

Please let me know if you find errors in this key. Thanks.

### Answers to Problems: Transmembrane Transport

1.  $K=1$ . At equilibrium, we expect  $[C]_{in} = [C]_{out}$ .
2.  $\Delta G^{o'} = -RT \ln K$ ;  $\ln K = \ln(1.0) = 0$ , so  $\Delta G^{o'} = 0$ .  
( $K=1$  and  $\Delta G^{o'} = 0$  for simple transport equilibrium)

$$\begin{aligned} 3. \Delta G &= \overset{\rightarrow 0.0}{\Delta G^{o'}} + RT \ln Q = RT \ln \left( \frac{[C]_{in}}{[C]_{out}} \right) \\ &= (8.314 \frac{J}{mol \cdot K})(298 K) \left[ \ln \left( \frac{24 \times 10^{-3} M}{1.2 \times 10^{-3} M} \right) \right] = \frac{1 kJ}{10^3 J} \\ &= +7.4 kJ/mol \end{aligned}$$

4. The process IS NOT spontaneous;  $\Delta G > 0$ .

$$5. \Delta G = RT \ln \left( \frac{[Na^+]_{in}}{[Na^+]_{out}} \right) = RT \ln \left( \frac{5.0 \times 10^{-3} M}{140 \times 10^{-3} M} \right) = \underline{\underline{-8.3 \frac{kJ}{mol}}}$$

6. This process IS spontaneous;  $\Delta G < 0$ .

7. This equation is the sum of the equilibrium equations in questions 1 and 5. By Hess's law,  $\Delta G$  is the sum of the  $\Delta G$ s for the two equations:  $\Delta G = (7.4 kJ/mol) + (-8.3 kJ/mol)$   
 $\Delta G = -0.9 kJ/mol$

NOTE: You could also calculate  $\Delta G$  this way:

$$\Delta G = RT \ln \left( \frac{[C]_{in} [Na^+]_{in}}{[C]_{out} [Na^+]_{out}} \right) = -0.9 kJ/mol$$

8. Co-transport IS spontaneous;  $\Delta G < 0$ . The  $Na^+$  gradient drives uptake of C.

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9.  $\Delta G = \underbrace{RT \ln Q}_{\text{from 7}} + nZ \Delta \Psi$ . For process shown in 7,

$$\Delta \Psi = \Psi_{\text{in}} - \Psi_{\text{out}} = -60 \text{ mV} \quad (60 \text{ mV "more negative" inside})$$

(charge on  $\text{Na}^+$ )

$$\Delta G = -0.9 \frac{\text{kJ}}{\text{mol}} + (1) \left( 96,485 \frac{\text{J}}{\text{V} \cdot \text{mol}} \right) (-60 \times 10^{-3} \text{ V}) \cdot \frac{1 \text{ kJ}}{10^3 \text{ J}}$$
$$= -0.9 \frac{\text{kJ}}{\text{mol}} - 5.8 \frac{\text{kJ}}{\text{mol}} = \underline{\underline{-6.7 \text{ kJ/mol}}}$$

10.  $\Delta \Psi$  makes co-transport MORE favorable.

$$(\Delta G = -0.9 \frac{\text{kJ}}{\text{mol}} \text{ versus } \Delta G = -6.7 \frac{\text{kJ}}{\text{mol}})$$

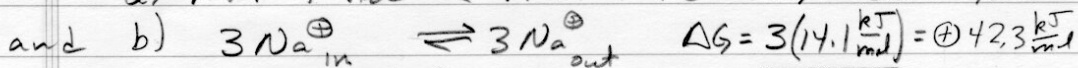
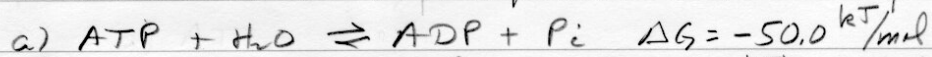
11.  $\Delta G = RT \ln \left( \frac{[\text{Na}^+]_{\text{out}}}{[\text{Na}^+]_{\text{in}}} \right) + nZ \Delta \Psi$ , and  $\Delta \Psi = \Psi_{\text{out}} - \Psi_{\text{in}} = \textcircled{+60 \text{ mV}}$  (NOTE)

$$\Delta G = \downarrow + 8.3 \frac{\text{kJ}}{\text{mol}} \quad \downarrow + 5.8 \frac{\text{kJ}}{\text{mol}} = \underline{\underline{+14.1 \frac{\text{kJ}}{\text{mol}}}}$$

$\uparrow$  (direction of process is reversed)

12. This process IS NOT spontaneous. Sodium ions are moving against the concentration and voltage gradients.

13. Use Hess's law. The overall process is the sum of



$$\Delta G_{\text{Total}} = \underline{\underline{-7.7 \text{ kJ/mol}}}$$

(NOTE)

14. ATP-driven transport of  $\text{Na}^+$  IS spontaneous.

15. Primary active transport of  $\text{Na}^+$  maintains ion and voltage gradients that support secondary active transport of C into intestinal cells.