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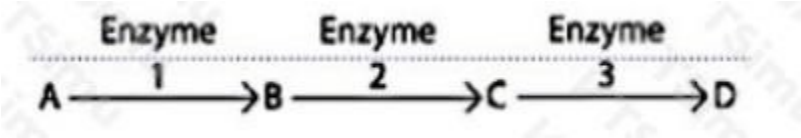
Topic Break Down

Topic	No. of Questions
Topic 1, Biology	110
Topic 2, Chemistry	79
Topic 3, Natural Sciences	119
Topic 4, Mathematics	93
Topic 5, Physics	93
Total	514

QUESTION NO: 1



Which of the following conditions could result in a decreased production of Substance C?

A. Addition of Substance B

B. Boiling Enzyme 1

C. Mixing Enzyme 1 with Enzyme 2

D. Addition of Enzyme 2

E. Removal of Substance D

ANSWER: B

Explanation:

Boiling Enzyme 1 could decrease production of Substance C because Enzyme 1 catalyzes the reaction that produces Substance C in the pathway shown. Enzymes function because their specific three-dimensional shapes create active sites that bind the appropriate reactant(s) and facilitate conversion to product. Exposure to the high temperatures of boiling commonly disrupts the noncovalent interactions—such as hydrogen bonds and ionic interactions—that maintain an enzyme's functional shape. This denaturation changes or destroys the active site, preventing Enzyme 1 from efficiently catalyzing its reaction. As a result, the conversion of the precursor substance into Substance C slows substantially or stops, so less Substance C is produced during the same period. This conclusion follows directly from the enzyme's position upstream of Substance C: impairing the catalyst required for that production step reduces pathway flux at that point. The OpenStax Biology 2e discussion of enzymes explains that changes in temperature can alter enzyme shape and activity, including irreversible denaturation at sufficiently high temperatures: OpenStax, Enzymes. A complementary overview from the National Library of Medicine describes how protein structure is essential to biological function: NCBI Bookshelf: Protein Structure.

QUESTION NO: 2

In response to attack by a pathogen or allergen, basophils and mast cells around the body release large amounts of which of the following substances, which is responsible for dilating walls of blood vessels and making capillaries leaky?

A. Interleukins

B. Antibodies

C. Lysozyme

D. Acetylcholine

E. Histamine

ANSWER: E

Explanation:

Histamine is correct. Mast cells in tissues and basophils in the blood store histamine in cytoplasmic granules and can rapidly release it when they are activated during allergic reactions or inflammatory responses to injury and pathogens. Histamine acts locally on nearby blood vessels, producing vasodilation and increasing vascular permeability. These changes increase local blood flow and allow fluid and immune-system components to move from the circulation into affected tissue. The resulting redness, warmth, and swelling are characteristic features of inflammation. In an allergic response, this same process can become extensive and contribute to symptoms such as hives, nasal congestion, wheezing, or potentially dangerous tissue swelling. Histamine's central role in allergy is also the basis for use of antihistamine medicines, which block

histamine receptors to reduce many allergy symptoms. The mechanism and clinical effects of histamine release are described by StatPearls: Histamine and the Merck Manual overview of allergic reactions.

QUESTION NO: 3

Which of the following do not require medium to propagate?

A. Sound waves

B. Seismic waves

C. Tides

D. Light waves

E. Waves on the surface of water

ANSWER: D

Explanation:

Light waves is correct because light is electromagnetic radiation and can travel through a vacuum; it does not depend on the vibration of matter to carry energy from one location to another. A light wave consists of coupled, changing electric and magnetic fields. These fields sustain one another as the wave moves, allowing electromagnetic radiation to propagate across empty space. This is why sunlight can reach Earth from the Sun even though most of the path between them is the near-vacuum of space. In a vacuum, light travels at approximately 3.00×10^8 meters per second, conventionally denoted by *c*. Light can also travel through materials such as air, water, or glass, although its speed and direction may change through interactions with the material. The key distinction is that such material is optional for light propagation, rather than necessary. The U.S. National Aeronautics and Space Administration describes light as electromagnetic radiation and notes that it can travel through space: NASA: The Electromagnetic Spectrum. A broader physics reference on electromagnetic waves and their propagation in vacuum is available from OpenStax Physics.

QUESTION NO: 4

Which of the following eukaryotic organelles is correctly linked to its function?

A. Golgi apparatus, packaging products for export out of the cell

B. ribosomes, RNA synthesis

C. lysosomes, protein synthesis

D. mitochondrion, site of photosynthesis

E. nucleus, mitotic spindle production

ANSWER: A

Explanation:

The correct organelle-function pairing is **Golgi apparatus, packaging products for export out of the cell**. The Golgi apparatus is a central component of the eukaryotic endomembrane system. It receives proteins and lipids, especially those transported from the endoplasmic reticulum in vesicles, and processes them as they move through its membrane-bound compartments. A major part of this processing is the modification of molecules, including the addition or alteration of carbohydrate groups on many proteins and lipids. These modifications can contribute to molecular recognition and help direct cargo to an appropriate destination.

After processing, the Golgi sorts cargo and packages it into transport vesicles. Some vesicles deliver material to locations within the cell, while secretory vesicles move to the plasma membrane and release their contents outside the cell by exocytosis. Thus, describing the Golgi as packaging products for export accurately captures one of its key biological roles,

particularly for substances that a cell secretes. This function is essential in cells that export enzymes, hormones, extracellular-matrix components, or signaling molecules. See NCBI Bookshelf: The Golgi Apparatus and OpenStax Biology 2e: Eukaryotic Cells.

QUESTION NO: 5

(i − 4)(2 + i) + (3i − 6) =

A. −15 + i

B. −14 + i

C. −12 + i

D. −21

E. −3

ANSWER: A

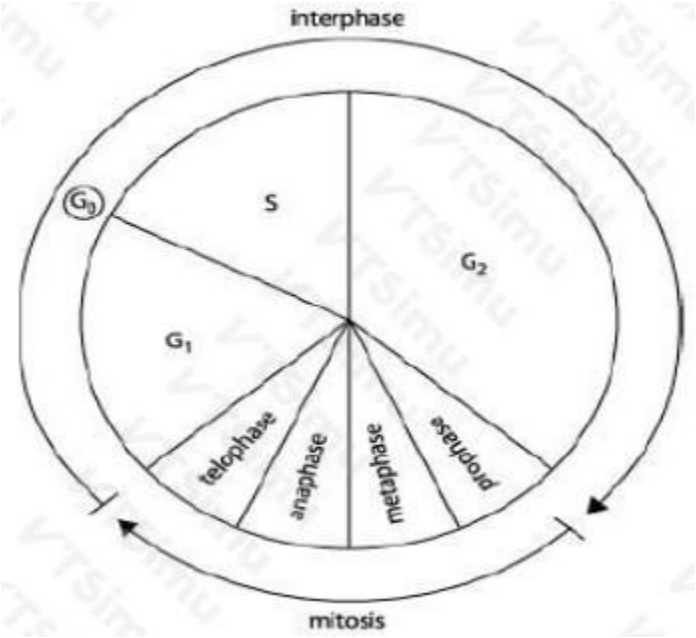
Explanation:

The correct result is **−15 + i**. To evaluate the expression, first distribute each term in *(i − 4)(2 + i)*: multiplying *i* by 2 gives 2i, multiplying *i* by *i* gives i², multiplying −4 by 2 gives −8, and multiplying −4 by *i* gives −4i. This produces 2i + i² − 8 − 4i. The defining property of the imaginary unit is i² = −1, so the product simplifies to −9 − 2i. Next, add the remaining complex number, 3i − 6. Combine real terms, −9 and −6, to obtain −15. Combine imaginary terms, −2i and 3i, to obtain i. Therefore, the expression is −15 + i. This calculation uses the standard rules for addition and multiplication of complex numbers: real and imaginary components are combined separately after replacing i² with −1. For further review of complex-number operations, see OpenStax College Algebra: Complex Numbers and Khan Academy: The complex number system.

QUESTION NO: 6

A diagram of the cell cycle of the eukaryotic species

C. elegans is shown below.



During "S" phase of the cell cycle,

C. elegans cells are

A. growing larger

B. dividing into two new cells

C. in a period of dormancy

D. copying DNA and organelles

E. synthesizing large amounts of ATP

ANSWER: D

Explanation:

copying DNA and organelles is correct because S phase is the synthesis phase of interphase, when a cell replicates its DNA before it divides. Each chromosome is copied to produce two identical sister chromatids. This duplication ensures that, when mitosis and cytokinesis occur later in the cell cycle, each resulting daughter cell can receive a complete, equivalent set of genetic information. The cell also continues preparing its internal contents for eventual division, including duplication of cellular components associated with successful cell reproduction. In the standard sequence of the eukaryotic cell cycle, S phase occurs after the initial growth stage and before the final preparation stage and mitotic phase. Thus, the essential event identifying S phase is genome replication rather than physical separation into daughter cells. The National Human Genome Research Institute describes DNA replication as the process by which DNA is copied before cell division: NHGRI: DNA Replication. A cell-cycle overview from OpenStax likewise identifies DNA replication as the defining event of S phase: OpenStax Biology 2e: The Cell Cycle.

QUESTION NO: 7

A flying disc initially at rest rotates with a constant acceleration. If after 5 s the flying disc has rotated by 200 radians, what is its angular acceleration?

A. 14 rad/s2

B. 15 rad/s2

C. 11 rad/s2

D. 12 rad/s2

E. 16 rad/s2

ANSWER: E

Explanation:

The correct answer is **16 rad/s2**. For rotational motion with constant angular acceleration, angular displacement is found from the kinematic relationship $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$, where θ is angular displacement, ω_0 is initial angular velocity, α is angular acceleration, and t is elapsed time. The phrase “initially at rest” establishes that the initial angular velocity is zero. Therefore, the first term drops out, leaving $200 \text{ rad} = \frac{1}{2}\alpha(5 \text{ s})^2$. Squaring the time gives 25 s^2, so $200 = 12.5\alpha$. Dividing 200 radians by 12.5 seconds squared yields $\alpha = 16 \text{ rad/s}^2$. Radians are dimensionless in SI analysis, but angular acceleration is conventionally reported in radians per second squared to show that the quantity describes the rate at which angular velocity changes. The result is consistent with a disc that begins from rest and accumulates 200 radians of angular displacement over five seconds under uniform rotational acceleration. This is the direct rotational analogue of the constant-acceleration linear-motion equation. See OpenStax Physics: Rotation with Constant Angular Acceleration and LibreTexts: Rotational Kinematics.

QUESTION NO: 8

CH3 – O – CH3

The organic molecule represented above is an example of a(n)

A. ester.

B. carboxylic acid.

C. ether.

D. alcohol.

E. amine.

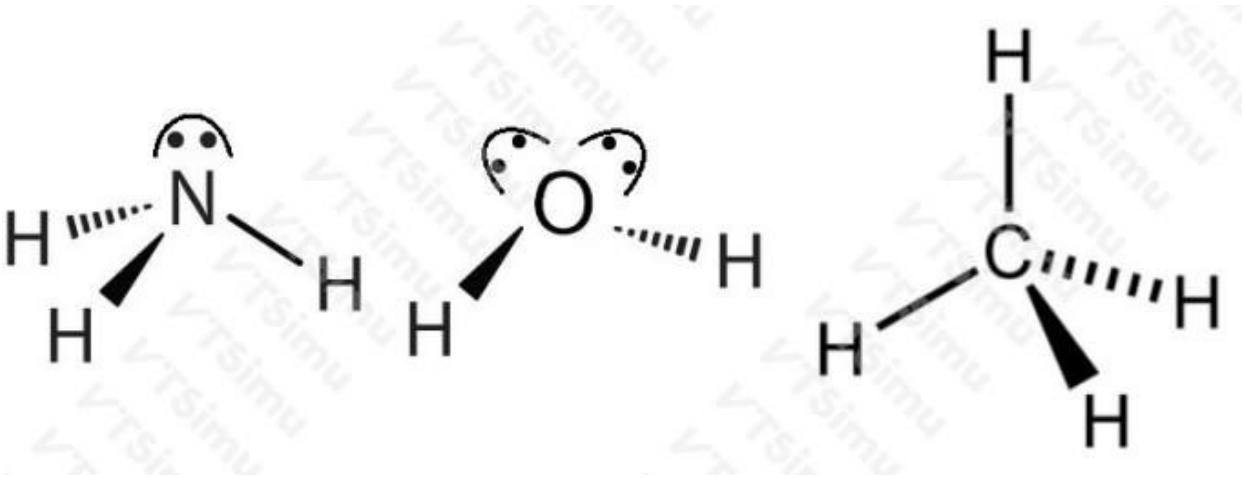
ANSWER: C

Explanation:

The correct answer is **ether.** The structure $CH_3–O–CH_3$ is dimethyl ether. Its defining structural feature is an oxygen atom single-bonded to two carbon-containing groups: in this case, two methyl (CH_3) groups. The general form of an ether is R–O–R′, where R and R′ are hydrocarbon groups that may be the same or different. Because both groups here are methyl groups, dimethyl ether is the simplest ether.

Functional-group classification depends on the arrangement of atoms in the molecule, rather than simply on the presence of oxygen. Here, the oxygen is located between two carbon atoms and is bonded to each through a single covalent bond. This carbon–oxygen–carbon linkage is the characteristic ether functional group. Dimethyl ether has molecular formula C_2H_6O and is a structural isomer of ethanol, illustrating that compounds can share a molecular formula while differing in connectivity and functional group. For an overview of ether structures and naming, see Chemistry LibreTexts: Structure and Nomenclature of Ethers. The IUPAC entry for dimethyl ether is available from PubChem.

QUESTION NO: 9



For the molecules above, the resultant dipole moments are oriented (from left to right):

A. ↑, ○, ↓

B. ↑, →, ↓

C. ↓, ↓, ○

D. ↑, ↑, ○

E. ↑, ○, ↑

ANSWER: D

Explanation:

The correct sequence is ↑, ↑, ○. A molecular dipole moment is the vector sum of all individual bond dipoles. Each bond dipole points toward the more electronegative end of that bond, and the final molecular dipole depends on both bond polarity

and molecular geometry. For the first molecular structure shown, the horizontal components cancel while the remaining vertical component is directed upward. Applying the same vector-addition approach to the second structure also produces a net upward resultant. In the third structure, the individual bond-dipole vectors cancel completely because of the molecule's symmetry, so its resultant dipole moment is zero, represented by the circle symbol. This is why dipole-moment questions must be evaluated from the complete three-dimensional arrangement rather than from electronegativity values alone. The OpenStax discussion of molecular polarity explains that symmetric arrangements can cancel bond dipoles, whereas asymmetric arrangements may have a nonzero net dipole: OpenStax Chemistry 2e: Molecular Structure and Polarity. A concise reference on dipole moments and their vector nature is also available from IUPAC Gold Book: dipole moment.

QUESTION NO: 10

A train at rest starts from station A and travels to station B at a distance of 2 km in 4 minutes.

Consider the following statements:

1. Instantaneous speed of the train is 8.33 m/s

2. Average speed of the train is 8.33 m/s

3. Instantaneous acceleration of the train is 8.33 m/s2

Which of the following statement(s) is/are true?

A. 1

B. 2

C. 3

D. Both 1 and 3

E. Both 2 and 3

ANSWER: B

Explanation:

The correct statement is **2**, because average speed is defined as the total distance traveled divided by the total elapsed time. The train travels 2 km, which is 2,000 m, in 4 minutes, which is 240 s. Therefore, its average speed is calculated as 2,000 m ÷ 240 s = 8.333... m/s, which rounds to 8.33 m/s. This value describes the train's rate of travel over the complete journey from station A to station B, regardless of how its speed may have varied during that time. The fact that the train begins at rest does not alter the average-speed calculation; the required quantities are the full distance traveled and the full travel time. In standard introductory mechanics, average speed is a scalar quantity obtained from total distance divided by total time. This relationship and the distinction between average and instantaneous quantities are described in OpenStax Physics: Speed and Velocity. The unit m/s is appropriate because the distance was converted to meters and the time to seconds. For additional treatment of average speed and its calculation, see The Physics Classroom: Speed and Velocity.

QUESTION NO: 11

$H_2S(aq) + MnO_4^-(aq) \rightarrow S(s) + MnO_2(s) + H_2O(l) + OH^-(aq)$. Balancing this equation yields the following coefficients from left to right:

A. 2, 1, 2, 1, 1, 1

B. 1, 3, 1, 2, 2, 1

C. 2, 3, 2, 3, 1, 2

D. 3, 2, 2, 3, 2, 3

E. 3, 2, 3, 2, 2, 2

ANSWER: E

Explanation:

The correct coefficients are **3, 2, 3, 2, 2, 2**, giving the balanced basic-solution equation: $3H_2S(aq) + 2MnO_4^-(aq) \rightarrow 3S(s) + 2MnO_2(s) + 2H_2O(l) + 2OH^-(aq)$. This result follows from balancing the oxidation and reduction half-reactions in basic solution. Sulfur in H_2S has an oxidation state of −2 and becomes elemental sulfur, oxidation state 0, so each sulfur atom loses two electrons. Manganese in permanganate is +7 and becomes +4 in MnO_2, so each manganese atom gains three electrons. The least common multiple of two and three is six, requiring three H_2S units and two MnO_4^- units. Completing the hydrogen and oxygen balance in basic medium produces two water molecules and two hydroxide ions. The equation conserves sulfur, manganese, hydrogen, oxygen, and total charge: both sides have an overall charge of −2. The half-reaction approach for balancing redox equations in acidic or basic solution is described by Chemistry LibreTexts and OpenStax Chemistry 2e.

QUESTION NO: 12

Chloroplasts and mitochondria have the following property in common.

A. Both are involved in protein synthesis.

B. Both are involved in energy generation in the cell.

C. Both are involved in regulating ion concentration in the cell.

D. Both are involved in the transcription of DNA into RNA.

E. Their functions are not related.

ANSWER: B

Explanation:

Both are involved in energy generation in the cell. Chloroplasts capture light energy through photosynthesis. Their light-dependent reactions use electron transport processes across thylakoid membranes to produce ATP and NADPH, which support the synthesis of energy-rich carbohydrates. Thus, chloroplasts convert solar energy into chemical energy that can be stored in sugars.

Mitochondria extract usable energy from organic molecules during cellular respiration. Electron transport across the inner mitochondrial membrane establishes a proton gradient, and ATP synthase uses that gradient to make ATP. ATP is the immediately usable energy currency for most cellular work. Although chloroplasts and mitochondria operate with different energy inputs and occur in different types of organisms and cells, both are membrane-bound organelles specialized for energy conversion through electron-transfer pathways and chemiosmosis.

This shared role in converting energy into biologically useful chemical forms is a central reason both organelles are studied together in cell biology. For further background, see OpenStax Biology 2e: Overview of Photosynthesis and OpenStax Biology 2e: Oxidative Phosphorylation.

QUESTION NO: 13

Which quadrants of the xy-plane contain points of the graph of $5x + y < 6$?

A. II and IV only

B. I, II, and IV only

C. II, III, and IV only

D. I, II, and III only

E. I, II, III, and IV

ANSWER: E

Explanation:

I, II, III, and IV is correct because the inequality describes the open half-plane below the boundary line $y = 6 - 5x$. This boundary has a y-intercept of 6 and a slope of −5, but the solution is not limited to points on that line: it includes every point whose y-coordinate is less than $6 - 5x$. There are valid solution points in every quadrant. For example, (1, 0) satisfies the inequality and lies in Quadrant I; (−1, 1) satisfies it and lies in Quadrant II; (−1, −1) satisfies it and lies in Quadrant III; and (1, −1) satisfies it and lies in Quadrant IV. Because each of these points makes $5x + y$ less than 6, the graph contains points in all four quadrants. Since the inequality is strict, the boundary line itself is not included, although that does not affect which quadrants contain solution points. For a review of graphing linear inequalities as regions bounded by a line, see OpenStax Elementary Algebra: Graph Linear Inequalities and Khan Academy: Graphing linear inequalities.

QUESTION NO: 14

During the winter, salt is spread on icy roads to

A. lower the boiling point of water

B. lower the melting point of ice

C. increase the frictional forces between car tires and the road

D. change the viscosity of water

E. help remove water from the road

ANSWER: B

Explanation:

Salt is spread on icy roads to **lower the melting point of ice**, a phenomenon called freezing-point depression. When salt dissolves in the thin liquid-water layer that naturally exists on the surface of ice, it forms a saltwater solution. This solution freezes at a lower temperature than pure water, so at temperatures near the normal freezing point, ice can melt and remain liquid rather than refreezing immediately. The resulting brine helps break up the ice and makes it easier for traffic and road-maintenance equipment to clear the roadway. This use of salt is a practical application of a colligative property: the change in freezing point depends primarily on the number of dissolved particles in the water. Sodium chloride is commonly used, although its effectiveness is limited at sufficiently low temperatures, where other de-icing materials may be used. The U.S. Geological Survey describes road salt as lowering water's freezing point, and Chemistry LibreTexts explains freezing-point depression for solutions: USGS: Road Salt and Salinity; Chemistry LibreTexts: Colligative Properties.

QUESTION NO: 15

3x (4x2 + 2) − (8 − 2x3 + 10x) − 4 =

A. 10x3 − 4x − 4

B. 14x3 + 4x + 4

C. 14x3 − 4x + 12

D. 14x3 − 4x − 12

E. 14x3 + 16x − 12

ANSWER: D

Explanation:

The expression simplifies to **14x3 − 4x − 12**. First distribute *3x* across the terms in the first parentheses: multiplying 3x by 4x3 gives 12x3, and multiplying 3x by 2 gives 6x. Next, subtracting the entire second parenthetical expression changes each of its signs, producing −8 + 2x3 − 10x. The remaining constant term is −4. Combining like terms gives 12x3 + 2x3 = 14x3, 6x − 10x = −4x, and −8 − 4 = −12. Therefore, the simplified polynomial is 14x3 − 4x − 12. This follows the distributive property and the standard rule that a minus sign before parentheses applies to every term within those parentheses. For a review of polynomial operations and combining like terms, see OpenStax Elementary Algebra: Add and Subtract Polynomials and Khan Academy: Adding and subtracting polynomials.

QUESTION NO: 16

A car speeds up from 15 m/s to 27 m/s in 45 s. What would be the acceleration of the car?

A. 0.15 m/s2

B. 0.32 m/s2

C. 0.38 m/s2

D. 0.27 m/s2

E. 0.4 m/s2

ANSWER: D

Explanation:

The correct answer is **0.27 m/s^2**. For motion with constant acceleration, acceleration is defined as the change in velocity divided by the elapsed time: *a* = (final velocity − initial velocity) / time. The car's velocity changes from 15 m/s to 27 m/s, so its change in velocity is 12 m/s. Dividing this change by the 45-second interval gives 12/45 = 0.2666... m/s^2, which rounds to 0.27 m/s^2. Equivalently, substituting the known values into the constant-acceleration relation $v = u + at$ gives 27 = 15 + 45*a*; solving yields *a* = 12/45 m/s^2. The positive value indicates that the velocity increases in the selected positive direction. Acceleration is expressed in meters per second squared because velocity, measured in meters per second, changes during each second. This use of the velocity-change-over-time definition is consistent with standard introductory physics kinematics. See OpenStax: Motion Equations for Constant Acceleration and NIST: SI Units for Speed and Acceleration.

QUESTION NO: 17

Has the highest boiling point.

A. H2O

B. H2S

C. H2Se

D. H2Te

E. HCl

ANSWER: A

Explanation:

H2O has the highest boiling point because its molecules form an extensive network of hydrogen bonds. Oxygen is highly electronegative, so each O–H bond is strongly polar: hydrogen bears a substantial partial positive charge, while oxygen has lone pairs that can attract hydrogen atoms on neighboring water molecules. Each water molecule can both donate hydrogen bonds through its two hydrogen atoms and accept hydrogen bonds through its oxygen lone pairs. This produces unusually strong intermolecular attraction throughout liquid water.

Boiling occurs when molecules gain enough energy to overcome the intermolecular forces holding the liquid together and enter the gas phase. Because water's hydrogen-bonded network requires comparatively large amounts of energy to disrupt, water has an exceptionally high normal boiling point for a molecule of its small molar mass. The boiling point of water at standard pressure is 100 °C (373.15 K). This behavior is a classic example of how intermolecular forces, particularly hydrogen bonding, can dominate boiling-point trends. See the NIST Chemistry WebBook entry for water and Chemistry LibreTexts' discussion of hydrogen bonding.

QUESTION NO: 19

How many electronic charges comprise a coulomb of charge?

A. 6 × 1018

B. 1018

C. 2 × 1018

D. 2 × 1019

E. 5 × 1015

ANSWER: A

Explanation:

The correct value is **6 × 1018**, interpreted as approximately 6×10^{18} elementary electronic charges. The magnitude of the charge of one electron, called the elementary charge, is exactly $1.602176634 \times 10^{-19}$ coulomb. The number of such charges corresponding to a total charge magnitude of 1 coulomb is found by dividing: 1 C ÷ ($1.602176634 \times 10^{-19}$ C per electronic charge) = $6.241509074 \times 10^{18}$. Rounded to one significant figure, this is 6×10^{18} electronic charges. This calculation uses charge magnitude: an electron itself has negative charge, so 1 coulomb of negative charge represents an excess of about 6.24×10^{18} electrons, while 1 coulomb of positive charge represents a deficit of that many electrons. The elementary-charge value is defined in the SI system and is listed by the NIST CODATA constants database. For the relationship between charge and the number of elementary charges, see OpenStax College Physics.

QUESTION NO: 20

r	*p(r)*
–4	–958
–2	98
0	50
2	–46
4	–286
6	1,922
8	15,698

The table above gives some of the values of a fifth degree polynomial p(r). Based on the values shown, what is the minimum number of real roots of the equation p(r) = 0?

A. Five

B. Four

C. Three

D. Two

E. One

ANSWER: C

Explanation:

Three is correct. A polynomial is continuous for every real input, so its graph cannot jump from a positive value to a negative value without passing through zero somewhere between the corresponding input values. The values in the table show three separate intervals in which the sign of *p(r)* changes. By the Intermediate Value Theorem, each such interval must contain at least one real number *r* for which *p(r) = 0*. Because these are distinct intervals, they guarantee at least three distinct real roots.

The question asks for the minimum number that must exist based on the displayed data, not the total number the polynomial could possibly have. A fifth-degree polynomial may have additional real roots outside the shown intervals, or it may have roots that are not revealed by a sign change in the listed values. Nevertheless, the three sign changes provide conclusive evidence of three real zeros. For a review of continuity of polynomial functions, see OpenStax Precalculus. The sign-change conclusion follows directly from the Intermediate Value Theorem.

QUESTION NO: 21

A common rule when preparing acidic solutions is to always add acid to water. Which of the following is not a reason for this rule?

A. Mixing strong acids with water produces a large amount of heat.

B. Mixing strong acids with water causes rapid cooling.

C. Adding water to acid could result in splashing concentrated acid.

D. Adding acid to water initially produces a very dilute solution.

E. There is no reason to add acid to water instead of adding water to acid.

ANSWER: B

Explanation:

“Mixing strong acids with water causes rapid cooling.” is the statement that is not a reason for the safety rule. Dilution of a strong acid in water is generally an exothermic process: hydration and ionization of the acid release heat rather than producing rapid cooling. The safety concern is controlling where that heat is generated. When acid is introduced gradually into a comparatively large volume of water with stirring, the water can absorb and distribute the released heat more effectively. This controlled dilution reduces the chance that a small, highly concentrated region becomes hot enough to boil suddenly or eject corrosive liquid. The phrase “add acid to water” is therefore a practical laboratory reminder based on heat management during dilution. It should be followed using appropriate personal protective equipment and with slow addition and stirring, particularly for concentrated strong acids. The Canadian Centre for Occupational Health and Safety specifically advises adding acid slowly to water, never water to acid, because dilution can generate considerable heat. See CCOHS: Acids—Working Safely and PubChem: Sulfuric Acid.

QUESTION NO: 23

Which of the following materials is formed by the solidification of magma?

A. Minerals

B. Igneous rock

C. Sedimentary rock

D. Metamorphic rock

E. Diamond

ANSWER: B

Explanation:

Igneous rock is formed through the cooling, crystallization, and solidification of molten rock. When molten material remains below Earth's surface, it is called magma. As magma loses heat, its atoms and ions arrange into interlocking mineral crystals, producing an igneous rock. The cooling environment affects the rock's texture: magma that cools slowly underground commonly produces larger crystals, while molten material that reaches the surface as lava cools more rapidly and generally forms finer-grained igneous rock. Granite is a familiar example formed from slowly cooled magma beneath the surface, whereas basalt commonly forms from rapidly cooled lava at or near the surface. Thus, the defining rock category associated with solidified magma is igneous rock. This process is a central part of the rock cycle, in which melted Earth material can become new rock after cooling. The U.S. Geological Survey describes igneous rocks as rocks formed when molten rock cools and solidifies; see its overview of igneous rocks. Additional background on the rock cycle is available from the National Geographic rock-cycle resource.

QUESTION NO: 24

The most probable oxidation number for the clement with atomic number 20 is

A. −2

B. −6

C. +2

D. +4

E. +10

ANSWER: C

Explanation:

Atomic number 20 identifies calcium, an alkaline-earth metal in Group 2 of the periodic table. A neutral calcium atom has the electron configuration [Ar]$4s^2$, meaning it has two electrons in its outermost energy level. Calcium most commonly loses those two valence electrons when it forms compounds, producing the Ca^{2+} ion. Therefore, its usual oxidation number is +2. This electron loss leaves calcium with the stable noble-gas electron configuration of argon, which is energetically favorable. Oxidation numbers describe the apparent charge an atom would have in a compound if bonding electrons were assigned according to standard conventions; for calcium in its typical ionic compounds, that value is consistently +2. For example, calcium chloride contains Ca^{2+} and chloride ions, and calcium oxide contains Ca^{2+} and oxide ions. The periodic-table placement of calcium provides a reliable basis for predicting this common oxidation state. The Royal Society of Chemistry lists calcium's common oxidation state as +2: Royal Society of Chemistry: Calcium. The electron configuration and elemental data are also provided by NIST: Calcium.

QUESTION NO: 25

Determine ΔH (in kJ) for the reaction H2O + Cl2 → 1/2O2 + 2HCl, given the following information.

(i) H2O → H2 + 1/2O2 ΔH = +286 kJ

(ii) H2 + Cl2 → 2HCl ΔH = −185 kJ

A. +84 kJ

B. +101 kJ

C. +391 kJ

D. −391 kJ

E. −101 kJ

ANSWER: B

Explanation:

+101 kJ is correct by Hess's law, which states that the enthalpy change for an overall reaction equals the sum of the enthalpy changes for a set of reactions that add to the same overall equation. Begin with $H_2O \rightarrow H_2 + \frac{1}{2}O_2$, for which $\Delta H = +286$ kJ. Then add $H_2 + Cl_2 \rightarrow 2HCl$, for which $\Delta H = -185$ kJ. The H_2 produced in the first reaction is consumed in the second, so it cancels when the equations are added. The remaining species yield $H_2O + Cl_2 \rightarrow \frac{1}{2}O_2 + 2HCl$, exactly matching the target reaction. Therefore, add the associated enthalpy changes: +286 kJ + (−185 kJ) = +101 kJ. The positive result means that, as written, the reaction absorbs 101 kJ of heat from its surroundings; it is endothermic. This use of enthalpy as a state function is the central principle behind thermochemical equation manipulation and Hess's law. See Chemistry LibreTexts: Hess's Law and IUPAC Gold Book: Hess law.

QUESTION NO: 26

Given the following reversible reaction, 2NiS(s) + 3O2(g) ↔ 2NiO(s) + 2SO2(g) how does one express the equilibrium constant, K?

A. $\left(\frac{2[SO_2]}{3[O_2]}\right)$

B. $\left(\frac{2[NiO] \times 2[SO_2]}{2[NiS] \times 3[O_2]}\right)$

C. $\left(\frac{[NiO]^2 \times 2[SO_2]^2}{[NiS]^2 \times [O_2]^2}\right)$

D. $\left(\frac{[NiS]^2 \times [O_2]^2}{[NiO]^2 \times [SO_2]^2}\right)$

E. $\left(\frac{[SO_2]^2}{[O_2]^2}\right)$

A. Option A

B. Option B

C. Option C

D. Option D

E. Option E

ANSWER: E

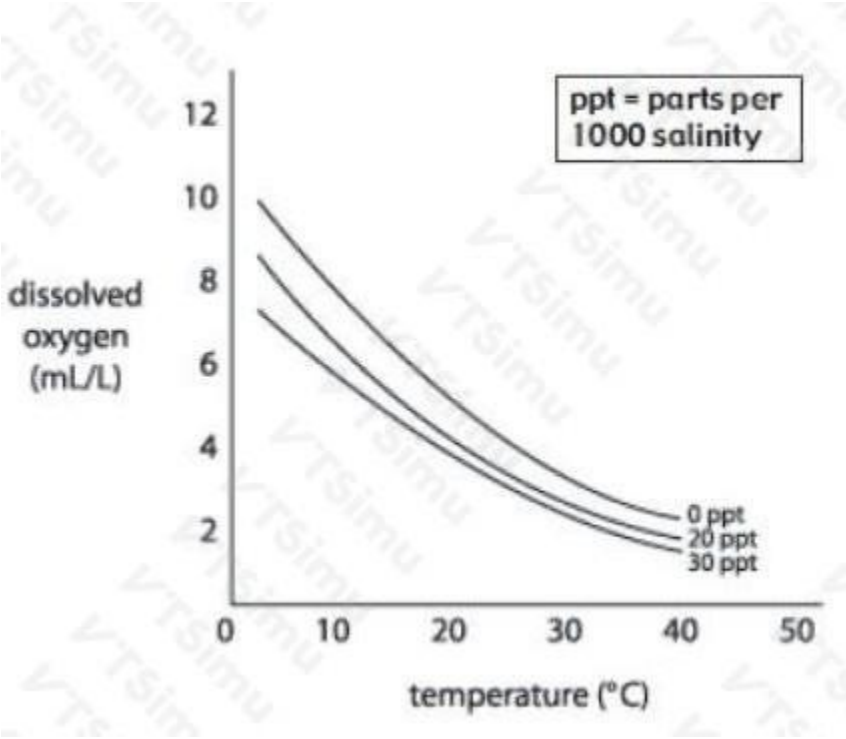
Explanation:

The equilibrium-constant expression is $K = [SO_2]^2/[O_2]^3$. An equilibrium constant is written as the activity of each product divided by the activity of each reactant, with every activity raised to the power of its balanced-equation coefficient. For this reaction, sulfur dioxide is the gaseous product and has coefficient 2, so its activity appears in the numerator squared. Oxygen is the gaseous reactant and has coefficient 3, so its activity appears in the denominator cubed. Nickel sulfide and

nickel oxide are pure solids. The activity of a pure solid is defined as 1 under the usual standard-state convention; therefore, neither solid is included in the equilibrium expression. In many introductory chemistry problems, gas activities are represented by concentration brackets, as shown here. If the constant is specifically expressed in terms of partial pressures, the equivalent form is $K_p = (P_{SO_2})^2/(P_{O_2})^3$. This treatment follows the standard thermodynamic definition of equilibrium constants and the convention that pure solids have unit activity. See the IUPAC Gold Book definition of equilibrium constant and OpenStax Chemistry 2e on equilibrium-constant expressions.

QUESTION NO: 27

In an aquatic environment, oxygen concentration depends on chemical and physical factors and is greatly affected by many biological processes. These is much less dissolved oxygen (DO) in aquatic environments than in dry air. In most aquatic environments, there are only 5 to 10 mL of dissolved oxygen in a liter of water. Chemical and physical factors, such as salinity, pH, and especially temperature, can affect the DO concentration and distribution. An experiment was done to study the effect of different salinity levels on DO in water of varying temperatures. The results are below. Salinity is expressed in parts per thousand (ppt) and is the content of dissolved salt in water.



The oxygen that is dissolved in the water is used by aquatic organisms for

A. photosynthesis

B. cellular respiration

C. digestion

D. dehydration synthesis

E. chemosynthesis

ANSWER: B

Explanation:

cellular respiration is correct because aquatic organisms use dissolved oxygen to obtain energy from food molecules. In aerobic cellular respiration, oxygen serves as the terminal electron acceptor in the electron-transport chain, a series of reactions associated with the inner mitochondrial membrane in eukaryotic cells. Electrons ultimately combine with oxygen and hydrogen ions to form water. This permits continued electron flow and supports the production of most of the cell's ATP through oxidative phosphorylation.

ATP is the immediately usable energy currency that powers essential cellular activities, including movement, active transport across membranes, synthesis of cellular materials, growth, and maintenance of internal conditions. Because oxygen availability can limit the rate of aerobic respiration, dissolved-oxygen concentration is an important ecological factor for fish, invertebrates, aerobic microbes, and other aquatic life. When dissolved oxygen is low, organisms that depend heavily on aerobic respiration may experience physiological stress or must rely more on less-efficient anaerobic pathways. The central role of oxygen as the final electron acceptor in aerobic respiration is described by OpenStax Biology 2e: Oxidative Phosphorylation and summarized by NCBI Bookshelf: Oxidative Phosphorylation.

QUESTION NO: 28

Female peacocks are drawn to male peacocks by the relative attractiveness and size of their tail and tail feathers.

A. Artificial selection

B. Natural selection

C. Sexual selection

D. Habitat selection

E. Mass extinction

ANSWER: C

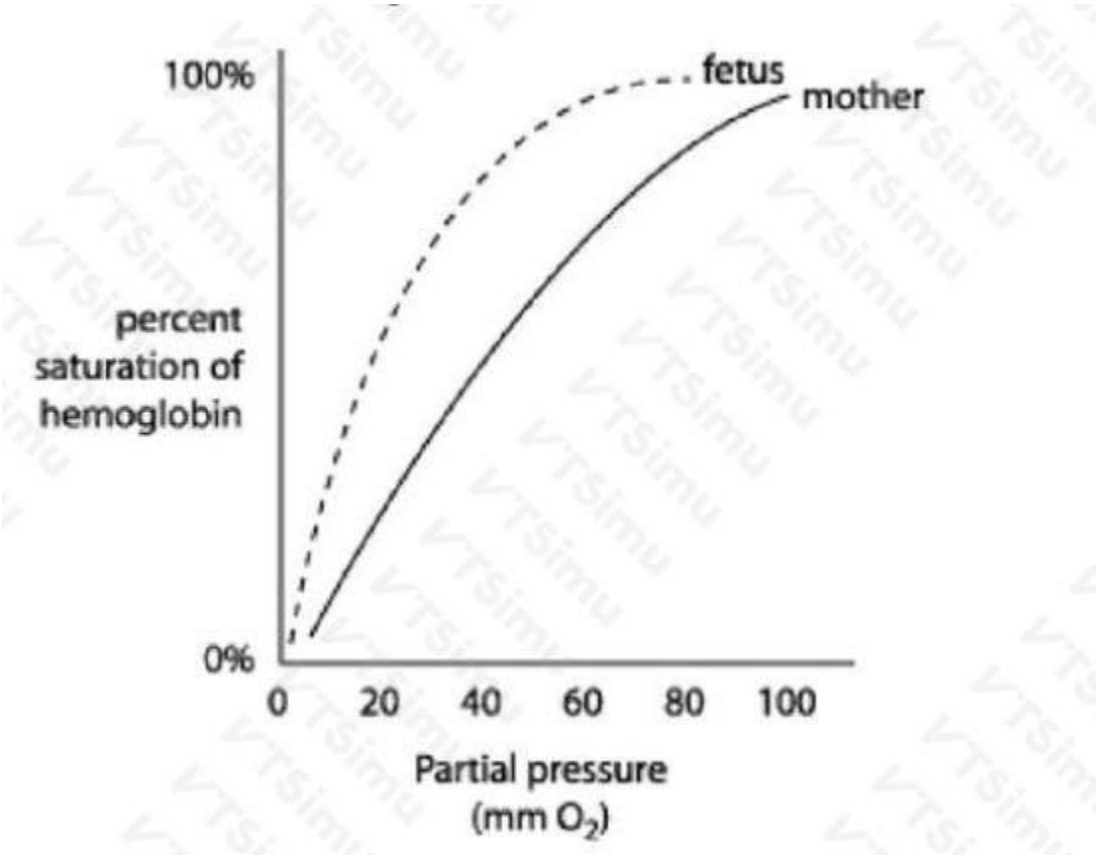
Explanation:

Sexual selection is correct because the stated preference involves mate choice based on an inherited display trait: the size and visual attractiveness of a male's tail feathers. Sexual selection is a form of evolutionary selection that occurs when differences in mating success cause certain heritable traits to become more common over generations. In peafowl, males with especially elaborate trains may obtain more mating opportunities if females preferentially choose them. Consequently, genes associated with traits that contribute to that display can be passed to more offspring, even when producing or carrying an extravagant display has energetic costs.

Charles Darwin specifically used peafowl ornamentation as a classic illustration of selection through mate preference. The process described is often called intersexual selection: members of one sex choose mates in the other sex according to particular characteristics. The key evidence in the question is not simply that an organism survives in an environment, but that reproductive success is influenced by attractiveness to potential mates. For background on Darwin's account of sexual selection, see the Darwin Correspondence Project. A concise overview of sexual selection and mate choice is also available from Understanding Evolution at UC Berkeley.

QUESTION NO: 29

The oxygen dissociation curve of human fetal hemoglobin differs significantly from that of the mother, as shown below. What characteristic of fetal hemoglobin might account for the fact that fetal hemoglobin is able to pick up oxygen from the mother's blood at a significant distance from the mother's lungs?



A. The hemoglobin of the fetus cannot bind oxygen as strongly as the hemoglobin of the mother.

B. Fetal hemoglobin binds oxygen at lower partial pressures and becomes fully saturated at lower partial pressures.

C. Fetal hemoglobin has iron unlike maternal hemoglobin.

D. Fetal hemoglobin needs higher partial pressures of oxygen than maternal hemoglobin in order to become fully saturated with oxygen.

E. There is more hemoglobin packed into the red blood cells of fetuses than into the red blood cells of adults.

ANSWER: B

Explanation:

Fetal hemoglobin binds oxygen at lower partial pressures and becomes fully saturated at lower partial pressures. This reflects fetal hemoglobin's higher oxygen affinity compared with adult maternal hemoglobin. On an oxygen–hemoglobin dissociation graph, higher affinity appears as a leftward-shifted curve: at the same partial pressure of oxygen, fetal hemoglobin has a greater percentage saturation. This permits oxygen transfer across the placenta even though maternal blood there has a lower oxygen partial pressure than blood freshly oxygenated in the lungs.

The molecular basis is that fetal hemoglobin (HbF, $\alpha_2\gamma_2$) interacts less strongly with 2,3-bisphosphoglycerate than adult hemoglobin (HbA, $\alpha_2\beta_2$). Because 2,3-bisphosphoglycerate normally stabilizes the lower-affinity form of hemoglobin, reduced binding by HbF favors the oxygen-bound form. The resulting affinity difference establishes a physiologically useful gradient: maternal hemoglobin can release oxygen in placental capillaries while fetal hemoglobin can load that oxygen efficiently. This adaptation supports fetal oxygenation without direct fetal exposure to air. See the NCBI Bookshelf discussion of fetal hemoglobin and NCBI Bookshelf's overview of oxygen transport.

QUESTION NO: 30

If the momentum of a photon is 2.5 × 10−25 kg m/s, what is the frequency of the photon? (Planck's constant = 6.6 × 10−34 Js)

A. 0.88 × 1017 Hz

B. 1.14 × 1017 Hz

C. 2.76 × 1017 Hz

D. 3.5 × 1017 Hz

E. 0.88 × 1015 Hz

ANSWER: B

Explanation:

The correct frequency is **1.14×10^{17} Hz**. A photon has zero rest mass, but it carries momentum and energy. Its energy is related to its momentum by $E = pc$, where p is momentum and c is the speed of light. Photon energy is also given by Planck's relation, $E = hf$, where h is Planck's constant and f is frequency. Equating these energy expressions gives $hf = pc$, so the frequency is $f = pc/h$.

Substituting the stated values gives $f = (2.5 \times 10^{-25}\ kg\ m/s)(3.0 \times 10^{8}\ m/s) / (6.6 \times 10^{-34}\ J\ s)$. This evaluates to approximately $1.136 \times 10^{17}\ s^{-1}$, which rounds to **$1.14 \times 10^{17}$ Hz**. The unit hertz is equivalent to inverse seconds, as required for frequency. This result follows directly from the standard photon energy–momentum relationship and Planck's quantum relation. See the NIST Planck constant reference and OpenStax discussion of photon momentum.

QUESTION NO: 31

If log2(x − 6) = 5, then what is the value of x?

A. 25

B. 31

C. 38

D. 41

E. 59

ANSWER: C

Explanation:

The correct value is **38**. Interpreting "log2" as a logarithm with base 2, the equation states that the exponent to which 2 must be raised to obtain $x - 6$ is 5. By the defining inverse relationship between logarithms and exponents, this is equivalent to $x - 6 = 2^5$. Since $2^5 = 32$, add 6 to both sides to isolate x: $x = 32 + 6 = 38$. This result also meets the logarithm's domain requirement, because its argument is positive: $38 - 6 = 32 > 0$. Logarithmic equations are commonly solved this way: first rewrite the logarithm in equivalent exponential form, then use ordinary algebra to solve for the variable. For a discussion of logarithms as inverse functions of exponentials, see OpenStax College Algebra: Exponential Functions and OpenStax College Algebra: Logarithmic Functions.

QUESTION NO: 32

A rotor with uniform angular speed of 210 rad/s needs a torque of 250 Nm from an engine. What would be the power of the engine required for the torque?

A. 54500 W

B. 52500 W

C. 34600 W

D. 1.19 W

E. None of the above choices

ANSWER: B

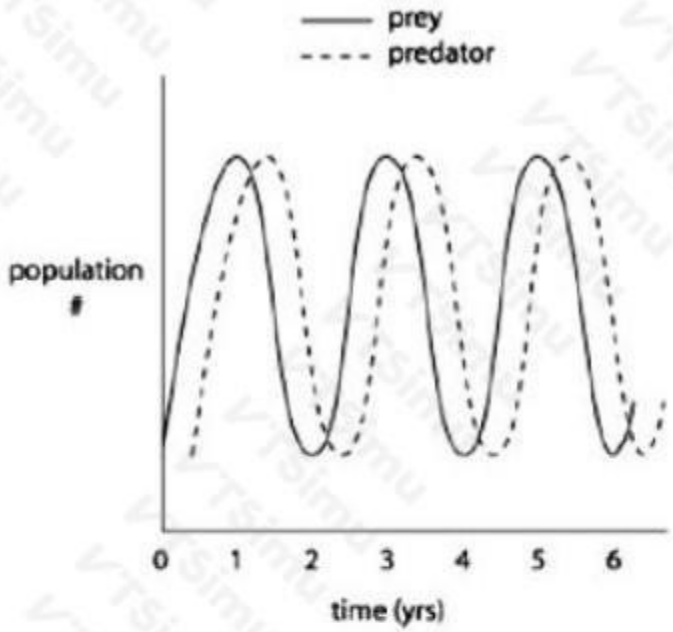
Explanation:

The required power is **52500 W**. For rotational motion at a constant angular speed, mechanical power equals torque multiplied by angular speed: $P = \tau\omega$. Here, the engine supplies a torque of 250 N·m and the rotor's angular speed is 210 rad/s. Substitution gives P = (250 N·m)(210 rad/s) = 52,500 N·m/s. Since one watt is one joule per second and a joule is equivalent to a newton-metre, this is 52,500 W, or 52.5 kW. The use of radians is appropriate because the radian is dimensionless in SI unit analysis, allowing torque times angular velocity to yield power directly. Uniform angular speed means there is no angular acceleration, but the engine may still need to provide this torque to overcome a specified load or resistive torque. This torque-power relationship is the rotational counterpart of the linear-motion formula P = Fv. See the OpenStax discussion of power in rotational motion at OpenStax University Physics and the SI definition of the watt from the National Institute of Standards and Technology.

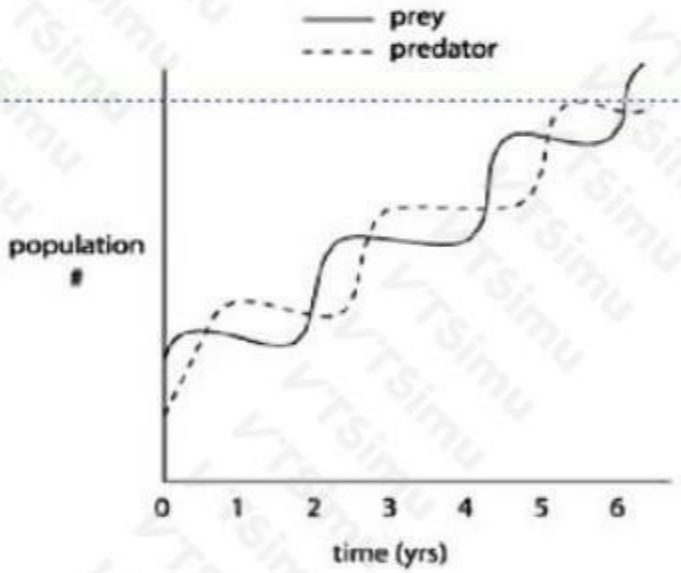
QUESTION NO: 33

Which graph shows the likely relationship between a predator species and its prey over a six year cycle?

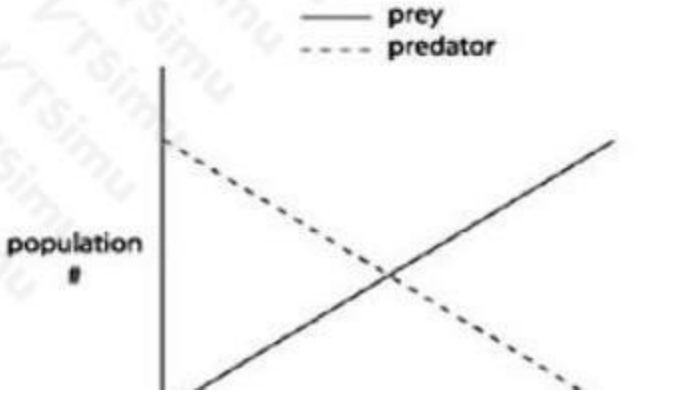
(A)

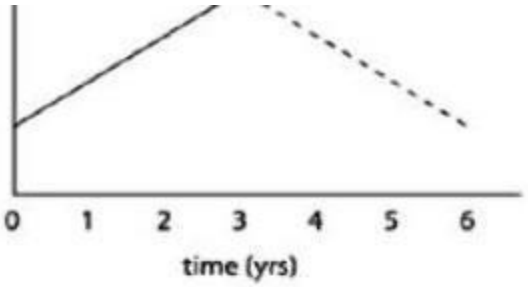

prey
predator
population
#
0 1 2 3 4 5 6
time (yrs)

(B)

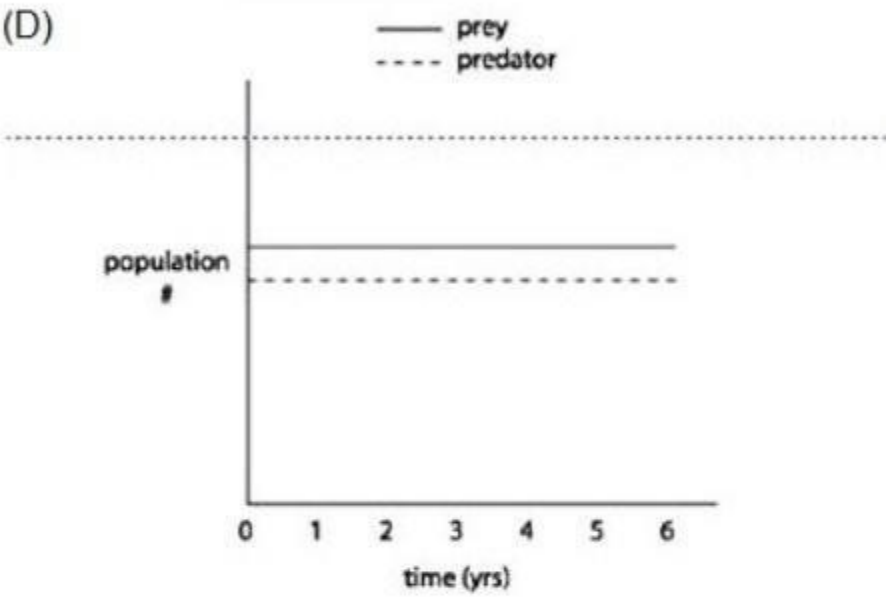

prey
predator
population
#
0 1 2 3 4 5 6
time (yrs)

(C)

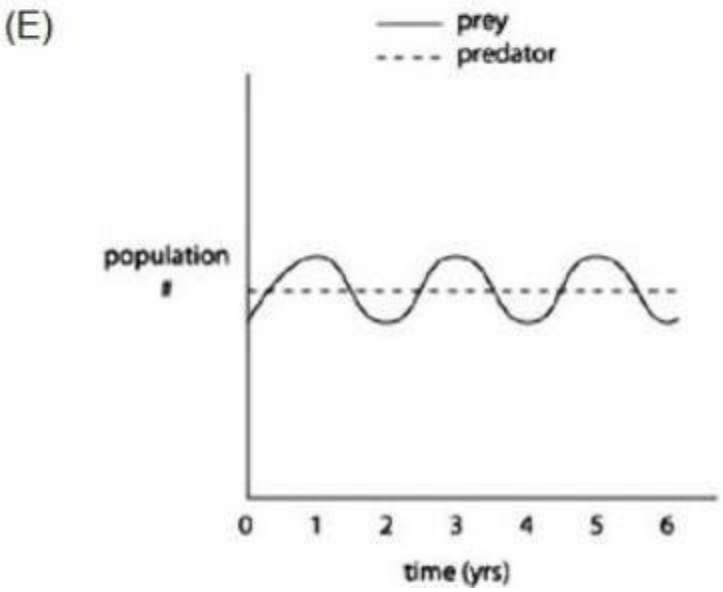

prey
predator
population
#



(D)



(E)



A. Option A

B. Option B

C. Option C

D. Option D

E. Option E

ANSWER: A

Explanation:

The selected graph is correct because predator and prey populations commonly undergo linked, repeating fluctuations in which changes in the predator population lag behind changes in the prey population. When prey become more abundant, food is more available to predators, so predator survival and reproduction tend to increase after a delay. As predator numbers rise, predation pressure reduces the prey population. With fewer prey available, the predator population subsequently declines as well. Reduced predation then allows the prey population to recover, beginning another cycle.

Thus, over a six-year interval, the expected graph should show both populations oscillating rather than remaining constant, with similar cycle lengths but offset peaks and troughs. Prey abundance reaches a maximum first; the predator maximum follows later. Likewise, a prey decline is followed by a predator decline. This time-lagged pattern reflects the biological dependence of the predator on the prey as a food resource and is a standard conceptual model of population dynamics. For additional background, see OpenStax Biology 2e: Environmental Limits to Population Growth and Encyclopaedia Britannica: Predation.

QUESTION NO: 34

Experiments involving the reduction of the blue dye DPIP, which loses its blue color and becomes clear as it absorbs electrons, have shown that the dye shows the greatest loss of color when in the presence of chloroplasts

A. under bright, white light

B. in a dark box

C. that have been boiled before exposure to light

D. exposed only to green light

E. in a sugar solution

ANSWER: A

Explanation:

under bright, white light is correct because DPIP functions as an artificial electron acceptor in the light-dependent reactions of photosynthesis. When chloroplasts receive light, chlorophyll pigments absorb photon energy and excite electrons in photosystem II. The photosynthetic electron-transport chain then transfers those electrons through a series of carriers. In this experiment, oxidized DPIP can accept electrons in place of its usual downstream acceptors. Reduction of DPIP removes its blue color, so a greater decrease in absorbance or visible blueness indicates more light-driven electron transfer.

Bright white light supplies a broad range of wavelengths that chlorophyll and accessory pigments can absorb efficiently, producing a high rate of photosynthetic electron flow. Functional chloroplast membranes and their photosystems use that absorbed energy to drive the reactions measured by the dye reduction. Thus, the condition with bright white light provides the strongest expected reduction of DPIP and consequently the greatest loss of color. The relationship between light absorption, excited electrons, and photosynthetic electron transport is described in OpenStax Biology 2e: The Light-Dependent Reactions of Photosynthesis and is consistent with the classic Hill-reaction use of artificial electron acceptors in chloroplast experiments.

QUESTION NO: 35

An elevator of mass 800 kg is moving upwards with a constant velocity of 3 m/s. What would be the resultant force acting on the elevator?

A. 7840 N

B. 2400 N

C. 266.67 N

D. 0 N

E. None of the above choices

ANSWER: D

Explanation:

The correct answer is **0 N**. Although the elevator is moving upward, its velocity is constant, so neither its speed nor its direction is changing. Therefore, its acceleration is zero. Newton's second law states that the net, or resultant, force on an object equals its mass multiplied by its acceleration: $F_{net} = ma$. With a mass of 800 kg and an acceleration of 0 m/s^2, the resultant force is $800 \times 0 = 0$ N.

A zero resultant force does not mean that no forces act on the elevator. Its weight acts downward due to gravity, while the supporting force from the elevator cable or lifting mechanism acts upward. For constant upward velocity, these forces have equal magnitudes and opposite directions, so they cancel. The stated mass and velocity are not needed to calculate a nonzero net force because the decisive fact is that the velocity remains constant. This is an application of Newton's first and second laws, which relate zero acceleration to balanced forces. See The Physics Classroom: Newton's Second Law and OpenStax Physics: Newton's First Law.

QUESTION NO: 36

Two boys are holding the ends of a string and one of them hits the string in such a way that waves start forming on the string. If it was observed that 4 troughs pass through a point in 10 seconds, what is the time period and frequency of the wave?

A. 1.5 s and 0.1 s−1

B. 15 s and 1 s−1

C. 0.4 s and 2.5 s−1

D. 2.5 s and 0.4 s−1

E. 4 s and 0.25 s−1

ANSWER: D

Explanation:

The correct answer is **2.5 s and 0.4 s−1**. At a fixed point on the string, successive troughs arrive one complete cycle apart. Therefore, observing four troughs pass the point in 10 seconds means that four wave cycles occur during that time. The frequency is the number of cycles per unit time: 4 cycles ÷ 10 s = 0.4 cycles per second, or 0.4 Hz (equivalently 0.4 s−1). The period is the time required for one cycle and is the reciprocal of frequency: T = 1/f = 1/0.4 s = 2.5 s. This also follows directly by dividing the total observation time by the number of cycles: 10 s ÷ 4 = 2.5 s per cycle. Thus, the wave has a period of 2.5 seconds and a frequency of 0.4 hertz. The relationship between frequency and period is fundamental for periodic motion and waves: f = 1/T. See OpenStax Physics: Period and Frequency in Oscillations and The Physics Classroom: Frequency and Period of a Wave.

QUESTION NO: 37

What is the geometry of NH3?

A. Linear

B. Tetrahedral

C. Octahedral

D. Trigonal-pyramidal

E. Trigonal-bipyramidal

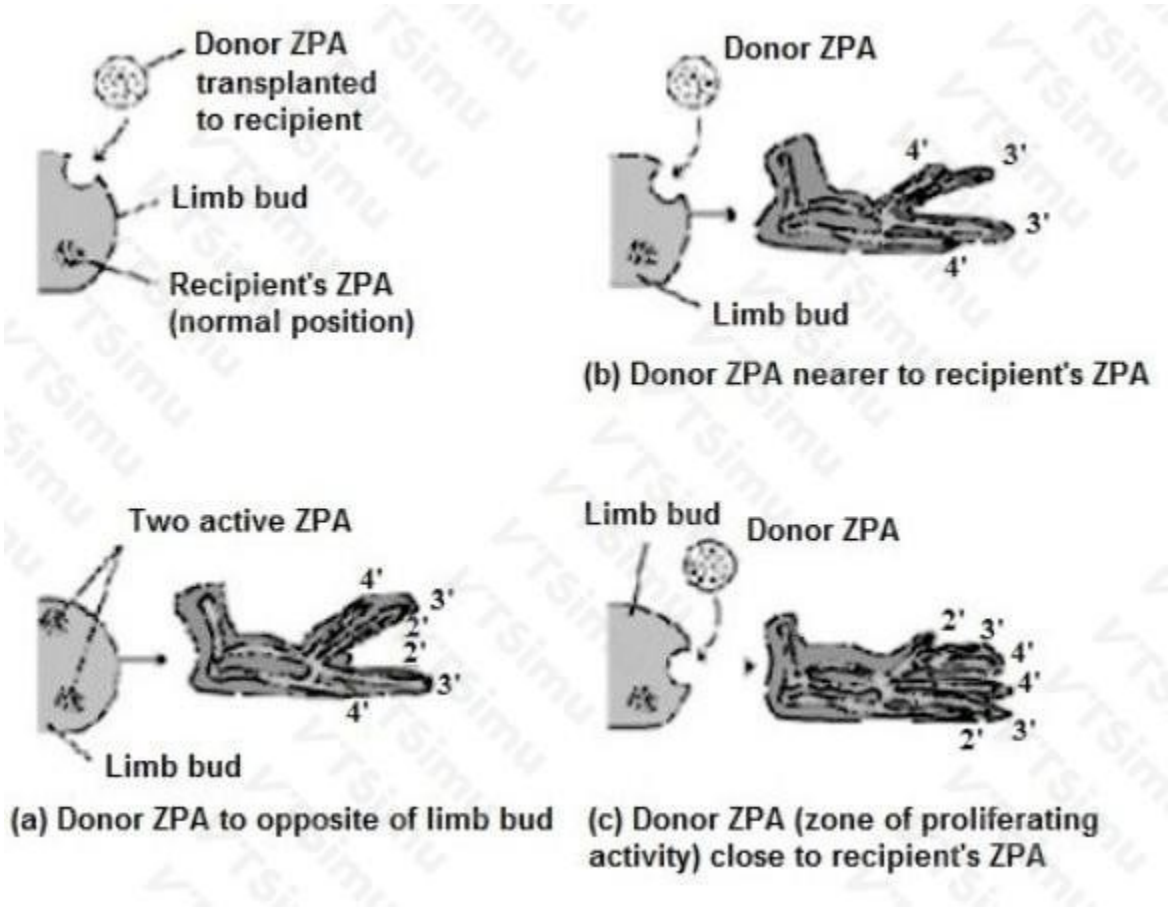
ANSWER: D

Explanation:

Trigonal-pyramidal is the molecular geometry of NH_3. Nitrogen is the central atom and has five valence electrons. It forms three single bonds to hydrogen atoms, leaving one lone pair on nitrogen. Thus, there are four electron domains around the central nitrogen atom: three bonding domains and one nonbonding domain. Under VSEPR theory, four electron domains have a tetrahedral electron-domain arrangement. However, molecular geometry describes the arrangement of the atoms only, rather than including lone pairs. With one lone pair and three bonded hydrogen atoms, the visible atomic arrangement is trigonal pyramidal. The lone pair repels the bonding electron pairs more strongly than bonding pairs repel one another, compressing the H–N–H bond angles from the ideal tetrahedral value of 109.5° to approximately 107°. This arrangement accounts for ammonia's nonplanar, pyramidal shape and its polar character. The American Chemical Society's overview of molecular shapes and VSEPR theory is available at ACS Middle School Chemistry: Molecule Shapes. Additional discussion of ammonia's trigonal-pyramidal molecular geometry is provided by Chemistry LibreTexts: Molecular Structure and Polarity.

QUESTION NO: 38

Chickens have three digits on each limb and the development of these digits is controlled by a region of cells called ZPA (zone of proliferating activity) cells. The digits are normally labeled 2', 3' and 4' to show that, over the course of evolution, chickens have lost digits 1' and 5' that mammals and most reptiles have retained. Below is a three-part experiment performed on chicken embryos, where some ZPA cells are transplanted from a donor embryo into the limb bud that is pictured. The limb bud is the limb of the developing chick before any differentiation of digits has taken place. Depending upon where the ZPA cells are transplanted, different results occur.



This experiment demonstrates that

A. ZPA regions have no effect on limb development

B. implanting a second ZPA region will cause shorter digits, such as the 2' digit, to disappear

C. the chicken embryo has mechanisms in place to turn off duplicate ZPA regions

D. the ZPA regions work by secreting neurotransmitters to control limb development

E. ZPA regions have to capacity to induce development of digits on limb buds

ANSWER: E

Explanation:

ZPA regions have to capacity to induce development of digits on limb buds. The zone of polarizing activity is a specialized signaling region at the posterior edge of an early vertebrate limb bud. Classic transplantation experiments in chick embryos showed that moving ZPA tissue to another location in a limb bud can organize an additional, ectopic digit pattern. Thus, the transplanted cells are not merely participating in digit formation where they originated; they provide positional developmental instructions to nearby undifferentiated limb-bud cells. The resulting digit arrangements depend on where the extra ZPA tissue is placed, demonstrating that location within the limb bud is central to the signal's effect. Molecular work later identified Sonic hedgehog (Shh) as the key signaling molecule produced by the ZPA, with differences in signal exposure helping specify digit identities along the anterior–posterior axis. This experiment therefore supports the conclusion that ZPA tissue has digit-inducing, pattern-organizing capacity in a developing limb. A detailed account of limb patterning and ZPA graft experiments is available from NCBI Bookshelf, Developmental Biology: Limb Development and the UNSW Embryology limb development resource.

QUESTION NO: 39

What is the buoyant force exerted on a 20 cm block of iron submerged completely inside water?

A. 0.234 N

B. 0.111 N

C. 2.289 N

D. 1.34 N

E. 0.196 N

ANSWER: E

Explanation:

0.196 N is correct when the stated 20 cm is interpreted as a volume of 20 cm^3, as indicated by the supplied calculation. By Archimedes' principle, a fully submerged object experiences an upward buoyant force equal to the weight of the fluid it displaces. The appropriate relationship is $F_B = \rho g V$, where ρ is the density of water, g is gravitational acceleration, and V is the submerged volume.

The entire iron block is underwater, so it displaces its full volume of water. Convert 20 cm^3 to SI units: 20 cm^3 = 20 × 10^{-6} m^3 = 2.0 × 10^{-5} m^3. Using water's density of approximately 1000 kg/m^3 and g = 9.8 m/s^2 gives F_B = (1000)(9.8)(2.0 × 10^{-5}) N = 0.196 N. The material of the submerged block does not enter this buoyancy calculation; the displaced water's density and the block's submerged volume determine the force. This application follows the standard statement of Archimedes' principle described in OpenStax College Physics and Encyclopaedia Britannica.

QUESTION NO: 41

The toad Bufo marinus generally lies in wait for prey such as cockroaches to wander past. As the cockroach enters the toad's field of view, the toad strikes with its sticky tongue. Yet, the cockroach begins its escape from the toad even before the tongue has left the toad's mouth, even though it may still be caught. Attacks generally occur at night and the tongue makes no detectable sound at all. Cockroaches have also seen climbing on the backs of sedentary toads.

These observations suggest that

A. cockroaches are repelled by the odor of a toad

B. cockroaches begin to flee at the sight of a toad

C. cockroaches can detect slight changes in wind direction

D. toads produce a high frequency sound detectable by the cockroach at the time of attack

E. the cockroach is responding to a previously misdirected attack

ANSWER: C

Explanation:

cockroaches can detect slight changes in wind direction is correct because cockroaches possess highly sensitive mechanoreceptors associated with the paired cerci at the rear of the abdomen. Fine hairs on the cerci bend in response to very small air movements, and the direction in which those hairs bend conveys the direction of the disturbance. This sensory system can trigger an exceptionally rapid escape response before a predator physically contacts the cockroach.

When a toad prepares to strike, its rapid movement and the projection of its tongue can displace nearby air. A cockroach need not see the predator or hear a sound to react; it can respond to this local air current. The fact that attacks occur at night and that cockroaches may climb on inactive toads supports the conclusion that the escape is linked to an immediate physical cue generated during the attack, rather than to the mere ongoing presence of the toad. Research on cockroach escape circuitry identifies the cercal system as a classic example of detection of air currents and rapid behavioral response. See this review of the cockroach cercal sensory system and Encyclopaedia Britannica's discussion of cockroach sensory hairs.

QUESTION NO: 42

The gene for a lethal disease is carried on the X chromosome. What is the probability that a woman who is a carrier passes this gene to her son?

A. 100 %

B. 75 %

C. 50 %

D. 25 %

E. 33 %

ANSWER: C

Explanation:

A carrier of an X-linked disease typically has one X chromosome carrying the disease-associated allele and one X chromosome without it. A son receives his Y chromosome from his father and receives his only X chromosome from his mother. During egg formation, the mother transmits either of her two X chromosomes with equal probability. Therefore, for each son, there is a 1 in 2, or 50%, probability that he receives the mother's X chromosome carrying the lethal-disease gene. The word "lethal" does not change the inheritance probability asked here; it describes the potential biological effect of inheriting the allele. This calculation is conditional on the child already being a son. If the question instead asked about the probability among all children, sex probability would also need to be considered. The

50 %

response correctly states the transmission risk to a son of a heterozygous carrier mother. For an overview of X-linked inheritance, see MedlinePlus: X-linked inheritance and NHGRI: X-Linked.

QUESTION NO: 43

Organisms in which type of relationship both benefit from their association?

A. Mutualism

B. Parasitism

C. Commensalism

D. Antagonism

E. None of the above

ANSWER: A

Explanation:

Mutualism is the relationship in which each participating organism gains a benefit from the association. It is a type of symbiosis, meaning that members of two different species live in close interaction. The benefits can take many forms, including access to food, protection from predators, shelter, pollination, seed dispersal, or help obtaining nutrients. For example, bees obtain nectar and pollen as food while pollinating flowering plants, which supports the plants' reproduction. Similarly, nitrogen-fixing bacteria receive carbohydrates and a protected place to live in the roots of legumes, while providing the plants with usable nitrogen compounds. The defining feature is that the interaction has a positive effect on the fitness or survival of both species involved. Mutualistic interactions may be obligate, where the species depend strongly on one another, or facultative, where both benefit but can survive independently. This use of mutualism as a mutually beneficial interspecific relationship is consistent with standard biological terminology described by OpenStax Biology 2e and the Encyclopaedia Britannica overview of mutualism.

QUESTION NO: 45

Which compound is the best conductor of electricity?

A. Water

B. Copper

C. Diamond

D. Graphite

E. Silicon

ANSWER: B

Explanation:

Copper is the best conductor of electricity among the listed substances. Copper is a metal with a metallic crystal structure containing many mobile, delocalized electrons. When an electric potential is applied, these electrons move readily through the metal lattice and carry electric charge efficiently. This low resistance to electron flow gives copper its very high electrical conductivity, approximately 5.8×10^7 siemens per meter near room temperature for pure copper. Its combination of excellent conductivity, mechanical strength, availability, and ease of fabrication is why copper is used extensively for electrical wiring, power cables, circuit-board traces, motor windings, and connectors. Conductivity can vary with purity and temperature, but copper remains the clear best choice in this group under ordinary conditions. The National Institute of Standards and Technology provides reference data for copper's electrical resistivity, the reciprocal of conductivity, in its materials-property resources. More information is available from NIST's copper electrical-properties table and the Encyclopaedia Britannica overview of copper.

QUESTION NO: 46

The burning of fossil fuels is thought to increase the possibility of global warming. When fossil fuels undergo a combustion reaction the by-products are carbon dioxide and water. Carbon dioxide contributes to the greenhouse effect by which of the following mechanisms?

A. Carbon dioxide absorbs short wavelengths and allows infrared radiation to escape.

B. Carbon dioxide absorbs infrared wavelengths and allows other wavelengths to escape.

C. All wavelengths of electromagnetic radiation are absorbed by carbon dioxide.

D. Carbon dioxide increases the temperature of the ocean.

E. Carbon dioxide does not have any effect.

ANSWER: B

Explanation:

Carbon dioxide absorbs infrared wavelengths and allows other wavelengths to escape. Earth's surface absorbs energy from sunlight and, because it is much cooler than the Sun, releases much of that energy back toward space as long-wavelength infrared radiation. Carbon dioxide has molecular vibrational modes that absorb specific bands of this outgoing infrared energy. After absorption, the molecule can re-emit infrared radiation in different directions, including back toward the surface and lower atmosphere. This reduces the rate at which Earth loses heat to space until the climate system reaches a warmer energy balance.

Carbon dioxide does not absorb every wavelength equally; its climate effect depends on absorption at particular infrared wavelengths. Increasing atmospheric carbon dioxide increases the absorption and re-emission of outgoing infrared radiation, which is why it is classified as a greenhouse gas. Water vapor is also produced during combustion, but its atmospheric concentration is strongly controlled by temperature and the water cycle, whereas emitted carbon dioxide can persist and accumulate, producing a sustained radiative influence. The National Aeronautics and Space Administration summarizes this heat-trapping process at NASA's greenhouse-effect overview. Additional spectral and climate context is provided by the National Oceanic and Atmospheric Administration Global Monitoring Laboratory.

QUESTION NO: 47

The product of this reaction is an insoluble precipitate.

A. HI(aq) + NaOH(aq)

B. H2O(l) + HOCl(aq)

C. K(s) + H2O (aq)

D. Xe(g) + H2O(g)

E. Zn(s) + CuSO4(aq)

ANSWER: E

Explanation:

Zn(s) + CuSO4(aq) is the correct choice because it is a single-displacement reaction that produces solid copper: Zn(s) + CuSO4(aq) → Cu(s) + ZnSO4(aq). Zinc is more readily oxidized than copper, so zinc atoms lose electrons to form Zn^{2+} ions in solution. At the same time, Cu^{2+} ions from aqueous copper(II) sulfate gain those electrons and are converted to elemental copper, Cu(s). Because elemental copper is a solid that is not soluble in water, it forms a visible solid deposit—an insoluble precipitate—while zinc sulfate remains dissolved in the aqueous phase. This reaction is also commonly observed as reddish-brown copper forming on the zinc surface, accompanied by the fading of the blue Cu^{2+} color. The activity-series concept underlying this displacement reaction is described by OpenStax Chemistry 2e. Solubility principles and the representation of solids in chemical equations are further covered by OpenStax Chemistry 2e: Precipitation Reactions.

QUESTION NO: 48

x	$f(x)$
0	20
2	–45
4	–80
6	–128
8	132
10	–160
12	90

The table above gives some values of a 5th degree polynomial f(x). Based on the values in the table, what is the minimum number of real roots of the equation f(x) = 0?

A. Five

B. Four

C. Three

D. Two

E. One

ANSWER: B

Explanation:

Four is correct because a polynomial is continuous for every real value of *x*. The table shows four intervals in which the listed values of *f(x)* have opposite signs at the two endpoints. Whenever a continuous function has a positive value at one point and a negative value at another point, it must equal zero at least once somewhere between those points. This is the Intermediate Value Theorem.

Each sign change therefore guarantees a real root in the corresponding interval. Because these intervals are separate, the guaranteed zeros are distinct, establishing a minimum of four real roots. The fact that the function is a fifth-degree polynomial is consistent with this result: its remaining degree can occur through multiplicity at one of those roots or through additional roots, but the information in the table guarantees only these four distinct real zeros. Thus, the minimum supported by the given values is four. See OpenStax: The Intermediate Value Theorem and Khan Academy: Intermediate Value Theorem.

QUESTION NO: 49

In humans, carbon dioxide in the bloodstream is mainly transported from cells to lungs

A. as bicarbonate ion

B. as carbon dioxide gas bubbles within red blood cells

C. attached to hemoglobin

D. as carbonic acid

E. as carbon dioxide gas bubbles within the plasma

ANSWER: A

Explanation:

The correct answer is **as bicarbonate ion**. Most carbon dioxide generated by cellular respiration enters red blood cells in systemic capillaries. There, carbonic anhydrase rapidly catalyzes its reaction with water to form carbonic acid. Carbonic acid

then dissociates into hydrogen ions and bicarbonate ions. Hemoglobin helps buffer much of the hydrogen ion, while bicarbonate moves out of the red blood cell into the plasma, commonly in exchange for chloride ions (the chloride shift). This allows the blood to carry a large amount of metabolically produced carbon dioxide efficiently from tissues to the lungs.

In the pulmonary capillaries, the process reverses. Bicarbonate re-enters red blood cells, combines with hydrogen ions to form carbonic acid, and is converted back into carbon dioxide and water. The carbon dioxide then diffuses into the alveoli and is exhaled. Thus, bicarbonate is the principal chemical form used for carbon dioxide transport in human blood, accounting for the majority of total carbon dioxide carried. This mechanism also contributes importantly to acid-base regulation through the bicarbonate buffer system. See NCBI Bookshelf: Physiology, Carbon Dioxide Transport and OpenStax: Gas Exchange.

QUESTION NO: 50

Mosses cannot grow very tall due to their lack of

A. specialized vascular tissues

B. a dominant gametophyte generation

C. chlorophyll

D. airborne spores

E. bark

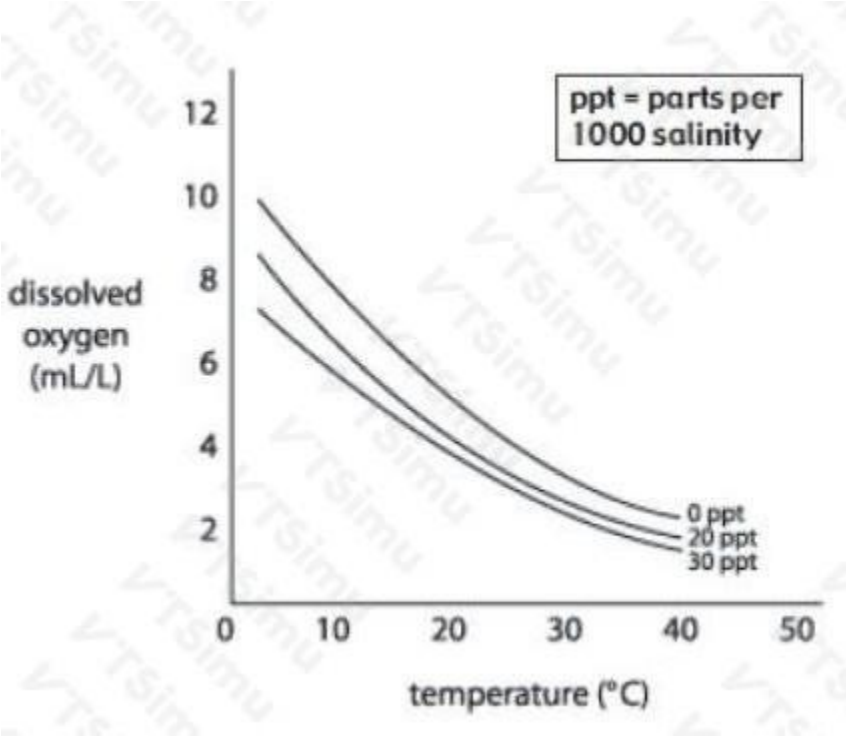
ANSWER: A

Explanation:

Mosses cannot grow very tall because they lack specialized vascular tissues. Vascular plants use xylem to transport water and dissolved minerals upward and phloem to distribute sugars and other organic nutrients through the plant. These conducting tissues allow water and nutrients to travel efficiently over substantial distances and also contribute structural support, making taller growth possible. Mosses are bryophytes, which are nonvascular plants. They absorb water across their surfaces and move it primarily by diffusion and capillary action over short distances. Because these mechanisms are effective only across small distances, moss tissues must remain relatively thin and close to reliably moist environments. Their height is therefore limited by the inability to deliver sufficient water to tissues far above the ground, especially because water is essential for photosynthesis and cellular function. Mosses do possess chlorophyll and reproduce with spores, but neither feature supplies the long-distance internal transport system needed for substantial vertical growth. The key biological distinction is the absence of xylem- and phloem-like vascular tissue. See the University of California Museum of Paleontology overview of bryophytes and Encyclopaedia Britannica's bryophyte reference.

QUESTION NO: 51

In an aquatic environment, oxygen concentration depends on chemical and physical factors and is greatly affected by many biological processes. These is much less dissolved oxygen (DO) in aquatic environments than in dry air. In most aquatic environments, there are only 5 to 10 mL of dissolved oxygen in a liter of water. Chemical and physical factors, such as salinity, pH, and especially temperature, can affect the DO concentration and distribution. An experiment was done to study the effect of different salinity levels on DO in water of varying temperatures. The results are below. Salinity is expressed in parts per thousand (ppt) and is the content of dissolved salt in water.



According to the data shown, a reasonable conclusion to form from the results of this experiment is that

A. higher temperatures result in greater dissolved oxygen in water

B. the greater the salinity, the lower the dissolved oxygen

C. salinity is not related to dissolved oxygen levels

D. the temperature of the water is more important than the salinity in determining dissolved oxygen levels

E. as salinity increases, dissolved oxygen levels increase

ANSWER: B

Explanation:

The conclusion that **the greater the salinity, the lower the dissolved oxygen** is supported by the pattern in the experimental data. At each temperature represented, the dissolved-oxygen measurements decline as salinity rises from freshwater conditions toward higher salt concentrations. Because this same downward relationship appears across the tested temperatures, salinity is a variable that the results consistently associate with lower oxygen availability in water.

This outcome also reflects the physical chemistry of gas solubility. When salts dissolve, their ions interact strongly with water molecules. That reduces the tendency of oxygen molecules to remain dissolved in the water, an effect commonly called “salting out.” Thus, saline water generally holds less dissolved oxygen than freshwater at the same temperature and pressure. The data allow the conclusion to be stated as a relationship observed over the tested salinity range, rather than as a claim that salinity is the only factor controlling oxygen concentration. The U.S. Geological Survey notes that dissolved oxygen is influenced by factors including temperature and salinity, and the U.S. Environmental Protection Agency identifies dissolved oxygen as an important water-quality measurement. See USGS: Dissolved Oxygen and Water and EPA: Dissolved Oxygen.