KEY for Q4 and Q5

A $\frac{R(t)}{R(t_0)} = \frac{t}{t_0}$, $q = \frac{1}{2}$, $t_0 = \frac{1}{2}(H_0)^{-1}$, $R(t) = \infty$ at $t = \infty$

B $\frac{R(t)}{R(t_0)} = \frac{t}{t_0}$, $q = 0$, $t_0 = (H_0)^{-1}$, $R(t) = \infty$ at $t = \infty$

C $\frac{R(t)}{R(t_0)} = \frac{t}{t_0}$, $q = 0$, $t_0 = \frac{2}{3}(H_0)^{-1}$, $R(t)$ becomes constant at $t = \infty$

D $\frac{R(t)}{R(t_0)} = \left(\frac{t}{t_0}\right)^{\frac{1}{2}}$, $q = \frac{1}{2}$, $t_0 = \frac{1}{2}(H_0)^{-1}$, $R(t) = \infty$ at $t = \infty$

E $\frac{R(t)}{R(t_0)} = \left(\frac{t}{t_0}\right)^{\frac{1}{2}}$, $q = \frac{2}{3}$, $t_0 = (H_0)^{-1}$, $R(t)$ becomes constant at $t = \infty$

F $\frac{R(t)}{R(t_0)} = \left(\frac{t}{t_0}\right)^{\frac{2}{3}}$, $q = \frac{2}{3}$, $t_0 = \frac{1}{2}(H_0)^{-1}$, $R(t) = \infty$ at $t = \infty$

G $\frac{R(t)}{R(t_0)} = \left(\frac{t}{t_0}\right)^{\frac{2}{3}}$, $q = \frac{1}{2}$, $t_0 = \frac{2}{3}(H_0)^{-1}$, $R(t)$ becomes constant at $t = \infty$

H $\frac{R(t)}{R(t_0)} = \left(\frac{t}{t_0}\right)^{\frac{2}{3}}$, $q = \frac{1}{2}$, $t_0 = \frac{3}{2}(H_0)^{-1}$, $R(t)$ becomes constant at $t = \infty$

Q6 What is meant by the term 'the observable Universe'? Choose one statement from the key, and pencil across *one* cell in row 6.

KEY for Q6

A All the stars and planets that can be seen by the naked eye on a clear dark night away from street lights

B Everything that can be seen by telescopes using visible light

C Everything in the Universe excluding matter swallowed up by black holes

D Everything in the universe, excluding dark matter

E Everything in the Universe excluding dark matter and matter that has been swallowed up in black holes

F Everything in the Universe that lies within the distance from us that is equal to the distance light could travel in the time elapsed since the Big Bang

Q7 For a universe in which the density parameter $\Omega < 1$, which two statements in the key are definitely *false*? Pencil across *two* cells in row 7.

KEY for Q7

A Under no circumstances could there ever be a Big Bounce.

B No two parallel straight lines ever meet.

C The angles of a rectangle add up to more than 360°.

D The value of Ω does not change as the Universe continues to expand.

E The type of geometry does not change as the Universe continues to expand.

F The size of the *whole* Universe is infinite at *all* times.

G The size of the *observable* Universe at the instant of the Big Bang was infinitesimally small.

H The Universe is said to be 'open'.

Q8 and Q9 These questions are concerned with the properties of an arbitrarily chosen pair of indefinitely extended straight lines. Each question assumes a different geometry for the Universe.

Q8 Suppose that the geometry of the Universe is that given by a value of the density parameter $\Omega > 1$ — how many times would the two straight lines intersect? Choose one item from the key for Q8 and Q9, and pencil across *one* cell in row 8.

Q9 Suppose that the geometry of the Universe is that given by a value of the density parameter $\Omega < 1$ — how many times would the two straight lines intersect? Choose one item from the key for Q8 and Q9, and pencil across *one* cell in row 9.

KEY for Q8 and Q9

A 0

B 1

C Either 0 or 1

D 2

E Either 1 or 2

F Either 0, 1 or 2

Q10 Imagine two galaxies, X and Y, almost in line with each other as seen from Earth. Both galaxies are a great distance from us and also from each other, with galaxy Y further away from us than X. Due to the expansion of the Universe, what observations in the key would *an observer on Y* make of galaxy X? Pencil across *one* cell in row 10.

KEY for Q10

A Galaxy X would appear to Y to be blue-shifted.

B Galaxy X would appear to Y to be red-shifted.

C Galaxy X would appear to Y to be blue-shifted if the separation between X and Y is less than between X and the Earth, but otherwise it would be red-shifted.

D Galaxy X would appear to Y to be red-shifted if the separation between X and Y is less than that