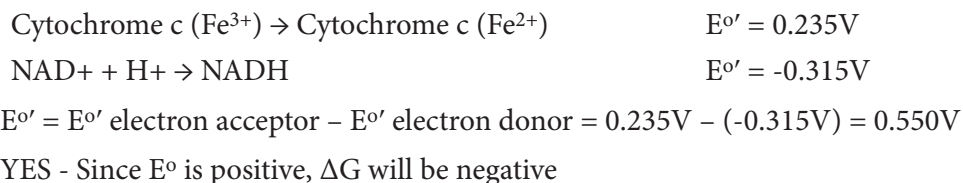




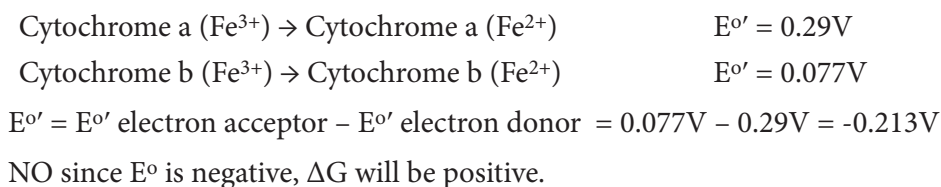
# **PRE-ACTIVITY**

# **ASSIGNMENT**

2a. Half-reactions (showing reduction):



2b. Half-reactions (showing reduction):



# **IN-CLASS**

# **ACTIVITY**

## **Critical Thinking Questions**

- Many of them contain transition metals which have multiple oxidation states, a few incorporate the extra electrons into ring structures that can accommodate the electron and form stable free radicals.
- The minerals are the metals found in ETC complexes and the vitamins provide some of the interesting organic molecules that form part of the structure of redox complexes, NADH (niacin). FAD (riboflavin).
- The  $E^{\circ}$  values referred to are for the reduction as in standard tables. Therefore an acceptor like  $\text{O}_2$  must have a more positive reduction potential to be favorable.

4.

$\Delta G^{\circ'} = -nFE^{\circ'}$		
<b>Complex I</b> $\text{NADH} + \text{CoQ(oxid.)} \rightarrow \text{NAD}^+ + \text{CoQ(red.)}$	$E^{\circ'}_{\text{cell}} = 0.36\text{V}$	$-(2e^-)(96,500\text{C/mol } e^-)(0.36\text{V})$ $-6.94 \times 10^4 \text{ J/mol rxn}$
<b>Complex II</b> $\text{FADH}_2 + \text{CoQ(oxid.)} \rightarrow \text{FAD} + \text{CoQ(red.)}$	$E^{\circ'}_{\text{cell}} = 0.085\text{V}$	$-(2e^-)(96,500\text{C/mol } e^-)(0.085\text{V})$ $-1.64 \times 10^4 \text{ J/mol rxn}$
<b>Complex III</b> $\text{CoQ(red.)} + \text{cyto. C(oxid.)} \rightarrow \text{cyto. C (red.)} + \text{CoQ(oxid.)}$	$E^{\circ'}_{\text{cell}} = 0.19\text{V}$	$-(2e^-)(96,500\text{C/mol } e^-)(0.19\text{V})$ $-3.66 \times 10^4 \text{ J/mol rxn}$

- The  $\Delta G^{\circ'}$  value for ATP synthesis is  $-30.4 \text{ kJ/mol}$  or  $-3.04 \times 10^4 \text{ J/mol}$  — Complexes I and III
- The order is from substrate electron carrier  $c \rightarrow b \rightarrow a \rightarrow d$  to  $\text{O}_2$
- A proton gradient is a gradual change of proton concentrations over distance. It is “electro” because the proton is charged and chemical because even it was not charged it is still a chemical.
- To move from an area of low concentration to high concentration is basically uphill, therefore this will require work so  $\Delta G$  will be positive. It is not spontaneous.

9. For a proton to move from areas of high concentration to low concentration is favorable due to entropy, more microscopic states with protons dissipated over a larger region and therefore the  $\Delta G$  is negative.
10. Complexes I, III, and IV pump protons.
- 11a. From the acidic outside to the basic inside  
They are flowing down a concentration gradient.
- 11b. from the basic inside to the acidic outside
- 11c. The reduction potentials get more positive in normal electron transport chain. This means that transfer of electrons along the chain is spontaneous ( $-\Delta G$ ).
- 11d. Issues stated in the problem
- $H_2$  is donor of electrons, so must have  $2H^+ + 2e^- \rightarrow H_2$  (notice it is written as a reduction potential as are all of the reactions)
  - $CO_2$  accepts the electrons and eventually becomes  $HCOOH$
  - Protons are used to drive electrons so protons must be used as reactants
  - $H_2$  provides electrons that are further transferred via electron carriers. So that must mean not to  $CO_2$  directly.

From thermodynamics we know that more useful work can be done if the steps are small rather in one giant step (glucose to  $CO_2$  and  $H_2O$  can be done by burning glucose with a Bunsen burner or in glycolysis and TCA. You get more work and less heat with the latter)

- If protons drive this reaction then the electrons can go up-hill or to a more negative reduction potential.

Since the  $H_2$  is donor, we should start with that reaction, and since  $HCOOH$  is the product that should be our last reaction. We should maximize the numbers of transfers since that will provide the largest amount of available work, but still need to have the reduction potentials becoming more negative.

From this, the reactions should be  $A \rightarrow C \rightarrow F \rightarrow B$