EN2002 - PYP 19/20 Sem 1

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1.

(i) d (ii) b (iii) c (iv) d (v) c

(vi) d (vii) c (viii) b (ix) c (x) b

2.

(a) (i)

$t_2 - t_1 = 5\ days$

$x_2 = 20x_1$

Specific growth rate $\mu = \dfrac{ln(x_2/x_1)}{t_2 - t_1} = \dfrac{ln20}{5} = 0.599\ day^{-1}$

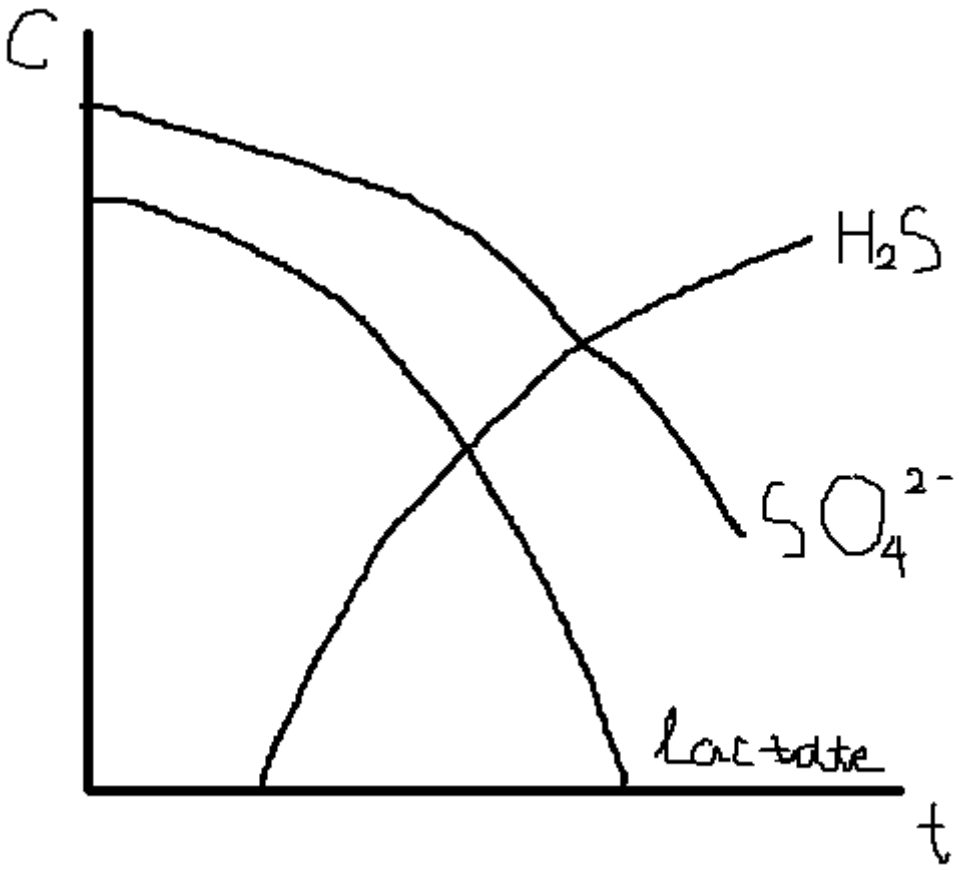
Doubling time $t_d = \dfrac{ln2}{\mu} = \dfrac{0.693}{0.599} = 1.157\ days$

(ii)

$(10^6\ cells)(3.8\ Mbp/cell)(2\ P_s/pair) = 7.6\text{x}10^{13} P_s$

$\Rightarrow \dfrac{7.6\text{x}10^{13}}{6.02\text{x}10^{23}} = 1.262\text{x}10^{-10}$ moles of phosphorus

(iii)



(b)

$5.815C_2O_4{}^{2-} + 0.2NH_4{}^{+} + 1.86O_2 + 0.8H^{+} + 5.41H_2O \rightarrow 10.63HCO_3{}^{-} + CH_{1.8}O_{0.5}N_{0.2}$

$\Rightarrow$ To produce 1 mole of biomass, we need 1.86 moles of O_2 (for catabolism) and 5.815 moles of $C_2O_4{}^{2-}$ (for both catabolism).

$$C_2O_4{}^{2-} + \frac{1}{2}O_2 + H_2O \rightarrow 2HCO_3{}^{-}$$

$\text{Amount of } C_2O_4{}^{2-} \text{ needed for catabolism} = \frac{1.86}{0.5} = 3.72\ moles$

$\text{Amount of } C_2O_4{}^{2-} \text{ needed for anabolism} = 5.815 - 3.72 = 2.095\ moles$

3.

(a)

(i) Chemotroph

(ii) Phototroph

(iii) Chemoheterotroph

(iv) Chemoautotroph

(v) Photoheterotroph

(vi) Photoautotroph

(b)

Bacteria	Metabolic Group	Electron Donor	Electron Acceptor
AOB	Chemoautotroph	NH_4^+	O_2
NOB	Chemoautotroph	NO_2^-	O_2
Anammox	Chemoautotroph	NH_4^+	NO_2^-

(c)

(i) (7) 3' to 5' direction

(ii) (5)

(iii) (6) translation

(iv) (1) aerobic conditions

(2) anaerobic conditions

4.

(a)

$$\text{Choose dilution } 10^{-4}, \text{ Avg CFU per plate} = (...)/6 = 60 \text{ CFU/plate}$$

$$\text{Conc. in original sample} = \frac{60}{0.1} : 10^{-4} = 6\text{x}10^6 \text{ CFU/plate}$$

(b)

The results from (a) are very different. There is Great Plate Count Anomaly (GPCA) occurring. GPCA is due to:

- Dead cells are counted in DAPI counting but do not form colonies in plate method.
- There are viable but non-culturable cells, i.e., alive but have very low metabolic state or do not form colonies. This phenomenon is due to

unfavorable conditions in the culture media or the leak of symbiotic/parasitic microorganisms.

(c)

- Mineralization (by X): Complete conversion of organic compounds into simpler inorganic compounds.
- Cometabolism (by Y): contaminants is taken up by microorganisms but is metabolized alongside the organism's food into a less hazardous chemical.
- Immobilization (by Z): Removal of contaminants, typically metals, by means of biosorption, bioaccumulation, or biotransformation, to insoluble forms.

(d)

From the microbial community in the water sample, extract the DNA and perform high-throughout sequencing. After getting the raw sequences, assemble them to get the genomes of the community. This analysis will determine what bacteria are present in the water sample.

5.

(a)

- BOD is Biochemical Oxygen demand, which is the amount of oxygen needed for the microorganisms to degrade organic compounds in the sample.
- To quantify BOD, we measure the change in the dissolved oxygen in the sample after 5 days of incubation at 20^oC.

(b)

- Profile A is for dissolved oxygen conc. and profile. Profile B is for viable bacterial cells.
- When untreated waste water is released into the river, it consists of a lot of organic matter, which is the carbon and energy sources for microorganisms. Therefore, the cells grow very quickly and consume a lot of O_2 for metabolism. Hence, there is a sharp decrease in the O_2 profile. When organic matter is depleted, the cells will graadually die, and dissolved oxygen increases.

(c)

- BOD can removed by the metabolism of the microorganisms. Organic matter in the waste water is the carbon and energy sources for the microorganisms and can be degraded into simpler inorganic compounds.
- Nitrogen can be removed by nitrifiers, denitrifiers, anammox bacteria and converted into nitrogen gas.
- Phosphorus can be removed using $PAOs$ (Phosphorus accumulating organisms). These microorganisms can uptake more P than they need to store in their cells.

(d)

Sludge would be the other most important end-product. Sludge consists of microorganisms which can degrade organic compounds under aerobic condition.