a) $P_0 + \frac{1}{2}\varrho \underbrace{V_0^2}_{\approx 0} = P_{atm} + \frac{1}{2}\varrho V_s^2 \Rightarrow U_s = \sqrt{\frac{2(P_0 - P_{atm})}{\varrho}} = 28,9 \ m/s$

b) $\underbrace{\frac{\partial}{\partial t}\iiint_{cv}\varrho \, dv}_{\frac{dm}{dt}} + \underbrace{\iint_{cs}\varrho(\vec{v}\cdot\vec{n})\,ds}_{\varPhi_m} = 0 \quad \Leftrightarrow \quad \frac{dm}{dt} = -\varrho A_s U_s \quad \Leftrightarrow$

$\Leftrightarrow \quad m(t) = \int_{t_0}^{t_f} -\varrho A_s U_s \, dt \Rightarrow m(t) = -\varrho A_s U_s (t-t_0) + m(t_0)$

$\Leftrightarrow \quad t_f - t_0 = \frac{m(t_0) - m(t_f)}{\varrho A_s U_s} \approx 1,7 \wedge$

with annotations: $\varrho^{5\times10^{-3}g}$, ^{0,4g}

c) $\varPhi_{EC} \equiv \iint_{saida} \frac{1}{2}\varrho V_s^3 \, ds = \frac{1}{2}\varrho U_s^3 A_s \quad \Leftrightarrow \quad \varPhi_{EC} = 1,45 \ W$

$E_{Diss} = \int_{t_0}^{t_f} \varPhi_{EC} \, dt \Leftrightarrow E_{diss} = 2,46 \ J$

d) $F_{prop} = \underbrace{\frac{\partial}{\partial t}\iiint_{cv}\varrho\vec{v}\,dv}_{\approx 0 \ (enunciado)} + \iint_{cs}\varrho\vec{v}(\vec{v}\cdot\vec{n})\,ds \approx -\varrho U_s^2 A_s \vec{e}_x = 0,1 \ N$

$|\vec{F}_{prop}| = |\vec{D}| \quad \Leftrightarrow \quad 0,01 V^2 = 0,1 \quad \Rightarrow \quad V = 3,2 \ m/s$

e) — tal como em (b): $m(t) = \int_{t_0}^{t} -\varrho A_s U_s \, dt \Leftrightarrow$

$\Leftrightarrow \quad m(t) = -\varrho A_s 30\int_{t_0}^{t}(1-t/t_f')^{1/2}\,dt \Leftrightarrow m(t) = -\varrho A_s 30\left[-\frac{2t_f'}{3}\left(1-t/t_f'\right)^{3/2}\right]$

$\Leftrightarrow \quad m(0) = \varrho A_s 20 \, t_f' \quad \Leftrightarrow \quad t_f' = 2,5 \wedge$

— tal como em (d): $0,01 V^2 = \varrho U_s^2 A_s \Leftrightarrow V = \sqrt{100 \varrho A_s \left[30\left(1-t/t_f'\right)^{1/2}\right]}$

$\Leftrightarrow \quad V = 300\sqrt{\varrho A_s}\left(1-t/t_f'\right)^{1/2}$

— $X(t) = \int_{t_0}^{t_f} V \, dt \Leftrightarrow X(t) = -300\sqrt{\varrho A_s}\,\frac{2t_f'}{3}\left(1-t/t_f'\right)^{3/2} + \underbrace{A}_{constante}$

$\hookrightarrow A: X(0) = 0 \Rightarrow A = 300\sqrt{\varrho A_s}\,\frac{2t_f'}{3}\left(1-t/t_f'\right)^{3/2}$

$X(t_f) = 5,5 \ m$