spurious) explanations of how resistance arises.

(ii) This was a description and many candidates were able to gain one point. But the second point for an analysis of the internal power dissipation of a cell was universally absent.

17. *[4 marks]*

Markscheme

(i) the force exerted on a small/test/point mass;
Do not allow bald “gravitational force”.

(ii) the force exerted on a small/point/test positive charge;
*To award **[1]** “positive” is required.*
Do not allow bald “electric force”.

(iii) the size/magnitude/value of the small/point mass;
Do not accept bald “mass”.

(iv) the magnitude/size/value of the small/point/test (positive) charge;
Do not accept bald “charge”.

Examiners report

In this part candidates were completely at a loss and could not state the meanings of the symbols in the definitions of gravitational or electric field strengths. This was a disappointing failure in what was meant to be an easy opener to the whole question.

18a. *[3 marks]*

Markscheme

(i) $\frac{\text{potential difference across the component}}{\text{current in the component}}$;

*Award **[0]** for simple statement of voltage divided by current*

(ii) Ohm's law states that voltage is (directly) proportional to current **or** $\frac{\text{potential difference}}{\text{current}}$ /resistance is a constant;

graph not linear/gradient not constant so Ohm's law not obeyed / calculation of $\frac{V}{I}$ at two points showing that they are different;

*Award **[0]** for bald statement of Ohm's law not obeyed.*

Examiners report

[N/A]

18b. *[5 marks]*

Markscheme

(i) (from graph, when *V* = 2.8 V,) *I* = 0.33 A; *(accept answers in range 0.32 to 0.34 A)*

$R = \frac{V}{I} = \frac{2.8}{0.34} = 8.5\Omega$; *(accept answers in range 8.2 to 8.8 Ω)*

(ii) $A = \left(\frac{\rho l}{R} = \frac{5.8\times10^{-7}\times0.40}{8.5} =\right) 2.7 \times 10^{-8}$;

(accept answers in range 2.6 to 2.8×10^{-8})

$r = \sqrt{\frac{A}{\pi}}$ seen/used;

=9.3×10^{-5}m; *(accept answers in range 9.2 to 9.5×10^{-5})*

Examiners report

[N/A]

18c. *[2 marks]*

Markscheme

each lamp has a potential difference of 3.0 V so current equals 0.35 A;

(accept answers in range 0.34 to 0.35 A)

2.1 W; *(accept answers in range 2.0 to 2.1 W)*

*Award **[1]** for answers that use voltage 6.0 V with current 0.52 A to get P=3.1W.*

Examiners report

[N/A]

19a.

[4 marks]

Markscheme

(i) the force exerted on a small/test/point mass;
Do not allow bald "gravitational force".

(ii) the force exerted on a small/point/test positive charge;
*To award **[1]** "positive" is required.*
Do not allow bald "electric force".

(iii) the size/magnitude/value of the small/point mass;
Do not accept bald "mass".

(iv) the magnitude/size/value of the small/point/test (positive) charge;
Do not accept bald "charge".

In part (a) only penalize lack of "small/test/point" once, annotate as ECF.
It must be clear that the mass/charge in (iii) & (iv) refer to the object in (i) and (ii).

Examiners report

In this part candidates were completely at a loss and could not state the meanings of the symbols in the definitions of gravitational or electric field strengths. This was a disappointing failure in what was meant to be an easy opener to the whole question.

19b.

[3 marks]

Markscheme

$E_p = \frac{e}{4\pi\varepsilon_0 r^2}$ and
$g_p = \frac{Gm_p}{r^2}$; *(both needed)*
$\frac{e}{4\pi\varepsilon_0 Gm_p}\left(= \frac{9\times10^9\times1.6\times10^{-19}}{6.7\times10^{-11}\times1.7\times10^{-27}}\right)$;
$\approx 10^{28}$;

*Award **[2 max]** if response calculates ratio of force as this is an ECF from the first marking point (10^{39}) .*
*Award **[3]** for solution that correctly evaluates field strengths separately and then divides.*

Examiners report

Following (a) candidates failed widely on this part too. They often had little idea which data to use (mass and charge were frequently confused) and sometimes the meaning of the constants in the equations failed them too. This was compounded by arithmetic errors to make a straightforward calculation very hard for many.

20a.

[2 marks]

Markscheme

conduction is due to movement of the free electrons (transferring charge around circuit);
tungsten is a good electrical conductor with large numbers of free electrons;
glass is a poor electrical conductor with few/no free electrons;

Examiners report

[N/A]

20b. *[3 marks]*

Markscheme

(i) $\frac{6^2}{15}$ ***or*** $I=\frac{15}{6}$ and $R=6\times\frac{6}{15}$;
$=2.4\Omega$

(ii) $\text{area}=\frac{5.6\times10^{-7}\times0.35}{2.4}$;
0.082mm^2 ***or*** 8.2×10^{-8}m^2

Examiners report

[N/A]

20c. *[2 marks]*

Markscheme

lamp connected so that pd can be varied;
ammeter in series with lamp and voltmeter
in parallel with lamp; *(both needed)*
*Award **[0]** if lamp cannot light.*

Examiners report

[N/A]

21a. *[6 marks]*

Markscheme

(i) upward arrow labelled *T*/tension/force in cable and downward arrow labelled *W*/*mg*/weight/gravity force;{ *(both needed)*
tension arrow length >weight length;

(ii) $a=\frac{2s}{t^2}$;
$a=\left(\frac{2\times8.0}{6.5^2}=\right)0.38\left(\text{ms}^{-2}\right)$;
T=*ma*+*mg* ***or*** *T*=350(0.38+9.8);
3.6 kN;
Allow g=10 N kg^{-1} (same answer to 2 sf).

Examiners report

[N/A]

21b. *[4 marks]*

Markscheme

(i) change in gpe=350×9.81×7.0(=24kJ);
power $\left(=\frac{24\times10^3}{15}\right)=1.6\text{kw}$;
Allow g=10Nkg^{-1}.

(ii) power input to motor=13.5 (kW);
efficiency=$\left(\frac{1.6}{13.5}=\right)0.12$ ***or*** 12%;

Examiners report

[N/A]

22a. *[3 marks]*

Markscheme

(i) arrow pointing away from nucleus;

(ii) $E = \frac{74\times1.6\times10^{-19}}{4\pi\times8.85\times10^{-12}\times\left[1.4\times10^{-10}\right]^2}$;
5.4×10^{12} Vm^{-1} or NC^{-1};
*Award **[2]** for a bald correct answer.*

Examiners report

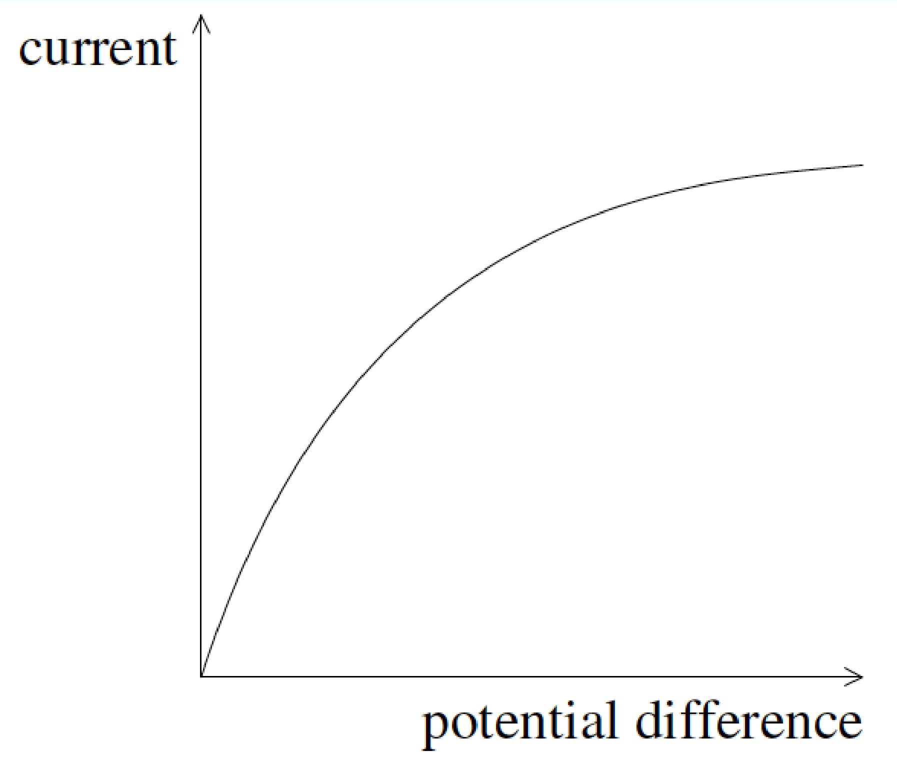
[N/A]

22b. *[4 marks]*

Markscheme

(i) lamp connected so that pd can be varied;
ammeter in series with lamp and voltmeter in parallel with lamp; *(both needed)*
*Award **[0]** if lamp cannot light.*

(ii) through origin;
correct shape;



Examiners report

[N/A]

22c. *[3 marks]*

Markscheme

minimum pd across bulb is when R=5.0Ω;
pd across bulb$= 6.0 \times \frac{2.4}{7.4}$
=1.9 (V) ***or*** 2.0 (V);
so range −1.9−6.0V ***or*** 0V across lamp cannot be obtained;

Examiners report

[N/A]

23a. *[1 mark]*

Markscheme

providing the temperature/physical conditions are constant and pd∝current;

or

providing the temperature/physical conditions are constant and the resistance is constant;

Examiners report

[N/A]

23b. *[8 marks]*

Markscheme

(i) current for one lamp =1.5 A;
$\frac{13}{1.5} = 8.67$;
so 8;
Must show working for full credit. Allow any suitable method.

(ii) 4.0 Ω;

(iii) *estimate:*
resistance of incorrect lamp=16Ω;
total resistance of “correct” lamps in parallel =1.3Ω ***or*** $\frac{1}{R} = \frac{1}{16} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4}$;
total resistance=1.2Ω;

assumption:
“incorrect” lamp will be at correct resistance/working temperature/normal brightness;

Examiners report

[N/A]

24. *[1 mark]*

Markscheme

B

Examiners report

25. *[1 mark]*

Markscheme

A

Examiners report

26.

[1 mark]

Markscheme

D

Examiners report

27.

[1 mark]

Markscheme

D

Examiners report

28.

[1 mark]

Markscheme

A

Examiners report

29.

[1 mark]

Markscheme

A

Examiners report

30.

[1 mark]

Markscheme

A

Examiners report

31.

[1 mark]

Markscheme

D

Examiners report

32. *[1 mark]*

Markscheme

D

Examiners report

33a. *[2 marks]*

Markscheme

use of $l = \frac{RA}{\rho}$; } *(allow if correct substitution seen – watch for use of circumference in place of area)*

$= \left(\frac{1.5 \times \pi \times [1.8]^2 \times 10^{-8}}{1.7 \times 10^{-8}} = \right) 9.0\text{m}$;

Examiners report

33b. *[6 marks]*

Markscheme

(i) the resistance of a conductor/copper/metal increases with increasing temperature;
increased power (dissipation) leads to higher temperature in the resistor/ resistor heating up;

(ii) $I = \left(\sqrt{\frac{P}{R}} = \right) \sqrt{\frac{1.0}{1.5}}$;
(=0.82A)
Allow working using 0.82A to show that power is 1.0086W, in this case final answer must be to 2 sig fig or better.

(iii) total resistance = [*R*+3.3];
6.0=0.82[*R*+3.3];
to give *R*=4.0Ω; *(allow use of 1.65Ω leading to 3.9Ω)*

or

total resistance in circuit = $\frac{6.0}{0.82} = (7.3\Omega)$;
internal resistance+fixed resistance=3.3Ω;
to give *R*=4.0Ω;

Examiners report

34. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

35. *[1 mark]*

Examiners report

[N/A]

36. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

37. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

38a. *[4 marks]*

Markscheme

(i) $v = \sqrt{\frac{2eV}{m}}$;

$v = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 250}{9.1 \times 10^{-31}}}$;

$= 9.4 \times 10^{6} \text{ms}^{-1}$

(ii) $evB = m\frac{v^2}{r}$;

$r = \frac{9.1 \times 10^{-31} \times 9.4 \times 10^{6}}{1.6 \times 10^{-19} \times 0.12}$;

$= 4.5 \times 10^{-4} \text{m}$

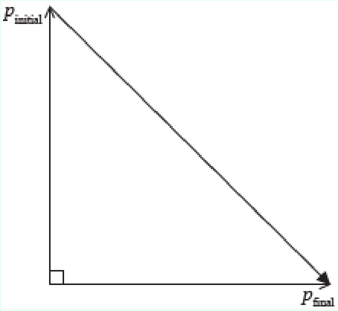
Examiners report

[N/A]

38b. *[3 marks]*

Markscheme

(i) vector as shown;



(ii) $\Delta p = \sqrt{\left[8.6 \times 10^{-24}\right]^2 + \left[8.6 \times 10^{-24}\right]^2}$;
$=1.2\times10^{-23}$Ns

(iii) $F\left(= \frac{\Delta p}{\Delta t} = \frac{1.2\times10^{-23}}{7.5\times10^{-11}}\right) = 1.6 \times 10^{-13}\text{N}$;

Examiners report

[N/A]

39a. *[2 marks]*

Markscheme

(i) the work done per unit charge in moving a quantity of charge completely around a circuit / the power delivered per unit current / work done per unit charge made available by a source;

(ii) the ratio of the voltage (across) to the current in the conductor;

Examiners report

[N/A]

39b. *[3 marks]*

Markscheme

(i) emf × current;

(ii) total power is $V_1I + V_2I$;
equating with EI to get result;
or
total energy delivered by battery is EQ;
equate with energy in each resistor $V_1Q + V_2Q$;

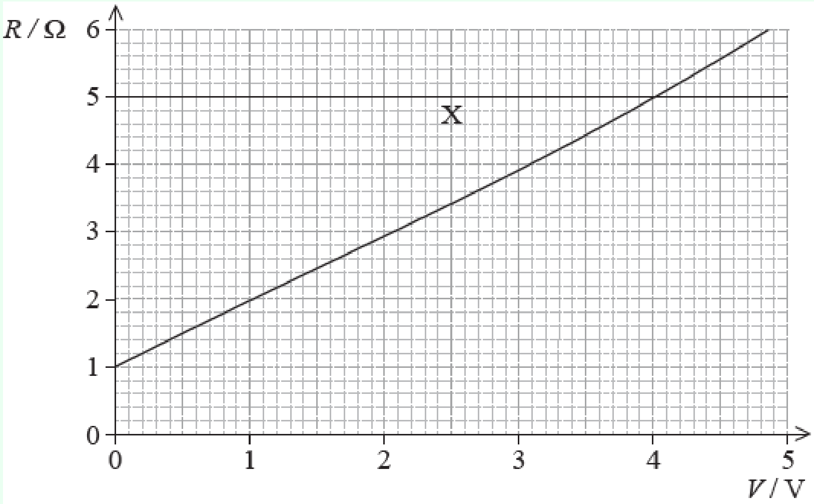
Examiners report

[N/A]

39c. *[3 marks]*

Markscheme

graph X: horizontal straight line;
graph Y: starts lower than graph X;
rises (as straight line or curve) and intersects at 4.0 V;



Do not pay attention to numbers on the vertical axis.

Examiners report

[N/A]

39d. *[4 marks]*

Markscheme

(i) realization that the voltage must be 4.0 V across each resistor;
and so emf is 8.0 V;

(ii) power in each resistor = 3.2W;
and so total power is 6.4 W;
or
current is 0.80 A;
so total power is 8.0×0.80 = 6.4W;

Examiners report

[N/A]