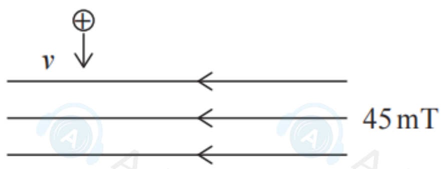
3 A proton travelling at speed v enters a uniform magnetic field.
The magnetic flux density of the field is 45 mT, as shown.



A force of 1.35×10^{-13} N is exerted on the proton.

Which of the following expressions gives v in m s^{-1}?

☒ **A** $\dfrac{1.35 \times 10^{-13}}{45 \times 1.6 \times 10^{-19}}$

☒ **B** $\dfrac{1.35 \times 10^{-13}}{45 \times 1.66 \times 10^{-27}}$

☒ **C** $\dfrac{1.35 \times 10^{-13}}{45 \times 10^{-3} \times 1.6 \times 10^{-19}}$

☒ **D** $\dfrac{1.35 \times 10^{-13}}{45 \times 10^{-3} \times 1.66 \times 10^{-19}}$

(Total for Question 3 = 1 mark)

A proton moving in a straight line with a speed v enters a magnetic field. The magnetic field is perpendicular to the direction of motion of the proton.

The proton follows a circular path of radius r in the magnetic field.

9 The path of the proton then decreases in radius.

Which of the following is a reason why the radius decreases?

☒ **A** The kinetic energy of the particle decreases.

☒ **B** The magnetic flux density decreases.

☒ **C** The mass of the proton increases.

☒ **D** The momentum of the proton increases.

(Total for Question 9 = 1 mark)

4 When the magnetic flux density is 0.024 T, the force on the wire is 4.8×10^{-4} N.

The length of wire in the field is 0.010 m.

Which of the following gives the current, in amps, in the wire?

☐ **A** $4.8 \times 10^{-4} \times 0.010 \times 0.024$

☐ **B** $\dfrac{0.024}{0.010 \times 4.8 \times 10^{-4}}$

☐ **C** $\dfrac{4.8 \times 10^{-4}}{0.010 \times 0.024}$

☐ **D** $\dfrac{0.024 \times 0.010}{4.8 \times 10^{-4}}$

(Total for Question 4 = 1 mark)

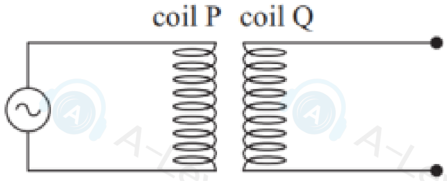
7 The diagram shows the paths of two charged particles, X and Y, moving at the same speed in a uniform magnetic field.

Which row of the table describes the properties of Y compared with the properties of X?

		Mass of Y	Charge of Y
☐	**A**	greater than	the same as
☐	**B**	less than	greater than
☐	**C**	the same as	less than
☐	**D**	greater than	less than

(Total for Question 7 = 1 mark)

6 Two coils, P and Q, are close to each other. An alternating supply is connected across coil P, as shown.



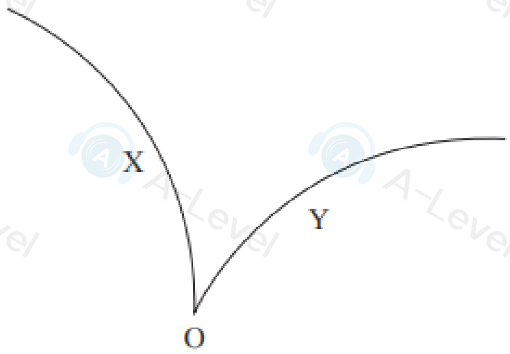
The number of turns on coil Q and the separation of coil P and coil Q can be changed.

Which row of the table gives the arrangement that produces the largest e.m.f. in coil Q?

	Number of turns	Separation of P and Q
☒ **A**	fewer turns in coil Q	closer together
☒ **B**	fewer turns in coil Q	further apart
☒ **C**	more turns in coil Q	closer together
☒ **D**	more turns in coil Q	further apart

(Total for Question 6 = 1 mark)

6 A particle detector shows tracks produced by two particles X and Y. The particles were created by the decay of a kaon at O.



Which of the following can be concluded from the tracks?

☒ **A** A magnetic field acts into the page.

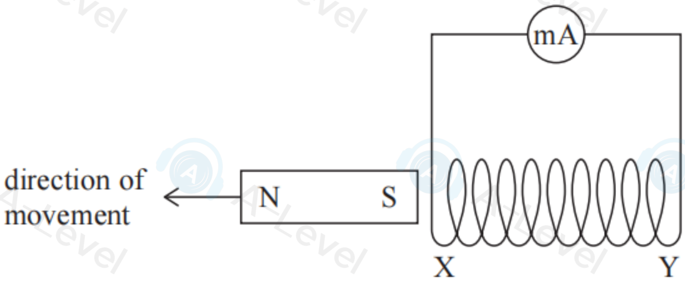
☒ **B** X is a positively charged particle.

☒ **C** Y is an electron.

☒ **D** X and Y have opposite charge.

(Total for Question 6 = 1 mark)

8 A magnet is moved away from a coil, as shown.



A current is produced in the coil, which creates a magnetic field around the coil.

Which row of the table shows the magnetic pole at X and the magnetic pole at Y?

		Magnetic pole at X	Magnetic pole at Y
☒	**A**	north	north
☒	**B**	north	south
☒	**C**	south	north
☒	**D**	south	south

(Total for Question 8 = 1 mark)

A proton moving in a straight line with a speed v enters a magnetic field. The magnetic field is perpendicular to the direction of motion of the proton.

The proton follows a circular path of radius r in the magnetic field.

9 The path of the proton then decreases in radius.

Which of the following is a reason why the radius decreases?

☒ **A** The kinetic energy of the particle decreases.

☒ **B** The magnetic flux density decreases.

☒ **C** The mass of the proton increases.

☒ **D** The momentum of the proton increases.

(Total for Question 9 = 1 mark)

10 An alpha particle also moving in a straight line with the same speed v enters the same magnetic field.
The alpha particle follows a circular path in the magnetic field.

Which of the following is the initial radius of the path?

☒ **A** $4r$

☒ **B** $2r$

☒ **C** $\frac{r}{2}$

☒ **D** $\frac{r}{4}$

(Total for Question 10 = 1 mark)

4 Which of the following is a possible unit for magnetic flux?

☒ **A** Tm^2

☒ **B** Tm^{-2}

☒ **C** $Wb\,m^2$

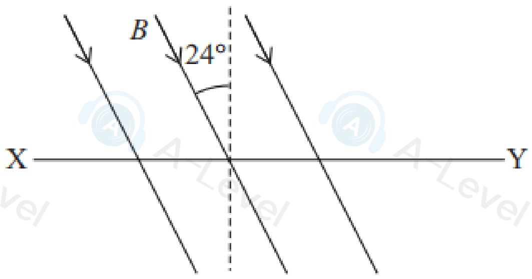
☒ **D** $Wb\,m^{-2}$

(Total for Question 4 = 1 mark)

5 An electron is travelling horizontally at velocity v through a uniform magnetic field of magnetic flux density B.

The magnetic field is at an angle of 24° to the vertical, as shown.

Not to scale



There is a force F acting on the electron due to the magnetic field. The force F is acting into the page.

Which row of the table gives the magnitude and direction of v?

	Magnitude of v	Direction of v
☒ **A**	$\frac{F}{B \times e \times \sin 24°}$	from X to Y
☒ **B**	$\frac{F}{B \times e \times \sin 24°}$	from Y to X
☒ **C**	$\frac{F}{B \times e \times \sin 66°}$	from X to Y
☒ **D**	$\frac{F}{B \times e \times \sin 66°}$	from Y to X

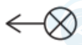
(Total for Question 5 = 1 mark)

A current-carrying wire is placed between two bar magnets, as shown.

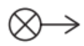
The current in the wire is into the page.

3 Which diagram shows the direction of the force on the wire due to the magnetic field?

☒ **A** 

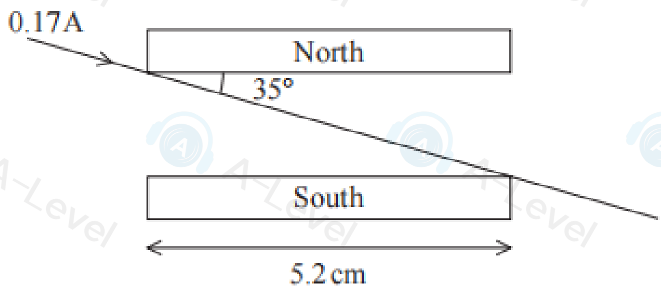
☒ **B** 

☒ **C** 

☒ **D** 

(Total for Question 3 = 1 mark)

10 The diagram shows a current-carrying wire between two magnetic poles.



The magnetic flux density between the poles is 0.85 T.

Which of the following gives the force on the wire in newtons?

☒ **A** $0.085 \times 0.17 \times 0.052$ into the page

☒ **B** $0.085 \times 0.17 \times 0.052 \times \sin 35°$ into the page

☒ **C** $0.085 \times 0.17 \times 0.052$ out of the page

☒ **D** $0.085 \times 0.17 \times 0.052 \times \sin 35°$ out of the page

(Total for Question 10 = 1 mark)

18 The diagram shows the track of a Σ^+ particle in a bubble chamber. The particle decays at point X.

There is a magnetic field of magnetic flux density B perpendicular to the velocity of the particle.

(a) The Σ^+ particle is following a circular path of radius 1.99 m.

Calculate the value of B.

momentum of Σ^+ particle $= 3.67 \times 10^{-19}\,\text{kg m s}^{-1}$

(2)

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(b) The equation shows the decay of the Σ^+ particle.

$$\Sigma^+ \rightarrow \pi^+ + n$$

(i) The Σ^+ particle is made of two up quarks and one strange quark.

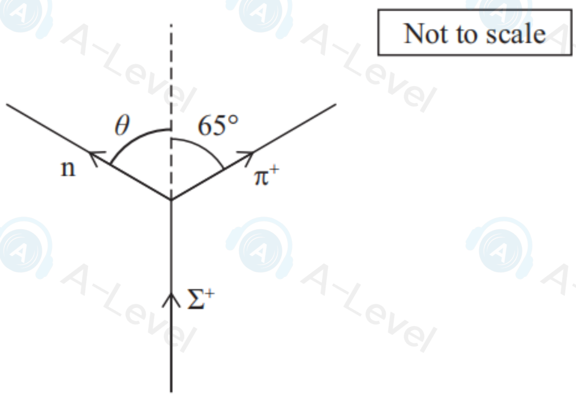
State what type of particle Σ^+ is.

(1)

(ii) Deduce whether the conservation of charge and the conservation of lepton number apply to this decay.

(4)

(iii) The diagram shows the directions of the three particles involved in the decay.



Determine the magnitude and direction of the momentum of the neutron.

momentum of Σ^+ particle $= 3.67 \times 10^{-19}\,\text{kg m s}^{-1}$
magnitude of momentum of $\pi^+ = 1.07 \times 10^{-19}\,\text{kg m s}^{-1}$

(6)

(iv) The diagram shows the track of the Σ^+ particle in the bubble chamber.

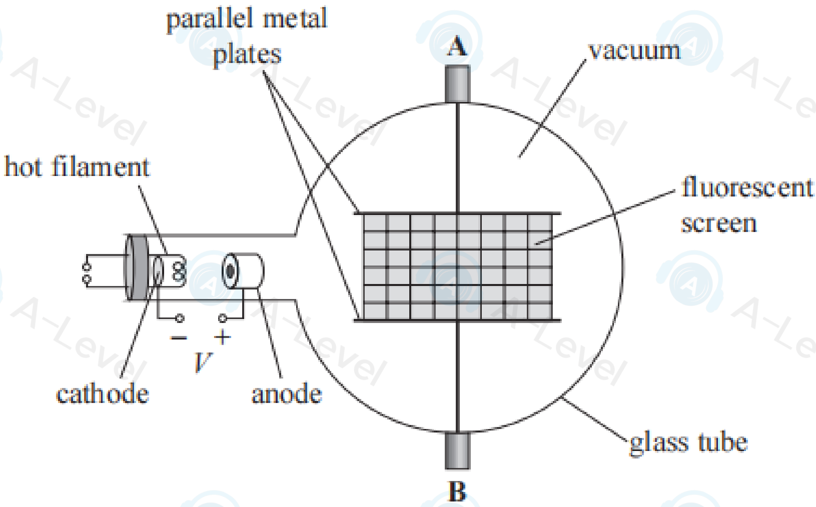
Add to the diagram to show all tracks visible in the bubble chamber after the decay at X.

You should label your diagram.

(4)

22 The electron beam tube can be used to determine the specific charge $\frac{e}{m}$ of an electron.

A potential difference V is applied between the cathode and the anode to produce a beam of electrons.



The beam is aimed at a fluorescent screen inside the tube and the path of the electrons is seen on the screen.

There are two parallel metal plates above and below the screen. A and B are connected to these plates and allow a potential difference to be applied across the plates.

(a) Explain why electrons are deflected into a parabolic path when a potential difference is applied between A and B.

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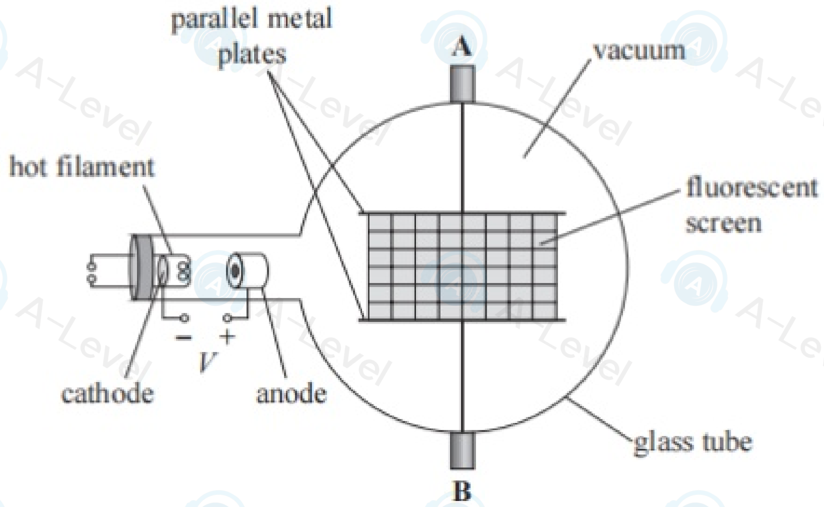

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(b) A potential difference V of 850 V is applied between the cathode and the anode.

(i) Show that the maximum speed of the electrons as they emerge from the anode is about $1.7 \times 10^7 \text{ m s}^{-1}$.

(3)

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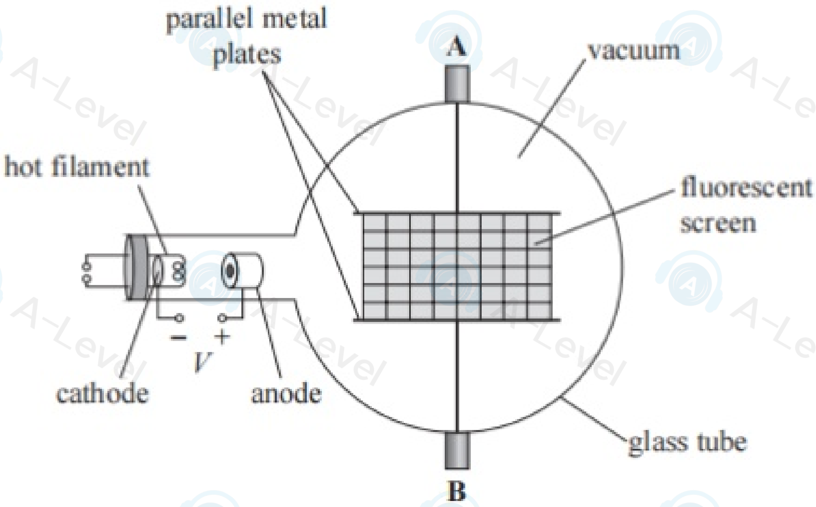

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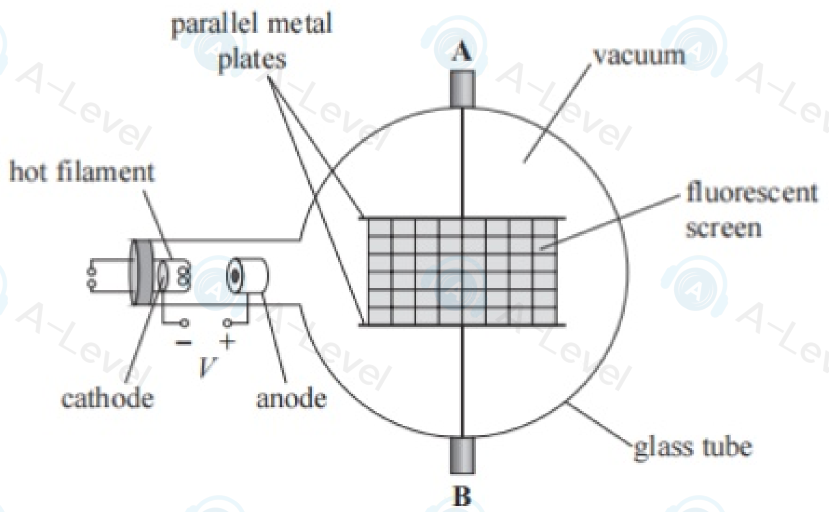

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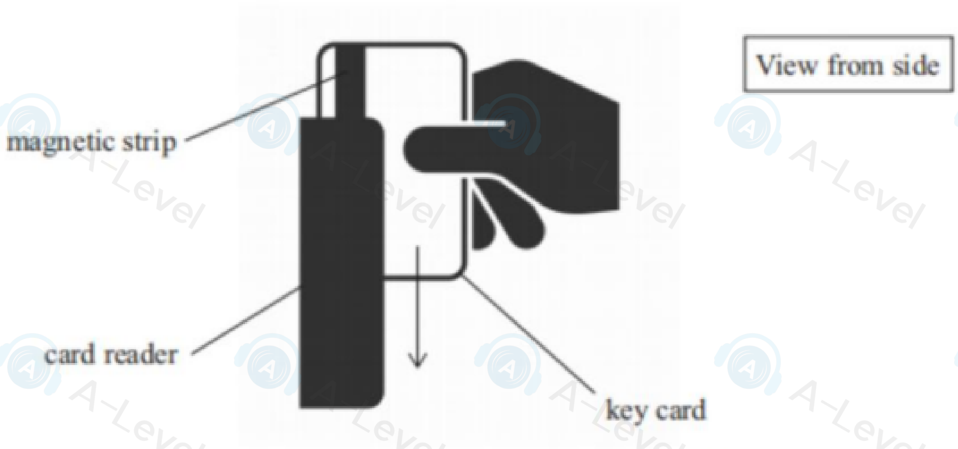
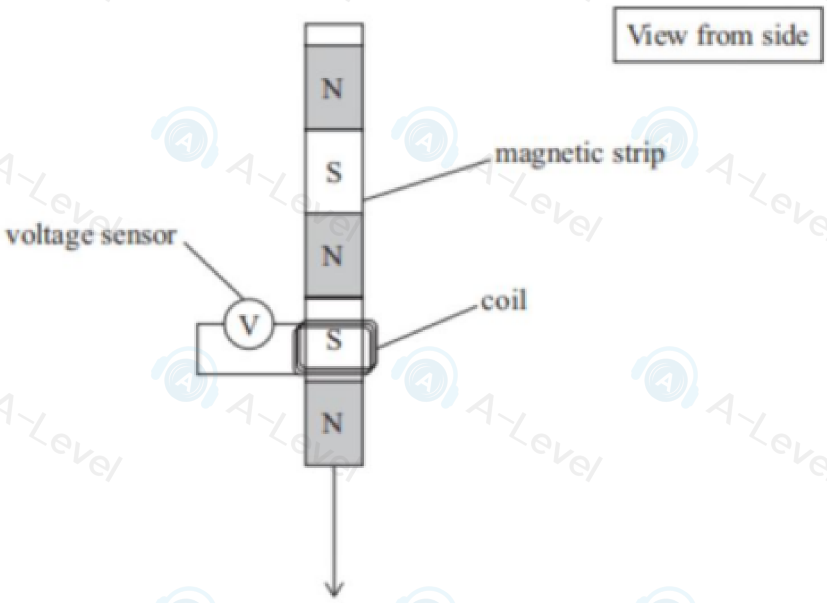
18 The diagram shows a key card and a card reader used to unlock a door. To unlock the door the key card is moved downwards through the card reader.



(Source: © Janis Abolins/Shutterstock)

The key card contains a magnetic strip consisting of many tiny bar magnets arranged side by side. The orientation of the magnetic poles of the bar magnets stores the code to unlock the door.

In the card reader there is a coil connected to a voltage sensor, as shown below.



(a) Explain how the voltage sensor detects the orientation of the magnetic poles.

(4)

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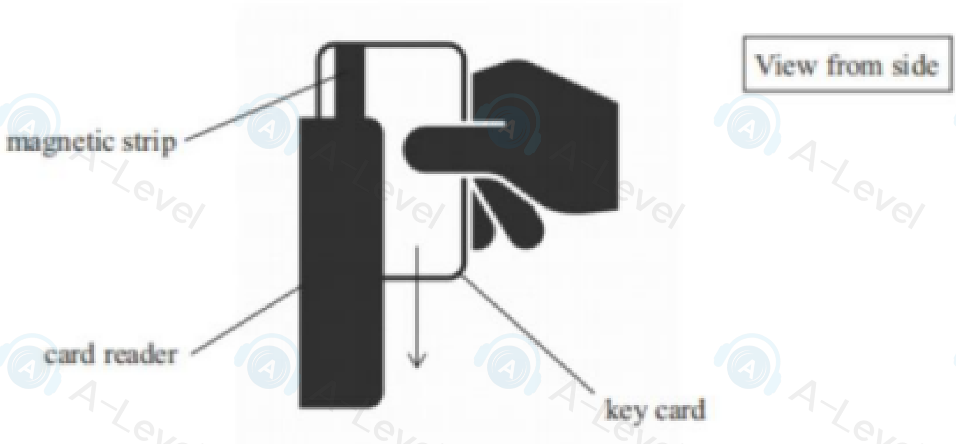

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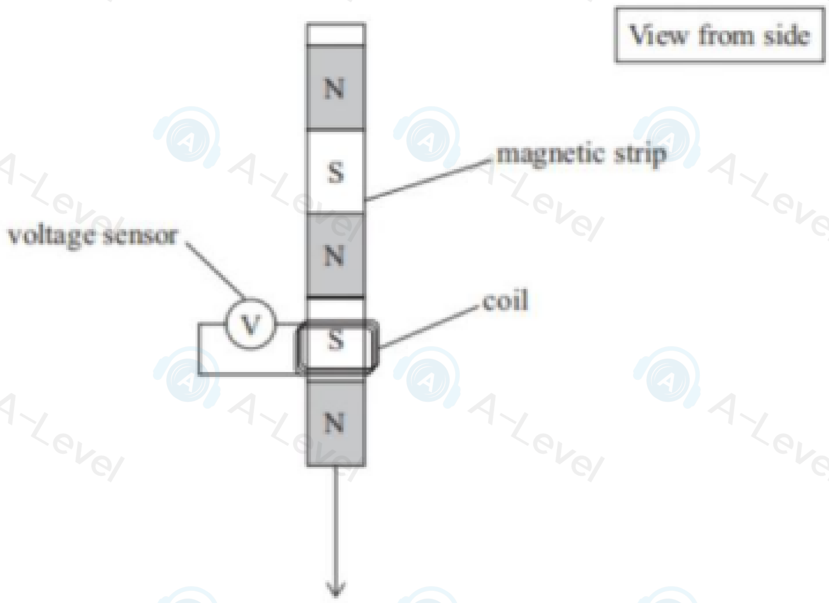

(a) Explain how the voltage sensor detects the orientation of the magnetic poles.

(4)

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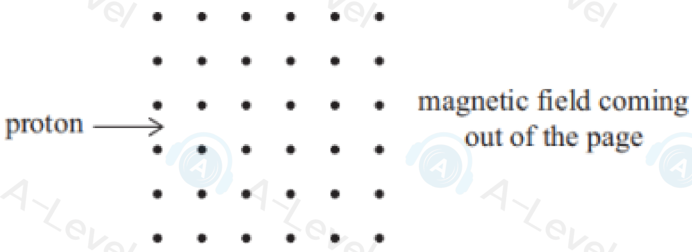
(b) The card reader can determine the orientation of a magnetic pole if the reading on the voltage sensor is greater than 1.5×10^{-6} V.

The key card is moved down a distance of 9.0 cm through the card reader in a time

11: A proton enters a magnetic field, as shown.



(a) The proton experiences a force of 6.5×10^{-13} N due to the magnetic field.

Calculate the speed of the proton.

magnetic flux density = 0.52 T

(2)

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Speed = ...

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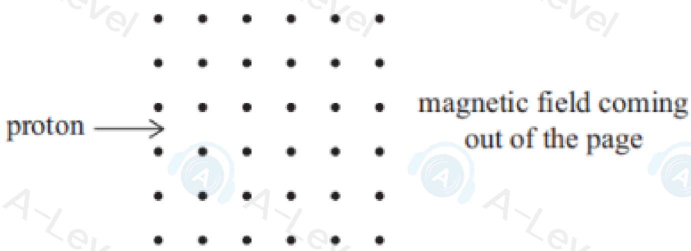

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Calculate the speed of the proton.

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(2)

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Speed = ...

(b) Draw, on the diagram above, the path of the proton in the magnetic field.

(2)

(Total for Question 11 = 4 marks)

(ii) The student replaces the sensitive voltmeter with a different voltmeter, with a resolution of 0.1 V.

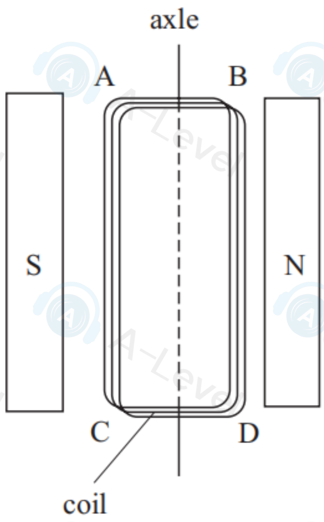
The coil makes one quarter of a turn, from a horizontal position to a vertical position.

Deduce whether this movement of the coil will produce a reading on the voltmeter.

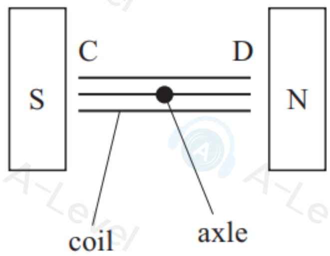
time for one quarter of a turn = 0.080 s
length of coil, BD = 5.0 cm
width of coil, DC = 3.5 cm
magnetic flux density = 0.68 T
number of turns on coil = 32

(5)

15 A student mounts a coil of wire on an axle. She places the coil between the north and south poles of two magnets to make a simple electric motor, as shown.



View from above



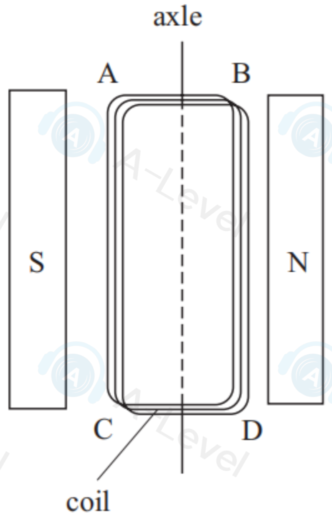
View from end

(a) The student connects the ends of the coil to a power supply. There is a current in the coil in the direction ABDC and the coil rotates.

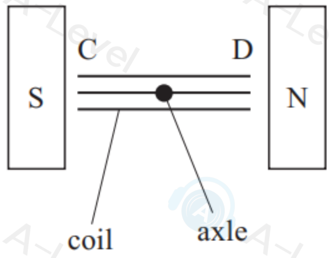
(i) Explain why the coil rotates in the clockwise direction when viewed from the end, as shown above.

(2)

15 A student mounts a coil of wire on an axle. She places the coil between the north and south poles of two magnets to make a simple electric motor, as shown.



View from above



View from end

(ii) Calculate the resultant moment, about the axle, of the magnetic forces acting on the coil.

length of coil, BD = 5.0 cm
width of coil, DC = 3.5 cm
magnetic flux density = 0.68 T
number of turns on coil = 32
current in coil = 0.24 A

(3)

(b) The student disconnects the motor from the power supply. She connects a sensitive voltmeter across the coil.

(i) She pushes one side of the coil down quickly, so that the coil starts to rotate.

Explain why a reading may be shown on the sensitive voltmeter.

(2)

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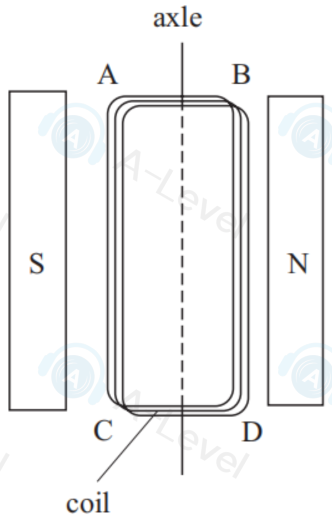

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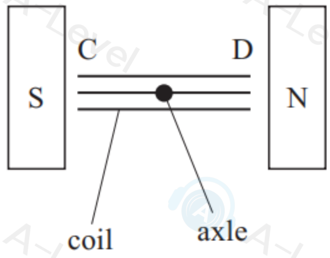

View from end

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The coil makes one quarter of a turn, from a horizontal position to a vertical position.

Deduce whether this movement of the coil will produce a reading on the voltmeter.

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