CSSA

2021

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

MARKING GUIDELINES

Physics

Section I
20 marks

Questions 1-20 (1 mark each)

Question	Answer	Outcomes Assessed	Targeted Performance Band
1	B	PH12-12	2-3
2	A	PH12-13	2-3
3	C	PH12-14	2-3
4	B	PH12-15	2-3
5	A	PH12-12	3-4
6	C	PH12-13	3-4
7	C	PH12-14	3-4
8	C	PH12-15	3-4
9	A	PH12-12	3-4
10	B	PH12-13	3-4
11	C	PH12-14	3-4
12	D	PH12-15	3-4
13	A	PH12-15	4-5
14	D	PH12-13	3-4
15	A	PH12-15	4-5
16	D	PH12-14	4-5
17	D	PH12-13	5-6
18	B	PH12-14	5-6
19	D	PH12-12	4-5
20	C	PH12-12	5-6

Section II
80 marks

Questions 21 - 30

Question 21 (3 marks)

(a) (1 mark)

Outcomes Assessed: 12-12

Targeted Performance Bands: 2-4

Criteria	Marks
• Indicates that the kinetic energy is less in the higher orbit	1

Sample answer:

At the higher orbit the velocity is lower and so the Kinetic Energy is lower. K=GMm/2r

(b) (2 marks)

Outcomes Assessed: 12-12

Targeted Performance Bands: 2-4

Criteria	Marks
• Relates gain in GPE to the need for onboard propulsion. • Identifies the reduction in kinetic energy of the satellite in a higher orbit being less than required gain in GPE.	2
• Identifies the satellite has a higher energy at the new orbit.	1

Sample answer:

The total energy of a satellite in orbit is the sum of its gravitational potential and kinetic energy. In moving to the new orbit, the gain in gravitational potential energy is higher than the reduction in kinetic energy. As a result, there is a net increase in the energy of the satellite and work must be done to move it to a higher orbit. The energy for this is provided by the onboard propulsion.

Mathematically:

In each orbit $T=U+K = -GMm/r + GMm/2r = -GMm/2r$

The higher the orbit the bigger the value for r and the less negative the total energy.

So the total energy has increased overall, even though the kinetic energy has decreased.

Question 22 (5 marks)

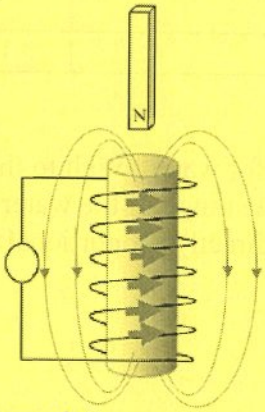
(a) (2 marks)

Outcomes Assessed: 12-13

Targeted Performance Bands: 2-4

Criteria	Marks
• Both Field AND current direction correct	2
• Field direction OR current direction correct	1

Sample answer:



(b) (3 marks)

Outcomes Assessed: 12-13

Targeted Performance Bands: 3-5

Criteria	Marks
• Correct description of the motion of the magnet through both pipes AND demonstrates a good understanding of Lenz's Law, Faraday's Law and Induced Eddy Currents and how it applies to this situation.	3
• Correct description of the motion of the magnet through both pipes AND demonstrates some understanding of Lenz's Law, Faraday's Law and induced Eddy currents.	2
• Correct description of the motion of the magnet through both pipes OR demonstrates some understanding of Lenz's Law and Faraday's Law	1

Sample answer:

No slit

As the magnet falls through the copper pipe without a slit, its acceleration is reduced.

Throughout the movement towards, through and leaving the full pipe the changing magnetic flux around the pipe will induce an emf in the pipe, (Faraday's law). The direction is described by Lenz's law as eddy currents will be induced to oppose the change in flux caused by the falling magnet.

This results in the magnet falling more slowly than in the other pipe.

Pipe with slit

As the magnet falls through the pipe with a slit it will fall with acceleration due to gravity. Due to the slit in the pipe, eddy currents are unable to form as the loop would be incomplete and will therefore not act to oppose the changing flux. Small eddy currents may form within the walls of the pipe, with size limited by the thickness of the walls, but the effect of these will be negligible.

Question 23 (7 marks)

(a) (3 marks)

Outcomes Assessed: 12-12

Targeted Performance Bands:3-5

Criteria	Marks
• Relates the increase in speed to greater coverage with reference to principles of projectile motion • Identifies the directly proportional relationship between speed of water and the radius of the coverage	3
• Relates the increase in speed to greater coverage with reference to principles of projectile motion	2
• Describes the increase in speed to a greater coverage on the floor.	1

Sample answer:

The initial vertical component of the velocity is zero and so the time taken for water to fall to the floor is unaffected by the initial speed of the water leaving the sprinkler. The range of the water is given by $s_x = u_x t$. Since t is constant, the diameter of the spray pattern is directly proportional to u_x (initial speed of the water).

(b) (4 marks)

Outcomes Assessed:12-12

Targeted Performance Bands: 3-5

Criteria	Marks
• Correctly calculates the spray angle	4
• Correct calculation of both components of the initial velocity of the water	3
• Correct calculation of one of the components of the initial velocity of the water.	2
• Provides some relevant information interpreted from the question.	1

Sample answer:

Horizontal component of initial velocity

$$s_x = u_x t$$
$$2.0 = u_x \times 0.65$$
$$\therefore u_x = 3.08 \text{ ms}^{-1} \text{ (to 2 sig figs)}$$

Find vertical component of the initial velocity

$$s_y = u_y t + \frac{1}{2} a_y t^2$$
$$-3.0 = u_y \times 0.65 - \frac{1}{2} \times 9.81 \times 0.65^2$$
$$u_y = -1.43 \text{ ms}^{-1}$$

Angle of initial velocity (to the vertical)

$$\tan\theta = \frac{3.08}{1.43}$$
$$\theta = 65°$$

Spray angle (2θ)

$$130°$$

Question 24 (4 marks)

(a) (3 marks)

Outcomes Assessed:

Targeted Performance Bands:

Criteria	Marks
• Defines Malus's law • Explains the change in intensity of light by time using Malus's law • Supports their answer by some examples from the graph	3
• Defines Malus's law and explains the change in intensity of light by time using Malus's law OR • Explains the change in intensity of light by time using Malus's law and supports their answer by some examples from the graph	2
• Defines Malus's law OR • Explains the change in intensity of light by time using Malus's law	1

Sample answer:

a) According to Malus's law $I=I_{max}\cos^2\theta$ when a plane polarised light pass through an analyser (polarising filter). The intensity of light passing through the analyser is proportional to $\cos^2\theta$. When the polarisation plane and analyser are perpendicular I is equal zero and when they are parallel I is equal to the maximum amount. As we can see in the graph by rotating the analyser the angle between the polarisation plane and analyser changes and as a result the intensity of light changes. for example, at times 0, 6,12, 18 seconds the polarisation plane and analyser are parallel, and I is equal 100 lumen (maximum amount). And at times 3, 9, 15 seconds, the polarisation plane and analyser are perpendicular and I is equal zero. In other times it also agrees with Malus's law.

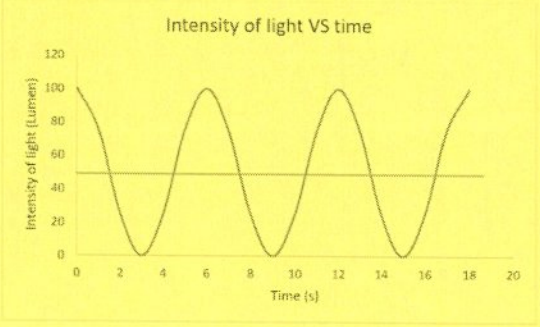
(b) (1 mark)

Outcomes Assessed: 12-14

Targeted Performance Bands: 3-5

Criteria	Marks
• Correctly sketches a graph for an unpolarised light at 50 %	1

Sample answer:



Question 25 (5 marks)

(a) (3 marks)
Outcomes Assessed: 12-13
Targeted Performance Bands: 3-5

Criteria	Marks
• Recognises force acting on both wires will be the same • Correctly calculates force on wires including units • Correctly determines direction of force on each wire (attractive force is sufficient)	3
• Any two points above	2
• Any one point above	1

Sample answer:
From the Right Hand Grip rule we can determine the magnetic force between the two wires to be attractive. i.e. Wire 1 will experience a force to the right and Wire 2 will experience a force to the left.

From Newton's Third Law the magnitude of the force acting on each wire will be the same.

$$\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi\ r}$$

$$\frac{F}{1} = \frac{4\pi\times10^{-7}\times1\times3}{2\pi\times0.15}$$

$$F = 4\times10^{-6}\ \text{N}$$

(b) (2 marks)
Outcomes Assessed: 12-13
Targeted Performance Bands: 3-5

Criteria	Marks
• Correct calculation AND direction	2
• Correct calculation OR direction.	1

Sample answer:

$$B = \frac{\mu_0 I}{2\pi r}$$

Combining for both wires

$$= \frac{4\pi\times10^{-7}\times1}{2\pi\times0.075} - \frac{4\pi\times10^{-7}\times3}{2\pi\times0.075}$$

$= 5.33 \times 10^{-6}$ T Out of the page.

Question 26 (5 marks)
Outcomes Assessed: 12-13
Targeted Performance Bands: 3-6

Criteria	Marks
• Covers internal and external parts of the motor. • Correctly uses equations to reinforce the answer • Includes the role of back EMF in terms of limiting the velocity of the motor. • Covers the essential aspects of Torque (*nIAB*) and Load including 4 factors that affect speed	4-5
• Gave 2 -3 factors that affect speed. Included a formula which helped the answer.	2-3
• Gave a factor that affects speed.	1

Sample answer:
Rotational speed of a DC motor is affected by torque acting on the current carrying loop AND the load on the motor. Friction may also be a factor.

The formula $\tau = nIA_{\perp}B = nIAB\sin\theta$ indicates the variables that can affect the size of the torque that will speed up the motor. So the size of the current in the winding, the area of the winding and the strength of the magnetic field. Increasing the number of coils in the winding will also increase the rate at which the motor can spin.

The faster the motor turns the greater the back EMF in the coils and reduces the current in the coil and this slows the motor down.

However the speed is also affected by the job the motor is doing. A bigger load to lift will slow the movement of the motor. This is an example of the conservation of energy.

Frictional effects within the commutator may also affect the speed of the motor.

Question 27 (7 marks)

(a) (3 marks)

Outcomes Assessed: 12-14

***Targeted Performance Bands*: 2-4**

Criteria	Marks
• Identifies both maxima and explains path difference clearly and relates to the maxima	3
• Identifies both maxima and explains path difference partially	2
• Identifies both maxima OR explains path difference partially	1

Sample answer:

On the diagram the two smallest outer bands should be circled.

The 5th bright band shown in the diagram above is there because the distance between slit one and that spot on the screen is exactly 5 wavelengths shorter or longer than the distance between slit two and that point on the screen. So at these spots both waves are at the same stage and so constructively interfere producing a maximum light.

(b) (2 marks)

Outcomes Assessed: 12-14

***Targeted Performance Bands*: 2-4**

Criteria	Marks
• Correctly calculates the angle of diffraction	2
• Provides some relevant information	1

Sample answer:

$$d \sin\theta = m\lambda$$

$$1.5 \times 10^{-3} \times \sin\theta = 5 \times 700 \times 10^{-9}$$

$$\theta = 0.134^{\circ}$$

(c) (2 marks)

Outcomes Assessed: 12-14

***Targeted Performance Bands*: 3-5**

Criteria	Marks
• Correct answer with correct justification for wavelength decreases and therefore smaller angle θ	2
• Correct answer OR correct inference on wavelength decrease	1

Sample answer:

$d \sin\theta = m\lambda$ therefore $\sin\theta = m\lambda/d$

With an increase in refractive index we have a decrease in wavelength. Thus as λ is smaller, and all the other variables are the same, the angle will be reduced.

The pattern will show the maxima closer together.

Question 28 (7 marks)

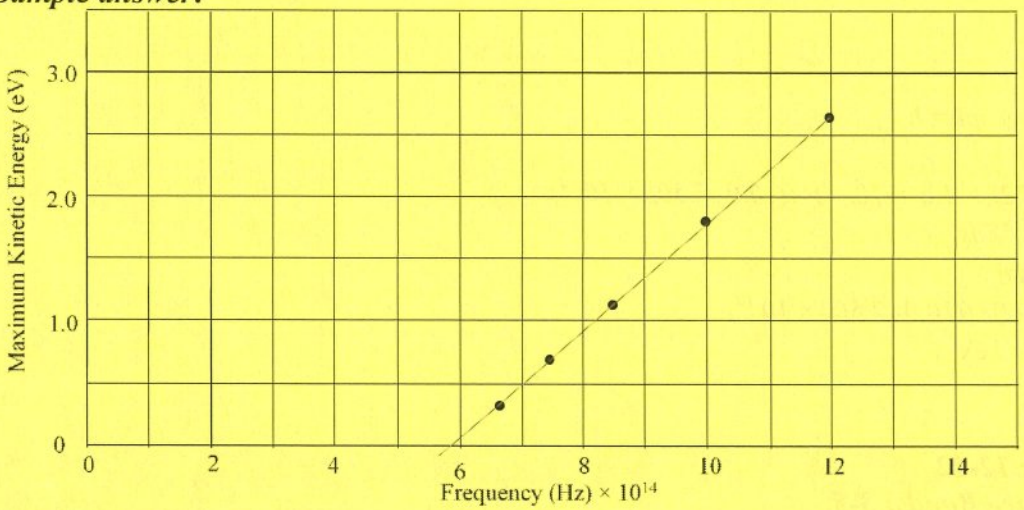
(a) (2 marks)

Outcomes Assessed: 12-14

Targeted Performance Bands: 3-5

Criteria	Marks
• Correctly plots data • Draws a sensible line of best fit	2
• One of the above	1

Sample answer:



(b) (1 mark)

Outcomes Assessed: 12-14

***Targeted Performance Bands*: 2-4**

Criteria	Marks
• Identifies the x intercept with correct units.	1

Sample answer:

$f_0 = 5.8 \times 10^{14}$ Hz [NB: This depends on the student's graph so may vary]

(c) (2 marks)

Outcomes Assessed: 12-12

Targeted Performance Bands: 3-6

Criteria	Marks
• Correctly calculates Planck's constant using gradient of the graph.	2
• Identifies Planck's constant is equal to the gradient of the graph and attempts to calculate it using the gradient.	1

Sample answer:

$K\ max = hf - \phi$

Gradient of the above graph $= h$

Gradient = rise/run

$= ((1.79-0.72) \times 1.6 \times 10^{-19}) / ((10.0- 7.50) \times 10^{14})$

$= 6.68 \times 10^{-34}\ Js$

OR Gradient = rise/run

$= ((1.79-0.72) / ((10.0- 7.50) \times 10^{14})$

$= 4.28 \times 10^{-15}$ eV s

(d) (2 marks)

Outcomes Assessed: 12-12

Targeted Performance Bands: 3-5

Criteria	Marks
• Identifies that photon energy is then shared to the kinetic energy and work function. • Relates this to the graph.	2
• Correctly identifies two of the parts of the energy process.	1

Sample answer:

The law of conservation of energy states that energy cannot be created or destroyed but can be changed from one form to another.

The photons of light hitting the cathode have an energy related to the frequency of the light. (E=hf)

If an electron absorbs a photon then it uses some of the energy to overcome the bonds holding it to the metallic lattice (the smallest needed energy is called the work function).

The rest of the energy is then used in the kinetic energy of the electron as it leaves the cathode.

The formula $K_{max} = hf - \phi$ is a statement of the conservation of energy in the photoelectric effect.

In the graph above f is the X axis, K_{max} is the Y axis and ϕ *is the Y intercept.*

As the work function does not vary and h is a constant we see that the frequency will produce a straight line graph with the kinetic energy.

Question 29 (6 marks)

(a) (1 mark)

Outcomes Assessed: 12-15

***Targeted Performance Bands*: 2-4**

Criteria	Marks
• Correctly names the reaction type using the word 'fission'	1

Sample answer:

Nuclear fission reaction

(b) (2 marks)

Outcomes Assessed: 12-15

***Targeted Performance Bands*: 2-4**

Criteria	Marks
• Recognises, represents and distinguishes between reactant and product species through the correct placement and direction of an arrow. • Represents a balanced nuclear equation using atomic notation for each species	2
• Recognises, represents and distinguishes between reactant and product species through the correct placement and direction of an arrow.	1

Sample answer:

$$^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{92}_{36}Kr + {}^{141}_{56}Ba + 3^{1}_{0}n$$

(c) (3 marks)

Outcomes Assessed: 12-15

***Targeted Performance Bands*: 2-4**

Criteria	Marks
• Explains the purpose of the moderator in terms of neutron energies/velocities • Describes the consequence of operating this type of reactor without a moderator	3
• Outlines the purpose of the moderator by referring to neutron energies/velocities	2
• Identifies the purpose of the moderator	1

Sample answer:

In a fission reactor of this type, the moderator reduces the kinetic energy and velocity of neutrons. The neutrons produced are known as fast neutrons with kinetic energies close to 1 MeV. Collisions with a moderator such as graphite slows neutron velocities and kinetic energies into a category known as thermal neutrons. Thermal neutrons have kinetic energies of about 0.025 MeV and are suitable for initiating the fission process. Without this reduction in energy, the neutrons move too fast to be absorbed by the uranium nuclei and tend to pass right through the fuel rods without initiating fission of the nucleus.

Question 30 (6 marks)

(a) (1 mark)
Outcomes Assessed: 12-15
***Targeted Performance Bands*: 3-4**

Criteria	Marks
• Correct answer relating to mass.	1

Sample answer:

The radius enabled Millikan to find the mass of each droplet.

(b) (2 marks)
Outcomes Assessed: 12-15
***Targeted Performance Bands*: 3-5**

Criteria	Marks
• Outlines an experimental observation consistent with Newton's first law • Relates the weight of the oil drop to the electric force and Newton's first law with an expression for charge	2
• Outlines an experimental observation consistent with Newton's first law	1

Sample answer:
When the sum of all forces on an oil drop is zero, it either becomes stationary, suspended in the chamber, or falls with uniform velocity. Millikan was able to focus on a single oil drop and adjust the potential difference to balance the weight of the drop (mg) with the force in the electric field (Eq) until the drop had zero acceleration. Millikan determined the electric field E using the formula $E = \frac{V}{d}$ [He knew the distance between the plates and found V using a voltmeter]. Equating the weight of the drop with the electric force provided an expression for the charge on the oil drop $q = \frac{mg}{E}$.

Question 30 continued..

(c) (3 marks)
Outcomes Assessed: 12-15
***Targeted Performance Bands*: 3-5**

Criteria	Marks
• Outlines why charge is a quantum property of matter • Links charge as a quantum property to the total charge on an oil drop • Explains how Millikan's experimental results allowed for the determination of charge on an electron	3
• Describes the procedure used by Millikan to determine the charge on an electron	2
• Identifies a correct aspect of the procedure used by Millikan to determine the charge on an electron	1

Sample answer:
At the time, electrons and protons were considered fundamental particles in that they could not be broken down into anything simpler. Being fundamental meant that these two particles carried the smallest possible quantity of charge q (now known to be 1.602×10^{-19} C). All charged bodies must, therefore, carry an integer multiple of q and this is what makes electric charge a quantum property of matter. Millikan used this concept in determining the charge on a single electron. Each oil drop contained a certain (very large) number of electrons and when the charge on a single electron was multiplied by this number, it would equal the charge on the oil drop such that $q_{\text{oil-drop}} = n_{\text{electrons}} \times q_{\text{electron}}$ where the number of electrons had to be an integer. By looking at the measured charge on thousands of oil drops Millikan was able to find this fundamental value of charge because all charged oil drops where a multiple of that value and because the difference between the charges on all drops was a multiple of that value.

Question 31 (6 marks)

(a) (2 marks)
Outcomes Assessed: 12-15
Targeted Performance Bands: 3-6

Criteria	Marks
• Correct calculation of lengths using trigonometric means for both diagrams.	2
• One length correct.	1

Sample answer:

Length of spring in Diagram A $= 25 \text{ cm} \times \sin 45°$
$= 17.68 \text{ cm}$

Length of spring in Diagram B $= \sqrt{17.68^2 + 25^2}$
Note distance along wall from hinge to spring is also 17.68cm $= 30.62 \text{ cm}$

(b) (4 marks)
Outcomes Assessed: 12-12
Targeted Performance Bands: 3-6

Criteria	Marks
• Correct comparison of the torque produced by the spring. (Ignore direction)	4
• Correct calculation of torque produced in either Diagram A or B • Single error leading to incorrect answer for other situation.	3
• Correct use of torque equation, but with minor errors in interpreting geometry or graph in either Diagram A or B	2
• Appropriate interpretation of the graph for either situation • Attempt at use of torque equation	1

Sample answer

Force exerted by spring *From graph = 23N (approx.)*
Torque produced by spring $\tau_A = 23 \times 0.25 \times \sin 45°$
$= 4.1 \text{ Nm}$

Note distance along wall from hinge to spring is also 17.68cm

Force exerted by spring From graph = 46N (approx.)
Angle between wood and spring $= \cos^{-1}\left(\frac{25}{30.6}\right) = 35.3°$

Torque produced by spring $\tau_B = 46 \times 0.25 \times \sin 35.3°$
$= 6.6 \text{ Nm}$

Comparison $\tau_B = 1.6\tau_A$ in the same direction

Question 32 (4 marks)

(a) (i) (2 marks)

Outcomes Assessed: 12-15

Targeted Performance Bands: 3-6

Criteria	Marks
• Describes the classical mechanical features of the Bohr model of the atom • Relates de Broglie's electron standing waves to the quantisation of angular momentum proposed by Bohr • Distinguishes classical and quantum mechanical features of each model of the atom	4
• Describes the classical mechanical features of the Bohr model of the atom • Describes de Broglie's contribution to the understanding of atomic structure	2-3
• Outlines the features of the Bohr model of the atom OR • Outlines the features of de Broglie's contribution to the understanding of atomic structure	1

Sample answer:

After observing the nature of Hydrogen spectral lines, Bohr developed a model of the atom that assumed that electrons moved around the nucleus in circular motion with only certain allowed radii and energies. At these radii the electrons did not give off EM radiation. Bohr did not have an explanation for this. Bohr's model of the atom relied almost entirely on principles derived from classical mechanics such as circular motion and angular momentum. There was a quantum component in that Bohr's model hypothesised that the angular momentum of electron orbits was quantised and that only certain values for momentum and orbital radius were allowed. However, at the time, classical mechanics provided no convincing reason as to why orbits were quantised in this way. In 1923, Louis de Broglie made a quantum leap(!) and proposed matter waves for particles whose wavelength could be calculated using the formula $\lambda = \frac{h}{mv}$. If an electron were assumed to be a wave, its wavelength could be calculated from its mass and the velocity of its orbit. De Broglie proposed that standing wave orbits were possible for electrons that corresponded to Bohr's quantised orbitals where their circumference had an integral multiple of electron wavelengths. Standing electron waves could thus be possible where no energy was lost and this was Bohr's second postulate that the angular momentum of electrons was quantised. De Broglie's proposal solved the problem of why some orbits were stable and introduced a quantum explanation for quantisation of angular momentum proposed by Bohr.

Question 33 (9 marks)
(a) (3 marks)
Outcomes Assessed: 12-15
Targeted Performance Bands: 4-6

Criteria	Marks
• Describes the ability for accelerators to validate a model predicted by mathematics • Outlines the operation of an accelerator (accelerates and collides high speed particles,) • Justifies the requirement for large amounts of energy to discover massive, exotic particles by using $E = mc^2$ and how these energies are required to isolate individual particles	3
• Outlines the operation of an accelerator (accelerates and collides high speed particles,) • Identifies the ability for accelerators to validate a model predicted by mathematics • Describes the large amounts of energy are required to discover new particles	2
• Outlines the operation of an accelerator (accelerates and collides high speed particles,)**OR** • Identifies the ability for accelerators to validate a model predicted by mathematics **OR** • Describes the large amounts of energy are required to discover new particles	1

Sample answer:

New particles not previously observed in experiments were being discovered after witnessing the interaction of highly energetic cosmic rays with particles in the upper atmosphere. Physicists determined that new particles would arise due to even higher energy collisions ($E = mc^2$). They devised ways to accelerate known particles (protons, etc.) using electric and magnetic fields. After colliding them with each other with very large kinetic energies, they found new particles. As they increased the kinetic energy of the colliding particles, new more exotic and more massive particles were being discovered, forming the standard model of matter.

Using this model, physicists were able to predict the existence of more massive particles, requiring huge amounts of energy. Once built, these particle accelerators were able to validate the mathematical predictions of the standard model of matter. The standard model of matter is still incomplete with predicted particles not yet found.

Question 33 continued

(b) (3 marks)

Outcomes Assessed: 12-12
Targeted Performance Bands: 4-6

Criteria	Marks
• Describes the perpendicular force of charged particles in a magnetic field • Demonstrates the relationship between radius and velocity by equating $F = \frac{mv^2}{r} = qvBsin\theta$ • Explains the very large radius due to the increased relativistic momentum	4
• Describes the perpendicular force of charged particles in a magnetic field • Demonstrates the relationship between radius and velocity by equating $F = \frac{mv^2}{r} = qvBsin\theta$ OR • Explains the very large radius due to the increased relativistic momentum	3
• Identifies the perpendicular force of charged particles in a magnetic field OR • Uses one equation to show how velocity will affect radius OR • Identifies relativistic momentum will affect radius size	2
•	1

Sample answer:

In circular accelerators (synchrotrons) a powerful magnetic field is required to direct the particles in a circular path. As protons are charged particles, the radius of their deflection is given by

$$F = \frac{mv^2}{r} = qvBsin\theta$$

$$r = \frac{mv}{qBsin\theta}$$

As the velocity increases, the radius of its path increases if all other variables are kept constant. In this particle accelerator, there will be relativistic momentum dilation which further increases the radius required.

Question 33 continued

(c) (3 marks)

Outcomes Assessed: 12-12 and 12-13 and 12-14
Targeted Performance Bands: 4-6

Criteria	Marks
• Correctly uses centripetal force, force of magnetic field on charged particle and momentum dilation to correctly calculate magnetic field strength and direction	3
• Shows some correct steps	2
• Provides some relevant information	1

Sample answer:

$$p_v = \frac{1.673 \times 10^{-27} \times 0.9999991 \times 3 \times 10^8}{\sqrt{1 - 0.9999991^2}}$$

$$p_v = 3.741 \times 10^{-16} kgms^{-1}$$

$qvB\sin\theta = mv^2/r$ so $qB\sin\theta = mv/r$ so $B = mv/qr\sin\theta = p_v/qr\sin\theta$

Substituting into

$$B = \frac{mv}{qr\sin\theta}$$

$$B = \frac{3.741 \times 10^{-16}}{1.602 \times 10^{-19} \times 13 \times 10^3}$$

$B = 0.18$T out of the page.

Question 34 (6 marks)

(a) (2 marks)

Outcomes Assessed: 12-12 & 12-13

Targeted Performance Bands: 4-6

Criteria	Marks
• Chooses the correct expression AND uses mg as the Force value	2
• One of the above	1

Sample answer:

Using the expression $\tau = Fd$ Where F=mg so $\tau = mgd$

(b) (4 marks)

Outcomes Assessed: 12-12 & 12-13

Targeted Performance Bands: 4-6

Criteria	Marks
• Average mass of marbles is correctly calculated using both motors and the largest number of marbles • Equates torque from mass of marbles with torque from motors	4
• Calculates the mass of a marble with one error OR uses current for one marble • Equates torque from mass of marbles with torque from motors	3
• Calculates torque of the two motors OR the torque provided by a marble	2
• Provides some relevant information	1

Sample answer:

$$\tau = Fd = nIAB \times 2$$

$$\tau = mgd = 2nIAB$$

use the current with 5 marbles

$$5m = \frac{2nIAB}{gd}$$

$$m = \frac{2 \times 100 \times 3.19 \times 1 \times 10^{-4} \times 0.5}{9.8 \times 0.1 \times 5}$$

$$m = 6.51 \times 10^{-3} kg$$

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