Key

Chem 352, Fall 2018 - Quiz 3

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

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1. Describe the metabolic purpose for each of the following pathways:
   a. Glycolysis: This is the pathway used to break the six-carbon glucose molecule down into two three-carbon pyruvate molecules, with the concomitant production of two ATP molecules.

   b. Alcohol fermentation: This is the pathway used by yeast and other organisms to reoxidize the NADH + H^+ that was reduced in glycolysis. This is done when the electron transport chain is not an option for reoxidizing the NADH + H^+.

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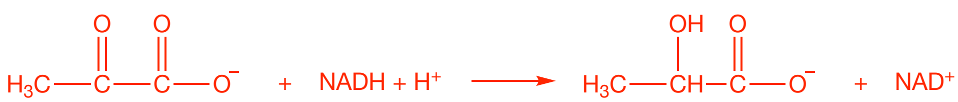
2. Lactic acid fermentation comprises a single reaction.
   a. Using structural formulas, write the *balanced reaction equation* for this reaction and label the reactants and products.



pyruvate *lactate*

   b. The enzyme that catalyzes this reaction is *lactate dehydrogenase*. What enzyme class does this enzyme belong to? oxidoreductase

   c. What role does lactic acid fermentation play in mammalian muscle tissue? Like alcohol fermentation (see above), lactic acid fermentation provides a way to reoxidize the reduced NADH produced in glycolysis, when using O_2 is not an option

   d. Using the appropriate reduction potentials provided in the table to the right, calculate the standard free energy change for this reaction.
   $\Delta G°'$ = -27.0 kJ/mol

Table 10.5 Standard reduction potentials of some important biological half-reactions

Reduction half-reaction	$E°'$ (V)
Acetyl CoA + CO_2 + $H^{\oplus}$ + $2e^{\ominus}$ → Pyruvate + CoA	−0.48
Ferredoxin (spinach). Fe^{3+} + $e^{\ominus}$ → Fe^{2+}	−0.43
2 $H^{\oplus}$ + $2e^{\ominus}$ → H_2 (at pH 7.0)	−0.42
α-Ketoglutarate + CO_2 + 2 $H^{\oplus}$ + $2e^{\ominus}$ → Isocitrate	−0.38
Lipoyl dehydrogenase (FAD) + 2 $H^{\oplus}$ + $2e^{\ominus}$ → Lipoyl dehydrogenase ($FADH_2$)	−0.34
$NADP^{\oplus}$ + $H^{\oplus}$ + $2e^{\ominus}$ → NADPH	−0.32
$NAD^{\oplus}$ + $H^{\oplus}$ + $2e^{\ominus}$ → NADH	−0.32
Lipoic acid + 2 $H^{\oplus}$ + $2e^{\ominus}$ → Dihydrolipoic acid	−0.29
Thioredoxin (oxidized) + $2H^{\oplus}$ + $2e$ → Thioredoxin (reduced)	−0.28
Glutathione (oxidized) + 2 $H^{\oplus}$ + $2e^{\ominus}$ → 2 Glutathione (reduced)	−0.23
FAD + 2 $H^{\oplus}$ + $2e^{\ominus}$ → $FADH_2$	−0.22
FMN + 2 $H^{\oplus}$ + $2e^{\ominus}$ → $FMNH_2$	−0.22
Acetaldehyde + 2 $H^{\oplus}$ + $2e^{\ominus}$ → Ethanol	−0.20
Pyruvate + 2 $H^{\oplus}$ + $2e^{\ominus}$ → Lactate	−0.18
Oxaloacetate + 2 $H^{\oplus}$ + $2e^{\ominus}$ → Malate	−0.17
Cytochrome b_5 (microsomal). Fe^{3+} + $e^{\ominus}$ → Fe^{2+}	0.02

		$E^{o'}$
pyruvate. + $2H^+$ + $2e^-$	→ lactate	-0.18 V
NADH + H^+	→ NAD^+ + $2H^+$ + $2e^-$	+0.32 V
pyruvate + NADH + H^+	→ lactate + NAD^+	$\Delta E^{o'}$ = +0.14 V

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

$$= -(2)\left(9.659 \text{ x } 10^4 \frac{\text{J}}{\text{mol•V}}\right)(0.14 \text{ V})$$

$$\Delta G^{o'} = -27{,}000 \frac{\text{J}}{\text{mol}} = -27.0 \frac{\text{kJ}}{\text{mol}}$$

   e. Is this reaction favorable under standard state conditions? (Y/N) Y
   Explain: Under standard state conditions $\Delta G = \Delta G^{o'}$, which is less than zero, so the reaction is favorable as written.

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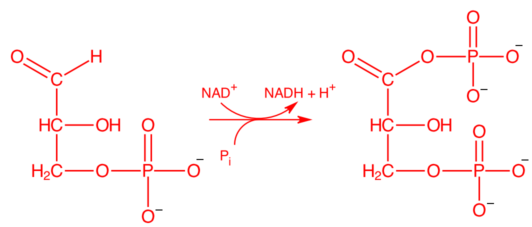
3. If you correctly drew the reaction equation in part a., it should show an NADH + H^+ being oxidizes to NAD^+. One source of the reduced NADH + H^+ for this reaction is a reaction in glycolysis that, in turn, reduces NAD^+ to NADH + H^+ Name the enzyme for this reaction, identify its class, and using structural formulas, write the balanced reaction equation for this reaction with reactants and products labeled.
Enzyme name glyceraldehyde 3-phosphate dehydrogenase Enzyme class: oxidoreductase
Reaction equation:



glyceraldehyde-3-phosphate *1,3-bisphosphoglycerate*

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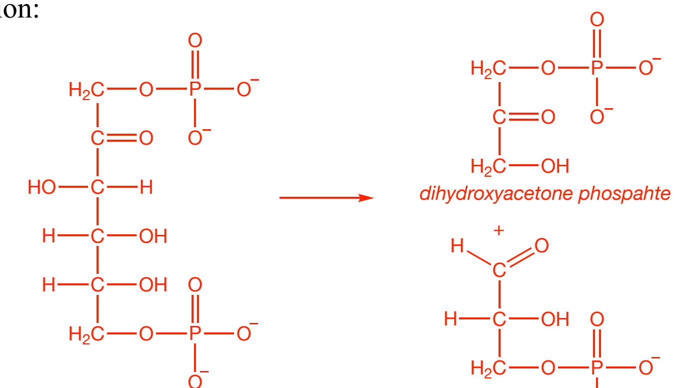
4. Glycolysis means *to slit sugar*, and the glycolytic pathway was given this name because it involves a reaction in which a six-carbon sugar derivative is split into two three-carbon sugar derivatives. Name the enzyme for this reaction, identify its class, and using structural formulas, write the balanced chemical reaction equation for this reaction with reactants and products labeled.
Enzyme name aldolase Enzyme class: Lyase
Reaction equation:



fructose-1,6-bisphosphate *glyceraldehyde-3-phosphate*

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5. There are three reactions in glycolysis that are regulated allosterically. Name two of these using their enzyme names and indicate at least one metabolite that regulates each allosterically. Also indicate the cellular condition that the regulation is responding to.

Enzyme Name	Allosteric Regulator	Is it an Activator or Inhibitor	Cellular Condition
Hexokinase	Glucose 6-phosphate	Inhibitor	Glucose 6-phosphate is not being used for glycolysis or the pentose-phosphate pathways and so is building up in the cell.
Phosphofructokinase I	ATP or Citrate	Inhibitor	This is the first committed step in glycolysis. Glycolysis is not needed for the regeneration of ATP or to generate biosynthetic precursors.

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