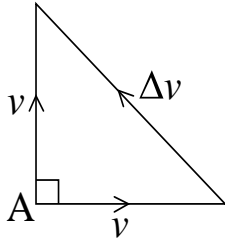


SECTION A

- A1.** (a) equation corresponds to a straight line (and this is a curve); [1]
- (b) (i) unit is s/seconds; [1]
- (ii) 2.35; (*3 significant digit essential*) [1]
Responses may be given in table. Do not penalize wrong units.
- (c) (i) 31.5, 3.10; (*plotted to within $\pm 1\text{ mm}$*) [2]
 22.5, 2.35; (*plotted to within $\pm 1\text{ mm}$*) (*allow e.c.f. from (b)(ii)*)
- (ii) reasonable best-fit straight-line; [1]
- (d) (i) at 35 ms^{-1} , allow $\frac{D}{v}$ in range $3.30 \rightarrow 3.45$ (s); [2]
 so D within range $116 \rightarrow 121$ m;
Penalize once if $\frac{D}{v}$ is not in the range $3.30 \rightarrow 3.45$ (s) and then use ECF for the second marking point.
- (ii) intercept within range $0.55 \rightarrow 0.70$ (s); [1]
- (iii) use of “triangle” with hypotenuse at least half length of graph line; $\left\{ \begin{array}{l} \text{Only allow use of data points if} \\ \text{the points lie on the graph line.} \end{array} \right.$ [2]
 gradient in range $0.074 \rightarrow 0.084$;
Allow candidate’s values in (d)(ii) and (d)(iii).
- (e) $D = 0.62v + 0.079v^2$; [1]
Accept correct equation or correct statement about the values of a and b .
- (f) (i) correct substitution and calculation into formula in (e); [1]
- (ii) *Appropriate comment:*
e.g. close values indicate that equation is correct / two values are within possible uncertainties of measurement; [1]

A2. (a)



arrow drawn (from A) of about correct length;
arrow drawn (from A) at about correct angle;
vector Δv labelled clearly and in correct direction;

[3]

Award [1 max] if vectors are added and [1 max] if Δv is opposite to correct direction.

(b) Δv is directed towards the centre of the circle;
force necessary to cause change in velocity/ Δv ;

[2]

Response must clearly refer to diagram and be consistent with it.

- A3.** (a) $\frac{\text{p.d. across resistor}}{\text{current in resistor}}$; (*ratio must be clear*) [1]
- (b) (i) combined resistance = 4.0Ω ; [1]
- (ii) use of parallel resistors formula to give 2.4Ω ;
combined resistance = $2.4 + 6.0$;
= 8.4Ω [2]
- (iii) (vertical) resistor either side of terminals AB circled;
resistor has shorted / became zero resistance; [2]

SECTION B

B1. Part 1 Linear motion

(a) (i) $E_k = \frac{1}{2} \times 72 \times 23^2;$
 $= 1.9 \times 10^4 \text{ J};$ [2]

(ii) uses area between the t -axis and the line;
 correctly converts area \rightarrow distance (one $1\text{cm} \times 1\text{cm}$ square $\equiv 5.0\text{m}$);
 distance between 90 m and 105 m;
 improved accuracy, distance between 95 m and 100 m; [4]
Do not accept kinematic formulas. Distance can only be found from area.

(b) (i) $\Delta E_p = 72 \times 9.8 \times 41;$
 $= 2.9 \times 10^4 \text{ J};$ [2]
Accept $3.0 \times 10^4 \text{ J}$ for responses using $g = 10 \text{ m s}^{-2}$.

(ii) ratio = $\frac{(2.9 \times 10^4 - 1.9 \times 10^4)}{(2.9 \times 10^4)};$
 $= 0.34;$ [2]
Accept 0.37 for responses using $g = 10 \text{ m s}^{-2}$.

(iii) fraction of energy lost due to air resistance / friction between skis and slope
 / work to push snow away from skis; [1 max]

(c) (i) $1.8 = \frac{1}{2} \times 9.8 \times t^2;$
 $t = 0.61\text{s};$ [2]

(ii) distance = $23 \times 0.61;$
 $= 14\text{m};$ [2]

Part 2 Nuclear reactions

- (a) (i) nucleus emits;
 an α -particle / a β -particle / *and/or* γ -ray photon / ionizing radiations; [2]
- (ii) cannot tell which nucleus will decay next;
 cannot state at what time a nucleus will decay; [2]
Award [2] for constant probability of decay per unit time.
- (b) (i) $^{17}_8\text{O}$;
 ^1_1p ; [2]
- (ii) mass difference = $(-)\text{1.29} \times 10^{-3} u$;
 energy = $(\text{1.29} \times 10^{-3} \times 931) = \text{1.20 MeV}$;
 indicates in some way that mass defect is on left-hand side of equation /
 mass defect is negative;
 α -particles must provide at least 1.20 MeV of energy; [4]

B2. Part 1 Momentum

- (a) the momentum of a system (of interacting particles) is constant;
if no external force acts on system / net force on system is zero / isolated system; [2]
A statement of “momentum before = momentum after” achieves first mark only.
- (b) (i) use of volume = $\pi r^2 \times v$;
= $\pi \times (1.4 \times 10^{-3})^2 \times 18$;
= $1.1 \times 10^{-4} \text{ m}^3$ [2]
- (ii) mass ejected per second = $1.1 \times 10^{-4} \times 1000 = 0.11 \text{ kg}$;
change in momentum per second = 0.11×18 ;
by Newton’s 2nd, this is force on (ejected) water ;
by Newton’s 3rd, equal force acts upwards on rocket ;
so force is 2.0 N [4]
Do not accept references to momentum conservation.
- (iii) weight of water to be ejected = 5.0 N / mass of water to be ejected = 0.51 kg ;
time delay = 4.6 s ; [2]

Part 2 Temperature and thermal energy

- (a) property measured at two known temperatures (and at unknown temperature);
 (temperature calculated) assuming linear change of property with temperature; [2]
Award [1] for descriptions of constructing a thermometer.

- (b) thermometer absorbs (thermal) energy/heat from the body / has a thermal capacity;
 so changes temperature of body;

or

time taken for (thermal) energy/heat to be conducted into thermometer;
 so may not be able to follow changing temperature; [2]

- (c) (i) quantity of (thermal) energy/heat required to raise temperature of unit mass;
 by one degree;

or

$$c = \frac{\Delta Q}{m\Delta\theta};$$

with ΔQ , m and $\Delta\theta$ explained; [2]

- (ii) $m \times 330$;
 $+m \times 4.2 \times 8$;
 $= 0.45 \times 4.2 \times 16$;
 $m = 0.083 \text{ kg}$; [4]
Award [2 max] for an answer $m = 0.092 \text{ kg}$ – ignoring ice-water.

- (d) (i) (both are change from liquid \rightarrow vapour phase)
evaporation:
 occurs at surface of liquid;
 occurs at all temperatures;

boiling:
 occurs in the body of the liquid;
 occurs at one temperature / boiling point; [2 max]

- (ii) separation of molecules increases in the change from liquid to vapour phase;
 this involves an increase in potential energy;
 but temperature observed to change only when kinetic energy changes; [3]

B3. Part 1 Wave properties


(a) (i) direction in which energy is travelling / locus of one point on a wavefront; [1]

(ii) speed at which energy is propagated along the wave; [1]

(b) (i) frequency $\left(= \{6.0 \times 10^{-3}\}^{-1} \right) = 170 \text{ Hz};$ [1]

(ii) at $t = 1.0 \text{ ms}$, displacement $(= 1.7 + 0.7) = 2.4 \text{ mm};$
 at $t = 8.0 \text{ ms}$, displacement $= 1.7 - 0.7;$
 $= 1.0 \text{ mm};$ [3]

(c) (i) wave (travels down tube and) is reflected at (water surface);
 incident and reflected waves interfere/superpose; [2]

(ii)  *i.e. $\frac{3}{4} \lambda$, 2 nodes, 2 antinodes;*
all nodes marked; [2]

Accept pressure nodes if clearly identified.

(iii) substitution in $v = f\lambda$;
 $\frac{1}{2} \lambda = 56 \text{ cm};$
 $v = (2 \times 0.56 \times 310) = 350 \text{ ms}^{-1};$ [3]

Part 2 Magnetic and electric fields

- (a) (i) use of $qV = \frac{1}{2}mv^2$;
 $1.6 \times 10^{-19} \times 420 = \frac{1}{2} \times 1.67 \times 10^{-27} \times v^2$
 $v = 2.8 \times 10^5 \text{ m s}^{-1}$; [2]
- (ii) arc of circle / continuous curve within region ABCD and deflected upwards
i.e. towards AB;
 straight-line as tangent to arc beyond BC; [2]
- (iii) $F = 1.5 \times 10^{-2} \times 1.6 \times 10^{-19} \times 2.8 \times 10^5$;
 $= 6.7 \times 10^{-16} \text{ N}$; (*allow* $6.8 \times 10^{-16} \text{ N}$) [2]
- (b) (i) force per unit positive charge;
 on small test charge (placed at that point); [2]
- (ii) $6.7 \times 10^{-16} = 1.6 \times 10^{-19} \times E$;
 $E = 4.2 \times 10^3 \text{ V m}^{-1}$; [2]
- (iii) undeviated / straight line (along original path);
 reason *e.g.* forces in field always equal and opposite; [2]
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