# Electrons, protons, and oxidation-reduction reactions.

- **Electrons** are negatively charged subatomic particles that circulate around the atom nucleus.
- Electrons are essential for atoms to form **covalent** (electron sharing) **bonds**.
- During many chemical reactions, electrons are either removed or added to molecules.
- Molecules that lose one or more electrons are ***oxidized***, whereas molecules that gain electrons are ***reduced***.

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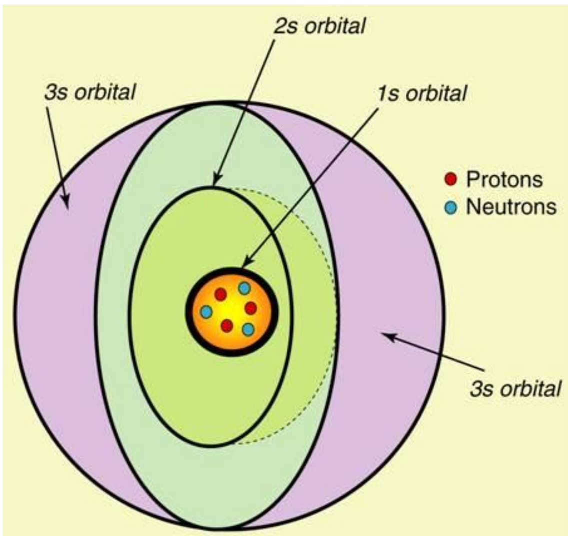
# Atoms & Electrons

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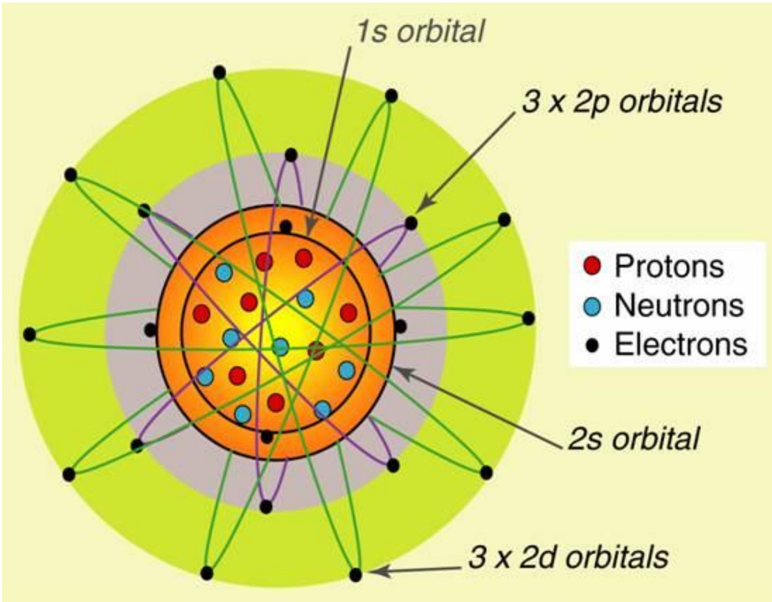
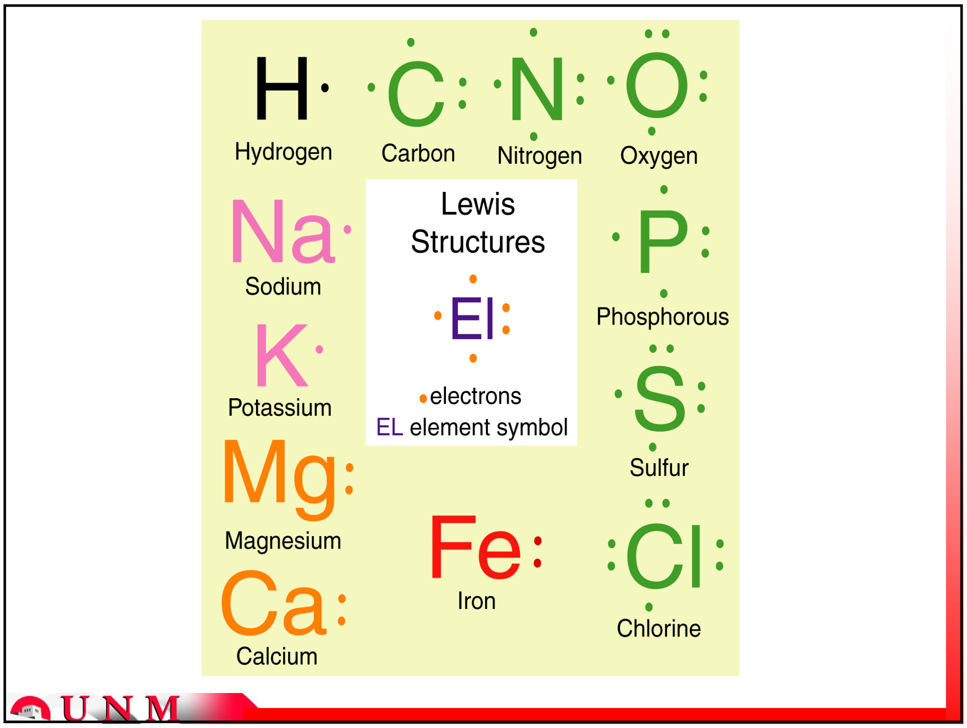



| Element | Atomic Number | Electron Configuration |
|---|---|---|
| Hydrogen | 1 | $1s^1$ |
| Helium | 2 | $1s^2$ |
| Lithium | 3 | $1s^2 2s^1$ |
| Beryllium | 4 | $1s^2 2s^2$ |
| Boron | 5 | $1s^2 2s^2 2p^1$ |
| Carbon | 6 | $1s^2 2s^2 2p^2$ |
| Nitrogen | 7 | $1s^2 2s^2 2p^3$ |
| Oxygen | 8 | $1s^2 2s^2 2p^4$ |
| Fluorine | 9 | $1s^2 2s^2 2p^5$ |
| Neon | 10 | $1s^2 2s^2 2p^6$ |
| Sodium | 11 | $1s^2 2s^2 2p^6 3s^1$ |
| Magnesium | 12 | $1s^2 2s^2 2p^6 3s^2$ |
| Aluminum | 13 | $1s^2 2s^2 2p^6 3s^2 3p^1$ |
| Silicon | 14 | $1s^2 2s^2 2p^6 3s^2 3p^2$ |
| Phosphorous | 15 | $1s^2 2s^2 2p^6 3s^2 2p^3$ |
| Sulfur | 16 | $1s^2 2s^2 2p^6 3s^2 2p^4$ |
| Chlorine | 17 | $1s^2 2s^2 2p^6 3s^2 2p^5$ |


H
Hydrogen
C
Carbon
N
Nitrogen
O
Oxygen
Na
Sodium
Lewis Structures
El
electrons
EL element symbol
P
Phosphorous
K
Potassium
S
Sulfur
Mg
Magnesium
Fe
Iron
Cl
Chlorine
Ca
Calcium
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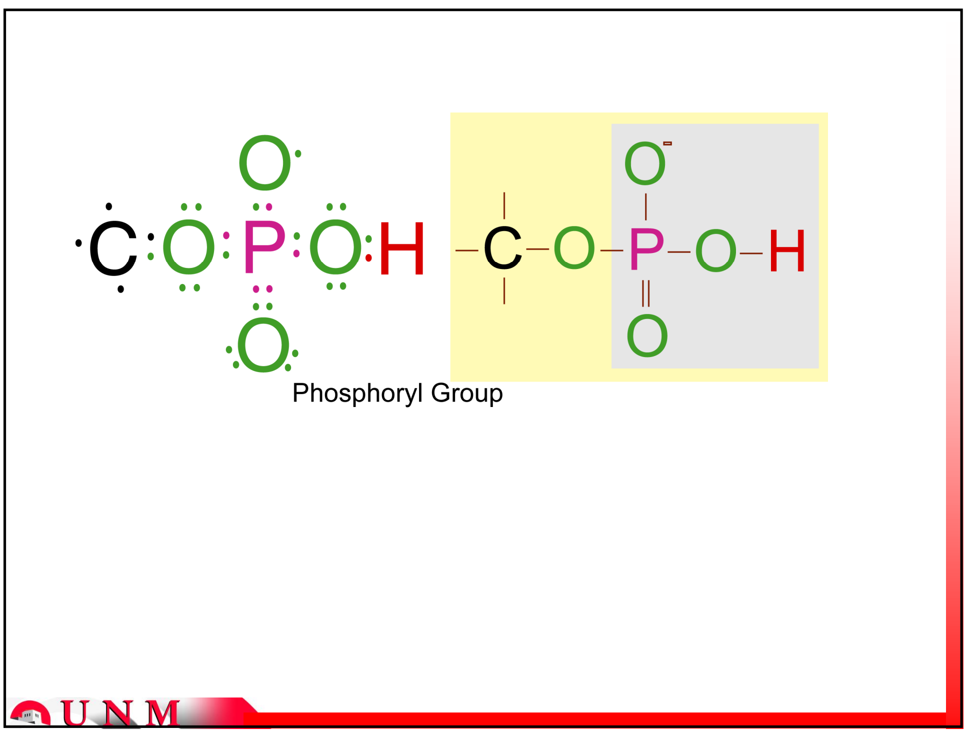
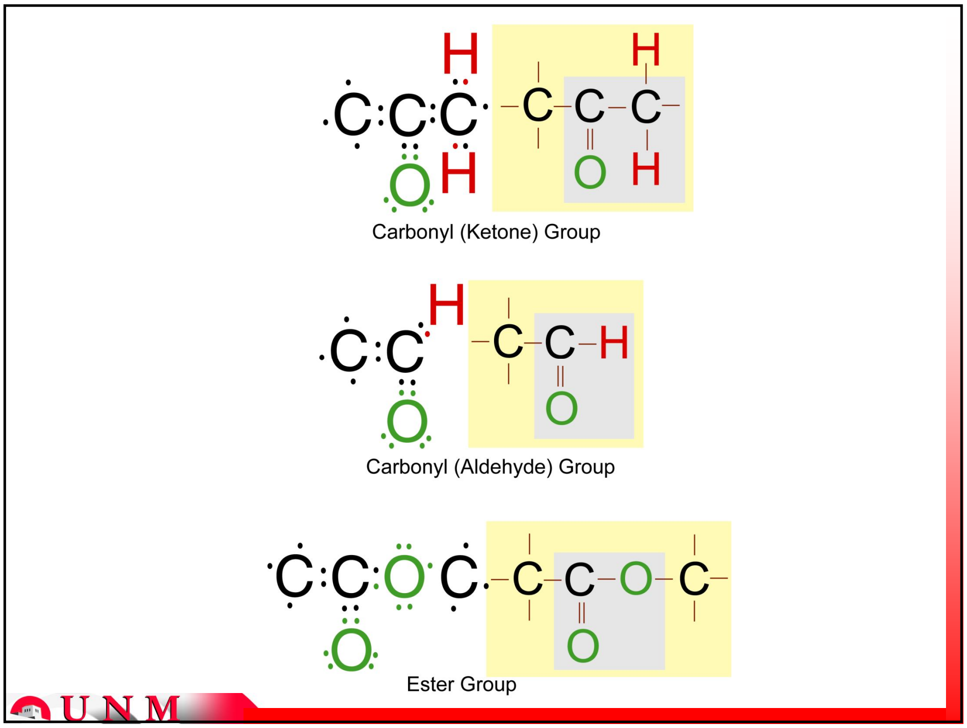
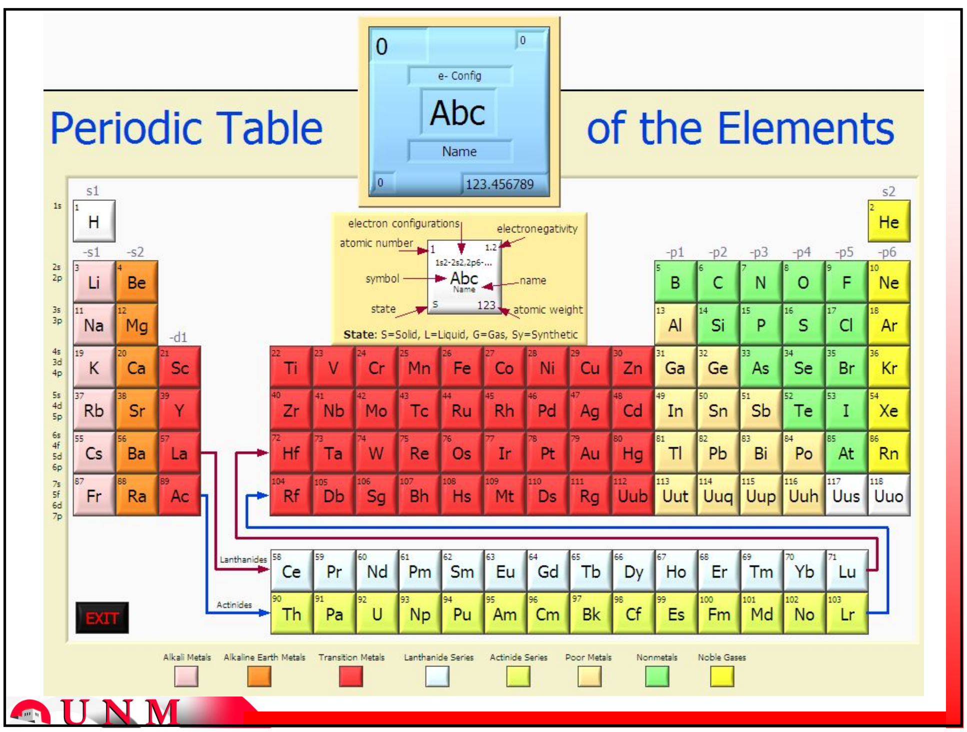
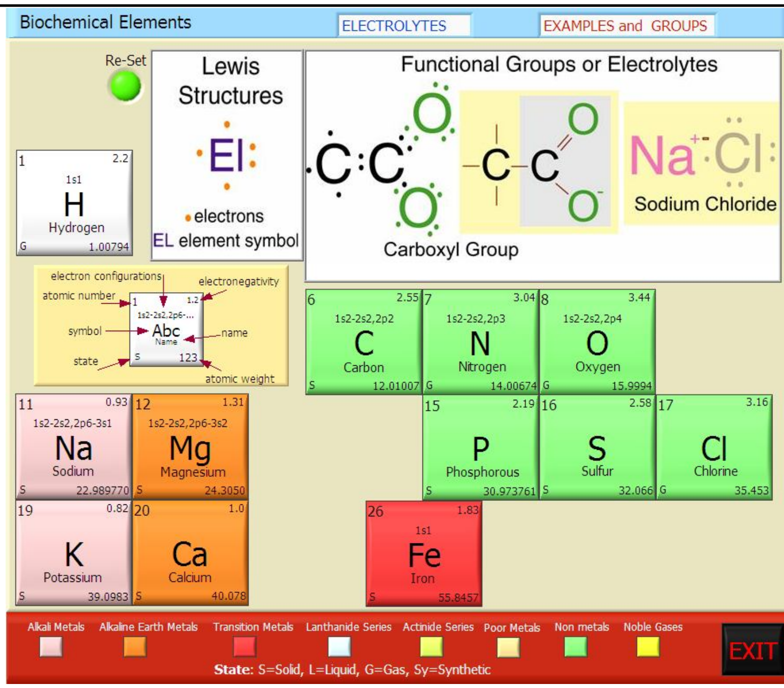

C O P O H
O
O
C O P O H
O
O
Phosphoryl Group
UNM


Carbonyl (Ketone) Group
Carbonyl (Aldehyde) Group
Ester Group
UNM


Periodic Table of the Elements
e- Config
Abc
Name
123.456789
electron configurations
electronegativity
atomic number
symbol
name
state
atomic weight
State: S=Solid, L=Liquid, G=Gas, Sy=Synthetic
s1
s2
-s1
-s2
-d1
-p1
-p2
-p3
-p4
-p5
-p6
H He
Li Be B C N O F Ne
Na Mg Al Si P S Cl Ar
K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
Cs Ba La Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn
Fr Ra Ac Rf Db Sg Bh Hs Mt Ds Rg Uub Uut Uuq Uup Uuh Uus Uuo
Lanthanides
Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu
Actinides
Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr
EXIT
Alkali Metals
Alkaline Earth Metals
Transition Metals
Lanthanide Series
Actinide Series
Poor Metals
Nonmetals
Noble Gases
UNM




Consequently, ***oxidation*** *involves the loss of electrons*, and ***reduction*** *involves the gaining of electrons*.

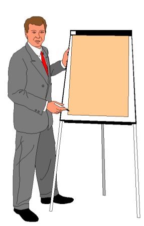
As oxidation and reduction reactions occur together, they are often termed *oxidation-reduction* or **redox reactions**.

$$A{:}e + B \longleftrightarrow A + B{:}e$$

for example,

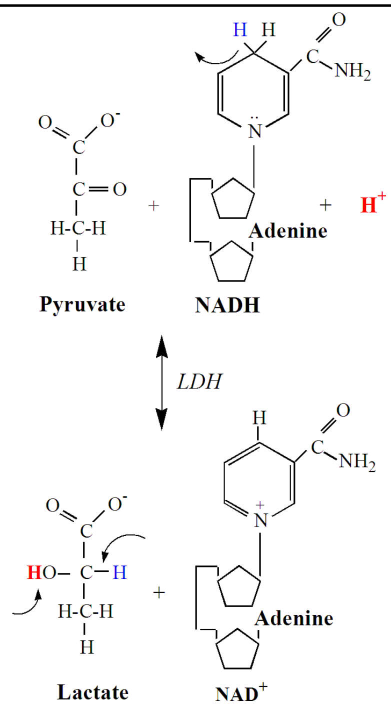
**pyruvate + NADH + $H^+$ ⟷ lactate + $NAD^+$**

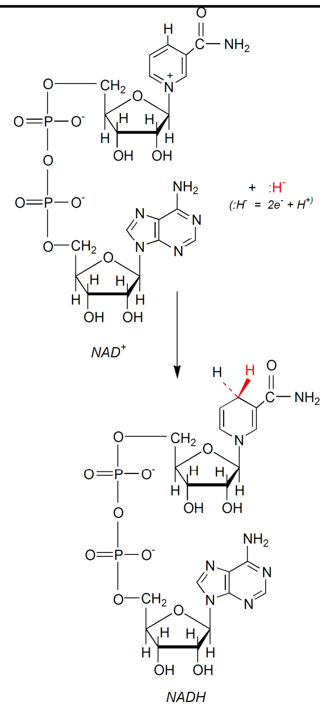
*Lactate dehydrogenase*

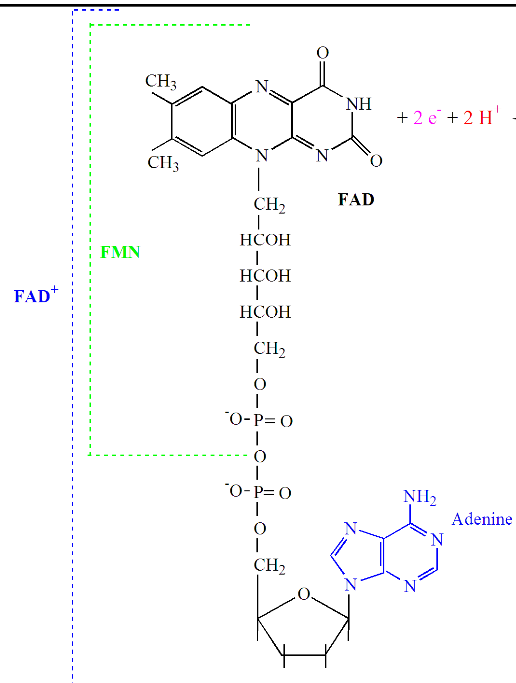


**Question**

*Which of the above molecules was reduced, and which was oxidized in the direction of lactate production?*


Pyruvate
NADH
Adenine
H+
LDH
Lactate
NAD+


+ :H-
(:H- = 2e- + H+)
NAD+
NADH




## Why are protons important?

A **proton** ($H^+$ ) is a hydrogen atom that has lost its electron.

The concentration of protons ($[H^+]$) in solution determines the acidity of the solution, and is represented numerically by the negative log of the $[H^+]$

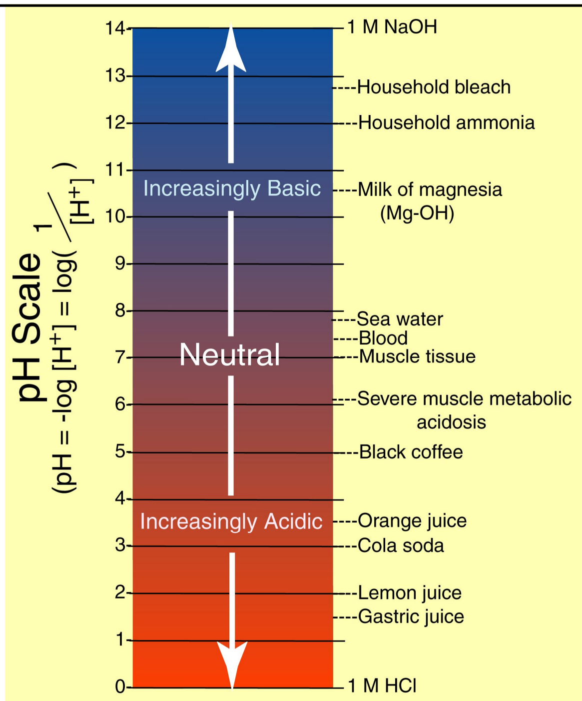
($pH = -\log [H^+]$)

Thus, ***a low pH represents high acidity***, and vice-versa.

*Cellular pH is important to maintain (7.0 at rest), for when pH falls too far (< 6.8), electrons are forced to leave certain molecules. For proteins (eg. enzymes), this occurrence can alter the shape of the molecule, decreasing its effectiveness.*

## pH Scale and Examples

| $[H^+]$ (M) | pH | $[OH^-]$ (M) | pOH |
|---|---|---|---|
| $10^0$(1) | 0 | $10^{-14}$ | 14 |
| $10^{-1}$ | 1 | $10^{-13}$ | 13 |
| $10^{-2}$ | 2 | $10^{-12}$ | 12 |
| $10^{-3}$ | 3 | $10^{-11}$ | 11 |
| $10^{-4}$ | 4 | $10^{-10}$ | 10 |
| $10^{-5}$ | 5 | $10^{-9}$ | 9 |
| $10^{-6}$ | 6 | $10^{-8}$ | 8 |
| $10^{-7}$ | 7 | $10^{-7}$ | 7 |
| $10^{-8}$ | 8 | $10^{-6}$ | 6 |
| $10^{-9}$ | 9 | $10^{-5}$ | 65 |
| $10^{-10}$ | 10 | $10^{-4}$ | 4 |
| $10^{-11}$ | 11 | $10^{-3}$ | 3 |
| $10^{-12}$ | 12 | $10^{-2}$ | 2 |
| $10^{-13}$ | 13 | $10^{-1}$ | 1 |
| $10^{-14}$ | 14 | $10^0$(1) | 0 |




| Acid | Ionization Reaction | Base | pKa |
|---|---|---|---|
| Acetic acid | $CH_3COOH \leftrightarrow CH_3COO^- + H^+$ | Acetate | 4.76 |
| Adenosine triphosphate | $HATP^- \leftrightarrow ATP^{-2} + H^+$ | $ATP^{-2}$ | 6.48 |
| Adenosine diphosphate | $HADP^- \leftrightarrow ADP^{-2} + H^+$ | $ADP^{-2}$ | 6.38 |
| Ammonium | $NH4^+ \leftrightarrow NH_3 + H^+$ | Ammonia | 9.26 |
| Carbonic acid | $H_2CO_3 \leftrightarrow HCO_3^- + H^+$ | Bicarbonate | 3.77 |
| Formic acid | $HCOOH \leftrightarrow HCOO^- + H^+$ | Formate | 3.75 |
| Histidine | $Histidine^+ \leftrightarrow Histidine + H^+$ | Histidine | 6.0 |
| Lactic acid | $CH_3CH(OH)COOH \leftrightarrow CH_3CH(OH)COO^- + H^+$ | Lactate | 3.67 |
| Phosphoric acid | $H_3PO_4 \leftrightarrow H_2PO_4^- + H^+$ | Dihydrogen phosphate | 2.14 |
| Dihydrogen phosphate | $H_2PO_4 \leftrightarrow HPO_4^{-2} + H^+$ | Monohydrogen phosphate | 6.75 |
| 3-Phosphoglyceric acid | $CH_2OPO_3^{-2}CH(OH)COOH \leftrightarrow CH_2OPO_3^{-2}CH(OH)COO^- + H^+$ | 3-Phosphoglycerate | 6.21 |
| 2-Phosphoglyceric acid | $CH_3(OH)CHOPO_3^{-2}COOH \leftrightarrow CH_3(OH)CHOPO_3^{-2}COO^- + H^+$ | 2-Phosphoglycerate | 7.0 |
| Propionic acid | $CH_3CH_2COOH \leftrightarrow CH_3CH_2COO^- + H^+$ | Propionate | 4.87 |
| Pyruvic acid | $CH_3COCOOH \leftrightarrow CH_3COCOO^- + H^+$ | Pyruvate | 2.26 |