

Name of the Student: _____

Max. Marks : 26 Marks

Time : 26 Minutes

Mark Schemes

Q1.

- (a) Quasars are produced by (supermassive) black holes. ✓

These black holes are at the centre of (active) galaxies (active galactic nuclei.) ✓

2

- (b) Using
- $v = cz$
- gives

$$v = 3 \times 10^8 \times 0.0415 \quad \checkmark = 1.25 \times 10^7 = 1.25 \times 10^4 \text{ kms}^{-1}$$

Using $1\text{pc} = 3.26 \text{ lyr}$

$$d = 5.81 \times 10^8 \text{ lyr} = 5.81 \times 10^8 / 3.26 \quad \checkmark = 1.78 \times 10^8 \text{ pc}$$

$$= 1.78 \times 10^2 \text{ Mpc} (= 5.5 \times 10^{24} \text{ m})$$

Using $v = Hd$

$$(H = v/d = 1.25 \times 10^4 / 1.78 \times 10^2 = 70 \text{ kms}^{-1} \text{ Mpc}^{-1})$$

$$\text{Age of Universe} = 1/H = d/v \quad \checkmark$$

$$= 5.81 \times 10^8 \times 9.47 \times 10^{15} / 1.25 \times 10^7 = 4.42 \times 10^{17} \text{ s} \quad \checkmark$$

*The first mark is for use of zc .**The second mark is for a calculation of d .**The third mark is for using the idea that the age of the Universe is $1/H$.**The fourth mark is for the answer.**Allow own H for 3rd and 4th marks.*

4

- (c) Both quasar and galaxy should have same brightness (and therefore similar received power) ✓

Use of Inverse square law eg

$$\text{Power of quasar} / (\text{distance to quasar})^2 = \text{power of galaxy} / (\text{distance to galaxy})^2 \quad \checkmark$$

$$\text{Or } 1000/d^2 = 1/1$$

$$\text{So distance to quasar} = (1000)^{1/2} = \text{about 30 times greater than distance to galaxy} \quad \checkmark$$

*The first mark is for relating the similar "brightness". Accept intensity.**Accept in form of equation linking quasar and galaxy.**The second mark is for applying the inverse square law. Simply*

quoting it does not get this mark.

The final mark is for coming to a valid conclusion related to the distance to the quasar compared to the distance to the galaxy.

Do not accept answers involving square roots.

These are standalone marks.

1
2

[9]

Q2.

- (a) It is the radiation coming from all parts of the Universe ✓

When the Universe cooled sufficiently for matter and radiation to 'decouple', with the combination of protons and electrons to form neutral atoms ✓

This radiation has been red-shifted into the microwave region as the Universe has expanded ✓

OR

This is (em) radiation from all parts of the Universe, ✓

the spectrum has a peak in the microwave region / corresponds to a temperature of 2.7 K ✓

It can be interpreted as the radiation left over from the Big Bang / the photons having been stretched to longer wavelengths and lower energies ✓

One mark is for stating that CMBR comes from all parts of Universe.

Accept Isotropic.

Condone homogeneous.

Condone same at all points in universe.

Another is for referencing the idea that the radiation has a peak in the microwave region.

The third is for linking it to the Big Bang theory.

Condone "left over heat from Big Bang".

3

- (b) (The Big Bang theory suggests that a very brief period of) fusion occurred (when the Universe was very young), resulting in the production of helium from fusing hydrogen. ✓

Fusion stopped as the Universe then expanded and cooled ✓

Resulting in a relative abundance of hydrogen and helium in the ratio of 3:1/ cooled too rapidly for the creation of larger nuclei,

Or suitable relevant observation ✓

One mark is for linking helium production to fusion in the early Universe. This mark can also be awarded for description of proton and neutron creation/ 7:1 ratio

3

[6]

Q3.

- (a) 15(.0) (Ω) ✓

Only acceptable answer

Must be on answer line or clearly identified as (largest)R

by $R = 15 \text{ (0) } (\Omega)$ seen.

Allow an answer just above (or below) the answer line in cases where a previous answer has been crossed out.

If not on the answer line, units must be stated.

1

(b) 1.4(1) (Ω) ✓✓

Only selects 2.2 Ω and 3.9 Ω in parallel ✓

Accept evidence from working or a clear labelled sketch of 2.2 Ω and 3.9 Ω in parallel

Possible allowed combinations include:

$$\left(\frac{1}{R} = \right) \frac{1}{2.2} + \frac{1}{3.9}$$

$$\text{Condone } R = \frac{1}{\frac{1}{2.2} + \frac{1}{3.9}}$$

$$(R =) \frac{1}{\frac{1}{2.2} + \frac{1}{3.9}}$$

$$(R =) \left(\frac{1}{2.2} + \frac{1}{3.9} \right)^{-1}$$

$$\left(\frac{1}{R} = \right) \frac{5}{11} + \frac{10}{39}$$

$$(R =) \frac{2.2 \times 3.9}{2.2 + 3.9}$$

Accept 1.407 Ω but not >4 sf

Must be on answer line or clearly identified as (smallest)R

by $R = 1.4 \text{ (1) } (\Omega)$ seen.

Allow an answer just above (or below) the answer line in cases where a previous answer has been crossed out.

Common wrong answer = 0.71 (Ω) is worth one mark with correct supporting working

2

(c) Any of the following statements:

Power supply is on open circuit (so current is zero)

OR

Voltmeter has a (very) large resistance (so current is zero)

OR

No current (load) (so no lost volts)

OR

(Current is zero) so no lost volts

Accept 'negligible' current for zero current

Accept 'very large' resistance; don't penalise 'voltmeter has very large internal resistance'

Do not allow:

Resistance is zero

Only resistance is the internal resistance
No other component (this implies that the internal resistance is zero)

1

(d) (Current through power supply leads to)

lost volts (across the internal resistance)

OR

(Current through power supply leads to)

voltage drop across the internal resistance

OR

(Current through power supply leads to)

Some of the emf is used in the internal resistance

OR

Voltage is shared between the internal and external resistances

Allow correct 'energy transfer in the internal resistance' arguments

*Must refer to a voltage across the internal resistance or r
except when the term "lost volts" is used.*

Do not allow:

The current decreases

1

(e) $\varepsilon - V = (1.62 - 1.14) = 0.48(0) \text{ (V)}$

and

$$\frac{V}{R} = \left(\frac{1.14}{9.0} \right) = 0.13(\text{V}\Omega^{-1}) \quad \checkmark$$

Both results required for $\checkmark$; accept 0.127 or 0.1267 for $\frac{V}{R}$

Do not allow answers expressed in terms of unknown variables

*Answers must be on answer line or clearly identified as answer by
using correct subject and equals sign*

*Allow an answer just above (or below) the answer line in cases where a
previous answer has been crossed out.*

1

(f) Point correctly plotted to nearest 1 mm (half a grid square)

and

continuous ruled best fit line for the 5 (originally printed) points $\checkmark$

*Withhold mark if point is hidden or if best fit line is of variable thickness
or has discontinuities.*

*Data point should be marked with a cross. Both $\times$ and $+$ marks are
acceptable.*

Do not allow points plotted as dots / dots in circles

If point is wrongly calculated in Part 1.5 allow CE for an accurate plot of

this but this should then be treated as anomalous when judging the best fit line.

The best fit line must intersect each of the 5 originally printed X symbols.

Allow no plot where ECF (even as algebraic equation) point won't fit on the grid and student has stated that it can't be plotted.

If no answer / no plottable answer in 1.5 but student chooses to plot a point then it must be the correct point only (0.13, 0.48)

1

- (g) Gradient triangle for **Figure 3**; correct read-offs for points (± 1 mm) from triangle with the $\varepsilon - V$ step at least 0.5 V

Allow $\frac{y_2 - y_1}{x_2 - x_1}$ seen or gradient triangle drawn with $\frac{\Delta y}{\Delta x}$ seen, read-offs must be substituted into $\frac{y_2 - y_1}{x_2 - x_1}$ or $\frac{\Delta y}{\Delta x}$

Condone one read-off error in four read-offs for gradient method (common error: candidates miss non-origin on ordinate axis)
(common error: makes a power of 10 error on abscissa)

r in range 3.49 to 3.95 (Ω)

Any correct method other than gradient method (no read-off errors here) allow 1 mark

i.e. allow 1 mark for the accurate use of 1 point from their line

r must be quoted to a minimum of 2 significant figures

ecf for r (their gradient from their best fit line)

r must be supported by correct working

2

- (h) The **Figure 1** method is better **because** more R values are available ✓

6 values of R (possible) for method (seen) in Fig 4 ✓

Do not allow:

The 2nd method has a wider range

The 2nd method has a larger maximum resistance

The 2nd method has a smaller minimum resistance

The 2nd method only goes up to 8.2 Ω

(resistances available in Fig 4: 2.0 Ω , 3.2 Ω , 4.3 Ω , 4.6 Ω , 5.0 Ω , 5.3 Ω)

2

[11]