2020 HSC Physics
Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21 (a)

Criteria	Marks
• Correctly calculates wavelength of light emitted	2
• Provides some relevant information	1

Sample answer:

$$\frac{1}{\lambda} = R\left(\frac{1}{n_{f^2}} - \frac{1}{n_{i^2}}\right)$$

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$\frac{1}{\lambda} = 1523611$$

$$\lambda = 6.563 \times 10^{-7} m$$

Question 21 (b)

Criteria	Marks
• Describes the behaviour of electrons in the Bohr model • Refers to the law of conservation of energy	3
• Shows some understanding of the behaviour of electrons in the Bohr model and/or the law of conservation of energy	2
• Provides some relevant information	1

Sample answer:

In the model, electrons move from lower to higher energy levels when they gain energy, and they emit energy as photons when they move from higher to lower energy levels.

Energy is conserved because the absorbed or emitted photon energy is equal to the energy difference between discrete electron energy levels.

Answers could include:

The energy of photons emitted or absorbed is equal to the difference in energy of the energy levels between which electrons move.

Question 22 (a)

Criteria	Marks
• Correctly calculates peak wavelength with correct unit	2
• Provides some relevant information	1

Sample answer:

$$\lambda_{\text{max}} = \frac{b}{T} = \frac{2.898 \times 10^{-3}}{3200} = 9 \times 10^{-7}\, m$$

Question 22 (b)

Criteria	Marks
• Outlines TWO limitations	3
• Outlines ONE limitation OR • Identifies TWO limitations	2
• Provides some relevant information	1

Sample answer:

The speed of the capsule is not a significant fraction of the speed of light, hence the effects of special relativity are insignificant. The capsule is in a non-inertial frame because it is accelerating, and therefore special relativity is not applicable.

This limits applying special relativity to the motion of the capsule.

Question 23

Criteria	Marks
• Identifies the consequence • Supports answer with relevant calculations	3
• Identifies the consequence and provides some relevant calculations OR • Provides the relevant calculations	2
• Provides some relevant information	1

Sample answer:

From the graph, at $\tau = 2.95$, $\omega = 100$

Rearranging the equation $\mathrm{I} = \tau \dfrac{\omega}{\mathrm{V}\eta} = 2.95 \times \dfrac{100}{240 \times 0.3} = 4.1\ \mathrm{A} = 4\ \mathrm{A}$

Hence at 2.95 N m, the motor will continue to run, as the circuit breaker will not cut the current.

Question 24

Criteria	Marks
• Correctly calculates the magnitude and direction of the initial velocity	4
• Provides the main steps for calculating the initial velocity	3
• Provides some steps for calculating the initial velocity	2
• Provides some relevant information	1

Sample answer:

From the graph, max height is 44 m and $v_y = 0$ at max height. Therefore:

$$v_y{}^2 = u_y{}^2 + 2a_y s_y$$

$$0 = u_y{}^2 + 2 \times (-9.8) \times 44$$

$$u_y = 29.4 \text{ m s}^{-1}$$

From the graph, time of flight is 6s. Therefore:

$$u_x = \frac{s_x}{t} = \frac{130}{6} = 21.7 \text{ m s}^{-1}$$

Applying Pythagoras' relationship:

$$u^2 = u_x{}^2 + u_y{}^2$$

$$u^2 = 21.7^2 + 29.4^2$$

$$u = 36.5 \text{ m s}^{-1}$$

Calculating angle of launch:

$$\tan\theta = \frac{u_y}{u_x}$$

$$\theta = 54^\circ$$

Therefore $u = 36.5 \text{ m s}^{-1}$, 54° above the horizontal.

$$= 37 \text{ ms}^{-1}$$

Answers could include:

Calculating u_y using $s_y = u_y t + 0.5 a_y t^2$ where $t = 3$ and $s_y = 44$ m.

Question 25

Criteria	Marks
• Provides a thorough description of the hydrogen atom in terms of the Standard Model	4
• Outlines some features of the hydrogen atom in terms of the Standard Model	3
• Outlines one feature of the hydrogen atom in terms of the Standard Model OR • Identifies some features of the Standard Model	2
• Provides some relevant information	1

Sample answer:

The hydrogen atom is composed of a proton nucleus and an electron. A proton is a hadron consisting of three quarks ie two up quarks, and 1 down quark. The quarks are bound together through the strong nuclear force.

The electron is classified as a lepton, a fundamental particle that can be isolated.

Answers can include

- Fractional charge of quarks
- Role of the electromagnet force
- Force-carrying bosons.

Question 26 (a)

Criteria	Marks
• Shows how the emission spectra differ	2
• Provides some relevant information	1

Sample answer:

Light from an incandescent lamp produces a continuous spectrum.

Light from a discharge tube produces a spectrum composed of only a few discrete wavelengths of light. (Diagrams acceptable)

Question 26 (b)

Criteria	Marks
• Identifies an assumption of each model	2
• Provides some relevant information	1

Sample answer:

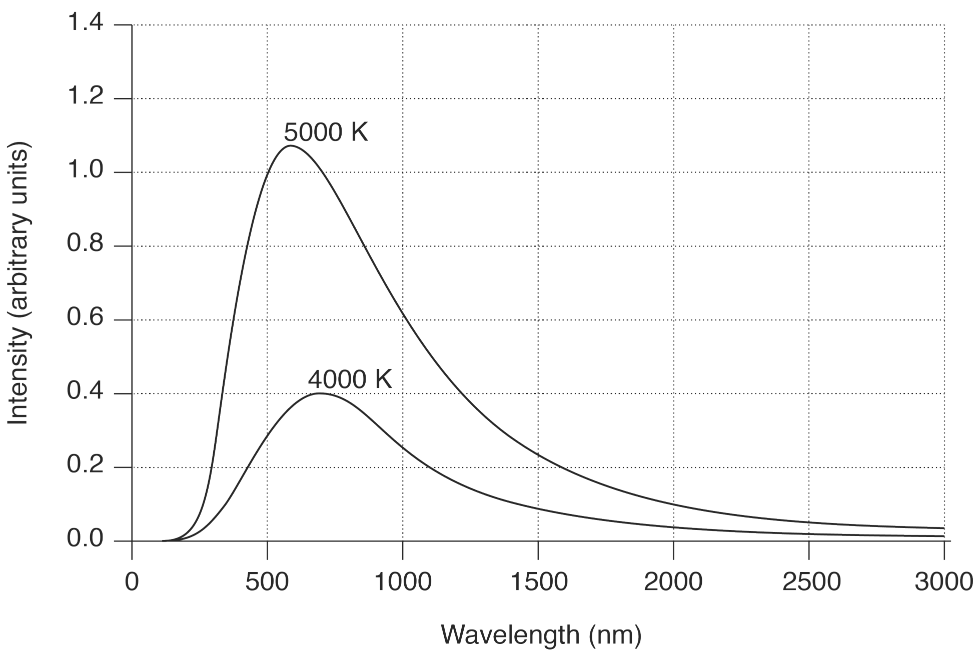
Model *X* requires that energy is absorbed and emitted in a continuous manner.

Model *Y* requires that energy is absorbed and emitted in discrete packets.

Question 26 (c)

Criteria	Marks
• Sketches the correct curve • Explains the differences	4
• Sketches a substantially correct curve • Provides some explanation	3
• Provides correct features of the curve OR • Shows some understanding of the differences	2
• Provides some relevant information	1

Sample answer:



The 4000 K curve has a peak intensity at a wavelength that is greater than for a body at 5000 K because the wavelength at which a black body reaches peak emissivity is inversely proportional to its absolute temperature.

The area under the curve at 4000 K is less than that for 5000 K because at every wavelength the intensity of the radiation produced at 4000 K is less.

Question 27

Criteria	Marks
• Explains TWO methods	4
• Explains ONE method and identifies another OR • Outlines TWO methods	3
• Outlines ONE method OR • Identifies TWO methods	2
• Provides some relevant information	1

Sample answer:

For diffraction $d\sin\theta = m\lambda$, where $m = 1$ for maxima *A*, *B*.

Hence $\sin\theta = \frac{\lambda}{d}$ and so decreasing λ decreases θ.

To keep the distance between *A* and *B* constant:

1. the slit separation *d* could be reduced causing θ to increase, compensating for the effect of reducing the wavelength
2. the distance '*y*' could be increased $\sin\theta$ for any angle θ, the distance between *A* and *B* increases and '*y*' increases and so increasing '*y*' would compensate for the reduction in θ due to the shorter wavelength.

Question 28 (a)

Criteria	Marks
• Provides working to show the change in magnetic flux	2
• Provides some relevant information	1

Sample answer:

$$\phi = BA\cos\theta = 1\times\left(0.3\times0.2\right)\times\cos30^\circ = 0.052 = 5.2\times10^{-2}\ Wb$$

Question 28 (b)

Criteria	Marks
• Provides correct working for calculating the emf and states correct direction of current flow	2
• Provides some working for calculating the emf OR • States correct direction of current flow	1

Sample answer:

$$\varepsilon = \frac{-N\Delta\phi}{t} = -1 \times \frac{5.2 \times 10^{-2}}{2.5} = 0.0208 = 2.1 \times 10^{-2}\ V$$

Direction of current flow is anticlockwise as viewed from above.

Answers could include:

$\varepsilon = Blv$

Question 28 (c)

Criteria	Marks
• Provides an explanation of why the force required is different	3
• Shows some understanding of why the force required is different	2
• Provides some relevant information	1

Sample answer:

Less force is required to move the rod. When the magnetic field is present, the force does work in providing the energy for the current to be induced in the circuit. With the removal of the field, this energy requirement no longer exists. However, energy will still be required since the force raises the rod up the rails against gravity.

Answers could include:

The induced current in the rod results in a force on the rod which opposes the motion that is inducing the current (Lenz's law).

Question 29 (a)

Criteria	Marks
• Explains why the hypothesis was proposed and then rejected	3
• Shows some understanding of why the hypothesis was proposed and/or then rejected	2
• Provides some relevant information	1

Sample answer:

The unknown radiation was not deflected by an electric field, so it was deduced that it could not consist of charged particles. This observation is consistent with the known behaviour of gamma rays and hence with the hypothesis. The inability of the radiation to produce the photoelectric effect was inconsistent with its being gamma radiation, which because of the high energy of the photons should have readily ejected electrons from a metal. The ejection of protons from paraffin was consistent with the unknown radiation having a significant momentum that was being transferred to the protons. This was also inconsistent with the radiation being gamma radiation.

Question 29 (b)

Criteria	Marks
• Shows a sound understanding of how the experiments changed the model of the atom	2
• Provides some relevant information	1

Sample answer:

These experiments showed the existence of neutral particles called neutrons that had a mass similar to protons. Hence the model for the atomic nucleus changed from containing only protons to consisting of protons and neutrons.

Question 30 (a)

Criteria	Marks
• Provides an explanation using a relevant example	3
• Outlines a relevant example and/or the application of a particle accelerator	2
• Provides some relevant information	1

Sample answer:

A linear accelerator was used to provide electrons with sufficient energy to penetrate protons. The scattering of these electrons was consistent with the protons having an internal structure. It was inferred that the proton itself was not an elementary particle, an observation that contributed to the idea that protons were made of quarks.

Question 30 (b) (i)

Criteria	Marks
• Applies a correct method to calculate the wavelength	2
• Provides some relevant information	1

Sample answer:

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}}{1.673 \times 10^{-27} \times 0.1 \times 3 \times 10^{8}}$$

$$= 1.32 \times 10^{-14} \text{ m}$$

$$= 1 \times 10^{-14} \text{ m}$$

Question 30 (b) (ii)

Criteria	Marks
• Provides a valid explanation	2
• Provides some relevant information	1

Sample answer:

The relativistic wavelength is shorter than would be predicted by classical mechanics because the momentum of the proton is greater than that predicted by classical mechanics.

Question 31 (a)

Criteria	Marks
• Accounts for the changes in velocity of the comet	3
• Provides a reason for a change in velocity of the comet	2
• Provides some relevant information	1

Sample answer:

As the comet moves toward the sun, its gravitational potential energy (GPE) is converted into kinetic energy (KE) consistent with the law of conservation of energy. The increase in KE results in an increase in velocity as it approaches the sun. As it returns to point P, it loses velocity as its KE is converted into GPE.

Answers could include:

Reference to a component of gravitational force acting parallel/antiparallel to the direction of the comet's velocity, changing its speed.

Question 31 (b)

Criteria	Marks
• Applies a correct method to derive an expression for the speed of *B*	3
• Shows some relevant steps for deriving an expression for the speed of *B*	2
• Provides some relevant information	1

Sample answer:

As the speed is constant, both stars must be in circular orbits with each other. As both stars have equal mass, the centre of mass, and hence the centre of the orbit of each star, is halfway between the stars.

$$F = \frac{Gm^2}{x^2} = \frac{mv^2}{\left(\frac{x}{2}\right)} = \frac{2mv^2}{x}$$

$$\therefore \quad \frac{Gm^{\not{2}}}{x^{\not{2}}} = \frac{2\not{m}v^2}{\not{x}}$$

$$\frac{Gm}{x} = 2v^2$$

$$v = \sqrt{\frac{Gm}{2x}}$$

Question 32

Criteria	Marks
• Provides a comprehensive explanation of the relevant factors • Supports the answer with mathematical models	7
• Provides explanations of relevant factors • Supports the answer with at least one mathematical model	6
• Describes some relevant factors and provides some explanation • Refers to at least one mathematical model	5
• Outlines relevant factor(s) and/or mathematical model(s)	3–4
• Outlines a relevant factor OR • Identifies relevant factors and/or features of a mathematical model	2
• Provides some relevant information	1

Answers could include:

Explanations related to the factors:

- Magnitude of the mass
- Friction between the block and the table (related to mass and coefficient of friction)
- Back emf in the motor
- Power input to the motor
- Diameter of the pulley
- Torque produced
- Motor efficiency.

Mathematical models could include:

- $F = ma$
- $P = VI$
- $F_f = \mu N$
- $\tau = rF\sin\theta$.

Question 33

Criteria	Marks
• Provides a comprehensive analysis of the motion of the magnet • Applies the law of conservation of energy • Refers to gravity and the copper cylinder • Includes quantitative information	9
• Provides a thorough analysis of the motion of the magnet • Applies the law of conservation of energy • Refers to gravity and the copper cylinder • Includes quantitative information	8
• Describes the motion of the magnet • Applies the law of conservation of energy • Refers to gravity and/or the copper cylinder • Includes quantitative information	6–7
• Describes the motion of the magnet AND/OR • Relates the law of conservation of energy AND/OR • Refers to gravity and/or the copper cylinder AND/OR • Includes quantitative information	4–5
• Shows some understanding of the motion of the magnet and/or gravity and/or the copper cylinder	2–3
• Provides some relevant information	1

Sample answer:

During the first 0.4 s, the magnet is free-falling due to gravitational force, falling a distance of 0.78 m, and accelerating at 9.8 m s^{-2} $\left(\frac{2s}{t^2}\right)$. Here, gravitational potential energy is being converted to kinetic energy as the magnet accelerates downward. This is shown by the non-linear line on the distance vs time graph.

At position Y, the induced currents in the cylinder produce a magnetic field that causes the magnet to decelerate to a constant velocity of 0.4 m s^{-1} for a period of 0.5 seconds as it passes through the copper cylinder. There is zero net force on the magnet as it passes through the cylinder, as shown by the straight line in the distance vs time graph

The magnet's kinetic energy is converted to heat energy during the deceleration.

As the magnet passes through the cylinder, the gravitational potential energy decreases and there is a corresponding increase in the heat energy in the cylinder. This is consistent with the law of conservation of energy.

Question 34 (a)

Criteria	Marks
• Correctly compares the work done on q_1 and q_2	3
• Shows some relevant calculation on the work done on q_1 and/or q_2	2
• Provides some relevant information	1

Sample answer:

Work on q_1 = Force x distance moved in the direction of the force

$$= \left(q_1 E\right) \times \frac{d}{2} = \left(q_1 \frac{V}{d}\right) \times \frac{d}{2}$$

Hence work $= q_1 \frac{V}{2}$

Work on q_2 = Force x distance moved in the direction of the force

$$= \left(q_2 E\right) \times \frac{3d}{2} = \left(q_2 \frac{V}{2d}\right) \times \frac{3d}{2}$$

Hence work $= \left(q_2 E\right) \times \frac{3d}{2} = 3q_2 \frac{V}{4}$

As $q_2 = q_1 = q$

$$\frac{W_2}{W_1} = \frac{\left(\frac{3qV}{4}\right)}{\left(\frac{qV}{2}\right)}$$

Hence, the work done on q_2 is $\frac{3}{2}$ times that done on q_1.

Question 34 (b)

Criteria	Marks
• Correctly compares the horizontal distances travelled by q_1 and q_2	3
• Shows some relevant calculation on the horizontal distances travelled by q_1 and/or q_2	2
• Provides some relevant information	1

Sample answer:

In both situations the distance travelled to the right is proportional to *v* and *t.*

Noting that $a_1 \neq a_2$

Figure 1 $a_1 \propto F_1 \propto \frac{V}{d}$

Figure 2 $a_2 \propto F_2 \propto \frac{V}{2d}$, ie the acceleration is half that of Figure 1

Since time to reach $Y \propto \sqrt{\frac{1}{a}}$ in both cases:

If a is halved, the time increases by $\sqrt{2}$.

In figure 1, q_1 moves a distance $\frac{d}{2}$ towards *Y*.

In figure 2, q_2 moves a distance $\frac{3d}{2}$ towards *Y*.

The time to reach the plate $Y = \sqrt{\frac{2 \times \text{distance moved in that direction}}{a}}$

Since in Figure 2, *t* is increased by $\sqrt{2}$ due to acceleration and *t* is increased by $\sqrt{3}$ due to distance, then distance travelled increases by $\sqrt{6}$.

2020 HSC Physics
Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	1	Mod 7 Light: Wave model	PH12-14
2	1	Mod 6 Applications of the motor effect	PH 12-13
3	1	Mod 7 Light: Quantum model	PH 12-14
4	1	Mod 8 Properties of the nucleus	PH12-15, PH11/12-6
5	1	Mod 5 Projectile motion	PH 12-12, PH11/12-6
6	1	Mod 8 Origins of elements	PH 12-15, PH11/12-5
7	1	Mod 6 The Motor Effect	PH12-13, PH11/12-5
8	1	Mod 8 Properties of the nucleus	PH12-15, PH11/12-5
9	1	Mod 8 Quantum Mechanical Nature of the Atom	PH12-15
10	1	Mod 6 Charged particles, conductors and electric and magnetic fields	PH12-13, PH11/12-5
11	1	Mod 8 Properties of the nucleus	PH12-15
12	1	Mod 5 Motion in Gravitational Fields	PH12-12, PH11/12-6
13	1	Mod 7 Light: Quantum Model	PH12-14, PH11/12-4
14	1	Mod 6 The Motor Effect	PH12-13, PH11/12-5
15	1	Mod 5 Projectile motion	PH12-12, PH11/12-6
16	1	Mod 8 Properties of the nucleus	PH12-15, PH11/12-5
17	1	Mod 7 Light and Special Relativity	PH12-14
18	1	Mod 7 Electromagnetic Spectrum	PH12-14, PH11/12-6
19	1	Mod 6 Charged particles, conductors and electric and magnetic fields	PH12-13, PH11/12-5
20	1	Mod 5 Projectile motion Mod 5 Circular motion	PH12-12, PH11/12-6

Section II

Question	Marks	Content	Syllabus outcomes
21 (a)	2	Mod 8 Quantum Mechanical Nature of the Atom	PH12-15, PH11/12-6
21 (b)	3	Mod 8 Quantum Mechanical Nature of the Atom	PH12-15, PH11/12-7
22 (a)	2	Mod 7 Light: Quantum Model	PH12-14, PH11/12-4
22 (b)	3	Mod 7 Light and Special Relativity	PH12-14, PH11/12-7
23	3	Mod 6 Applications of the motor effect	PH12-13, PH11/12-4, PH11/12-5
24	4	Mod 5 Projectile motion	PH12-12, PH11/12-5, PH11/12-6
25	4	Mod 8 Deep inside the Atom	PH12-15, PH11/12-7
26 (a)	2	Mod 7 Electromagnetic Spectrum Mod 8 Origins of elements	PH12-14, PH12-15, PH11/12-7
26 (b)	2	Mod 7 Light: Wave model Mod 7 Light: Quantum Model	PH12-14, PH11/12-4, PH11/12-7

Question	Marks	Content	Syllabus outcomes
26 (c)	4	Mod 7 Light: Quantum Model	PH12-14, PH11/12-7
27	4	Mod 7 Light: Wave model	PH12-14, PH11/12-2
28 (a)	2	Mod 6 Electromagnetic induction	PH12-13, PH11/12-6
28 (b)	2	Mod 6 Electromagnetic induction	PH12-13, PH11/12-5, PH11/12-6
28 (c)	3	Mod 5 Motion in Gravitational Fields Mod 6 Electromagnetic induction	PH12-12, PH12-13, PH11/12-5, PH11/12-6
29 (a)	3	Mod 8 Structure of the atom	PH12-15, PH11/12-7
29 (b)	2	Mod 8 Structure of the atom	PH12-15, PH11/12-7
30 (a)	3	Mod 8 Deep inside the Atom	PH12-15, PH11/12-7
30 (b) (i)	2	Mod 7 Light and Special Relativity	PH12-14, PH11/12-6
30 (b) (ii)	2	Mod 7 Light and Special Relativity	PH12-14, PH11/12-6
31 (a)	3	Mod 5 Motion in Gravitational Fields	PH12-12, PH11/12-6, PH11/12-7
31 (b)	3	Mod 5 Motion in Gravitational Fields	PH12-12, PH11/12-6, PH11/12-7
32	7	Mod 5 Motion in Gravitational Fields Mod 6 Applications of the motor effect	PH12-13, PH12-12, PH11/12-5, PH11/12-6, PH11/12-7
33	9	Mod 5 Motion in Gravitational Fields Mod 6 Electromagnetic induction	PH12-13, PH12-12, PH11/12-4, PH11/12-5, PH11/12-6, PH11/12-7
34 (a)	3	Mod 6 Charged particles, conductors and electric and magnetic fields	PH12-13, PH11/12-4, PH11/12-6
34 (b)	3	Mod 5 Projectile motion Mod 6 Charged particles, conductors and electric and magnetic fields	PH12-12, PH12-13, PH11/12-4, PH11/12-6