2019 HSC Physics
Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21

Criteria	Marks
• Refers to de Broglie's characterisation of the wave nature of matter • Refers to a relevant equation	2
• Refers to de Broglie's characterisation of the wave nature of matter OR • Refers to a relevant equation	1

Sample answer:

It was postulated by de Broglie that particles, such as electrons, possess wave properties. The wavelength associated with such particles is predicted by:

$$\lambda = \frac{h}{mv}$$

Question 22

Criteria	Marks
• Relates observations to features of stars	3
• Relates an observation to a feature of a star	2
• Identifies an observation or other feature of a star	1

Sample answer:

Absorption spectra can reveal information about the density of a star. Darker, broader spectral lines indicate significant levels of absorption associated with denser stars, whereas fainter, narrower spectral lines are associated with less dense stars.

The frequency of lines in absorption spectra can reveal information about the motion of a star. A shift towards lower frequencies indicates that the star is moving away from the observer.

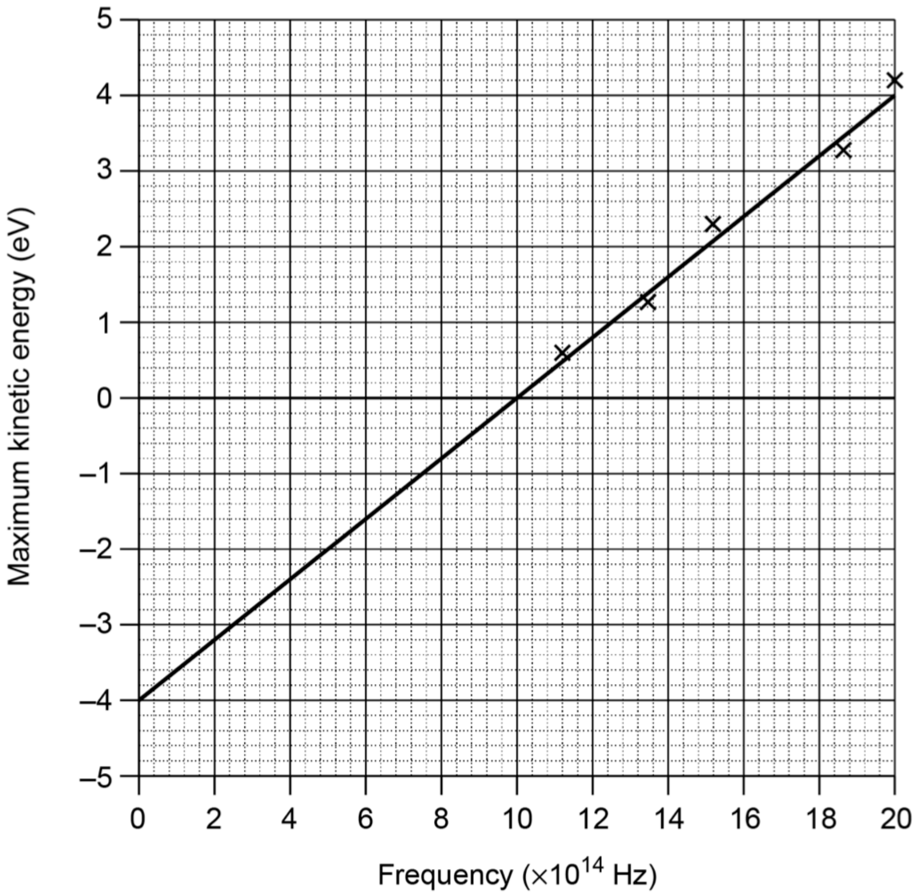
Answers may include:

Red and blue shifts from the edges of a star's light disc which can provide information about its rotational velocity. Binary/multiple star systems.

Question 23

Criteria	Marks
• Determines the correct work function using the line of best fit	3
• Plots the values on the graph • Draws a line of best fit or determines work function from the graph	2
• Correctly plots some points OR • Correctly draws a line of best fit	1

Sample answer:



The work function of the metal is 4 eV.

Answers could include:

Calculation based on the threshold frequency.

Question 24 (a)

Criteria	Marks
• Explains how the operation of the transformer is consistent with conservation of energy • Includes a relevant calculation	3
• Relates transformer input and output using power or energy calculations	2
• Provides some relevant information	1

Sample answer:

The energy input is 500 J s^{-1}.

The electrical energy output is $V_s I_s$ per second = 450 J s^{-1}

To be consistent with the law of conservation of energy, 50 J s^{-1} of energy must be converted into other forms, such as heat.

Question 24 (b)

Criteria	Marks
• Explains how modifications improve efficiency	4
• Explains how a modification improves efficiency and identifies a second modification OR • Outlines how modifications improve efficiency	3
• Identifies modifications OR • Outlines how a modification improves efficiency	2
• Provides some relevant information	1

Sample answer:

The iron core could be laminated. Laminations reduce the magnitude of the induced eddy currents, minimising energy loss.

The thicker wire could be used in the primary coil rather than the secondary coil to decrease the resistance where there is a higher current, and hence reduce energy lost as heat.

Both modifications would increase its efficiency.

Question 25

Criteria	Marks
• Relates the model to predictions made by Maxwell	4
• Relates the model to a prediction made by Maxwell • Identifies another prediction made by Maxwell or another feature of the model	3
• Identifies prediction(s) made by Maxwell AND/OR • Identifies feature(s) of the model	2
• Provides some relevant information	1

Sample answer:

The model shows alternating electric and magnetic fields perpendicular to each other. This is consistent with Maxwell's prediction that a changing electric field produces a changing magnetic field and vice versa.

The model shows a wave propagating at velocity v. Maxwell predicted the existence of a range of waves with different wavelengths, all travelling with the same speed.

Answers could include:

The model shows an oscillating charge and an e/m wave emanating from it. This is consistent with Maxwell's prediction that an oscillating charge produces an e/m wave.

Ways in which this model differs from Maxwell's predications.

Question 26 (a)

Criteria	Marks
• Provides reasons for the validity of the model	3
• Provides a reason for the validity of the model	2
• Provides some relevant information	1

Sample answer:

The graph shows a linear relationship with a gradient of 1.7, consistent with the model $\tau = k\theta$. The model can be used to accurately predict the torque at any angle within the range of angles measured.

Question 26 (b)

Criteria	Marks
• Justifies an increasing reduction in the student's model's accuracy using another model	3
• Outlines a reduction in the model's accuracy using another model	2
• Identifies a feature of an alternative model OR • Identifies a reduction in the model's accuracy	1

Sample answer:

The torque produced by a force is more accurately described by $\tau = rF\sin\theta$, which predicts values of torque smaller than those predicted by the student's model. The discrepancy between the models increases as the angle is increased.

Question 27 (a)

Criteria	Marks
• Outlines a thought experiment related to the prediction of time dilation	3
• Provides features of a relevant thought experiment	2
• Identifies a thought experiment or a feature of time dilation	1

Sample answer:

Imagine a person on a train travelling at near the speed of light with a light pulse that bounces up and down between two mirrors. An observer outside the train sees the light pulse travel in a triangular path. This path is longer than that observed by the person on the train. Since the speed of light is constant for both observers, their measured times would be different. The observer outside the train observes a longer time demonstrating time dilation.

Question 27 (b)

Criteria	Marks
• Outlines experimental evidence that validates time dilation	3
• Outlines a relevant experiment	2
• Provides some relevant information	1

Sample answer:

Measurements of the decay time of muons produced by cosmic rays in the upper atmosphere, and traveling >0.99c, were made on top of a mountain and at sea level. The data from the mountain top allowed the number of muons that would be observed at sea level, assuming no relativistic effects, to be predicted. The actual number observed at sea level was greater that this model predicted, and was consistent with the increase in the muons' half-life, predicted by taking time dilation into account, thus validating the prediction of time dilation.

Answers could include:

- Evidence from atomic clocks on planes
- Evidence from particle accelerators, or
- Evidence from cosmological studies.

Question 28

Criteria	Marks
• Compares the forces acting on *WX* and *XY* before and after the rotation	3
• Identifies some features of the forces acting on *WX* and *XY* OR • Compares the forces acting on *WX* or *XY* before and after the rotation	2
• Identifies a feature of the force acting on *WX* or *XY*	1

Sample answer:

The magnitude and direction of the force on *WX* remains the same when it is rotated. Initially, *XY* experiences no force, whereas after rotation it experiences a force to the right.

Question 29

Criteria	Marks
• Correctly derives the relationship	3
• Shows some correct steps or reasoning	2
• Provides some relevant information	1

Sample answer:

The work done is equal to the change in kinetic energy.

$\therefore W = \Delta K$

$$qV = \frac{1}{2}mv^2 - 0$$

$$\therefore v = \sqrt{\left(\frac{2qV}{m}\right)}$$

Answers could include:

Use of calculus.

Question 30 (a)

Criteria	Marks
• Correctly calculates the difference in height	3
• Provides some relevant steps	2
• Provides some relevant information	1

Sample answer:

$$\Delta U = \Delta K$$

$$mg\Delta h = \frac{1}{2}\ mv^2$$

$$\Delta h = \frac{v^2}{2\ g}$$

$$= \frac{1.5^2}{2 \times 9.8}$$

$$= 0.1145\ m$$

Height is 0.11 m

Question 30 (b)

Criteria	Marks
• Correctly calculates the height	3
• Provides some relevant steps	2
• Provides some relevant information	1

Sample answer:

$$u_y = u\sin\theta$$
$$= 1.50 \sin 50$$
$$= 1.15 \text{ m s}^{-1} \text{ downward}$$

$$s = ut + \frac{1}{2}at^2$$
$$= -1.15 \times 0.5 + \frac{1}{2}(-9.80) \times 0.5^2$$
$$= 1.8 \text{ m}$$

Height is 1.8 m

Question 31 (a)

Criteria	Marks
• Explains the changes observed on the spring balance	4
• Explains a change observed on the spring balance OR • Relates changes observed on the spring balance to forces acting on the fan	3
• Identifies changes observed on the spring balance and/or forces acting on the fan	2
• Provides some relevant information	1

Sample answer:

After being switched on, the fan exerts a downward force on the air and due to Newton's 3rd Law an equal upward force is exerted on the fan by the air. This reduces the net vertical force observed on the spring balance. This effect increases as the fan's speed increases.

Since the fan increases in speed until reaching its maximum after 10 seconds, the force observed on the spring balance will decrease until it reaches a minimum at ten seconds, after which it remains constant because the forces are balanced.

Question 31 (b)

Criteria	Marks
• Assesses features of the prediction	4
• Assesses a feature of the prediction OR • Outlines issues with the prediction	3
• Outlines an issue with the prediction	2
• Provides some relevant information	1

Sample answer:

Between 0–10 s the student's prediction incorrectly shows an increasing current. During this time the magnitude of back emf in the motor is increasing, therefore reducing the current in the motor.

From 10–15 s the student's prediction correctly shows a constant current. Since the fan has reached a constant speed, the magnitude of the back emf is also constant, so the net current in the motor is constant.

Question 32

Criteria	Marks
• Presents features of relevant experiments and how their results increased our understanding	5
• Presents feature(s) of relevant experiments and how their results increased our understanding	4
• Presents features of a relevant experiment and how the result increased our understanding OR • Presents feature(s) of relevant experiments	3
• Identifies a relevant experiment and its result or its effect on our understanding	2
• Provides some relevant information	1

Sample answer:

In an experiment, the velocity of charged oil droplets moving under the influence of gravitational and electric fields was measured. Discrete differences in velocity were observed, providing evidence to determine the charge on an electron.

Other fundamental particles include quarks. In one experiment, an accelerated beam of electrons was fired at protons. Scattering patterns produced were interpreted to show that the protons they struck consisted of three smaller particles, later named quarks.

Answers could include:

Experimental evidence showing properties of cathode rays in glass tubes, electron properties such as charge : mass ratio or wave properties.

Experiments which revealed information about second or third generation quarks (strange, charm, top, bottom).

Question 33

Criteria	Marks
• Explains a similarity and a difference	4
• Explains a similarity or a difference AND • Outlines the other	3
• Explains a similarity or a difference OR • Outlines a similarity and a difference	2
• Provides some relevant information	1

Sample answer:

Similarity – both particles will experience a force perpendicular to both their velocity and the magnetic field lines. This will result in both particles experiencing circular motion (in a clockwise direction).

Difference – since the radius is proportional to the mass and inversely proportional to the charge of the particle, the radius of the alpha particle trajectory is greater.

Answers could include:

Sketches the diagram in the question.

Difference related to $r = \frac{mv}{qB}$ or other equation.

Question 34

Criteria	Marks
• Describes the production and radiation of energy • Provides quantitative analysis of power output and surface temperature	9
• Describes aspects of the production and radiation of energy • Provides aspects of quantitative analysis of power output and surface temperature	7–8
• Describes aspect(s) of the production and radiation of energy • Provides aspects of quantitative analysis of power output or surface temperature OR • Describes aspects of the production or radiation of energy • Provides aspects of quantitative analysis of power output and surface temperature	5–6
• Outlines aspect(s) of the production and/or radiation of energy AND/OR • Provides aspect(s) of quantitative analysis of power output and/or surface temperature	3–4
• Identifies aspect(s) of the production and/or radiation of energy	1–2

Sample answer:

Most of the sun's energy is produced by the proton-proton chain fusion reactions which convert hydrogen into helium via intermediate reactions involving the formation of deuterium and helium. During this process mass is converted to energy.

The sun acts like a black body and its radiation is characterised by a black body curve. Energies are determined by the wavelength of the radiation. It peaks at a specific wavelength which characterises its temperature.

The sun's surface is a black body radiator with a temperature T where
$\lambda_{max} = b/T$

$\lambda_{max} = 5.00 \times 10^{-7}$ m from the graph

Hence $T = b/\lambda_{max} = 2.898 \times 10^{-3} / 5.0 \times 10^{-7} = 5800$ K

Total power output (P) of the sun is $P = IA = I \times 4\pi r^2$

where I = intensity at Earth's distance (r) = 1360 W m^{-2}

and $r = 1.5 \times 10^{11}$ m

Total power output of sun $P = I \times 4\pi r^2 \pi r^2 = 1360 \times 4 \times 3.142 \times (1.5 \times 10^{11})^2 = 3.85\ 10^{26}$ W

Answers could include:

Quantitative analysis relating the calculated power and $E = mc^2$ in lieu of proton–proton chain.

Question 35

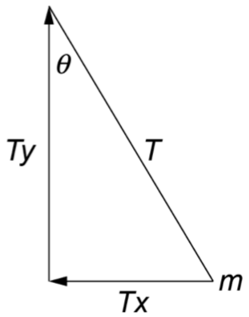
Criteria	Marks
• Relates observations to features of the car's motion • Derives an expression that relates the radius in terms of θ	4
• Relates observations to features of the car's motion • Provides some steps toward determining an expression for a feature of the motion in terms of θ	3
• Relates an observation to a features of the car's motion	2
• Provides some relevant information	1

Sample answer:

The constant deflection of the pendulum to the right indicates that the car has a uniform acceleration to the left, and is therefore travelling in uniform circular motion.

Larger values of θ indicate smaller radii of motion.

The radius of motion can be expressed in terms of θ:



① $$Ty = T\cos\theta = mg$$

② $$Tx = T\sin\theta = ma = \frac{mv^2}{r}$$

from ① $$T = \frac{mg}{\cos\theta}$$

in ② $$\frac{mg\sin\theta}{\cos\theta} = \frac{mv^2}{r}$$

$$\therefore \; g\tan\theta = \frac{v^2}{r}$$

$$r = \frac{v^2}{g\tan\theta}$$

Question 36

Criteria	Marks
• Applies correct method to calculate KE of the alpha particle • Explains the greater KE of the alpha particle using the principle of conservation of momentum	7
• Applies correct method to calculate KE of the alpha particle • Applies the principle of conservation of momentum	6
• Shows the main steps of the calculation of KE AND/OR • Shows a sound understanding of the conservation of momentum	4–5
• Shows step(s) of the calculation of KE AND/OR • Shows some understanding of the conservation of momentum	2–3
• Provides some relevant information	1

Sample answer:

Alpha decay

Mass defect $= 197.999 - (193.988 + 4.000260) = 0.0084\text{u}$

Converting to kilograms $= 0.0084 \times 1.661 \times 10^{-27} = 1.395 \times 10^{-29}$ kg

Total energy produced $= mc^2 = 1.395 \times 10^{-29} \times (3 \times 10^8)^2 = 1.256 \times 10^{-12}$ J

KE_{alpha} = Total Energy produced $- KE_{polonium} = 1.256 \times 10^{-12} - 2.44 \times 10^{-14}$

$= 1.23 \times 10^{-12}$ J

Since the radon atom is initially at rest, the decay products move away from each other with equal and opposite momenta. As the alpha particle's mass is significantly less than that of the polonium atom, it therefore has a significantly higher velocity ($p = mv$), and consequently a higher KE. Despite the higher mass of the polonium atom, the higher velocity of the alpha particle has a more significant effect on its KE ($KE = \frac{1}{2} mv^2$).

Answers could include:

Calculation not using mass defect ($K \rightarrow P$).

2019 HSC Physics Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	1	M5 Projectile Motion	12-6, 12-12
2	1	M7 Electromagnetic Spectrum	12-5, 12-6, 12-14
3	1	M8 Structure of the Atom	12-6, 12-15
4	1	M8 Origins of the Elements	12-5, 12-6
5	1	M6 Electromagnetic Induction	12-6, 12-13
6	1	M7 Light: Quantum Model	12-6, 12-14
7	1	M6 Applications of the Motor Effect	12-6, 12-13
8	1	M8 Origins of the Elements	12-5, 12-6
9	1	M5 Motion in Gravitation Fields	12-6, 12-12
10	1	M7 Light: Wave Model	12-6, 12-14
11	1	M5 Motion in Gravitational Fields	12-6, 12-12
12	1	M8 Deep inside the Atom	12-6, 12-15
13	1	M7 Light: Quantum Model M8 Quantum Mechanical Nature of the Atom	12-6, 12-14
14	1	M5 Motion in Gravitation Fields	12-6, 12-12
15	1	M7 Light: Wave Model	12-6, 12-14
16	1	M6 Charged Particles, Conductors, Electric and Magnetic Fields	12-6, 12-12
17	1	M6 Motor Effect	12-6, 12-13
18	1	M6 Applications of the Motor Effect	12-6, 12-13
19	1	M8 Properties of the Nucleus	12-6, 12-15
20	1	M5 Circular Motion	12-6, 12-12

Section II

Question	Marks	Content	Syllabus outcomes
21	2	M8 Quantum Mechanical, Nature of the Atom	12-15, 12-6
22	3	M7 Electromagnetic Spectrum	12-14, 12-6
23	3	M7 Light: Quantum Model	12-4, 12-14, 12-5, 12-6
24 (a)	3	M6 Electromagnetic Induction	12-13, 12-6
24 (b)	4	M6 Electromagnetic Induction	12-13, 12-6
25	4	M7 Electromagnetic spectrum	12-14, 12-6
26 (a)	3	M5 Circular Motion	12-4, 12-12, 12-5, 12-6
26 (b)	3	M5 Circular Motion	12-5, 12-12, 12-6
27 (a)	3	M7 Light and Special Relativity	12-14, 12-6
27 (b)	3	M7 Light and Special Relativity	12-14, 12-6
28	3	M6 Motor Effect	12-13, 12-6

Question	Marks	Content	Syllabus outcomes
29	3	M6 Charged Particles, Conductors and Electric and Magnetic Fields	12-6, 12-13, 12-6
30 (a)	3	M5 Projectile Motion	12-6, 12-12, 12-6
30 (b)	3	M5 Projectile Motion	12-6, 12-12, 12-6
31 (a)	4	M5 Circular Motion, Motion in Gravitational Field	12-12, 12-6
31 (b)	4	M6 Applications of the Motor Effect	12-5, 12-13, 12-6
32	5	M8 Structure of the Atom, Deep Inside the Atom	12-15, 12-6
33	4	M6 Charged Particles, Conductors and Electric and Magnetic Fields	12-6, 12-13, 12-6
34	9	M7 Light: Quantum Model M8 Properties of the Nucleus	12-14, 12-15, 12-6
35	4	M5 Circular Motion	12-2, 12-12, 12-6
36	7	M8 Properties of the Nucleus	12-15, 12-6