Indraprastha Institute of Information Technology Delhi (IIITD)

Department of Computational Biotechnology

BIO211 – Cell Biology and Biochemistry

Mid-Semester Exam (October 31, 2021)

Question 1. Differentiate between **any two** of the following: [1.5 marks x 2]

(i) RNA and DNA nucleotides

(ii) Endocytosis and Exocytosis

(iii) Anabolism and Catabolism

You may grade this question on your own. Please make sure the main differences have been listed.

Question 2. Neurons are one of the largest cells found in human body. Some of these neurons are as long as 2 μm extending from spinal cord to the muscles of the toes. Trafficking of small vesicles usually takes place along the microtubules of the cytoskeleton, from the cell body of the neuron to its axonal tip. Assuming the average velocity of a vesicle is 1 μm/s, calculate the time taken by a vesicle to move from the neuronal cell body in the spinal cord to the axonal tip in the toes?

Answer: Time = distance/velocity = (2 μm) / (1 μm/s) = 2s [2 marks]

Question 3. Firewood is chemically unstable compared with its oxidation products- CO_2 and H_2O.

(i) Comment on the standard free-energy change for this reaction,
Firewood + O_2 → CO_2 + H_2O. [2 marks]
Answer: Standard free-energy change is negative and relatively large.

(ii) Why does not firewood stacked beside the fireplace undergo spontaneous combustion to make more stable products, CO_2 + H_2O. [2 marks]
Answer: Thermal energy in the wood is not sufficient to overcome the activation energy.

(iii) What can provide the activation energy for this reaction to proceed? [2 marks]
Answer: Initial heat provided by the burning match stick supplies the thermal energy to overcome the activation energy barrier

(iv) Imagine there existed an enzyme for catalyzing the rapid oxidation of firewood at room temperature. Explain the role of enzyme in this case in terms of thermodynamics.
Answer: Enzyme decreases the activation energy enough for the reaction to occur at room temperature. [2 marks]

Question 4. If a 0.1 M solution of glucose 1-phosphate is incubated with a catalytic amount of phosphoglucomutase, the glucose 1-phosphate is transformed to glucose 6-phosphate. At equilibrium, the concentrations of the reaction components are

glucose-1-phosphate $\rightleftharpoons$ glucose-6-phosphate

4.5×10^{-3} M 9.6×10^{-2} M

(i) Calculate K'_{eq} and $\Delta G'^{o}$ for this reaction at 25°C.

Answer: K'_{eq} = [glucose-6-phosphate]/[glucose-1-phosphate]

= 9.6 X 10^{-2} M / 4.5 X 10^{-3} M = 21.3 [2.5 marks]

$\Delta G'^{o} = -RT \ln K'_{eq}$

= -(2.48 kJ/mol)(ln 21) = -2.48 x 3.0445 kJ/mol = -7.550 kJ/mol [2.5 marks]

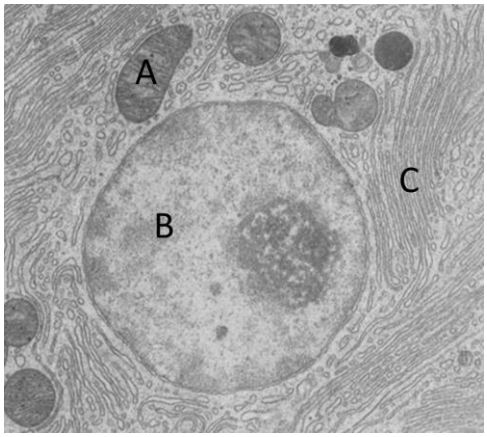
(ii) For a thermodynamically favorable reaction, comment on the change in free energy, enthalpy and entropy of the system.

Answer: Standard free energy change = negative and relatively large [2 marks]

Change in enthalpy = negative

Change in entropy = positive

Question 5. Identify **any 2** of the cellular organelles marked in the following image and explain their structure and function.



Answer: A. Mitochondria; B. Nucleus; C. Endoplasmic reticulum [2 marks X 2]

For structure and function, you may grade this question on your own.

Question 6. Answer **any one** of the following questions:

Conversion of Glucose 1-phosphate to fructose 6-phosphate occurs in a two steps reaction:

Glucose 1-phosphate → glucose 6-phosphate ($\Delta G'^{o}$= -7.3 kJ/mol)

Glucose 6-phosphate → fructose 6-phosphate ($\Delta G'^{o}$= 1.7 kJ/mol)

Calculate the equilibrium constant, K_{eq}, for the sum of the two reactions (Glucose 1-phosphate → fructose 6-phosphate) at 25°C.

Answer: $\Delta G'^{o}_{sum}$ = -7.3 kJ/mol + 1.7 kJ/mol = -5.6 kJ/mol [2 marks]

$\ln K'_{eq} = -\Delta G'^{o}/RT$ [2 marks]

$\ln K'_{eq}$ = (-5.6 kJ/mol) / (2.48 kJ/mol) = 2.3

K'_{eq} = 10

OR

The process of complete oxidation of 1 mole of glucose to CO_2 and H_2O yields 686 kcal of free energy. How many ATP molecules could maximally be generated from one molecule of glucose, if the useful chemical energy available in the high energy phosphate bond of 1 mole of ATP is 12 kcal? (Hint: Avogadro's number = 6.023×10^{23}) [4 marks]

Answer: 6.023×10^{23} molecules of glucose = 686 kcal
6.023×10^{23} molecules of ATP = 12 kcal
No. of ATP molecules generated by 1 molecule of glucose = 686 kcal / 12 kcal = ~ 57

Question 7. What do you understand by the "polarity" of a polypeptide chain and that of a DNA molecule?

Answer: A polypeptide chain has polarity because its ends are different, with an amino group at one end and a carboxyl group at the other. [1.5 marks]

3' and 5' polarity of DNA refers to the two ends of the DNA (3'-OH and 5'-P). [1.5 marks]

Question 8. A number of regulatory proteins present in *E. coli* can be found as one or two molecules per cell. If we assume that an *E. coli* contains just one molecule of a particular protein, (Hint: Vol. of *E. coli* = 1fL; Avogadro's number = 6.023×10^{23})

(i) What is the molar concentration of this protein in the cell? [2.5 marks]

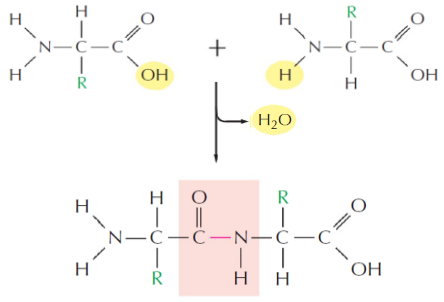
Answer: Molar concentration = No. of moles / volume
6.023×10^{23} molecules = 1 mole
1 molecule = $(1/6.023 \times 10^{23})$ moles = 1.66×10^{-24} mole
Therefore, Molar concentration = $(1.66 \times 10^{-24}$ mole) / (1fL)
= $(1.66 \times 10^{-24}$ mole) / $(1 \times 10^{-15}$ L)
= 1.66×10^{-9} mole/L = 1.7 nM

(ii) If the molecular weight of this protein is 40 kDa, what is its concentration expressed as mg/ml? [2.5 marks]

Answer: Concentration of protein = 1.66×10^{-9} mole/L x 40 kDa
= 1.66×10^{-9} mole/L x 40×10^3 g/mole
= 6.64×10^{-5} g/L
= 6.64×10^{-5} mg/mL

Question 9. Write the chemical formula for a condensation reaction of two amino acids to form a peptide bond. [2 marks]

Answer:



Question 10. Answer **any 10** of the following: [1 mark X 10]

(i) A polysaccharide used by animal as energy reservoir: Glycogen
(ii) One unsaturated fatty acid: Oleic acid
(iii) A steroid that makes up the male sex hormone: Testosterone
(iv) Ordered display of full set of chromosomes of an organism.: Karyotype
(v) Linker histone that pulls adjacent nucleosomes together into a regular repeating array: H1
(vi) Enzyme that locks a sliding clamp around a newly formed DNA double helix: Clamp loader
(vii) A eukaryotic transcriptional promoter: TATA box
(viii) Enzyme responsible for recognition and attachment of the correct amino acid to appropriate tRNA: Aminoacyl-tRNA synthetases
(ix) RNA molecule with catalytic activity: Ribozyme
(x) Enzyme responsible for mRNA degradation: Ribonuclease / RNAse
(xi) Initiator tRNA in prokaryotes: Formyl-methionine
(xii) Enzymes that degrade proteins: Proteosomes

Question 11. Why replication of DNA is called semi-conservative in nature? [2 marks]
Answer: DNA replication is semiconservative because each daughter DNA double helix is composed of one conserved (or parental) strand and one newly synthesized strand.

OR

Question 11. What is meant by the discontinuous replication of DNA template? [2 marks]
Answer: At each replication fork, the lagging strand of DNA is synthesized in short pieces called Okazaki fragments.