

2024 HSC Physics Marking Guidelines

Section I

Multiple-choice Answer Key

Question	Answer
1	C
2	B
3	C
4	D
5	A
6	C
7	B
8	B
9	B
10	C
11	D
12	B
13	A
14	B
15	D
16	A
17	C
18	D
19	C
20	B

Section II

Question 21 (a)

Criteria	Marks
• Correctly calculates the magnitude of the torque	2
• Provides a relevant step	1

Sample answer:

$$\tau = rF \sin \theta = 0.18 \times 75 \times \sin 40 = 8.7 \text{ Nm}$$

Question 21 (b)

Criteria	Marks
• Explains TWO ways of increasing the torque in a DC motor	4
• Identifies TWO ways of increasing the torque in a DC motor with a partial explanation of either way	3
• Identifies TWO ways of increasing the torque OR • Identifies and partially explains ONE way of increasing the torque	2
• Provides some relevant information	1

Sample answer:

- Increase the area of the motor coil as this increases torque according to $\tau = nIA_{\perp}B$.
- Increase the current through the motor by increasing the voltage as this increases the force on the sides of the motor coil.

Answers could include:

- Radial magnetic field
- More turns.

Question 22 (a)

Criteria	Marks
• Describes the significance of the graph	2
• Provides some relevant information	1

Sample answer:

The graph shows that the further away the galaxy, the faster it is receding. From this it was concluded that the universe is expanding.

Question 22 (b)

Criteria	Marks
• Demonstrates understanding of how the recessional velocities of galaxies were determined	3
• Outlines some aspects of determination of recessional velocities of galaxies	2
• Provides some relevant information	1

Sample answer:

The spectra of the galaxies were compared to the spectra of hydrogen. The degree of red-shift of the galaxies was determined. The larger the red-shift is, the greater recessional velocity of the light source, hence the velocities of the galaxies were able to be determined.

Question 23 (a) (i)

Criteria	Marks
• Outlines the role of paraffin in the experiment	2
• Provides some relevant information	1

Sample answer:

Paraffin has a large number of hydrogen atoms containing single protons. When the unknown radiation hit these protons, they were ejected from the paraffin. These protons were then analysed.

Question 23 (a) (ii)

Criteria	Marks
• Demonstrates understanding of how Chadwick’s experiment changed the model of the atom	3
• Outlines the change in the model of the atom	2
• Provides some relevant information	1

Sample answer:

Chadwick deduced that there were neutral particles that were of similar mass to protons coming from the target. From this, the model of the atom changed to include neutrons as well as protons in the nucleus of atoms.

Question 23 (b)

Criteria	Marks
• Explains how the de Broglie hypothesis addressed limitations in the Bohr–Rutherford atomic model	4
• Describes how the de Broglie hypothesis addressed limitations in the Bohr–Rutherford atomic model OR • Explains how the de Broglie hypothesis addressed a limitation in the Bohr–Rutherford atomic model	3
• Demonstrates some understanding of the de Broglie hypothesis and/or a limitation in the Bohr–Rutherford atomic model	2
• Provides some relevant information	1

Sample answer:

De Broglie’s hypothesis suggested that electrons in the hydrogen atom are in a stable state when they formed standing waves. As the electron was no longer considered an accelerating charge, the problem of accelerating charges producing electromagnetic radiation was resolved. Additionally, the problem of why electrons had only certain allowed orbits was resolved by the criteria of an electron orbit only being allowed when it consisted of a whole number of electron wavelengths.

Question 24 (a)

Criteria	Marks
• Determines the surface temperature of the star	2
• Provides a relevant step	1

Sample answer:

From the graph, the peak wavelength is 500 nm. Using Wien's Law, $T = \frac{b}{\lambda_{\max}}$,

$$T = \frac{2.898 \times 10^{-3}}{500 \times 10^{-9}} = 5796 \text{ K}$$

Question 24 (b)

Criteria	Marks
• Calculates the frequency of light associated with absorption line W using provided equation	3
• Provides a correct calculation	2
• Provides a relevant step	1

Sample answer:

Using the relationship, and treating it as an emission spectrum

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{2^2} - \frac{1}{6^2} \right) = 2.44 \times 10^6 \text{ m}^{-1}$$

Wavelength is therefore $4.1 \times 10^{-7} \text{ m}$. So $f = \frac{c}{\lambda} = 7.3 \times 10^{14} \text{ Hz}$

Question 24 (c)

Criteria	Marks
• Explains the physical processes that result in the absorption spectrum	3
• Outlines some aspects of physical processes involved in the production of an absorption spectrum	2
• Provides some relevant information	1

Sample answer:

The star produces a continuous spectrum of light. When this light passes through the hydrogen atmosphere, certain frequencies of light are absorbed as they have energies (from $E = hf$) that correspond to particular transitions of electrons to higher energy levels. Such frequencies produce wavelengths that do not progress through the atmosphere, and as a result show as a drop in intensity on the graph.

Answers could include:

Absorption spectrum of non-stellar origin

Question 25 (a)

Criteria	Marks
• Shows how the mathematical model is derived	2
• Shows some relevant steps	1

Sample answer:

$$F_C = F_G$$

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

$$\left(\frac{2\pi r}{T}\right)^2 = \frac{GM}{r}$$

$$\frac{4\pi^2 r^2}{T^2} = \frac{GM}{r}$$

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

Question 25 (b)

Criteria	Marks
• Calculates the mass of the planet using the graph's line of best fit and correct working	4
• Show some steps in calculating the gradient • Relates the gradient to the mathematical model and/or mass of the planet	3
• Show some steps in calculating the gradient OR • Relates the graph to the mathematical model and/or mass of the planet	2
• Provides some relevant information	1

Sample answer:

Using the line of best fit

$$\text{Gradient} = 0.0008 \times \frac{\text{days}^2}{10^{12} \text{ km}^3} = \frac{0.0008 \times (24 \times 60 \times 60)^2}{10^{12} \times 1000^3} \text{ s}^2\text{m}^{-3} = 6.0 \times 10^{-15} \text{ s}^2\text{m}^{-3}$$

$$\text{Gradient} = \frac{T^2}{r^3} = \frac{4\pi^2}{GM}$$

$$6.0 \times 10^{-15} = \frac{4\pi^2}{6.67 \times 10^{-11} \times M}$$

$$M = 9.9 \times 10^{25} \text{ kg}$$

Question 26

Criteria	Marks
<ul style="list-style-type: none"> Explains why muons reach the Earth's surface with reference to relativistic effects in both frames of reference 	3
<ul style="list-style-type: none"> Outlines some relativistic effects that apply to the muon OR <ul style="list-style-type: none"> Explains one relativistic effect that applies to the muon 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:

In the muon's reference frame, the distance travelled is less than that observed by a stationary observer on Earth's surface, due to the effects of length contraction. This shortened distance means that they will get further than would be expected by an observer observing the rest length.

From the Earth's frame of reference, the time dilation means that the half-life of the muon is dilated compared to the half-life measured in the rest frame of the muon. This greater time allows more muons to reach the ground than would otherwise be expected.

Question 27 (a)

Criteria	Marks
<ul style="list-style-type: none"> Identifies the quarks in all three pions 	2
<ul style="list-style-type: none"> Identifies the quarks in at least one pion 	1

Sample answer:

$$\pi^-: \bar{u}d$$

$$\pi^+: u\bar{d}$$

$$\pi^0: u\bar{u}$$

Question 27 (b)

Criteria	Marks
• Calculates the energy released per pion	2
• Shows a relevant calculation	1

Sample answer:

Initial mass: $940 + 940 = 1880 \text{ MeV}/c^2$

Final mass: $3 \times 140 = 420 \text{ MeV}/c^2$

Mass change = $\frac{1460}{3}$ per pion = $487 \text{ MeV}/c^2$

So, $E = mc^2 = 487 \text{ MeV}$

Answers could include:

Answers in joules or electron volts

Question 27 (c)

Criteria	Marks
• Explains the problem and how it can be resolved	3
• Demonstrates understanding of the problem and/or its solution	2
• Provides relevant information	1

Sample answer:

The problem raised by this calculation is that the pions' velocities exceed the velocity of light (3×10^8), which is impossible.

The pions' velocities are relativistic, so their relativistic masses are greater than their rest masses which limits their velocity to less than the speed of light. Some of the energy imparted to each pion is converted into increased mass.

Answers could include:

Reference to relativistic momentum increase.

Question 28 (a)

Criteria	Marks
• Shows the acceleration of the electron is $2.6 \times 10^{15} \text{ m s}^{-2}$	2
• Shows a correct substitution	1

Sample answer:

$$\text{From } F = ma \text{ and } F = Eq, a = \frac{qE}{m} = \frac{1.5 \times 10^4 \times 1.602 \times 10^{-19}}{9.109 \times 10^{-31}} = 2.6 \times 10^{15} \text{ m s}^{-2}$$

Question 28 (b)

Criteria	Marks
• Shows the vertical displacement is approximately 8.1 mm	2
• Shows a correct substitution	1

Sample answer:

$$\text{The beam travels through the plates in } t = \frac{s}{v} = \frac{5 \times 10^{-3}}{2 \times 10^6} = 2.5 \times 10^{-9} \text{ seconds.}$$

$$\text{Vertical displacement is } s = \frac{1}{2} at^2 = 0.5 \times 2.6 \times 10^{15} \times (2.5 \times 10^{-9})^2 = 0.008125 \text{ m} = 8.1 \text{ mm}$$

Question 28 (c)

Criteria	Marks
• Correctly calculates the distance between point X and the final position	3
• Completes relevant steps	2
• Provides some relevant information	1

Sample answer:

The electron beam velocity in the vertical direction when leaving the plates is $v = at = 2.6 \times 10^{15} \times 2.5 \times 10^{-9} = 6.5 \times 10^6 \text{ m s}^{-1}$

$$\text{After leaving the plates, the beam takes } t = \frac{s}{v} = s = \frac{0.03}{2 \times 10^6} = 1.5 \times 10^{-8} \text{ s}$$

The vertical displacement is from the end of the plates

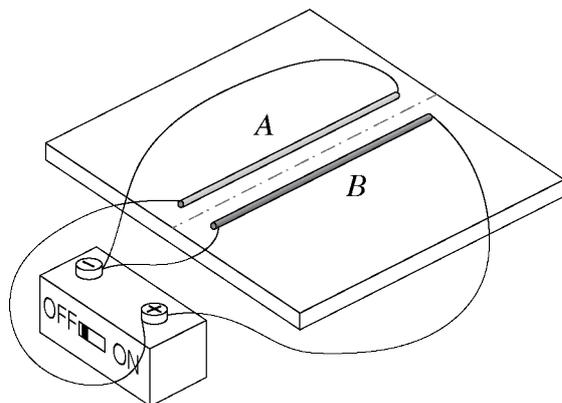
$$s = vt = 6.5 \times 10^6 \times 1.5 \times 10^{-8} = 0.0975 \text{ m}$$

So the final position on the screen is $0.0081 + 0.0975 = 0.11 \text{ m}$

Question 29 (a)

Criteria	Marks
<ul style="list-style-type: none"> Draws connections to both rods that show different currents flowing in opposite directions 	2
<ul style="list-style-type: none"> Draws a complete circuit incorporating both rods 	1

Sample answer:


Question 29 (b)

Criteria	Marks
<ul style="list-style-type: none"> Evaluates the statement with thorough reference to relevant physics principles 	4
<ul style="list-style-type: none"> Evaluates the statement using some relevant physics principles 	3
<ul style="list-style-type: none"> Demonstrates some understanding of relevant physics principle(s) 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:

Rod *B* does have a larger displacement from the original position than rod *A*. However this is not due to the current in rod *A* being larger. The force on rod *B* due to electromagnetic force from rod *A* is the same magnitude as the force on rod *A* due to electromagnetic force from rod *B*, according to Newton's third law. The magnitude of electromagnetic force between

both rods is given by $\frac{F}{l} = \frac{\mu_0}{2\pi} \frac{I_1 I_2}{r}$.

Since the larger displacement of Rod *B* cannot be explained by a larger electromagnetic force acting on it, it must be due to Rod *B* having a smaller mass. A smaller mass would mean that it has a larger acceleration ($a = \frac{F}{m}$), causing it to have a larger displacement during time t ($s = \frac{1}{2}at^2$).

Question 30

Criteria	Marks
<ul style="list-style-type: none"> Explains the effect of halving the period on all the forces acting on the object 	4
<ul style="list-style-type: none"> Demonstrates understanding of the change in the period on the forces acting on the object 	3
<ul style="list-style-type: none"> Outlines an effect of the rotation of the object on a force on the object 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:

The forces acting on the object are gravitational force downwards, force from the floor upwards and centripetal force from the side of the cylinder towards the centre of the cylinder.

The period of rotation is related to centripetal force by:

$$F_C = \frac{mv^2}{r} = \frac{m}{r} \left(\frac{2\pi r}{T} \right)^2 = \frac{4m\pi^2 r^2}{rT^2} = \frac{4m\pi^2 r}{T^2}$$

Therefore, halving the period will increase the centripetal force by a factor of 4. The gravitational force downward and the force of the floor upward remains unchanged because the changing period does not affect gravitational or the vertical reaction force.

Question 31

Criteria	Marks
<ul style="list-style-type: none"> Correctly compares the maximum height of the projectile in each model Describes the energy change of the projectile in each model 	4
<ul style="list-style-type: none"> Compares maximum height with reference to the models Refers to energy change in each model 	3
<ul style="list-style-type: none"> Provides aspects of a comparison of maximum heights and/or energy change 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:

In both models, the initial kinetic energy is the same and at the maximum height, the initial kinetic energy is fully converted to gravitational potential energy.

In Model A, for each metre moved vertically, the same amount of kinetic energy is converted to gravitational potential energy. In Model B, because of the decreasing gravitational field strength, the amount of kinetic energy converted to gravitational potential energy per metre decreases as the object travels upward.

Therefore, in Model B, the object reaches a greater maximum height before all the kinetic energy is converted to potential energy.

Question 32

Criteria	Marks
<ul style="list-style-type: none"> Provides a detailed analysis using evidence from at least THREE experiments investigating the interaction of light and matter Provides a clear link between experimental evidence and greater understanding of physics 	8
<ul style="list-style-type: none"> Provides analysis using evidence from experiments investigating the interaction of light and matter Provides a link between experimental evidence and greater understanding of physics 	6–7
<ul style="list-style-type: none"> Provides evidence from experiments investigating the interaction of light and matter Relates evidence to a greater understanding of physics 	4–5
<ul style="list-style-type: none"> Provides some information about evidence from an experiment AND/OR a link to physics 	2–3
<ul style="list-style-type: none"> Provides some relevant information 	1

Answers could include:

Reference to:

- Black body radiation experiments and the development of quantum physics
- Photoelectric experiments and the development of quantum physics
- Spectroscopy experiments and the development of astrophysics and the atomic model
- Polarisation experiments and the development of the wave nature of light
- Interference and diffraction and the development of the wave model of light
- Cosmic gamma rays and the development of theory of special relativity and/or the standard model.

Question 33

Criteria	Marks
<ul style="list-style-type: none"> Provides a detailed analysis of the motion of the can AND the magnet Provides a detailed analysis of the energy transformations in the system 	7
<ul style="list-style-type: none"> Analyses the motion of the can AND the magnet Provides an analysis of the energy transformations in the system 	6
<ul style="list-style-type: none"> Describes the motion of the can and/or the magnet Describes the energy transformations of the magnet and/or can 	4–5
<ul style="list-style-type: none"> Demonstrates some understanding of the motion of the can and/or the magnet and/or the energy transformations of both magnet and/or can 	2–3
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:

As the magnet swings from a high position towards the can, it loses gravitational potential energy and gains kinetic energy.

The motion of the magnet provides changing magnetic flux through the aluminium can. This change in flux is greatest when the relative motion of the magnet and can is greatest, and induces an emf according to $\varepsilon = -N \frac{\Delta\Phi}{\Delta t}$.

This emf gives rise to eddy currents in the can, which produces resistive heating as well as a magnetic field that opposes the movement of the magnet, according to Lenz’s law.

The interaction of the magnetic fields of the magnet and the can, due to Eddy currents, also results in the can rotating clockwise initially.

Over time, this results in a dampening of the magnet’s movement, and the interaction of the eddy currents’ magnetic field with the magnet results in the rotation of the can backwards and forwards, with diminishing amplitude as the total energy is ultimately converted to heat.

Answers could include:

Reference to non-uniform, clockwise rotation of the can

2024 HSC Physics Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	1	Mod 5 Circular Motion	PH12-12
2	1	Mod 7 Light Wave Model	PH12-14
3	1	Mod 8 Deep Inside the Atom	PH12-15
4	1	Mod 6 Applications of the Motor Effect	PH12-6, PH12-13
5	1	Mod 8 Origins of the Elements	PH12-5, PH12-15
6	1	Mod 7 Light Quantum Model	PH12-14
7	1	Mod 8 Properties of the Nucleus	PH12-15
8	1	Mod 6 Electromagnetic Induction	PH12-13
9	1	Mod 5 Projectile Motion	PH12-12
10	1	Mod 6 The Motor Effect	PH12-13
11	1	Mod 5 Motion in Gravitational Fields	PH12-12
12	1	Mod 7 Light and Special Relativity	PH12-5, PH12-14
13	1	Mod 5 Motion in Gravitational Fields	PH12-12
14	1	Mod 8 Quantum Mechanical Nature of the Atom	PH12-15
15	1	Mod 6 Electromagnetic Induction	PH12-6, PH12-13
16	1	Mod 7 Light Quantum Model	PH12-5, PH12-14
17	1	Mod 5 Circular Motion	PH12-12
18	1	Mod 6 Electromagnetic Induction	PH12-6, PH12-13
19	1	Mod 8 Structure of the Atom	PH12-6, PH12-15
20	1	Mod 7 Light and Special Relativity	PH12-14

Section II

Question	Marks	Content	Syllabus outcomes
21 (a)	2	Mod 5 Circular Motion	PH12-6, PH12-12
21 (b)	4	Mod 6 Applications of the Motor Effect	PH12-13
22 (a)	2	Mod 8 Origins of the Elements	PH12-5, PH12-15
22 (b)	3	Mod 7 Electromagnetic Spectrum	PH12-14
23 (a) (i)	2	Mod 8 Structure of the Atom	PH12-15
23 (a) (ii)	3	Mod 8 Structure of the Atom	PH12-15
23 (b)	4	Mod 8 Quantum Mechanical Nature of the Atom	PH12-15
24 (a)	2	Mod 7 Light Quantum Model	PH12-6, PH12-14
24 (b)	3	Mod 8 Quantum Mechanical Nature of the Atom	PH12-6, PH12-15
24 (c)	3	Mod 8 Structure of the Atom Mod 8 Quantum Mechanical Nature of the Atom	PH12-15
25 (a)	2	Mod 5 Motion in Gravitational Fields	PH12-6, PH12-12
25 (b)	4	Mod 5 Motion in Gravitational Fields	PH12-5, PH12-6, PH12-12

Question	Marks	Content	Syllabus outcomes
26	3	Mod 7 Light and Special Relativity	PH12-14
27 (a)	2	Mod 8 Deep Inside the Atom	PH12-5, PH12-15
27 (b)	2	Mod 7 Light and Special Relativity	PH12-14
27 (c)	3	Mod 7 Light and Special Relativity	PH12-14
28 (a)	2	Mod 6 Charged Particles, Conductors and Electric and Magnetic Fields	PH12-6, PH12-13
28 (b)	2	Mod 5 Projectile Motion Mod 6 Charged Particles, Conductors and Electric and Magnetic Fields	PH12-6, PH12-12, PH12-13
28 (c)	3	Mod 5 Projectile Motion	PH12-6, PH12-12
29 (a)	2	Mod 6 Charged Particles, Conductors and Electric and Magnetic Fields	PH12-13
29 (b)	4	Mod 6 The Motor Effect	PH12-13
30	4	Mod 5 Circular Motion	PH12-12
31	4	Mod 5 Motion in Gravitational Fields	PH12-6, PH12-12
32	8	Mod 7 Electromagnetic Spectrum Mod 8 Quantum Mechanical Nature of the Atom	PH12-7, PH12-14, PH12-15
33	7	Mod 6 Electromagnetic Induction	PH12-6, PH12-7, PH12-13