Key

Chem 352, Fall 2018 - Quiz 4

Use constants: Ideal gas law constant, R = 0.08206 (l•atm)/(mol•K) = 8.314 (J/(mol•K); Faraday's constant, $\mathscr{F}$ = 9.659 x 10^4 J/(V•mol); Planck's constant, h = 6.626 x 10^{-34} J•s.

1. The citric acid cycle, along with the pyruvate dehydrogenase reaction, play a major role in the complete oxidation of the glucose to CO_2 and H_2O ($C_6H_{12}O_6 + 6\ O_2 \rightarrow 6CO_2 + 6\ H_2O$). In this net reaction the carbon atoms from the glucose are oxidized to CO_2 while the hydrogen atoms are used to reduce NAD^+ and ubiquinone (Q) to NADH + H^+ and ubiquinol (QH_2).

    a. Pick one of the three reactions among the pyruvate dehydrogenation reaction and the reactions in the citric acid cycle in which both CO_2 is produced, and *using structural formulas* for the intermediates, write a balanced chemical reaction equation for the reaction you have chosen. Also, label the intermediates (reactants and products) and name of the enzyme involved.

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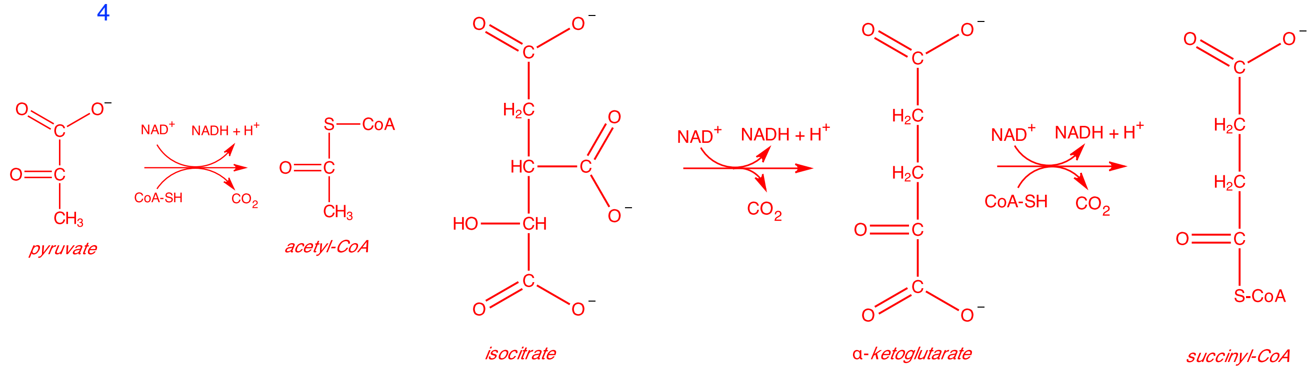
2 Enzyme Name Pyruvate Dehydrogenase or Isocitrate Dehydrogenase or α-Ketoglutarte Dehydrogenase

Reaction Equation:

4

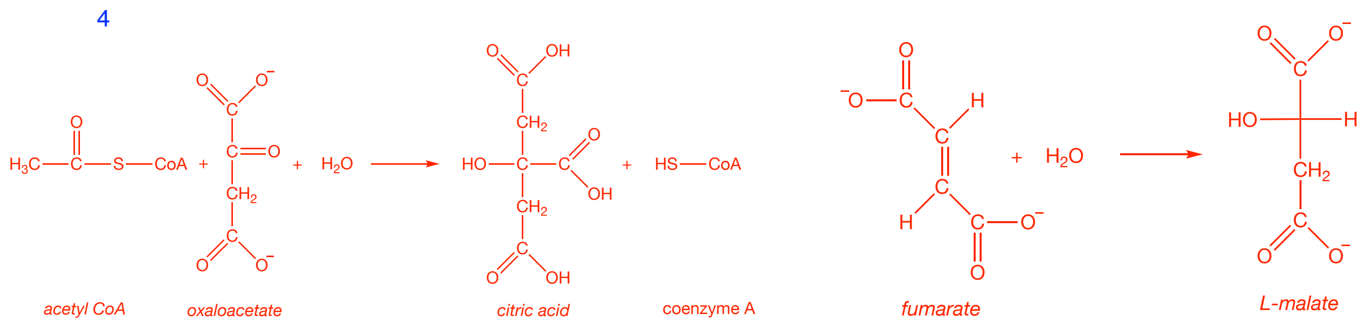


    b. In addition to the acetyl group, which enters the citric acid cycle as acetyl-CoA and contains 2 carbon atoms, 2 oxygen atoms, and 3 hydrogen atoms, there are additional hydrogen and oxygen atoms that enter the citric acid cycle as water. Pick one of the three reactions where this occurs, and *using structural formulas* for the intermediates, write a balanced chemical reaction equation for the reaction you have chosen. Also, label the intermediates (reactants and products) and give the name of the enzyme involved.

2 Enzyme Name Citrate synthase or Fumarase

Reaction Equation:

4



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2. The electron transport chain (ETC) comprises a series of redox reagents that are linked together.
   a. Identify the redox reagent found in the ETC that fits each of the following descriptions:

Description	Redox agent
The initial donor of electrons to Complex II	1 Succinate
The acceptor of electrons at the end of the ETC	1 O_2
The mobile 1-electron carrier connecting Complex III to Complex IV	1 Cytochrome *c*
The mobile 2-electron carrier connecting Complex II to Complex III	1 Ubiquinol (QH_2)
The complex that is site of the Q-cycle	1 Complex III
The initial donor of electrons to Complex I	1 NADH + H^+

a. Starting at the initial donor to Complex II and ending with the acceptor from Complex III, write the *net balanced reaction equation* for the flow of 2 electrons from this donor to this acceptor.

3

$$2\text{ cyt } c_{ox} + 2e^- \longrightarrow 2\text{ cyt } c_{red} \qquad E^{o'} = +0.23\text{ V}$$

$$\text{succinate} \longrightarrow \text{fumaraate} + 2H^+ + 2e^- \qquad -0.03\text{ V}$$

$$\text{succinate} + 2\text{ cyt } c_{ox} \longrightarrow \text{fumarate} + 2\text{ cyt cred} + H^+ \qquad \Delta E^{o'} = +0.20\text{ V}$$

b. Using the appropriate reduction potentials provided in the table below, calculate the standard free energy change per mole of this reaction. (Show your calculations.)

4

$$\Delta G^{o'} = -n\mathscr{F}\Delta E^{o'}$$

$$= -(2)\left(9.659 \times 10^4 \frac{\text{J}}{\text{mol•V}}\right)(0.20\text{ V})$$

$$\Delta G^{o'} = -38{,}600 \frac{\text{J}}{\text{mol}} = -38.6 \frac{\text{kJ}}{\text{mol}}$$

$\Delta G°' =$ -38.6 kJ/mol

TABLE 10.4 Standard reduction potentials of some important biological half-reactions

Reduction half-reaction	$E°'$ (V)
Cytochrome b_5 (microsomal), $Fe^{3+} + e^- \rightarrow Fe^{2+}$	0.02
Fumarate + 2 H^+ + 2e^- → Succinate	0.03
Ubiquinone (Q) + 2 H^+ + 2e^- → QH_2	0.04
Cytochrome *b* (mitochondrial), $Fe^{3+} + e^- \rightarrow Fe^{2+}$	0.08
Cytochrome c_1, $Fe^{3+} + e^- \rightarrow Fe^{2+}$	0.22
Cytochrome *c*, $Fe^{3+} + e^- \rightarrow Fe^{2+}$	0.23
Cytochrome *a*, $Fe^{3+} + e^- \rightarrow Fe^{2+}$	0.29
Cytochrome *f*, $Fe^{3+} + e^- \rightarrow Fe^{2+}$	0.36
Plastocyanin, $Cu^{2+} + e^- \rightarrow Cu^+$	0.37
$NO_3^- + 2H^+ + 2e^- \rightarrow NO_2^- + H_2O$	0.42
Photosystem I (P700)	0.43
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	0.77
$\frac{1}{2}O_2 + 2H^+ + 2e^- \rightarrow H_2O$	0.82
Photosystem II (P680)	1.1

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