Name of the Student:_____
Max. Marks : 24 Marks **Time : 24 Minutes**

Mark Schemes

Q17.

(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

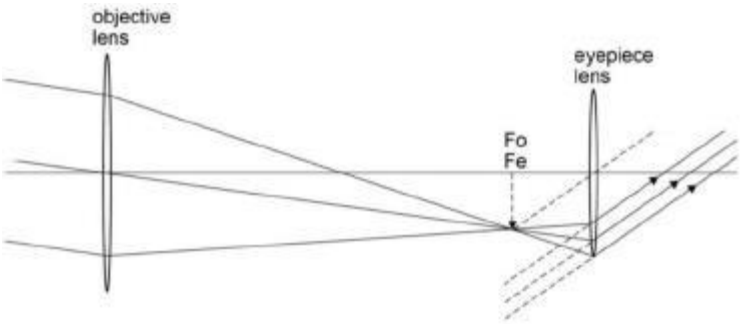
(b) Both focal points labelled, on the principal axis, and coincide, with $f_o > f_e$ ✔

$f_o > f_e$ 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 ✔



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]

Q18.

6	A coverage of all three aspects. There may be the occasional slip-up.
5	Two aspects are well covered and partial coverage of the other. There may be some misunderstanding – for example that stars are moving away from us.
4	Two aspects are well covered, or one well covered and a brief coverage of the others. There may be some misunderstanding – for example that stars are moving away from us.
3	Includes a clear coverage of one aspect and at least an attempt at another OR a partial coverage of all three.
2	Includes a clear coverage of one aspect OR a partial discussion of two.
1	Partial coverage of one aspect.
0	No relevant comment.

There must be an attempt at a relevant calculation for 5 or 6 marks (this could be the age of universe).

Points made in a good answer could include: Aspect 1 - RedShift

- Theory predicts that distant galaxies are all moving away from us
- The further away the galaxy the faster it moves
- Reference to Hubble's Law

Aspect 2 -CMBR

- Theory predicts black body radiation at microwave wavelengths (2.7 K)
- from all directions which indicates that the universe was once very small/in a hot dense state
- Graph shows peak in microwave region
- General shape of graph is the same as a black body
- CMBR is not predicted by any other theory
- Condone suggestion that it's leftover radiation from Big Bang

Aspect 3 - Hydrogen/Helium ratio and/or Wien's Law calculation. Treat calculation of age of universe as partial Aspect 3. Answers which cover H/He and Wien's Law can be used to support partial Aspect 1 or 2.

- Theory predicts 3:1 H/He ratio
- In deep space (not stars) this is observed in practice
- Calculation shows peak corresponds to 2.7 K (approx)

[6]

Q19.

(a) High power/powerful radio emitter. ✔

Some indication of high power needed.

1

(b) Use of $m - M = 5 \times \log\frac{d}{10}$ ✔

1

$M = m - 5 \times \log\frac{d}{10}$ ✔

$M = 12.8 - 5 \times \log\frac{760 \times 10^6}{10} = -26.6$ ✔

1

(c) Quasar is brighter because more negative abs magnitude. ✔

Difference in absolute magnitudes 26.6 − 22.8 = 3.8 ✔

Brighter by $2.51^{3.8} = 33$ times ✔

Use of -27 (giving 48 times brighter) scores mp2 and mp3
Allow any value of absolute magnitude which rounds to -27.
Use of apparent magnitudes scores no marks.

3

(d) $R_s = \frac{2GM}{c^2} = \frac{2\times6.67\times10^{-11}\times7.1\times10^{11}\times1.99\times10^{30}}{3.00\times10^{8^2}} = \checkmark (2.1 \times 10^{15}\ \text{m})$

$\text{volume} = \frac{4}{3}\pi R_s^{\ 3} = \frac{4}{3}\pi 2.1 \times 10^{15^3} = \checkmark (3.7 \times 10^{46}\ \text{m}^3)$

If the mass of the Sun is not included mp1 is not awarded – ecf for mp2 and mp3.
2.094×10^{15} m
3.85×10^{46} m^3

1

$\rho = \frac{\text{mass}}{\text{volume}} = \frac{7.0\times10^{11}\times1.99\times10^{30}}{3.7\times10^{46}\text{m}^3}$ = 3.7 (3.67)× 10^{-5} $kg\ m^{-3}$ ✔

2

[9]