Name Key

Chem 452 - Fall 2010 - Quiz 5

Potentially useful facts:

Ideal Gas Law constant, R = 8.314 J/(mol•K) = 0.08206 (L•atm)/(mol•K)

Faraday's Constant, F = 9.65 x 10^4 J/mol•V

1. In our discussion of signal transduction pathways, we encountered a number of defined protein domains. For each of the following domains, describe their function and give one example of a signal transduction pathway that makes use of this domain.

   a. SH2 (Src homology domain 2): The SH2 domain recognizes and binds to phosphotyrosine groups. Examples are found on both the IRS-1 peptide and the phosphoinositide 3-kinase in the insulin signal transduction pathway.

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   b. PH (Pleckstrin homology domain): The PH domain recognizes and binds to phosphotidylinositol 4,5-bisphosphosphate (PIP_2) and phosphotidylinositol 3,4,5-trisphosphosphate (PIP_3) membrane phospholipids. Examples are found on both the IRS-1 peptide and the PIP_3-dependent kinase (PDK) in the insulin signal transduction pathwathway

   c. SH3 (Src homology domain 3): The SH3 domain recognizes and binds to polyproline sequences. An example can be found on Grb-2 adaptor protein in the epidermal growth factor (EGF) signal transduction pathway

   d. P-loop nucleotide binding domain: This domain binds both nucleotide diphosphates and nucleotide triphosphates. The G-proteins are an example where conformational changes that occur produce an "on" state associated with the GTP-bound form, and and "off" state associated with the GDP-bound form. This domain also has hydrolase activity which converts the GTP-bound form the the GDP-bound form. G-proteins are found in the β-adrenergic signal pathway.

2. Name the second messenger(s) for each of the following receptors and describe the reaction by which each is produced.

   a. insulin receptor: Phosphotidylinositol 3,4,5-trisphoshate (PIP_3), which is produced by the phosphorylation of phosphotidylinositol 4,5-bisphosphate (PIP_2) with ATP using the enzyme Phosphoinositide 3-kinase.

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   b. epinephrin (β-adrenergic) receptor: Cyclic-AMP (cAMP), which is produced from ATP by the enzyme adenyl cyclase.

   c. angiotensin II receptor: Inositol 1,4,5 trisphosphate (IP_3), which is produced from phosphotidylinositol 4,5-bisphoshate (PIP_2) by the enzyme Phospholipase C.

3. In class we studies a couple of different examples of active transport proteins; one was the Na^+/K^+ pump and the other was the lactose permease.

a. What is the direct source of free energy used in each of these transport systems?

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i. Na^+/K^+: The hydrolysis of ATP

ii. Lactose permease: A proton gradient across the cytoplasmic membrane.

b. If the *pH* on the outside of a cell membrane is 6.2 while the *pH* on the inside is 7.4, and the membrane potential is -70 mV (outside is more positive), what quantity of free energy is available to the permease system? (Assume *T* = 37°C) ΔG = -12.7 kJ/mol

Show calculations:

$$\Delta G = RT\ln\left(\frac{[H^+]_{in}}{[H^+]_{out}}\right) + zFV$$

$$= (8.314\ \text{J/mol•K})(37+273\ \text{K})\ln\left(\frac{10^{-7.4}}{10^{-6.2}}\right) + (1)(9.65\text{x}10^4\ \text{J/mol•V})(-0.070\ \text{V})$$

$$= -13{,}900\ \frac{\text{J}}{\text{mol}} = -13.9\frac{\text{kJ}}{\text{mol}}$$

c. What is the maximum ratio of the lactose concentration that the permease system can support across the cell membrane under the conditions described above? 220

Show calculations:

The proton gradient provides -12.7 kJ/mol of free energy, therefore the free energy difference for the lactose gradient can be as high as 12.7 kJ/mol. Since the charge on lactose is zero, the electrical potential gradient term can be ignored

$$\Delta G = RT\ln\left(\frac{[lactose]_{in}}{[lactose]_{out}}\right)$$

$$\left(\frac{[lactose]_{in}}{[lactose]_{out}}\right) = e^{\frac{\Delta G}{RT}} = e^{\frac{13{,}900\ \text{J/mol}}{(8.314\ \text{J/mol•K})(310K)}} = 220$$

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