T5-1 *[237 marks]*

1. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

2. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

3. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

4. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

5. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

6.

[1 mark]

Markscheme

C

Examiners report

[N/A]

7.

[1 mark]

Markscheme

C

Examiners report

[N/A]

8a.

[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) place voltmeter across battery;

Examiners report

[N/A]

8b.

[2 marks]

Markscheme

(periodic) motion in which acceleration/restoring force is proportional to the displacement from a fixed point;

directed towards the fixed point / in the opposite direction to the displacement;

Examiners report

[N/A]

8c.

[4 marks]

Markscheme

(i) $\omega = (2\pi f = 2\pi \times 1250)$ 7854 rad s^{-1};

$a_0 = (-\omega^2 x_0 = -7854^2 \times 0.85 \times 10^{-3} =)$ $(-)5.2 \times 10^4$ ms^{-2};

(ii) correct substitution into
$E_T = \frac{1}{2} m \omega^2 {x_0}^2$ irrespective of powers of 10;

0.14 to 0.15 J;

Examiners report

[N/A]

8d. *[2 marks]*

Markscheme

(i) 0.264 m;

(ii) longitudinal;

progressive / propagate (through the air) / travels with constant speed (through the air);

series of compressions and rarefactions / high and low (air) pressure;

Examiners report

[N/A]

8e. *[6 marks]*

Markscheme

(i) S leads L / idea that the phase of L is the phase of S minus an angle;

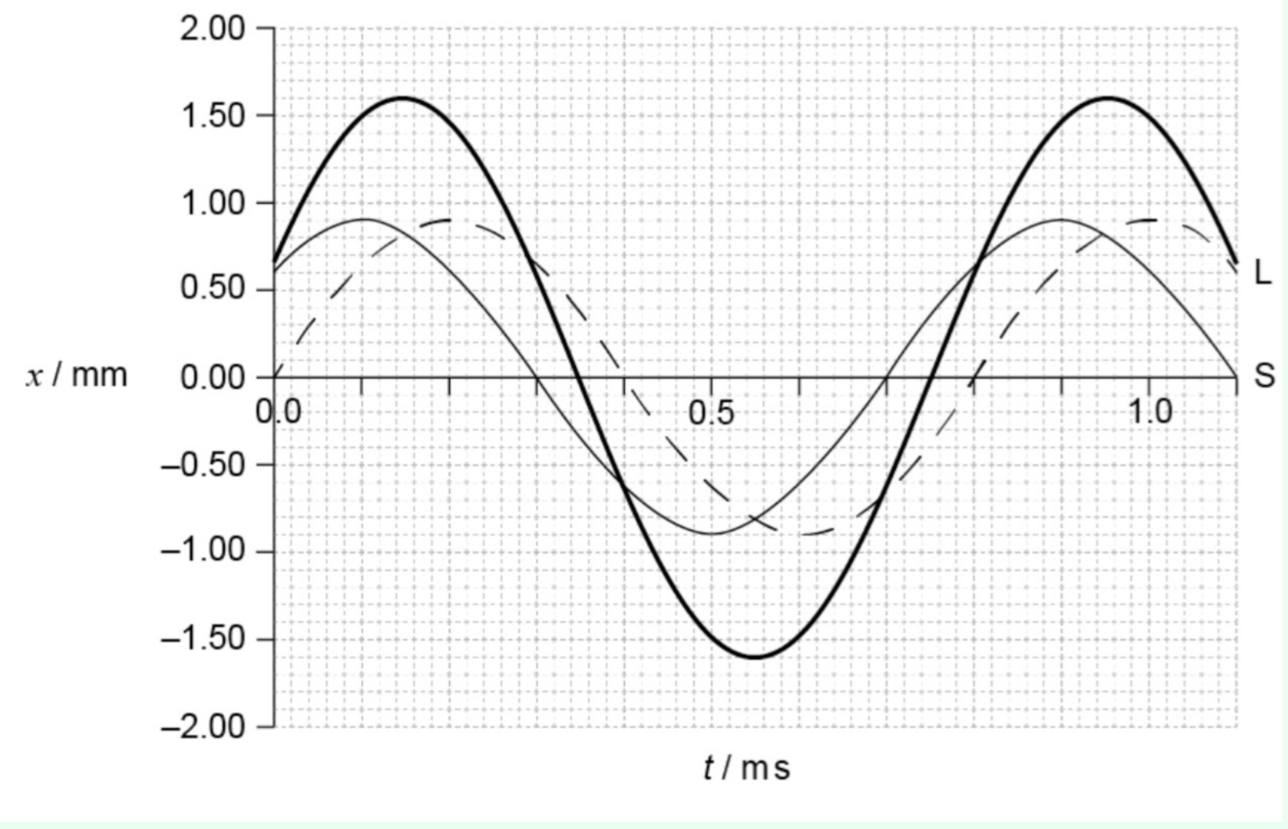
$\frac{1}{8}$ period / 1×10^{-4} s / 0.1 ms;

$\frac{\pi}{4}$ / 0.79 rad / 45 degrees;

(ii) agreement at all zero displacements;

maxima and minimum at correct times;

constant amplitude of 1.60 mm;



Examiners report

[N/A]

9a. *[1 mark]*

Markscheme

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;

Examiners report

[N/A]

9b. *[7 marks]*

Markscheme

(i) $V_X = 7.5$ (V);

$I\left(=\frac{4.5}{100\times10^3}\right) = 4.5\times10^{-5}\,\mathrm{A}$ ***or***

$\frac{V_X}{V_R} = \frac{R_X}{R_R}$;

$R_X\left(=\frac{7.5}{4.5\times10^{-5}}\right) = 1.67\times10^5\,\Omega$ ***or***

$R_X\left(=\frac{7.5}{4.5}\times100\times10^3\right) = 1.67\times10^5\,\Omega$;

$T = -37$ ***or***

-38 °C

(ii) −50 to (up to) −30 °C / at low temperatures;

(iii) as the temperature decreases R_X increases; same current through R and X so the ratio increases ***or*** V_X increases and V_R decreases so the ratio increases;

Examiners report

[N/A]

10a. *[2 marks]*

Markscheme

force in correct location on diagram, *ie* arrow on coil;
force direction to the right;
*Award **[1 max]** if any other forces drawn.*

Examiners report

[N/A]

10b. *[3 marks]*

Markscheme

$L = (2\pi rN) = 2\times\pi\times1.25\times10^{-2}\times150 = (11.8)\,\mathrm{m}$;

$F = (\mathrm{BIL}) = 0.40\times10^{-3}\times0.45\times10^{-3}\times11.8$;

$= 2.1\times10^{-6}\mathrm{N}/2.1\mu\mathrm{N}$

Examiners report

[N/A]

10c.

[3 marks]

Markscheme

(as the coil moves the) conductor cuts the magnetic field / there is a change in flux linkage;
induces an emf across the coil / a current through the coil;
opposes the driving potential difference;
reduces the (net) current;

Examiners report

[N/A]

11a.

[2 marks]

Markscheme

ma
$= -kx$;
$a = -\frac{k}{m}x$; (*condone lack of negative sign*)
$\left(\omega^2 = \frac{k}{m}\right)$

or

implied use of defining equation for simple harmonic motion $a = -\omega^2 x$;
$\left(\text{so}\omega^2 = \frac{k}{m}\right)$
$ma = -kx$ so $a = -\left(\frac{k}{m}\right)x$;

Examiners report

[N/A]

11b.

[3 marks]

Markscheme

(i) 0.833 (Hz);

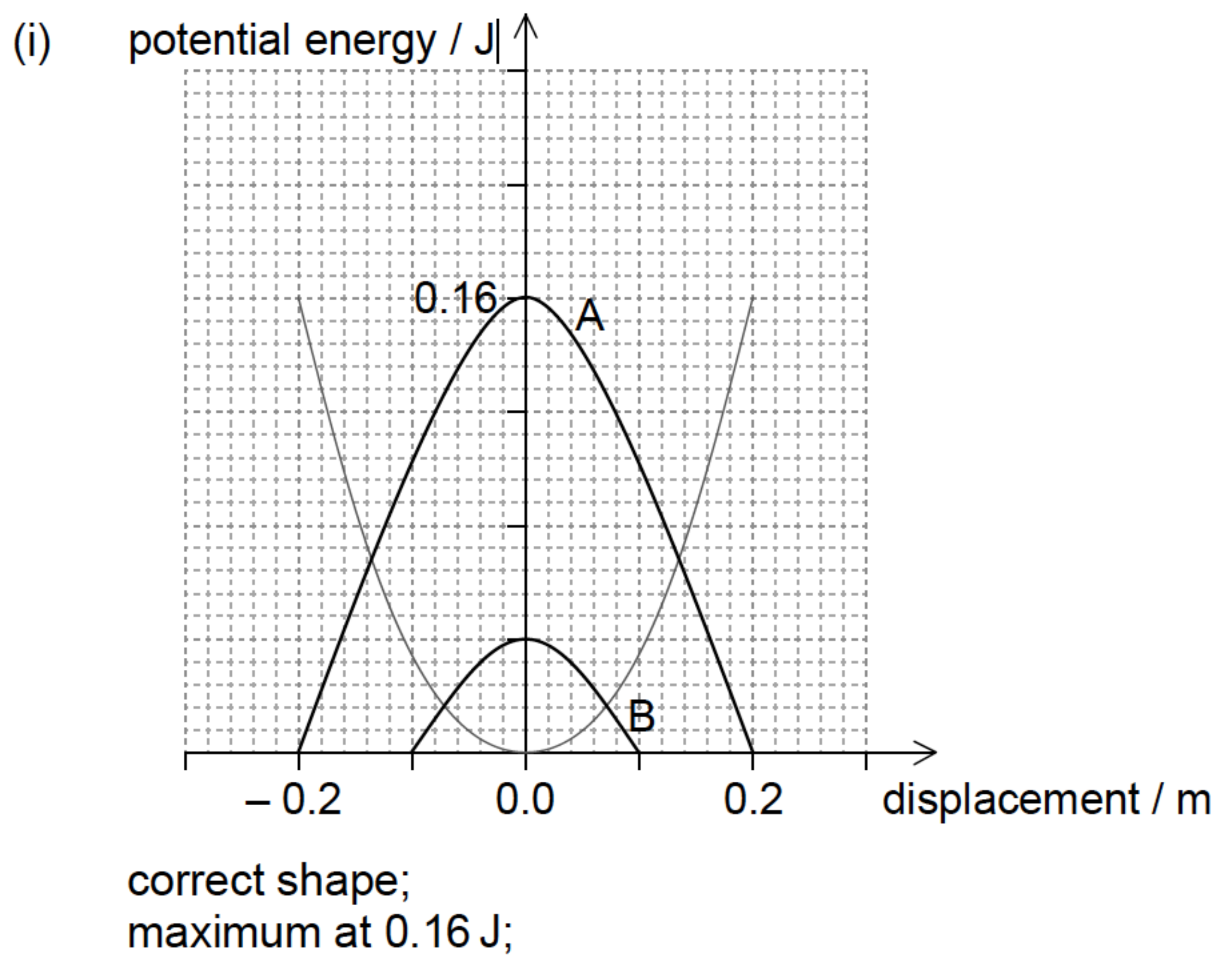
(ii) frequency/period is the same so ω is the same;
k is the same (as springs are identical);
(so *m* is the same)

Examiners report

[N/A]

11c. *[5 marks]*

Markscheme



(ii) end displacements correct $\pm$ 0.01m;
maximum lower than 0.16J;
maximum equal to 0.04J $\pm$ half square;

Examiners report

[N/A]

11d. *[4 marks]*

Markscheme

(i) $l = \frac{\pi d^2 R}{4\rho}$ seen / correct substitution into equation: $24 = \frac{l \times 1.7 \times 10^{-8}}{\pi \times \left(0.15 \times 10^{-3}\right)^2}$; } *(condone use of r for $\frac{d}{2}$ in first alternative)*

99.7 (m);
*Award **[2]** for bald correct answer.*
*Award **[1 max]** if area is incorrectly calculated, answer is 399 m if conversion to radius ignored, ie: allow ECF for second marking point if area is incorrect provided working clear.*

(ii) any line showing resistance decreasing with increasing diameter **and** touching point;
correct curved shape showing asymptotic behavior on at least one axis;

Examiners report

[N/A]

11e. *[3 marks]*

Markscheme

current/conduction is (related to) flow of charge;
conductors have many electrons free/unbound / electrons are the charge carriers / insulators have few free electrons;
pd/electric field accelerates/exerts force on electrons;
smaller current in insulators as fewer electrons available / larger current in conductors as more electrons available;

Examiners report

[N/A]

11f. *[8 marks]*

Markscheme

(i) use of total resistance = 11Ω; *(can be seen in second marking point)*
$\frac{1}{11}=\frac{1}{R}+\frac{1}{24}$;
20.3(Ω) ;

(ii) as current is same in resistor network and cell and resistance is same, half of emf must appear across resistor network;
6.0 (V);

or

$I=\frac{12}{(11+11)}=0.545\,(\mathrm{A})$;
V=(0.545×11=) 6.0 (V);

Other calculations are acceptable.
Award ***[2]*** *for a bald correct answer.*

(iii) use of 22 (ohm) ***or*** 11+11 (ohm) seen;
use of $\frac{V^2}{R}$ or equivalent;
6.54 (W);
Award ***[3]*** *for bald correct answer.*
Award ***[2 max]*** *if cell internal resistance ignored, yields 3.27 V.*

Examiners report

[N/A]

12a. *[2 marks]*

Markscheme

total momentum does not change/is constant; } *(do not allow "momentum is conserved")*
provided external force is zero / no external forces / isolated system;

Examiners report

[N/A]

12b. *[4 marks]*

Examiners report

[N/A]

12c.

[2 marks]

Markscheme

electric force per unit charge;
acting on a small/point positive (test) charge;

Examiners report

[N/A]

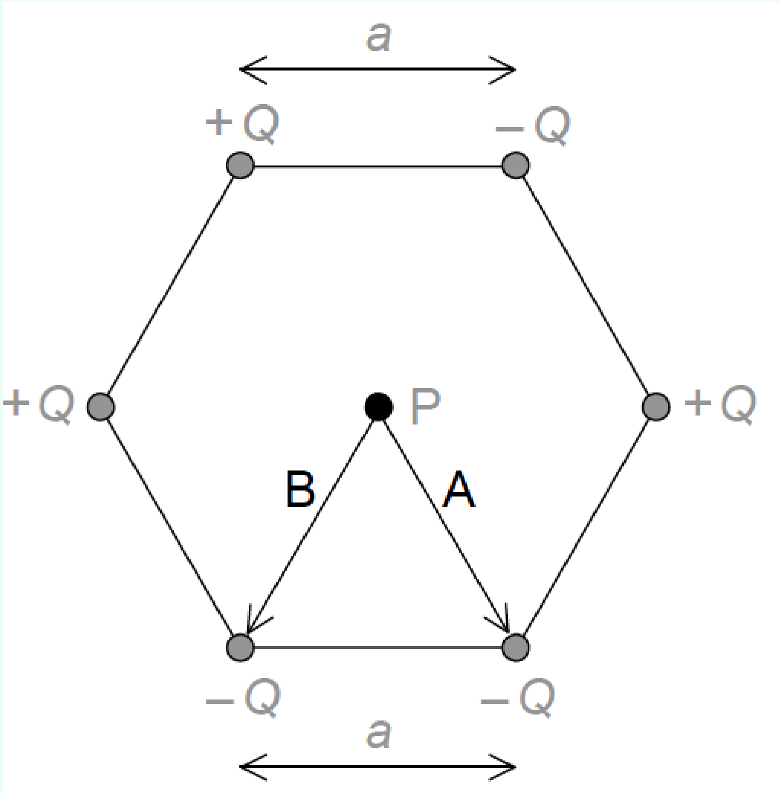
12d.

[8 marks]

Markscheme

(i) states Coulomb's law as $\frac{kQq}{r^2}$ ***or*** $\frac{F}{q} = \frac{kQ}{r^2}$
states explicitly q=1;
states r=a;

(ii)



arrow labelled A pointing to lower right charge;
arrow labelled B point to lower left charge;
Arrows can be anywhere on diagram.

(iii) overall force is due to +Q top left and -Q bottom right / top right and bottom left and centre charges all cancel; }
(can be seen on diagram)
force is therefore $\frac{2kQ}{a^2}$;

2.6×106 (N C^{-1}) ;
towards bottom right charge; *(allow clear arrow on diagram showing direction)*

Examiners report

[N/A]

13a. *[8 marks]*

Markscheme

(i)

$l = \frac{\pi d^2 R}{4\rho}$ seen / correct substitution

into equation:

$24 = \frac{l \times 1.7 \times 10^{-8}}{\pi \times \left(0.15 \times 10^{-3}\right)^2}$; } *(condone use of r for* $\frac{d}{2}$ *in first alternative)*

99.7 (m);

*Award **[2]** for bald correct answer.*

*Award **[1 max]** if area is incorrectly calculated, answer is 399 m if conversion to radius ignored, ie: allow ECF for second marking point if area is incorrect provided working clear.*

(ii) electric field=

$\left(\frac{12}{99.7} =\right) 0.120\ \left(\text{Vm}^{-1}\right)$; *(allow ECF from (a)(i))*

electric force=($e \times E$=$0.120 \times 1.6 \times 10^{-19}$ =)1.92×10^{-20}(N);

acceleration

$= \left(\frac{F}{m} = \frac{1.92 \times 10^{-20}}{9.1 \times 10^{-31}} =\right) 2.11 \times 10^{10} (ms^{-2})$; } *($5.27 \times 10^9$ if radius used in (a)(i) allow as ECF)*

or

work done on electron = (Vq =)$12 \times 1.6 \times 10^{-19}$;

energy gained by electron = $m_e \times a \times$distance travelled = $9.11 \times 10^{-31} \times a \times 99.8$;

2.11×10^{10} (ms^{-2});

*Award **[3]** for a bald correct answer.*

(iii) free electrons collide with ions and other electrons;

speed decreases during collisions / transfer their kinetic during collisions;

kinetic energy transferred to heat / wires have resistance;

and speed increases/acceleration until next collision;

Examiners report

[N/A]

13b. *[7 marks]*

$\frac{1}{11} = \frac{1}{R} + \frac{1}{24}$

$I = \frac{12}{(11+11)} = 0.545\,(\text{A})$

$\left(\frac{V^2}{R} = \frac{36}{24} =\right) 1.5\,(\text{W})$

Examiners report

[N/A]

13c. *[1 mark]*

Markscheme

measure of the probability of finding an electron (at a particular place and time);

Examiners report

[N/A]

13d. *[9 marks]*

Markscheme

(i)

$\Delta p = \frac{h}{4\pi\Delta x}$ and $\Delta x = 2.0\times10^{-10}$; *(both needed)*

2.64×10^{-25}(Ns); *(also accept 5.28×10^{-25}(Ns))*

*Award **[2]** for a bald correct answer.*

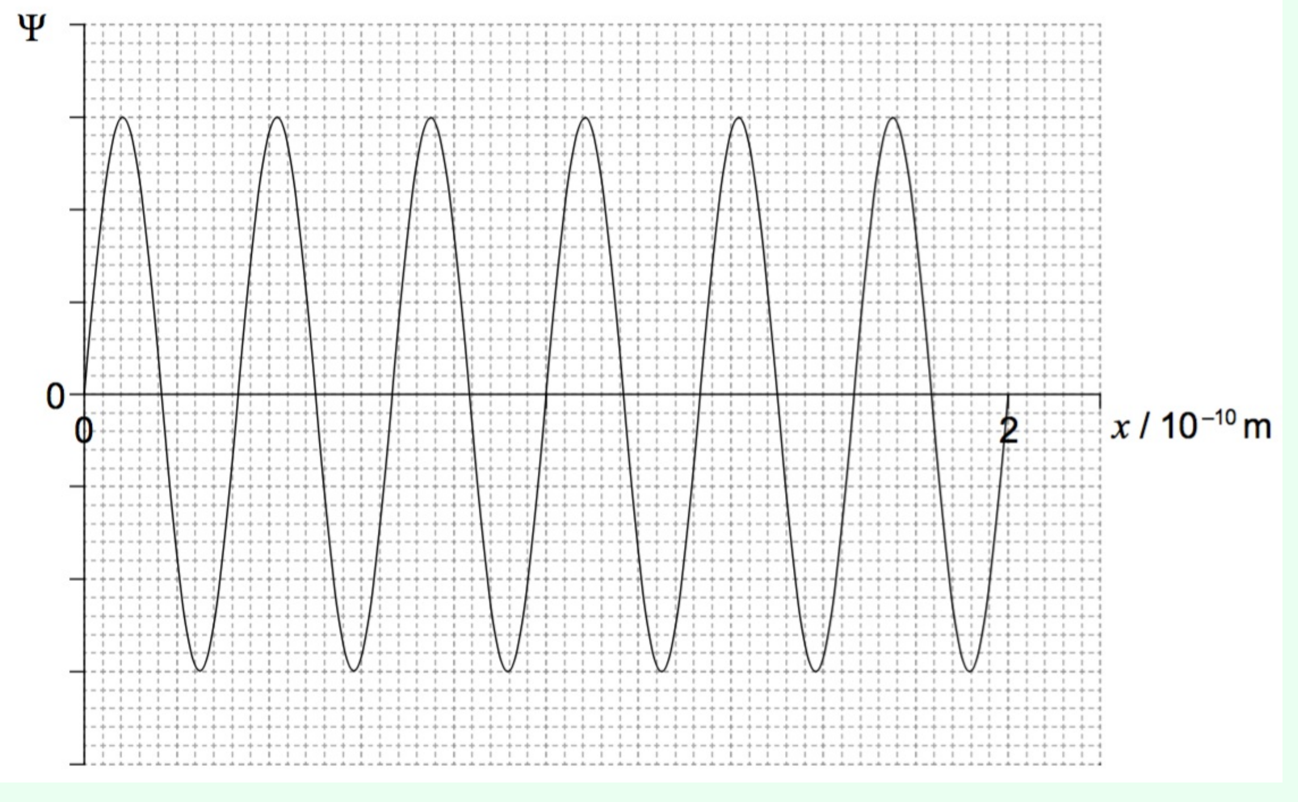
(ii)

$\lambda = \frac{h}{p}\left(= \frac{6.63\times10^{-34}}{2\times10^{-23}}\right)$;

3.3×10^{-11} (m);

*Award **[2]** for a bald correct answer.*

(iii)



periodic behaviour shown anywhere between 0 nm and 0.2 nm;

6 loops/repetitions shown anywhere between 0 nm and 0.2nm; } *(allow ECF for division of 2×10^{-10} by answer to d(ii))*

wavefunction completely fills from 0 nm to 0.2 nm and does not go beyond;

(iv) amplitude of Ψ/graph;

squared;

Examiners report

[N/A]

14.

[1 mark]

Markscheme

C

Examiners report

This was a simple question yet a good number of candidates opted for A, showing perhaps that they had not read the question carefully (and were answering the question: In which arrangement is the resistance greatest?)

15.

[1 mark]

Markscheme

B

Examiners report

Power is inversely proportional to R when the potential difference is constant (as here) and proportional to R if the current is held constant. Many candidates were confused by this.

16.

[1 mark]

Markscheme

D

Examiners report

17.

[1 mark]

Markscheme

A

Examiners report

18.

[1 mark]

Markscheme

A

Examiners report

19. *[1 mark]*

Markscheme

C

Examiners report

Many candidates were distracted by D and there were quite a few comments from teachers suggesting that this should be accepted. But D is not true as in most cases the varying current will change the temperature of the wire causing a change in resistance. It is only true in the case that temperature is kept constant – and that is the correct statement of Ohm's Law. C is an alternative statement of Ohm's law, given that resistance is calculated from V/I in any particular situation.

20. *[1 mark]*

Markscheme

C

Examiners report

As these are identical lamps we can assume that their brightness depends either on the current through them or on the voltage across them, whichever is easier to find. (Note that if they had been non-identical lamps, then we would have had to find the power, VI, to detect the brightness).

Opening the switch will increase the total resistance of the circuit, reducing the current through W. Hence B and D can be eliminated. And opening the switch will also increase the voltage across Y – from about V/3 to V/2. Hence C.

21. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

22a. *[2 marks]*

Markscheme

$F=qE$ ***or*** $1.6\times10^{-19}\times2.0\times10^{3}$;
$=3.2\times10^{-16}$(N);

Examiners report

This calculation was successfully done by the majority of candidates.

22b.

[5 marks]

Markscheme

(i)

$\left(F = qvB \Rightarrow\right) B = \frac{F}{qv}$ ***or***

$\left(Eq = qvB \Rightarrow\right) B = \frac{E}{v}$;

$\left(= \frac{3.2\times10^{-16}}{1.6\times10^{-19}\times1.6\times10^{4}}\right) = 0.13$ ***or*** 0.125(T);

directed into the page / *OWTTE*;

(ii) both electric and magnetic forces double / both forces increase by the same factor / both forces scale with *q*/charges and cancel;

so straight line followed; *(only award if first mark awarded)*

or

straight line followed if $qE = qvB \Rightarrow E\ v = B$;

E, *v* and *B* constant (so straight line followed);

Examiners report

bi) The magnitude of the magnetic field was often successfully calculated, but few candidates were able to identify the direction. Most thought that it was in the opposite direction to the electric field, presumably confusing it with magnetic force.

bii) Many thought that it would carry on in a straight line but this was often based on spurious reasoning.

23.

[1 mark]

Markscheme

C

Examiners report

[N/A]

24.

[1 mark]

Markscheme

B

Examiners report

[N/A]

25.

[1 mark]

Markscheme

B

Examiners report

[N/A]

26.

[1 mark]

Markscheme

A

Examiners report

This should have been a straightforward question but many candidates opted for B. This highlights the importance of carefully reading the question. Candidates must not assume that all relevant information will be on the diagram.

27.

[1 mark]

Markscheme

D

Examiners report

[N/A]

28.

[1 mark]

Markscheme

B

Examiners report

Many candidates opted for D, failing to see that the wire is a resistance wire and will drop voltage along its length.

29.

[1 mark]

Markscheme

D

Examiners report

The GeV prefix was apparently unknown by a significant number of candidates at both levels.

30.

[1 mark]

Markscheme

D

Examiners report

[N/A]

31.

[1 mark]

Markscheme

D

Examiners report

[N/A]

32.

[1 mark]

Markscheme

C

Examiners report

[N/A]

33.

[1 mark]

Markscheme

C

Examiners report

[N/A]

34.

[1 mark]

Markscheme

B

Examiners report

[N/A]

35.

[1 mark]

Markscheme

B

Examiners report

The correct response here is B. As the rod falls, an electric current in induced, forcing the electrons across the diameter of the wire. This in turn, produces an upward force on the rod as a whole in line with Lenz's Law.

36a.

[2 marks]

Markscheme

force per unit charge;

on a positive test charge / on a positive small charge;

Examiners report

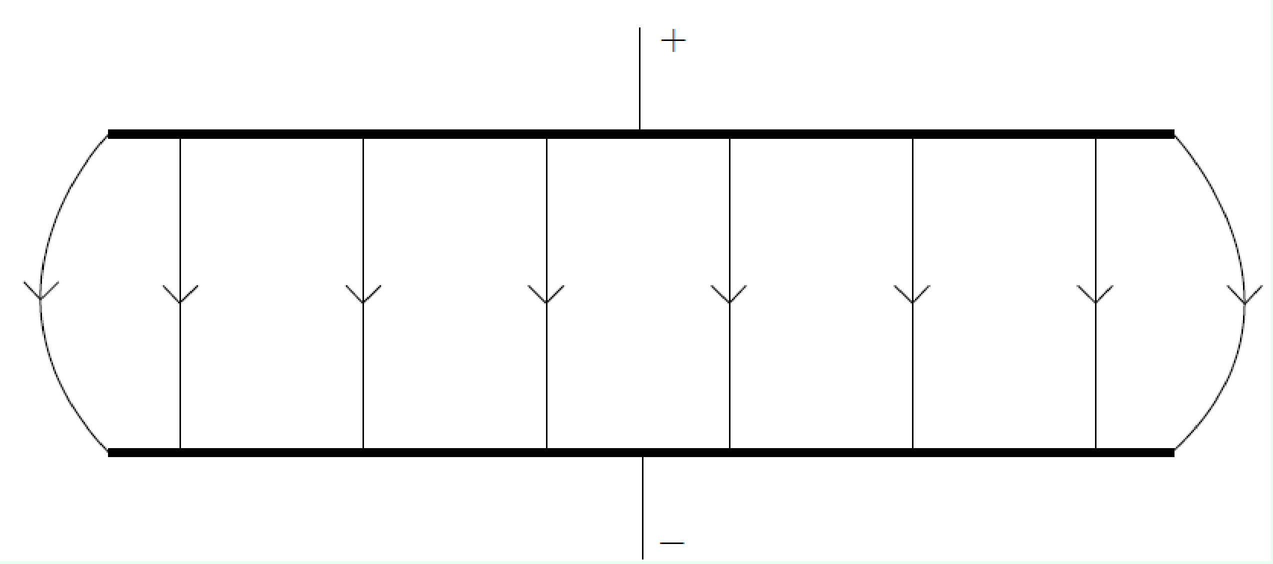
(i) As this is worth two marks, candidates should see the signal that force per unit charge is unlikely to gain full marks; and so it proved. Although a mark was available for saying this there needed to be a reference to the charge being a positive test charge.

36b. *[5 marks]*

Markscheme

(i) top plate positive and bottom negative (or +/- and ground);

(ii)



uniform (by eye) line spacing and edge effect, field lines touching both plates;

downward arrows (minimum of one and none upward);

(iii) $F=2.5\times10^{3}\times1.6\times10^{-19}$
4.0×10^{-16} (N);

*Award **[2]** for a bald correct answer.*

Examiners report

(i) G2 comments that the term ‘polarity’ was confusing to candidates proved to be unfounded and nearly all candidates marked in a positive and negative terminal – although the actual polarity was often incorrect.

(ii) With error carried forwards, the direction of the field was often correct but the drawing often was below an acceptable standard with line of force not bridging the plates, being very unevenly spaced and having no edge effect.

(iii) This calculation was almost invariably very well done.

36c. *[8 marks]*

Markscheme

(i) use of $F=\frac{(1.60\times10^{-19})^2}{4\pi\varepsilon_0(5.0\times10^{-3})^2}$ ***or*** $F=\frac{(1.60\times10^{-19})^2}{(5.0\times10^{-3})^2}\times8.99\times10^9$;

9.2×10^{-24}(N);

(ii) 1.0×10^{7} (ms^{-2}) (9.9×10^{6} (ms^{-2}) if 9×10^{-24} (N) used);

(iii) electron will continue to accelerate;
speed increases with acceleration;
acceleration reduces with separation;
when outside the field no further acceleration/constant speed;
any reference to accelerated charge radiating and losing (kinetic) energy;

(iv) minimum of two concentric circles centred on Y;
anti-clockwise;

Examiners report

(i) In another ‘show that’ question it was expected that candidates would use Coulombs law and the data value for the electronic charge to give a value of more than one digit; often this was not the case but otherwise this was generally well done

(ii) Most candidates used their value for the force (or 9 x 10-24 N) and the mass of the electron on the data sheet to calculate a correct value for the acceleration.

(iii) This was an unusual opportunity for candidates to use Newton’s laws and many did say that the acceleration would decrease with distance. Too often they incorrectly believed that this meant that the electron would slow down – it continues to accelerate but at an ever decreasing rate.

(iv) Clearly, this part represented a simplification of a complex situation but as set up was not beyond the skills of most of the candidates. The electron represents an instant in which a conventional current would leave the page and the field at this instant would be that of concentric circles with an anti-clockwise (counter-clockwise) direction. Many candidates did draw this but diagrams were too frequently hurriedly drawn and of a poor standard.

37a.

[7 marks]

Markscheme

(i) mention of blades/propeller and turbine/generator/dynamo;

kinetic energy of wind → kinetic energy of turbine;

(rotational) kinetic energy → electricity/electrical energy;

*Award **[1 max]** for statement of (unqualified) kinetic energy to electrical energy*

(ii) $A(=\pi r^2)=6.4\times10^3(\text{m}^2)$;
(P=)1.95 MW;

(iii) 0.24×1.95MW (=0.47 MW/0.48 MW);
(0.47 MW = 470 kW thus) two generators would meet the maximum demand;
Allow only two generators for the second mark. Do not accept fractional generators.

Examiners report

(i) Many did not mention the kinetic energy of the wind (often referring to ‘wind energy’). All types of kinetic energy were referred to as ‘mechanical’ energy by many candidates. The general structure of this type of wind generator was generally well-known.

(ii) This part was generally well answered with those candidates completing the area calculation usually going on to gain both marks.

(iii) Again, this was well answered with nearly all candidates recognising that is not possible to have fractional generators and, therefore, rounding up their answers to 2 from the 1.7 calculation.

37b.

[2 marks]

Markscheme

photovoltaic cells generate emf/electricity;
solar panels generate thermal energy/heat / *OWTTE*;

Examiners report

Most candidates knew the difference between photovoltaic cells and solar heating panels. A minority believed that both would normally produce electricity.

37c. *[8 marks]*

Markscheme

(i) emf=3.0 (V);

(ii) series combination of resistance=7.2(Ω);
use of parallel resistance formula;
2.4(Ω);
*Award **[3]** for a bald correct answer*

(iii) attempted use of *IV*, I^2R or $\frac{V^2}{R}$;
0.94 (W);
Allow ECF from (d)(i) and (d)(ii).
Must see values substituted to gain first mark as compensation.

(iv) (series) increases the total emf/voltage;
(parallel) increases the current/decreases internal resistance/ensures some power if single cell fails / *OWTTE*;

Examiners report

(i) This was not well known and many candidates simply added the emfs to give a value of 9.0 V rather than the correct 3.0 V.

(ii) Nearly all candidates correctly calculated the resistance of the series portions of the modules but there were frequent errors in combining these to find the total resistance – with the parallel formula often being incorrectly written in shorthand

(iii) Although many candidates recognised how they should use the power formula, very few were able to used the correct resistance and the correct voltage.

(iv) Many candidates knew that a failing cell would still allow current in other parallel branches, but few explained that the series combination increased the emf and the parallel combination increased the current in a module.

37d. *[5 marks]*

Markscheme

(i) the solar radiation is captured by a disc of area πR^2 where *R* is the radius of the Earth;
but is distributed (when averaged) over the entire Earth's surface which has an area four times as large;

or

rays make an angle θ with area of Earth's half-sphere and so average intensity is proportional to average of $\cos^2\theta$ i.e. $\frac{1}{2}$;
there is an additional factor of $\frac{1}{2}$ due to the other half of the sphere;

(ii) variation of solar emission / Earth's orbit is elliptical/not quite circular;

(iii) input power needed =(5×850(kW)=) 4.25×10^6 (W);
$\frac{4.25\times10^6(\mathrm{W})}{3.5\times10^2(\mathrm{Wm^{-2}})} = 1.2\times10^4\left(\mathrm{m}^2\right)$;
*Award **[2]** for a bald correct answer.*

Examiners report

(i) A significant minority of candidates insisted that the reduction in the Sun's intensity was due to radiation reflected from atmosphere. Few went on to do the calculation to support their answer but there were a small number of very good answers to this part.

(ii) Here again, many mentioned radiation reflected by atmosphere rather than variations in solar emissions or the non-circularity of Earth's orbit.

(iii) This part was generally poorly done. The '24-hour period' confused many candidates and few were able to follow the argument through to a logical conclusion.

38a. *[2 marks]*

Markscheme

the force between two (point) charges;
is inversely proportional to the square of their separation and (directly) proportional to (the product of) their magnitudes;

*Allow **[2]** for equation with F, Q and r defined.*

Examiners report

Many were able to state Coulomb’s law or to give the equation with explanations of the symbols. Some candidates however failed to define their symbols and lost marks.

38b. *[7 marks]*

Markscheme

(i) $F = \left(k\frac{q_1 q_2}{r^2} =\right) \frac{9\times10^9\times\left[1.6\times10^{-19}\right]^2}{4\times10^{-20}}$;
$=5.8\times10^{-9}$(N);
*Award **[0]** for use of masses in place of charges.*

(ii) ($\frac{(b)(i)}{1.6\times10^{-19}}$ **or** 3.6×10^{10} (NC^{-1}) **or** (Vm^{-1});
(directed) away from the proton;
Allow ECF from (b)(i).
Do not penalize use of masses in both (b)(i) and (b)(ii) – allow ECF.

(iii) $H = \left(G\frac{m}{r^2} =\right) \frac{6.67\times10^{-11}\times1.673\times10^{-27}}{4\times10^{-20}} = 2.8\times10^{-18}\ \left(\text{Nkg}^{-1}\right)$;

$\frac{H}{E} = \frac{2.8\times10^{-18}}{3.6\times10^{10}}$ **or** 7.8×10^{-29}(Ckg^{-1});
($\approx10^{28}Ckg^{-1}$)
Allow ECF from (b)(i).

(iv) 3.4(V);

Examiners report

(i) The electric force was calculated well by many.

(ii) The answer to (i) was well used to determine the magnitude of *E*. However, many candidates did not read the question and failed to state the direction of the field or gave it in an ambiguous way.

(iii) Calculations to show the order of magnitude of *H/E* were generally well done. The last step was often missing with the answer simply given as a fraction.

(iv) Many obtained this simple mark.

38c. *[6 marks]*

Markscheme

(i) power supplied per unit current / energy supplied per unit charge / work done per unit charge;

(ii) energy supplied per coulomb= $\frac{5.1\times10^{-19}}{1.6\times10^{-19}}$ ***or*** 3.19(V);
(≈3.2V)

(iii) pd across 5.0Ω resistor= $\left(\frac{4.0\times10^{-19}}{1.6\times10^{-19}} =\right) 2.5\,(\mathrm{V})$;
pd across *r*=(3.2-2.5=)0.70(V);

and

either

current in circuit= $\left(\frac{2.5}{5.0} =\right) 0.5\,(\mathrm{A})$;
resistance of *r*= $\left(\frac{0.70}{0.50} =\right) 1.4\,(\Omega)$;

or

resistance of *r*= $\frac{0.70}{2.5}\times 5.0$;
=1.4(Ω);

or

3.2=0.5(R+*r*);
resistance of *r*=1.4(Ω);
*Award **[4]** for alternative working leading to correct answer.*
*Award **[4]** for a bald correct answer.*

Examiners report

(i) Many candidates gave confused or incorrect definitions of the emf of a cell. Previous comments in this report on the memorizing of definitions apply. Too many had recourse to the next part and used this idea in their answer.

(ii) This was well done.

(iii) A large number of candidates completed this calculation stylishly, generally explaining steps (or at least writing down the algebra) in a logical way. There were many correct and original solutions that gained full marks.

39. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

40. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

41. *[1 mark]*

Markscheme

C

Examiners report

B was the most popular response, presumably as the candidates were thinking 'twice the charge, twice the potential difference'. A moment's back checking, however, would show that this would lead to an alpha particle with four times the energy of the proton; therefore the correct response must be C.

42.

[1 mark]

Markscheme

B

Examiners report

The candidates were not sure of how to tackle this. At some stage in their course, however, they should have seen wires carrying a current in the same direction, attracting each other; in which case this question is trivial.

43.

[1 mark]

Markscheme

C

Examiners report

[N/A]

44.

[1 mark]

Markscheme

B

Examiners report

This question stem needed careful reading. The discrimination index of 0.00 showed that even the better candidates were jumping to conclusions. When work is done, it must be stated clearly what it is that is doing the work, and on what. So if a weight is being lifted, then the lifter is doing (positive) work against the field, which means that the field is doing negative work on the ball. This needs to be clearly spelt out to candidates. In this case there is a charge moving in an electrical field and the candidates are being invited to state the work done by the field on the charge.

45a.

[1 mark]

Markscheme

(electric current means) movement of charge;
Do not allow references to current alone – this is in the question.
Do not allow references to charges repelling.

Examiners report

[N/A]

45b. *[2 marks]*

Markscheme

at least two concentric circles;
with clockwise direction indicated;

Examiners report

[N/A]

46a. *[2 marks]*

Markscheme

the force exerted per unit charge;
on a positive small/test charge;

Examiners report

[N/A]

46b. *[2 marks]*

Markscheme

$E = \frac{ke}{r^2} = \frac{9\times10^9\times1.6\times10^{-19}}{10^{-30}}$;
$= 1.4 \times 10^{21}\mathrm{NC}^{-1}$ ***or*** Vm^{-1};

Examiners report

[N/A]

46c. *[4 marks]*

Markscheme

(i) into the (plane of the) paper;
(ii) $Ee=Bev$ ***or*** $E=Bv$;
$=(2.3\times10^{-4}\times3.9\times10^{6}=)900/897$;
NC^{-1} ***or*** Vm^{-1};

Examiners report

[N/A]

46d. *[1 mark]*

Markscheme

proton number: 8
nucleon number: 17
(both needed)

Examiners report

[N/A]

46e.

[3 marks]

Markscheme

16.9991u+1.0073u-[14.0031u+4.0026u];
=-7.00×10^-4^;
7.000×10^-4^×931.5=0.6521MeV;
(~0.7MeV)

Examiners report

[N/A]

46f.

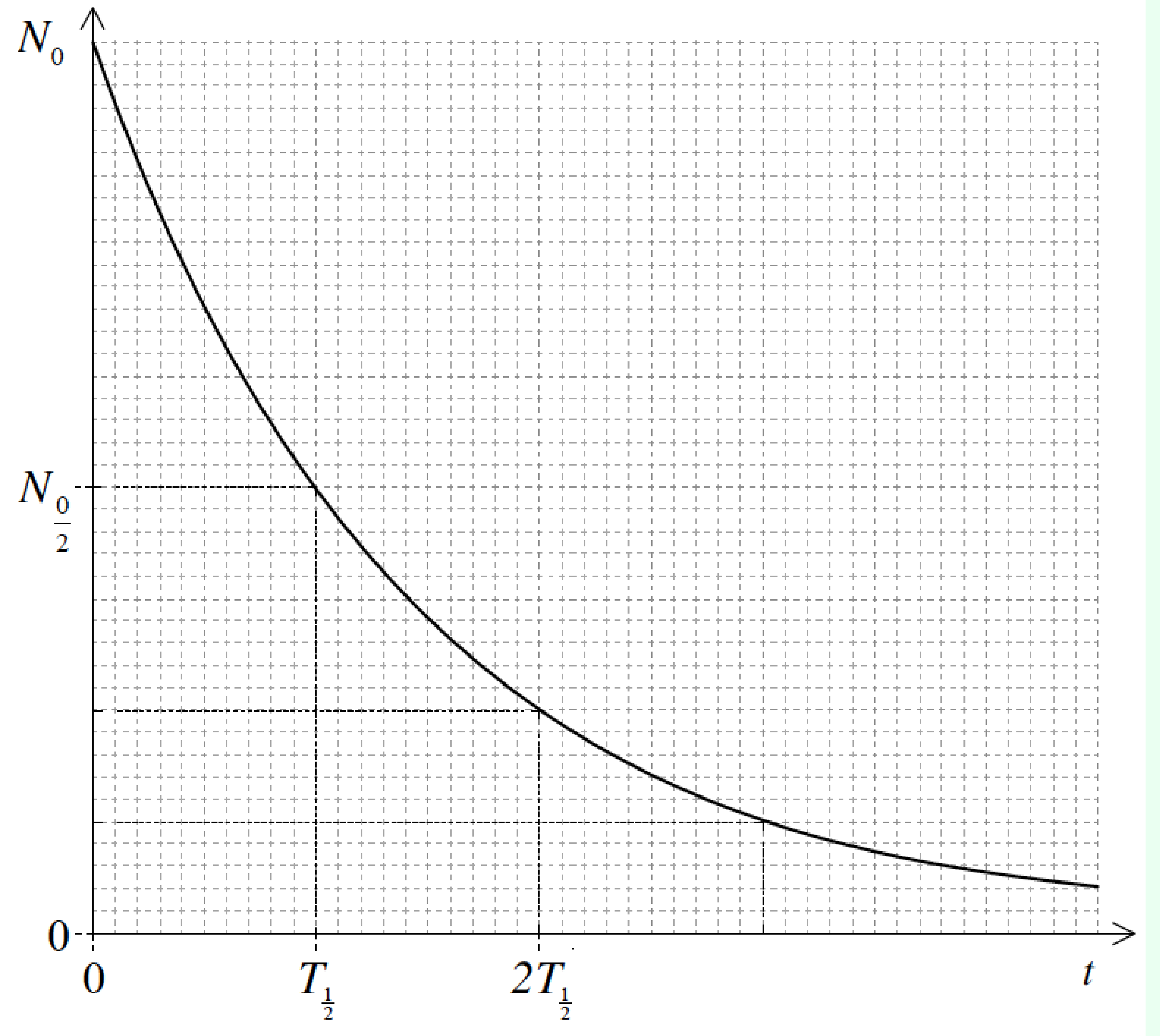
[5 marks]

Markscheme

(i) *isotope:*
same proton number/element/number of protons ***and*** different number of neutrons/nucleon number/neutron number; } *(both needed)*

half-life:
time for the activity (of a radioactive sample) to fall by half its original value / time for half the radioactive/unstable nuclei/atoms (in a sample) to decay;

(ii)



(approximately) exponential shape;
minimum of three half lives shown;
graph correct at $\left[T_{\frac{1}{2}}, \frac{N_0}{2}\right]$, $\left[2T_{\frac{1}{2}}, \frac{N_0}{4}\right]$, $\left[3T_{\frac{1}{2}}, \frac{N_0}{8}\right]$;

Examiners report

[N/A]

46g. *[2 marks]*

Markscheme

temperature is a measure of the (average) kinetic energy of the molecules;
at the boiling point, energy supplied (does not increase the kinetic energy) but (only) increases the potential energy of the molecules/goes into increasing the separation of the molecules/breaking one molecule from another / *OWTTE*;

Examiners report

[N/A]

46h. *[4 marks]*

Markscheme

(energy gained by cold water is) 0.300×4180×[34.6-15.2] / 24327;
(energy lost by cooling water is) 0.012×4180×[100-34.6] / 3280;
(energy lost by condensing steam is) 0.012*L*;
1.75×10^{6}(Jkg^{-1})/
$\frac{[\text{their energy gained by cold water} - \text{their energy lost by cooling water}]}{0.012}$;

*Award **[4]** for 1.75×10^{6}(Jkg^{-1}).*
*Award **[2 max]** for an answer that ignores cooling of condensed steam.*

Examiners report

[N/A]

46i. *[2 marks]*

Markscheme

some of the energy (of the condensing steam) is lost to the surroundings;
so less energy available to be absorbed by water / rise in temperature of the water would be greater if no energy lost;

Examiners report

[N/A]

47a. *[2 marks]*

Markscheme

the acceleration (of a particle/P) is (directly) proportional to displacement;
and is directed towards equilibrium/in the opposite direction to displacement;
Do not accept "directed towards the centre".

Examiners report

[N/A]

47b. *[5 marks]*

Markscheme

(i) the direction of energy propagation is at right angles to the motion of the particles/atoms/molecules in the medium;

(ii) $\lambda = \frac{v}{f} = vT$;

$= (0.40 \times 0.3 =)\, 0.12\text{m}$;

(iii) $n/1.8 = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$;

to give λ_2=0.067m;

Examiners report

[N/A]

47c. *[3 marks]*

Markscheme

X: graph is a straight line and through the origin / resistance is constant;

so because $V \propto I$ it is ohmic;

Y: not ohmic because graph is not straight/is curved / resistance is not constant;

*Award **[3]** for an answer where resistance values are calculated to show constancy or otherwise.*

Examiners report

[N/A]

47d. *[8 marks]*

Markscheme

(i) read-off of intersection of lines X and Y [4.0,6.0] / reference to 4.0V **and** 6.0mA; { *(allow power of 10 error)*

$R_X = R_Y = \frac{6.0}{4.0 \times 10^{-3}} = 1.5 \times 10^3\,\Omega$;

resistance of combination=750Ω;

(ii) use the idea of potential divider $\frac{R}{750} = \frac{2.0}{6.0}$;

R=250Ω;

or

current=8mA;

$R = \frac{2.0}{0.008} = 250\,(\Omega)$;

(iii) total resistance=1000Ω;

total current=8.0×10^{-3}A ***or*** pd=8.0V;

total power=($8.0\times8.0\times10^{-3}$=)64mW;

Examiners report

[N/A]