CSSA

2022
TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

MARKING GUIDELINES

Physics

Section I
20 marks

Questions 1-20 (1 mark each)

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

Section II
80 marks

Question 21 (4 marks)

21 (a) (2 mark)

Outcomes Assessed: 12-15

Targeted Performance Bands: 1-4

Criteria	Mark
• Correctly calculates the binding energy in MeV.	2
• Correctly calculates mass defect OR correctly calculates binding energy from incorrect mass defect.	1

Sample answer:

Mass defect= [(3 × mass of proton)+ (4 × mass of neutron)+(3 × mass of electrons)]- mass of the lithium atom.

$= [(3 \times \frac{1.673\ x\ 10^{-27}}{1.661\ x\ 10^{-27}}) + (4 \times \frac{1.675\ x\ 10^{-27}}{1.661\ x\ 10^{-27}}) + (3 \times \frac{9.109\ x\ 10^{-31}}{1.661\ x\ 10^{-27}})]$- 6.941=0.116 u

$E = 0.116 \times 931.5 = 1.081 \times 10^{2}$ MeV

21 (b) (2 marks)

Outcomes Assessed: PH11/12-6; PH12-15

Targeted Performance Bands: 2-3

Criteria	Marks
• Correct format for the equation and correct products shown	2
• Correctly identifies the formula for either alpha particle or hydrogen particle.	1

Sample Answer:

$$^{5}_{3}Li \rightarrow {}^{4}_{2}He + {}^{1}_{1}H$$

Question 22 (5 marks)

22 (a) (5 marks)
Outcomes Assessed: 12-13
Targeted Performance Bands: 2-5

Criteria	Marks
• 5 useful suggestions	5
• 4 useful suggestions	4
• 3 useful suggestions	3
• 2 useful suggestions	2
• 1 useful suggestion	1

Sample Answer:
Increasing the strength of the magnetic field by using stronger magnets.
Placing a laminated core (or nails) into the centre of the cardboard cube.
Place more windings above and below the drive shaft.
Decrease the radius of the drive shaft to decrease the torque required to lift the mass.
Make the cube of cardboard taller so that the windings have a greater torque.

Also
Use windings with less resistance
Increase the area of the windings.

Question 23 (5 marks)

23 (a) (2 marks)

Outcomes Assessed: 12-12

Targeted Performance Bands: 2-4

Criteria	Marks
• Identifies that there is negligible gravity in deep space. • Explains that magnetic boots will create a downward force simulating weight.	2
• Identifies that the boots will create a magnetic force downward on the travellers.	1

Sample Answer:

In deep space, far from the centre of any massive body, the force of gravity is negligible and astronauts are literally weightless. Walking around the interior of a large spacecraft would be difficult without magnetic boots that simulate the attractive force of gravity between the boots and the floor.

23 (b) (3 marks)

Outcomes Assessed: 12-12

Targeted Performance Bands: 4-5

Criteria	Marks
• Correct result from correct substitutions	3
• Combines 9.8 m/s^2 with centripetal acceleration.	2
• Correct formula for centripetal acceleration OR Using 9.8m/s^2	1

Sample Answer:

$$a = \frac{v^2}{r}$$

$$v = \frac{2\pi r}{T}$$

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

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

$$9.8 = \frac{(4\pi^2 \times 500)}{T^2}$$

$$T = \sqrt{\frac{(4\pi^2 \times 500)}{9.8}}$$

$$= 45 \text{ s}$$

Question 24 (3 marks)

24 (a) (3 marks)
Outcomes Assessed: 12-13
Targeted Performance Bands: 3-5

Criteria	Marks
• Correct answer for size comparison	3
• Uses the correct equation F=IlB sinθ with θ=90 • Attempts to find Length in terms of the angle and d	2
• Uses or implies the use of the correct equation F=IlB sinθ OR • Realises that they are both at right angles to the magnetic field	1

Sample Answer:

For A $F = ILBsin\theta \quad where\ \theta = 90^{\circ}\ and\ L = \frac{d}{sin30} = 2d \qquad \therefore F = 2IdB$

For B $F = ILBsin\theta \quad where\ \theta = 90^{\circ}\ and\ L = d \qquad \therefore F = IdB$

So the force on A is twice that of the force on B

Question 25 (4 marks)

Outcomes Assessed: 12-12
Targeted Performance Bands: 3-5

Criteria	Marks
• Correct value for speed and angle.	4
• Correct value for angle based on wrong value for speed • Combines horizontal and vertical values to find speed.	3
• Combines horizontal and vertical values to find speed • Attempt to find initial speed values	2
• Attempt to use vertical and horizontal value to find speed or angle	1

Sample Answer:

$$v_x = \frac{s_x}{t}$$
$$= u\cos\theta$$
$$= 119 \times \cos 15.6$$
$$= 115 \text{ m s}^{-1}$$
$$t = \frac{s_x}{u_x}$$
$$= \frac{23.5}{119\cos 15.6}$$
$$= 0.205 \text{ s}$$
$$v_y = u_y + at$$
$$u_y = v_y - at$$
$$= 119\sin 15.6 - (-9.8 \times 0.205)$$
$$= 34.0 \text{ m s}^{-1}$$
$$u = \sqrt{u_x^2 + u_y^2}$$
$$= \sqrt{115^2 + 34.0^2}$$
$$= 120 \text{ m s}^{-1}$$
$$\theta = \tan^{-1}\left(\frac{34.0}{115}\right)$$
$$= 16.5°$$

Question 26 (7 marks)

26 (a) (2 marks)

Outcomes Assessed: 12-12

Targeted Performance Bands: 2-3

Criteria	Marks
• Correct acceleration.	2
• Attempt to use constant acceleration formula or formulae.	1

Sample Answer:

$s_y = u_y t + 1/2 a_y t^2$

$-0.1 = 0 + \frac{1}{2} a_y 1^2$

$a_y = -0.2$ ms^{-2} or 0.2 ms^{-2}downwards

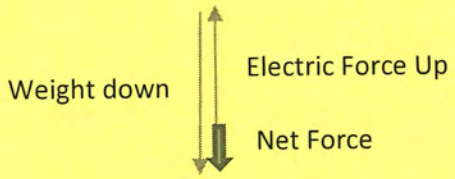
26 (b) (2 marks)

Outcomes Assessed: 12-12/13

Targeted Performance Bands: 4-5

Criteria	Marks
• Shows the two force vectors -electric up and gravity down. • Gravity is bigger than electric	2
• Shows the two force vectors-electric up and gravity down	1

Sample Answer:



26 (c) (3 marks)

Outcomes Assessed: 12-13
Targeted Performance Bands: 4-5

Criteria	Marks
• Correct answer for q	3
• Correct calculation of two of the following ○ Net Force ○ Electric Field ○ Gravitational Force ○ Combining forces using correct directions	2
• Correct calculation of one of the above points.	1

$F_{net}=ma=8 \times 10^{-6} \times(-0.2)= -1.6 \times 10^{-6}$ *or* 1.6×10^{-6} *downwards*

$$E = \frac{V}{d} = \frac{10}{0.1} = 100\ Vm^{-1}$$

$F_{net}\downarrow=mg\downarrow+Eq\uparrow$

$-1.6 \times 10^{-6}=8 \times 10^{-6} \times(-9.8)+ 100 \times q$

$q=-7.68 \times 10^{-7}\ C$

Question 27 (5 marks)

27 (a) (2 marks)

Outcomes Assessed: 12-14

Targeted Performance Bands: 3-5

Criteria	Marks
• Correct answer using W=qV formula and answer in Joules OR answer in eV	2
• Attempts to use Work equation OR recognises that KE = work done	1

Sample Answer:

$KE_{max}=W=qV=1.602 \times 10^{-19} \times 2.7= 4.3254 \times 10^{-19}$ J $= 4.3254 \times 10^{-19}/1.602 \times 10^{-19}=2.7$eV
OR 2.7V of work on an electron is 2.7 eV.

27 (b) (3 marks)

Outcomes Assessed: 12-14

Targeted Performance Bands: 3-5

Criteria	Marks
• Correct answer including ○ Correct conversion from eV to Joules ○ Correct use of $K_{max} = hf-\phi$ ○ Correct use of $c=f\lambda$	3
• Two of the above points correctly completed	2
• One of the above points correctly completed	1

Sample Answer:

$K_{max} = hf-\phi$
$4.3254 \times 10^{-19} = 6.626 \times 10^{-34}f - 4.7 \times 1.602 \times 10^{-19}$
$f= 1.789 \times 10^{15}$ Hz
$c=f\lambda$
$\lambda=3 \times 10^{8}/1.789 \times 10^{15}=1.6768 \times 10^{-7}m = 167nm$
OR
$K_{max} = hf-\phi$
$2.70=hf-4.70$
$hf=7.4$ eV $=7.4 \times 1.602 \times 10^{-19} =1.185 \times 10^{-16}$J
$6.626 \times 10^{-34}f=1.185 \times 10^{-16}$
$f=1.789 \times 10^{15}$ Hz
$c=f\lambda$ so $\lambda=3 \times 10^{8}/1.789 \times 10^{15}=1.6768 \times 10^{-7}m = 167nm$

Question 28 (9 marks)
28 (a) (2 marks)
Outcomes Assessed: 12-15
Targeted Performance Bands: 3-4

Criteria	Marks
• Correct estimate of half life from graph (0.83-0.85) • Correct value for decay constant using formula	2
• One of the points above	1

Sample Answer:
Finding Half Life from the graph. 100 to 50 is about 0.84 s 40 to 20 is 0.85 s.
$\lambda = \frac{ln2}{t_{1/2}} = \frac{ln2}{0.84} = 0.8251 = 0.83s^{-1}$

28 (b) (2 mark)
Outcomes Assessed: 12.15
Targeted Performance Bands: 4-5

Criteria	Marks
• Same as detector 1 established • Justified using clear explanation of frames of reference in Special relativity (Einstein's First Postulate)	2
• Correct statement about same physics in all inertial frames of reference	1

Sample Answer:

Detector 3 will show the same results as detector 1. This is because the detector 1 & 3 are both moving at the same speed as the experiments they are measuring. Thus we will not see any difference in the physics for the two detectors as they are each in the same inertial frames of reference as the experiment they are detecting. (Detector 2 will see time dilation as the experiment is moving relative to the detector.)

Einstein's First postulate stated that the laws of physics are the same in all inertial frames of reference. So the half life measurements should have the same results as the first detector which was in the same frame of reference as the stationary radioisotope.

28 (c) (3 marks)
Outcomes Assessed: 12-14
Targeted Performance Bands: 4-5

Criteria	Marks
• Correct readings for both half-life graphs • Substituted correctly into formula • Correct calculation	3
• Two of the points above	2
• One of the points above	1

Sample Answer:

Using the half lives from the two graphs
T_0=0.84s T=1.45s

$$T = \frac{T_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

1

$$1.45 = \frac{0.84}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\frac{v}{c} = 0.8151 = 0.82c \;\; OR \;\; 2.45 \times 10^8 \; m/s$$

28 (d) (2 marks)
Outcomes Assessed: 12-14
Targeted Performance Bands: 4-6

Criteria	Marks
• Proposed an experiment that validated special relativity • Explained how it worked	2
• Proposed an experiment that validated special relativity	1

Sample Answer:

Comparing regularly timed events at different speeds relative to the detectors can be seen in the Hafele Keating experiment.
In atomic clocks the regular oscillation of electrons in atoms is a physical process that happens at a precise rate. In 1971 The Hafele Keating experiment had four atomic clocks taken on airliners flying directly east and then directly west. The clocks were found to disagree with clocks left behind the US. Their differences were explainable using special relativity. Thus the clock processes were happening more slowly in some reference frames compared to others. The principle of Time Dilation was supported.
Note: Muon decay experiment would also be a good example for students to use.

Question 29 (8 marks)

29 (a) (4 mark)
Outcomes Assessed: 12-14
Targeted Performance Bands: 3-5

Criteria	Mark

• Comparison of the two experiments showed a thorough knowledge of
  • Safety aspects of lasers and hydrogen lamps.
  • Advantage of using each equipment
  • Disadvantage of using each method
  • Equipment and measurements required
	4

• Demonstrating a knowledge of the experimental methods students achieved 3 points from the above list.	3
• Demonstrating a knowledge of the equipment required students fulfilled 2 of the criteria above	2
• Students demonstrated some knowledge of the equipment.	1

Sample Answer:

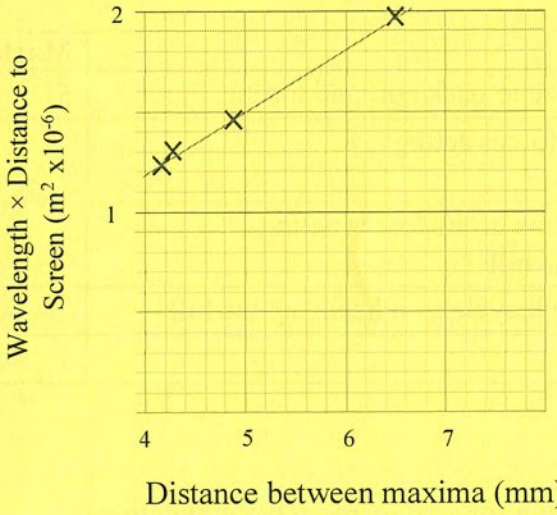
Student A uses lasers that do not use high voltages but are dangerous to the eyes. The double slit experiment will produce precise dots on a distant screen. No single slit would be required before the double slit. It is achievable in a room that is not totally dark.
Student B uses a hydrogen lamp which runs at high voltages and so must be used with great care not to touch. The light needed to be sent through a single slit first before going through a double slit. All the bands of four colours will be displayed at once. So time will be saved the room must be very dark.

Both experiments would work and need a distant screen to be able to measure the small angle of diffractions.
The lasers would be easier to set up as the light source is coherent and no single slit would be needed.

29 (b) (3 marks)
Outcomes Assessed: 12-5
Targeted Performance Bands: 3-5

Criteria	Marks
• Accurate plotting of all four points with axes drawn with correct scale and correct units included on labels. • Line of best fit is straight, is close to all points and points are scattered evenly above and below the line. • Calculation of slope is clear and correct.	3
• Two correct from above	2
• One correct from above	1

Sample Answer:



Slope =rise/run=$(2\times10^{-6}-1.2\times10^{-6}/(6.6\times10^{-3}-4.05\times10^{-3})=3.14\times10^{-4}$ or 0.314 mm

29 (c) (1 mark)
Outcomes Assessed: 12-5
Targeted Performance Bands: 4-5

Criteria	Marks
• A suitable explanation is given.	1

Sample Answer:

In the mathematical method each measurement is given equal importance for the calculation. However, one measurement might be an outlier. The graphical method enables the scientist to spot outliers and hence ignore them.

Question 30 (5 marks)
Outcomes Assessed: 12-13
***Targeted Performance Bands*: 3-5**

Criteria	Mark
• Provides thorough explanation incorporating reference to back emf and torque	5
• Explains both the slowing of the bicycle in terms of forces acting • Relates the increase of current to the back emf	4
• Adequately explains the slowing of the bicycle in terms of the forces acting • Adequately explains the increase in the current on the hill	3
• Reference to the net force and the acceleration of the bicycle as it heads up the hill.	2
• Some relevant reference to the weight force	1

Sample Answer:

To head up the hill, the motor must work against the weight force to increase the gravitational potential energy of the bicycle. This is in addition to the frictional forces already acting against the motion. As a result, there will initially be a net force acting down the hill and the bicycle will slow down.

As the rate at which the motor spins decreases, the back emf reduces. The current passing through the motor therefore increases. This results in an increasing torque on the motor. The rotation and back emf continues to decrease until the torque produced by the motor balances the increased forces on the wheels. The bicycle continues up the hill at a constant (but lower) speed.

Question 31 (6 marks)

31 (a) (3 marks)
Outcomes Assessed: 12-12
Targeted Performance Bands: 4-5

Criteria	Marks
• Correct formulae using both Kinetic and Gravitational Energy • Correct formula substitution • Correct use of the -ve sign in the working	3
• 2 correct from above list	2
• 1 correct from above list	1

Sample Answer:
K=-1/2U U=-GMm/r
Total Energy=U+K=U-1/2U=U/2
Total Energy=-GMm/2r= $-\frac{6.67\times10^{-11}\times6.0\times10^{24}\times920}{2\times44428000}$ =4143603133=4.14×10^{9} J

31 (b) (2 marks)
Outcomes Assessed: 12-12
Targeted Performance Bands: 4-6

Criteria	Marks
• Correct subtraction of the two energy values	2
• Correct process but incorrect substitution or incorrect use of the -ve sign.	1

Sample Answer:
At the initial orbital radius of 44,428 km: -4.14 GJ

At the final orbital radius of 42, 164km

$$T = -\frac{GMm}{2r}$$

$$= -\frac{(6.67\times10^{-11})\times(6.00\times10^{24})\times920}{(2\times42164000)}$$

$$= -4.37 \text{ GJ}$$

To calculate work:

$$\Delta E = E_f - E_i$$
$$= -4.37 - (-4.14)$$
$$= -4.37 + 4.14$$
$$= -0.230 \text{ GJ}$$

31 (c) (1 marks)
Outcomes Assessed: 12-12
Targeted Performance Bands: 5-6

Criteria	Marks
• States that the energy is lower. Justified by the mathematics in part b of the two energies.	1

Sample Answer:
The satellite's total energy has decreased from –4.14 to –4.37 GJ so it has lost energy equivalent to the work done. This is shown by the fact that the change in energy has a negative sign. (The way that gravitational energy is defined, with energy at infinity being zero, means that a more negative number means less energy)

Question 32 (10 marks)

32 (a) (1 marks)
Outcomes Assessed: 12-13
Targeted Performance Bands: 3-4

Criteria	Marks
• Arrows clearly show current going in anticlockwise direction in both coils	1

Sample Answer

Current in both coils goes in the anticlockwise direction

32 (b) (6 marks)
Outcomes Assessed: 11/12-4, 12-13
Targeted Performance Bands: 2-6

Criteria	Marks
• Mentions sensible safety protocols and the need to avoid parallax error on ruler. • Includes changing one quantity (B or V) systematically to get a spread of values • Includes the measurement of radius using the ruler. • Includes repetition of each value to check reliability. • Demonstrates understanding of why the path is circular. ($qvB=mv^2/r$) • Suggests altering B (or V) to get a circular path and hence a good value for r.	5-6
• Includes 3-4 points from the above list	3-4
• Includes1-2 points from the above list	1-2

Sample Answer:

Safety: Establish protocols for using high voltage equipment. Eg do not work alone, have one hand in your pocket and don't touch the equipment when it is switched on.

Method:
1 Stand directly in front of the equipment (to avoid parallax error when reading the ruler) and switch on the current in the coil and electron gun voltage.
2 Starting from zero voltage increase the voltage until a clear curve of electron beam can be seen in the flask. Alter the magnetic field until the beam hits the left side of the electron gun. (ie is perfectly circular)
3 Read the diameter of the circle and divide by two to obtain the radius.
4 Record the values for r, B and V
5 Take 10 more readings spreading the voltage evenly up to 500 Volts.
6 Repeat the same readings to see if the radius values are coming out reliably.
7 Calculate the value for q/m using the equations.

32 (c) (2 marks)
Outcomes Assessed: 11/12-2,3 12-13
Targeted Performance Bands: 5-6

Criteria	Marks
• Gets the correct relationship.	3
• Attempts to use W=qV, F=mv^2/r and F=qvB • Some logical working	2
• Works with some formulae	1

Sample Answer

Formulae: for settings of Accelerating Voltage (V) on the electron gun the electrons will travel at different speeds (v). The speeds are determined by the formula
W=qV= ½ mv^2

$$\therefore v = \sqrt{\frac{2qV}{m}}$$

Using the equipment for each setting of the Voltage alter the Magnetic field (B) until a complete circle is obtained in the flask. For this circle measure the diameter of the circle using the ruler. Halve the diameter to find r. The magnetic force acts as the centripetal force therefore

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

$$\therefore v = \text{qBr/m}$$

$$\therefore \sqrt{\frac{2qV}{m}} = \frac{qBr}{m}$$

$$\frac{2qV}{m} = \frac{q^2B^2r^2}{m^2}$$

$$\frac{q}{m} = \frac{2V}{B^2r^2}$$

Question 33 (9 marks)
Outcomes Assessed: 12-14/15
Targeted Performance Bands: 3-6

Criteria	Marks
• Clearly outlines at a wide variety of discoveries related to atoms, stars and universe • Indicates a clear understanding of what spectroscopy is. • Discoveries range from work of Hubble to work of Bohr and beyond. • Demonstrates extensive knowledge on this subject.	8-9
• Outlines a variety of discoveries that are related to spectroscopy. • Relates them to change in view of atom or universe. • Indicates an understanding of what spectroscopy is. • Covers both universe and atom examples.	6-7
• Outlines some discoveries that are related to spectroscopy. • Relates them to change in view of atom, stars or universe.	4-5
• Outlines at some examples of discoveries that are related to spectroscopy	2-3
• Gives some examples of spectroscopy usage.	1

Sample Answer:

Spectroscopy is taking the light from star or gaseous element and splitting that light into the individual colours using a prism or diffraction grating. This results in spectra including spectral lines which can be bright if emitted from atoms or dark lines if absorbed by atoms.

Changes in our view of the stars and universe

1 It was the study of galaxy spectra that enabled Hubble to discover a Doppler shift in the spectra establishing the theory that the universe is expanding according to Hubble's Law. This led to the idea of a beginning to the universe (the Big Bang Theory)

2 Stella spectra establish that there is plenty of Helium in stars which indicates that Helium was present before the formation of stars. This helps establish the idea that the universe was once very dense and very hot. This is part of the steps in the Big Bang theory.

3 Comparing the Sun's spectra to other stars enabled scientists to establish that the sun is the same as other stars. Thus the universal laws apply to our solar system and beyond. This has led to scientists confidently studying the universe using the laws of physics we have established on Earth.

4 Stella spectra also enabled scientists to know the elements present in stars by comparing spectral lines in stars with emission spectra of elements in evacuated flasks in the laboratory,

5 The density of stars outer layers and the surface temperature of stars was found by studying the thickness of the spectral lines. Thick lines meant denser atmospheres.

6 The surface temperature of stars was found by studying the darkness of the hydrogen lines and other clues including the presence of lines from molecules rather than just elements. Suggesting cooler star surfaces.

7 From this the nuclear reactions within stars have been found AND the life cycle of stars has been established. We now know for example that our Sun will not last forever and in fact has about 5 billion years to go before it becomes unstable.

8 Spectroscopy also confirms that Stars in the center of the galaxy are rotating about an invisible giant mass (a black hole) and that the galaxy is rotating.

Changes in our view of the atom

The study of the spectra of the elements has also changed our view of the structure of the atom.
9 Balmer used the spectrum of hydrogen to establish the Rydberg equation which shows a mathematical relationship between the wavelengths of the spectral lines of Hydrogen. This led Bohr to develop his idea of the quantum nature of the electron orbits. This led to quantum physics as a whole.
10 The electron orbits led to the study of standing waves of matter by de Broglie AND the Heisenberg uncertainty principle. Changing our entire view on matter vs waves.
Hence the study of spectroscopy has totally changed our view of the universe and the atom.