1. a. $S_{unfold} - S_{fold} = R \ln\left(\frac{W_{unfold}}{W_{fold}}\right)$

$= R \ln \frac{(3^{100})}{1} = 100 R \ln 3 = 913 \frac{J}{mole}$

b. $T_m = 330\ K$ $\quad (n)(8000 \frac{J}{mole}) = (330\ k)(913 \frac{J}{mole})$

$n = 38$

c. Reasonable => 100 residue folded protein can have 38 backbone H-bonds (40-residue helix)

d. In unfolded protein in water, many backbone CO and NH will H-bond with water. So, the $-8 \frac{kJ}{mole}$ in b will not be relevant

e. Not a potential problem. There isn't water in the membrane so the backbone CO and NH in the unfolded protein won't be H-bonded

2. a. $3Na^+_{in} + 2K^+_{out} \longrightarrow 3Na^+_{out} + 2K^+_{in}$

$$\Delta G = (3\,mole)\left(RT \ln \frac{[Na^+]_{out}}{[Na^+]^3_{in}}\right) + (2\,mole)\left(RT \ln \frac{[K^+]_{in}}{[K^+]_{out}}\right)$$

$$+ (1\,mole)(1.602 \times 10^{-19}\,C)\left(0.0700\,\frac{J}{C}\right)$$

$$= \left(8.314\,\frac{J}{mole\text{-}K}\right)(310\,K)\{3\,mole \ln(14) + 2\,mole \ln(20)\}$$

$$+ (6.022 \times 10^{23})(1.602 \times 10^{-19})(.0700\,J)$$

$$= 35847\,J + 6753\,J = 42600\,J = 42.6\,kJ$$

b. $ATP^{4-} + H_2O \rightarrow ADP^{3-} + HPO_4^{2-} + H^+$

$[ATP^{4-}] = 0.00185M$
$[ADP^{3-}] = 0.00138M$
$[HPO_4^{2-}] = 0.00100\,M$

$$\Delta G = \Delta G^\circ + RT \ln \frac{[ADP][HPO_4]}{[ATP]}$$

$$= -30.5\,\frac{kJ}{mole} + \left(8.314\,\frac{J}{mole\text{-}K}\right)(310\,K) \ln \frac{(0.001)(0.00138)}{0.00185}$$

$$= -30.5\,\frac{kJ}{mole} - 18.56\,\frac{kJ}{mole} = -49.1\,\frac{kJ}{mole}$$

c. $\Delta G_{coupled} = (42.6 - 49.1)\,kJ/mole = -6.5\,\frac{kJ}{mole} < 0$

At constant T (37°C) and p (1atm), system processes with $\Delta G < 0$ occur spontaneously.

d. $\Delta U = q + w = \Delta G - p\Delta V + T\Delta S$

$q = \Delta G - p\Delta V + T\Delta S - w$

Only w that isn't accounted for is $-p\Delta V$

There is no change in the number of particles inside the cell. (loss of one particle in transport is compensated by gain of one particle in reaction) In ideal gas model, for particles of approximately the same mass, if $\Delta N = 0$ and c is constant, $\Delta S = 0$ (Sackur-Tetrode equation for ideal gas)

$q = \Delta G_{coupled} - \cancel{p\Delta V} + \cancel{T\Delta S} + \cancel{p\Delta V}$

$q = \Delta G_{coupled} = -6.5 \text{ kJ/mole}$

e. $[K^+]_{in} + [Na^+]_{in} = 0.110\,M$

$[K^+]_{out} + [Na^+]_{out} = 0.145\,M$

$[H_2O]_{in} > [H_2O]_{out}$

H_2O flows from higher to lower $[H_2O]$,

i.e. out of the cell.

f. The net flow of positive ions out of the cell helps to maintain the positive voltage outside vs. inside the cell. Also, having water flow out of the cell will help to prevent cell rupture.