1.

i. D

ii. C

iii. C - some bacteria have DNA eg bacteriophage, while others have RNA e.g. animal viruses such as influenza virus. However, they usually do not have **both** DNA and RNA. They have instead enzymes that can produce RNA/reverse transcribe DNA when they become active in host cells.

iv. B - Not all organisms have 16S rRNA genes, and not all regions of this gene is conserved.

v. D

vi. D – Archaea do not have peptidoglycan. Their cell wall is made up of other complex molecules.

vii. D - Cell wall, proteins and nucleic acid all contains organic materials which can be oxidised

viii. A

ix. C

x. C – May not be pathogen containing.

All the other answers not explained are content/theories that can be easily found in notes. If you don't get it, read the notes again :D

2(a) $n N = \frac{0.1 \times 10^{-3}}{14} = 7.14 \times 10^{-6}$ mol

$n C_{106}H_{263}O_{110}N_{16}P$ produced $= 7.14 \times 10^{-6} \times \frac{1}{16}$

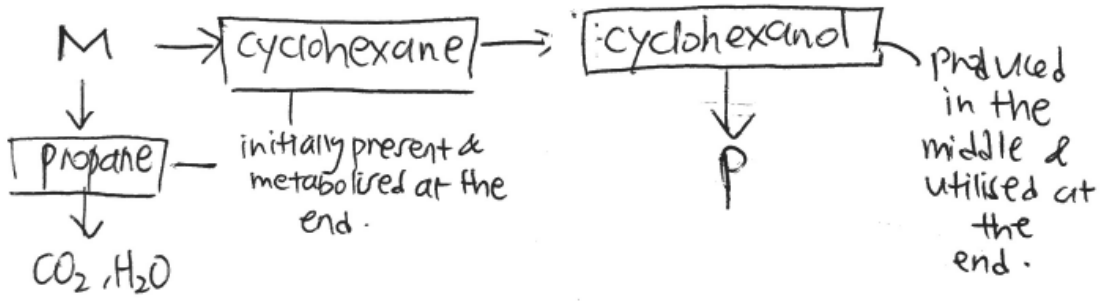
$= 4.46 \times 10^{-7}$ mol

$n P = \frac{0.04 \times 10^{-3}}{15} = 2.67 \times 10^{-6}$ mol

$n C_{106}H_{263}O_{110}N_{16}P$ produced $= 2.67 \times 10^{-6} > 4.46 \times 10^{-7}$

N is the limiting reagent.

(b)



Cyclohexane — C

Cyclohexanol — A

Propane — C

(c) $\ln\left(\frac{X}{X_0}\right) = \mu(t - t_0)$

$\ln X = \mu(10 - 5) + \ln(3 \times 10^5)$

$= 15.111$

$X = 3.65 \times 10^6$ cells/mL

$t_d = \frac{\ln 2}{0.5} = 1.386$ h

(d) $C_6H_6 + 18H_2O + 30Fe^{3+} \rightarrow 6HCO_3^- + 30Fe^{2+} + 36H^+$

$n C_6H_6 = \frac{20 \times 10^{-3}}{12 \times 6 + 6} = 2.564 \times 10^{-4}$ mol

$n Fe^{3+} = 2.564 \times 10^{-4} \times 30 = 0.007692$ mol

Mass of $Fe^{3+} = 0.007692 \times 56$

$= 0.431$ g/L

3(a) E coli can utilize nitrate as an electron acceptor in anaerobic respiration to produce energy for cell growth. However, when the culture is highly aerated, oxygen is readily available to the bacteria. Since bacteria utilizes oxygen more efficiently than nitrate, the culture can grow even faster.

(b) 3 ways:

Transduction - the bacteriophage mediates DNA exchange

Transformation – free DNA released by one cell is taken up by another

Conjugation – DNA transfer from one bacteria to another through a cytoplasmic mating bridge

(c) The production and use of nitrogen fertilisers can lead to soil acidification as NH_4^+ produces protons. Plants do not grow well under acidic conditions (optimal pH is between 5.5-7), hence affecting crop harvest and causing the land to eventually become obsolete.

As NH_4^+ and NO_3^- are very soluble in water, they can dissolve in rain/surface runoffs and be washed into river bodies, causing eutrophication, algae bloom and explosions of dead zones. The marine ecosystem will be adversely affected.

(d)(i) Coliform (including E. Coli)

Fecal streptococci

(ii)

- Does not give indication of the turbidity of water
- Does not provide indication of the ions present in water
- Bacteria may not grow not because the water is clean, but due to high toxicity of the sample.
- Absence of FIB does not absolutely confirm the absence of pathogenic bacteria. Pathogens may still exist even when FIB do not grow.

4 (a) Using the second column,

$$CFU/mL = \left(\frac{50+56+68}{3}\right) \times 10 \times \frac{1}{10^{-4}}$$

$$= 5.8 \times 10^{6} \text{ CFU/mL in original sample.}$$

(b) Avg cells per square = 31 cells.

Cells in 50 squares = 1550 cells

Volume of coverslip = $2 \times 0.02 = 0.04 \text{ mm}^3$

$= 0.04 \times 10^{-3}$

$= 4 \times 10^{-5} \text{ cm}^3$

Microbial concentration = $\frac{1550}{4 \times 10^{-5}} = 3.875 \times 10^{7}$ cells/mL

4(c) No. It may be due to the Great Plate Count Anomaly, ie a discrepancy between the number of cells observed by microscope and the number of colonies that can be cultivated from the same natural sample, as some bacteria cannot grow under laboratory conditions. OR the cells may not be distributed uniformly in the solution/squares.

(d) Larger size:

- Greater surface area to allow for floating.
- More organelles packed within, allows for more sophisticated metabolism (eg more ribosomes, or even chlorophyll can be packed inside)
- Possible movement through the presence of flagella

Smaller size:

- Rate of metabolism is high due to the short distance of nutrients and waste transport in the cell
- High growth rate

5(a) Algae can utilize N and P in the water to grow and this removes organic materials.

The algae layer also provides a barrier between the water and the air, preventing oxygen from dissolving in the lagoon and be transferred to the lower bottom. This maintains the anaerobic conditions at the bottom of the lagoon and allows for aerobic treatment at the top.

(b) Temperature, pH and light intensity can affect algae growth, as with most plants.

Presence of N and P will also enhance algae growth, as N and P are often limiting in the environment.

Presence of organic nutrients will also increase algae growth as the algae can metabolize them for energy.

(c) **Hydrolysis** to convert complex organic molecules to soluble ones, by hydrolytic bacteria and acidogens

Acidogenesis to convert soluble organic molecules to fatty acid, catalyzed by acidogens and fermentative bacteria

Acetogenesis to convert fatty acid to acetic acid and CO2, by fermentative bacteria and acidogens

Methanogenesis to convert acetic acid to methane, by methanogens.

	Facultative lagoons	**Activated sludge**
Cost	Lower	More expensive
Time	High retention time	Fast process
Quality of effluents	Need further treatment	Good quality
Reactor volume	Large	Smaller
Operation	No need for operation, just leave it there	Need for more sophisticated operation of process/machines
Odor	Bad odor	No odor

Hui Ling