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Principles of Human Physiology, 4e **(Stanfield)**
Chapter 3 Cell Metabolism

3.1 Multiple Choice Questions

1) In the chemical equation A + B ⇔ C + D, which of the chemicals would be termed the reactant(s)?
A) A only
B) B only
C) A and B
D) C and D
E) C only
Answer: C
Diff: 2 Page Ref: 57

2) In the chemical equation A + B ⇔ C + D, which of the chemicals would be termed the product(s)?
A) A only
B) B only
C) A and B
D) C and D
E) C only
Answer: D
Diff: 2 Page Ref: 57

3) The sum of the thousands of chemical reactions that occur within the body is called _____.
A) metabolism
B) hydrolysis
C) phosphorylation
D) oxidation
E) reduction
Answer: A
Diff: 2 Page Ref: 57

4) Metabolism is a term that describes _____.
A) all work done by a living organism
B) all chemical reactions that take place within an organism
C) only chemical reactions that release ATP from living cells
D) the energy released from chemical bonds in living cells
E) the extraction of nutrients from biomolecules
Answer: B
Diff: 3 Page Ref: 57

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5) Which of the following is a correct description of an anabolic pathway?
A) Proteins are transcribed from DNA in the nucleus.
B) Proteins are degraded by mRNA in the cytoplasm.
C) Glycogen is synthesized in the cytosol from glucose.
D) The primary site of the synthesis of triglycerides is in the liver.
E) The primary site of the breakdown of triglycerides is in the adipose tissue.
Answer: C
Diff: 5 Page Ref: 57

6) The addition of a phosphate group to a substrate is called _____. The enzyme that catalyzes this reaction is referred to as a _____.
A) proteolysis : peptidase
B) phosphorylation : phosphatase
C) proteolysis : kinase
D) phosphorylation : kinase
E) hydrolysis : hydrase
Answer: D
Diff: 5 Page Ref: 58

7) The addition of two hydrogens and two electrons to NAD^+ is an example of what type of chemical reaction?
A) hydrolysis
B) oxidation
C) condensation
D) phosphorylation
E) reduction
Answer: E
Diff: 5 Page Ref: 58

8) Chemical reactions that involve the formation of peptide bonds between amino acids that produce water as a byproduct are called _____ reactions.
A) hydrolysis
B) phosphorylation
C) condensation
D) oxidation
E) reduction
Answer: C
Diff: 5 Page Ref: 58

9) Chemical reactions that involve the production of a phosphate bond are called _____ reactions.
A) condensation
B) phosphorylation
C) dephosphorylation
D) oxidation
E) reduction
Answer: B
Diff: 3 Page Ref: 58

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10) Chemical reactions that involve the breaking of a phosphate bond are called _____ reactions.
A) condensation
B) phosphorylation
C) dephosphorylation
D) oxidation
E) reduction
Answer: C
Diff: 3 Page Ref: 58

11) In a reduction reaction, which of the following is most likely added to the reactants?
A) water
B) neutrons
C) oxygen
D) electrons
E) phosphate
Answer: D
Diff: 5 Page Ref: 58

12) During what type of reaction are electrons removed from the reactant?
A) oxidation
B) reduction
C) phosphorylation
D) electrocution
E) deelectronofication
Answer: A
Diff: 5 Page Ref: 58

13) What type of reaction occurs when a saturated fatty acid becomes unsaturated?
A) oxidation
B) reduction
C) lipolysis
D) phosphorylation
E) hydrolysis
Answer: A
Diff: 7 Page Ref: 58

14) If the energy change of a reaction (ΔE) is positive, then _____.
A) the reactants had more energy than the products
B) the products had more energy than reactants
C) energy has been released as a byproduct
D) no energy was added to the reaction
E) the reactants had the same energy as the products
Answer: B
Diff: 5 Page Ref: 62

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15) Which of the following is true of an endergonic reaction?
A) The change in energy of the reaction is positive.
B) The reaction proceeds spontaneously.
C) The only product of the reaction is heat.
D) The only product of the reaction is water.
E) Endergonic reactions never occur.
Answer: A
Diff: 5 Page Ref: 60

16) The kinetic energy of a molecule can be increased by _____.
A) increasing its mass
B) increasing its temperature
C) decreasing its mass
D) decreasing its temperature
E) decreasing its velocity
Answer: B
Diff: 4 Page Ref: 62

17) The energy that is stored within an object for later use is referred to as _____.
A) kinetic energy
B) thermal energy
C) potential energy
D) radiant energy
E) kinesthetic energy
Answer: C
Diff: 3 Page Ref: 62

18) Which of the following statements about chemical equilibrium is FALSE?
A) At equilibrium, the rate of formation of products equals the rate of formation of reactants.
B) At equilibrium, the concentration of products equals the concentration of reactants.
C) Increasing the amount of reactant will increase the production of product.
D) Decreasing the amount of product will increase the production of product.
E) Adding an enzyme will not alter the equilibrium.
Answer: B
Diff: 5 Page Ref: 61

19) When an enzyme-catalyzed reaction is at equilibrium, _____.
A) there is no net change in the amount of reactants or products
B) the reaction is proceeding at its maximum rate
C) the reaction is prevented from occurring
D) there are equivalent amounts of substrate and enzyme present
E) there are equivalent amounts of substrate and product present
Answer: A
Diff: 6 Page Ref: 61

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20) Start with the following chemical reaction at equilibrium: A ↔ B. If you add product B to the system from a separate pathway, then what change in the reaction occurs?
A) Because the reaction is at equilibrium, there will be no change in rates of either the forward or reverse reaction.
B) Because the reaction is at equilibrium, the rates of both the forward and reverse reactions increase.
C) The rate of the forward reaction increases.
D) The rate of the reverse reaction increases.
E) The rate of the forward and reverse reactions both decrease.
Answer: D
Diff: 6 Page Ref: 61

21) The enzyme carbonic anhydrase catalyzes the following reaction:
$CO_2 + H_2O \leftrightarrow H_2CO_3$, then H_2CO_3 dissociates reversibly to form $H^+ + HCO_3^-$
When tissue becomes more active, carbon dioxide increases due to its production in _____, causing hydrogen ion concentration to _____.
A) the cytosol : increase
B) the cytosol : decrease
C) mitochondria : increase
D) mitochondria : decrease
E) both the cytosol and mitochondria : decrease
Answer: C
Diff: 9 Page Ref: 61

22) Molecules must have sufficient potential energy to overcome the _____ and, thereby, allow the reaction to proceed.
A) transformation state
B) mass action
C) transitional energy barrier
D) activation energy barrier
E) kinetic energy
Answer: D
Diff: 6 Page Ref: 62

23) Once a molecule is already in motion, conversion of that molecule's kinetic energy into potential energy occurs as a consequence of _____.
A) the collision of molecules
B) an increased temperature
C) its transition state
D) its transfer state
E) mass action
Answer: A
Diff: 4 Page Ref: 63

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24) Decreasing temperatures will _____ the frequency of collisions between molecules, thereby _____ the reaction rate.
A) increase : decreasing
B) decrease : decreasing
C) not alter : not changing
D) increase : increasing
E) not alter : increasing
Answer: B
Diff: 4 Page Ref: 64

25) As the _____ energy of a molecule increases with temperature, the molecule will _____ more frequently with other reactants, thereby increasing reaction rate.
A) potential : oxidize
B) kinetic : hydrolyze
C) kinetic : collide
D) potential : hydrolyze
E) activation : collide
Answer: C
Diff: 5 Page Ref: 64

26) As the energy required to overcome the activation energy barrier increases, the reaction rate will _____.
A) decrease
B) increase
C) occur more frequently
D) remain unaltered
E) depend solely upon temperature
Answer: A
Diff: 4 Page Ref: 64

27) Enzymes act as _____ to increase reaction rate.
A) an energy source
B) reactants
C) products
D) catalysts
E) intermediates
Answer: D
Diff: 4 Page Ref: 65

28) Which of the following would NOT increase the rate of a chemical reaction?
A) increasing the concentration of reactants
B) increasing the temperature
C) increasing the activation energy barrier
D) adding a catalyst
E) adding an enzyme
Answer: C
Diff: 4 Page Ref: 66

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29) Enzymes are what class of molecule?
A) trace metals
B) nucleic acids
C) proteins
D) carbohydrates
E) lipids
Answer: C
Diff: 3 Page Ref: 67

30) How do enzymes increase the rate of chemical reactions?
A) changing the equilibrium of the reaction
B) bringing the substrates together to undergo collision
C) adding potential energy to the reaction
D) adding kinetic energy to the reaction
E) converting kinetic energy to potential energy
Answer: B
Diff: 6 Page Ref: 67

31) Which of the following statements about enzymes is FALSE?
A) An enzyme shows specificity for its substrate(s).
B) An enzyme can be used over and over again because it is not changed in the chemical reaction.
C) Enzymes are necessary to cause certain reactions to occur in cells that cannot occur in the absence of enzymes.
D) Some enzymes require the presence of trace metals to be active.
E) Once a substrate binds to an enzyme, it can leave the active site unaltered.
Answer: C
Diff: 5 Page Ref: 66

32) In the induced-fit model for enzyme activity, the substrate alters the _____ of the _____ site on the enzyme.
A) conformation : allosteric
B) conformation : inactive
C) activity : active
D) conformation : active
E) shape : allosteric
Answer: D
Diff: 5 Page Ref: 67

33) The rate at which an enzyme-catalyzed reaction occurs can be increased by _____.
A) decreasing substrate concentration
B) releasing the cofactor that was bound to the enzyme
C) increasing enzyme concentration
D) decreasing temperature
E) changing the enzyme's conformation, thereby reducing its affinity for the substrate
Answer: C
Diff: 4 Page Ref: 67

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34) The measure of how many product molecules can be produced by an enzyme per unit of time is referred to as that enzyme's _____.
A) specificity
B) cofactor rate
C) affinity
D) catalytic rate
E) coenzyme rate
Answer: D
Diff: 4 Page Ref: 67

35) Which of the following is NOT a mechanism for regulating the flow of molecules through metabolic pathways?
A) changing the amount of enzyme that a cell has available
B) allosteric regulation of enzymes
C) isolating enzymes within a particular organelle
D) covalent regulation of enzymes
E) changing the potential energy of reactants and products
Answer: E
Diff: 6 Page Ref: 70

36) Which of the following would decrease the rate of an enzyme-catalyzed reaction?
A) increasing the concentration of enzyme
B) increasing the affinity of the enzyme for its substrate
C) increasing the concentration of substrate
D) increasing the concentration of product
E) increasing the kinetic energy
Answer: D
Diff: 4 Page Ref: 68

37) Some enzymes require trace metals to function as cofactors. What do the trace metals do?
A) Trace metals must be present in the enzyme in order for the enzyme to bind substrate.
B) Trace metals are necessary for the transfer of electrons between substrates.
C) Trace metals are necessary for the transfer of uncharged chemical groups between substrates.
D) Trace metals provide energy for the reaction.
E) Trace metals covalently modulate the enzyme.
Answer: A
Diff: 5 Page Ref: 68

38) Coenzyme A is derived from which of the following vitamins?
A) niacin
B) vitamin A
C) vitamin C
D) riboflavin
E) pantothenic acid
Answer: E
Diff: 4 Page Ref: 68

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39) What are coenzymes?
A) inorganic molecules derived from trace metals that function in the transfer of a chemical group
B) organic molecules derived from vitamins that function in the transfer of a chemical group
C) inorganic molecules derived from vitamins that function in the transfer of a chemical group
D) organic molecules derived from trace metals that function in the transfer of a chemical group
E) protein complexes that function as enzymes with more than one active site
Answer: B
Diff: 5 Page Ref: 68

40) The greater the attractive forces between substrate and enzyme, that enzyme is said to have a higher _____ for the substrate.
A) repulsion
B) catalytic rate
C) coenzyme activity
D) cofactor activity
E) affinity
Answer: E
Diff: 3 Page Ref: 69

41) Which of the following describes the strength of binding between a protein and a ligand?
A) chemical specificity
B) affinity
C) saturation
D) competition
E) lock-and-key model
Answer: B
Diff: 5 Page Ref: 69

42) Affinity is a measure of _____.
A) the rate of an enzyme catalyzed reaction
B) the rate of a metabolic pathway, from initial substrate to final product
C) the degree of phosphorylation of a molecule
D) the strength of interactions between a ligand and binding site
E) the rate of electron flow down the electron transport chain
Answer: D
Diff: 4 Page Ref: 69

43) Which of the following statements best describes allosteric regulation?
A) A modulator molecule loosely binds to a protein, altering its activity.
B) Rate of protein synthesis is changed by binding of a regulator molecule to the promoter sequence.
C) A phosphate group is attached to a protein, changing its activity.
D) Coenzymes bind to a protein, changing its activity.
E) A trace metal binds to an enzyme and a substrate, linking the two together.
Answer: A
Diff: 4 Page Ref: 71

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44) If the graph of an enzyme-catalyzed reaction shows a sigmoidal relationship between substrate concentration and reaction rate, then what can be said about the reaction?
A) It is endergonic.
B) It is exergonic.
C) It is allosterically regulated.
D) It is covalently regulated.
E) It is part of an oxidation-reduction process.
Answer: C
Diff: 5 Page Ref: 71

45) In allosteric regulation, the modulator molecule binds to the _____.
A) catalytic site of the enzyme by weak, reversible interactions
B) regulatory site of the enzyme by weak, reversible interactions
C) catalytic site by covalent bonds
D) regulatory site by covalent bonds
E) cofactor by weak, reversible interactions
Answer: B
Diff: 5 Page Ref: 71

46) Regulation of an enzyme through reversible binding of a modulator to a regulatory site on an enzyme is specifically called _____.
A) allosteric regulation
B) covalent regulation
C) the induced-fit model
D) the lock-and-key model
E) pH regulation
Answer: A
Diff: 5 Page Ref: 71

47) Regulating an enzyme through protein kinase-induced phosphorylation of that enzyme is an example of _____.
A) allosteric regulation
B) covalent regulation
C) the induced-fit model
D) feedback inhibition
E) cofactor regulation
Answer: B
Diff: 5 Page Ref: 71

48) Which of the following enzymes covalently modulates another enzyme?
A) DNA polymerase
B) protein kinase
C) RNA polymerase
D) catalase
E) phosphatase
Answer: B
Diff: 4 Page Ref: 71

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49) A protein kinase catalyzes which of the following types of chemical reactions?
A) phosphorylation
B) dephosphorylation
C) condensation
D) oxidation
E) hydrolysis
Answer: A
Diff: 4 Page Ref: 71

50) Which of the following statements about end-product inhibition is FALSE?
A) The last product of a metabolic pathway inhibits the activity of an enzyme earlier in that path.
B) It usually involves allosteric modulation of an enzyme.
C) It is an example of negative feedback.
D) The enzyme modulated is often the rate-limiting enzymes.
E) The amount of product produced is increased by this process.
Answer: E
Diff: 6 Page Ref: 72

51) What type of enzyme catalyzes the phosphorylation of another enzyme, thereby altering that enzyme's activity?
A) Dehydrogenase
B) Phosphorylase
C) Protein kinase
D) Synthase
E) Cofactor
Answer: C
Diff: 4 Page Ref: 71

52) During end-product inhibition, _____.
A) the initial substrate of an enzyme-catalyzed reaction inhibits the rate-limiting enzyme via allosteric regulation
B) the product of the rate-limiting step of an enzyme-catalyzed reaction inhibits the rate-limiting enzyme via covalent regulation
C) the product of the rate-limiting step of an enzyme-catalyzed reaction inhibits the rate-limiting enzyme via allosteric regulation
D) the final product of an enzyme-catalyzed reaction inhibits the rate-limiting enzyme via allosteric regulation
E) the final product of an enzyme-catalyzed reaction inhibits the rate-limiting enzyme via covalent regulation
Answer: D
Diff: 5 Page Ref: 72

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53) What is the most important energy-transferring compound in cells?
A) glucose
B) fructose
C) protein
D) adenosine triphosphate
E) deoxyribonucleic acid
Answer: D
Diff: 2 Page Ref: 73

54) In skeletal muscle, ATP can be synthesized by transferring a phosphate group from creatine-P to ADP to form ATP and creatine. In this example, ATP was synthesized by what process?
A) oxidative phosphorylation
B) substrate-level phosphorylation
C) oxidation
D) reduction
E) condensation
Answer: B
Diff: 4 Page Ref: 73

55) The complete oxidation of glucose releases how many kcal of energy for every mole of glucose?
A) 686
B) 7
C) 266
D) 420
E) 98
Answer: A
Diff: 4 Page Ref: 73

56) The reaction whereby energy is released from an ATP molecule can be described by which of the following?
A) ATP reduction
B) ATP oxidation
C) ATP hydrolysis
D) ATP synthase
E) ATP hydrogenation
Answer: C
Diff: 5 Page Ref: 73

57) How much energy is required to produce 1 mole of ATP?
A) 7 kcal
B) 686 kcal
C) 266 kcal
D) 420 kcal
E) 98 kcal
Answer: A
Diff: 3 Page Ref: 73

58) Where does glycolysis occur?

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A) cytosol
B) mitochondrial matrix
C) mitochondrial intermembrane space
D) mitochondrial inner membrane
E) lysosomes
Answer: A
Diff: 4 Page Ref: 74

59) Which of the following associations between metabolic pathway and location in the cell is INCORRECT?
A) glycolysis : cytosol
B) electron transport system : inner mitochondrial membrane
C) transcription : nucleus
D) lipid synthesis : smooth endoplasmic reticulum
E) Krebs cycle : mitochondrial intermembrane space
Answer: E
Diff: 6 Page Ref: 74

60) ATP is synthesized by substrate-level phosphorylation during which of the following?
A) glycolysis only
B) conversion of pyruvate to lactate only
C) Krebs cycle only
D) glycolysis and the Krebs cycle only
E) glycolysis, the Krebs cycle, and during conversion of pyruvate to lactate
Answer: D
Diff: 6 Page Ref: 75

61) Which of the following does NOT occur in mitochondria?
A) Krebs cycle
B) oxidative phosphorylation
C) consumption of oxygen
D) production of carbon dioxide
E) conversion of pyruvate to lactate
Answer: E
Diff: 5 Page Ref: 76

62) The final product of glycolysis under aerobic conditions is pyruvate. What happens to pyruvate under aerobic conditions?
A) Pyruvate is converted into acetyl CoA in the cytosol, and the acetyl CoA then enters the mitochondrial matrix.
B) Pyruvate enters the mitochondrial matrix where it is converted into acetyl CoA.
C) Pyruvate is converted to lactic acid in the cytosol.
D) Pyruvate is converted to lactic acid in the mitochondrial matrix.
E) Pyruvate provides electrons to the electron transport chain.
Answer: B
Diff: 6 Page Ref: 77

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63) With the 38 moles of ATP that are generated within a cell from 1 mole of glucose, what percentage of the energy released from glucose is lost as heat?
A) 25%
B) 33%
C) 40%
D) 60%
E) 70%
Answer: D
Diff: 5 Page Ref: 74

64) In the presence of oxygen, the process of glycolysis produces which of the following products?
A) 1 pyruvate
B) 1 lactate
C) 2 pyruvate
D) 2 lactate
E) 2 glycerol
Answer: C
Diff: 3 Page Ref: 75

65) Where are the enzymes of glycolysis located within the cell?
A) inner mitochondrial membrane
B) outer mitochondrial membrane
C) lysosome
D) cytosol
E) nucleus
Answer: D
Diff: 4 Page Ref: 74

66) In the presence of a limited oxygen supply, pyruvate is converted to what?
A) lactate
B) acetyl CoA
C) NADH
D) ATP
E) glucose
Answer: A
Diff: 3 Page Ref: 82

67) How many ATP are generated per acetyl coenzyme A going through the Krebs cycle followed by the electron transport system?
A) 2
B) 3
C) 12
D) 24
E) 36-38
Answer: C
Diff: 4 Page Ref: 78

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68) Which of the following statements about the Krebs cycle is FALSE?
A) The initial substrate is acetyl CoA.
B) Three NADs are reduced to NADH + H^+.
C) Two FADs are reduced to $FADH_2$.
D) Carbon dioxide is produced.
E) One ATP (GTP) is formed by substrate phosphorylation.
Answer: C
Diff: 5 Page Ref: 78

69) In terms of energy production, the Krebs cycle is significant because it _____.
A) directly produces large amounts of ATP
B) breaks down glucose
C) reduces the coenzymes NAD and FAD for oxidative phosphorylation
D) produces acetylcoenzyme A for fatty acid synthesis
E) provides acetylcoenzyme A for glucose synthesis
Answer: C
Diff: 7 Page Ref: 78

70) Which of the following statements about oxidative phosphorylation is FALSE?
A) More ATP can be produced when NADH provides electrons to the electron transport chain than when $FADH_2$ provides electrons.
B) Hydrogen ion movement from the mitochondrial matrix to the intermembrane space activates the enzyme ATP synthase.
C) As electrons move down the electron transport chain, released energy is used to transport hydrogen ions across the inner mitochondrial membrane.
D) Oxygen is reduced to water.
E) The components of the electron transport chain are located on the inner mitochondrial membrane.
Answer: B
Diff: 6 Page Ref: 80

71) What is the final acceptor of electrons in the electron transport?
A) pyruvate
B) carbon dioxide
C) water
D) oxygen
E) glucose
Answer: D
Diff: 3 Page Ref: 80

72) Where is the electron transport chain?
A) cytosol
B) outer mitochondrial membrane
C) inner mitochondrial membrane
D) intermembrane space of the mitochondria
E) mitochondrial matrix
Answer: C
Diff: 3 Page Ref: 78

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73) Chemiosmotic coupling refers to _____.
A) chemical coupling between substrate and enzymes
B) chemical coupling of each reaction within the mitochondria
C) coupling of the Krebs cycle to the electron transport chain
D) the harnessing of energy from the reactions of the electron transport chain to make ATP
E) the transfer of a phosphate group from one molecule to another
Answer: D
Diff: 5 Page Ref: 80

74) Hydrogen ions activate the enzyme ATP synthase by moving from _____.
A) cytosol to inner mitochondrial membrane
B) inner mitochondrial membrane to cytosol
C) cytosol to outer mitochondrial membrane
D) mitochondrial matrix to intermembrane space
E) intermembrane space to mitochondrial matrix
Answer: E
Diff: 7 Page Ref: 80

75) Each time an electron is passed between the molecules of the electron transport chain, _____.
A) energy is gained
B) energy is released
C) an ATP molecule is produced
D) oxygen accepts the electrons
E) carbon dioxide is produced
Answer: B
Diff: 4 Page Ref: 80

76) What is the first component of the electron transport chain that accepts electrons from an NADH molecule?
A) flavin mononucleotide
B) cytochrome b
C) cytochrome a_3
D) coenzyme Q
E) flavin adenine dinucleotide
Answer: A
Diff: 5 Page Ref: 79

77) What is the first component of the electron transport chain that accepts electrons from an $FADH_2$ molecule?
A) flavin mononucleotide
B) cytochrome b
C) cytochrome a_3
D) coenzyme Q
E) flavin adenine dinucleotide
Answer: D
Diff: 6 Page Ref: 80

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78) ATP synthase is able to use the potential energy that originates from _____ to produce ATP.
A) the hydrogen gradient across the inner mitochondrial membrane
B) the phosphorylation of cytochromes
C) the sodium gradient across the inner mitochondrial membrane
D) complex I
E) complex IV
Answer: A
Diff: 6 Page Ref: 80

79) Under low oxygen conditions, _____ must unload its electrons to allow glycolysis to continue the production of ATP.
A) $FADH_2$
B) lactate
C) NAD^+
D) NADH
E) pyruvate
Answer: D
Diff: 5 Page Ref: 82

80) What is the net energy yield for the anaerobic metabolism of one glucose molecule?
A) two molecules of ATP and two NADH
B) two molecules of NADH and 0 ATP
C) two molecules of ATP and 0 NADH
D) 36 molecules of ATP and 0 NADH
E) two molecules of ATP and three NADH
Answer: C
Diff: 5 Page Ref: 84

81) Under anaerobic conditions, what is pyruvate converted to and where does this occur?
A) acetyl coenzyme A in the mitochondria
B) acetyl coenzyme A in the cytosol
C) lactate in the mitochondria
D) lactate in the cytosol
E) fatty acid in the cytosol
Answer: D
Diff: 5 Page Ref: 83

82) Under anaerobic conditions, which of the following is a final product of glucose catabolism?
A) pyruvic acid
B) lactic acid
C) carbon dioxide
D) acetyl coenzyme A
E) water
Answer: B
Diff: 3 Page Ref: 84

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83) How is glucose stored in muscle and liver cells?
A) starch
B) glycogen
C) cellulose
D) lipids
E) amino acids
Answer: B
Diff: 3 Page Ref: 84

84) Glycogen in muscle is used to _____.
A) contribute to the maintenance of blood glucose
B) convert glucose to amino acids
C) convert glucose to fats
D) fuel the activity of that muscle exclusively
E) both fuel muscle activity and maintain blood glucose
Answer: D
Diff: 6 Page Ref: 86

85) What organ contains glucose-6-phosphatase?
A) brain
B) heart
C) liver
D) skeletal muscle
E) all organs in the body
Answer: C
Diff: 6 Page Ref: 86

86) What is the function of glucose-6-phosphatase?
A) catalyze addition of one phosphate group to glucose
B) catalyze removal of one phosphate group from glucose
C) catalyze addition of six phosphate groups to glucose
D) catalyze removal of six phosphate groups from glucose
E) catalyze the removal of the phosphate group from glucose and add it to ADP to form ATP by substrate-level phosphorylation
Answer: B
Diff: 7 Page Ref: 86

87) Which of the following molecules is NOT converted to glucose through the process of gluconeogenesis?
A) glycerol
B) lactate
C) amino acids
D) pyruvate
E) fatty acids
Answer: E
Diff: 5 Page Ref: 86

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88) What is glycogenolysis?
A) the synthesis of membrane carbohydrates
B) the breakdown of glycoproteins
C) the synthesis of glycogen from glucose
D) the breakdown of glycogen to glucose
E) a form of gluconeogenesis
Answer: D
Diff: 3 Page Ref: 86

89) Which of the following molecules is a substrate for gluconeogenesis?
A) amino acids only
B) glycogen only
C) glycerol only
D) amino acids and glycerol only
E) amino acids, glycogen, and glycerol
Answer: D
Diff: 5 Page Ref: 86

90) Gluconeogenesis refers to synthesis of _____ and occurs in _____.
A) glycogen : the liver
B) triglycerides : adipose tissue
C) glucose : liver
D) fatty acids : adipose tissue
E) glucose : all organs
Answer: C
Diff: 4 Page Ref: 86

91) The conversion of triglycerides to glycerol and fatty acids is called _____.
A) triglycerolysis
B) glycolysis
C) gluconeogenesis
D) lipolysis
E) liposuction
Answer: D
Diff: 4 Page Ref: 87

92) A substantial amount of ATP is generated from the metabolism of long carbon chains called _____.
A) glycogen
B) fatty acids
C) glycerol
D) glucose
E) amino acids
Answer: B
Diff: 3 Page Ref: 87

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93) Metabolism of fatty acids that results in the accumulation of acetyl CoA can lead to a buildup of _____.
A) ketones
B) ATP
C) glycerol
D) lactate
E) amino acids
Answer: A
Diff: 7 Page Ref: 87

94) Beta-oxidation of a 14-chain fatty acid results in how many acetyl CoA molecules?
A) 1
B) 2
C) 4
D) 7
E) 14
Answer: D
Diff: 5 Page Ref: 87

95) Where does beta-oxidation of fatty acids occur?
A) cytosol
B) smooth endoplasmic reticulum
C) mitochondrial matrix
D) mitochondrial intermembrane space
E) peroxisome
Answer: C
Diff: 4 Page Ref: 87

96) Before converting amino acids into intermediates for energy metabolism, they must first undergo _____.
A) denaturation
B) deamination
C) detoxification
D) depeptidization
E) oxidation
Answer: B
Diff: 7 Page Ref: 90

97) Any nutrient that is not synthesized by the body and must, therefore, be acquired through the diet is a(n) _____ nutrient.
A) essential
B) primary
C) secondary
D) non-essential
E) consumptive
Answer: A
Diff: 4 Page Ref: 90

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98) The amine group removed from an amino acid must be converted to _____ before being eliminated from the human body.
A) uric acid
B) ornithine
C) keto acid
D) urea
E) ammonium
Answer: D
Diff: 4 Page Ref: 88

99) Insulin levels in the blood are elevated in response to which of the following?
A) increased blood glucose levels
B) decreased blood fatty acids
C) decreased blood triglycerides
D) fasting for 12 hours
E) sleep
Answer: A
Diff: 5 Page Ref: 89

100) Which of the following is not an action of insulin on liver cells?
A) increase glucose uptake
B) activate glycogen synthetase
C) activate glucokinase
D) inhibit glucose-6-phosphatase
E) increase gluconeogenesis
Answer: A
Diff: 9 Page Ref: 89

3.2 True/False Questions

1) Chemical reactions are only able to occur in one direction.
Answer: FALSE
Diff: 3 Page Ref: 57

2) Phosphorylation reactions are specific examples of a condensation reaction.
Answer: FALSE
Diff: 4 Page Ref: 58

3) Sucrose is synthesized from the condensation of fructose and glucose.
Answer: TRUE
Diff: 4 Page Ref: 58

4) The following reaction is an example of an oxidation: $FAD + 2\ H^+ \rightarrow FADH_2$
Answer: FALSE
Diff: 5 Page Ref: 59

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5) According to the first law of thermodynamics, energy cannot be created or destroyed.
Answer: TRUE
Diff: 4 Page Ref: 59

6) Potential energy describes the energy possessed by an object in motion.
Answer: FALSE
Diff: 4 Page Ref: 60

7) A reaction is at equilibrium when the rate of the forward and reverse reactions are equal.
Answer: TRUE
Diff: 4 Page Ref: 61

8) Energy-releasing reactions occur spontaneously.
Answer: TRUE
Diff: 4 Page Ref: 61

9) Energy-requiring reactions will always proceed spontaneously in the forward direction.
Answer: FALSE
Diff: 4 Page Ref: 61

10) An increase in the concentration of a product will increase the rate of a reaction in the reverse direction.
Answer: TRUE
Diff: 4 Page Ref: 61

11) An increase in temperature increases the potential energy of molecules.
Answer: FALSE
Diff: 4 Page Ref: 64

12) Most enzymes only catalyze reactions in one direction.
Answer: FALSE
Diff: 5 Page Ref: 67

13) An increase in the affinity of an enzyme for its substrate will increase the reaction rate.
Answer: TRUE
Diff: 4 Page Ref: 69

14) According to the induced fit model for enzymes, the binding of substrate to the active site alters the structure of the enzyme.
Answer: TRUE
Diff: 4 Page Ref: 68

15) A single enzyme could be simultaneously affected by both allosteric regulation and covalent regulation.
Answer: TRUE
Diff: 4 Page Ref: 71

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16) Enzymes increase the activation energy of a reaction.
Answer: FALSE
Diff: 4 Page Ref: 66

17) An increase in the concentration of enzyme will increase the reaction rate.
Answer: TRUE
Diff: 4 Page Ref: 69

18) Binding of a modulator to a regulatory site alters the structure of the enzyme in a way that can affect catalytic rate and/or affinity.
Answer: TRUE
Diff: 4 Page Ref: 71

19) Addition of a phosphate group to an enzyme to change its activity is an example of covalent regulation.
Answer: TRUE
Diff: 4 Page Ref: 71

20) A phosphatase is an enzyme that catalyzes the addition of a phosphate group to a protein.
Answer: FALSE
Diff: 5 Page Ref: 71

21) All of the energy released by the oxidation of glucose is converted and stored in the form of ATP.
Answer: FALSE
Diff: 2 Page Ref: 74

22) Carbon dioxide can react with water to produce bicarbonate and hydrogen ions through 2 reversible reactions as follows:

$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$

Blood flows from arteries into capillaries and then into veins. As the blood moves through the capillaries, carbon dioxide produced by the cells enters the blood. Therefore, venous blood has a higher pH than arterial blood.
Answer: FALSE
Diff: 9 Page Ref: 62

23) The condensation of ATP releases energy to drive cellular processes.
Answer: FALSE
Diff: 5 Page Ref: 74

24) The carbohydrate in adenosine is ribose.
Answer: TRUE
Diff: 8 Page Ref: 73

25) Complete oxidation of 1 mole glucose produces 6 moles of water and 6 moles of carbon dioxide.
Answer: TRUE
Diff: 4 Page Ref: 73

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26) Pyruvate is converted to lactate in the cytosol under anaerobic conditions, but it is converted to acetyl CoA in the mitochondrial matrix under aerobic conditions.
Answer: TRUE
Diff: 6 Page Ref: 77

27) Glycogenolysis is an example of a catabolic reaction.
Answer: TRUE
Diff: 4 Page Ref: 85

28) Lactate dehydrogenase is an enzyme in the mitochondrial matrix.
Answer: FALSE
Diff: 5 Page Ref: 83

3.3 Matching Questions

Match the correct metabolic pathway to the following descriptions.

A) gluconeogenesis
B) Krebs cycle
C) glycogenesis
D) oxidation of fatty acids
E) glycolysis
F) electron transport chain

1) Acetyl CoA is the initial substrate.
Diff: 4 Page Ref: 77

2) Pyruvate is the final product.
Diff: 3 Page Ref: 76

3) Glucose is synthesized.
Diff: 4 Page Ref: 85

4) It occurs within the inner mitochondrial membrane.
Diff: 3 Page Ref: 79

5) Glucose is used to synthesize a larger molecule.
Diff: 4 Page Ref: 85

Answers: 1) B 2) E 3) A 4) F 5) C

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Match the correct location in the cell for the following metabolic pathways.

A) nucleus
B) mitochondrial intermembrane space
C) inner mitochondrial membrane
D) mitochondrial matrix
E) rough ER
F) cytosol
G) free ribosomes

6) Glycolysis.
Diff: 3 Page Ref: 76

7) Krebs cycle.
Diff: 3 Page Ref: 77

8) Electron transport system.
Diff: 3 Page Ref: 79

9) Conversion of pyruvate to lactate.
Diff: 5 Page Ref: 84

10) Conversion of pyruvate to acetyl CoA.
Diff: 4 Page Ref: 77

Answers: 6) F 7) D 8) C 9) F 10) D

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Match the following chemical reactions with its correct name.

A) dephosphorylation
B) hydrolysis
C) phosphorylation
D) reduction
E) condensation
F) oxidation

11) Protein + H_2O → Amino acids.
Diff: 5 Page Ref: 58

12) Monounsaturated fatty acid + 2H → Saturated fatty acid.
Diff: 6 Page Ref: 58

13) Protein + Phosphate → Protein - Phosphate.
Diff: 4 Page Ref: 58

14) ADP + Pi → ATP + H_2O.
Diff: 5 Page Ref: 58

15) FAD + 2H → $FADH_2$.
Diff: 4 Page Ref: 58

16) $C_6H_{12}O_6$ + 6 O_2 → 6 CO_2 + 6 H_2O.
Diff: 4 Page Ref: 58

Answers: 11) B 12) D 13) C 14) E 15) D 16) F

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3.4 Essay Questions

1) Chemical reactions are essential to a multitude of functions within the human body. Describe the general properties of a chemical reaction.
Answer: A reaction can be written in the form A + B ⇔ C + D. A and B are considered the reactants, whereas C and D are the products of the reaction. The ⇔ is pointing out that reactions can occur in both directions (forward reaction produces C and D, whereas reverse reaction produces A and B). In metabolism, many of these reactions are linked to one another, creating a metabolic pathway of reactions. The final product of the reaction is the end product, and all of the reactants in between are considered intermediates.
Diff: 4 Page Ref: 57

2) Several types of chemical reactions are involved in the process of metabolism. Provide a general description of these reactions: hydrolysis, condensation, phosphorylation, dephosphorylation, oxidation, and reduction reactions.
Answer: Hydrolysis/condensation reactions involve either the addition or production of water. Hydrolysis reactions are driven by the cleavage of water. One example of a hydrolysis reaction is the breaking of a peptide bond between amino acids. Water is split into a hydroxyl group and a hydrogen, each of which combine with one of the amino acids. The reverse of a hydrolysis reaction is a condensation reaction, where water is a product of the reaction.

Phosphorylation/dephosphorylation reactions involve the addition or removal of a phosphate group. Addition of a phosphate group involves a kinase enzyme in a process called phosphorylation. Alternatively, the loss of a phosphate group requires a phosphatase enzyme and is called dephosphorylation. These two reactions are unique examples of the first reaction, with phosphorylation requiring the splitting of water (hydrolysis) and dephosphorylation resulting in the production of water (condensation). Oxidation/reduction reactions involve the transfer of electrons. Oxidation reactions can be narrowly defined as the loss of electrons, which can involve the addition of oxygen. Reduction reactions involve the addition of electrons or hydrogen molecules.
Diff: 6 Page Ref: 58

3) Describe the role that energy (potential and kinetic) plays in mediating chemical reactions.
Answer: Energy is broadly defined as the capacity to do work. A reaction's energy requirement can be determined by the simple equation ($\Delta E = E_{products} - E_{reactants}$). A negative ΔE indicates a reaction where energy is released, whereas a positive ΔE indicates that energy is consumed. At the same time, energy can be present in two forms: kinetic and/or potential. Kinetic energy is the energy of motion, which depends upon the speed and mass of the object. Molecules possess kinetic energy because they undergo thermal motion. Thus, the kinetic energy of a molecule is directly proportional to its temperature and is, therefore, referred to as thermal energy. This can be contrasted with potential energy, which is energy that is stored and eventually converted into kinetic energy. When referring to the energy change in a reaction, we are referring to potential energy. An energy-releasing reaction may occur spontaneously in the forward direction, whereas an energy-requiring reaction does not move forward spontaneously and will only move forward when more energy is applied to the system.
Diff: 5 Page Ref: 59

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4) The rates of chemical reactions are important to their biological function. Describe the factors that can affect reaction rates and how these changes are mediated (do not include enzymes in this discussion).
Answer: The rate of a reaction can be expressed as a change in concentration per unit time. First, reaction rates can be determined by the concentration of reactants and products. Since reactions are bi-directional, we are really referring to the net rate of a reaction. Any increase in a reactant's concentration will increase the reaction rate in the forward direction. In addition, any increase in product will increase the reaction rate in the reverse direction. Any increase in concentration will increase the frequency of collisions between reactants, thus increasing the likelihood that, when they collide, a reaction will occur. However, the occurrence of a reaction is dependent upon the energy of the collision and, therefore, another way to increase the rate of a reaction is to increase temperature. When temperature increases, each molecule will have more kinetic energy, thereby increasing the likelihood that a collision between reactants will result in product (i.e., the activation energy barrier can be overcome). Finally, any change in the amount of energy required to overcome the activation energy barrier (height of the activation energy barrier) will alter the rate of a reaction. An elevated activation energy barrier will make it less likely that a collision between two reactants will result in product. Conversely, as the activation energy barrier is reduced, a collision between reactants will be more likely to result in a product, thereby increasing the reaction rate.
Diff: 6 Page Ref: 64

5) Enzymes are important determinants of chemical reaction rates in the body. Describe the mechanisms by which enzymes function to stimulate a reaction.
Answer: Enzymes act as catalysts to increase the rate of a chemical reaction. Most enzymes are specific for a particular reaction through a two-step process. The enzyme must first bind to the substrate to form an enzyme-substrate complex. The substrate is then acted on by the enzyme to form a product. The initial step is referred to as the binding step, which is a reversible process. If the complex is around for long enough, the second step, or catalytic step, of the reaction will occur. Each enzyme has a specificity for a particular substrate or class of substrates. The site of substrate binding has been termed the active site, whose binding to the substrate has been modeled in two ways: lock-and-key or induced-fit models. Both of these models refer to the complementary nature of the substrate's conformation for an enzyme. Many of these enzyme reactions require a cofactor, either a trace metal or a coenzyme. Trace metals bind to an enzyme on a site other than the active site, and maintain the enzyme in a structure that will bind to the substrate. The coenzyme is a particular type of cofactor that does not have any catalytic activity of its own but does participate directly in the reaction catalyzed by its partner enzyme by transferring a chemical group with the substrate.
Diff: 6 Page Ref: 65

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6) Describe the factors that affect the rates of enzyme reactions.
Answer: The presence of an enzyme increases reaction rates by decreasing the activation energy required to initiate a reaction. The rate at which an enzyme catalyzes a reaction can be altered by several variables. First, reaction rates can be affected by the catalytic rate of an enzyme. This is a measure of how many substrate molecules an enzyme can convert to product within a given period of time, reflecting how quickly the enzyme can move through the second step of the reaction (the catalytic step). Some enzymes are inherently faster acting than others. Another way enzymes can alter reaction rates is through their affinity for the substrate (how easily the substrate binds to the enzyme). This is a reflection of how well an enzyme facilitates the first step of a reaction (the binding step). A higher affinity implies the substrate is a better fit within the active site of the enzyme. Based upon what we know about reactions, both substrate and enzyme concentrations will also affect reaction rates. The more enzyme present, the more product that can be produced. The more substrate, the more likely that substrate will collide with and be bound to the enzyme. However, as concentration increases, there is a limit to how much reaction rates will increase once all of the enzymes present are saturated (bound) by substrate. In addition, any situation that can alter the structure of an enzyme will affect reaction rates. This includes temperature, pH, allosteric regulation, and covalent regulation. Each enzyme has an optimal value of pH and temperature at which it has the highest reaction rates.
Diff: 6 Page Ref: 67

7) With the plethora of enzymes that are present within each cell, the activity of each enzyme must be carefully regulated. Describe the two ways that enzyme reactions are regulated within the body and give examples of each.
Answer: Reaction rates of enzymes are continuously changing within the body and can occur through alterations in enzyme concentration or enzyme activity. Concentration of an enzyme can be altered by rates of synthesis, rates of release, and stability (degradation or inactivation). Alternatively, the activity of an enzyme can be altered. Certain enzymes have another site (other than the active site) where molecules can bind and alter reaction rates. This is the regulatory site where modulators can bind and thereby alter reaction rates. This type of regulation is called *allosteric* regulation, since the modulator alters the structure of the enzyme in a way that affects its activity (either to increase or decrease). Binding to that allosteric site is reversible, which means that the activity of the enzyme can be altered by the concentration of the modulator. Alternately, enzymes can be controlled via *covalent* regulation, where changes in enzyme activity are brought about by covalent bonding of specific chemical groups to enzymes. These covalent bonds are usually created by another enzyme. A common form of covalent regulation involves the addition or removal of a phosphate group. Addition is called phosphorylation, whereas removal is called dephosphorylation. Protein kinases are enzymes that phosphorylate enzymes while phosphatases dephosphorylate enzymes. Interestingly, enzymes can also be regulated by feedback loops involving the product of a series of reactions. This type of feedback inhibition is quite common in metabolic pathways where it has been called end-product inhibition. The product of one reaction will alter the structure of an earlier enzyme, thereby decreasing its activity. Thus, feedback inhibition is a specific form of allosteric regulation. Finally, some reactions are controlled through a feedforward activation. In a series of enzyme-mediated reactions, products from an earlier reaction will activate the enzyme for a reaction that is downstream from the product in question.
Diff: 7 Page Ref: 69

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8) Describe the process whereby energy is obtained by glucose oxidation.
Answer: The oxidation of glucose requires three steps: glycolysis, Krebs cycle, and oxidative phosphorylation. Glycolysis takes place in the cytosol and is the conversion of glucose to 2 pyruvate molecules, generating 2 ATP and 2 NADH + 2 H^+.

The two pyruvate molecules enter the mitochondrial matrix, where they are converted to 2 acetyl CoA. In the process, 2 NAD^+ are reduced to 2 NADH + 2 H^+.

The 2 acetyl CoA each enter the Krebs cycle of the mitochondrial matrix. In the process, 2 ATP, 6 NADH + 6 H^+, and 2 $FADH_2$ are produced.

Thus, from one glucose, the processes of glycolysis and the Krebs cycle directly produce 4 ATP by substrate-level phosphorylation. More importantly, they produced reduced coenzymes. In the cytosol, 2 NADH + 2 H^+ are produced, and in the mitochondrial matrix, 8 NADH + 8 H^+ and 2 $FADH_2$ are produced. These coenzymes provide electrons to the electron transport chain to synthesize ATP by oxidative phosphorylation.

For electrons to enter the electron transport chain, they must be located in the mitochondria. Thus, the electrons associated with the 2 NADH + 2 H^+ produced in the cytosol must be moved into the mitochondria. NADH + H^+ cannot permeate the membranes of the mitochondria; therefore, the electrons are shuttled across. In the process, either an NAD+ or an FAD can accept the electrons inside the mitochondrial matrix.

For each NADH + H^+ that provides electrons for the electron transport chain, a maximum of 3 ATP are produced by oxidative phosphorylation. For each $FADH_2$ that provides the electrons, a maximum of 2 ATP can be produced by oxidative phosphorylation. Thus there are 8 NADH + 8 H^+, 2 $FADH_2$, and 2 more of either NADH + H^+ or $FADH_2$. Therefore, the net number of ATP produced by oxidative phosphorylation from one glucose is (8 × 3) + (2 × 2) + (2 × 3 or 2 × 2) = 32 or 34.

The total number of ATP by oxidation of glucose is 36 - 38.
Diff: 7 Page Ref: 72

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3.5 Short Answer Questions

1) A□B + H_2O → A□OH + H□B describes what type of reaction?
Answer: hydrolysis
Diff: 3 Page Ref: 58

2) A□OH + H□B → A□B + H_2O describes what type of reaction?
Answer: condensation
Diff: 3 Page Ref: 58

3) $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ is an example of what type of reaction?
Answer: oxidation
Diff: 4 Page Ref: 58

4) HA□BH → A□B + 2H is an example of what type of reaction?
Answer: oxidation
Diff: 4 Page Ref: 58

5) A□B + 2H → HA□BH is an example of what type of reaction?
Answer: reduction
Diff: 4 Page Ref: 58

6) When a reaction occurs and that reaction is moving equally in a forward and reverse direction, that reaction is said to be at _____.
Answer: equilibrium
Diff: 5 Page Ref: 61

7) A + B ⇔ C + D How will this reaction be altered if an excess of C is added to the reaction?
Answer: The reverse direction will be favored.
Diff: 5 Page Ref: 61

8) A + B ⇔ C + D How will this reaction be altered if an excess of B is added to the reaction?
Answer: The forward direction will be favored.
Diff: 5 Page Ref: 61

9) In order for a reaction to proceed past the transition state, the reaction must overcome what energy barrier?
Answer: the activation energy barrier
Diff: 6 Page Ref: 62

10) According to the law of mass action, an increase in the concentration of product will cause a reaction to move in the (forward / reverse) direction.
Answer: reverse
Diff: 4 Page Ref: 61

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11) In a reaction that proceeds in the forward direction spontaneously, which has more free energy, the reactant or the product?
Answer: reactant
Diff: 3 Page Ref: 61

12) Metabolism includes _____ reactions, which release energy and result in the breakdown of large biomolecules, and _____ reactions, which require a net input of energy and result in the synthesis of large biomolecules.
Answer: catabolic : anabolic
Diff: 3 Page Ref: 57

13) What is the strength of binding between an enzyme and substrate called?
Answer: affinity
Diff: 3 Page Ref: 69

14) During (allosteric / covalent) regulation, a modulator binds to a regulatory site on an enzyme by weak interactions altering the activity of the enzyme.
Answer: allosteric
Diff: 4 Page Ref: 71

15) An enzyme that catalyzes phosphorylation of a protein is called a(n) _____. An enzyme that catalyzes dephosphorylation of a protein is called a(n) _____.
Answer: protein kinase : phosphatase
Diff: 5 Page Ref: 71

16) What chemical group is most commonly added to a protein during covalent regulation?
Answer: phosphate
Diff: 5 Page Ref: 71

17) During end-product inhibition, the final product in a metabolic pathway (allosterically / covalently) regulates the activity of an enzyme earlier in the pathway.
Answer: allosterically
Diff: 5 Page Ref: 72

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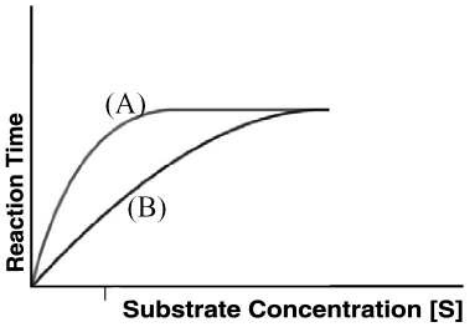
18) The figure below shows the relative activity of an enzyme in two states: high affinity and low affinity. Which curve, A or B, represents the high affinity state?



Answer: A
Diff: 5 Page Ref: 69

19) What chemical group is transferred by the following coenzymes: NAD? FAD? Coenzyme A?
Answer: hydrogens or electrons : hydrogen or electrons : acetyl group
Diff: 5 Page Ref: 67

20) A (coenzyme / trace metal) alters the ability of an enzyme to bind its substrate.
Answer: trace metal
Diff: 6 Page Ref: 67

21) Provide the correct number in each blank. For each acetyl CoA that enters the Krebs cycle, _____ NAD(s) are reduced, _____ FAD(s) are reduced, and _____ ATP are synthesized by substrate-level phosphorylation.
Answer: 3 : 1 : 1
Diff: 6 Page Ref: 77

22) Which of the following is the reduced form: FAD or $FADH_2$?
Answer: $FADH_2$
Diff: 4 Page Ref: 67

23) During _____, a phosphate group is transferred from a metabolic intermediate to an ADP to synthesize ATP.
Answer: substrate-level phosphorylation
Diff: 4 Page Ref: 72

24) Fill in the blanks with the appropriate numbers. For each $FADH_2$ that supplies electrons to the electron transport system, _____ ATP(s) is/are synthesized. For each $NADH + H^+$ that supplies electrons to the electron transport system, _____ ATP(s) is/are synthesized.
Answer: 2 : 3
Diff: 4 Page Ref: 80

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25) How many ATP are produced for each acetyl coenzyme A completely catabolized in the presence of oxygen?
Answer: 12
Diff: 6 Page Ref: 78

26) Glucose is stored in the form of glycogen primarily within what two organs?
Answer: skeletal muscle and liver
Diff: 4 Page Ref: 87

27) Most of our fat is stored in adipocytes in the form of _____. This fat can be broken down by a process called _____ to _____ and _____.
Answer: triglycerides : lipolysis : glycerol : 3 fatty acids
Diff: 6 Page Ref: 88

28) Proteins are broken down to amino acids by _____.
Answer: proteolysis
Diff: 4 Page Ref: 89

29) In the liver, ammonia is converted to _____ for eventual elimination in the urine.
Answer: urea
Diff: 5 Page Ref: 89

30) The synthesis of glucose from non-carbohydrate precursors is called _____ and it occurs in the _____.
Answer: gluconeogenesis : liver
Diff: 6 Page Ref: 87

31) What is the storage form of carbohydrates in animal cells?
Answer: glycogen
Diff: 3 Page Ref: 87

32) The organ that stores glucose as glycogen and then provides glucose to the blood when needed is the _____.
Answer: liver
Diff: 4 Page Ref: 87

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