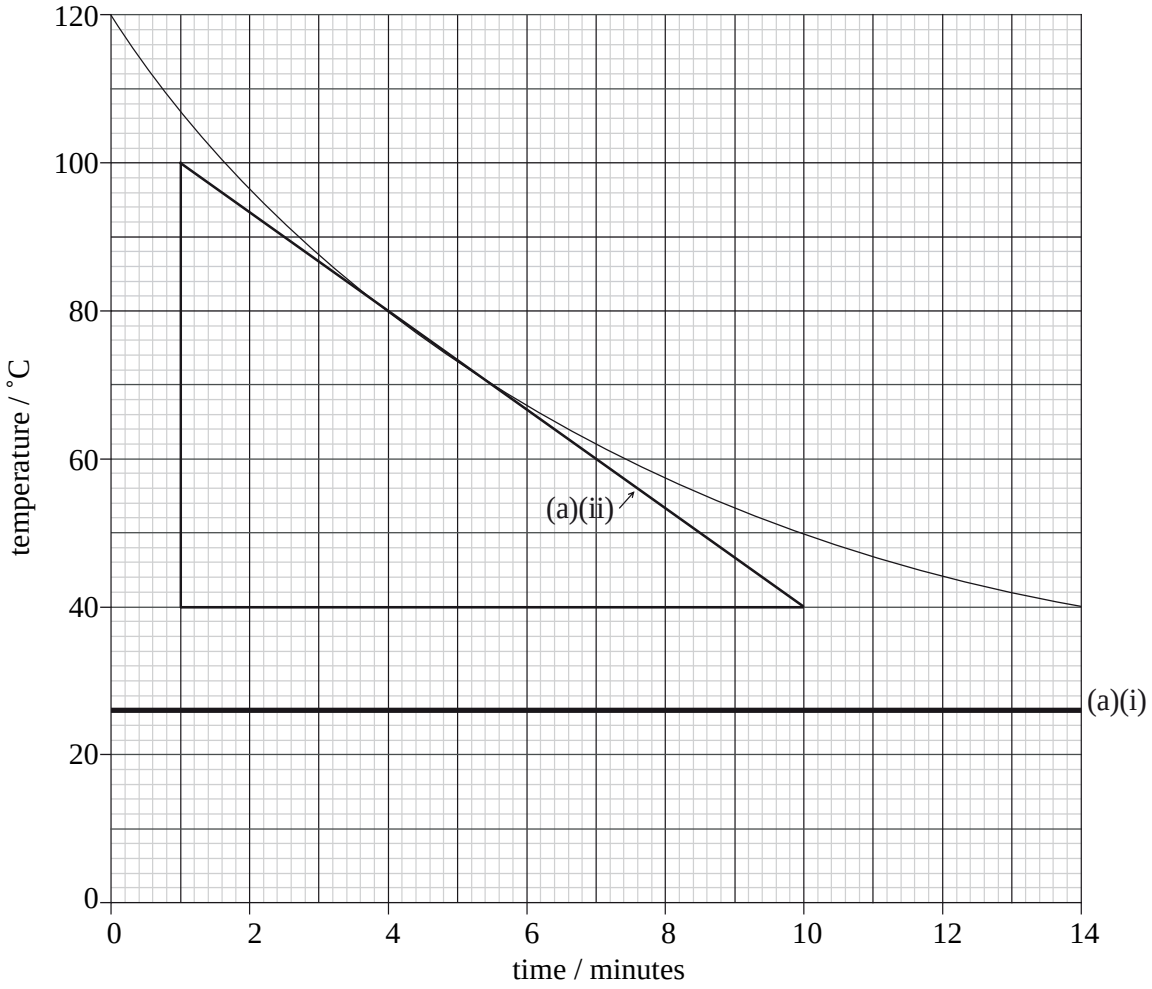
SECTION A

A1.



(a) (i) line in correct position from $t = 0$ to $t = 14\,\text{min}$; ***[1]***

Allow $\pm\frac{1}{2}$ *square*.

(ii) reasonable tangent drawn at correct position *i.e.* at $76\,^{\circ}\text{C}$ but allow $70\,^{\circ}\text{C} \rightarrow 85\,^{\circ}\text{C}$;

If tangent position is not acceptable, award ***[1 max]*** *in this section for length of tangent.*

line length used for tangent at least 8 cm;

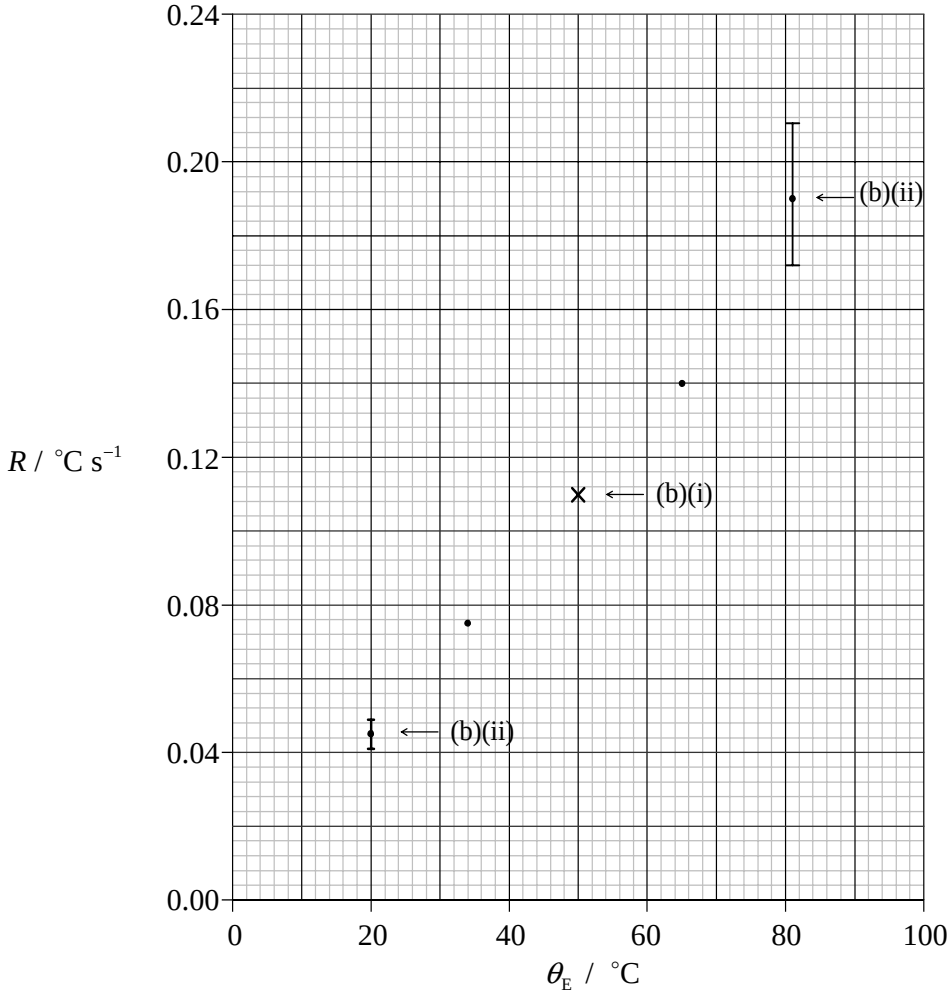
value $0.09 \rightarrow 0.13$;

accuracy – value within $0.10 \rightarrow 0.12$; ***[4]***

Award ***[1]*** *for value between* $\pm 10\%$ *and* $\pm 20\%$ *of 0.11 and* ***[2]*** *for value* $0.11 \pm 10\%$.

Unit of answer is not required. If the candidate fails to convert to s^{-1}, *then award one of the last two marks for answer in range* $6.0 \rightarrow 7.2\,^{\circ}\text{C}\,\text{min}^{-1}$.

(b)



(i) point plotted correctly; *(allow ECF from (b))* ***[1]***

(ii) error bar at $\theta_E = 20\,^{\circ}\text{C} : 4\,(\pm 2)\,\text{mm}$ long;
error bar at $\theta_E = 81\,^{\circ}\text{C} : 20\,(\pm 4)\,\text{mm}$ long; ***[2]***
Ignore any horizontal error bars.

(c) allowing for uncertainties in readings;
points lie on straight-line;
and line passes through origin; ***[3]***
*Award **[1]** for "last point off line, so not obeyed".*

A2. (a) suitable choice of scale *e.g.* 4 cm represents 10 N ; } (*scale must not be awkward or give rise to short vectors)*

correct construction of triangle/parallelogram;
reading on spring balance A: 16.0 (±0.5) N ;
reading on spring balance B: 12.5 (±0.5) N ; ***[4]***

(b) for equilibrium there must be an upward force and horizontal strings provide no upward force; ***[1]***

A3. changes in internal energy depend on mass, specific heat capacity and temperature rise;
specific heat capacity and temperature rise are unchanged;
mass changes so statement incorrect; ***[3]***

A4. (a) difference in mass between mass of nucleus;
and mass of (totally) separate nucleons; ***[2]***

(b) mass of helium-4 $= 4 \times 0.00760 = 0.0304u$
and mass of two deuteriums $= 4 \times 0.00120 = 0.0048u$;
mass defect $= 0.0256u$;
energy $= 0.0256 \times 1.66 \times 10^{-27} \times (3 \times 10^{8})^{2}$;
$= 3.8 \times 10^{-12}$ J ; ***[4]***

If a candidate has given an incorrect mass defect, award the last two marking points as ECF.

SECTION B

B1. Part 1 Linear motion

(a) change in velocity / rate of change of velocity;
per unit time / with time; *(ratio idea essential to award this mark)* ***[2]***

(b) (i) acceleration is constant/uniform; ***[1]***

(ii) $t = \frac{2s}{(u+v)}$ and $t = \frac{(v-u)}{a}$;
clear working to obtain $v^2 = u^2 + 2as$; ***[2]***

(c) (i) $1.96 = \frac{1}{2} \times 9.81 \times t^2$;
$t = 0.632\,\text{s}$; ***[2]***

(ii) time to fall $(1.96 + 0.12)\,\text{m}$ is $0.651\,\text{s}$;
shutter open for $0.019\,\text{s}$; ***[2]***
If the candidate gives a one significant digit answer treat it as an SD-1.
*Award **[0]** if the candidate uses* $s = \frac{1}{2}at^2$ *and* $s = 12\,cm$.

Part 2 Collisions

(a) (i) centripetal force is provided by the cable / the ball is moving along the arc of a circle; ***[1]***

(ii) centripetal force $= \frac{(350 \times 2.6^2)}{5.8}$;

$= 410\,\text{N}$;

$\text{tension} = 410 + (350 \times 9.8) = 3800\,\text{N}$; ***[3]***

*Award **[0]** if* $\frac{v^2}{r}$ *is not used.*

(b) idea of use of area under graph / appropriate equation;

distance $= \frac{1}{2} \times 0.15 \times 2.6$ (*allow 0.14 → 0.15 s for the time)*

$= 0.195\,\text{m}$; *(allow 0.20 m, not 0.2 m)* ***[2]***

(c) idea of momentum as *mv*;

total change $(= 2.6 \times 350) = 910\,\text{Ns}$; ***[2]***

(d) (i) for isolated/closed system;

total momentum remains constant; ***[2]***

(ii) external force acts on ball;

so law does not apply to the ball;

or

system is ball + wall/Earth;

momentum loss of ball = momentum gain of wall/Earth; ***[2]***

(e) $E_K = \frac{1}{2} \times 350 \times 2.6^2$;

$\text{thermal energy} = 350 \times 450 \times \Delta\theta$;

idea of $0.12 \times E_K = mc\Delta\theta$;

$\Delta\theta = 9.0 \times 10^{-4}\,\text{K}$; ***[4]***

B2. Part 1 Wave phenomena

(a) (i) wave that transfers energy; ***[1]***

(ii) amplitude $= 4.0\,\text{mm}$; ***[1]***

wavelength $= 2.4\,\text{cm}$; ***[1]***

frequency $= \frac{1}{0.3}$;
$= 3.3\,\text{Hz}$; ***[1 max]***

speed $= 3.3 \times 2.4$;
$= 8.0\,\text{cm}\,\text{s}^{-1}$; ***[1 max]***

(b) (i) angle of incidence $= 40^\circ$;
$\sin r = \frac{\sin 40}{1.4}$
$r = 27^\circ$;
angle $= 63^\circ$; ***[3]***
*Award **[1 max]** for angle of incidence $= 50^\circ$, $r = 33^\circ$.*

(ii) construction: wavefronts equally spaced;
separation less in medium B;
angle in medium B correct – by eye; ***[3]***

B2. Part 2 Gases

(a) temperature of air is $290\,\text{K}$;

$$\text{amount} = \frac{(2.7\times10^{5}\times1.17\times10^{4}\times1.0\times10^{-6})}{(8.31\times290)};$$

$$= 1.31\,\text{mol};$$ ***[3]***

(b) $$\text{new amount} = 1.31\times\left(\frac{3.10}{2.70}\right);$$ *(or full substitution)*

$$= 1.51\,\text{mol};$$

$$\text{number of strokes} = \frac{(1.51-1.31)}{0.008};$$

$$= 25;$$ ***[4]***

(c) (i) $$\text{work done} = 280\times9.0\times10^{-2}\times25;$$

$$= 630\,\text{J};$$ ***[2]***

(ii) $$\text{efficiency} = \frac{(225\times100)}{630};$$

$$= 36\,\%;$$ ***[2]***

(d) *V* is volume in which the gas molecules can move;
molecules cannot move "inside" each other;
so reduce *V*; *(do not award this mark if <u>both</u> the answers above are incorrect)* ***[3]***

B3. Part 1 Electricity

(a) metal conductor: positive charges fixed;
mobile electrons;
plastic insulator: (positive charges and) electrons fixed; ***[3]***

(b) (i) electric field causes movement of electrons (in metal);
and charges are not moving; ***[2]***

(ii) electrons move;
from Earth to the electroscope; ***[2]***

(c) (i) e.m.f. is the p.d. across cell when current is zero;
find intercept on *V*-axis; ***[2]***

(ii) r is $(-)$ gradient of graph ***or*** r = e.m.f./current when $V = 0$ ***or*** value of R quoted at a given voltage;
relevant working shown on graph ***or*** use $E = Ir + IR$; ***[2]***

(d) diagram showing resistor in series with device;
from graph, at 1.5 A, p.d. is 2.7 V ***or*** use of $E = I(R + r)$ to give total external resistance as $1.8\,\Omega$;

p.d. across $R = 2.7 - 0.8 = 1.9\,\text{V}$ resistance of device $= \dfrac{0.8}{1.5} = 0.53\,\Omega$;

resistance $= \dfrac{1.9}{1.5} = 1.27\,\Omega$ resistance $= 1.8 - 0.53 = 1.27\,\Omega$; ***[4]***

(e) $2P$;
P;
$\frac{1}{2}P$; ***[3]***

Part 2 Radioactivity

(a) different forms of same element / nuclei having same proton number;
with different nucleon / mass numbers; ***[2]***

(b) $^{42}_{20}\text{Ca}$;
$^{0}_{-1}\text{e}$ ***or*** $^{0}_{-1}\beta$; (*do not accept* e^-). ***[2]***
Award ***[1 max]*** *if any extra particle e.g. neutron is included in equation.* ***[2]***

(c) line as "inverse" of given line, *i.e.* starts at zero, curves correct direction and flattens out reasonably; ***[1]***

(d) ratio of 7.0 means $\frac{1}{8}$ of nuclei are potassium-42;
time is $(3\times12.5=)37.5$ hours; } *award this mark for reading from graph based on fraction* $\frac{1}{7}$. ***[2]***