

SECTION A

- A1.** (a) 1: the lines do not go through the origin;
 2: the lines are not straight (lines) / gradient is not constant; [2]
Award full marks if the candidate combines the two statements.
- (b) the petrol is stored in cans / initial volume of petrol not taken into account;
 the radius at $t = 0$ is probably the size/radius of the can;
or
 difficulty in measuring R ;
 some comment as to the whereabouts of the zero point in the experiment; [2]
- (c) (i) by reading the value of R at $t = 20$ ms for each of the five lines / *OWTTE*; [1]
- (ii) smooth curve with an intercept of $R = 5.0(\pm 1.0)$ m ;
 and does not go outside error bars; [2]
- (iii) no the line is not a straight-line;
 even with the error bars it cannot be made to be a straight-line / *OWTTE*; [2]
Award [0] if “no” and incorrect explanation or if there is no explanation.
- (d) choice of suitable data point in the range $V = 5 \rightarrow 15$
e.g. $R = 10.5$ for $10 \times 10^{-3} \text{ m}^3$;

$$E = \frac{r^5}{t^2} ;$$

$$= \frac{10.5^5}{(20 \times 10^{-3})^2} = 320 \times 10^6 ;$$
 divide by 10 / other chosen value of V ;
 $\approx 30 \text{ MJ}$ for $1.0 \times 10^{-3} \text{ m}^3$ [4]

- A2.** (a) (i) *e.m.f.*:
the power supplied per unit current / the energy supplied per unit charge;
Ohm's law:
the resistance of a conductor is constant / current proportional to potential difference if its temperature is constant; [2]
- (ii) by dividing the value of V at any point by the corresponding value of I ; [1]
Award [0] for $R = \frac{V}{I}$ without comment.
- (b) (i) $(2.5 \times 0.10) = 0.25 \text{ W}$; [1]
- (ii) $0.23 = I^2 R$;
 $R = \left(\frac{0.23}{0.10^2} \right) = 23 \Omega$; [2]
- (iii) power dissipated in cell = $0.02 \text{ W} = I^2 r$;
 $r = \frac{0.02}{0.10^2} = 2.0 \Omega$;
- or*
- use $E = IR + Ir$*
 $2.5 = 0.10 \times 23 + 0.10r$;
 $r = \frac{0.20}{0.10} = 2.0 \Omega$; [2]
- (c) new internal resistance = 4.0Ω and new e.m.f. = 5.0 V ;
 $5.0 = 0.15R + 0.15 \times 4.0$;
to give $R = 29 \Omega$;
therefore, a non-ohmic device as resistance has changed/increased; [4]
Allow calculation of what current should be (0.19A) if R were constant.
Allow calculation based on power.

SECTION B

- B1.** (a) before and after collision there are no forces acting on the objects;
 from Newton 3 when the two bodies are in contact the forces that they exert on each other are equal and opposite / *OWTTE*;
 therefore, the net force on the two balls is always zero;
 therefore, there is no change in momentum (of the objects) / momentum is conserved;

or

*Accept an argument based on change in momentum of each individual object.
 e.g.*

from Newton 3 $F_{12} = -F_{21}$; (*accept statement in words*)

$$F_{12} = \frac{\Delta p_1}{\Delta t} \text{ and } F_{21} = \frac{\Delta p_2}{\Delta t};$$

$$\frac{\Delta p_1}{\Delta t} = -\frac{\Delta p_2}{\Delta t};$$

therefore, $\Delta p_1 + \Delta p_2 = 0$;

[4]

- (b) the blades exert a force on the air and by Newton's third law the air exerts an equal and opposite force on the blades / air has change in momentum downwards giving rise to a force and from Newton 3 there will a force upwards;
 if this force equals the weight of the helicopter;
 the net vertical force on the helicopter will be zero / *OWTTE*;

[3]

- (c) area = $\pi 0.7^2$;
 = 1.5 m^2

[1]

- (d) (i) volume of air per second = $1.5 \times 4.0 (\text{m}^3 \text{ s}^{-1})$;
 mass = volume \times density = $(1.2 \times 1.5 \times 4.0) = 7.2 \text{ kg s}^{-1}$;
No unit error for 7.2 kg.

[2]

- (ii) momentum per second = $(7.2 \times 4.0) = 29 \text{ N}$;

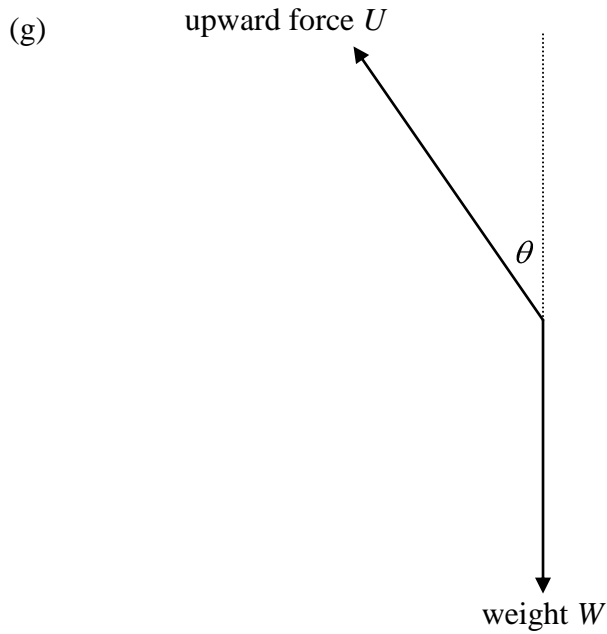
[1]

- (e) 29 N;

[1]

- (f) recognise that the force on the blades = Mg ;
 to give 3.0 kg;

[2]



correct relative directions of forces;
 upward force length greater than weight by eye;
 appropriate labelling of forces;
 angle θ as shown above;

[4]

Award [2 max] if extra force(s) drawn.

- (h) the forward force is the horizontal component of U ;
 resolve vertically $U \cos \theta = W$;
 horizontal component $F = U \sin \theta$;

divide to get $\frac{F}{W} = \tan \theta$;

$$F = (W \tan \theta) = Mg \tan \theta = Ma;$$

to give $a = g \tan \theta$

[5]

Award [5 max] for a correctly labelled force diagram incorporating mass with a justifying statement. Award [1 max] for triangle mixing accelerations and force.

- (i) air resistance increases as speed of helicopter increases;
 until this resistance equals the forward force;

[2]

B2. Part 1 Stationary (standing) waves and resonance

- (a) no energy is transferred;
 variable amplitude / variable maximum displacement of particles / *OWTTE*;
 points along the wave where amplitude is always zero / reference to phase / *OWTTE*; [2 max]
- (b) if two or more waves overlap / *OWTTE*;
 the resultant displacement at any point is found by adding the displacements
 produced by each individual wave / *e.g.* peak/trough meets peak/trough to give
 maximum/minimum / *OWTTE*; [2]
- (c) (i) $t = \frac{T}{4}$: straight-line; (*a line must be drawn on the diagram*)
 $t = \frac{T}{2}$: negative sine; [2]
- (ii) the points of no displacement/nodes (at middle and ends) do not change with
 time;
 therefore, the wave cannot be moving forward / does not progress; [2]
- (d) (i) maximum amplitude of oscillation;
 when a periodic force is applied to it and the frequency of the force is equal to
 the natural frequency of vibration of the system / *OWTTE*; [2]
- (ii) frequency of wave $f = \frac{c}{\lambda} = \left(\frac{6.0 \times 10^3}{1.2 \times 10^4} \right) = 0.50 \text{ Hz}$;
 natural frequency of oscillation of building = $\frac{1}{2.0} = 0.50 \text{ Hz}$;
 the waves therefore, cause the building to resonate/vibrate violently / *OWTTE*; [3]

B2. Part 2 Radioactive decay

- (a) (i) proton or neutron; [1]
- (ii) both have the same number of protons but different number of neutrons;
 strong force and Coulomb force between nucleons;
 in Ar-36 strong force attraction and Coulomb repulsion balanced therefore
 nucleus stable;
 in Ar-39 excess neutrons lead to an imbalance in forces hence nucleus
 unstable; [4]
Accept answer in terms of energy i.e. excess neutrons raises the PE of the nucleus.
- (b) (i) $Z = 19$;
 $N = 39$; [2]
- (ii) $\Delta m = 0.00061 \text{ u}$;
 $\Delta E (= 0.00061 \times 932) = 0.568 \text{ MeV}$;
 $(= 0.568 \times 1.6 \times 10^{-13}) = 9.1 \times 10^{-14} \text{ J}$; [3]
- (c) 270 (± 10) years;
 time for A to halve e.g. from 1600 \rightarrow 800 / any compatible two values; [2]

B3. Part 1 Gases and liquids

- (a) forces between gas molecules (except during collisions) are much smaller than between liquid molecules;
 speed of gas molecules much greater than speed of liquid molecules;
 motion/movement of gas molecules is less restricted than that for liquid molecules;
average separation of molecules much greater in a gas than in a liquid; [2 max]
- (b) the molecules do not have the same speed / the molecules have different speeds;
 the speed of the molecules change each time they collide / the speed of individual molecules is always changing / *OWTTE*; [2]
Accept use of words “kinetic energy” in place of speed.
- (c) the energy/heat required to raise/change the temperature of a substance by 1 K/°C; [1]
- (d) (i) the water is changing phase/boiling / KE of molecules is constant, (PE is changing); [1]
- (ii) time = 420(s);
 energy supplied = 300×420 ;
 $= 4.2 \times 10^3 \times 0.40 \times \Delta\theta$;
 to give $\Delta\theta = 75$;
 therefore, boiling temperature $\theta = 95^\circ\text{C}$; [5]
- (e) $300 \times 3.0 \times 10^3 = 0.40 L$;
 to give $L = 2.3 \times 10^6 \text{ J kg}^{-1}$; [2]

Part 2 Electrical conduction and the force on a conductor in a magnetic field

(a) (i) ; [1]

(ii) the force on the electrons produced by the electric field causes them to accelerate along the direction of the rod; however, they will (soon) collide with a lattice ion but after collision will again be accelerated (along the rod) before making another collision / *OWTTE*; hence the electrons gain a drift/net velocity in the direction of the wire / in the (opposite) direction to the field even though they still have random velocities / *OWTTE*; [3]

(b) (i) ; [1]

(ii) $F = BIL = Ma$;
to give $a = \frac{BIL}{M}$; [2]

(c) (i) let the body move a distance Δx in time Δt , then work one by F is $W = F\Delta x$;
therefore rate of working = power = $P = \frac{F\Delta x}{\Delta t} = Fv$; [2]

i.e. Look for expression for work done and identifying power as rate of working.

(ii) $P = BILv = EI$;
to give $v = \frac{E}{BL}$;
 $v = \left(\frac{0.8}{0.60 \times 0.25} \right) = 5.3 \text{ms}^{-1}$; [3]