

**Semester 2 Examination, 2022 Question/Answer booklet**

**PHYSICS**

**Units 3 & 4**

**MARKING KEY**

**Time allowed for this paper**

Reading time before commencing work: ten minutes

Working time: three hours

**Materials required/recommended for this paper**

***To be provides by the supervisor***

This Question/Answer booklet

Formulae and Data booklet

***To be provided by the candidate***

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener,

correction fluid, eraser, ruler, highlighters.

Special items: up to three non-programmable calculators approved for use in the WACE examinations, drawing templates, drawing compass and a protractor.

**Important note to candidates**

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised material. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

**Structure of this paper**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Section | Number of Questions | Questions to be answered | Suggested working time (minutes) | Marks available | Percentage of exam |
| Section One  Short Response | 10 | 10 | 50 | 54 | 30 |
| Section Two  Problem Solving | 6 | 6 | 90 | 90 | 50 |
| Section Three  Comprehension | 2 | 2 | 40 | 36 | 20 |
| **Total** | 180 | 100 |

**Instructions to candidates**



1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 11 Information Handbook 2022: Part II Examinations.* Sitting this examination implies that you agree to abide by these rules.
2. Write your answers in this Question/Answer booklet preferably using a black/blue pen. Do not use erasable or gel pens.
3. You must be careful to confine your answers to the specific questions asked and follow any instructions that are specific to a particular question.
4. When calculating or estimating answers, show all your working clearly. Your working should be in sufficient detail to allow your answers to be checked readily and for marks to be awarded for reasoning.

In calculations, give final answers to three significant figures and include appropriate units where applicable.

In estimates, give final answers to a maximum of two significant figures and include appropriate units where applicable.

1. Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate in the original answer where the answer is continued, ie – give the page number.
2. The Formulae and Data booklet is not to be handed in with your Question/Answer booklet.



**Section One: Short Response 30% (54 marks)**

This section has ten (10) questions. Answer **all** questions. Write your answers in the spaces provided.

Suggested working time: 50 minutes.

**Question 1 (5 marks)**

1. Calculate the expected combined mass of these two particles in kilograms. Use your Formulae and Data Booklet.

(3 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |

1. Calculate the electric charge on a Kaon meson.

(2 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |

**Question 2 (6 marks)**

1. Calculate the velocity of spaceship ‘X’ relative to ‘Y’ and ‘Z’.

(3 marks)

|  |  |
| --- | --- |
|  |  |
|  | 1 mark |
|  | 1 mark |
| 3 sf | 1 mark |

1. State and explain which observer or spaceship external to Spaceship ‘Y’ will view the length of Spaceship ‘Y’ as the longest **and** which will view the length as the shortest. (3 marks)

|  |  |
| --- | --- |
| Longest: observer on spaceship ‘Z’; shortest: observer on spaceship ‘X’. | 1 mark |
| Velocity of spaceship ‘Z’ relative to spaceship ‘Y’ is zero (same Inertial Reference Frame); observers on ‘Z’ will observe true length of ‘Y’. | 1 mark |
| Velocity of spaceship ‘X’ relative to spaceship ‘Y’ is the highest value (0.940c); hence, will observe the greatest length contraction. | 1 mark |

**Question 3 (6 marks)**

Calculate ‘ϴ’ and, hence, the period (T) of the object’s circular motion. Show all working.

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |

**Question 4 (5 marks)**

1. State the direction in which conventional current must be flowing in the copper tube.

(1 mark)

|  |  |
| --- | --- |
| Out of the page | 1 mark |

1. Calculate the strength of the magnetic field (B) between the poles of the horseshoe magnet if a current of 1.30 A is flowing in the copper tube.

(4 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |

**Question 5 (7 marks)**

An electron in an electron microscope is accelerated by an electric potential to 15.0% of the speed of light.

1. Calculate the de Broglie wavelength for this electron. As part of your answer, calculate the **relativistic** momentum of the electron at this speed.

(4 marks)

|  |  |
| --- | --- |
| Relativistic momentum: | 1 mark |
|  | 1 mark |
| De Broglie wavelength: | 1 mark |
|  | 1 mark |

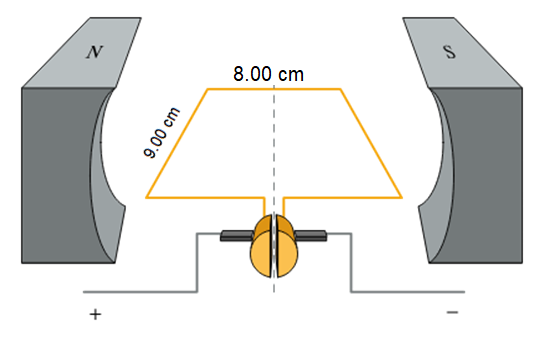
1. Atoms have a size that is on a scale of 10-10 metres. Explain how the electron beam in part a) would need to be changed to achieve maximum resolution of objects at this scale.

(3 marks)

|  |  |
| --- | --- |
| The de Broglie wavelength of the electron beam would need to be increased in magnitude. | 1 mark |
| Hence, the relativistic momentum of the electron beam would need to be decreased. | 1 mark |
| This can be achieved by reducing the relativistic speed and mass of the electrons. By reducing the velocity (can’t reduce mass of electrons??) | 1 mark |

**Question 6 (4 marks)**

A simple DC motor, 8.00 cm wide and 9.00 cm long, rotates through a magnetic field of 0.430 T at a rotational operating speed of 11.5 m s-1. The motor consists of 70 turns of conductor wire.



1. Calculate the Back EMF induced in the coil at the operating speed. (3 marks)

|  |  |
| --- | --- |
|  | Finds period of rotation (1 mark) |
|  | Calculates time for quarter-turn (1 mark) |
|  | Calculates voltage (1 mark) |

1. If the supply voltage is 140.0 V, and the resistance in the coil is 55.0 Ω, find the average current through the coil once it has reached operating speed. (1 mark)

|  |  |
| --- | --- |
|  | Calculates current correctly (1 mark) |

**Question 7 (4 marks)**

A particle interaction called ‘electron capture’ can be represented by the following incomplete equation:

1. Write the name and symbol of the unidentified particle in the spaces provided below.

(2 marks)

|  |  |
| --- | --- |
| Electron neutrino | 1 mark |
|  | 1 mark |

1. Using relevant conservation laws, explain how you determined the unidentified particle in part a).

(2 marks)

|  |  |
| --- | --- |
| To conserve electric charge, the particle must have a neutral charge (Q = 0). | 1 mark |
| To conserve baryon number, the particle must have a quantum number B = 0; and to conserve lepton number, the particle must have a quantum number L = 1. | 1 mark |

**Question 8 (5 marks)**

1. The intensity of the incident electromagnetic radiation is slowly increased whilst the wavelength remains constant. Explain what happens to the current measured in the ammeter.

(2 marks)

|  |  |
| --- | --- |
| Increasing the intensity of the incident electromagnetic radiation without changing the wavelength will increase the number of photons incident on the metal surface. | 1 mark |
| This will increase the rate of production of photoelectrons and, hence, increase the reading on the ammeter. | 1 mark |

1. The intensity of the incident electromagnetic radiation is returned to its original value and its wavelength is continually increased. Explain what would be observed by the ammeter over time.

(3 marks)

|  |  |
| --- | --- |
| Increasing the wavelength of the incident electromagnetic radiation will decrease its photon energy. | 1 mark |
| ~~This will decrease the kinetic of the photoelectrons and, hence, decrease the reading on the ammeter.~~  Current would remain constant until it reaches the threshold frequency. | 1 mark |
| Eventually, the frequency of the incident radiation will become less than the threshold frequency and zero photoelectric current will be detected in the ammeter. | 1 mark |

**Question 9 (7 marks)**

1. An electron undergoes a downward transition between n = 6 and n = 4. As a result, a photon of wavelength 548 nm is emitted. Calculate the value (in eV) of energy level n = 6.

(4 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |

1. If an electron of energy 5.00 eV bombards a mercury atom in ground state, calculate **all** the possible energies of the electrons after they have been scattered.

(3 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |

**Question 10 (6 marks)**

1. Explain how the airplane can create a ‘weightless’ environment at the top of the vertical circle. Include a diagram showing the force(s) acting on the airplane at this point, including the resultant force.

(3 marks)

W = mg

∑F = Fc

|  |  |
| --- | --- |
| Vector diagram shows two (2) vectors: net force/centripetal force (∑F or Fc). | 1 mark |
| Both vectors are the same length. | 1 mark |
| If weight = centripetal force, normal force (N) will be equal to zero. | 1 mark |

1. Calculate the speed ‘v’ at which this airplane would need to be travelling to simulate a weightless environment at the top of the vertical circle.

(3 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |

**END OF SECTION ONE**

**Section Two: Problem Solving 50% (90 marks)**

This section contains six (6) questions. Answer **all** questions. Answer the questions in the space provided.

Suggested working time is 90 minutes.

**Question 11 (15 marks)**

1. Explain how the motion of a bobsled changes on the banked turn as its speed ‘v’ increases.

(2 marks)

|  |  |
| --- | --- |
| For a fixed value of ‘ϴ’, increasing ‘v’ will cause a corresponding increase in ‘r’. | 1 mark |
| For this to occur, the car must move higher up on to the banked track. | 1 mark |

Using appropriate equipment, the officials gathered the following data.

|  |  |  |  |
| --- | --- | --- | --- |
| v (kmh-1) | v (ms-1) | v (m2s-2) | r (m) |
| 95 | 26.4 | 697 | 193 |
| 100 | 27.8 | 772 | 215 |
| 105 | 29.2 | 853 | 238 |
| 110 | 30.6 | 936 | 264 |
| 115 | 31.9 | 1020 | 285 |
| 120 | 33.3 | 1110 | 312 |

1. Complete the table by calculating the missing values in the table above. Show any calculations in the space below.

(2 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |

1. On the grid on the next page, plot a graph of ‘v2’ against ‘r’. Place ‘r’ on the y-axis. Draw a line of best fit or the data.

(4 marks)

(4 marks)

r (m)

v2 (m2s-2)

|  |  |
| --- | --- |
| Axes correctly labelled – ‘r’ on y axis. | 1 mark |
| Axes labelled with correct units (see graph above). | 1 mark |
| Points correctly plotted. | 1 mark |
| Line of best fit correctly drawn. | 1 mark |

1. Calculate the gradient of the line of best fit. Show clearly how you did this. Include units in your answer.

(4 marks)

|  |  |
| --- | --- |
| Uses points from the line of best fit: (1070, 300) and (560, 150) | 1 mark |
|  | 1 mark |
|  | 1 mark |
| Units: s2m-1 | 1 mark |

1. Use the gradient from part d) to calculate an experimental value for ‘g’ (acceleration due to gravity on the Earth’s surface).

(3 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |

**Question 12 (18 marks)**

1. Explain how a current reading can be sent to the meter without the clamp touching the conductor.

(4 marks)

|  |  |
| --- | --- |
| The AC current in the conductor creates an alternating magnetic field around the iron clamp. | 1 mark |
| This creates a changing flux through the secondary coil. | 1 mark |
| The changing flux induces an alternating EMF, according to Faraday’s Law. | 1 mark |
| Hence, an induced current/signal is sent to the meter. | 1 mark |

1. Calculate the peak current (IPEAK) in the conductor.

(2 marks)

|  |  |
| --- | --- |
|  | 1 mark |
| (accept a positive value only) | 1 mark |

1. Calculate the maximum magnitude of the magnetic field strength at the distance where the clamp is positioned.

(2 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |

1. Calculate the maximum flux change experienced by the coil if its cross-sectional area is 4.00 cm2. [If you were unable to calculate an answer for part c), use a value of 1.30 x 10-4 T]

(4 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |

1. Hence, calculate the average EMF (Ɛ) generated in the secondary coil if it consists of 250 turns.

(3 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |

1. Would this particular type of circuit clamp work for a DC circuit? Explain.

(3 marks)

|  |  |
| --- | --- |
| No. | 1 mark |
| A DC power supply would not create a change in flux through the iron clamp. | 1 mark |
| Hence, no change in flux will occur through the secondary coil and zero EMF/current will be induced. | 1 mark |

**Question 13 (14 marks)**

1. Calculate the tension in each cable when the tarmac sections are in the position shown.

(4 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |
|  | 1. mark |

1. Hence, calculate the magnitude and direction (find the angle with the vertical) of the force on each hinge when the tarmac sections are in this position. (If you were unable to calculate a value for part a), use 2.70 x 104 N)

(6 marks)

|  |  |
| --- | --- |
|  | 1-2 marks |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |

1. Use this data to calculate the average force of friction experienced by the bin on the tarmac.

(4 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |

**Question 14 (13 marks)**

1. Calculate the horizontal component (uh) of the athlete’s launch velocity ‘v’.

(2 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |

1. Using the vertical displacements shown, calculate the vertical component (uv) of the athlete’s launch velocity ‘v’.

(4 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |

1. Hence, calculate the magnitude of the launch velocity ‘v’ and the launch angle ‘ϴ’. [If you were unable to calculate answers for parts a) and b), use values of 8.00 ms-1 and 3.40 ms-1 respectively]

(4 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |

1. State how the horizontal length of the athlete’s jump could be expected to change if it took place in Mexico City. Explain two (2) reasons for your answer. Air resistance can be considered in this question.

(3 marks)

|  |  |
| --- | --- |
| Expected range would be greater than 6.85 metres. | 1 mark |
| REASON 1: At this altitude, g < 9.80 ms-2. Hence, flight time would be longer. | 1 mark |
| REASON 2: At this altitude, air resistance is lower than at sea level (the air is thinner). | 1 mark |

**Question 15 (17 marks)**

1. Each H-2+ ion achieves a speed of 6.19 x 105 ms-1. Calculate the magnitude of the accelerating potential (in Volts). The mass of a H-2+ ion is 3.34 x 10-27 kg.

(4 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |

1. In Stage 2 (Velocity Selection), the effects of an electric field and a magnetic field combine to ensure the velocity of the H-2+ ions are constant and in a straight line.
2. Given the direction of the electric field in STAGE 2, state the direction of the magnetic field by circling the correct option.

(1 mark)

|  |  |
| --- | --- |
| INTO THE PAGE. | 1 mark |

1. Derive an expression showing the relationship between the electric field strength ‘E’; the magnetic field strength ‘B’, and the speed of the H-2+ ions ‘v’.

(2 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |

1. (i) Based on the diagram, state the direction of the magnetic field in the chamber.

(1 mark)

|  |  |
| --- | --- |
| Out of the page. | 1 mark |

1. Explain why the chamber is filled with a vacuum. As part of your answer, describe how the path of the beam of H-2+ ions would change if the chamber was filled with a low-pressure gas.

(3 marks)

|  |  |
| --- | --- |
| If the chamber was filled with a low-pressure gas, the H-2+ ions would collide with these atoms reducing their EK and speed ‘v’. | 1 mark |
| The radius ‘r’ of the circular path taken by the ions is given by:  , so, if ‘v’ decreases, ‘r’ decreases and a spiral path will result. | 1 mark |
| Therefore, a vacuum ensures a constant speed ‘v’ and radius ‘r’. | 1 mark |

1. (i) Use the appropriate formulae in your data booklet to derive the following expression for the frequency ‘f’ of the charged particle’s rotation in the field:

where B = magnetic field strength (T);

q = electric charge on the particle (C); and

m = mass of the particle (kg).

(4 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |
| (cancels out ‘r’) | 1 mark |
|  | 1. mark |

(ii) Hence, calculate the frequency of circular rotation of the H-2+ ions if the magnetic field strength in the vacuum chamber is 1.20 T.

(2 marks)

|  |  |
| --- | --- |
|  |  |
|  | 1 mark |
|  | 1 mark |

**Question 16 (13 marks)**

1. Calculate the transmission current in the line between the AC generator and the substation.

(2 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |

1. Hence, calculate the power lost in the transmission line between the AC generator and the substation.

(2 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |

1. Calculate the electric power generated at the AC generator.

(2 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |

1. Determine the voltage at which electric power is generated at the AC generator.

(2 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |

1. Calculate the ideal turns ratio in the transformer at the substation.

(2 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |

1. If all other factors were kept equal, would an increase in AC frequency from 50 Hz to 60 Hz increase or decrease the power loss in a transformer due to eddy currents? Explain.

(3 marks)

|  |  |
| --- | --- |
| Increasing the AC power frequency will also increase the rate of change of flux due to the alternating currents in the transformer coils. | 1 mark |
| Increasing the rate of change of flux will increase the size of the eddy currents generated in the iron cores. | 1 mark |
| Hence, power losses due to eddy currents will also increase. | 1 mark |

**END OF SECTION TWO**

**Section Three: Comprehension 20% (36 marks)**

This section has two (2) questions. Answer **both** questions. Answer the questions in the spaces provided.

Suggested working time: 40 minutes.

**Question 17 (18 marks)**

1. Using information from the article - and data from your Formulae and Data Booklet – calculate the centripetal force acting on the James Webb Telescope while it is in orbit at L2 La Grange Point. [Note, the distance between the Earth’s centre of mass and L2 is 1.5 million kilometres].

(3 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |

1. (i) State the orbital period (T) of the James Webb Telescope around the Sun in seconds.

(2 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |

(ii) Hence (or otherwise) calculate the average orbital speed of the James Webb Telescope around the Sun.

(3 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |
| OR |  |
|  | 1 mark |
|  | 1 mark |
|  | 1 mark |

1. The James Webb Telescope is tuned to infrared radiation that is emitted by extremely distant luminous objects (eg – galaxies). To be able to detect this faint IR radiation, the telescope needs to be cooled to a very low operating temperature of 50 K. Suggest a reason for this.

(3 marks)

|  |  |
| --- | --- |
| The infrared radiation from different galaxies will be very low intensity. | 1 mark |
| At greater than 50 K, the JWT will emit black body radiation in the infrared region. This will overwhelm the faint incoming infrared signals from distant objects. | 1 mark |
| By cooling the JWT to 50 K or less, the JWT will emit body radiation in the radio waves region and not interfere with the faint incoming infrared signals. | 1 mark |

1. The James Webb Telescope’s four instruments collect radiation in the 0.5 to 28 micron range. Calculate the corresponding frequency range for these instruments.

(2 marks)

|  |  |
| --- | --- |
|  | 1 mark |
|  | 1 mark |

1. Explain why conducting astronomy in the infrared region of the electromagnetic spectrum will allow the James Webb telescope to view the Universe as it was 100 million to 250 million years after the Big Bang.

(3 marks)

|  |  |
| --- | --- |
| Ever since the Big Bang 13.7 billion years ago, the Universe has been expanding. | 1 mark |
| Stars and galaxies formed about 100 million to 250 million years after the Big Bang. | 1 mark |
| The light emitted by these first stars and galaxies is still travelling to us and has been redshifted into the infrared region. | 1 mark |

1. The first light emitted in the Universe – the Cosmic Microwave Background Radiation – is evidence supporting Big Bang Theory. Explain.

(2 marks)

|  |  |
| --- | --- |
| According to Big Bang Theory, the Universe was filled with plasma which absorbed and scattered any radiation travelling through it. | 1 mark |
| About 380 000 years after the Big Bang, atoms began to form, and radiation was no longer absorbed or scattered – the CMB is a remnant of this radiation. | 1 mark |

\*Accept alternative: CMBR was predicted to exist as a consequence of the Big Bang (a microwave signal emanating from all directions) (1). This was confirmed (accidentally) through observations by Penzias & Wilson, providing evidence for the theory (1).

**Question 18 (18 marks)**

**Hubble’s Law**

When a source of waves is moving, a stationary observer notices a change in frequency of the waves. This effect is observed for both longitudinal and transverse waves. For example, if an ambulance moves towards you the sound frequency you hear is higher than the frequency its siren is emitting. This is known as the Doppler Effect.

If a source of electromagnetic waves, such as a star, is travelling away from an observer then the wavelengths of the lines in its electromagnetic spectrum are shifted to higher values. This is called red shift. An equation for the relationship is as follows:

z = red shift

Δλ = change in wavelength (moving source) (nm)

λ = wavelength of stationery source (nm)

v= recessional speed of galaxy (m s-1)

c0 = speed of light in a vacuum (m s-1)

 It can also be shown that: 

Edwin Hubble analysed the red shifts of various galaxies in 1920 and deduced that most galaxies are moving away from the Earth, this suggests that the Universe is expanding. Hubble also discovered that the further away a galaxy is, the bigger its red shift and the faster it is moving away. This relationship is known as Hubble’s Law and can be stated algebraically as follows:

v galaxy = recessional speed of galaxy (km s-1)

d = distance to galaxy (Mpc)

H0 = Hubble’s constant (km s-1 Mpc-1)



The distances to galaxies can be estimated by observing Cepheid Variables within a galaxy. A Cepheid Variable is a class of star that pulsates. The relationship between the period of pulsation and the size of the star is very precise. An understanding of how brightness diminishes with distance allows astronomers to estimate distances to galaxies with a high degree of confidence.

The following data was recorded by the Hubble Space Telescope for five galaxies.

|  |  |  |
| --- | --- | --- |
| **Distance**  (Mpc) | **Red shift - z** | **Recessional speed of galaxy vgalaxy** (km s-1) |
| 3.1 | 0.00095 | 285 |
| 8.6 | 0.00212 | **636** |
| 12.2 | 0.00273 | **819** |
| 16.1 | 0.00402 | **1206** |
| 19.4 | 0.00473 | **1419** |

1. Fill in appropriate values in the final column of the table (the first value has been done for you)

As above ✓✓

(2)

1. Plot a correctly labelled graph of **recessional speed** versus **distance to galaxy** on the graph paper and draw a line of best fit .

(4)

Correct plotting ✓ labels✓ units✓ line of best fit ✓





1. Calculate a value for Hubble’s constant, in the correct units, showing how you obtained this value from your graph.

(3)

Identifies rise and run on line of best fit ✓ (not data points)

H0 = gradient = rise / run

H0 = 1440 / 20 ✓

H0 = 72.0 km s-1 Mpc-1 ✓

Allow small range for “line of best fit” variations.

1. State two reasons why you think that measurements of Hubble’s constant have varied widely since Hubble’s first determination in 1920.

(2)

* Improved technology to measure red shift (diffraction gratings)
* Better telescopes (e.g. Hubble and others located in space – no atmospheric distortion.)
* More Cepheid Variables discovered – better averages on distance measurements.

Any 2 credible points ✓ ✓

Why does the value of red shift z, have no units?

(1)

Same units top and bottom so it is a ratio of length ✓

1. A line in the spectrum of ionised calcium has a wavelength of 393.3 nm when measured in the laboratory. When similar light from the galaxy NGC 3350 is measured, its wavelength is 394.64 nm. Use the red shift formulae to determine the recessional speed of this galaxy.

(2)

Δλ / λ = v / c0

v = (Δλ 🞩 c0) /λ

v = ((394.64 – 393.3) 🞩 3 🞩 108 ) / 393.3 ✓

v = 1.02 🞩 106 m/s ✓ ( = 1.02 🞩 103 km/s )

1. For the recessional speed you calculated in part f), use your graph and line of best fit to determine the distance to this galaxy in Mpc.

(1)

From the graph is approximately 14 Mpc ✓

1. Calculate the approximate Age of the Universe based upon your answer to part c):

(3)

✓

**END OF EXAMINATION**

**Additional working space and spare graph paper**

