72. (a) We denote the mass of the car (and cannon) as M (excluding that of the cannonballs) and the mass of all the cannonballs as m. For concreteness, we assume that before firing all the cannonballs are at the front (left side of Fig. 9-52) of the car, which we choose to be the origin of the x axis; we choose $+x$ rightward. The coordinate of the center of mass of the car-cannonball system is

$$x_{\text{com}} = \frac{(0)m + \left(\frac{L}{2}\right)M}{M+m} = \frac{LM}{2(M+m)} \ .$$

After the firing, we assume all the cannonballs are at the other end of the car; the train will have moved (in the negative x direction) by a distance d, at which time

$$x_{\text{com}} = \frac{\left(\frac{L}{2} - d\right)M + (L-d)m}{M+m} \ .$$

Equating the two expressions, we obtain $d = \frac{mL}{M+m} < L$. If $m \gg M$, the distance d can be very close to (but can never exceed) L. Thus $d_{\text{max}} = L$.

(b) After each impact, there is no relative motion in the system; thus, the final speed of the car is equal to that of the center of mass of the system, which is zero.