BMI2601

CLINICAL BIOCHEMISTRY II

ASSIGNMENT 2 MEMO 2018

QUESTION 1 [10]

1.1 **Buffers** are molecules that donate or accept protons to resist changes in pH as acids or bases are added to the solution. A buffer consists of a weak acid and its conjugate base, or a weak base and its conjugate acid. In biological systems, many biomolecules are weak acids or bases or have functional groups that behave as acids or bases, and can therefore act as buffers by accepting or donating a proton if there is a sudden change in the concentration of H^+ (**$[H^+]$**).

For example:

Blood contains large amounts of carbonic acid, a weak acid, and bicarbonate, a base. Together they help maintain the bloods pH at 7.4. If blood pH falls below 6.8 or rises above 7.8, one can become sick or die. The bicarbonate neutralizes excess acids in the blood while the carbonic acid neutralizes excess bases.

Phosphate buffer system operates in the internal fluids of all cells. It consists of dihydrogen phosphate ions as the hydrogen ion donor (acid) and hydrogen phosphate ion as the ion acceptor (base). If additional hydroxide ions enter the cellular fluid, they are neutralised by the dihydrogen phosphate ion. If extra hydrogen ions enter the cellular fluid, then they are neutralised by the hydrogen phosphate ion.

Protein buffer system helps to maintain acidity in and around the cells. Haemoglobin makes an excellent buffer by binding to small amounts of acids in the blood, before they can alter the pH of the blood. Other proteins containing amino acid histidine are also good at buffering in biological systems. (4)

1.2 Alcohols, aldehydes, ketones and amides. (4)

1.3 **A covalent bond** is a chemical bond that involves the sharing of electron pairs between adjacent atoms. This is the strongest type of bond that holds atoms together.

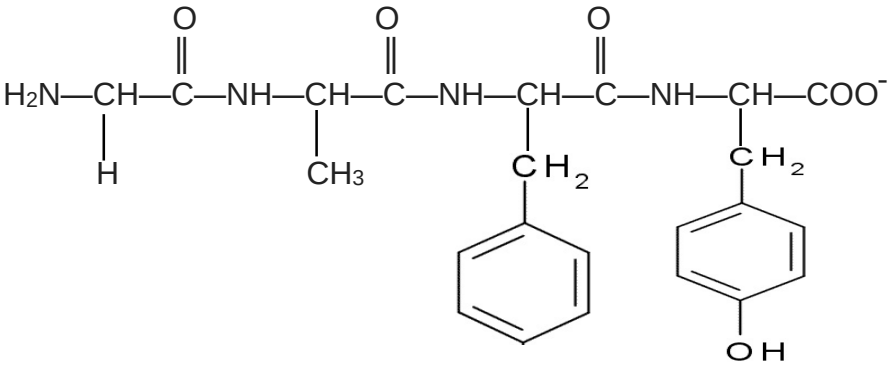
A non-covalent interaction differs from a covalent bond in that it does not involve the sharing of electrons, but rather involves more dispersed variations of electromagnetic interactions between molecules or within a molecule. Noncovalent forces are weaker, but are still important in determining the structure, stability and function of biomolecules. (2)

QUESTION 2 [15]

2.1 Many proteins are made up of multiple polypeptide chains, often referred to as protein subunits. A protein subunit is a single protein molecule that assembles (or "coassembles") with other protein molecules to form a protein complex.

The quaternary structure refers to the number, type and arrangement (assemblies) of the protein subunits with respect to one another. The quaternary structure refers to how these protein subunits interact with each other and arrange themselves to form a larger oligomers and complexes with defined or variable numbers of subunits. Subunits can be identical (homodimers) or different (heterodimers). (4)

2.2 **Amino terminus** - Glycine
Carboxyl terminus -Tyrosine



(6)

2.3 Protein domains are structurally independent units that typically perform a particular function. A protein domain is a conserved part of a given protein sequence and (tertiary) structure that can evolve, function, and exist independently of the rest of the protein chain. Each domain forms a compact three-dimensional structure and often can be independently stable and folded.

Protein domains are stabilized by hydrophobic interaction among nonpolar side chains in the core of the protein. In addition, stabilizing forces include electrostatic interactions between ionic groups of opposite charge, hydrogen bonds between polar groups, and disulfide bonds. (3)

2.4 Protein misfolding is the incorrect folding of proteins which result in a dysfunctional protein. (2)

QUESTION 3 [16]

a)

Centrifugation is a process used to separate or concentrate materials suspended in a liquid medium. The theoretical basis of this technique is the effect of gravity on particles (including macromolecules) in suspension.

Chromatography is a physical method of separation that distributes components to separate between two phases, one stationary (stationary phase), the other (the mobile phase) moving in a definite direction. The components in the medium move at different rates. (4)

b)

Isoelectric focusing (IEF) is an electrophoresis technique that separates proteins based on their isoelectric point (pI). (4)

Isoelectric point is the pH at which a protein has no net charge and does not move in an electric field. (4)

c)

Ion-exchange chromatography is a chromatographic process that separates ions and polar molecules based on their affinity to the ion exchanger. It works on almost any kind of charged molecule, including large proteins, small nucleotides, and amino acids, cation or anion exchangers are used.

Size-exclusion chromatography (SEC), also known as molecular sieve chromatography, is a chromatographic method in which molecules in solution are separated by their size, and in some cases molecular weight. It is usually applied to large molecules or macromolecular complexes such as proteins and industrial polymers.

(4)

3.2

In **SDS-PAGE**, the use of sodium dodecyl sulfate (SDS, also known as sodium lauryl sulfate) and polyacrylamide gel largely eliminates the influence of the structure and charge by making all protein acquire a negative charge and β-mercaptoethanol disrupts disulphide bonds so that proteins are separated solely based on polypeptide chain length or charge to mass ratio. As a result the proteins will migrate at different rates through the gel with smaller proteins moving faster and larger proteins moving slower. (4)

QUESTION 4 [16]

4.1 **Feedback inhibition**, a cellular control mechanism in which an enzyme that catalyzes the production of a particular substance in the cell is **inhibited** when that substance has accumulated to a certain level, thereby balancing the amount provided with the amount needed.

Feedback regulation, the process by which the product of a metabolic pathway influences its own production by controlling the amount and/or activity of one or more enzymes involved in the pathway. It can be positive or negative feedback regulation. (4)

4.2 **Replication** is the biological process of producing two identical replicas of DNA from one original DNA molecule. This process occurs in all living organisms and is the basis for biological inheritance.

Transcription is the process by which the information in a strand of DNA is copied into a new molecule of messenger RNA (mRNA). DNA safely and stably stores genetic material in the nuclei of cells as a reference, or template.

Translation is a step in protein biosynthesis wherein the genetic code carried by mRNA is decoded to produce the specific sequence of amino acids in a polypeptide chain. The process follows transcription in which the DNA sequence is copied (or transcribed) into an mRNA, tRNA and protein in ribosomes (6)

4.3

a) RNA polymerase I, which transcribes genes encoding tRNAs, rRNAs and other small RNAs

b) RNA polymerase II, which transcribes most genes, including protein encoding genes

c) RNA polymerase III, which transcribes genes encoding tRNAs, rRNAs and other small RNAs. (6)

QUESTION 5 [16]

5.1

TACCGAGCTTAACGAAGAATT (6)

5.2 In biology, a mutation is the permanent alteration of the nucleotide sequence of the genome of an organism, virus, or extrachromosomal DNA or other genetic elements. (1)

5.3 A point mutation is a single base change, and may have a number of effects when an mRNA molecule is translated into a protein. Point mutations may be silent mutations, missense mutations or nonsense mutations. (4)

5.4 The basis for selective toxicity of an antibiotic rests on the ability of the drug to attack or interfere with a structure or processes found in bacterial cells that our cells do not have.

There are 5 mechanisms by which an antibiotic can attack a bacterial cell:

Inhibition of cell wall synthesis

Inhibition of cell membrane function

Inhibition of protein synthesis

Inhibition of nucleic acid synthesis

Inhibition of bacterial enzymes / metabolic pathways. (5)

QUESTION 6 [16]

6.1 Examples of monosaccharides include glucose (dextrose), fructose (levulose) and galactose. Monosaccharides are the building blocks of disaccharides (such as sucrose and lactose) and polysaccharides (such as cellulose and starch). The physiologically important monosaccharides include glucose, the "blood sugar," and ribose and deoxyribose, an important constituent of nucleotides and nucleic acids. Galactose for the synthesis of lactose in milk, in glycolipids, and in combination with protein in glycoproteins and proteoglycans.

Polysaccharides generally perform one of two functions: energy storage or structural support. Starch and glycogen are highly compact polymers that are used for energy storage. Cellulose and chitin are linear polymers that are used for structural support in plants and animals, respectively. (6)

6.2 A oligosaccharide is a carbohydrate whose molecules are composed of a relatively small number of monosaccharide units. (1)

6.3 Maltose, sucrose and lactose. (3)

6.4 Glycogen is the storage polysaccharide in animals. It is a homopolymer of glucose, made up of straight α(1→4) linked D-glucose units and branched α(1→6) linked glucose units. It is stored primarily in the cells of the liver and skeletal muscle.

Cellulose is another homopolymer of glucose, made up of β(1→4) linked D-glucose units. It is the main constituent of plant cell walls. Cellulose is a polysaccharide consisting of long unbranched chains of linked glucose units the main constituent of plant cell walls and used in making paper, rayon, and film. (6)

QUESTION 7 [13]

7.1 Saturated fats are solid at room temperature, while unsaturated fats are liquid at room temperature. This is because saturated and unsaturated fats differ in their chemical structures. Saturated fats have no double bond within molecules, while unsaturated fats have double bonds within molecules. (2)

7.2 The triacylglycerols are the principal storage fats in humans and other animals, as well as vegetable fat. Triglycerides are a type of fat that plays a major role as an energy source when they are metabolized in the human body. They are the most abundant class of lipids in the body. A triglyceride is an ester derived from glycerol and three fatty acids. (2)

7.3 Sphingomyelins, ceramides, glycosphingolipids and gangliosides. (3)

7.4

Phosphatidylcholine is a key structural component of cellular membranes and also plays an important role in the transport of fats throughout the bloodstream. Phosphatidylcholine serves as the body's main source of choline, Choline is a crucial component of acetylcholine, a neurotransmitter essential for normal brain function. (2)

7.5 Liposomes are composed of a lipid bilayer separating an aqueous internal compartment from the bulk aqueous phase. Micelles are closed lipid monolayers with a fatty acid core and polar surface, or polar core with fatty acids on the surface (inverted micelle). (2)

7.6 An emulsion is a mixture of two or more liquids that are normally immiscible. Emulsions are part of a more general class of two-phase systems of matter called colloids. (2)

QUESTION 8 [13]

8.1 Anabolism refers to the process which builds molecules the body needs; it usually requires energy for completion. Catabolism refers to the process that breaks down complex molecules into smaller molecules; it usually releases energy for the organism to use.

OR

Catabolism is all of the chemical reactions that break down molecules, either to extract energy or to produce simple molecules for constructing others. Anabolism refers to all of the metabolic reactions that build or assemble more complex molecules from simpler ones. (2)

8.2

a) Oxidative phosphorylation in the mitochondria.

b) Substrate level phosphorylation, which takes place during the tricarboxylic acid cycle in the mitochondrion and during glycolysis in the cytoplasm. (2)

8.3 β-oxidation is the catabolic process by which fatty acid molecules are broken down in the cytosol in prokaryotes and in the mitochondria in eukaryotes to generate acetyl-coA, which enters the citric acid cycle, and NADH and $FADH_2$, which are co-enzymes used in the electron transport. This process involves the sequential removal of two carbon units. The end product of each cycle is the fatty acid shortened by 2 carbons and acetyl CoA. (2)

8.4 Ketone bodies are three water-soluble molecules (acetoacetate, beta-hydroxybutyrate, and their spontaneous breakdown product, acetone) that are produced by the liver from fatty acids during periods of low food intake (fasting), carbohydrate restrictive diets, starvation, prolonged intense exercise, alcoholism or in untreated (or inadequately treated) type 1 diabetes mellitus. (4)

8.5

a) Enter the citric acid cycle to generate energy.

b) Be converted to cholesterol or other steroids.

c) Be used to form ketone bodies. (3)

QUESTION 9 [15]

9.1

Vitamin	Function in the body	Deficiency syndrome
A	Maintenance of vision, gene expression and cell differentiation	Night blindness and xerophthalmia
D	Maintenance of calcium balance, gene expression and cell differentiation	Rickets in children and osteomalacia in adults
E	Antioxidant and cell signalling	Neurologic disorders, haemolytic anaemia in newborns
K	Blood clotting	Impaired blood clotting and haemorrhagic disease

(12)

9.2

A carboxypeptidase is a protease enzyme that hydrolyzes (cleaves) a peptide bond starting at the carboxyl-terminal (C-terminal) end of a protein or peptide) while aminopeptidase is an enzyme that catalyses the cleavage (hydrolysis) of amino acids starting from the amino terminus (N-terminus) of proteins or peptides. (2)

9.3

An essential amino acid, or indispensable amino acid, is an amino acid that cannot be synthesized de novo (from scratch) by the organism, and thus must be supplied in its diet. (1)