d) $\frac{d(m_{tot} \cdot X_{tank})}{dt} = -\dot{m}_{outlet} X_{NaNO_3}$

$(200)\frac{dX_{tank}}{dt} = -\dot{m}_{outlet} X_{NaNO_3}$ ✱ $t=0$, $m_{tank} = 200$

$\frac{dX_{tank}}{X_{NaNO_3}} = -\frac{1}{200}\dot{m}_{outlet}\, dt$

$\ln|X_{NaNO_3}| = -t/200\ \dot{m}_{outlet} + C$

$X_{NaNO_3} = e^{-t/200\ \dot{m}_{outlet} + C}$

$= e^{C} e^{-t/200\ \dot{m}_{outlet}}$

$X_{NaNO_3} = Ce^{-t/200\ \dot{m}_{outlet}}$ ✱ $t=0$, $X_{NaOH} = 90/200 = 0.45$

$0.45 = Ce^{0}$

$C = 0.45$

$\boxed{X_{NaNO_3} = (0.45)e^{-t/200\ \dot{m}_{outlet}}}$

$\dot{m} = 100$ kg/min $\rightarrow$ 90% out

$X_{NaNO_3} = 9\text{kg}/200\text{kg} = 0.045$

e) ① 90%

$X_{NaNO_3} = 0.45\, e^{-1/2t}$

$0.045 = 0.45\, e^{-1/2t}$

$0.1 = e^{-1/2t}$

$\boxed{t_{90\%} = 4.61 \text{ min}}$

② 99%

$0.0045 = 0.45\, e^{-1/2t}$

$\boxed{t = 9.21 \text{ min}}$

③ 99.9%

$0.001 = 0.45\, e^{-1/2t}$

$\boxed{t = 13.82 \text{ min}}$