Practice Question Set For A-Level
Subject : Physics
Paper-3 Topic: Section B(SECTION 9_ ASTROPHYSICS)

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Name of the Student:____

Max. Marks : 24 Marks **Time : 24 Minutes**

Mark Schemes

Q1.

(a) Diagram with 1 AU, 1 pc **and** $\frac{1}{3600}$° labelled ✔

Allow 1 arc second ***or*** *1"* ***or*** *2.8×10^{-4} °*
or *4.8×10^{-6} rad for angle.*
1 AU can be shown as Sun-Earth distance.
Condone 'au' for 'AU'.
1 pc can be either long side. Condone label d for 1 pc.

1

(b) B ✔

1

(c) evidence of 10^x seen

OR

evidence of 0.11 - (-7.84) seen✔

condone 0.11 + 7.84 provided m-M seen.

d = 390 (pc) ✔

Calculator value is 389.0451

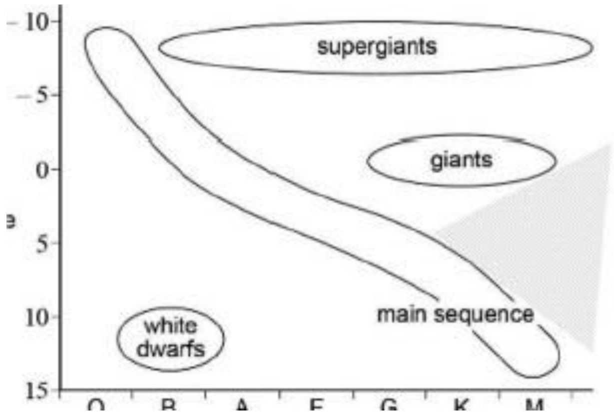
2

(d) Line coming in from the right to mag 5/class G

then to giants and

then to white dwarfs (in that order) ✔

Condone lack of arrow.
The shaded area shows the acceptable region for the initial line (from protostar).



1

(e) (GRB produced when) supergiant collapses ✔

(and) forms a neutron star **OR** a black hole ✔

Ignore references to 'supernova'

2

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Q2.

(a) Final image at infinity. ✔

Accept answers which describe how the telescope is set up with named lenses unless f_o and f_e are used e.g.

the focal plane/point of the eyepiece and objective lenses are co-incident.

OR

'distance between lenses is $f_o + f_e$'

Condone 'rays leaving eyepiece/entering eye are parallel'

If F_o and F_e are used they must be defined.

1

(b) 100 converging 5 converging ✔

1

(c) (Each step on magnitude scale is 2.51)

(Hence) $2.51^x = 40$

$x = \log_{2.51}(40) = 4(.01)$

OR

Adding 6 to their x ✔

(6 + 4 =)10 ✔

Condone trial and error (2.51^1, 2.51^2,...).

Award MAX 1 if no working shown for a bald correct answer.

2

(d) (Collecting power of telescope is)

$\left(\frac{60}{7}\right)^2$ = 73 or 74 (times greater than naked eye) ✔

MP1 can be given for 73 or 74 seen.

Accept $\left(\frac{7}{60}\right)^2$ *= 0.014 for MP1*

73 (or 74) is greater than 40 so the astronomer can see WASP-82. ✔

Allow an ecf in MP2 from '8.6 times greater'

($\frac{60}{7}$ *= 8.6) , with idea that 8.6 is less than 40 and therefore astronomer cannot see Wasp-82.*

Allow ecf in MP2 for an arithmetic error in MP1.

2

(e) Two clear reasons given ✔✔

Correct justification linked to one reason ✔

Reason	Justification
Better/greater quantum efficiency	A greater proportion of (incident) photons are detected
Can expose for long periods / many images can be combined	More light is collected / better image contrast
Can operate remotely	The telescope can be positioned where light pollution/atmospheric absorption is minimised
Idea that it can detect (more) wavelengths beyond the visible	More energy is collected from the star

MAX 3

If no justification given then ***MAX 2****.*

In the first row:

Do not allow 'efficiency' alone.

The reason and justification marks can both be awarded for an answer based on the definition of 'quantum efficiency' e.g.a greater proportion/ percentage of the incident photons are detected (by the CCD).

In the justification condone 'light' for 'photons' and condone 'number' for 'proportion'

Treat 'image processing' as neutral.

Ignore references to resolution.

3

[9]

Q3.

(a) An object that has an escape velocity greater than the speed of light.

Reject idea of 'beyond' or 'past' the event horizon if the direction is unclear.

OR

An object that has a gravitational field strength that is so great that light cannot escape. ✔

Do not accept 'mass' 'density' 'light cannot escape' 'light cannot escape its gravity' on their own.

1

(b) $R_s = \frac{2GM}{c^2} = \frac{2 \times 6.67 \times 10^{-11} \times 6.5 \times 10^9 \times 1.99 \times 10^{30}}{(3 \times 10^8)^2}$ 1✔

Angle subtended by region around event horizon of black hole

$= \frac{1.917 \times 10^{13} \times 2 \times 1000}{5.3 \times 10^7 \times 9.46 \times 10^{15}}$ = 7.64 × 10^{-8} (rad) 2a✔

resolution of EHT = $(\frac{1.3 \times 10^{-3}}{1.3 \times 10^7} =)$ 1(.0) × 10^{-10} (rad)

OR

resolution of Hubble = $(\frac{410 \times 10^{-9}}{2.4} =)$ 1.71 × 10^{-7} (rad) 3✔

Both resolutions calculated correctly **and** conclusion drawn that EHT is better than Hubble. 4✔

Condone rounding errors in this question.
Award MP1 for R_s = 1.9(17) × 10^{13}(m) seen
Condone missing mass of Sun (1.99 × 10^{30}) in MP1
Condone missing '2' in MP2.
*Award MP2 for 7.6(4) × 10^{-8} **OR** 3.8(2) × 10^{-8} seen.*
Allow POT error in MP1 and MP3
ALTERNATIVE
$R_s = \frac{2GM}{c^2} = \frac{2 \times 6.67 \times 10^{-11} \times 6.5 \times 10^9 \times 1.99 \times 10^{30}}{(3 \times 10^8)^2}$ ✔
One resolution calculated 2✔
Determination of the size of the object that can be resolved by a telescope at the distance of black hole
*For EHT size = 5(.0) × 10^{13} (m) **OR***
For Hubble size = 8.6 × 10^{16} (m) 3✔
*Both sizes calculated correctly **and** conclusion drawn that EHT is better than Hubble.* 4✔

4

(c) Evidence of difference in wavelength = 374.96 - 373.53 ✔

(= 1.43 nm)

Evidence of sum of wavelengths = 374.96 + 373.53 ✔

(= 748.49 nm)

($z = \frac{\Delta\lambda}{\lambda} = \frac{0.72}{374.25}$ = 1.9 × 10^{-3})

($v = zc$ = 1.9 × 10^{-3} × 3.00 × 10^8 =)

5.7 × 10^5 (m s^{-1}) ✔

MP1 can be given for determination of Δλ (= 0.72 nm)

MP2 can be given for determination of average (= 374.25 or 374.24(5) nm)

Alternative method for z:

$z = \frac{374.96 - 373.53}{374.96 + 373.53} = 1.9 \times 10^{-3}$

3

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