HW1:

2)c) Assuming E. coli % calculated by weight

$$\left.\begin{aligned} m_E &= .3 \times 10^{-12}\,g \\ m_c &= .5\, m_E \\ m_n &= .14\, m_E \end{aligned}\right\}$$

Glucose ~ $C_6H_{12}O_6$

Ammonium Chloride ~ NH_4Cl

Atomic mass of Carbon : ~ $2 \times 10^{-23}\,g$ ~ m_{ac}

Atomic mass of Nitrogen : ~ $2.3 \times 10^{-23}\,g$ ~ m_{an}

\# Glucose: $N_G = m_c / 6 m_{ac}$, $\therefore N_G = \dfrac{.15 \times 10^{-12}\,g}{2 \times 10^{-23}\,g} = .075 \times 10^{11}$

\# Ammonium: $N_A = m_n / m_{an}$, $\therefore N_A = \dfrac{.042 \times 10^{-12}\,g}{2.3 \times 10^{-23}\,g} = .018 \times 10^{11}$

$\boxed{N_G = 7.5 \times 10^9}$ $\boxed{N_A = 1.8 \times 10^9}$

c) $\begin{cases} N_A^\circ \sim \text{\# ammonia per 1 cell} \\ N_G^\circ \sim \text{\# Glucose per 1 cell} \end{cases}$ from c)

In 100mL,

$$\begin{cases} N_A = 5\,mM \cdot 100mL = 5\times10^{-4}\,mol \\ m_G = .5\% \,w/v \cdot 100mL = .5\,g \end{cases}$$

$$\frac{m_{aG}}{mol} \sim 6C + 12H + 6O$$

$$\frac{m_{aG}}{mol} = 6\cdot(12\,g/mol) + 12(1\,g/mol) + 6(16\,g/mol)$$

$$\frac{m_{aG}}{mol} = 180\,g/mol$$

$$\therefore N_G = \frac{.5}{180}\,mol = 2.7\times10^{-3}\,mol$$

$$\begin{cases} N_A = 5.0\times10^{-4}\,mol & \text{\# of available ammonia} \\ N_G = 2.7\times10^{-3}\,mol & \text{\# of available glucose} \end{cases}$$

\# cells from ammonia: $N_A/N_A^\circ = 2.78\times10^{-13}\,mol$

\# cells from glucose: $N_G/N_G^\circ = 3.6\times10^{-13}\,mol$

So Ammonia is the limiter. Converting to \# cells

Max OD of E. Coli: $D_E = \text{\# cells/volume}$

$$D_E = \left(\frac{N_A}{N_A^\circ}\cdot\frac{1}{100mL}\right)\left(\frac{1\,OD}{10^9\,\frac{cells}{mL}}\right)$$

$$D_E = \left(1.67\times10^{11}\,\frac{cells}{100mL}\right)\left(10^{-11}\,\frac{100mL}{cells}\cdot OD\right)$$

$$\boxed{D_E = 1.67\,OD}$$

f) $\begin{cases} D_f = 1.67\ OD = 1.67\times 10^{9} \frac{\text{cells}}{\text{mL}} & \text{final density} \\ D_0 = \frac{N_0}{V} = 10^7 \frac{\text{cells}}{\text{mL}} & \text{initial density} \end{cases}$

$N(t) = N_0 \cdot 2^{t/t_d}$, $D_f = \frac{N}{V}$

$\Rightarrow \frac{D_f}{D_0} = 2^{t/t_d}$

$\boxed{t = t_d \log_2\left(\frac{D_f}{D_0}\right)}$

$\therefore t = t_d \log_2(167) \rightarrow \boxed{t \simeq 332 \text{ mins}}$

So ~ 5 hours for the cells to use everything up.