Soln 1-3

Easiest to use length contraction from Astrid's point of view. That is, Astrid is stationary and the sun and Tau Ceti system slides by her at speed 0.99c.

L_o = 12 lyrs
L is the distance between the sun and Tau Ceti as seen by Astrid.
t_o is the time Astrid measures for this to happen.

From Astrid's POV,

$$L = \gamma^{-1} L_o = \sqrt{1-\beta^2}\, L_o = \sqrt{1-0.99^2}(12) = 1.69 \text{ lys}$$

At 0.99c, it will take

$$t_o = L/v = \frac{1.69 \text{ lyrs}}{.99c} = 1.71 \text{ years}$$

So, she'll be 21 years, 8½ months old.

Alternatively, let's imagine that Astrid has a clock that 'ticks' once during her trip; t_o is the length of the tick as seen by Astrid, which is what we're trying to find. An observer in the sun-Tau Ceti POV would observe this tick to take time t, where

$$t = \gamma t_o \ .$$

This t is also the time required for Astrid to travel 12 lyrs at 0.99c:

$$t = \frac{12 \text{ lyrs}}{0.99c} = 12.12 \text{ years} \ .$$

Then,

$$t_o = \frac{t}{\gamma} = 12.12\sqrt{1-0.99^2} = 1.71 \text{ years} \ .$$