A-Level Physics

Classification of Ions

Mark Scheme

Time available: 70 minutes
Marks available: 48 marks

1.

(a) The minima are caused when one star passes in front of the other. ✓

2nd mp could be expressed in other ways eg G class in front of B class; cooler star passes in front.

1

Deeper minima are caused by the cooler star passing in front of the hotter star. ✓

NB this is NOT related to the diameter of the star.

1

(b) The system is moving towards us

AND mention of Doppler/red shift/effect ✓

Do not allow 'stars are moving towards us'

1

(c) $\Delta\lambda = \frac{486.498-485.672}{2} = 0.413$ nm = 0.413 nm ✓

$z = \frac{\Delta\lambda}{\lambda} = \frac{0.413}{486.085\checkmark} = 8.50 \times 10^{-4}$ ✓

2

$v = zc = 8.50 \times 10^{-4} \times 3.00 \times 10^{8} = 2.55 \times 10^{5}$ m s^{-1} = 255 km s^{-1} ✓

Denominator must be average value. Use of any other value loses 3rd mp (NB likely to give same answer to 3 sf).

Marks awarded…

Final answer ✓

Calc of 0.413 ✓

Use of average value (486.085) ✓

1

(d) Identifies time period is 2.5 days ✓

$v = \frac{2\pi R}{T}$

$R = \frac{v \times T}{2\pi} = \frac{2.55\times10^{5} \times 2.5\times24\times3600}{2\pi} = 8.76 \times 10^{9}$ m ✓

Allow ecf from ***(c)***

1

Use of 250 km s^{-1} gives 8.59 × 10^{9} m✓✓

1

(e) hydrogen and helium ✓

1

(f) Radio emissions from neutron star blocked by white dwarf ✓

Spectroscopic variation in white dwarf seen ✓

No change in optical brightness (as neutron star too small) ✓

Max 2

2

[11]

2. (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 full marks.

Use of apparent magnitudes scores no marks.

3

(d) $R_s = \frac{2GM}{c^2} = \frac{2\times6.67\times10^{-11}\times7.0\times10^{11}\times1.99\times10^{30}}{3.00\times10^{8^2}} = ✓ (2.1 \times 10^{15}\ \text{m})$

2.065 × 10^15 m

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

1

3.69 × 10^46 m^3

$\rho = \frac{\text{mass}}{\text{volume}} = \frac{7.0\times10^{11}\times1.99\times10^{30}}{3.7\times10^{46}\text{m}^3} = 3.8 \times 10^{-5}\ \text{kg m}^{-3}$

Accept 3.6 × 10^−5 kg m^−3 (rounding error from using 2.1 × 10^15 m)

2

[9]

3. (a) W – protostar/gas cloud ✓1

Candidates may add to the diagram – this should be credited

Accept formation stage for W

X – main sequence star ✓2

Y – (Red) giant AND Z – (white) dwarf ✓3

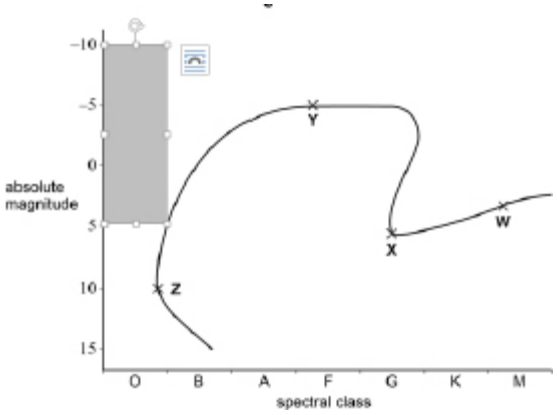
Condone Supergiant for Y

3

(b) Positioned magnitude less than 5

…and class O✓

Grey box shows accepted region



1

(c) Transit method measures how much light is blocked by planet.✓$_1$

MP1 Candidate demonstrates they know what the transit method is. Any suggestion that method involves seeing a dot moving across the face of the star award 0 marks.

1

Planet is small (and star is very big) so little light blocked out.✓$_2$

MP2 Links this to Earth-sized planet.

1

(d) Use of σAT^4 ✓$_1$

Condone incorrect A formula but must include other quantities.

3

= 8.0 (7.97) × 10^{30}(W) ✓$_2$

Attempt to use inverse square law for Earth or find ratio of powers (allow ecf) ✓$_3$

Equates intensities for Earth and planet orbiting TC✓$_4$

√their ratio × 1.5 × 10^{11} or $\sqrt{\frac{\text{their power for TC}}{1.7 \times 10^4}}$✓$_5$

(= 2.2 (2.17) × 10^{13} m)

For example

Power output of Theta Carinae = σAT^4=

$5.67 \times 10^{-8} \times 4\pi R^2 \times 31000^4$ ✓$_1$

$= 8.0\ (7.97) \times 10^{30}$ W ✓$_2$

Ratio of power outputs = $\frac{7.97 \times 10^{30}}{3.8 \times 10^{26}}$

2.10×10^4✓$_3$

So planet must be $\sqrt{2.10 \times 10^4}$ *1.45×10^2 times further away* ✓$_4$

$1.45 \times 10^2 \times 1.5 \times 10^{11}$ 2.2×10^{13} m ✓$_5$

2

[11]

4. (a) Tick (✓) only against Tsih

Accept other clear indication (eg x)

1

(b) Temperature:

Attempt to use Wiens Law. ✓
Correct calculation of T for both stars. ✓

Colour:
Links colour to wavelengths produced ✓
Schedar longer wavelengths so 'redder' than Caph ✓
Or
Links temperature to spectral class ✓
Caph F (therefore White), Schedar K (therefore Orange) ✓

For Caph T = $\frac{2.9 \times 10^{-3}}{410 \times 10^{-9}}$ *= 7250 K (6900–7630)*

For Schedar T = $\frac{2.9 \times 10^{-3}}{660 \times 10^{-9}}$ *= 4400 K (3600–5200)*

Allow ecf for incorrect temperatures.

No mark for just stating colours

4

(c) Caph ✓

1

(d) Conversion of distance to parsec (70) ✓

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

to give $M = m - 5\log(\frac{d}{10})$ ✓

$(M = 2.2 - 5\log(\frac{70}{10})) = -2.0$ (–2.025) ✓

1 mark for correct distance conversion

1 mark for re-arranging formula

1 mark for correct answer (min 2 sf)

Ecf for incorrect conversion only if there is an attempt to convert.

3

(e) $R_s\ (= \frac{2GM}{c^2}) = \frac{2 \times 6.67 \times 10^{-11} \times 15 \times 1.99 \times 10^{30}}{(3.00 \times 10^8)^2} =$ ✓

4.4×10^4 m ✓

OK to use ≈ instead of = (as in the specification)

Allow ecf for POT error only.

2

[11]

5.

Mark	Criteria
6	All 3 areas covered in some detail. 6 marks can be awarded even if there is an error and/or parts of one aspect missing.
5	All 3 areas covered at least 2 in detail. Whilst there will be gaps, there should only be an occasional error.
4	Two areas successfully discussed, or one discussed and two others covered partially. Whilst there will be several gaps, there should only be an occasional error.
3	One area discussed 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 or makes a partial attempt at two areas.
1	None of the three areas covered without significant error.
0	No relevant analysis.

Examples of points made in a good answer

Overall shape

• Overall curve is a black body spectrum

• Links λ_{max} to temperature

• Continuous spectrum emitted by star

Absorption lines

• Dips are due to absorption

• Light of particular wavelengths absorbed by gases in outer layers

• And re-emitted in random directions

• Leaving dark lines

• E.g. Balmer lines are produced by hydrogen

The hydrogen must be excited to the $n = 2$ state

Choice of star

• Miaplacidus (class A)

• Temperature calculated (~9000 K)

• temperature is class A

OR

• Miaplacidus (class A)

• Absorption lines are Hydrogen (Balmer) lines

• strong Hydrogen/Balmer absorption lines seen in class A but not in class K

AO1 - 4
AO3 - 2

[6]