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. $\Delta G^{\circ\prime} = -RT \ln K$; $\ln K = \ln(1.0) = 0$, so $\Delta G^{\circ\prime} = 0$.
(K = 1 and $\Delta G^{\circ\prime} = 0$ for simple transport equilibria)

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

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

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

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, ΔG is the sum of the ΔGs 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 ΔG 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 $Na^{\oplus}$ gradient drives uptake of C.

Answers, p. 2

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

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

(charge on $Na^{\oplus}$)

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

$$= -0.9\,\frac{kJ}{mol} - 5.8\,\frac{kJ}{mol} = \underline{\underline{-6.7\,kJ/mol}}$$

10. $\Delta\Psi$ makes co-transport MORE favorable.
($\Delta G = -0.9\,\frac{kJ}{mol}$ versus $\Delta G = -6.7\,kJ/mol$)

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

$\Delta G = +8.3\,\frac{kJ}{mol} + 5.8\,\frac{kJ}{mol} = \underline{+14.1\,\frac{kJ}{mol}}$

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

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

a) $ATP + H_2O \rightleftharpoons ADP + P_i \quad \Delta G = -50.0\,kJ/mol$

and b) $3Na^{\oplus}_{in} \rightleftharpoons 3Na^{\oplus}_{out} \quad \Delta G = 3\left(14.1\,\frac{kJ}{mol}\right) = \oplus 42.3\,\frac{kJ}{mol}$ (NOTE)

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

14. ATP-driven transport of $Na^{\oplus}$ <u>IS</u> spontaneous.

15. <u>Primary active transport</u> of $Na^{\oplus}$ maintains ion and voltage gradients that support <u>secondary active transport</u> of C into intestinal cells.