Discussion Exercise 7: Qualitative Thermodynamics

Skill 1: Recognize hydrolysis and condensation reactions and predict their spontaneity

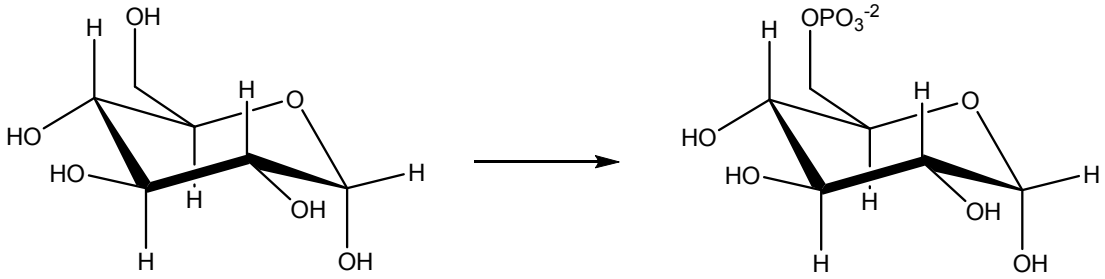
- Hydrolysis reactions and condensation reactions are inverse reactions.
- Hydrolysis reactions are spontaneous under cellular conditions; condensation reactions typically require an input of energy.

Problem 1: Label each reaction as spontaneous or nonspontaneous.

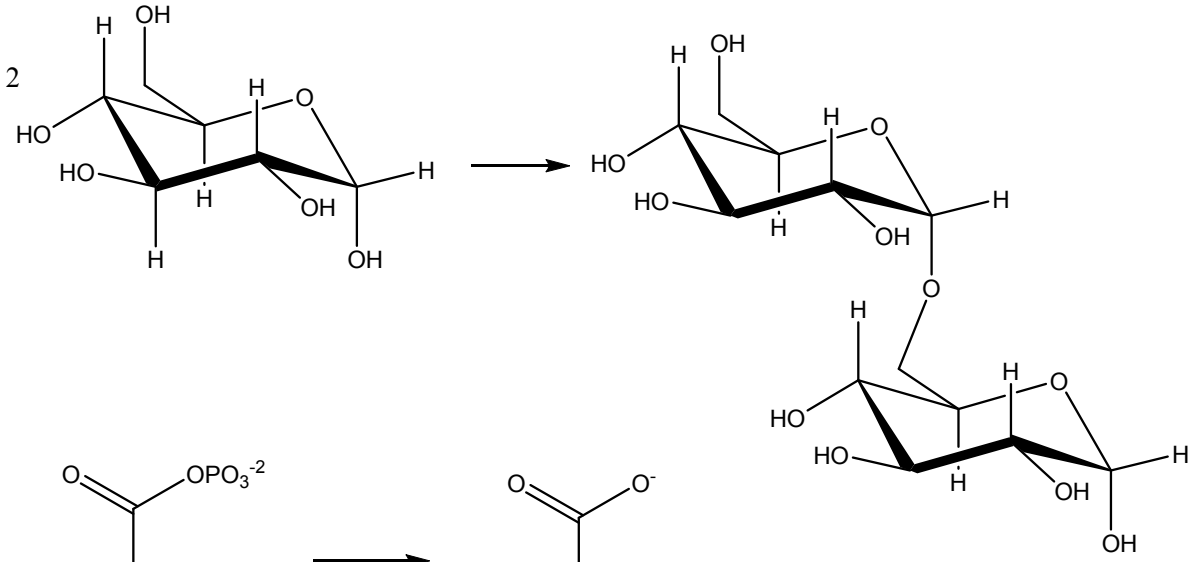
A. 2 glucose → maltose (a disaccharide)
B. Ala-Gly → Ala + Gly
C. glycerol + 3 fatty acids → triacylglyceride
D. glucose-6-phosphate → glucose + inorganic phosphate

Problem 2: Which of the following reactions requires input of ATP?

A.



B.



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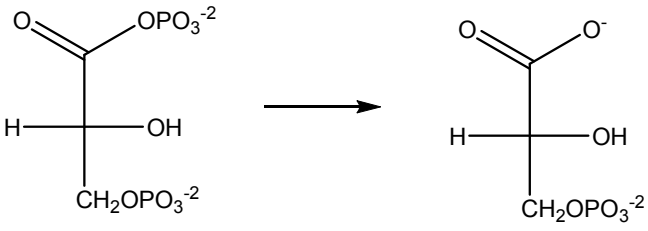
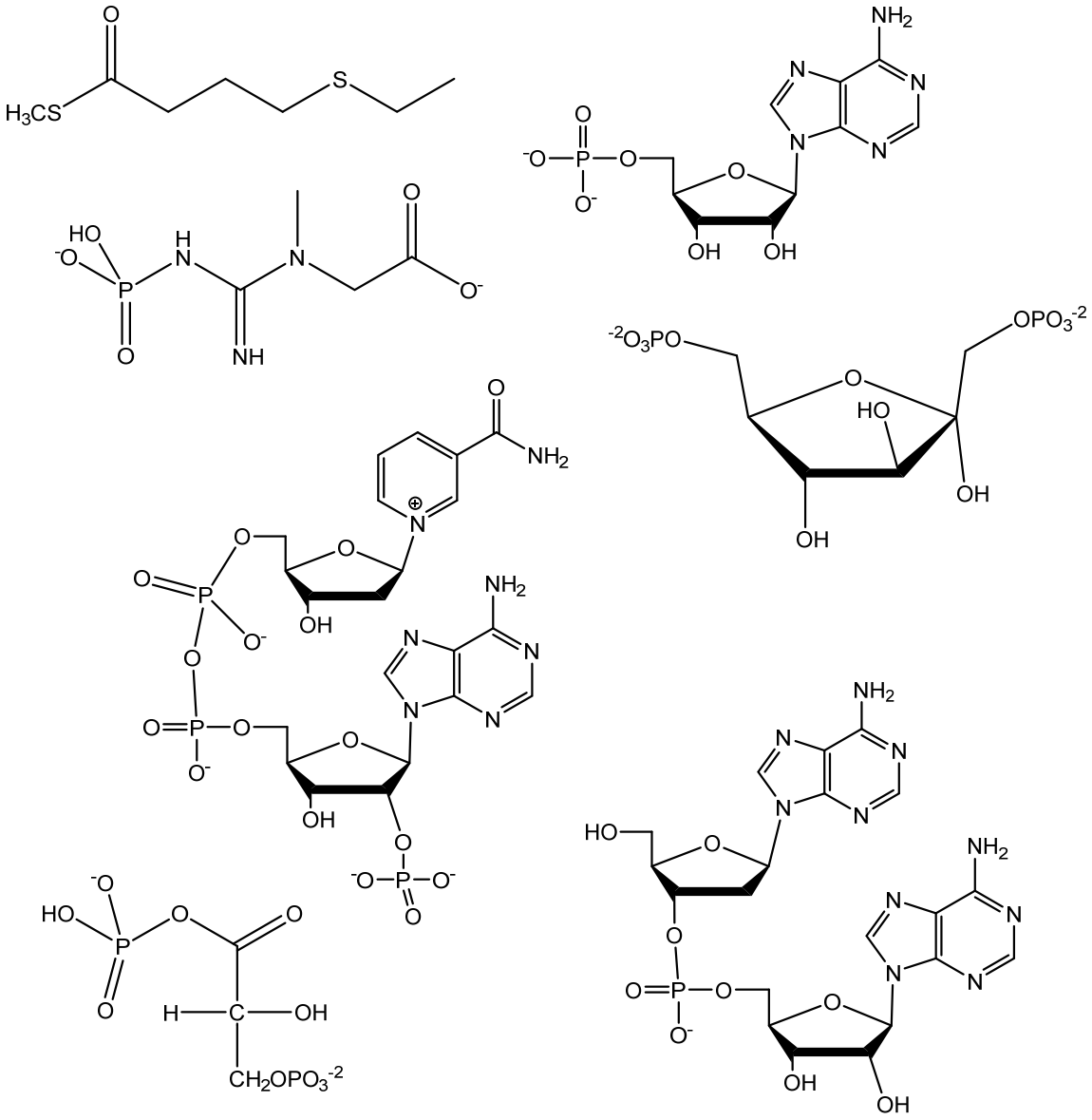


Problem 3: Explain why a ligase requires ATP, but a hydrolase does not.

Skill 2: Predict the direction of equilibrium of reactions by recognize high energy bonds

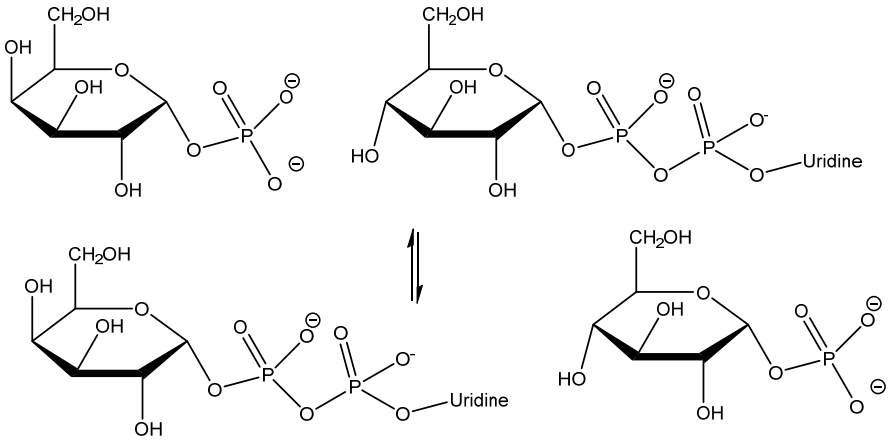
- High energy bonds are unstable bonds that have highly exothermic hydrolysis reactions
- High energy bonds include phosphoanhydrides and thioesters.
- Reactions in which more high energy bonds are broken than formed are exothermic
- Reactions in which more high energy bonds are made than broken are endothermic
- Reactions in which the numbers of high energy bonds are unchanged are near-equilibrium reactions.

Problem 4: Indicate the high energy bond(s) in each of these compounds, or say "no high energy bond."

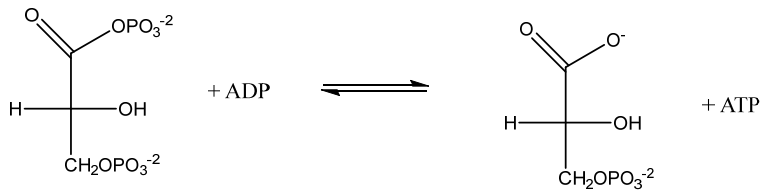


Problem 5: Indicate the number of high energy bonds in the reactants and products, and indicate the direction of equilibrium for the reaction.

A.



B



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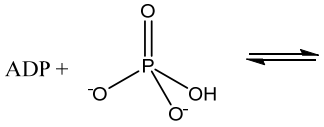
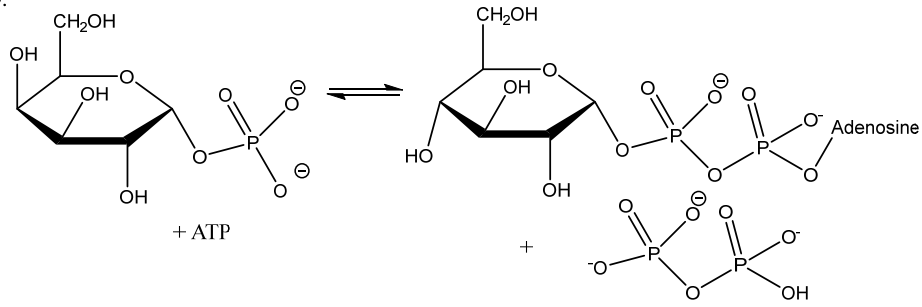


D.



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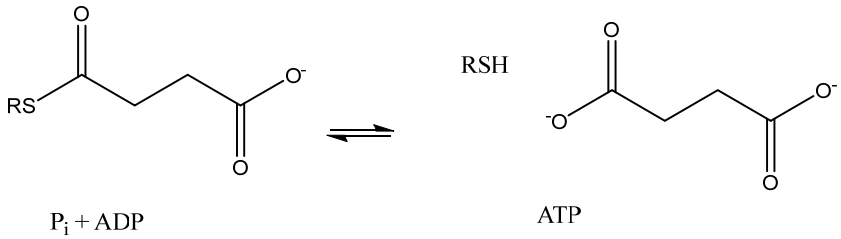
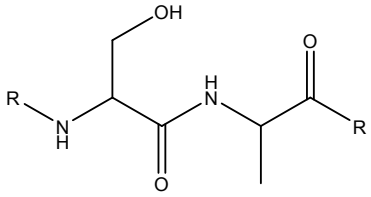


Skill 3: Predict the products of kinase reactions

- Kinases transfer phosphate groups.
- These reactions are spontaneous when the phosphate is transferred from a high energy bond (phosphoanhydride) to a low energy bond (phosphate ester.)
- Most commonly, kinases transfer a phosphate from ATP to another molecule.

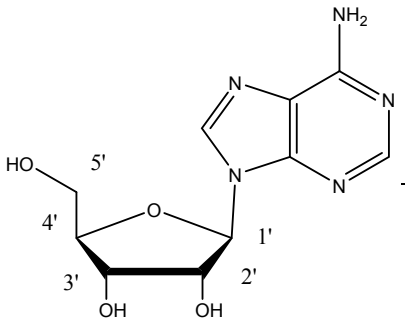
Problem 6: Draw the structures of the products of these kinase catalyzed reactions. The name of each product is given. Explain why the reaction is thermodynamically favorable in terms of bonds made and broken.



ATP

Protein Kinase A

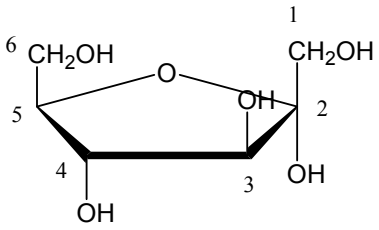
PKA phosphorylates serine residues of proteins



adenosine

ATP

5'-adenosine monophosphate



fructose

2 ATP

fructose-1,6-bisphosphate