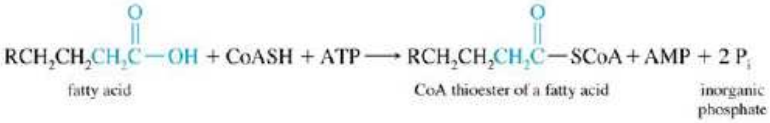
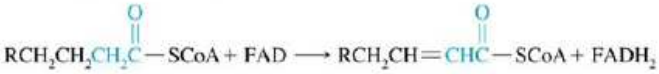
Answer the following questions about beta-oxidation:

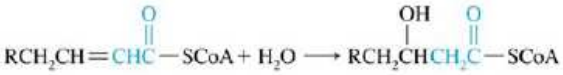
**Step 1** **Activation (formation of thioester with CoA):**




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

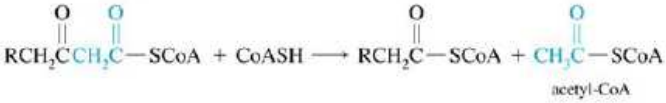



**Step 3** **Hydration (conversion to a secondary alcohol):**




**Step 4** **Oxidation [dehydrogenation of carbon 3 ($\beta$-carbon) to a keto group]:**


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




(a) In which step(s) does the cell gain energy? Explain.

Step 2 and 4. $FADH_2$ and NADH are produced.

(b) Is which step(s) does the cell lose energy? Explain.

Step 1, an ATP is used to start the reaction

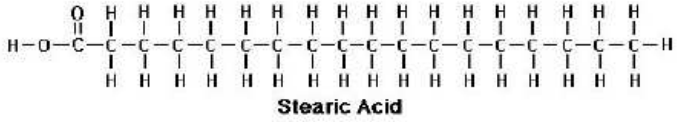
(c) How much ATP (or equivalents) are produced per cycle of beta-oxidation?

1 - $FADH_2$ and 1 – NADH therefore 2 + 3 = 5 ATP/cycle

(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)?

18 carbons would require 8 chops producing (5*8) = 40 ATP, - 1 ATP to start the process = 39 ATP

Answer the following questions about the molecule below undergoing beta-oxidation:



Stearic Acid

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

18 carbons would require 8 chops producing 9 acetyl-CoA

(b) How many NADH are produced? Explain.

8 chops, each produces 1 NADH = 8 NADH

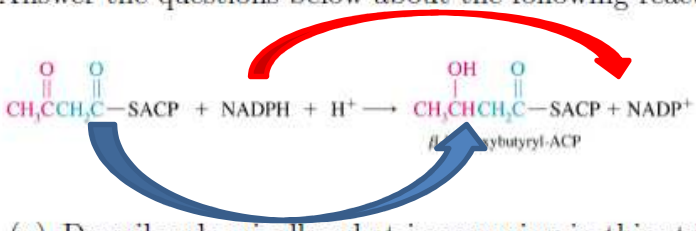
(c) How many $FADH_2$ are produced? Explain.

8 chops, each produces 1 $FADH_2$ = 8 $FADH_2$

(d) How many ATP total can be produced after the NADH and $FADH_2$ undergo oxidative phosphorylation? Explain.

$FADH_2$ = 2 ATP each, NADH = 3 ATP each, therefore 8*5 = 40 ATP

Answer the questions below about the following reaction:




(a) Describe chemically what is occurring in this step.

The molecules is reduced (Ketone → Alcohol) by addition of $H_2$ across the C=C.

(b) Is this step adding or removing energy from the cell? Explain.

Removing, NADPH is used

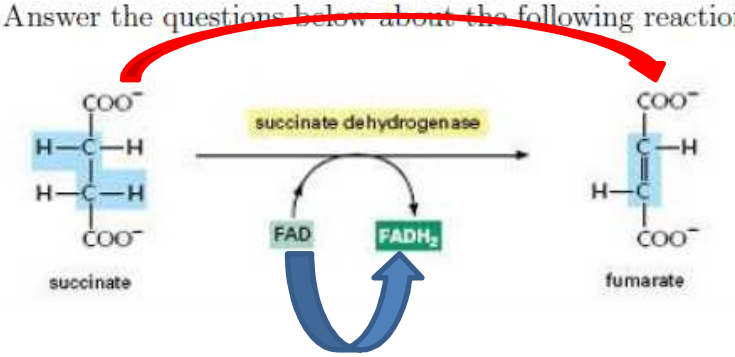
(c) Indicate with arrow any oxidation/reduction occurring in the reaction.

Molecule is reduced, NADPH is oxidized

(d) Is this step an example of catabolic or anabolic metabolism? Explain.

Anabolism as the molecule is reduced

Answer the questions below about the following reaction:




(a) Describe chemically what is occurring as (Succinic Acid ⟶ Fumaric Acid).

Molecule is oxidized (loses $H_2$) via dehydrogenation

(b) Is this step adding or removing energy from the cell? Explain.

Adding FAD is reduced to $FADH_2$

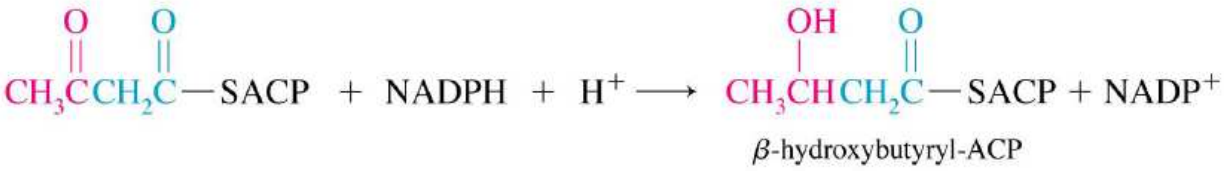
(c) Indicate with arrow any oxidation/reduction occurring in the reaction.

Molecule is oxidized, FAD is reduced

(d) Is this step an example of catabolic or anabolic metabolism? Explain.

Catabolism as the molecule loses energy

Answer the questions below about the following reaction:




(a) Describe chemically what is occurring in this step.

The molecules is reduced (Ketone → Alcohol) by addition of $H_2$ across the C=C.

(b) Is this step adding or removing energy from the cell? Explain.

Removing, NADPH is used

(c) What is oxidized in this reaction? Explain.

NADPH is oxidized (loses energy)

(d) What is reduced in this reaction? Explain.

Molecule (gains bonds to $H_2$)

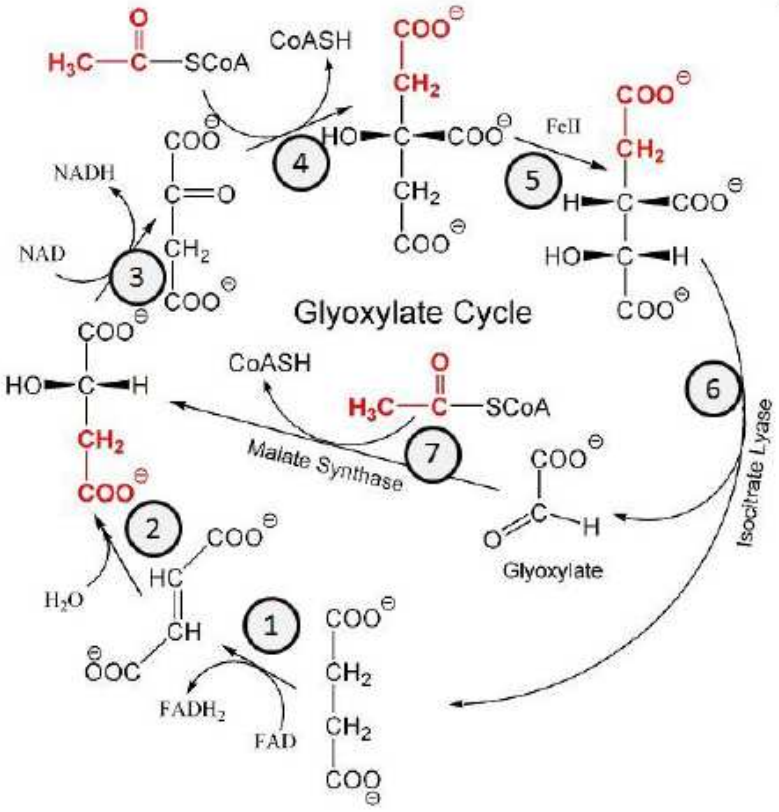
(e) Is this step an example of catabolic or anabolic metabolism? Explain.

Anabolism as the molecule is reduced

(f) Is this a step from beta-oxidation or lipogenesis. Explain.

Lipogenesis - the coenzyme is SACP

Answer the following questions about the Glyoxylate Cycle.




(a) Describe chemically what is occurring in Step 1.

Molecule is oxidized (loses $H_2$) via dehydrogenation

(b) Is this step adding or removing energy from the cell? Explain.

Adding FAD is reduced to $FADH_2$

(c) What is oxidized in this reaction? Explain.

Molecule is oxidized – loses bonds to $H_2$

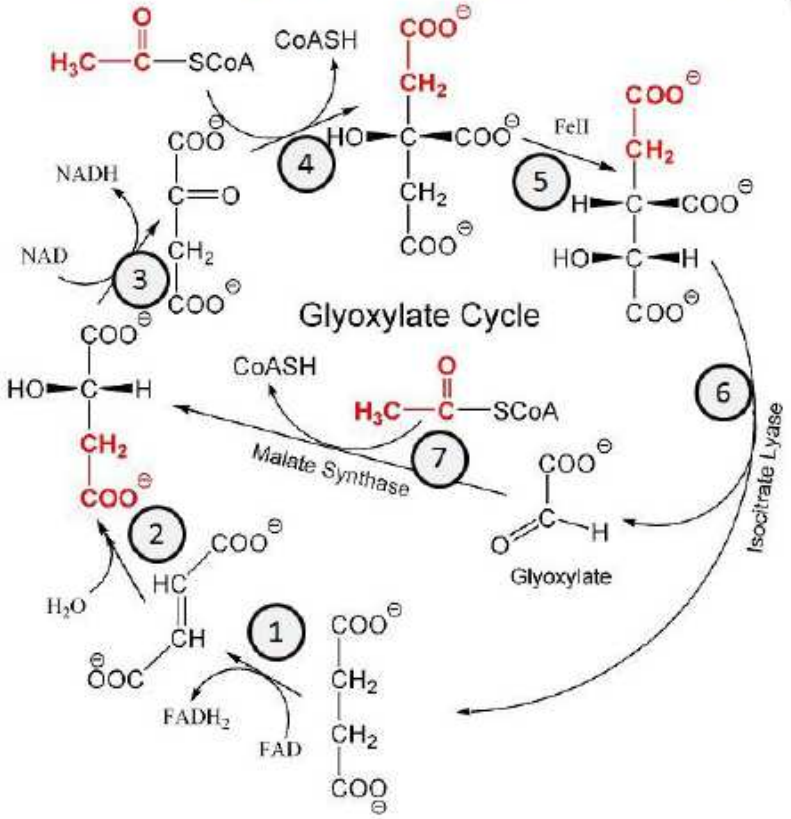
(d) What is reduced in this reaction? Explain.

FAD is reduced – gains bonds to $H_2$

(e) Is this step an example of catabolic or anabolic metabolism? Explain.

Catabolism as the molecule loses energy

Answer the following questions about the Glyoxylate Cycle.




(a) Describe chemically what is occurring in Step 2.

Hydration reaction (adding $H_2O$ across the C=C).

(b) Is this step adding or removing energy from the cell? Explain.

Neither, it is energy neutral

(c) What is oxidized in this reaction? Explain.

Nothing

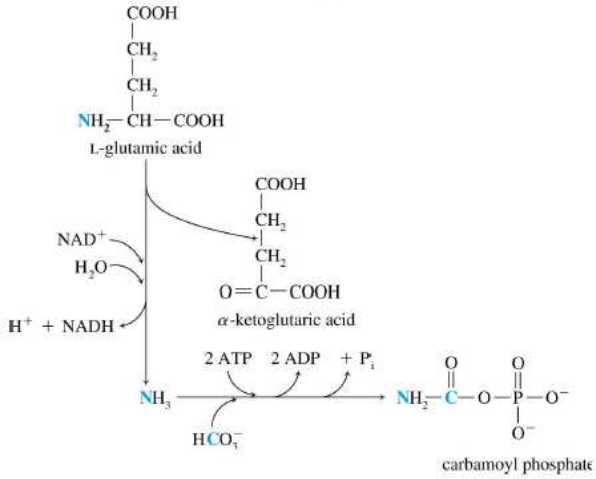
(d) What is reduced in this reaction? Explain.

Nothing

(e) Is this step an example of catabolic or anabolic metabolism? Explain.

Anabolic, the molecule is made larger

Answer the following questions about the Urea Cycle.




(a) In the first step of the reaction, does the cell gain or lose energy. Explain.

Gain, NADH is a product

(b) Is the first step of the reaction an example of Catabolism or Anabolism? Explain.

Catabolism, energy is lost by the molecule

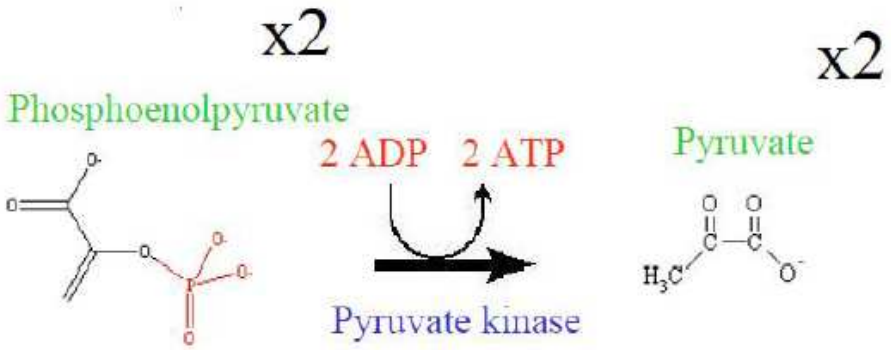
(c) In the second step of the reaction, does the cell gain or lose energy. Explain.

Lose, ATP is used

(d) Is the first step of the reaction an example of Catabolism or Anabolism? Explain.

Anabolism, energy is gained by the molecule

The following reaction is part of the glycolysis pathway.




(a) Describe chemically what is occurring in this step.

Substrate level phosphorylation – phosphate is transferred from the substrate to an ATP

(b) Is this step adding or removing energy from the cell? Explain.

Adding, ATP is produced

(c) What is oxidized in this reaction? Explain.

The molecule oxidized, gained a bond to oxygen (4 to 5)

(d) What is reduced in this reaction? Explain.

ATP, gains energy

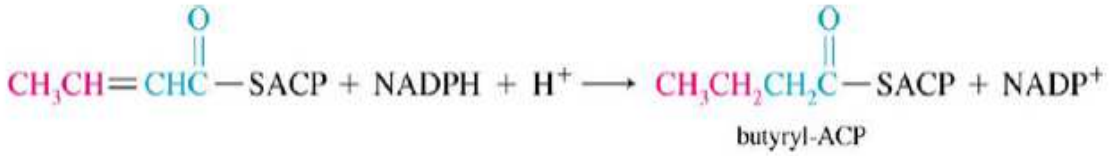
(e) Is this step an example of catabolic or anabolic metabolism? Explain.

Catabolic, the molecule is broken down, and the cell gains energy

(f) What enzyme catalyzes this reaction?

Pyruvate Kinase

Answer the questions below about the following reaction:




(a) Describe chemically what is occurring in this step.

Hydrogenation, $H_2$ is added across the C=C

(b) Is this step adding or removing energy from the cell? Explain.

Removing, NADPH is oxidized (used)

(c) What is oxidized in this reaction? Explain.

NADPH, lost bond to H

(d) What is reduced in this reaction? Explain.

Molecule, gains bonds to H

(e) Is this step an example of catabolic or anabolic metabolism? Explain.

Anabolic, the molecules gains energy

(f) Is this a step from beta-oxidation or lipogenesis. Explain.

Lipogenesis because the coenzyme is SACP