Answer the following questions about beta-oxidation:

Step 1 Activation (formation of thioester with CoA):

$$\begin{array}{c} & & & & & & & & & \\ RCH_2CH_2CH_2C - OH + CoASH + ATP \longrightarrow RCH_2CH_2CH_2C - SCoA + AMP + 2 P_i \\ & & & & & & & & \\ fatty \ acid & & & & & & & \\ \end{array}$$

Step 2 Oxidation [dehydrogenation at carbons 2 and 3  $(\alpha$ - and  $\beta$ -carbons)]:

$$\begin{array}{c} O \\ \parallel \\ RCH_2CH_2CH_2C - SCoA + FAD \longrightarrow RCH_2CH = CHC - SCoA + FADH_2 \end{array}$$

Step 3 Hydration (conversion to a secondary alcohol):

$$\begin{array}{ccc} O & OH & O \\ \parallel & \parallel & \parallel \\ RCH_2CH = CHC - SCoA + H_2O \longrightarrow RCH_2CHCH_2C - SCoA \end{array}$$

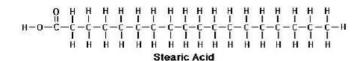
Step 4 Oxidation [dehydrogenation of carbon 3 (β-carbon) to a keto group]:

$$\begin{array}{c|c} OH & O & O & O \\ | & || & || \\ RCH_2CHCH_2C - SCoA + NAD^+ \longrightarrow RCH_2CCH_2C - SCoA + NADH + H^+ \end{array}$$

Step 5 Carbon-chain cleavage (reaction with CoA to produce acetyl-CoA and an activated thioester of a fatty acid shortened by two carbons):

$$\begin{array}{c|c} O & O & O \\ \parallel & \parallel & \parallel \\ RCH_2CCH_2C - SCoA + CoASH \longrightarrow RCH_2C - SCoA + \frac{O}{CH_2C} - SCoA \\ & \text{acetyl-CoA} \end{array}$$

- (a) In which step(s) does the cell gain energy? Explain.
- (b) Is which step(s) does the cell lose energy? Explain.
- (c) How much ATP (or equivalents) are produced per cycle of beta-oxidation?
- (d) If stearic acid (an 18 carbon fatty acid) is completely converted to acetyl-CoA), how much energy would the cell gain (assuming all the molecules are converted to ATP)?



(a) How many acetyl-CoA molecules are produced Explain.

(b) How many NADH are produced? Explain.

(c) How many FADH<sub>2</sub> are produced? Explain.

(d) How many ATP total can be produced after the NADH and FADH<sub>2</sub> undergo oxidative phosphorylation? Explain.

Answer the questions below about the following reaction:

$$\begin{array}{c} O \\ O \\ CH_1CCH_2C - SACP + NADPH + H^+ \longrightarrow \begin{array}{c} OH \\ O \\ I \\ CH_2CHCH_2C - SACP + NADP^+ \\ \beta - \text{hydroxybutyryl-ACP} \end{array}$$

- (a) Describe chemically what is occurring in this step.
- (b) Is this step adding or removing energy from the cell? Explain.
- (c) Indicate with arrow any oxidation/reduction occurring in the reaction.
- (d) Is this step an example of catabolic or anabolic metabolism? Explain.

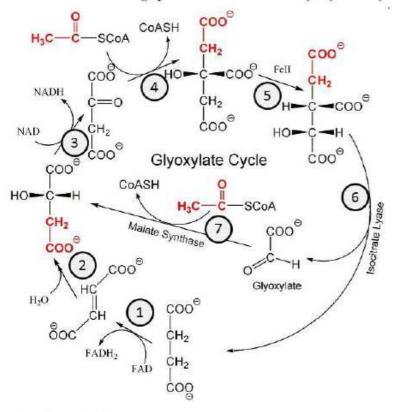
Answer the questions below about the following reaction:

- (a) Describe chemically what is occurring as (Succinic Acid → Fumaric Acid).
- (b) Is this step adding or removing energy from the cell? Explain.
- (c) Indicate with arrow any oxidation/reduction occurring in the reaction.
- (d) Is this step an example of catabolic or anabolic metabolism? Explain.

Answer the questions below about the following reaction:

- (a) Describe chemically what is occurring in this step.
- (b) Is this step adding or removing energy from the cell? Explain.
- (c) What is oxidized in this reaction? Explain.
- (d) What is reduced in this reaction? Explain.
- (e) Is this step an example of catabolic or anabolic metabolism? Explain.
- (f) Is this a step from beta-oxidation or lipogenesis. Explain.

Answer the following questions about the Glyoxylate Cycle.



- (a) Describe chemically what is occurring in Step 1.
- (b) Is this step adding or removing energy from the cell? Explain.
- (c) What is oxidized in this reaction? Explain.
- (d) What is reduced in this reaction? Explain.
- (e) Is this step an example of catabolic or anabolic metabolism? Explain.

Answer the following questions about the Glyoxylate Cycle.

- (a) Describe chemically what is occurring in Step 2.
- (b) Is this step adding or removing energy from the cell? Explain.
- (c) What is oxidized in this reaction? Explain.
- (d) What is reduced in this reaction? Explain.
- (e) Is this step an example of catabolic or anabolic metabolism? Explain.

Answer the following questions about the Urea Cycle.

COOH
$$CH_{2}$$

$$CH_{2}$$

$$NH_{2}-CH-COOH$$

$$L-glutamic acid$$

$$COOH$$

$$CH_{2}$$

$$CH_{2}$$

$$O=C-COOH$$

$$\alpha\text{-ketoglutaric acid}$$

$$2 \text{ ATP } 2 \text{ ADP } + P_{1}$$

$$O$$

$$CATD$$

$$CATD$$

$$ACCO$$

$$CATD$$

- (a) In the first step of the reaction, does the cell gain or lose energy. Explain.
- (b) Is the first step of the reaction an example of Catabolism or Anabolism? Explain.
- (c) In the second step of the reaction, does the cell gain or lose energy. Explain.
- (d) Is the first step of the reaction an example of Catabolism or Anabolism? Explain.

The following reaction is part of the glycolysis pathway.

## Phosphoenolpyruvate 2 ADP 2 ATP Pyruvate Pyruvate kinase

- (a) Describe chemically what is occurring in this step.
- (b) Is this step adding or removing energy from the cell? Explain.
- (c) What is oxidized in this reaction? Explain.
- (d) What is reduced in this reaction? Explain.
- (e) Is this step an example of catabolic or anabolic metabolism? Explain.
- (f) What enzyme catalyzes this reaction?

Answer the questions below about the following reaction:

- (a) Describe chemically what is occurring in this step.
- (b) Is this step adding or removing energy from the cell? Explain.
- (c) What is oxidized in this reaction? Explain.
- (d) What is reduced in this reaction? Explain.
- (e) Is this step an example of catabolic or anabolic metabolism? Explain.
- (f) Is this a step from beta-oxidation or lipogenesis. Explain.