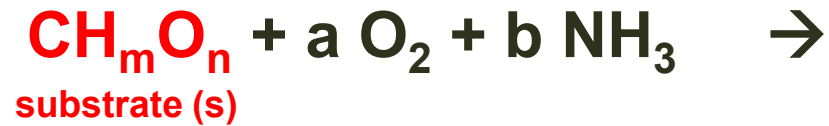


Aerobic production of a single extracellular product



$$\text{C :} \quad 1 = c + d + f$$

$$\text{N :} \quad b = c \delta + d z$$

$$\text{O :}$$

$$\text{H :}$$

$$e^- : \quad \gamma_s - 4 a = c \gamma_b + d \gamma_p \quad (\gamma \text{ for CO}_2, \text{H}_2\text{O, and NH}_3 \text{ is zero})$$

$$\text{RQ} = f / a$$

$$Y_{x/s} = c$$

$$Y_{p/s} = d$$

→ determine stoichiometric coefficients (a, b, c, d, e, and f)



Determination of stoichiometric coefficients

- Eq(4) can lead to
 - elemental balance on C, H, O, and N
 - available electron balance

$$\gamma_s = 4 + m - 2n$$

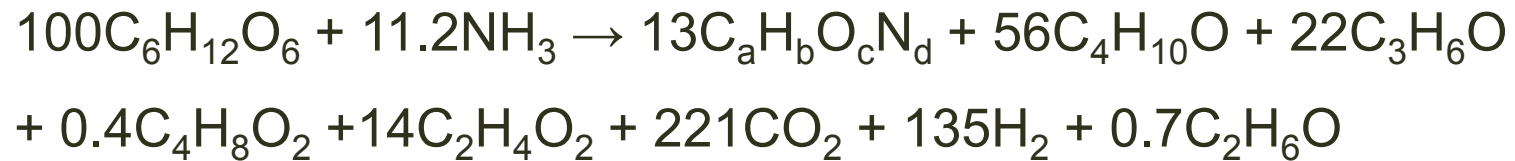
$$\gamma_b = 4 + \alpha - 2\beta - 3\delta$$

$$\gamma_p = 4 + x - 2y - 3z$$



Example

For the following biological conversion,



- (a) Determine the chemical composition of the bacteria (a, b, c, and d).
- (b) Determine the degree of reduction of the bacteria.

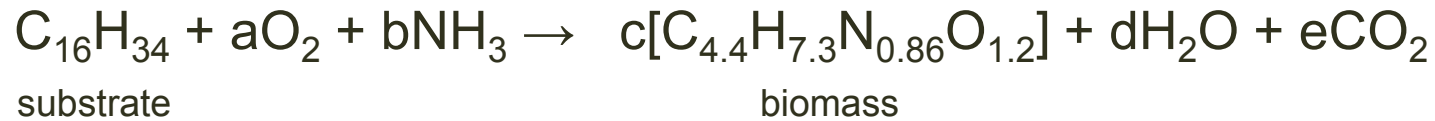


Example

a) $a = 4.46$
 $b = 16.01$
 $c = 3.88$
 $d = 0.86$

b) $\gamma = 5.27$

Example 7.1



2/3 of substrate carbon is converted into cell biomass.

(a) Stoichiometric coeff a, b, c, d, e = ?

(b) $Y_{x/s}$, Y_{x/o_2} = ?

(a) - g of C converted to cell = $(16)\left(\frac{2}{3}\right) = c(4.4)$

$$c = 2.42$$

- C converted to CO_2 = $192 - (16)\left(\frac{2}{3}\right) = e(12)$

$$e = 5.33$$

- N balance

$$b(14) = c(0.386)$$

$$b = 2.085$$

- H balance

$$34 + 3b = 7.3c + 2d$$

$$d = 11.29$$

- O balance : a = 12.43

Example 7.1

(b) $Y_{x/s}$, $Y_{x/o_2} = ?$

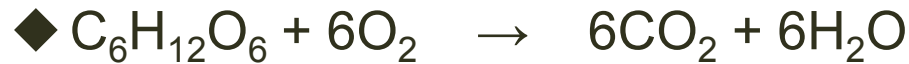
$$Y_{x/s} = \frac{c \text{ (biomass M.W.)}}{\text{substrate M.W.}} = \frac{2.42 (91.34)}{226} = 0.98 \text{ g cell / g substrate}$$

$$Y_{x/o_2} = \frac{c \text{ (biomass M.W.)}}{a \text{ (oxygen M.W.)}} = \frac{2.42 (91.34)}{12.43 (32)} = 0.56 \text{ g cell / g O}_2$$

Theoretical predictions of yield coeff

(1) Aerobic fermentation

◆ Cell growth yield per available electron in substrate = $3.14 \frac{\text{g dw cells}}{\text{electron}}$



$$Y_{x/s} = ?$$

of available electrons in 1 mol of glucose = 24

$$Y_{x/s} = \left(3.14 \frac{\text{g dw cells}}{\text{electron}} \right) \left(24 \frac{\text{electrons}}{1 \text{ mol glucose}} \right)$$

$$= 76 \frac{\text{g dw cells}}{1 \text{ mol glucose}}$$

$$= \left(76 \frac{\text{g dw cells}}{1 \text{ mol glucose}} \right) \left(\frac{1 \text{ mol glucose}}{180 \text{ g glucose}} \right)$$

$$= 0.4 \frac{\text{g dw cells}}{\text{g glucose}}$$

Theoretical predictions of yield coeff

(2) Anaerobic fermentation

$$\blacklozenge Y_{x/ATP} = 10.5 \frac{\text{g dw cells}}{\text{mol ATP}}$$

$$\blacklozenge Y_{x/s} = ?$$

If N moles of ATP are produced per 1 g substrate consumed

$$Y_{x/s} = Y_{x/ATP} \cdot N$$

$$\frac{\text{g dw cells}}{\text{g substrate}} = \left(\frac{\text{g dw cells}}{\text{mol ATP}} \right) \left(\frac{\text{mol ATP}}{\text{g substrate}} \right)$$



Stoichiometry for cell growth

Yeast cells are growing in a culture medium that contains methanol and ammonia as the only carbon-energy and nitrogen sources, respectively. The cell composition (mass basis) of yeast cell is C 50%, O 25%, H 7%, and N 10%.

If the experimental cell yield was determined to be 0.35 g of cell/g methanol:

(1) What is the oxygen yield coeff. (g O₂/g cell) of the organism?

(2) What is the corresponding respiratory quotient (RQ, mM CO₂/mM O₂)?



Alcohol Fermentation

Ethanol was produced by batch fermentation of facultative yeasts.

The carbon source was glucose.



The initial glucose concentration was 200 g/l and the glucose was completely consumed for both cell growth and ethanol production through the fermentation. The final cell concentration was 15 g/l, and $Y_{x/s} = 0.5$. Calculate the maximum ethanol concentration at the end of the fermentation.