Answers for Star Formation and U/HLXs in the Cartwheel Galaxy Pencil & Paper Investigation:

1. The diameter of the ring is ~170 pixels.
   170 pixels (0.5 arcsec / 1 pixel)(1 rad / 206,625 arc sec) = 0.00041 rad

2. (0.00041 rad)(380 X 10^6 ly) = 160,000 ly

3. (200,000 mi/h) / (5.88 X 10^{12} mi/ly) X (24 h/day) X (365.25 days/y) = 0.0003 ly/y
   v = d/t so t = d/v = (80,000 ly) / (0.0003 ly/y) = 300 million years

4. No, there is no X-ray source corresponding to the galactic nucleus as seen in the optical image.

5. The blue knots in the optical image in figure 1 are blue stars. X-ray sources along the ring (marked in Figure 5) could be supernova remnants, neutron stars or black holes because the lifetime of a massive star is less than 300 MY which is approximately when the galaxy collision occurred. The object marked by the crosshairs in the optical image in Figure 6 appears to be a galaxy so the X-ray source could be an active galactic nucleus.

6. Hubble's Law: $D = V/ H_o$
   (9415 km/s) / (72 km/s/Mpc) = 131 Mpc
   (9656 km/s) / (72 km/s/Mpc) = 134 Mpc
   The average of these two is 132.5 Mpc X (3.26 million ly/Mpc) = 432 million ly

7. (17")(1 rad / 206,625 arc sec) = 0.000082 rad
   (0.000082 rad)(432 X 10^6 ly) = 36,000 ly
   less than $1/4^{th}$ the size of the Cartwheel

8. There is a ULX near the center of the elliptical galaxy as seen in Figure 8 that could be a candidate for an AGN.

9. "Both the color of the intruder [elliptical] galaxy and the absence of indicators of star formation in its ring suggest that this galaxy was gas poor at the time of the collision." (Rappaport et. al. 2010)

10. "In the Cartwheel, it appears that a shock wave is moving radially outward in the disk, and star formation has occurred over a long interval (i.e., hundreds of Myr) along or just behind the leading edge of the wave and is still ongoing at present." (Rappaport et. al. 2010)

11. "... the absence of extremely luminous X-ray sources in Arp 147 may indicate that the peak of star formation therein occurred some tens of Myr in the past and has declined sharply as of 15 Myr ago. Rather than a disk with a propagating ring of star formation, Arp 147 is likely a small, tidally elongated and twisted galaxy that does not have such a radially propagating ring of star formation." (Rappaport et. al. 2010)