Name of the Student:_____
Max. Marks : 17 Marks **Time : 17 Minutes**

Mark Schemes

Q1.

The marking scheme for this part of the question includes an overall assessment for the Quality of Written Communication (QWC). There are no discrete marks for the assessment of written communication but the quality of written communication will be one of the criteria used to assign the answer to one of three levels.

The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.

There are three areas:

Structure: silicon chip into pixels

The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.

Function: photon incident, electron excited, electron trapped in potential well, one electron per photon, no of electrons (and therefore charge) proportional to number of incident photons, after sufficient exposure charge on each pixel measured and image produced

Advantage: most will say the QE>70%

High Level (Good to excellent): 5 or 6 marks
The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.

A 6 mark answer need not be "perfect" but should be substantially complete, correct and free from major errors. One of the above points may be missing. Eg charge integration

The candidate provides a comprehensive and logical description of the structure of the CCD. The answer includes a clear description of how the light causes a release of charge and why the charge is stored. The answer also includes an explanation of what is meant by quantum efficiency and a correct value for the q.e. of a CCD.
Confusion with the photoelectric effect would reduce a 6 mark answer to 5.

5 marks may have 2 missing eg silicon chip and charge integration

Intermediate Level (Modest to adequate): 3 or 4 marks
The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.

4 probably has more than 2 missing or no correct advantage

The candidate provides a comprehensive and logical description of the CCD. The answer demonstrates some understanding of how the light is used to generate charge. The answer also includes some reference the efficiency of the CCD or other advantage

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Low Level (Poor to limited): 1 or 2 marks.
The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate.

The candidate demonstrates an understanding that an image is formed on the CCD and that this image is transferred to a computer.

Zero: Incorrect, inappropriate or no response.

Points that can be used to support the explanation:

- The CCD is a silicon chip
- The chip is divided into picture elements
- Each picture element is associated with a potential well in the silicon
- Incident photons are focused on the CCD
- The photons cause the release of electrons within the semiconductor
- The number of electrons liberated is proportional to the intensity of the light.
- Electrons are trapped in the potential wells
- An electron pattern is built up which is identical to the image formed on the CCD
- When exposure is complete the charge is processed to form an image.

Advantages:
High quantum efficiency > 70%
Light integration – using long exposure times to capture faint images.
Device can be directly linked to computer for capture and analysis.

6

[6]

Q2.

(a) (i) Similarity both would appear the same <u>brightness</u>
As the apparent magnitudes are the same ✓

Description and explanation needed for mark.

Any references to same size gets zero for 1st mark.

Difference Kocab would appear orange / red, Polaris yellow / white
Due to their spectral classes / different temperatures ✓

Allow different colours + ref to spectral class for second mark

If colour named, should be correct.

2

(ii) Polaris is further from Earth:

Alternative:

Polaris hotter and same size

Both stars same size and Polaris is hotter ✓

As $P = \sigma AT^4$

Hence, Polaris has brighter absolute magnitude / is intrinsically brighter

Same A, would mean that Polaris has greater power output. ✓

Polaris must be further from Earth to appear same brightness as Kocab. ✓

Same apparent brightness, therefore Polaris is further away.

3

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(b) (i) $v = Hd$

$v = 0.025 \times 3 \times 10^5 = 7.5 \times 10^3$ km s^{-1} ✓

1st mark is for calculating v

$d = 340 \times 10^6$ l yr = 340 / 3.26 Mpc = 104 Mpc ✓

2nd mark is for working out d in Mpc

$H = 7.5 \times 10^3 / 104 = 72$ kms^{-1} Mpc^{-1} ✓

3rd mark is for calculating H in the correct unit.

3

(ii) Age of Universe = 1 / H

1st mark is for the equation

$= 0.014 \times 10^6 \times 3.26 \times 9.5 \times 10^{15} / 1000$

2nd is for the answer with working

$= 4.3 \times 10^{17}$ seconds

(= 13.6 billion years)

Unit consistent with calculation.

3rd is for a time unit consistent with their answer / working

3

[11]

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