2022 HSC Physics
Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21 (a)

Criteria	Marks
• Correctly compares the surface temperatures and luminosities of *X* and *Y*	2
• Correctly compares the surface temperatures or luminosities of *X* and *Y*	1

Sample answer:

The surface temperature of *X* is greater than the surface temperature of *Y*.
The luminosity of *X* is less than the luminosity of *Y*.

Question 21 (b)

Criteria	Marks
• Identifies the elements undergoing fusion in *X* and *Y*	2
• Identifies an element undergoing fusion in *X* or *Y*	1

Sample answer:

In star *X* fusion of hydrogen is taking place and in star *Y* helium is fusing.

Question 22

Criteria	Marks
• Describes effects of TWO features that contribute to efficiency	4
• Describes effect of ONE feature that contributes to efficiency and identifies an effect of another feature	3
• Identifies effect of ONE feature that contributes to efficiency	2
• Provides some relevant information	1

Sample answer:

The laminations in the core minimise the production of eddy currents that would heat the core, reducing efficiency. The fact that the iron core is continuous enables maximum transfer of flux from the primary to the secondary coil, increasing efficiency.

Answers could include:

The high conductivity/low resistance of copper wire reduces heating loss.

Question 23

Criteria	Marks
• Outlines the steps necessary to conduct measurements in a relevant experiment • Outlines how measurements are used to determine the speed of light • Identifies a limiting factor	4
• Outlines some steps necessary to conduct measurements in a relevant experiment • Outlines how measurements are used to determine the speed of light or identifies a limiting factor	3
• Provides some details about a relevant experiment or calculation or limiting factor	2
• Provides some relevant information	1

Sample answer:

A light source is directed at a mirror a large distance away. The light and a stopwatch are turned on at the same instant.

The stopwatch is stopped when the reflected light is observed.

The total distance to the mirror and back is measured and the speed of light can be determined by dividing the distance travelled by the time taken.

A limitation to the accuracy of the experiment could be the reaction time in stopping the stopwatch when the reflected light is observed.

Answers could include:

- The passing of light through the teeth of a rotating cog and using the speed of rotation and the flickering of the reflected light in making the calculation of the speed of the light
- Other experimental setups involving lasers, retro reflectors, interferometers and resonant cavities etc
- Rømer's experiment involving light from Jupiter.

Question 24 (a)

Criteria	Marks
• Correctly uses half-life to calculate the decay constant	2
• Provides one correct step in calculation	1

Sample answer:

$t_{\frac{1}{2}}$ = 16 hours

So $\lambda = \dfrac{\ln 2}{t_{\frac{1}{2}}}$

$\lambda = \dfrac{\ln 2}{16} = 0.043 \text{ h}^{-1}$

Question 24 (b)

Criteria	Marks
• Correctly calculates time taken	2
• Provides one correct step in calculation	1

Sample answer:

$N_t = N_0 e^{-\lambda t}$

$8 = 80\ e^{-0.043t}$

$\ln\left(\dfrac{8}{80}\right) = -0.043t$

$t = 54$ hours

Answers could include:

53 hours if using unrounded value from part (a).

Question 25 (a)

Criteria	Marks
• Correctly calculates the change in kinetic energy	2
• Provides a substitution into a relevant equation	1

Sample answer:

Change in kinetic energy = $\dfrac{mv^2}{2} - \dfrac{mu^2}{2} = \dfrac{200}{2}(8\ 410\ 000 - 30\ 250\ 000) = 2.2 \times 10^9$ J

Question 25 (b)

Criteria	Marks
• Correctly calculates mass of the planet	3
• Applies the law of conservation of energy OR • Shows steps in calculating the mass of the planet	2
• Provides a step in the calculation of the mass of the planet	1

Sample answer:

Change of kinetic energy = change in potential energy

$$2.2 \times 10^9 = \text{GMm}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\text{M} = \frac{2.2 \times 10^9}{6.67 \times 10^{-11} \times 200\left(\dfrac{1}{4.3 \times 10^6} - \dfrac{1}{2.5 \times 10^7}\right)}$$

$\text{M} = 8.6 \times 10^{23}$ kg

Answers could include:

$\text{M} = 8.5 \times 10^{23}$ kg depending on rounding.

Question 26 (a)

Criteria	Marks
• Correctly calculates K	3
• Provides substantial working for calculating K	2
• Provides one correct step in calculation	1

Sample answer:

$$K = hf - \phi = 6.626 \times 10^{-34} \times 7.5 \times 10^{14} - 2.9 \times 1.602 \times 10^{-19}$$

$$= 4.9695 \times 10^{-19} - 4.6458 \times 10^{-19} = 3.2 \times 10^{-20} \text{ J}$$

Question 26 (b)

Criteria	Marks
• Correctly calculates *d*	3
• Provides some working for calculating *d*	2
• Provides one correct step in calculation	1

Sample answer:

Photoelectron stops when work done by field = kinetic energy at surface

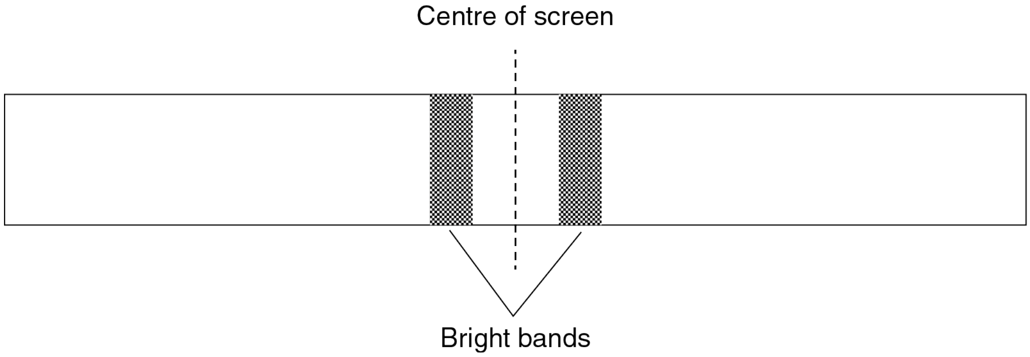
$$\text{Work} = Vq = qEd = 1.602 \times 10^{-19} \times 5.2 \times d = 3.2 \times 10^{-20}$$

$$d = \frac{3.2 \times 10^{-20}}{8.33 \times 10^{-19}} = 0.038 \text{ m} = 3.8 \text{ cm}$$

Question 27 (a)

Criteria	Marks
• Correctly sketches and labels the expected pattern	2
• Shows two bands of light OR • Identifies a feature of Newton's model	1

Sample answer:



Question 27 (b)

Criteria	Marks
• Calculates the angle θ	3
• Provides substantial working to calculate the angle θ	2
• Provides one correct step in calculation	1

Sample answer:

$d\sin\theta = m\lambda$

$5.0 \times 10^{-5} \sin\theta = 2\left(655 \times 10^{-9}\right)$

$\theta = \sin^{-1}\dfrac{\left(2\left(655 \times 10^{-9}\right)\right)}{5.0 \times 10^{-5}}$

$\theta = 1.5$ degrees

Question 27 (c)

Criteria	Marks
• Describes and clearly explains the difference in the pattern	2
• Describes the difference in the pattern	1

Sample answer:

The bright lines would be closer together, because θ is smaller if λ is smaller.

Question 28

Criteria	Marks
• Correctly calculates energy released and suggests why it is greater than *X*	3
• Correctly calculates energy released or identifies that more mass is lost in Step *Y*	2
• Provides some relevant information	1

Sample answer:

Change of mass in Step $Y = \Delta m = 13.003 + 1.007 - 14.003 = 0.007u$

Energy released $E = 0.007 \times 931.5 = 6.52\ MeV$

This is more energy than was released in Step *X*, so more mass must have been lost.

Question 29

Criteria	Marks
• Describes and explains the horizontal component of the apple's motion • Describes and explains the vertical component of the apple's motion	4
• Relates features of the apple's horizontal and vertical motion to a force acting on it	3
• Describes features of the apple's motion OR • Relates a feature of the apple's motion to the forces acting on it	2
• Provides some relevant information	1

Sample answer:

The horizontal component of the motion of the apple remains constant because there is no net force acting on it in the horizontal direction. The initial horizontal velocity of the apple is the vector sum of the car's velocity relative to the ground plus the apple's initial velocity relative to the car.

The vertical motion of the apple is accelerated uniformly vertically downward from rest by the gravitational force acting on it.

Question 30 (a)

Criteria	Marks
• Describes the process that led to the prediction of time dilation	3
• Outlines parts of the process	2
• Provides some relevant information	1

Sample answer:

The distance travelled by the light, *X* to *Y* to *X*, appears to be greater to the observer outside the train than to the observer in the train. Since both observe the same speed of light, then the return trip must have taken longer for the observer outside the train, since $t = \frac{d}{c}$. This is what Einstein called time dilation.

Question 30 (b)

Criteria	Marks
• Calculates the outside observer's time, includes relevant unit	3
• Provides substantial working to calculate outside observer's time	2
• Provides a correct step in calculation	1

Sample answer:

$$t = \frac{t_0}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$$

So $$t = \frac{1.5 \times 10^{-8}}{\sqrt{\left(\frac{1-(0.96)^2 c^2}{c^2}\right)}}$$

$$= \frac{1.5 \times 10^{-8}}{0.28}$$

$$= 5.4 \times 10^{-8} s$$

Answers could include:

= 54 ns

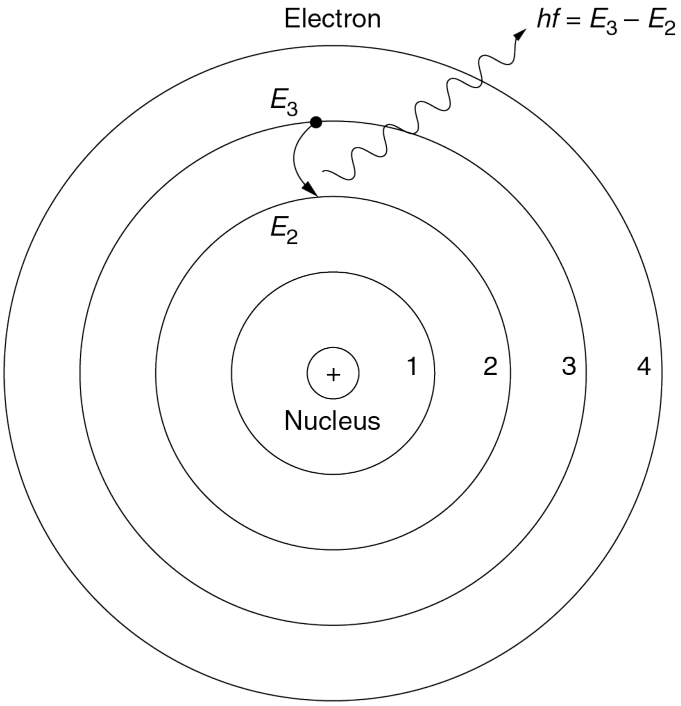
Question 31

Criteria	Marks
• Provides a comprehensive analysis, relating features of the model to the experimental evidence • Incorporates a relevant calculation and detailed diagram in analysis	9
• Provides a thorough analysis, relating features of the model to the experimental evidence • Includes a relevant calculation and detailed diagram	8
• Relates features of the model to the experimental evidence • Includes a relevant calculation and/or a diagram	6–7
• Identifies some links between the model and the experimental evidence and/or a calculation	4–5
• Provides details of the model and/or the experimental evidence	2–3
• Provides some relevant information	1

Sample answer:

In the Geiger–Marsden experiment, the fact that most alpha particles went straight through the gold atom was accounted for by the atom being mostly empty space in the model. The small fraction of alpha particles that were deflected through large angles were accounted for by the dense positive nucleus that exerted a repulsive electrostatic force on the alpha particles headed towards it. The large mass of the nucleus relative to the alpha particles made them bounce back while the nucleus remained stationary. Alpha particles passing near the nucleus were deflected by smaller amounts due to a smaller electrostatic force.

The model was able to account for experimental results of the spectrum of hydrogen using the postulates that electrons exist in stable energy states around the nucleus. If an electron moves from a higher-energy state to a lower one, it emits a photon with energy given by $E_p = hf = E_f - E_i$.



The four visible spectral lines of the Balmer series have wavelengths that were accounted for in the model using the equation:

$\frac{1}{\lambda} = R\left[\frac{1}{n_f^2 - n_i^2}\right]$, where n_f is 2 and n_i is 3, 4, 5 and 6.

For $n_i = 3$, this gives $\frac{1}{\lambda} = 1.097 \times 10^7 \left[\frac{1}{4} - \frac{1}{9}\right]$, so λ=656 nm, which is shown in the diagram as the line furthest to the right.

Question 32 (a)

Criteria	Marks
• Explains how the magnets make it harder to pedal	3
• Relates magnetic effects to induced currents	2
• Outlines magnetic effects	1

Sample answer:

Relative motion between the magnets and the moving flywheel induce eddy currents in the flywheel. These produce magnetic fields and a subsequent force on the wheel that opposes the changing flux. This produces a torque that opposes the pedalling action of the person, making it harder for them to pedal.

Question 32 (b)

Criteria	Marks
• Justifies a method for increasing torque	3
• Outlines a method that would increase torque	2
• Links torque to parts of the bike OR • Identifies a related method	1

Sample answer:

The magnets could be moved closer to the wheel causing the induced eddy currents to be larger due to the greater flux change. The stronger field produced by these currents thus exerts a greater force and greater opposing torque on the flywheel.

Answers could include:

Moving the magnets further away from the flywheel's axis.

Question 33 (a)

Criteria	Marks
• Correctly calculates vertical component of velocity	2
• Provides one correct step in calculation	1

Sample answer:

Speed of hammer in circular motion is $v = \dfrac{2\pi r}{t} = \dfrac{2 \times \pi \times 1.6}{0.5} = 20.1\ \text{ms}^{-1}$

Vertical component $v_y = 20.1 \times \sin 45° = 14.2\ \text{ms}^{-1}$

Question 33 (b)

Criteria	Marks
• Correctly calculates range	4
• Provides substantial working to calculate range	3
• Calculates one relevant quantity	2
• Provides one correct step in calculation	1

Sample answer:

At top of trajectory, $v_y = 0$

$$0 = 14.2 - 9.8t, \text{ so } t_{\text{up}} = 1.45\ \text{s}$$

$$\text{Distance risen} = s = ut + \frac{1}{2}at^2$$

$$= 14.2 \times 1.45 - 4.9 \times 1.45^2$$

$$= 10.3\ \text{m}$$

At top, distance from ground $= 10.3 + 1.2 = 11.5\ \text{m}$

$$\text{Distance fallen} = s = ut + \frac{1}{2}at^2$$

$$11.5 = 4.9t^2, \text{ so } t_{\text{down}} = 1.53\ \text{s}$$

$$t_{\text{total}} = 1.45 + 1.53 = 2.98\ \text{s}$$

$$\text{Range } x = v_x t = 14.2 \times 2.98 = 42.3\ \text{m}$$

Question 34

Criteria	Marks
• Comprehensively explains the different paths of each particle *X*, *Y* and *Z* through the magnetic field	7
• Explains the paths of particles *X*, *Y* and *Z*	6
• Explains some aspects of the paths of particles *X*, *Y* and *Z*	4–5
• Provides details of particle properties and/or paths in the field	2–3
• Provides some relevant information	1

Sample answer:

X and *Y* are both positive since they are deflected towards the top of the page when they initially enter the magnetic field which exerts a force on the charges, initially up the page. As they travel through the magnetic field, the force is applied perpendicular to their velocity, causing them to curve in the arc of a circle as shown, with the magnetic force providing the centripetal force.

This allows the curvature of each charge's circular path to be expressed as $r = \dfrac{mv}{qB}$.

X has a smaller radius of arc which indicates it has a smaller mass or greater charge than *Y*.

Z must have the same charge to mass ratio as *X*, but an opposite sign charge. This would explain the identical curvature of the path through the magnetic field in the opposite direction.

Question 35

Criteria	Marks
• Provides correct calculations to reject the hypothesis	5
• Provides calculations which analyse the system	4
• Makes some calculations using appropriate formulae OR • Provides a correct calculation or evidence and makes a relevant conclusion	3
• Substitutes into a relevant formula	2
• Provides some relevant information	1

Sample answer:

$$F_c = \frac{mv^2}{r} = 1.2\times10^4 \times \frac{(0.233)^2}{200}$$

$$= 3.26 \text{ N}$$

$$F_G = \frac{GMm}{r^2} = \frac{6.67\times10^{-11}\times4.2\times10^5\times1.2\times10^4}{200^2}$$

$$= 8.4\times10^{-6} \text{ N}$$

Hence the centripetal force required to accelerate the capsule around the ISS is much greater than the gravitational force of attraction between the two space vehicles. The hypothesis is rejected.

2022 HSC Physics Mapping Grid

Section I

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

Section II

Question	Marks	Content	Syllabus outcomes
21 (a)	2	Mod 8 Origins of the Elements	12-5, 12-15
21 (b)	2	Mod 8 Origins of the Elements	12-15
22	4	Mod 6 Electromagnetic Induction	12-7, 12-13
23	4	Mod 7 Electromagnetic Spectrum	12-2, 12-14
24 (a)	2	Mod 8 Properties of the Nucleus	12-5, 12-15
24 (b)	2	Mod 8 Properties of the Nucleus	12-15
25 (a)	2	Mod 5 Motion in Gravitational Fields	12-12
25 (b)	3	Mod 5 Motion in Gravitational Fields	12-12
26 (a)	3	Mod 7 Light Quantum Model	12-4, 12-14
26 (b)	3	Mod 6 Charged Particles, Conductors and Electric and Magnetic Fields Mod 7 Light Quantum Model	12-13, 12-14

Question	Marks	Content	Syllabus outcomes
27 (a)	2	Mod 7 Light Wave Model	12-1, 12-14
27 (b)	3	Mod 7 Light Wave Model	12-14
27 (c)	2	Mod 7 Light Wave Model	12-14
28	3	Mod 8 Properties of the Nucleus	12-15
29	4	Mod 5 Projectile Motion	12-7, 12-12
30 (a)	3	Mod 7 Light and Special Relativity	12-7, 12-14
30 (b)	3	Mod 7 Light and Special Relativity	12-14
31	9	Mod 8 Quantum Mechanical Nature of the Atom	12-7, 12-15
32 (a)	3	Mod 6 Electromagnetic Induction	12-13
32 (b)	3	Mod 5 Circular motion Mod 6 Electromagnetic Induction	12-12 12-13
33 (a)	2	Mod 5 Circular Motion	12-12
33 (b)	4	Mod 5 Projectile Motion	12-6, 12-12
34	7	Mod 5 Circular Motion Mod 6 Charged Particles, Conductors and Electric and Magnetic Fields	12-5, 12-12, 12-13
35	5	Mod 5 Circular Motion Mod 5 Motion in Gravitational Fields	12-6, 12-12