Q10 $\boxed{\text{E}}$ The given metric is that of a plane in plane polar coordinates, with x^1 representing the radial coordinate (traditionally ρ) and x^2 representing the angular coordinate (traditionally ϕ). It follows that the curvature is everywhere zero and the geodesics are straight lines. With this in mind, C_1 is a circle and C_2 a straight line. Thus C_2 is a geodesic and C_1 is not, while the surface is flat.

Q11 $\boxed{\text{B,C}}$ Statement (a) is false. The radial coordinate does not have direct metrical significance. [The proper length of the rod is actually $\Delta r/\left(1-2mG/c^2r\right)^{1/2}$.]

Statement (b) is true. Adding a constant to t does not change the metric.

Q12 $\boxed{\text{B,C}}$ Statement (a) is false. In fact, $\Delta r/\Delta t = c(1-2mG/c^2r)$ for a light pulse with $\Delta\tau = 0$. (Light travels along null geodesics.)

Statement (b) is true. A freely falling observer would measure the speed of light as c, but note that $\Delta r/\Delta t < c$ for a light pulse.

Q13 $\boxed{\text{A,C,E}}$ Statement (a) is true. If $\Delta r > c\Delta t$, then $(\Delta\tau)^2 < 0$ and no communication is possible.

Statement (b) is true. If $(\Delta t)^2 \geqslant 0$ then $\Delta r < c\Delta t$.

The second statement implies the first if light requires a time $\Delta t > \Delta r/c$, then so does a material particle, and hence events with $\Delta t < \Delta r/c$ are not causally related.

Q14 $\boxed{\text{A,E}}$ A is true, as shown by the statements about Birkhoff's theorem in Unit 12. E is also true as shown by evaluating the Schwarzschild radius using the formula $r_s = 2Gm/c^2$. All the other statements contradict statements made in Unit 12.

Q15 $\boxed{\text{C}}$ From Section 2 of Unit 12 the time required is given by

$$\tau(r_2) - \tau(r_1) = \frac{2}{\pi}\tau_0\left[\frac{\pi}{2} - \frac{2}{3}\left(\frac{r_2}{r_1}\right)^{3/2}\right]$$
$$= \tau_0\left[1 - \frac{4}{3\pi}\left(\frac{r_2}{r_1}\right)^{3/2}\right]$$

(See Errata 3, Unit 12, page 15, equation 6.)

In this case, $r_2/r_1 = 2\times10^{-8}$, so

$$\frac{\tau(r_2)-\tau(r_1)}{\tau_0} = 1 - 1.2\times10^{-12} \approx 1 - 12\times10^{-13}$$

Q16 $\boxed{\text{F}}$ The lifetime of the described black hole is proportional to m^3, *not* m^2. Thus item F is false. All the others are supported by the text of Unit 12.