Name of the Student:_____
Max. Marks : 20 Marks **Time : 20 Minutes**

Mark Schemes

Q1.

(a) Line of best fit drawn through origin. ✔

Evidence of $\frac{\Delta v}{\Delta d}$ used. ✔

Age in range 4.1 to 5.1 × 10^{17} s ✔

Accept lines that intersect v / km s^{-1} = 12000 somewhere between d / Mpc = 160 and 200

Do not accept use of H = 65 km s^{-1} Mpc^{-1} unless obtained from gradient.

3

(b) expansion is accelerating

OR

rate of expansion is increasing ✔

(due to) dark energy ✔

Treat descriptions of how the rate is increasing as neutral

Do not allow 'dark matter'

2

[5]

Q2.

The mark scheme gives some guidance as to what statements are expected to be seen in a 1- or 2-mark (L1), 3- or 4-mark (L2) and 5- or 6-mark (L3) answer. Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist in marking this question.

Mark	Criteria
6	All three areas (as outlined alongside) covered with at least two aspects covered in some detail. 6 marks can be awarded even if there is an error and/or parts of one aspect missing.
5	A fair attempt to analyse all three areas, with two areas discussed successfully and one area partially.

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4	Two areas successfully discussed, or one discussed and two others covered partially. Whilst there will be gaps, there should only be an occasional error.
3	One area discussed successfully and one discussed partially, or all three covered partially. There are likely to be several errors and omissions in the discussion.
2	Only one area discussed successfully, or makes a partial attempt at two areas.
1	One of the three areas covered partially. There are likely to be many errors or omissions.
0	No relevant analysis.

Area 1: Stars compared for colour
M40 B will appear more red than M40 A as it is cooler.
M40 A is an F/G star; M40 B is a K class star Therefore M40 A is white/yellow-white and M40 B is orange
Ignore calculation of λ_{max} unless linked correctly to colour.
Classes are related to colour/temperature

Area 2: Stars compared for brightness

M40 A will appear (~1.5 times) brighter than M40 B, as the apparent magnitude is 0.4 less than that of M40 B.
Difference in magnitude = 0.4
Ratio in brightness = $2.51^{0.4} = 1.5$

Area 3: Distance discussed

Powers compared:
Using $P = \pi A T^4$ gives
For A: $P = 5.67 \times 10^{-8} \times 4\pi \times (6.3 \times 10^9)^2 \times 6000^4 = 3.66 \times 10^{28}$ W
For B: $P = 5.67 \times 10^{-8} \times 4\pi \times (1.1 \times 10^{10})^2 \times 4700^4 = 4.22 \times 10^{28}$ W

As power output of **A** is less than that of **B** but **A** appears brighter, **A** must be closer and therefore they are not a binary.

[6]

Q3.

(a) Two pairs of rays drawn parallel to the principal axis coming to different foci.
Outer rays focus closer to lens than inner rays. ✔

1

(b) Both focal points labelled, on the principal axis, and coincide, with $f_o > f_e$ ✔

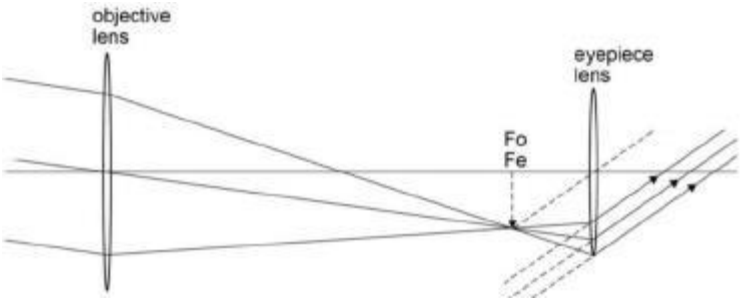
$f_o > f_e$ judged by eye. Condone a single label F or '(principal) foci'.

Three off-axis rays through objective lens correct, as far as the eyepiece ✔

Ignore labels outside the space between the two lenses.
Rays must be off-axis to get the second mark.

Three rays through eyepiece correct, parallel to a construction line ✔

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Construction line does not need to be drawn.
If only two rays drawn then max 2.

3

(c) (f_o / f_e = 750 and f_e + f_o = 17.4)

Accept any correct unit

$f_e = (f_e + f_o)/751$ ✔

Use of $f_e = (f_e + f_o)/750$ without explanation scores 0

= 17.4/751

(Calculator value = 0.0231691079)

$f_e = 2.3(17) \times 10^{-2}$ m ✔

If no other mark given award max 1 for 0.023 or 0.0232 but treat evidence of incorrect calculation as a talkout.

2

(d) Resolution is limited by the diameter of the objective ✔$_a$
so it will make no difference ✔$_b$
OR
CCD has better resolution due to having smaller pixels ✔$_a$
so the stars could be more easily seen as separate (OWTTE) ✔$_b$

General principle is difference ✔$_a$ followed by consequence. ✔$_b$
If no consequence relevant to observation of binary stars, then max 2

(candidates may combine these ideas)

CCDs have higher quantum efficiency and/or can be exposed for a long time ✔$_a$
so dimmer or more distant binaries can be observed ✔$_b$

CCDs can detect a wider range of wavelengths ✔$_a$
enabling the observation of more binary pairs. ✔$_b$

Description of why CCD is more convenient in use ✔$_a$ with a specific example of why this helps in the observation of binary stars. ✔$_b$

Examples of 'convenience' include use when astronomer not present, image can be stored and analysed (on computer).
Ignore reasons based on cost.

Max 3

[9]

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