1. a. acetyl-CoA + 3NAD\(^+\) + FAD + GDP + P\(_i\) + 2H\(_2\)O → 2CO\(_2\) + CoA + 3NADH + FADH\(_2\) + GTP + 2H\(^+\)
   b. 3 NADH → 3*2.5 ATP = 7.5 ATP; 1 FADH\(_2\) → 1.5 ATP; 1 GTP ≈ 1 ATP
   7.5 + 1.5 + 1 = 10 ATP equivalents

2. a. FMN
   b. NADH:CoQ oxidoreductase (Complex I of ETC)

3. a. Complex I: D, E
   Complex II: C, E, F
   Complex III: E, F
   Complex IV: B, F
   b. succinate → complex II → CoQ → complex III → cytochrome c → complex IV → O\(_2\), so:
   C E A E F B F B

4. a. False; ∆G depends only on reactants and products, not how reactants are converted to products
   b. True
   c. False; it predominantly binds the O-state (open or empty conformation).
   d. True
   e. True
   f. True; the proton gradient, which drives the rotation of ATP synthesis, results in lower pH in the intermembrane space than in the matrix
   g. True
   h. True; carbon monoxide can bind in place of oxygen in Complex IV, stopping electron transport
   i. False; P\(_i\) attached by GAPDH to form 1,3-BPG is then transferred to ADP to make ATP. This can happen in anaerobic metabolism, which doesn’t require a pH gradient, or even mitochondria.
   j. False; they bring the electrons from NADH into the electron transport chain.
   k. False; FADH\(_2\) is a prosthetic group of Complex II; it is succinate that diffuses to Complex II to ‘drop off’ its electrons.

5. a. B, G, I, K, L
   b. A, B, L
   c. A
   d. C, G, L
   e. A, B
   f. B, C, G
   g. D, E, L

6. Coenzyme Q. It has a long, hydrophobic (isoprene-based) tail.

7. b, c, d

8. a. FAD is the 1\(^{st}\) redox center in complex 2, so:
   \[
   \Delta E^{\circ}_{\text{redox}} = E^{\circ}_{\text{acceptor}} - E^{\circ}_{\text{donor}} = E^{\circ}_{\text{O}_2} - E^{\circ}_{\text{FAD}} = 0.82 \text{ V} - 0.05 \text{ V} = 0.77 \text{ V}
   \]
   b. \[
   \Delta G^{\circ} = -nF \Delta E^{\circ}_{\text{redox}} = -2(96.5 \text{ kJ/V mol})(0.77 \text{ V}) = -148 \text{ kJ/mol}
   \]
   c. 6 protons are pumped across the inner membrane as a result of two electrons going from FAD to O\(_2\) (or 6 moles of protons pumped for 2 moles of electrons transferred). So,
   6 moles of protons × 20 kJ/mol = 120 kJ
   -148 kJ (released) + 120 kJ (stored) = -28 kJ (not stored; released as heat)
   100% × (-28 kJ/-148 kJ) = 19%
9. a. \[ \Delta E = \Delta E^\circ - \frac{RT}{nF} \ln Q \] so at equilibrium, when \( \Delta E = 0 \) and \( Q = K'_{eq} \), \[ \Delta E^\circ = \frac{RT}{nF} \ln K'_{eq} \]

\[ \Delta E^\circ = \left( \frac{0.008315 \text{ kJ/mol-K}(298 \text{ K})}{2(96.5 \text{ kJ/V-mol})} \right) \ln \left( \frac{0.09}{0.09} \right) = 0.0128 \times \ln(81) = 0.056 \text{ V} \]

b. To the right. Under these conditions, \( Q = 1 \), so \( \Delta G = \Delta G^\circ = \text{negative} \), since \( \Delta E^\circ \) is positive.

c. It depends, since both \( Q \) and \( K'_{eq} < 1 \). If \( Q < K'_{eq} \), reaction goes right; if \( Q = K'_{eq} \), neither (at equilibrium); if \( Q > K'_{eq} \), reaction goes left.

10. a. B

b. A

c. B

11. a. Ethanol, \( \text{C}_3\text{H}_7\text{OH} \)

b. glucose (\( \text{C}_6\text{H}_{12}\text{O}_6 \)) + 2 \( \text{CO}_2 \) → 2 malate (2 × \( \text{C}_4\text{H}_4\text{O}_5 \)) + 4 \( \text{H}^+ \)

c. 1. Glucose is broken down to pyruvate in glycolysis.

2. Pyruvate is converted to oxaloacetate (OAA) by pyruvate carboxylase.

3. OAA is reduced to L-malate by malate DH (which reoxidizes NADH to NAD\(^+\)).