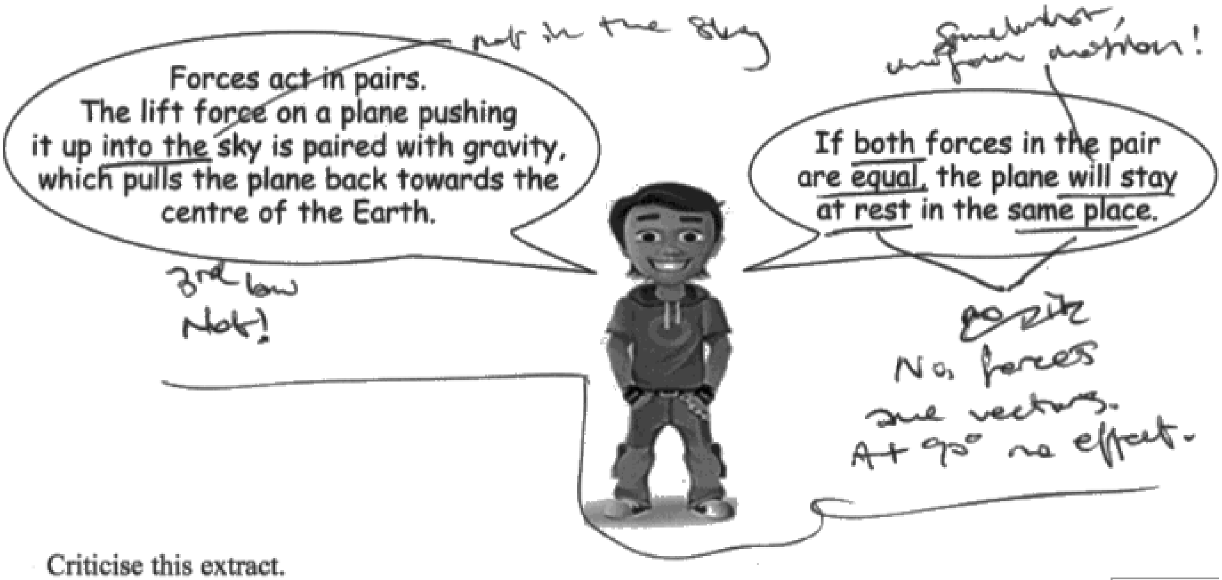
Edexcel Pearson IAL

Marking exercise

Exemplar material

Question 1 sample A

5 The following extract comes from a section on forces, on a website written for children.



Criticise this extract.

(6) Q05

• The first statement attempts to pair gravity and lift as a ~~pair~~ Newton's third law pair.

• However, it is not correct as the force of lift is not a reaction to gravity, but due to aerodynam[ic] forces. Nevertheless, for an aeroplane at cruise they balance out and resultant force is zero.

• Gravity acts regardless of plane flying.

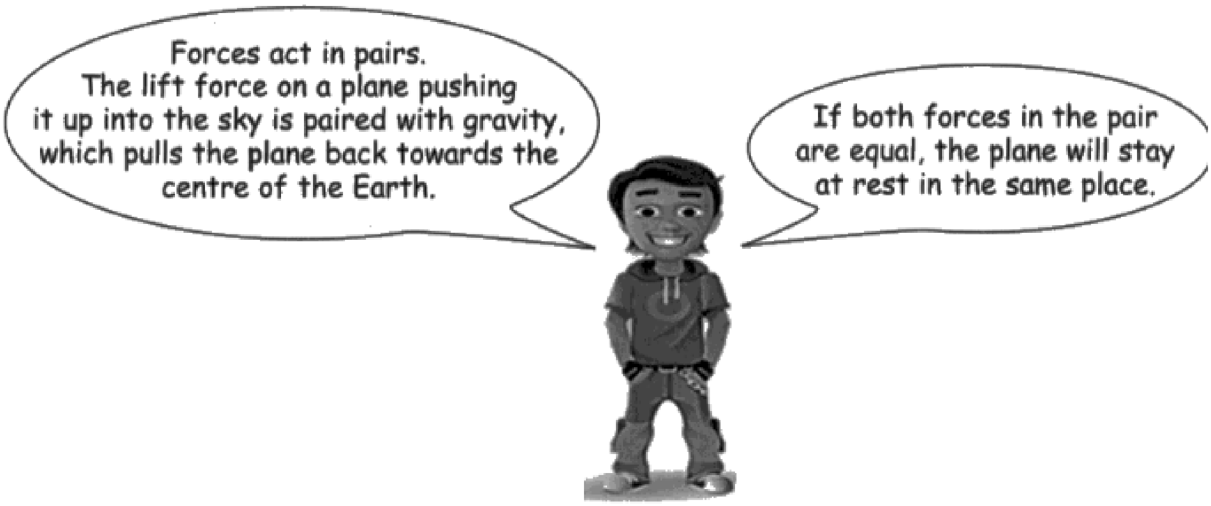
• The second statement is incorrect that a pair of forces balancing out will mean the plane remains at rest. This is because resultant force is directly proportional to acceleration, as per Newton's second law, not velocity. Therefore, the plane can still move with uniform motion and zero resultant force.

• Also, force is a vector, therefore there can still be horizontal acceleration even if vertical resultant force is zero.

(Total for Question 5 = 6 marks) Q05_Total

Question 1 Sample B

*5 The following extract comes from a section on forces, on a website written for children.



Criticise this extract.

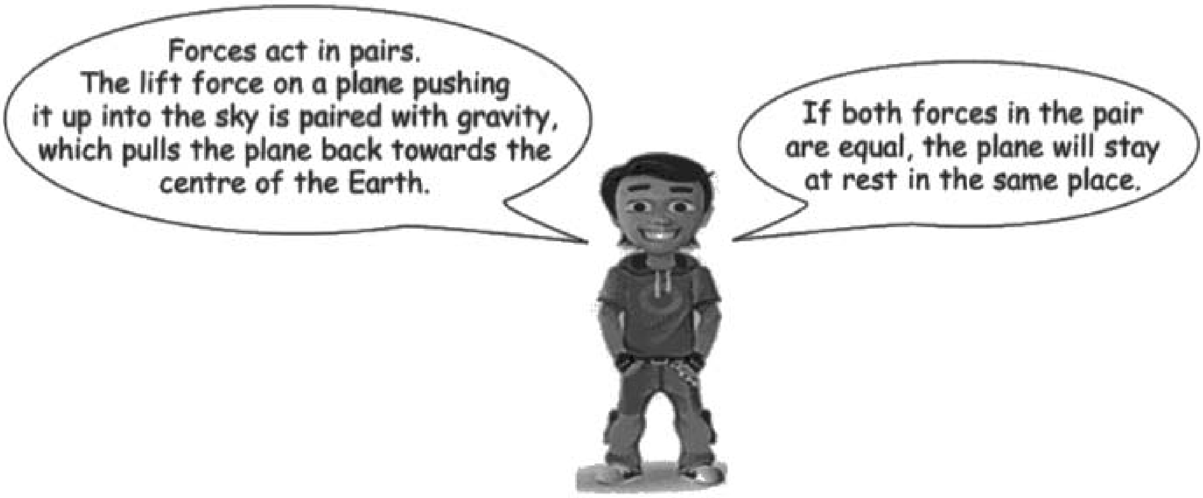
(6) Q05

By Newton's 3rd law, forces do act in pairs. However, these forces will be the same type and magnitude, and act on different bodies. The lift force on a plane is not paired with gravity, ~~so~~ as they are different types of force and both act on the plane. The Newton's third law pair of the Earth pulling the plane ~~towards~~ downwards is the plane pulling the Earth upwards with an equal magnitude.
By Newton's first law, if the two forces are equal and opposite, there is no resultant force, and so the plane will continue to move at constant velocity with no acceleration, not stay at rest. The plane would only stay at rest if the forces were balanced and it was initially stationary. If weight = lift and engine thrust = air resistance, the plane will fly at a constant velocity.

Q05 Total

Question 1 Sample C

*5 The following extract comes from a section on forces, on a website written for children.



Criticise this extract.

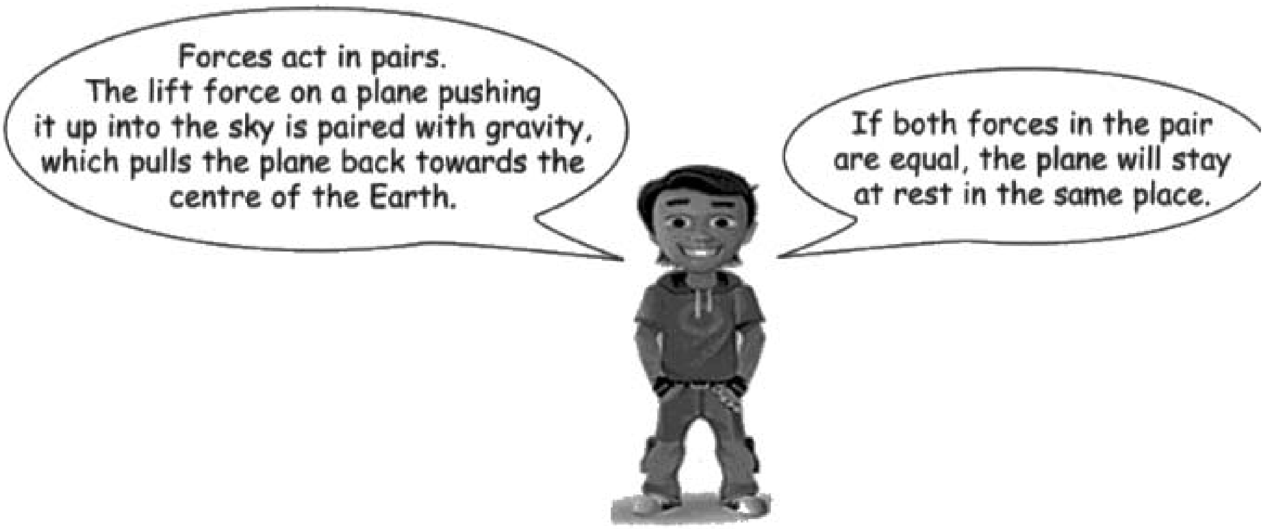
(6 Q05

Newton's third law does involve forces in pairs and states that if object A exerts a force on object B then object ~~A~~ B exerts a force of equal magnitude but opposite direction on object A. However these forces must be of the same type. So the lift force is not paired with gravity but rather a downward force on the air. And the plane is ~~pully~~ pulling up on the Earth ~~to~~ through gravity. Newton's first law states that if there is no resultant force acting on an object it will ~~contude~~ continue moving at a constant velocity. Therefore the statement is True in some cases where the plane is stationary for example. But when the plane is flying at constant ~~s~~ velocity there are more than 2 ballanced forces acting on it. The plane will stay at the same ~~cap~~ altitude if there is no vertical resultant force on it.

(Total for Question 5 = 6 marks) Q05_Total

Question 1 Sample D

*5 The following extract comes from a section on forces, on a website written for children.



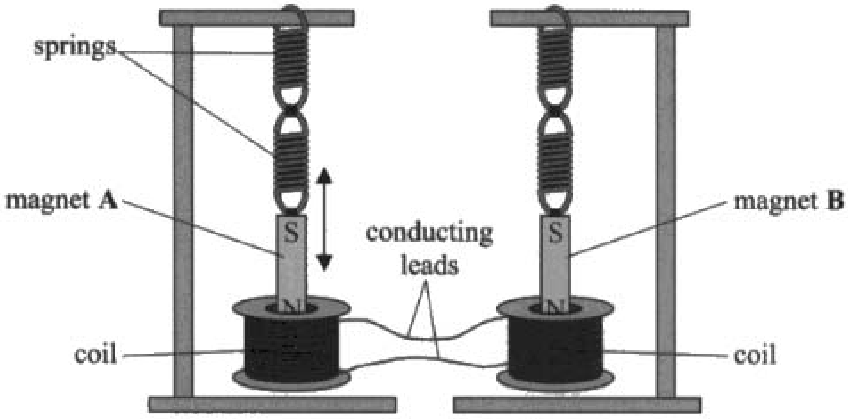
Criticise this extract.

(6) Q05

The extract is correct that forces act in pairs however the claim that lift is paired with gravity is incorrect. Newton's third law states that both forces must be of the same type, of which lift and gravity are not. It is also wrong when claiming that if both forces in the pair are equal, the plane will stay at rest. Force pairs are always equal and if their claim was true then no ~~forces would~~ movement would ever happen. It is only true that if the resultant force on an object is zero then it will remain at a constant velocity, not necessarily at rest. As stated before, they have not mentioned correct pairing. gravity acting downwards on the plane is paired with the ~~gra~~ gravity of the plane pulling the Earth upwards

Question 2 Sample A

*(d) Identical bar magnets are suspended from identical springs, with the North pole of each magnet inside a coil of wire as shown. The two coils are connected together with conducting leads.



A

Magnet A is displaced so that it oscillates vertically. The North pole of magnet A moves into and out of the coil of wire with simple harmonic motion. As this motion continues, magnet B starts to oscillate. The amplitude of oscillation of magnet B increases over time.

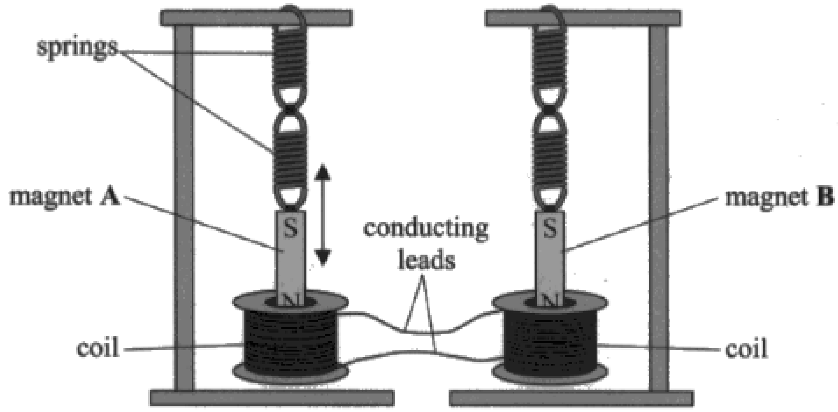
Explain why magnet B starts to oscillate with an increasing amplitude.

(6) Q11d

When magnet A is set into ossilation it causes the coil to experience a changing flux linkage. Due to Faraday's law, $\mathcal{E} = -\frac{dN\Phi}{dt}$, this induces an EMF in the coil which because it is connected by conducting leads to another coil, induces a alternating current in both coils. The alternating current in the second coil induces an alternating magnetic field which in turn puts a changing force on magnet B. Because the driving frequency of this force is the same as the natural frequency of magnet B because the springs and masses are the same of A and B, this causes resonance in the magnet B system. Resonance means that there is increased energy transfer from the driving ossilation to the driven and so because energy $\propto$ to amplitude^2 the amplitude of magnet B increases. If the coils are in same direction as magnet A goes down it should put an upward force on magnet B due to Lenz's law. Kinetic energy is transfered to electric and back to kinetic in the other magnet

Question 2 Sample B

(d) Identical bar magnets are suspended from identical springs, with the North pole of each magnet inside a coil of wire as shown. The two coils are connected together with conducting leads.



Magnet A is displaced so that it oscillates vertically. The North pole of magnet A moves into and out of the coil of wire with simple harmonic motion. As this motion continues, magnet B starts to oscillate. The amplitude of oscillation of magnet B increases over time.

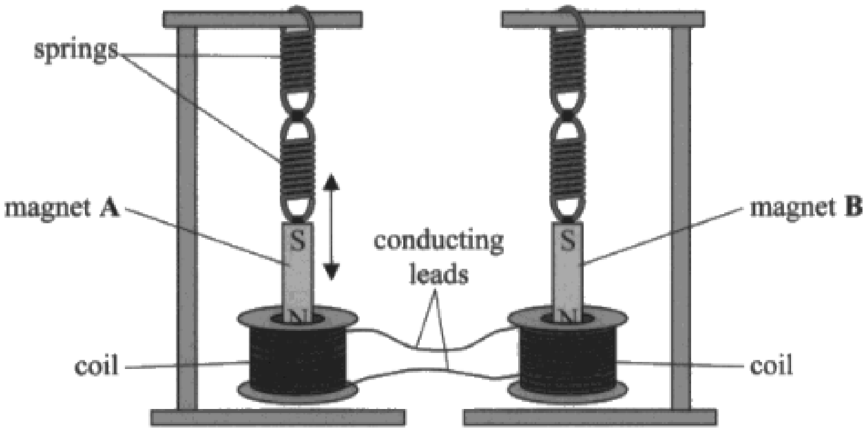
Explain why magnet B starts to oscillate with an increasing amplitude.

(6) Q11d

As magnet A oscillates, coil A experiences a changing magnetic field, which means there is a changing magnetic flux linkage in the coil, which induces an emf by Faraday's law. As the coil forms a complete circuit, the induced emf creates a current in both coils, as they are connected by conducting leads. The current in the second coil is alternating with the same frequency as magnet A oscillates with. The second coil has its own magnetic field, which interacts with magnet B's magnetic field to produce a changing magnetic field. Magnet B is now experiencing a changing resultant magnetic field so it experiences a force to oppose the change creating it, by Lenz's law. As the polarity of the current switches, the resultant field switches so the force on magnet B changes direction, causing it to oscillate with SHM. Magnet B is being driven at the natural

Question 2 Sample C

*(d) Identical bar magnets are suspended from identical springs, with the North pole of each magnet inside a coil of wire as shown. The two coils are connected together with conducting leads.



Magnet A is displaced so that it oscillates vertically. The North pole of magnet A moves into and out of the coil of wire with simple harmonic motion. As this motion continues, magnet B starts to oscillate. The amplitude of oscillation of magnet B increases over time.

Explain why magnet B starts to oscillate with an increasing amplitude.

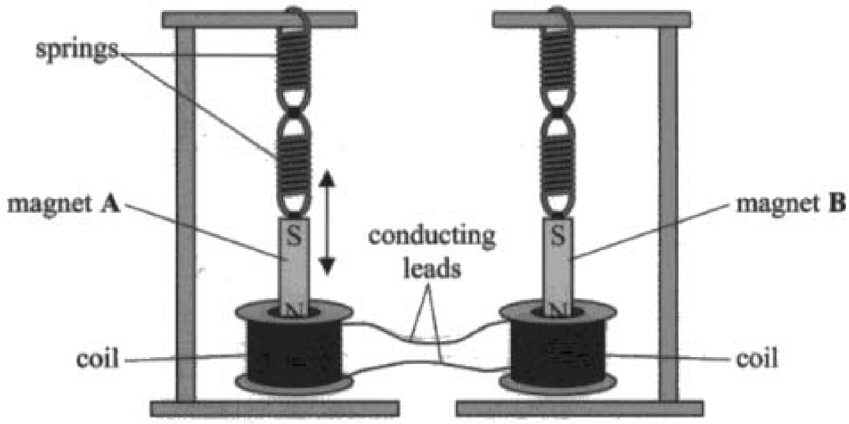
Q11d

(6)

The oscillating magnet A causes a changing magnetic field around the wire, by causing a ~~rate of~~ ~~the~~ constant change in flux ~~density~~ linkage, and the rate of change in flux linkage then induces an ~~alternating~~ emf in the coil around magnet A, inducing an alternating current in the coil. As the two coils are connected by conducting leads, this also induces an alternating current in the coil B, ~~causing a~~ inducing a changing ~~electric~~ ~~magnetic~~ magnetic field around coil B. The changing ~~magnetic~~ magnetic field then interacts with magnet B as ~~it cuts the~~ ~~fie~~ field lines cut, attracting and repelling magnet B at the same frequency at the oscillation of magnet A, causing an oscillation of magnet B with an increasing amplitude.

Question 2 Sample D

*(d) Identical bar magnets are suspended from identical springs, with the North pole of each magnet inside a coil of wire as shown. The two coils are connected together with conducting leads.



Magnet A is displaced so that it oscillates vertically. The North pole of magnet A moves into and out of the coil of wire with simple harmonic motion. As this motion continues, magnet B starts to oscillate. The amplitude of oscillation of magnet B increases over time.

Explain why magnet B starts to oscillate with an increasing amplitude.

(6) Q11d

When the bar magnet move w/ SHM, the field lines of the magnet cut the coils to create a change of flux linkage. Now, Faraday's Law states that the EMF induced is DP to the rate of change of flux linkage. This means that an EMF is induced across the conducting leads causing an EMF in the coil at B. This causes the magnet at B to experience a force as according to Fleming's left hand rule ~~a [illegible]~~ an object will experience a force when the magnetic field and current are perpendicular to one another. ~~Now, as magnet B moves up, there is once again a change in flux linkage across the coils at this time at B. This causes an EMF [illegible] in the coil [illegible] again~~ ~~This causes the~~ As magnet A moves up and down, it is constantly reversing the potential difference across the coils. This means that the magnetic field across B is constantly changing. The direction of that field depends on ~~[illegible]~~ ~~[illegible]~~ the direction of the magnet, If the north pole is moving in, it will generate a south pole in the coil. As this alternating field continues, the magnet begins to gain energy as it is constantly accelerated by the magnetic field.

(Total for Question 11 = 14 marks) Q11_Total

Question 3 Sample A

*(c) Explain the variation of resistance with potential difference for the filament bulb in terms of particle behaviour.

(6)

As ~~the~~ energy / potential difference increases, the energy transferred when ~~an~~ charge carrying electron hits an ion ~~atom~~ in the lattice ~~material~~ is increased, as the electrons have more energy. This increases the kinetic energy of the lattice ions ~~particles~~, causing them to vibrate more. This in turn, increases ~~both~~ the probability of a collision occuring, and ~~of~~ thus the frequency of these collisions. This increased frequency of collisions makes it harder for electrons to flow through the material, thereby reducing the current, ~~and~~ (thus resistance has increased) as $I = \frac{Q}{t}$, so if fewer electrons flow per unit time, then the current must of decreased, and due to $V = IR$, $R \propto I$, ie as current decreases, Resistance increases.

Question 3 Sample B

*(c) Explain the variation of resistance with potential difference for the filament bulb in terms of particle behaviour.

(6)

As the potential difference increases in ~~a~~ across a filiment lamp, the flow of electrons increases. This means there are more electrons in ~~the~~ the filimant lamp at a certain time then before. Due to increased velocity and energy of the electrons more collisions will occur between them and the ions in the filiment lamp. Due to the increased collisions the filiment lamp will heat up as more kinetic energy from the collisions is converted into thermal energy. ~~This means that ions in the filiment will also gain more energy~~ Due to the increased number of collisions the ~~dr~~ average drift velocity of the electrons will decrease. This means that the resistance in the bulb has increased. Eventually it is so high that the resistance stays constant as p.d increases.

(Total for Question 14 = 11 marks)

Question 3 Sample C

*(c) Explain the variation of resistance with potential difference for the filament bulb in terms of particle behaviour.

(6)

As the potential difference increases the current increases. As the current increases resistance increases. This is because an increase in current causes a temperature rise, so the ~~atoms~~ electrons (charge carriers) gain more kinetic energy and move around faster, this causes them to collide more with the particles and loose the kinetic energy, so the average velocity (drift velocity) of the charge carriers decreases. Current is determined by the equation $I = nqvA$, if the number of charge carriers, the charge they carry and the cross sectional area all remain constant then ~~Ex~~ current is proportional to the drift velocity so as the drift velocity decreases so does curret. $V = IR$ so for a constant voltage a lower current means an increase in ~~voltage~~ resistance. ~~so as~~

Question 3 Sample D

*(c) Explain the variation of resistance with potential difference for the filament bulb in terms of particle behaviour.

(6)

A filament bulb is a non-ohmic component ~~xx~~ in which resistance increases with potential difference. As the potential difference increases, so does the current. An increase in current causes an increase in the amplitude of ionic lattice vibrations. As the metal ions begin to vibrate more, they collide with the flow of electrons more frequently, therefore decreasing the current. Current and resistance have an inverse relationship shown in the equation $R = \frac{V}{I}$, so as current decreases, resistance increases.

Question 4 Sample A

*(a) Explain how the cyclotron produces the high-energy proton beam.

(6)

The protons enter the cyclotron in the middle and are accelerated due to Alternating potential difference between the dees which causes an electric field. This increases the velocity of the particle and so the momentum of it increases due to $p = mv$. Because the momentum is increased the radius also increases following $r = \frac{p}{BQ}$ and since B and Q are constants only p changes. The protons are kept in circular motion due to the magnetic field that acts into the page meaning that a centripetal force is felt by the protons towards the centre of the circle. As the protons move from one dee to another they also experience an increase in energy as their velocity increases using $KE = \frac{1}{2}mv^2$ so that is how the proton beam exits the cyclotron as a high-energy beam.

Question 4 Sample B

*(a) Explain how the cyclotron produces the high-energy proton beam.

(6)

Protons emerger from the source and are accelerated across the potential difference between the dees. After each acceleration the polarity of the Pd flips in order to accelerate across again in the opposite direction. As momentum of the protons increase, the radius of their path increase in a circular spiral, which increases until they emerge from the exit hole as a high-energy proton beam.

Question 5 Sample A

A motorist received a speeding penalty notice, from the police, for a short journey along 120 m of road.

(a) The car's specification states that the minimum time for the car to accelerate from 0 to 60 miles per hour is 9.5 seconds.

Show that the maximum value for the average acceleration of the car over 9.5 s is about 3 m s^{-2}.

2s.f.

1 mile = 1600 m

(2

1·6km/mile × 60 miles/hour = 96km/hour

96km/hour × $\frac{1}{3600}$ hours/second = 0·027km/s

= 26·7 ms^{-1}

$\frac{26.7 \text{ ms}^{-1}}{9.5 \text{ s}}$ = 2·8 ms^{-2} (2s.f.)

(b) The police recorded a maximum speed for the car of 20 m s^{-1}.

The motorist knows that the speed at the start and at the end of the 120 m journey was z

Assume that the car had:

- constant positive acceleration, equal to the value in part (a), for the first 60 m of the journey
- constant negative acceleration of the same magnitude for the final 60 m of the journe

Determine whether the motorist should challenge the penalty notice.

(3

s 60m
u 0ms^{-1}
v
a 2·8ms^{-2}
t

carrying exact values from (a) for a:

$v^2 = u^2 + 2as$

$v = \sqrt{u^2+2as} = \sqrt{0^2 + 2\times60\times2.8} = 18.4$ ms^{-1}

which is lower than 20 ms^{-1}

so he should challenge.

Question 5 sample B

(a) The car's specification states that the minimum time for the car to accelerate from 0 to 60 miles per hour is 9.5 seconds.

Show that the maximum value for the average acceleration of the car over 9.5 s is about 3 m s^{-2}.

1 mile = 1600 m

(2)

60 mph = 96000 metres/h = ~~1600 m/s~~ 26.67 ms^{-1}

s =
u = 0 $v = u + at$ $a = \frac{v-u}{t} = \frac{26.67}{9.5}$
v = 26.67
a = a $= 2.807$ ms^{-2}
t = 9.5 $= 3$ ms^{-2} (1 s.f.)

(b) The police recorded a maximum speed for the car of 20 m s^{-1}.

The motorist knows that the speed at the start and at the end of the 120 m journey was zer

Assume that the car had:

- constant positive acceleration, equal to the value in part (a), for the first 60 m of the journey
- constant negative acceleration of the same magnitude for the final 60 m of the journey

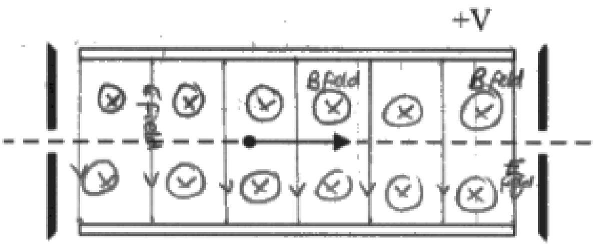
Determine whether the motorist should challenge the penalty notice.

(3)

~~2.807 × 60 =~~

s = 60 $v^2 = u^2 + 2as$
u = 0
v = v $= 2 \times 3 \times 60 =$ ~~[illegible]~~ 360
a = 3
t   v = ~~[illegible]~~ 18.97 His maximum speed was 18.97 ms^{-1} (~~[illegible]~~) so he should dispute the police's claim.

Question 6 Sample A



In one mass spectrometer the plates are 2.5 cm apart and a p.d. of 135 V is applied.

A magnetic field is also applied to produce a force on the ions in the opposite direction to the force from the electric field. For one particular speed the ions travel in a straight line and emerge from the selector.

(i) Add to the diagram to indicate the directions of the electric field and the magnetic field. (2) Q13ci

(ii) The magnetic flux density applied to the velocity selector is 24.5 mT.

Deduce whether this magnetic flux density is suitable to produce a beam of chlorine-35 ions of speed 2.2×10^5 m s^{-1}. (4) Q13cii

$Bqv = \frac{V}{d} q$.

$Bv = \frac{V}{d}$.

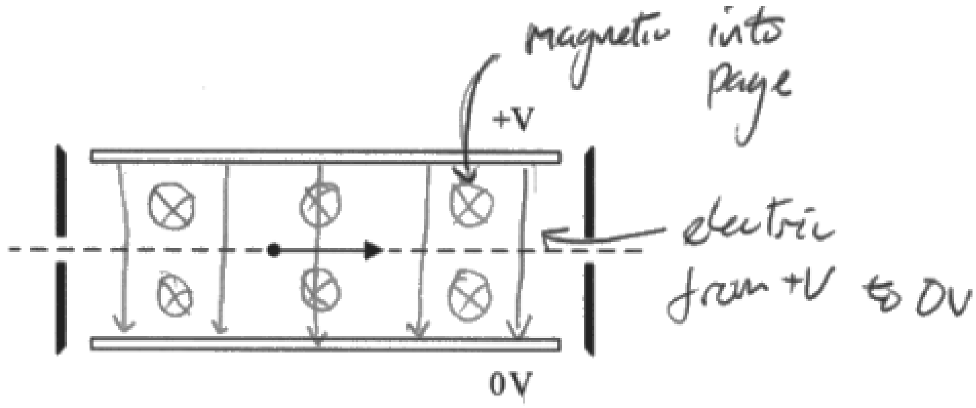
$24.5 \times 10^{-3} \times v = \frac{135\,V}{2.5 \times 10^{-2}\,m}$

$v = 2.204 \times 10^3$ ms^{-1}

yes, it is suitable as at $v = 2.20 \times 10^3$

The forces due to the E and B fields are equal, and in opposite directions.

Question 6 Sample B



In one mass spectrometer the plates are 2.5 cm apart and a p.d. of 135 V is applied.

A magnetic field is also applied to produce a force on the ions in the opposite direction to the force from the electric field. For one particular speed the ions travel in a straight line and emerge from the selector.

(i) Add to the diagram to indicate the directions of the electric field and the magnetic field.

(2) Q13ci

(ii) The magnetic flux density applied to the velocity selector is 24.5 mT.

Deduce whether this magnetic flux density is suitable to produce a beam of chlorine-35 ions of speed 2.2×10^5 m s^{-1}.

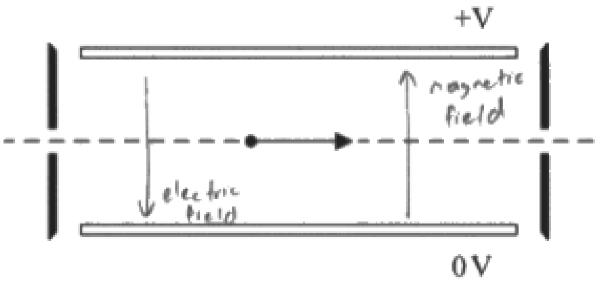
(4) Q13cii

$E = \frac{V}{d} = \frac{135}{0.025} = 5400$ N/C $F = EQ$ $1.6 \times 10^{-19} \times 5400 = 8.64 \times 10^{-16}$ N

$F = Bqv$ $24.5 \times 10^{-3} \times 1.6 \times 10^{-19} \times 2.2 \times 10^5 = 8.624 \times 10^{-16}$

force due to Electric field = force due to magnetic field = 8.6×10^{-16} N so beam will pass through without being deflected if ions have velocity 2.2×10^5 ms^{-1}

Question 6 Sample C



In one mass spectrometer the plates are 2.5 cm apart and a p.d. of 135 V is applied.

A magnetic field is also applied to produce a force on the ions in the opposite direction to the force from the electric field. For one particular speed the ions travel in a straight line and emerge from the selector.

(i) Add to the diagram to indicate the directions of the electric field and the magnetic field.
(2) Q13ci

(ii) The magnetic flux density applied to the velocity selector is 24.5 mT.

Deduce whether this magnetic flux density is suitable to produce a beam of chlorine-35 ions of speed 2.2×10^5 m s^{-1}.
(4) Q13cii

$F_{MAG} = Bqv = 24.5\times10^{-3} \times 1.6\times10^{-19} \times 2.2\times10^{5}$

$= 8.624 \times 10^{-16}$ N

$\frac{F}{Q} = \frac{V}{d} \rightarrow F = \frac{VQ}{d} = \frac{135 \times 1.6\times10^{-19}}{0.025}$

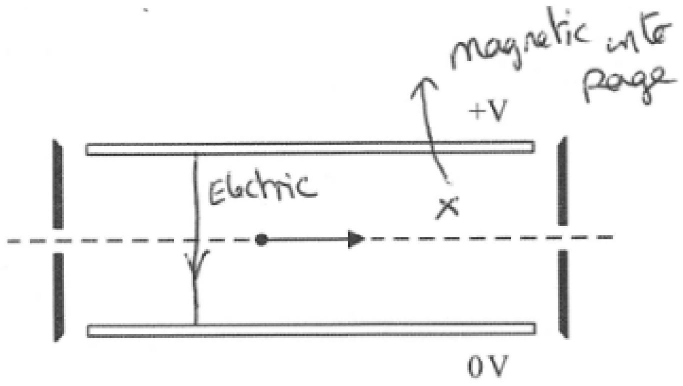
$= 8.64 \times 10^{-16}$ N

Resultant force of 1.6×10^{-18} N in direction of elec field

There is a resultant force, which will cause the ions to accelerate away from its linear path, thus it will not pass through the velocity selector.

∴ The flux density of 24.5 mT is not appropriate to produce a beam of Cl-35 ions of speed 2.2×10^{5} m s^{-1}

Question 6 Sample D



In one mass spectrometer the plates are 2.5 cm apart and a p.d. of 135 V is applied.

A magnetic field is also applied to produce a force on the ions in the opposite direction to the force from the electric field. For one particular speed the ions travel in a straight line and emerge from the selector.

(i) Add to the diagram to indicate the directions of the electric field and the magnetic field. (2)

(ii) The magnetic flux density applied to the velocity selector is 24.5 mT.

Deduce whether this magnetic flux density is suitable to produce a beam of chlorine-35 ions of speed 2.2×10^5 m s^{-1}. (4)

For the ion to emerge from the selector the magnetic force is equal in magnitude to the electric force.

$$Bqv = \frac{Vq}{d} \qquad B = \frac{V}{vd} = \frac{135\,V}{2.2\times10^5\,m/s \times 0.025\,m}$$

$B = 0.0245\,T$ = 24.5 mT as quoted in passage so it is suitable.

Question 7 Sample A

(ii) Show that the activity of this sample is about 5 Bq.

half-life of potassium-40 = 1.25×10^9 years

(3)

$A = \lambda N = \frac{N \ln 2}{t_{\frac{1}{2}}} = \frac{2.42 \times 10^{17} \times \ln 2}{1.25 \times 10^9 \times 365 \times 24 \times 60^2}$

A = ~~[illegible] Bq~~ 5.13 Bq

≈ 5 Bq.

(iii) With no sample in front of the Geiger-Müller tube, a count rate of 15 counts per minute is recorded. When the potassium chloride test sample is placed next to the Geiger-Müller tube 176 counts are recorded in a period of 10 minutes.

A detector is considered efficient if it detects at least 7.5% of beta emissions from the source.

Determine whether this Geiger-Müller tube can be considered efficient.

(3)

$10 \times 60 \times 5.13 = 3080$ nuclear decays

∴ 3080 β^- released.

$\frac{(176 - 15)}{3080} \times 100 = 5.23\%$

⇒ 5.23% < 7.5%

∴ Geiger-Müller tube is not efficient.

Question 7 Sample B

(ii) Show that the activity of this sample is about 5 Bq.

half-life of potassium-40 = 1.25×10^9 years

(3)

$A = \lambda N$

$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$ ~~$= \frac{\ln 2}{1.25 \times 10^9 \times 365 \times 24 \times 60 \times 60}$~~

$t_{\frac{1}{2}} = 1.25 \times 10^9$ years $= 3.942 \times 10^{16}$ s

$\lambda = 1.758 \times 10^{-17}$

$\therefore A = \lambda \times 2.92 \times 10^{17} = 5.1$ Bq

(iii) With no sample in front of the Geiger-Müller tube, a count rate of 15 counts per minute is recorded. When the potassium chloride test sample is placed next to the Geiger-Müller tube 176 counts are recorded in a period of 10 minutes.

A detector is considered efficient if it detects at least 7.5% of beta emissions from the source.

Determine whether this Geiger-Müller tube can be considered efficient.

(3)

176 counts in 10 minutes = 17.6 counts per minute therefore the collected count rate is 2.6 counts per minute. As activity = 5.1 Bq then the count rate should be 306. 7.5% of 306 = 22.95, so therefore this Geiger-Müller tube detect way under 7.5% so should not be considered efficient.

Question 7 Sample C

(ii) Show that the activity of this sample is about 5 Bq.

half-life of potassium-40 = 1.25×10^9 years

(3)

$A = \lambda N \qquad \lambda = \frac{\ln 2}{1.25\times10^9}$

$A = \frac{\ln 2}{1.25\times10^9} \times 3\times10^{17} = 1.6\times10^8$?

(iii) With no sample in front of the Geiger-Müller tube, a count rate of 15 counts per minute is recorded. When the potassium chloride test sample is placed next to the Geiger-Müller tube 176 counts are recorded in a period of 10 minutes.

A detector is considered efficient if it detects at least 7.5% of beta emissions from the source.

Determine whether this Geiger-Müller tube can be considered efficient.

(3)

Corrected value of the potassium Chloride = 176 − (10 × 15) = 26 counts. Assuming the reader should've detected ~~50 counts~~. 5×10×60 = 3000

~~$\frac{26}{50} \times 100 = 52\%$ of the counts~~

$\frac{26}{3000} \times 100 = 0.86\%$ ∴ not efficient.