2024

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

CSSA

MARKING GUIDELINES

Physics

Section I

20 marks
Questions 1–20 (1 mark each)

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

Section II

80 marks

Question 21 (2 marks)

Outcomes Assessed: PH 12-14

Targeted Performance Bands: 2–3

Criteria	Mark
• Calculates the relativistic momentum of the spaceship	2
• Provides some relevant information	1

Sample Answer:

$$\rho_v = \frac{m_0 v}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$$

$$\rho_v = \frac{(35000)(0.8)(8 \times 10^8)}{\sqrt{(1 - (0.8)^2)}}$$

$\rho_v = 1.4 \times 10^{13}$ kgms^{-1}

Question 22 (4 marks)
Question 22 (a) (2 marks)
Outcomes Assessed: PH 12-12
Targeted Performance Bands: 2–5

Criteria	Marks
• Correctly calculates the total energy of the moon	2
• Provides some relevant steps	1

Sample Answer:

$$g = \frac{GM}{r^2}$$

$$1.6 = \frac{6.67 \times 10^{-11} \times M_m}{1737000^2}$$

$$M_m = \frac{1.6 \times 1737000^2}{6.67 \times 10^{-11}}$$

$$M_m = 7.24 \times 10^{22}\ kg$$

$$Total\ Energy = -\frac{GM_E M_m}{2r}$$

$$Total\ Energy = -\frac{6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times 7.24 \times 10^{22}}{2 \times 300\,000\,000}$$

$$Total\ Energy = -4.83 \times 10^{28} J$$

Question 22 (b) (2 marks)
Outcomes Assessed: PH 12-12
Targeted Performance Bands: 2–5

Criteria	Marks
• Correctly calculates escape velocity from the moon	2
• Any relevant information	1

Sample Answer:

$$v_{escape} = \sqrt{\frac{2GM_m}{r}}$$

$$v_{escape} = \sqrt{\frac{2 \times 6.67 \times 10^{-11} \times 7.24 \times 10^{22}}{1737000}}$$

$$v_{escape} = 2358\ ms^{-1}$$

Question 23 (4 marks)
Question 23 (a) (2 marks)
Outcomes Assessed: PH 12-12
Targeted Performance Bands: 2–5

Criteria	Marks
• Correctly calculates the magnitude of angular velocity of the disc	2
• Provides some relevant steps	1

Sample Answer:

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

$$v = \sqrt{\frac{Fr}{m}}$$

$$v = \sqrt{\frac{160 \times 0.2}{2}}$$

$$v = 4\ ms^{-1}$$

$$\omega = \frac{v}{r}$$

$$\omega = \frac{4}{0.2}$$

$$\omega = 20\ rad.s^{-1}$$

Question 23 (b) (2 marks)
Outcomes Assessed: PH 12-12
Targeted Performance Bands: 2–5

Criteria	Marks
• Correctly calculates the magnitude of centripetal force required for object B	2
• Provides some relevant steps	1

Sample Answer:

Length of arc of circle = $\Delta s = r\Delta\theta$

$$\frac{\Delta s}{\Delta t} = r \times \frac{\Delta \theta}{\Delta t}$$

$$v = r\omega$$

$v = 1.3 \times 20$

$v = 26\, ms^{-1}$

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

$$F = \frac{5 \times 26^2}{1.3}$$

$F = 2600N$

Question 24 (3 marks)
Outcomes Assessed: PH 12-12
Targeted Performance Bands: 2–5

Criteria	Marks
• Correct answer for radius of Y AND Mass of star	3
• Correct answer for radius of Y OR Mass of star	2
• Attempts to use Kepler's equation for at least one calculation	1

Sample Answer:

Radius of Orbit of Y

$$\frac{r_x^3}{T_x^2} = \frac{r_y^3}{T_y^2}$$

$$\frac{(1.9 \times 10^{11})^3}{326^2} = \frac{r_y^3}{516^2}$$

$R_y = 2.58 \times 10^{11}$ m = $2.6 \times 10^{11}\, m$

Mass of Central Star

$$\frac{r_x^3}{T_x^2} = \frac{GM}{4\pi^2}$$

$$\frac{(1.9 \times 10^{11})^3}{(326 \times 24 \times 60 \times 60)^2} = \frac{6.67 \times 10^{-11} M}{4\pi^2}$$

$M = 5.1 \times 10^{30} kg$

Question 25 (4 marks)
Outcomes Assessed: PH 12-12
Targeted Performance Bands: 3–5

Criteria	Marks
• Correctly calculates the horizontal displacement	4
• Correctly calculates the time of flight	3
• Attempts some relevant substitutions	2
• Provides some relevant information	1

Sample Answer:

Upwards direction is considered as positive.

$v_y = vsin45$

$v_x = vcos45$

$v_y = v_x = 13ms^{-1}$

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

$(-13)^2 = u_y^2 + 2(-9.8)15$

$u_y = 21.52\, ms^{-1}$

$v_y = u_y + gt$

$-13 = 21.52 + (-9.8)t$

$t = 3.5\, s$

$s_x = u_x t$

$s_x = 13\, x\, 3.5 = 45.8\, m$

Question 26 (4 marks)
Outcomes Assessed: PH 12-14; PH 12-7
Targeted Performance Bands: 2–5

Criteria	Marks
• Discusses THREE features of the photoelectric effect and how they cannot be explained using the wave model of light	4
• Discusses TWO features of the photoelectric effect and how they cannot be explained using the wave model of light	3
• Discusses ONE feature of the photoelectric effect and how it cannot be explained using the wave model of light	2
• Identifies some features of the photoelectric effect that cannot be explained using the wave model of light	1

Sample Answer:

According to the wave model, light travels as a continuous wave, and its properties are described by wavelength (λ) and frequency (f), related by the equation $c = \lambda f$ (where c is the speed of light). The amplitude of the wave determines its intensity.
The photoelectric effect, however, posed a significant challenge to the wave model. In this phenomenon, light shining on a metal surface ejects electrons.
The kinetic energy of emitted electrons: Classical wave theory predicts that increasing the intensity of light should increase the kinetic energy of emitted electrons. Contrary to this prediction, experimental observations revealed that the kinetic energy of emitted electrons depended on the frequency of light, not its intensity.
Instantaneous emission: Additionally, electrons were ejected instantaneously upon light exposure. Classical waves would require a buildup of energy before electron ejection, contrary to observations.
Threshold Frequency: Classical wave theory predicts that the intensity of light governs the amount of energy available, however experimental observations revealed that changing the frequency of light greatly impacted on the ejection of electrons. Only when a threshold frequency and above was supplied the ejection of electrons will happen. The intensity of light affects the size of photocurrent.

Question 27 (6 marks)
Outcomes Assessed: PH 12-15; PH 12-7
Targeted Performance Bands: 2–5

Criteria	Marks
• Complete reaction written with correct formatting and identifying neutrons • Links neutrons to the possibility of further reactions and showing how exponential increase could occur • Outlines how the absorption of neutrons by the control rods keeps the reaction rate steady	5–6
• Covers two points from above OR fails to give detail in explanation	3–4
• Covers one point from above	2
• Any relevant information	1

Sample Answer:

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

The reaction is started by a slow neutron colliding with a uranium nucleus. The reaction produces three more neutrons. If each of them is absorbed by other uranium nuclei that would produce 9 neutrons which could then produce 27. The result is an exponential increase in the reaction rate which would be uncontrolled.

To increase the reaction rate:

- the neutrons are slowed down by a moderator like heavy water so they are more likely to be absorbed by a uranium nucleus.
- the fuel rods are placed near to each other
- neutron absorbing control rods are lifted away.

To decrease the reaction rate:

- The control rods are lowered between the fuel rods

Careful adjustment of the above parameters enables the reaction rate to stay constant.

Question 28 (4 marks)
Question 28 (a) (2 marks)
Outcomes Assessed: PH 12-13
Targeted Performance Bands: 2–5

Criteria	Marks
• Correctly shows the direction of current and explained their answer	2
• Correctly shows the direction of current	1

Sample Answer:

Rod moves to the right. Using the Right Hand Palm rule. The field is up, the push is to the right so the current must be flowing into the page (towards the back). So current must flow to the left on the front rail and to the right on the back rail.

Question 28 (b) (2 marks)
Outcomes Assessed: PH 12-13
Targeted Performance Bands: 2–5

Criteria	Marks
• Correctly calculates the electromagnetic force acting on the rod	2
• Correctly calculates the magnitude of the current	1

Sample Answer:

$V=IR$
$20=I\times0.02$
$I=1000A$
$F=lIB\ sin\theta$
$F=1000\times0.08\times0.005=0.4$ N to the right

Question 29 (5 marks)
Question 29 (a) (2 marks)
Outcomes Assessed: PH 12-14
Targeted Performance Bands: 2–5

Criteria	Mark
• Correct electric and magnetic field directions	2
• Correct electric or magnetic field direction	1

Sample Answer:

Electric field is down the page and magnetic field is up the page.

Question 29 (b) (3 marks)
Outcomes Assessed: PH 12-14
Targeted Performance Bands: 2–5

Criteria	Marks
• States proton moving downward due to electric field AND • Clockwise due to magnetic field AND • Spiralling with a bigger radius	3
• Two of the points above	2
• One of the points above	1

Sample Answer:

- The proton will spiral downwards due to electric field instead of upwards.
- Spiral in the opposite direction to the electron (clockwise when seen from above) due to magnetic field.
- The spiral will have larger radius because the mass is greater.

Question 30 (7 marks)
Question 30 (a) (1 mark)
Outcomes Assessed: PH 12-14
Targeted Performance Bands: 2–5

Criteria	Marks
• Correctly calculates the mass of hydrogen needed	1

Sample Answer:

$$E = mc^2$$

$$7145000 = m(3 \times 10^8)^2$$

$$m = \frac{7145000}{(3 \times 10^8)^2}$$

$$m = 7.94 \times 10^{-11} \text{ kg}$$

Question 30 (b) (3 marks)
Outcomes Assessed: PH 12-14; PH 12-7
Targeted Performance Bands: 3–6

Criteria	Marks
• Correctly compares the mass values of the two processes with respect to their relevant energy output • Demonstrates an understanding of the source of the energy in the two processes to account for this difference	3
• Correctly compares the mass values of the two processes with respect to their relevant energy output	2
• Gives some reasoning to account for the difference	1

Sample Answer:

Direct mass-energy transformation accounts for 100% of the rest mass released as energy, whereas during combustion, only a miniscule proportion of the mass is released as energy. 50 g of hydrogen can produce 7145 kJ of energy through this process.
To produce 7145 kJ of energy through mass-energy transformation only 7.94×10^{-11} kg of hydrogen is required. The energy release from this process can be enormous, as it is governed by $E=mc^2$, and releases more energy compared to chemical reactions like combustion.

Question 30 (c) (3 marks)
Outcomes Assessed: PH 12-14
Targeted Performance Bands: 3–6

Criteria	Marks
• Correctly uses the nuclear equation, including electrons • Calculates mass defect in amu or kg • Calculates energy output in Joules	3
• Two steps above	2
• One step above	1

Sample Answer:

Mass defect $= (4)(1.00784) - [4.00260 + (2)(0.00055)]$

$= 0.02766 \text{ u}$

Mass defect $= (0.02766)(1.661 \times 10^{-27})$

$= 4.59433 \times 10^{-29} \text{ kg}$

$E = (4.59433 \times 10^{-29})(3 \times 10^{8})^{2}$

$E = 4.13 \times 10^{-12} \text{ J}$

Question 31 (4 marks)
Question 31 (a) (3 marks)
Outcomes Assessed: PH 12-15; PH 12-5
Targeted Performance Bands: 2–5

Criteria	Marks
• Finds the half-life for both sources • Finds the decay constant for both sources • Compares them clearly	3
• Finds the half-life for one source correctly and finds decay constants OR • Finds the half-life for both sources	2
• Finds the half- life for one source	1

Sample Answer:

X half- life 1 year. Y half- life of 2 years.

$\lambda = \frac{ln2}{t_{1/2}}$

X decay constant of 0.693. Y decay constant of 0.347
So Y has double the half- life and half the decay constant.

Question 31 (b) (1 mark)
Outcomes Assessed: PH 12-15
Targeted Performance Bands: 3–6

Criteria	Marks
• Demonstrates understanding that the majority of the nucleons are still present in the daughter nuclei	1

Sample Answer:

The daughter nucleus is still part of the source. Also, the number of atoms in a source is incredibly high even after a few years the number of undecayed atoms will be high.

Question 32 (5 marks)
Question 32 (a) (3 marks)
Outcomes Assessed: PH 12-15; PH 12-7
Targeted Performance Bands: 2–5

Criteria	Marks
• Correctly states 2 key experimental results AND • Correctly relates both results to the corresponding feature of Rutherford's atomic model	3
• Correctly states 2 key experimental results AND • Correctly relates 1 result to its corresponding feature of Rutherford's atomic model	2
• Correctly relates 1 experimental result to a feature of Rutherford's atomic model OR • Provides relevant information regarding 2 or more experimental results OR • Provides relevant information for 2 or more features of Rutherford's atomic model	1

Sample Answer:

Any 2 of:

Experimental Result	Evidence for
Most alpha particles passed straight through foil	Empty spaces inside the atoms of the foil, big enough to cause such large numbers to pass straight through undeflected, and so the atom was mostly empty space.
Some particle showed deflection through small angles	Some sort of repulsive electrostatic interaction between the positively charged alpha particles and a small region of the atoms, implying that there is a concentrated area of positive charge in the atom.
A small number of particles (~1 in 8000) were deflected through large angles	Implies some sort of collision between masses or extremely close interaction of electrostatic repulsion and since the deflections were so rare, further implies a high concentration of mass and charge in a small part of the atom (probably at the centre)

Question 32 (b) (2 marks)
Outcomes Assessed: PH 12-15; PH 12-7
Targeted Performance Bands: 2–5

Criteria	Marks
• Correctly relates the experimental evidence to both conservation laws	2
• Correctly relates the experimental evidence to one of the conservation laws	1

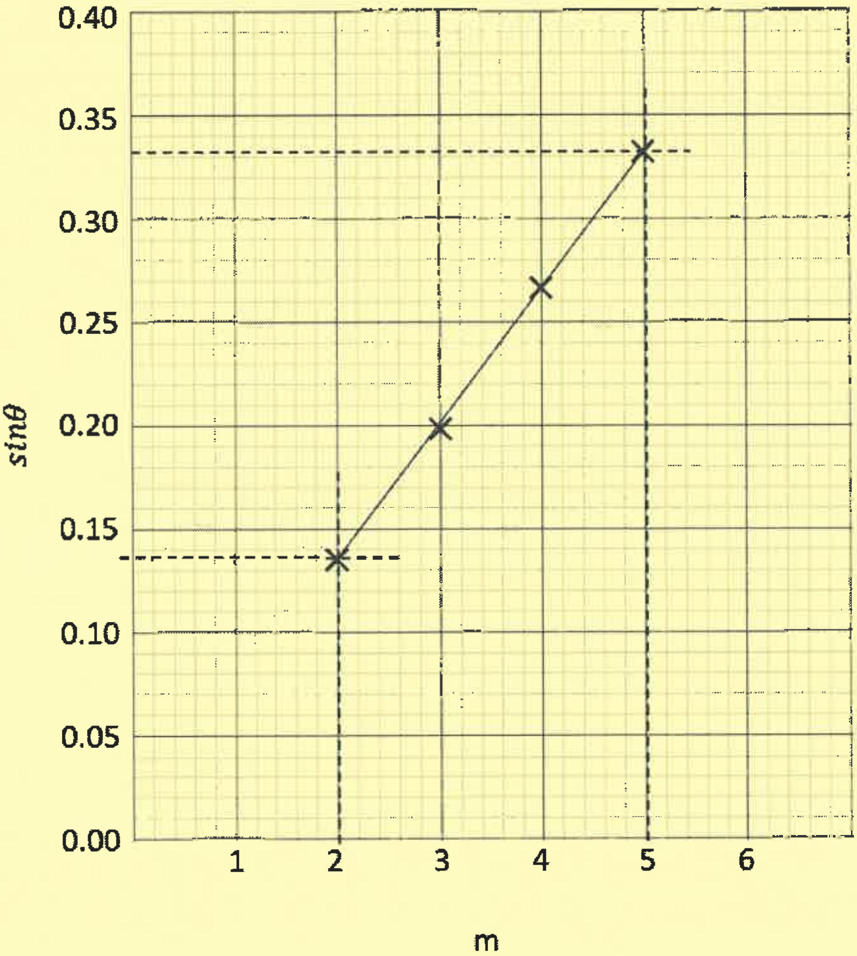
Sample Answer:

Chadwick observed the conservation of atomic mass and atomic numbers, and measured the momentum and kinetic energy of the ejected protons. He deduced that electromagnetic radiation would not provide enough energy to eject the protons and only a particle would be capable of such a collision and satisfy the laws of conservation of momentum and conservation of energy.

Question 33 (6 marks)
Outcomes Assessed: PH 12-14; PH 12-5; PH 12-6
Targeted Performance Bands: 3–6

Criteria	Marks
• Correctly chooses the axes as $d\sin\theta$ or $\sin\theta$ versus m • Correctly formats the scale for axes • Correctly plots points • Correctly draws a line of best fit • Correctly uses the line of best fit to calculate the gradient • Correctly calculates the wavelength of light using the gradient	6
• Achieves any five of the above criteria	5
• Achieves any four of the above criteria	4
• Achieves any three of the above criteria	3
• Achieves any two of the above criteria	2
• Correctly plots at least one point or identifies the correct equation. OR • Attempts to calculate the wavelength of light	1

Sample Answer:



$d \sin\theta = m\lambda$

$\lambda = d\dfrac{\sin\theta}{m}$

$\frac{\sin\theta}{m}$ is the gradient of the graphed data.

$\lambda = (1 \times 10^{-5})\frac{(0.331-0.136)}{(5-2)}$

$\lambda = 6.50 \times 10^{-7}$ m

OR

$\lambda = 650$ nm

Question 34 (4 marks)
Question 34 (a) (1 mark)
Outcomes Assessed: PH 12-12
Targeted Performance Bands: 2–6

Criteria	Marks
• States the grey ball	1

Sample Answer:

The grey ball has a greater velocity than the black ball.

Question 34 (b) (3 marks)
Outcomes Assessed: PH 12-12
Targeted Performance Bands: 2–6

Criteria	Marks
• Correctly calculates the velocity of the grey ball	3
• Attempts some relevant calculations	2
• Provides some relevant information	1

Sample Answer:

$$N\sin\theta = mg$$
$$N\cos\theta = F_c$$
$$N = \frac{mg}{\sin\theta}$$
$$\frac{mg}{\tan\theta} = F_c$$
$$\frac{mg}{\tan\theta} = \frac{mv^2}{r}$$
$$v = \sqrt{\frac{rg}{\tan\theta}}$$
$$v = \sqrt{\frac{9.8 \times 6}{tan25}}$$

$$v = 11.2\ ms^{-1}$$

Question 35 (9 marks)
Outcomes Assessed: PH 12-12; PH 12-13; PH12-7
Targeted Performance Bands: 2–6

Criteria	Marks
• Explains how eddy currents are produced as the centrifuge rotates near the solenoids (Faraday's law) • Explains how the eddy currents create a magnetic force in the opposite direction as they cut field lines (Lenz's Law) • Recognises that increasing the current in the solenoids is necessary as the centrifuge slows down • Relates the current in the solenoid to the size of the brake force with a clear explanation as to why this is the case • Demonstrates understanding of how increasing the magnetic field around the centrifuge at slower speeds will allow the centrifuge to slow down at a steady rate (rather than at a decreasing rate if the magnetic field was kept constant)	8–9
• Covers four points above	6–7
• Covers three points above	4–5
• Covers two points above	2–3
• Identifies features of magnetic braking	1

Sample Answer:

Magnetic Braking is the result of relative motion between a conducting surface and a magnetic field. This motion induces an emf in the conductor (Faraday's law) and the emf will induce eddy current. As a result, a force is exerted on the eddy current which opposes the motion of charges through the field, in keeping with the Law of Conservation of Energy (Lenz's law).
At the beginning of the slowing down phase the eddy currents will be large as the conductor is moving quickly through the magnetic field. This could create a large deceleration. Which could damage the sample.
Therefore, setting the magnetic field to low is desirable. A low current setting would let the deceleration be less.
However, if the current was kept constant and the conductor slows down the eddy currents would reduce and this would mean the centrifuge would slow down at a much lower rate. This would be good for the sample but could result in very long time to slow down.
To keep the rate of deceleration constant increasing the magnetic field in the solenoids would be ideal. Thus, increasing the current towards the end of the slowing down phase would be best.

Question 36 (9 marks)
Outcomes Assessed: PH 12-14; PH 12-15; PH12-7
Targeted Performance Bands: 2–6

Criteria	Marks
• Provides a comprehensive analysis, relating features of the experimental facilities, instruments and processes to the experimental evidence for matter-waves • Incorporates a correct and balanced fission reaction equation • Includes relevant calculations • Correctly determines the velocity of the neutron	9
• Provides a thorough analysis, relating features of the experimental facilities and processes to the experimental evidence for matter-waves • Includes a fission reaction equation, calculation and detailed diagram	8
• Relates features of the facilities and processes to the experimental evidence • Includes a fission reaction equation or description, and a relevant calculation	6–7
• Identifies some links between the facility and/or processes to the experimental evidence for matter-waves, and/or a calculation	4–5
• Provides details of some experimental evidence	2–3
• Provides some relevant information	1

Sample Answer:

Neutrons are produced in nuclear reactors via fission reactions. Fission reactions are usually stimulated by a single neutron, yet produce 2 or 3 free neutrons per reaction. An example fission reaction is:

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

If neutrons hit the opening of a neutron guide they can enter and travel through the guide if they satisfy the specific angle requirements of the material for that guide. Since neutrons have to satisfy some angle condition to avoid passing through the material, this implies there is (total internal) reflection at the walls/boundaries of the guide, thus neutrons could be travelling in a wave-like manner.

Since diffraction patterns are produced when neutrons are passed through materials, this further implies that the spaces between particles/atoms/molecules in the material act as slits for diffraction in the same way as for electromagnetic radiation, with the resulting images produced via interference of the waves from each spacing. This is further evidence of the wavelike behaviour of neutrons. and supports the de Broglie hypothesis of matter waves.

The de Broglie wavelength is given by $\lambda = \frac{h}{mv}$ where h is Planck's constant, m is the mass of the neutron, and v is the velocity of the neutron. This further implies that neutrons of different energies will have different de Broglie wavelengths. Since diffraction works best when the wavelength is the same order of magnitude as the slit size, different energy neutrons could be used to probe materials with different inter-particle spacings.

For the material shown:

$d = 2.82 \times 10^{-10}$ m $\theta = 4°$, $m = 1$

$d \sin\theta = m\lambda$

$\lambda = 2.82 \times 10^{-10} \times \sin 4 = 1.967 \times 10^{-11}$ m

also, $\lambda = \dfrac{h}{mv}$

$$1.967 \times 10^{-11} = \frac{6.626 \times 10^{-34}}{1.675 \times 10^{-27} \times v}$$

$$v = \frac{h}{m\lambda} = \frac{6.626 \times 10^{-34}}{1.675 \times 10^{-27} \times 1.967 \times 10^{-11}} = 20110\ m\,s^{-1} = 20100\ m\,s^{-1} \text{ (to 3 sig. fig)}$$

The advantage of using neutrons in this manner, is that neutrons predominantly interact via the strong force and there are no electro-static interactions between the diffracting particles and the particles in the material, so it is a more accurate probe of the atomic structure of materials.

BLANK PAGE

BLANK PAGE