4 Which of the following gives the base units of impulse?

- ☒ **A** $\mathrm{kg\,m\,s^{-1}}$
- ☒ **B** $\mathrm{kg\,m\,s^{-2}}$
- ☒ **C** Nm
- ☒ **D** Ns

(Total for Question 4 = 1 mark)

5 Scientists use particles with high energy to investigate the structure of nucleons.

Which of the following statements is **not** a reason why particles with high energy are required?

- ☒ **A** to allow forces between particles to be overcome
- ☒ **B** to ensure particles have a very high momentum
- ☒ **C** to ensure particles have a very small de Broglie wavelength
- ☒ **D** to provide sufficient energy for the production of new particles

(Total for Question 5 = 1 mark)

4: In the upper atmosphere, high-energy cosmic rays collide with molecules of air to produce muons. The average speed of these muons is v.

The average lifetime of these muons is greater than the average lifetime of stationary muons.

Which of the following gives the reason for this increase in average lifetime?

- ☒ **A** $v > c$
- ☒ **B** $v = c$
- ☒ **C** $v \approx c$
- ☒ **D** $v \ll c$

(Total for Question 4 = 1 mark)

6 A capacitor of capacitance C is charged to a potential difference of V_0. The capacitor then discharges through a resistor of resistance R.

After time t the potential difference across the capacitor is V.

Which of the following gives the time constant for this circuit?

☒ A $\dfrac{-t}{\ln\left(V - V_0\right)}$
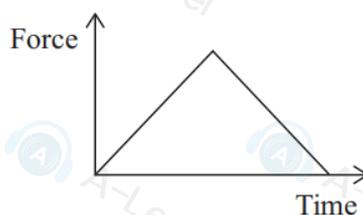
☒ B $\dfrac{-t}{\ln V + \ln V_0}$

☒ C $\dfrac{-t}{\left(\dfrac{\ln V}{\ln V_0}\right)}$

☒ D $\dfrac{-t}{\ln\left(\dfrac{V}{V_0}\right)}$

(Total for Question 6 = 1 mark)

8 A ball collides with a wall and moves off in the opposite direction. The wall exerts a force on the ball during the collision.

The force-time graph for the collision is shown.

Which of the following is given by the area under the graph?

☒ A acceleration of the ball

☒ B average force acting on the ball

☒ C change in momentum of the ball

☒ D distance travelled by the ball

(Total for Question 8 = 1 mark)

6 An electron has a kinetic energy of 3.5×10^{-28} J.

Which of the following gives the momentum of the electron in $kg\,m\,s^{-1}$?

☒ **A** $\dfrac{(3.5 \times 10^{-28})^2}{2 \times 9.11 \times 10^{-31}}$

☒ **B** $\dfrac{(9.11 \times 10^{-31})^2}{2 \times 3.5 \times 10^{-28}}$

☒ **C** $\sqrt{2 \times 1.6 \times 10^{-19} \times 3.5 \times 10^{-28}}$

☒ **D** $\sqrt{2 \times 9.11 \times 10^{-31} \times 3.5 \times 10^{-28}}$

(Total for Question 6 = 1 mark)

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7 In the early 1900s, scientists carried out alpha particle scattering experiments.

Which of the following statements is **not** a valid conclusion from their observations?

☒ **A** Most of the atom is empty space.

☒ **B** The nucleus is made of neutrons and protons.

☒ **C** There is a concentration of charge in the atom.

☒ **D** There is a concentration of mass in the atom.

(Total for Question 7 = 1 mark)

6: In an electron gun, a current heats a metal filament to release electrons.

Which of the following is the name of this process?

☒ **A** beta decay

☒ **B** ionisation

☒ **C** photoelectric effect

☒ **D** thermionic emission

(Total for Question 6 = 1 mark)

3 Two identical charged particles were placed in a vacuum 0.020 m apart. The charge on each particle was $+8.0 \times 10^{-6}$ C.

Which of the following gives the magnitude of the force, in newtons, on each particle?

☒ **A** $\dfrac{8.99 \times 10^9 \times (8.0 \times 10^{-6})}{0.020}$

☒ **B** $\dfrac{8.99 \times 10^9 \times (8.0 \times 10^{-6})^2}{0.020^2}$

☒ **C** $\dfrac{8.99 \times 10^9 \times (8.0 \times 10^{-6})^2}{0.020}$

☒ **D** $\dfrac{8.99 \times 10^9 \times (8.0 \times 10^{-6})}{0.020^2}$

(Total for Question 3 = 1 mark)

9: In a nuclear fission reaction, a nucleus splits into a nucleus S, a nucleus T and several neutrons.

S and T have the same kinetic energy. T has twice the mass of S.

Which of the following is the ratio $\dfrac{\text{momentum of T}}{\text{momentum of S}}$?
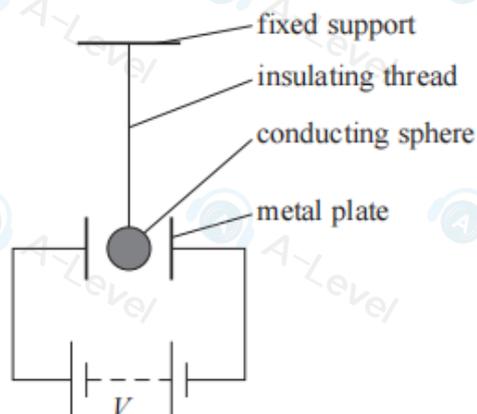
☒ **A** $\dfrac{1}{2}$

☒ **B** $\dfrac{1}{\sqrt{2}}$

☒ **C** $\sqrt{2}$

☒ **D** 2

(Total for Question 9 = 1 mark)

20 In the 18th century, a scientist called Gordon made the first device that used electrostatic forces to produce continuous motion.

A demonstration of the principle of Gordon's device is shown.

A light, conducting sphere of radius r is suspended from an insulating thread between two parallel metal plates. A large potential difference V is applied between the plates.

(a) There is an electrostatic force on the sphere when the sphere is charged.

The capacitance C of the sphere is given by

$$C = 4\pi\varepsilon_0 r$$

where r is the radius of the conducting sphere.

The sphere is charged by touching it onto one of the plates. The plates are a distance d apart.

Calculate the electrostatic force exerted on the sphere.

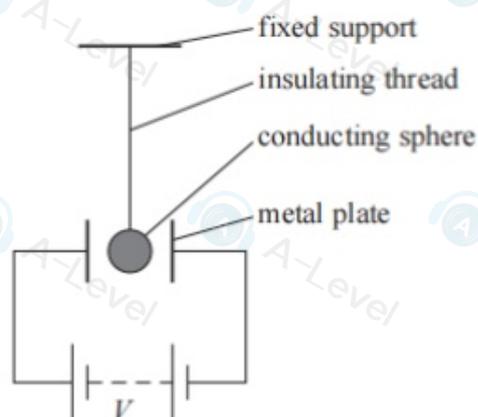$V = 4500\,\text{V}$
$d = 5.0\,\text{cm}$
$r = 3.5\,\text{cm}$

(5)

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Electrostatic force on sphere = ...

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Calculate the electrostatic force exerted on the sphere.

$V = 4500\,\text{V}$
$d = 5.0\,\text{cm}$
$r = 3.5\,\text{cm}$

(5)

Electrostatic force on sphere = _____

(b) After the sphere has been charged, the sphere starts to oscillate between the plates. The sphere touches each plate alternately.
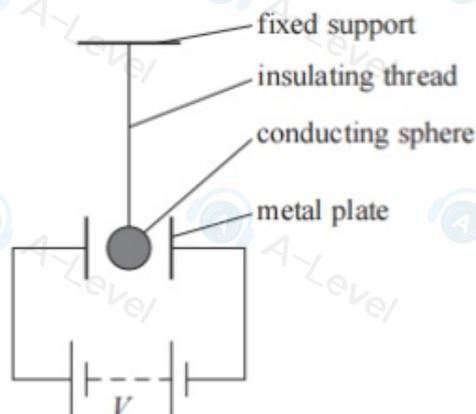
Explain why the conducting sphere oscillates between the two plates.

(3)

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(3)

14 A cathode ray tube can be used to demonstrate the properties of electrons. In the cathode ray tube, a beam of electrons is produced using the arrangement shown.
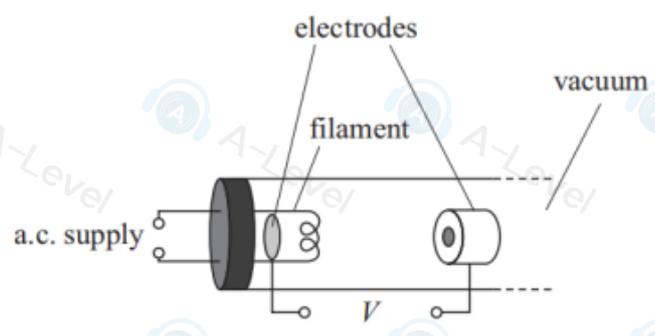
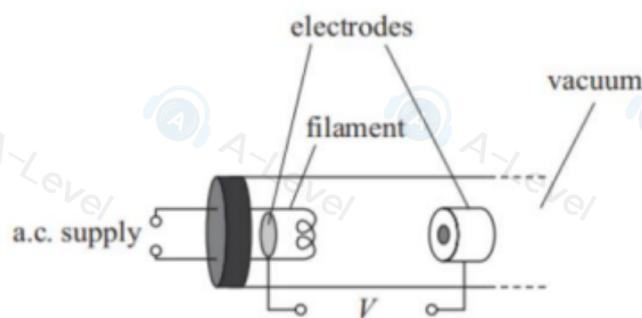(a) Explain why electrons are released when there is a current in the filament.
(2)

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....

14 A cathode ray tube can be used to demonstrate the properties of electrons. In the cathode ray tube, a beam of electrons is produced using the arrangement shown.

(a) Explain why electrons are released when there is a current in the filament.

(2)

(b) In one cathode ray tube, the electrons in the beam had a de Broglie wavelength of 2.65×10^{-11} m.

Calculate the potential difference V required to accelerate these electrons between the electrodes.

(4)

$V = $ ....

(Total for Question 14 = 6 marks)

17 The photograph shows a toy aeroplane suspended from a fixed point by a thread.
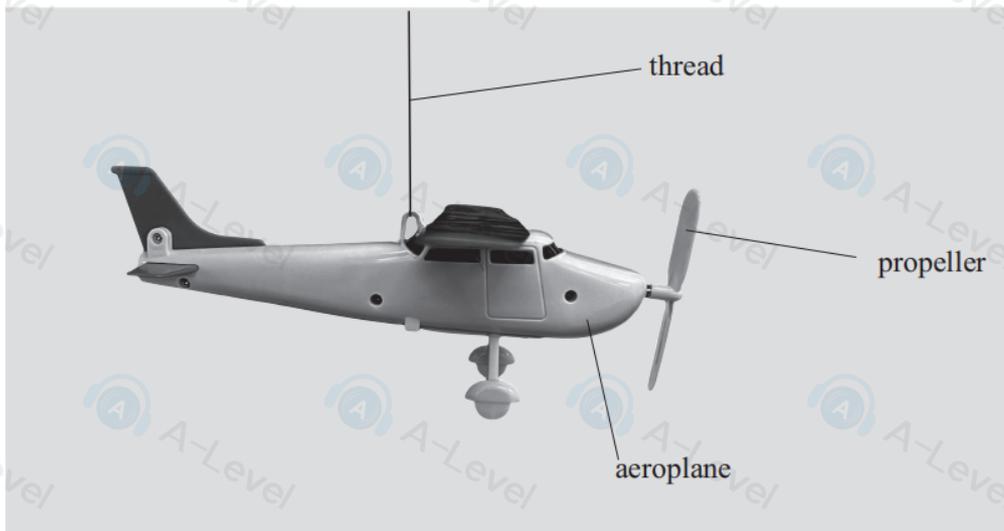
(a) The toy aeroplane has a motor that turns a propeller.

As the propeller rotates, it sweeps out a circle of radius 4.1 cm. The propeller pushes air backwards at a speed of 2.4 m s^{-1}.

(i) Show that the propeller pushes a mass of air of about 3×10^{-3} kg backwards in a time of 0.20 s.

density of air = 1.3 kg m^{-3}

(5)

(ii) Determine the momentum of the air pushed backwards by the propeller in a time of 0.20 s.

(2)

(iii) Determine the forwards force exerted on the aeroplane by the action of the propeller.
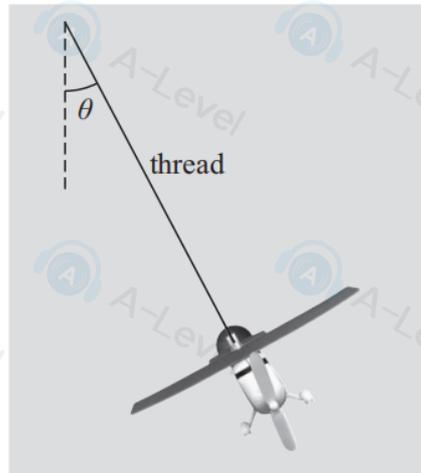
(2)

(ii) Show that the angle θ of the thread to the vertical is given by

$$\tan \theta = \frac{v^2}{rg}$$

(3)

(b) The toy aeroplane moves in a horizontal circular path of radius r at constant speed v. The thread is at an angle θ to the vertical, as shown.

thread

(i) The forwards and backwards forces on the toy aeroplane are equal in magnitude.

Add to the diagram to show the other forces acting on the toy aeroplane.

(2)

(iii) Calculate the time taken for the toy aeroplane to complete one revolution.

$\theta = 22°$
$r = 21\,\text{cm}$

(3)