DAT*

Practice Test Explanations

KAPLAN

TEST PREP AND ADMISSIONS

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SURVEY OF THE NATURAL SCIENCES

ANSWER KEY

1. (C)	21. (A)	41. (E)	61. (C)	81. (A)
2. (E)	22. (A)	42. (B)	62. (B)	82. (A)
3. (D)	23. (E)	43. (D)	63. (B)	83. (E)
4. (C)	24. (C)	44. (C)	64. (E)	84. (D)
5. (D)	25. (D)	45. (A)	65. (C)	85. (E)
6. (D)	26. (A)	46. (C)	66. (C)	86. (E)
7. (B)	27. (A)	47. (D)	67. (D)	87. (A)
8. (B)	28. (C)	48. (D)	68. (A)	88. (A)
9. (D)	29. (B)	49. (D)	69. (E)	89. (C)
10. (B)	30. (B)	50. (C)	70. (B)	90. (C)
11. (A)	31. (D)	51. (E)	71. (A)	91. (B)
12. (B)	32. (C)	52. (A)	72. (A)	92. (C)
13. (C)	33. (A)	53. (A)	73. (D)	93. (B)
14. (A)	34. (D)	54. (D)	74. (A)	94. (A)
15. (B)	35. (C)	55. (D)	75. (E)	95. (B)
16. (B)	36. (D)	56. (B)	76. (B)	96. (B)
17. (A)	37. (B)	57. (E)	77. (A)	97. (D)
18. (A)	38. (B)	58. (C)	78. (D)	98. (C)
19. (D)	39. (A)	59. (E)	79. (A)	99. (C)
20. (D)	40. (D)	60. (A)	80. (D)	100. (A)

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1. (C)

Snails are mollusks, which are characterized by being soft bodied and having mantles which secrete calcareous (calcium carbonate) exoskeletons. Lobsters are Arthropods that have jointed appendages, chitinous exoskeletons, and open circulatory systems. They are one of three subclasses of Arthropoda: Insects, Arachnids, and Crustaceans. Insects are also Arthropods and in the class Insecta. Scorpions are Arachnids in the order Arthropoda. Spiders are Arachnids in the order Arthropoda.

2. (E)

Open circulatory systems, such as those found in insects, are characterized by having blood (interstitial fluid) which is in direct contact with the body tissues. The blood is circulated primarily by body movements and blood flows through a dorsal vessel and into spaces called sinuses where exchange occurs. Annelids have a closed circulatory system with five pairs of vessels called aortic loops connecting the dorsal vessel to the ventral vessel. These aortic loops act as additional pumps. In mammalian and other highly developed circulatory systems, arteries branch into arterioles. Blood is oxygenated at the lungs in terrestrial organisms such as lizards and humans. Xylem does carry water in the plant; however, it is not an open circulatory system, as xylem and phloem are closed vessels.

3. (D)

The muscles within the body wall of advanced flatworms such as Planaria are arranged in two antagonistic layers: longitudinal and circular. The muscles contract against the resistance of the incompressible fluid of its hydrostatic skeleton. Contraction of the circular layer lengthens the animal while contraction of the longitudinal layer shortens the animal. Echinoderms have a thin skin that covers an endoskeleton made of hard, calcareous plates. Hydra move via impulses sent down its nerve net. Amoebae extend pseudopodia for locomotion; the advancing cell membrane extends forward, allowing the cell to move. Insects have chitinous exoskeletons that cover all of their muscles and organs.

4. (C)

Lacteals are tiny lymph vessels that extend into the intestinal villi and are the site of absorption of fatty acids that have been packaged into chylomicrons.

5. (D)

The organism is the individual unit of an ecological system. A population is a group of organisms of the same species living together in a given location. A community consists or populations of different plants and animal species interacting with each other in a given environment. An ecosystem encompasses the interaction between living biotic communities and the non-living environment. The biosphere includes all portions of the planet that support life—the atmosphere, lithosphere, and hydrosphere.

6. (D)

All organisms are assigned a scientific name consisting of the genus and species name of that organism. The genus for orange bread mold is *Neurospora* whereas the species is *crassa*.

7. (B)

Budding results in the production of two asymmetrical cells because of unequal division of the cytoplasm, although they both receive duplicate copies of the parent DNA, while fission results in two equally sized cells with equal amounts of cytoplasm and duplicate copies of the parent DNA. Budding may occur in yeast, a unicellular fungi, or hydra, a multicellular organism. Budding occurs in yeast or hydra while binary fission is used by prokaryotic organisms such as bacteria. Polar bodies are produced in oogenesis via unequal cytoplasm distribution. One primary oocyte will produce one fertile egg that contains most of the cytoplasm, one and two or three polar bodies.

8. (B)

Amylase, either salivary or pancreatic, hydrolyzes starch, a polysaccharide, to maltose, a disaccharide. Maltase hydrolyzes maltose to two glucose molecules. Lactase hydrolyzes lactose to glucose and galactose. Sucrase hydrolyzes sucrose to glucose and fructose. Carboxypeptidase hydrolyzes the terminal peptide bond at the carboxyl end.

9. (D)

Extinction is the gradual elimination of conditioned responses in the absence of reinforcement. The recovery of the conditioned response after extinction is called spontaneous recovery. Classical conditioning involves the association of a normally autonomic or visceral response with an environmental stimulus. In operant conditioning, the response is diminished and finally eliminated in the absence of reinforcement. The response is not completely unlearned—rather it is inhibited in the absence of reinforcement. Positive

reinforcement includes providing food, light, or electrical stimulation of the animal's brain pleasure centers. Following positive reinforcement, the animal is much more likely to repeat the desired behavioral response. Instrumental conditioning is the same as operant conditioning.

10. (B)

Imprints are fossils that are impressions left by an organism such as footprints. Sedimentary rocks, choice **(A)**, are rocks formed from sand and mud that once settled in layers on the bottom of seas, lakes, and marshes. They are often rich in fossils. Petrification, choice **(C)**, is the process in which minerals replace an organism's cells. Molds, choice **(D)**, form in hollow spaces of rocks, as the organisms within decays. Casts, choice **(E)**, are formed by minerals deposited in molds.

11. (A)

Glucocorticoids such as cortisol and cortisone, are involved in glucose regulation and protein metabolism. They are derived from cholesterol, as are mineralocorticoids, and cortical sex hormones. Epinephrine, choice **(B)**, is a peptide hormone that is secreted by the adrenal medulla. ADH, choice **(C)**, is also a peptide hormone secreted by the hypothalamus and stored in the posterior pituitary. Insulin, choice **(D)**, is a peptide hormone secreted by the pancreas. Thyroxine, choice **(E)**, is a peptide hormone secreted by the thyroid gland.

12. (B)

Cnidarians have a simple nervous system called a nerve net. This network of nerve cells may have limited centralization. Some jellyfish have clusters of cells and pathways that coordinate the relatively complex movements required for swimming. Protozoans, choice **(A)**, possess no organized nervous system. The single-celled organisms may respond to stimuli such as touch, heat, light, and chemicals. Annelida, choice **(C)**, earthworms, have a primitive nervous system consisting of a defined ventral nerve cored and an anterior "brain" of fused ganglia. Definite nerve pathways lead from receptors to effectors. Rays, choice **(D)**, have a complex nervous system with sensory (afferent) neurons and motor (efferent) neurons. Arthropods, choice **(E)**, such as lobsters, have simple brains similar to those of annelids but more specialized sense organs such as eyes and tympanic membranes for detecting sound.

13. (C)

When the fibers of a muscle are exposed to very frequent stimulation, the muscle cannot fully relax. The contractions begin to combine, becoming stronger and more prolonged. This is known as temporal summation. The contractions become continuous when the stimuli are so frequent that the muscle cannot relax. This type of contraction is known as tetanus and is stronger than a simple twitch of a single fiber. A simple twitch is the response of a single muscle fiber to a brief stimulus at or above the threshold stimulus, and consists of a latent period, a contraction period, and a relaxation period. Following the contraction period, there is a brief relaxation period in which the muscle is unresponsive to a stimulus; this period is known as the absolute refractory period. During the latent period, the action potential spreads along the sarcolemma and calcium ions are released.

14. (A)

Some freshwater protozoa, such as the paramecium, possess a contractile vacuole—an organelle specialized for water excretion via active transport. Excess water, which continually diffuses into the cell from the hypotonic environment, is collected and periodically pumped out of the cell. The earthworm, choice **(B)**, excretes CO_2 directly through moist skin, and two pairs of nephridia in each body segment excrete water, mineral salts, and urea. Arthropods, choices **(C)** and **(D)**, release carbon dioxide into tube-like tracheae and excrete nitrogenous wastes in the form of solid uric acid crystals. Mineral salts and uric acid accumulate in the Malpighian tubules and are then transported to the intestine to be expelled with the solid wastes of digestion. Mammals, choice **(E)**, excrete excess water and wastes after filtration through the kidney.

15. (B)

Agonistic displays involve a contest of some kind, involving both threatening and submissive behavior. These contests determine which competitor gains access to some resource such as food or mates. Usually, they involve threat displays and then submission by one individual. Courtship behavior, choice **(A)**, is an example of a reproductive display found in all animals. Many animals have evolved a variety of complex actions that function as signals in preparation for mating. In agonistic behavior, choice **(C)**, natural selection favors a strong tendency in both individuals to end the contests as soon as the ultimate winner is clearly established, because violent combat could reduce the reproductive fitness of the victor as well as the defeated. The waggle dance of bees, choice **(D)**, is another example of a behavior display used to

convey information. Scent retrieval by dogs, choice **(E)**, is another example of a behavior display that is a means of communication. If a dog does not have vision to use, he will abandon sight and work only by scent weaving back and forth until he locates what he is looking for.

16. (B)

Lichens are a symbiotic relationship between an alga and a moss and are part of the biotic environment. Water, choice **(A)**, is the major component of the internal environment of all living things and is part of the physical environment. Temperature, choice **(C)**—another aspect of the physical environment—must be maintained at an optimal level for each individual organism. The temperature of a geographic local depends on both latitude and altitude. Sunlight, choice **(D)**—part of the physical environment—is the ultimate energy source for all organisms. Soil, choice **(E)**—another aspect of the physical environment—determines the nature of plant and animal life in the soil, as well as the area that contains that soil.

17. (A)

Commensalism occurs when one organism benefits by the association and the other is not affected. The cattle egret receives food while the cattle are neither helped nor harmed. A parasite, choice **(B)**, benefits at the expense of the host. Predators, choice **(C)**, are free-living organisms that feed on other living organisms. Saprophytes, choice **(D)**, include those protists and fungi that decompose dead organic matter externally and absorb the nutrients. Mutualism, choice **(E)**, is a symbiotic relationship from which both organisms derive some benefit.

18. (A)

Bryophytes are simple plants with few specialized organs and tissues. They lack the water-conducting xylem and retain flagellated sperm that must swim to the eggs. Because their sperm must swim, they have never become successful terrestrial plants and must live in moist places. Tracheophytes, choice **(B)**, are complex plants with a great degree of cell differentiation; they contain xylem and phloem and have radial symmetry. Lycophytes, choice **(C)**, belong to an ancient subdivision, have roots, and are non-woody. Pterophytes, choice **(D)**, belong to the largest division and include the familiar fern. They contain large leaves that possess many vascular bundles. Ferns grow lengthwise, not in diameter, and contain xylem as tracheids, not vessels. They do not produce seeds, and their short-lived gametophytes generation possesses heart-shaped leaves. Conifers, choice **(E)**, are the largest grouping of gymnosperms, which are naked-seeded plants. They include cycads, pines, spruce, and firs.

19. (D)

Let's look at each statement individually.

(1) A smallpox vaccination is an example of active immunity; vaccination induces the production of antibodies. Active immunity can be conferred by vaccination when an individual is injected with a weakened, inactive, or elated form of a particular antigen, which stimulates the immune system to produce specific antibodies against it. Active immunity may require weeks to build up.

(2) Passive immunity involves the transfer of antibodies produced by another individual or organism. Passive immunity is acquired either passively or by injection. During pregnancy, some maternal antibodies cross the placenta and enter fetal circulation, conferring passive immunity upon the fetus. Although passive immunity is acquired immediately, it is very short-lived, lasting only as long as the antibodies circulate in the blood.

(3) Gamma globulin, the fraction of the blood containing a wide variety of antibodies, can be used to confer temporary protection against hepatitis and other diseases by passive immunity.

Since (2) and (3) are examples of passive immunity, the correct answer is **(D)**.

20. (D)

The pineal gland is a tiny structure at the base of the brain that secretes the hormone melatonin. The role of melatonin in humans is unclear, but it is believed to play a role in the regulation of circadian rhythms—physiological cycles lasting 24 hours. Melatonin secretion is regulated by light and dark cycles in the environment. Prolactin is secreted by the anterior pituitary, calcitonin by the thyroid gland, renin by the kidney, and gastrin by the stomach.

21. (A)

Some bacteria form carbohydrates by the use of chemical energy, rather than by using the radiant energy of the sun. These bacteria oxidize compounds of nitrogen, sulfur, or iron. The small amount of energy

released by this oxidation is sufficient for the formation of glucose.

22. (A)

Myoglobin is a hemoglobin-like protein found in muscle tissue. Myoglobin has a high oxygen affinity and maintains the oxygen supply in muscles by binding oxygen tightly. Creatinine phosphate, choice **(B)**, is used by vertebrates and some invertebrates to store energy temporarily in muscles. It will be rapidly converted into ATP. Arginine phosphate, choice **(C)**, is similar to creatinine phosphate but used solely by invertebrates. Hemoglobin, choice **(D)**, is the oxygen, binding molecule in red blood cells that transports oxygen to the tissues. ATP, choice **(E)**, is the primary source of energy for muscle contraction. Very little ATP is actually stored in the muscles, and other forms of energy, such as creatinine phosphate and arginine phosphate, must be stored and rapidly converted to ATP.

23. (E)

Imprinting is a process in which environmental patterns or objects presented to a developing organism during a brief critical period in early life become accepted permanently as an element of their behavioral environment. Behavioral displays, such as reproductive and agonistic displays, are interactions that occur as a means of communication between members of a species. When food, mates, or territory are disputed, a dominant member of the species will prevail over a subordinate one. The social hierarchy is frequently referred to as the pecking order. It minimizes violent intra-specific aggression by defining stable relationships among members of the group. Members of most land-dwelling species defend a limited area or territory from intrusion by other members of the species. These territories are typically occupied by a male or a male–female pair and are frequently used for mating, nesting, and feeding. The olfactory sense is immensely important as a means of communication in many animals. Many animals secrete substances called pheromones, which influence the behavior of other members of the same species.

24. (C)

The Protist kingdom contains primitive eukaryotic organisms with both plant- and animal-like characteristics. These organisms are either single cells or colonies of similar cells with no differentiation of specialized tissues. Viruses, choice **(A)**, are generally not considered to be living organisms, as they cannot function outside of a host cell and are obligate parasites. Monerans, choice **(B)**, are prokaryotes, lacking a nucleus or any membrane-bound organelles. Fungi, choice **(D)**, are multicellular, differentiated, and non-motile, but they are not photosynthetic. They are either saprophytic or parasitic. The plant kingdom, choice **(E)**, includes multicellular organisms that exhibit differentiation of tissues, which are non-motile and photosynthetic.

25. (D)

The two-layer gastrula is a stage in development between the blastula and the three-layer gastrula. In humans, the appendix, choice **(A)**, is small and useless. In herbivores, it assists in the digestion of cellulose. In humans, the tail is reduced to a few useless bones (coccyx, choice **(B)**) at the base of the spine. In other animals, it functions in balance or grasping. The splints on the legs of the horse, choice **(C)**, are the vestigial remains of the two side toes of Eohippus. The whale has the remnants of hind limb bones, choice **(E)**, which are useless; these are embedded in the sides of the adult.

26. (A)

A deme is a small local population. Members of a deme resemble one another more closely than they resemble the members of other demes. They are also closely related genetically, as mating between members of the same deme occurs more frequently. They are influenced by similar environmental factors and thus are subject to the same selection process. Biomes, choice **(B)**, are the world's major communities, classified according to the predominant vegetation and characterized by adaptations of organisms to the particular environment. A niche, choice **(C)**, is the sum total of an organism's use of both the physical and biotic environments. The gene pool, choice **(D)**, is the sum of the genes in a population at any given time. Casts, choice **(E)**, are types of fossils formed by mineral deposits in molds.

27. (A)

Veins contain valves that prevent backflow; xylem vessels do not contain valves. As water evaporates from the leaves of plants, a vacuum is created that pulls water up the stem. This is known as transpirational pull, choice **(B)**. Any liquid in a thin tube will rise due to the surface tension of the liquid and interactions between the liquid and tube. This is known as capillary action, choice **(C)**. Water entering the root hairs exerts a pressure that pushes water up the stem. This is known as root pressure, choice **(D)**. The cohesion of water due to hydrogen bonding, choice **(E)**,

makes it possible to pull a column of water upward through the xylem.

28. (C)

Auxins are responsible for phototropism, the tendency of the shoots of plants to bend toward light sources (such as the sun), as well as geotropism, the growth of portions of plants toward or away from gravity. Gibberellins, choice **(A)**, stimulate rapid stem elongation. They also inhibit the formation of new roots and stimulate the production of new phloem cells by the cambium. Kinins, choice **(B)**, promote cell division. Ethylene, choice **(D)**, stimulates fruit ripening and induces senescence or aging. Anti-auxins, choice **(E)**, regulate the activity of auxins.

29. (B)

The palisade layer has elongated chloroplast that contains cells spread over a large surface area. The palisade cells are directly under the upper epidermis and are well exposed to light. The waxy cuticle, choice **(A)**, reduces transpiration and conserves water. Leaves have no openings on their upper surface. The upper epidermis, choice **(C)**, is the outermost layer of cells on the top side of the leaf. The spongy layer, choice **(D)**, has stomata which open into air spaces that contact an internal moist surface of loosely packed spongy layer cells. As in animals, the moist surface, for both photosynthesis and respiration, is necessary for diffusion of gases into and out of cells. The air spaces also increase the surface area available for gas diffusion by the cells. Spongy cells also contain chloroplasts. Guard cells, choice **(E)**, surround each of the stomata on the lower surface of the leaves.

30. (B)

Although plants are able to use many of their waste products, any excess carbon dioxide, as well as waste oxygen and water vapor, leaves the plant by diffusion through stomata (pores in leaves) and lenticels (pores in stems). This is known as transpiration. Flame cells, choice **(A)**, are the excretory system of Planaria. Contractile vacuoles, choice **(C)**, are the excretory system of protozoa. Nephridia, choice **(D)**, are the excretory system of earthworms. Kidneys, choice **(E)** are part of the excretory system of humans.

31. (D)

Members of most land-dwelling species defend a limited area or territory from intrusion by other members of the species. These territories are typically occupied by a male or a male–female pair and are frequently used for mating, nesting, and feeding. Agonistic displays, choice **(A)**, involve contests between members of the same species for food or mates. They threaten each other until one backs down and shows sign of submission. The dominance hierarchy, choice **(B)**, is a linear pecking order of animals where position dictates characteristic social behaviors. Conditioned reflexes, choice **(C)**, are responses learned through classical conditioning, the association of a normally autonomic or visceral response with an environmental stimulus. Reproductive displays, choice **(E)**, have evolved to function as a signal that an organism is prepared to mate.

32. (C)

Animals have developed many adaptations for maintaining their internal osmolarity and conserving water. This is known as osmoregulation. Osmoregulation in insects and birds involves the secretion of uric acid crystals. Cooperativity, choice **(A)**, is the interaction of the subunits of proteins that enables a conformational change in one subunit to be transmitted to others and strengthen binding. Thermoregulation, choice **(B)**, is the maintenance of a consistent internal temperature within a tolerable range. Passive excretion, choice **(D)**, will occur in a hyperosmotic environment. Because the salt concentration of the water is higher than that of the organism, salt flows passively into the water and out of the organism. To compensate for this, the organism (such as a saltwater fish) must constantly drink and actively excrete salt across his gills. Secretion, choice **(E)**, involves the passage of anything across a membrane.

33. (A)

The gametes that can form from an AABbCc mouse are: ABC, ABc, AbC, and Abc. Therefore, the correct answer is four. This corresponds with answer choice **(A)**.

34. (D)

Prokaryotes are unicellular organisms with a simple cell structure. They have an outer cell membrane but do not contain any membrane-bound organelles. There is no true nucleus; the genetic material consists of a single circular molecule of DNA concentrated in an area of the cell called the nucleoid region. They have a cell wall, a cell membrane, cytoplasm, ribosomes (different from those found in eukaryotes), and sometimes flagella. Eukaryotes are bounded by cell membranes and contain cytoplasm. Cytoplasm contains organelles suspended in a semifluid medium called the cytosol. The genetic material consists of linear strands of DNA organized into

chromosomes and located within a membrane-enclosed organelle called the nucleus.

35. (C)

The parathyroid glands are four small pea-shaped structures embedded in the posterior surface of the thyroid. These glands synthesize and secrete parathyroid hormone, which together with calcitonin and vitamin D, regulates plasma Ca^{2+} concentration. In turn, the plasma Ca^{2+} concentration regulates PTH secretion by means of a negative feedback mechanism. PTH raises the Ca^{2+} concentration in the blood by increasing bone resorption and decreasing Ca^{2+} excretion in the kidneys. In addition, PTH converts vitamin D into its active form, which stimulates intestinal calcium absorption. Glucagon stimulates the conversion of glycogen to glucose in the liver and, therefore, increases blood glucose. Insulin lowers blood glucose and increases storage of glycogen. Aldosterone regulates plasma levels of sodium and potassium and, consequently, the total extracellular water volume. It causes the active reabsorption of sodium and passive reabsorption of water in the nephron. ADH stimulates water reabsorption by the kidneys by increasing the nephron's permeability to water.

36. (D)

Female carriers who pass a sex-linked lethal recessive on to their offspring will have death of their male offspring while their female offspring will be carriers. Females will never die from this recessive sex-linked lethal because a homozygous female would be impossible to produce without the X^a affected allele gamete from the male, who is unable to reach maturity to produce gametes.

37. (B)

With no gamma globulins (antibodies), an organism cannot produce a specific immune response to pathogens. Clinical manifestations of this are frequent, severe, prolonged infections by organisms of typically low pathogenicity.

38. (B)

Directional selection, statement (1), is the shift in allele frequencies of the population as a whole toward variants of one extreme. Disruptive selection is the shift in allele frequencies of the population, toward variants of either extreme, leading to the creation of two subpopulations that do not favor the intermediate variants of the original population and which grow more disparate over time. Thus disruptive selection, statement (2), is most likely to lead to speciation. Sexual selection, statement (3), is the selection for factors that give the individual an advantage in finding a mate. Sexual selection often acts opposite to the effects of natural selection; e.g., brighter feathers may make a male bird more vulnerable to predators, but give him an advantage during reproduction. It has been hypothesized that sexual selection is the factor that has led to sexual dimorphism. Stabilizing selection, statement (4), is the shift in variants toward the intermediate by disfavoring variants at either extreme. This type of selection reduces variation within the species and helps maintain the status quo. Thus **(B)**, (2) only, is the correct answer.

39. (A)

There are four stages to the cell cycle: M, G_1, S, and G_2. Cell division, or mitosis, occurs during the M phase. In G_1, the cell doubles in size and new organelles are produced. In S (synthesis), each chromosome is replicated. In G_2, the cell continues to grow and assembly of new organelles continues. Stages G_1, G_2, and S are interphase stages that occur between cell divisions. The correct answer is choice **(A)**.

40. (D)

Organisms are classified according to evolutionary relationships in the following categories: Kingdom > Phylum > Class > Order > Family > Genus > Species. The largest group or kingdom is broken down into smaller and smaller subdivisions. Each smaller group has more specific characteristics in common. Of the choices listed, genus is the smallest subdivision, and organisms in the same genus would be more similar than organisms that were only classified in the same kingdom, phylum, class, or family. Thus the correct answer is choice **(D)**.

41. (E)

This problem has two main steps. First, we need to determine which of the reactants will limit the amount of products; then, we can use the balanced equation to calculate how much product is formed. We are told that we begin with one mole of each of the reactants. When we divide this by the coefficients of the reactants in the balanced equation, we find that hydrogen is the limiting reactant. For every two moles of hydrogen, we produce two moles of water, so using the one mole of hydrogen we are given, we can produce one mole of water.

42. (B)

Recall that the solubility product expression is written for species in solution. Therefore, the solid ammonium sulfate will not be a part of the equation. In addition to this, we must keep in mind that the concentration of

each species will be raised to the power of its coefficient. As there are three ammonium ions per dissolved ammonium sulfate unit, the ammonium ion concentration will be raised to a power of three. Overall, this gives: $[NH_4^+]^3[PO_4^{3-}]$.

43. (D)

When we are asked to determine an empirical formula from percentages by weight, it is usually most convenient to think of a 100-g sample. Of course, any sample would give the correct answer, but using a 100-g sample, the percentages translate directly into weights (in g). In a 100-g sample of the compound, we, therefore, have 42 g chlorine and 57 g oxygen. To deduce the empirical formula, we need to find out the number of moles of Cl and O atoms to which these values correspond. The atomic weight of chlorine is 35.5 g/mol, so 42 g corresponds to 42/35.5 (or 1.2 mol), and the atomic weight of oxygen is 16 g/mol, which corresponds to 57/16, or 3.6. Our next step is to divide both of these values by the smaller of the values. From this, we obtain a ratio of 3 oxygen atoms to 1 chlorine atom. The only compound in which the ratio of oxygen to chlorine is 3:1 is choice **(D)**. Had you been really stuck, you could have eliminated choice **(C)** because it is the only compound of the five that contains only oxygen and chlorine. In addition, the given weight percentages did not add up to 100, so there must have been another element in the correct compound.

44. (C)

We know that the general rate expression for a bimolecular reaction, like the one given in this problem, is $k[A]^x[B]^y$. We need to use the rate data given to determine the values of x and y. First, take a look at the first and second experiments. The concentration of [A] was varied, while [B] was held constant. [A] doubled, and so did the rate. This represents a first-order dependence on [A], so $x = 1$. Now take a look at the first and third experiments. The concentration of [B] doubled, while [A] was held constant, and the rate increased fourfold. This represents a second-order dependence on [B], so $y = 2$. Therefore, the rate expression is $k[A][B]^2$.

45. (A)

Although it is not stated explicitly in the problem, this question asks you to determine the density of the unknown liquid and use this to find a volume. Using dimensional analysis will be very helpful here: the answer must be in milliliters, so we need to get rid of g and kg. We also do not want to forget that the mass of the beaker is given as 115 g, as we will want to determine the actual mass of the liquid in the beaker by subtracting one from the other. This quantity will be 427 – 115, so eliminate any answer choices that do not contain that difference—this takes care of **(D)**. Since we are trying to cancel the mass of the liquid with the mass of the given quantity, one must appear in the denominator and the other in the numerator. Finally, multiply this by the 300 mL of the original unknown experiment, and choice **(A)** is clearly correct.

46. (C)

This question tests your knowledge of colligative properties. The correct answer will be the one that does not allow the temperature of the liquid to rise above 100 degrees Celsius under the given conditions. Let's work by process of elimination. Choice **(A)** suggests that the liquid is a solution of water and table salt. Dissolved particles cause the boiling point of liquids to rise, so **(A)** is incorrect, and so are **(D)** and **(E)**. We are now left with choices **(B)** and **(C)**. Assuming the liquid is pure water and the atmospheric pressure is varied because of the altitude, which one will cause the boiling point of water to rise? To answer this, think back to the definition of boiling point: the point at which the vapor pressure of a liquid is equal to the atmospheric pressure. This will happen at a lower temperature for lower pressures, which corresponds to higher altitudes, so choice **(C)** is correct.

47. (D)

Metals are good conductors of electricity. From this, we know that we can eliminate choices **(A)** and **(E)** because both are metals. Now we are left with three different forms of sodium chloride. What are the differences between them? Well, the aqueous solution of sodium chloride will be a superb conductor of electricity; ionic solutions are well-known conductors. The molten form will also be a good conductor. Only the solid form will be an insulator, so it is the correct choice.

48. (D)

For dilution problems like this one, a helpful formula will simplify your calculations: $M_iV_i = M_fV_f$, where M_i and M_f are the initial and final molarity of the solution, respectively, and V_i and V_f are the initial and final volume of the solution, respectively. To determine the amount of water needed to perform the dilution, our first step is to determine the final volume of the solution (the volume after dilution):

$$(18\ M)(0.025\ L) = (3\ M)V_f$$

V_f = 0.150 L = 150 mL

The amount of water we need to add is, therefore, the difference between the final and initial volumes, or (150 – 25) mL = 125 mL.

49. (D)

Recall that the second law of thermodynamics states that in a real, spontaneous process, the entropy of the universe (the system being considered plus its surroundings) must increase. We can think of entropy as disorder or randomness. It is also helpful to keep a few typical entropically-favored processes in mind, such as boiling, sublimation, melting, and mixing. Take a look at the answer choices. Choice **(A)**, sorting, will be the opposite of mixing, so it is accompanied by a decrease in entropy. The same goes for choice **(B)**, which separates two things by filtration. Condensation is the opposite of boiling, so choice **(C)** is incorrect. Choice **(E)**, deposition, is also incorrect, because it is the opposite of sublimation. This leaves choice **(D)**, evaporation, as the correct answer, as evaporation is entropically equivalent to boiling.

50. (C)

This is an example of a question for which choosing the correct answer depends solely on your knowledge of general chemistry. How are hydrogen, deuterium, and tritium related? They have identical structures, except that deuterium has an extra neutron and tritium has two extra neutrons in their nuclei. Therefore, they are isotopes. Allotropes are different forms of elements; isomers are molecules with the same formula and different structures; and resonance structures are different ways of representing the electron density in a molecule. The three isotopes given are not identical—they have different nuclear structures, though they are all electrically neutral (each contains one electron per atom).

51. (E)

A Brønsted acid (or Brønsted-Lowry acid) is a species that can donate one or more proton. Do not confuse this definition with other acid definitions, such as Arrhenius and Lewis. Choice **(A)** is not basic or acidic, as most hydrocarbons are neutral. Choice **(B)** should be recognized as hydroxide ion, a strong base. Choice **(C)** is a Lewis acid but not a Brønsted acid, so it is incorrect. Choice **(D)** is a Lewis acid because it can accept an electron pair, but it does not have a hydrogen ion to donate. Therefore, the correct answer is choice **(E)**, acetic acid, which can donate a proton in solution.

52. (A)

The question stem gives a helpful clue—we are looking for a pair that has the most ionic character. What makes a bond ionic? The most ionic pair will be one in which the two ions most closely approximate point charges. This is possible when the positive ion completely donates its electron to the negative ion. Another way of saying this is that the species involved in the bond differ greatly in electronegativity. So, we are looking for a positive ion that completely loses its valence electron and a very electronegative element for the anion. Which of the anions is most electronegative? F, which appears in choice **(A)**. However, we must also consider the cation. The cation that most closely approximates a point positive charge will be one that has the most shielding between the nucleus (the positive charge) and the valence electron to be lost. This will be Rb, so choice **(A)** is correct. Choices **(B)** and **(C)** will have significant ionic character as well, but not to the extent that **(A)** does. Choices **(D)** and **(E)** both contain elements, Si and P, from the center of the periodic table, so it will be more difficult to pair them with elements of differing electronegativity. Therefore, these combinations will not have high ionic character when bonded.

53. (A)

This question calls for an application of Le Châtelier's principle to the given system. Le Châtelier's principle states that when a system is in equilibrium, any stress applied to it will cause the equilibrium to shift in a direction that alleviates the stress. The stress can be in the form of a change in temperature, pressure, volume, or concentration of any of the species in the system. For the system given in the question stem, we have one mole of $N_2(g)$ and three moles of $H_2(g)$ in equilibrium, with two moles of $NH_3(g)$. All species are in the gas phase. If we decrease the volume after the system has reached equilibrium, the equilibrium will shift towards the side with the smaller number of moles of gases, i.e., to the right. Therefore, choice **(A)** is correct.

Choice **(B)** is incorrect because decreasing the pressure would have the opposite effect. It would cause the equilibrium to shift to the side with the larger number of moles of gas—in this case, the reactant side. Since the reaction is exothermic ($\Delta H < 0$), increasing the temperature would favor the reactants; therefore choice **(C)** is incorrect. Choice **(D)** is incorrect because the addition of a catalyst does not affect the thermodynamics of a reaction. It increases both the forward and reverse rates of reaction, so it would not

affect the equilibrium. Removing chlorine from the container will shift the reaction left to compensate, so choice **(E)** is incorrect.

54. (D)

The best thing to do here is to examine the electron configuration given, and determine which electrons are the valence electrons. Clearly, the $n = 1$ and $n = 2$ levels are filled, so only $n = 3$ must be considered. The *s* subshell is full (2 electrons) and the *p* subshell is full (6 electrons), thus leaving the *d* orbitals. Remember that electrons prefer to be unpaired if they can be, so place each electron in an empty orbital. This works for the first five electrons; however, there is one additional electron. Place this electron in one of the half-full orbitals, and you'll see that you have four unpaired electrons left. This is choice **(D)**.

55. (D)

At its core, this is a Lewis dot structure/VSEPR question. In order to determine which of the compounds is not planar, we must calculate the number of valence electrons for each. The nitrate ion has 24 electrons—six from each of the three oxygen atoms, five from the nitrogen atom, and one from the negative charge. Boron trifluoride also has 24 electrons—three from boron and seven from each of the three fluorine atoms. SO_3 has 24 electrons—six from each of the oxygens and six from the sulfur atom. Aluminum trichloride has 24 electrons—three from the aluminum atom, 21 total from the chlorines. Phosporus tribromide differs from the other four compounds because it has 26 electrons—five from the phosphorus, 21 total from the three bromine atoms. Since it has an extra pair of valence electrons, the three substituents around the central phosphorus atom will be pushed out of the plane. Instead of having a trigonal planar shape, this compound will have a trigonal pyramidal shape.

56. (B)

The key to answering this question correctly is to balance the equation given, then choose the corresponding element. The mass numbers and the atomic numbers must be balanced in order for the equation to be valid. Only choices **(B)** and **(C)** satisfy this requirement. Choice **(C)** is incorrect because it denotes the wrong element; the subscript (6, in this case) is the atomic number of the species in question, whereas choice **(C)** uses the mass number, the superscript to determine the identity of the element. Choice **(A)** adds the masses and atomic numbers instead of balancing them.

57. (E)

Electronegativity and ionization energy decrease down a column in the periodic table, so choices **(A)** and **(D)** are incorrect. Ductility (the ability of a substance to be pulled into wires) and electrical conductivity vary by substance and do not demonstrate a clear trend based on the position within a column of the periodic table, so choices **(B)** and **(C)** are incorrect. Only **(E)**, atomic radius, increases as we move down a column. Since there is more shielding due to additional filled orbitals of electrons, the valence electrons are not as tightly held and the atomic radius increases. Therefore, choice **(E)** is correct.

58. (C)

The half-life of a radioactive substance is the time it takes for half of the sample to decompose. Therefore, after three minutes, this sample will have one-half of its original activity. After an additional three minutes (6.0 total) the sample will have one-fourth of its original activity. After another three minutes (9.0 minutes total) the sample will have one-eighth of its original activity. Therefore, the answer is choice **(C)**. Choice **(A)** is a trap, as just multiplying 3.0 minutes by one-eighth will not give the correct answer.

59. (E)

Answering this question correctly requires an understanding of the common ion effect. We know that if a solution already contains some iodate ions, less silver iodate will dissolve. Le Châtelier's principle also tells us that the equilibrium will lie to the left. Therefore, our task is to determine how the common ion effect will operate in this case. The simplest way to approach the calculation is to think of how much silver iodate would dissolve if the liter contained only water. This is just the square root of the solubility product constant given. Then, we can subtract the ions that are already there from the sodium iodate, and we have choice **(E)**.

60. (A)

Reduction leads to the gain of electrons, while oxidation removes electrons. Therefore, we can rewrite all the equations in oxidation form, i.e., reverse them. At the same time, we need to reverse the sign for the standard reduction potentials to convert them into oxidation potentials. Recall that $\Delta G = -nFE$. Thermodynamically, the reaction with the most negative ΔG is the most spontaneous, so the most positive E_{ox} is the most spontaneous. Choose $E_{ox} = +1.706$ V, which is choice **(A)**, after it has been converted into an oxidation half-

reaction. Do not be misled by choice **(E)**, which at 1.776 has a greater magnitude.

61. (C)

It is not necessary to assign oxidation numbers to all species in this reaction. Just focus on the species that contain nitrogen. Nitric acid on the left and NO gas on the right. Determining the oxidation number of nitrogen in NO is relatively easy, since the compound contains only two atoms. From this, we will be able to eliminate some of the wrong answer choices and move on to nitric acid. NO is neutral, so the oxidation numbers of nitrogen and oxygen will have to add up to zero. The oxidation number of oxygen is –2, except in rare cases, so the oxidation number of nitrogen is +2. Armed with this information, we can eliminate all the choices, except **(A)** and **(C)**. Now, let's examine the oxidation number of nitrogen in nitric acid. Each of the oxygen atoms contributes a –2 charge, which gives –6 total. Hydrogen will be +1, leaving a +5 oxidation number for the overall neutral compound. Therefore, the correct answer is choice **(C)**.

62. (B)

Predicting the answer is a good plan, as this question is a tough one, but you will still need to check all the answer choices because they are so complex. You do not want to miss any subtleties! Raising the temperature is a way of saying "adding kinetic energy" to a system. Therefore, when we raise the temperature of a reaction system, we will be imparting kinetic energy to the reactants (and products, if there are any already). Why will this increase the rate of reaction? Well, now the reactants have more energy, so when they collide with one another there is a greater chance that they will have sufficient energy to overcome the activation energy barrier. Keep in mind that not all collisions between reactant species will result in reactions. If the molecules have the wrong spatial orientation or if they collide with insufficient force, no reaction will occur and the reactants will leave the collision exactly as they entered it. Therefore, choice **(B)** is correct. Choice **(A)** is not untrue: as concentrations of reactants increase, the reaction rate will also increase. However, this is irrelevant because the question asks about temperature (this is only true if the reaction is not zero order). Although geometry is key to a successful reaction collision, choice **(C)** is incorrect because it is not a rise in temperature that causes the correct spatial orientation to occur. Choice **(D)** is the exact opposite of the correct reasoning. If the reactant particles are moving more slowly, they will be less likely to collide effectively since the collision will not be energetic enough. Choice **(E)** is incorrect because it brings in irrelevant information—we do not know whether most reactions are exothermic, so we cannot make a generalization about that.

63. (B)

Assigning an electron configuration to an ion is a matter of determining the number of electrons surrounding that ion, followed by using the Aufbau (building-up) principle to place the electrons in their proper orbitals. Manganese has seven valence electrons, so when it loses two to achieve a +2 charge, it will be left with five. Do not be thrown off by choice **(E)**, which suggests that the +2 charge represents an additional two electrons! Since we know we have five electrons, we can eliminate choices **(A)** and **(D)**. This leaves us with **(B)** and **(C)**. Since the Aufbau series tells us that electrons will be removed from a 4*s* orbital before a 3*d* orbital, the answer is choice **(B)**.

64. (E)

There are a couple of important things to keep in mind when constructing a proper Lewis structure. First, the number of valence electrons in the molecule must match the structure. Then, the structure with the least separation of charge will be preferable to the others. Therefore, our first step is to determine the number of valence electrons in the correct molecular structure. Nitrogen, oxygen, and fluorine contribute five, six, and seven valence electrons, respectively. This gives a total of 18 electrons. Armed with this information, we can eliminate choices **(A)**, **(B)**, and **(D)**, since those choices contain 20, 20, and 16 electrons, respectively. Choices **(C)** and **(E)** both contain the correct number of electrons, so we will need to consider the positions of the atoms in order to determine which is the correct structure. Choice **(C)** shows fluorine as the central atom. This is not possible, since fluorine will have a positive charge and the negative charge will lie on the oxygen. Fluorine is more electronegative than oxygen, so the opposite will be true. Therefore, oxygen is the central atom, and choice **(E)** is correct.

65. (C)

Use an effective Kaplan strategy here: estimate! The value given for sulfur trioxide is very close to –400, and that given for sulfur dioxide is close to –300, so use that to your advantage instead of keeping track of lots of numbers. The answer choices are quite far apart, so there is no risk that you'll go astray. The enthalpy change for the reaction is simply the enthalpy of the products minus the reactants: in this case, 2(–400) –

2(–300), or about –200. The only answer choice that comes close is choice **(C)**.

66. (C)

A compound can hydrogen bond if it has an electronegative element (N, O, or F) bonded to a hydrogen atom. In order to determine which of the listed compounds does not meet this requirement, draw the structures as carbon chains. Choice **(C)** cannot hydrogen bond because the fluorine atoms are bonded to a carbon atom. We know that they cannot be bonded to hydrogen atoms because fluorine only forms one bond per atom, and the compound contains more than just HF.

67. (D)

This is a fairly straightforward Boyle's law question. We know that the expansion was effected isothermally (at a constant temperature), so we can use $P_1V_1 = P_2V_2$ to determine the fourth variable when we have the other three. In this case, that is (2 L)(P_1) = (3.5 L)(0.4 atm), or P_1 = 0.7 atm.

68. (A)

There are two key elements to solving this problem: properly assessing what is meant by beta-decay, then writing the correct balanced reaction for a uranium-235 beta-decay. Beta decay is the emission of a beta particle, which is essentially an electron. However, since it is emitted from the nucleus, the nucleus effectively gains a proton. Therefore, Z will increase by +1, while A will remain the same. Choice **(A)** conveys this accurately. Uranium-235 gains a proton to become neptunium-235, and a beta particle (or electron) balances the reaction on the right. Choice **(B)** is the balanced equation for an alpha decay reaction; choice **(C)** depicts gamma decay; choice **(E)** depicts positron emission; and choice **(D)** is simply a trap.

69. (E)

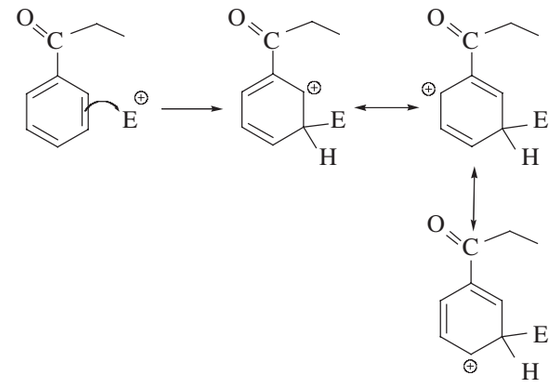
This question might seem daunting, as it asks you to put a battery into three categories: positive or negative Gibbs free energy change, spontaneity, and electrode character. In addition to that, you might be wondering, what kind of cell is a battery? The most helpful thing here is to take a step back and ask yourself what you already know about batteries. The main distinction between galvanic (or voltaic) cells and electrolytic cells is that one is used to do work, while the other requires electrical energy to induce the reaction. A battery most certainly falls into the first category—we use batteries all the time to run small appliances. Therefore, you know that the correct answer will be one that contains the attribute "spontaneous." This eliminates choices **(B)** and **(D)**. The next step is to consider how spontaneity is related to the change in Gibbs free energy. When a reaction is spontaneous, it has a negative change in Gibbs free energy. This allows us to eliminate choice **(A)**. Finally, consider what is true for all kinds of cells: that the oxidation half-reaction occurs at the anode, bringing us to choice **(E)**.

70. (B)

The pH and proton (hydrogen ion) concentration of an aqueous solution are related in the following way: pH = $-\log[H^+]$. We know the pH, so we must work backwards. Luckily, we are given a number that is relatively easy to work with. If the pH is 3, the $[H^+]$ is 10^{-3} M.

71. (A)

Electron-donating, activating substituents inductively activate the benzene ring and direct electrophiles ortho and para. Their electron-accepting, deactivating counterparts deactivate the benzene ring and direct electrophiles to the meta positions. Since the electrophilic attack affords a carbocation, attack leading to the most stable carbocation is favored. Ketones are meta-directors because the most stable carbocations result from meta attack:



Attack at the meta position avoids placing the positive charge next to the electron-withdrawing carbonyl group. Therefore, choice **(A)** is correct.

72. (A)

Resonance structures have the characteristic property of being interconvertible by electron-pair movement only, while the nuclear positions in the molecule remain unchanged. For example, converting **(B)** into **(C)** requires shifting an electron pair, while converting **(C)**

into **(D)** requires shifting two electron pairs. Conversely, converting **(A)** into **(B)** requires shifting a hydrogen atom from the benzene ring to the carbonyl group. Choice **(A)**, therefore, is not a resonance form of the others.

73. (D)

Protic solvents have a hydrogen attached to an electronegative atom such as O or N. These solvents contain highly-polarized bonds in which the hydrogen has proton-like character and can interact particularly strongly with anionic nucleophiles. These interactions are called hydrogen bonds. Solvents not capable of hydrogen bonding are called aprotic. Choices **(A)**, **(C)**, and **(E)** do not have H atoms attached to the electrophilic O. Choice **(B)** is incorrect because there is no electronegative atom in the molecule. Ethanol, choice **(D)**, is the only solvent capable of hydrogen bonding.

74. (A)

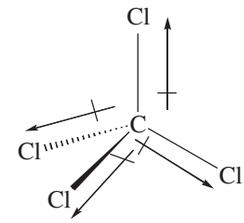
Increasing alkyl substitution increases carbocation stability. The order of carbocation stability parallels that of the corresponding radicals.

Primary (least stable) < Secondary < Tertiary (most stable).

In both cases, the alkyl group donates electron density to and stablizes the electron-deficient center. Of the answer choices, choice **(A)** is the most stable as it is a tertiary carbocation. Choice **(C)** is the second most stable as it is a secondary carbocation. Choices **(B)**, **(D)**, and **(E)** are all primary carbocations. The electron-withdrawing effect of Cl reduces the electron density around the carbocationic center. Therefore, choice **(D)** is more stable than choice **(E)**.

75. (E)

One of the characteristics of haloalkanes and haloalkenes is their polar C–X bond. Halogens are more electronegative than carbon. Thus the electron density along the C–X bond is displaced in the direction of X, thereby giving the halogen a partial negative charge (δ^-) and the carbon a partial positive charge (δ^+). In a polar molecule, electron density accumulates toward one side of the molecule, giving that side a slightly negative charge and leaving the other side with a slightly positive charge. Totally symmetrical tetrahedral molecules are nonpolar because their dipole moments cancel when added together. Choice **(E)**, is therefore, the correct answer. In all of the other answer choices, addition of the bond dipole moments will result in a net accumulation of charge (net dipole moment). Molecules with a net dipole moment are polar.

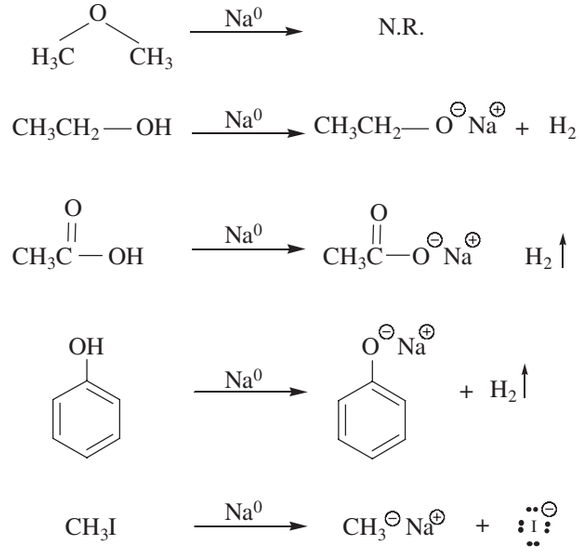


76. (B)

Electrophiles are "electron-seeking" reagents that have room in their orbitals to accept a pair of electrons. Choice **(A)** is a nucleophile because the nitrogen has a lone pair of electrons. The same is true for choice **(C)**, ethanol, which can act as an electron-pair donor. Choice **(D)** bears a negative charge and is, therefore, electron-rich. Choice **(E)** is incorrect because compounds with bonds can act as electron-donors.

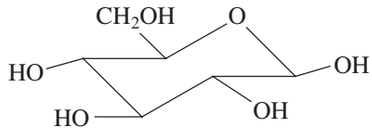
77. (A)

The electronic configuration of sodium metal is $1s^2 2s^2 2p^6 3s^1$. It will react in favor of losing its 3*s* electron in order to form a noble gas configuration. Na^0 will, therefore, react with species that act as electron acceptors. Because dimethyl ether, choice **(A)**, is a weak electron donor, it will not readily react with sodium metal. Choices **(B)**, **(C)**, and **(D)** are all acids which can accept electrons. In choice **(E)**, methyl iodide, the iodine will react to gain an electron in order to complete its octet.



78. (D)

Glucose, the primary source of energy in the human body, is a typical carbohydrate whose structure is shown below:



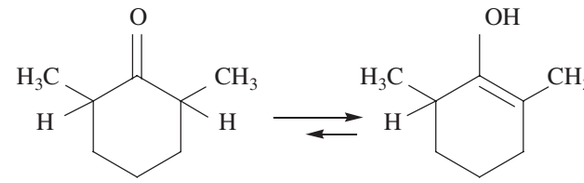
From this structure, it is evident that glucose is a monosaccharide. Therefore, choice **(D)** is correct.

79. (A)

Factors influencing boiling point include chain length, hydrogen bonding, and degree of branching. Of the compounds listed, choice **(A)**, propanol, has the highest boiling point (97.4°C). Only choices **(A)** and **(D)** are capable of hydrogen bonding. Electronegativity decreases as you move down a column in the periodic table. Since strength of hydrogen bonding is a factor of electronegativity, it follows that propanol has a higher boiling point than propanethiol. The carbonyl groups in choices **(B)** and **(E)** are polar groups and, therefore, aldehydes and ketones have higher boiling points (2-butanone, choice **(B)**, 79.5°C and propionaldehyde, choice **(E)**, 48.8°C) than hydrocarbons of the same molecular weight. However, since aldehydes and ketones cannot form strong hydrogen bonds between their molecules, they have lower boiling points than the corresponding alcohols. Ethers generally have low boiling points (methyl ethyl ether, choice **(C)**, 10.8°C) that are roughly comparable with those of hydrocarbons of similar molecular weight.

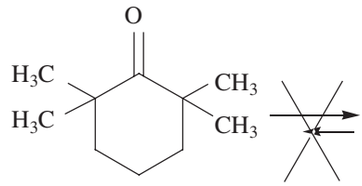
80. (D)

The conversion of an enol to a ketone by protonation at the carbon atom of the double bond and deprotonation at the oxygen atom is known as tautomerization. The ketone and its enol form are examples of tautomers, which are readily interconvertible constitutional isomers that exist in equilibrium with each other. Tautomers differ from each other in the locations of atoms as well as of electrons, and are thus not resonance contributors. Of the answer choices, only choice **(D)** cannot be converted to its enol form if a hydrogen atom and double bond are shifted. The C atoms adjacent to the ketone in choice **(D)** are fully substituted and have no H atoms. If there were hydrogens on the α carbons, as in choice **(B)**, it could be converted to its enol form.



Choice (**B**)
keto form

Choice (**B**)
enol form



can't interconvert

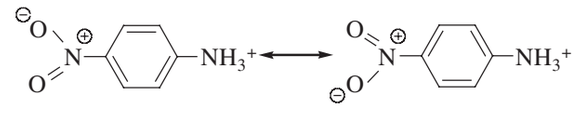
Choice (**C**)
keto form

81. (A)

The lower the pK_a, the stronger the acid. The most consistent way to analyze acidity is to consider the basicity of the conjugate bases in terms of their ability to donate electrons to a hydrogen atom. Listed in order of influence, the factors that control basicity include resonance, polarizability, electronegativity, and inductive effect. The pK_a's for the answer choices in this problem are listed below:

Compound	pK_a
p-nitro anilinium	1.0
anilinium	4.6
phenol	9.9
methyl anilinium	11
ethanol	16

Resonance is the most influential factor in determining base strength. Resonance delocalizes negative charge on a molecule, thus reducing its basicity and increasing the acidity of the conjugate acid. Of these compounds, only choices **(A)**, **(B)**, and **(C)** are capable of resonance. Choice **(A)**, *p*-nitroanilinium, exhibits a greater degree of resonance than choices **(B)** and **(C)**, and is, therefore, the strongest acid with the lowest pK_a. This is due to the presence of a nitro group that can stabilize negative charge through resonance:



The nitro group is also a powerful electron-withdrawing group because of the positively charged nitrogen atom, which is more electronegative than a neutral nitrogen atom. This inductive effect also helps to stabilize the negative charge on the conjugate base of nitroanilinium.

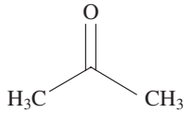
Choice **(B)** is more acidic than choice **(C)** because removal of a proton from anilinium forms the neutral aniline, which is a weaker base than the negatively-charged phenoxide ion.

82. (A)

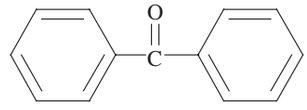
The iodoform reaction is useful in qualitative analysis as a test for methyl ketones and compounds that can be oxidized to methyl ketones. Acetaldehyde is the only aldehyde that gives a positive test, and ethanol the only primary alcohol. A positive iodoform test is characterized by the yellow color of methyl iodide, CH_3I, which is very insoluble in water. Choice **(A)** is the only methyl ketone.

83. (E)

If a compound produces a single proton NMR signal, all of its protons must be in identical chemical environments; i.e., they are all equivalent. The only compounds for which this is true are the ones listed in choices **(B)** and **(E)**, with structures shown below:



(B)



(E)

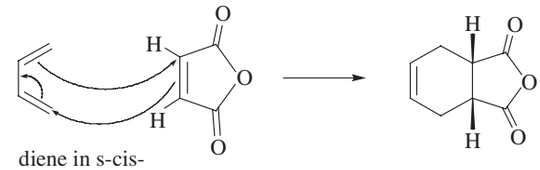
Both structures have a ketone functional group, which is consistent with the absorption band in the infrared spectrum at 1670 cm^{-1}. Choice **(B)** can be eliminated on the basis of the NMR data. Acetone shows a peak at δ 2.1 p.p.m, whereas chemical shifts for aromatic protons are in the range of δ 7–8 p.p.m. Strong absorption in the ultraviolet suggests a highly conjugated system, also consistent with choice **(E)**.

84. (D)

The correct answer is choice **(D)**. When carbon forms four single bonds, its hybridization is sp^3. When carbon forms one double bond and two single bonds, it is sp^2. Carbon atoms that are *sp* hybridized can form either one single bond and one triple bond, or two double bonds. The carbonyl carbon in acetamide is sp^2 because it forms a double bond with oxygen and single bonds to nitrogen and carbon. The nitrile carbon atom in acetonitrile is *sp* because it forms a triple bond with nitrogen and a single bond to carbon.

85. (E)

The essential aspects of a Diels–Alder reaction are illustrated in the example below:



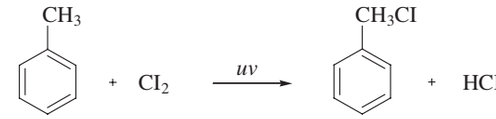
diene in s-cis-conformation

dienophile

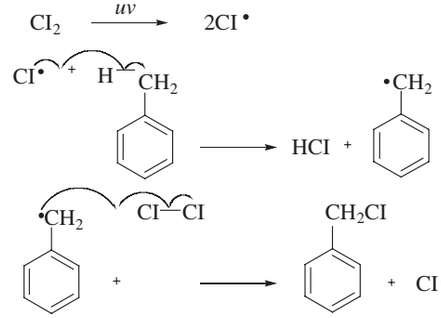
In a Diels–Alder reaction, a conjugated diene reacts with a dienophile to give a six-membered ring with a double bond in it. The reaction is highly stereoselective. Substituents on the dienophile, as well as those on the diene, retain the stereochemistry they had relative to each other before the reaction. As seen in the above example, the diene must be in the *s*-cis conformation in order to react. Choice **(E)** is, therefore, correct.

86. (E)

The important phrase here is "in the presence of light." When you see this in an DAT question, think radical mechanism. In this example, toluene undergoes chlorination according to a radical process involving a chain reaction. The overall reaction for this process is given below:

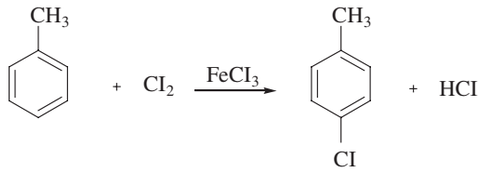


The reaction mechanism involves attack of chlorine radical on toluene to give tolyl radical, which subsequently reacts with chlorine to give chlorotoluene and chlorine radical. The chain continues:



Note the difference between chlorination of toluene in the presence of light and in the presence of a *catalyst*. In the presence of a catalyst such as $FeCl_3$, the reaction proceeds according to a mechanism which

involves a cationic intermediate leading to a para substituted product. Do not confuse choice **(B)** with the correct answer for the radical mechanism. Answer choice **(B)** is simply a trap!



87. (A)

An electrophile is a species that gains a pair of electrons from another atom to form a new covalent bond: a Lewis acid. Therefore, choice **(A)** is correct. Defining an electrophile as a species that is electron deficient, having areas of full or partial positive charge is not enough. Electrophiles may or may not have noble gas configurations [eliminate choice **(C)**]. Na^+ is an oxidizing agent but not an electrophile, as it does not readily form a bond with a nucleophile.

88. (A)

The Cahn–Ingold–Prelog rules are used to assign a configuration at a stereocenter. The rules are as follows: 1) The higher the atomic number, the higher the priority of the substituent. 2) If two identical atoms are attached to a stereocenter, the next atoms in both chains are investigated, moving away from the stereocenter until some difference is found. 3) A double bond is counted as two single bonds for both of the atoms involved. Applying these rules to the substituents listed, we have an order corresponding to I > III > IV > II [choice **(A)**].

89. (C)

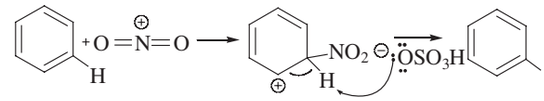
The rate of an S_N2 reaction is influenced by the degree of steric hindrance at the carbon undergoing substitution. The more highly substituted the carbon, the slower the reaction. In *t*-butyl iodide [choice **(C)**], this carbon is tertiary (3°) and will react more slowly than 2-iodo-1-phenyl propane [choice **(E)**, 2°] and isopropyl iodide [choice **(B)**, 2°], and thus will react more slowly than ethyl iodide [choice **(D)**, 1°] and methyl iodide [choice **(A)**, 1°].

90. (C)

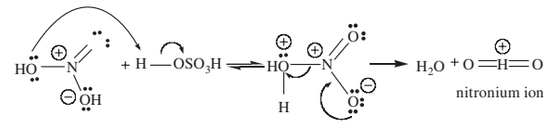
Alkene stability increases with the number of carbons directly attached to the sp^2 carbon atoms of the alkene. The most stable alkene is, therefore, **III** (2,3-dimethyl-2-butene) because it is tetrasubstituted. The least stable alkene is 2-propylcyclopropene because it is disubstituted. Whereas **I** is also disubstituted, **II** is less stable than **I** because of the strain associated with a 3-C ring.

91. (B)

The rate-determining step of an EAS reaction is formation of the carbocation intermediate because this results in disruption of the aromaticity. Choice **(B)** is, therefore, the correct answer. Choice **(A)** is a true statement. The nitration of benzene is irreversible.



Choice **(C)** is also true. The electrophile, NO_2^+, is generated from protonation of HNO_3 by H_2SO_4, followed by loss of water.



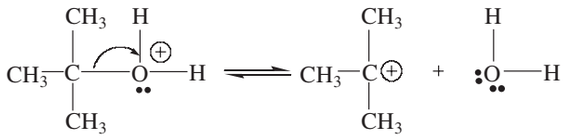
According to this mechanism, the role of H_2SO_4 is to generate the nitronium ion and deprotonate the carbocation intermediate. HF could perform a similar role, since HF itself does not react with benzene. Choice **(E)** is, therefore, true. Among the resonance contributors for the intermediates resulting from bonding of a nitronium ion at the *ortho* and *para* positions of nitrobenzene, one is particularly unfavorable because two positive charges are juxtaposed. This is not the case for meta substitution, however, so choice **(D)** is also true.

92. (C)

Hückel's rule predicts that for a monocyclic compound to be aromatic, there must be a fully-conjugated pi system containing $(4n + 2)$ pi electrons. The correct answer is choice **(C)**. Two pi electrons are provided by each of the double bonds to give a total of 6, satisfying $4n + 2$ when $n = 1$. The unshared electron pair on nitrogen is perpendicular to the pi cloud and does not count in determining aromaticity. Choice **(A)** is incorrect because there are eight pi electrons and the compound is not aromatic. When nitrogen is bonded as in **(A)**, the unshared electron pair is parallel to the pi system and counts toward determining aromaticity. Choice **(B)** is incorrect because it is not fully conjugated; there is a CH_2 group in the ring. Cyclic conjugation is necessary for a compound to be aromatic. Choice **(D)** is incorrect because, even though it is aromatic, it is not a heterocycle. The same is true of choice **(E)**. The heteroatom (nitrogen or oxygen in this problem) must be one of the atoms in the ring for a compound to be a heterocycle.

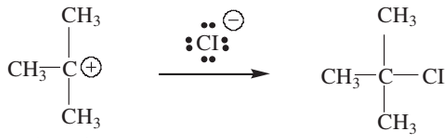
93. (B)

It is true that H_2SO_4 is a stronger acid than HCl. However, in an alcohol dehydration reaction, the first step involves proton transfer from the acid to the OH group of the alcohol. Any strong acid will serve this purpose. Choice **(A)** is, therefore, incorrect. HCl is *not* a stronger acid than H_2SO_4, so choices **(C)** and **(D)** are also incorrect. If HCl were a weaker acid than H_2SO_4, and H_2SO_4 is the acid typically used in the alcohol dehydration reaction, HCl would not be too strong an acid to be appropriate. Following protonation of the alcohol, the carbon–oxygen bond breaks heterolytically. The bonding electrons depart with the water molecule and leave behind a carbocation. This equilibrium is shown below:

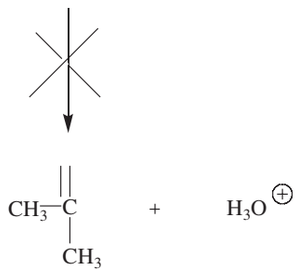


carbocation intermediate

The carbocation formed in this step is, of course, highly reactive because the central carbon atom has only six valence electrons rather than eight. HCl is a strong acid, so sufficient hydronium ion will be present in solution for the equilibrium in the first step to favor formation of the protonated alcohol. Choice **(E)** is, therefore, incorrect. The carbocation shown is electron deficient and is thus highly reactive toward nucleophiles. If a good nucleophile is present, it will react with the carbocation and prevent it from transferring a proton to a water molecule. Cl^- is a good nucleophile, whereas HSO_4^- is not. Choice **(B)** is the correct answer.



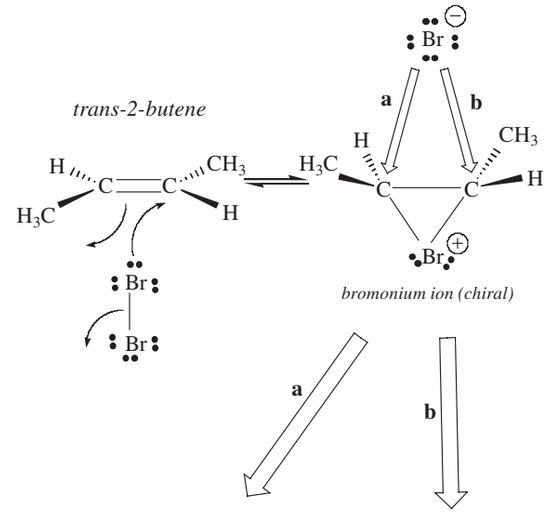
carbocation intermediate

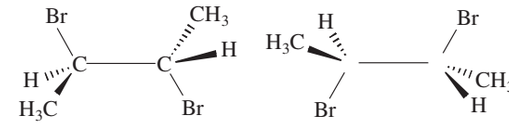


alkene won't form if nucleophile is present!

94. (A)

Choice **(A)**, *trans*-2-butene will react with bromine to yield a meso compound.

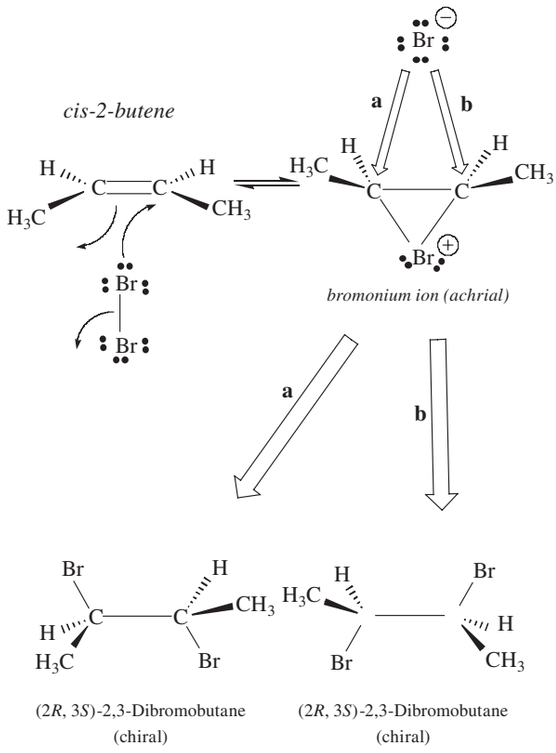




(2*R*, 3*S*)-2,3-Dibromobutane (meso)

(2*R*, 3*S*)-2,3-Dibromobutane (meso)

The anti addition of a halogen to an alkene is stereospecific. *Trans*-2-butene reacts with bromine to yield chiral bromonium ions and bromide ions. Reaction at the other face (top) would give the enantiomer of the bromonium ion shown above. When the bromonium ions react by either pathway (**a** or **b**), they give the same meso compound, which is achiral. Note that reaction of the enantiomer of the intermediate bromonium ion would give the same result.



Conversely, *cis*-2-butene (choice **(E)**) reacts with bromine to give achiral bromonium ions and bromide ions (see below). Reaction at the other face of the alkene (top) would give the same bromonium ions. The bromonium ions react with the bromide ions by either pathway to yield a racemic mixture of the two enantiomers.

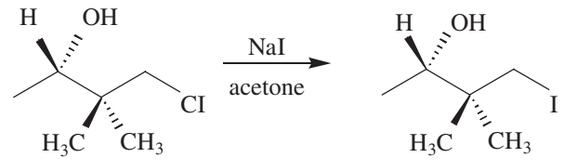
Choice **(C)** is incorrect because it does not undergo bromination to yield a product that contains a mirror plane of symmetry (meso compound). Choice **(D)** is incorrect because the product after bromination does not contain chiral centers.

95. (B)

Hydrogen always adds *cis* across a double bond so the hydrogenation of 1,2-dimethyl cyclohexene will give only the *cis* isomer, choice **(B)**. Choice **(A)** is incorrect because only one C–C bond is reduced in the process. This is an example of an addition reaction; one atom of hydrogen *adds* to each carbon of the double bond. The resulting product is an alkane. Without a catalyst the reaction does not take place at an appreciable rate.

96. (B)

The reagents given (sodium iodide in acetone) are typical for a reaction proceeding by the S_N2 mechanism. Bimolecular (S_N2) substitutions proceed with inversion of configuration; however, in this problem, the leaving group is not attached to the stereogenic center.



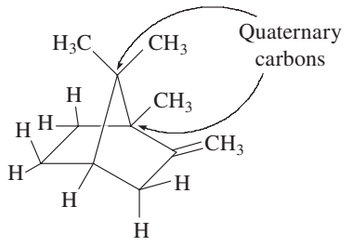
As a result, the product will have the same absolute configuration as the starting material (S). Therefore, the correct answer is choice **(B)**. Choice **(A)** is incorrect because the stereochemistry of the stereocenter is inverted. Choice **(C)** is incorrect because racemization accompanies S_N1 reactions, not S_N2. Choice **(D)** is incorrect because the product retains its stereogenic center and is chiral. Similarly, choice **(E)** is incorrect because the product does not contain a mirror plane of symmetry.

97. (D)

A large value of K_a (acidity constant) means that the acid is strong, while a small value of K_a means the acid is weak. There is an inverse relationship between the magnitude of pK_a and the strength of the acid, thus a small pK_a corresponds to a strong acid (choice **(A)** is incorrect). The conjugate base of a strong acid is a weak base, not a strong one, so choice **(B)** is also incorrect. Since the pK_a's of acids are commonly measured relative to water as the base, strong acids can indeed have negative pK_a's. Choice **(D)** is, therefore, the correct answer. Choice **(C)** is incorrect because acid-base reactions always favor formation of a weak base if a strong acid is present, and a strong base if a weak acid is present. By definition, a Bronsted–Lowry acid is a substance that can donate a proton. Hydrogen must be present in a Bronsted–Lowry acid, so choice **(E)** is also incorrect.

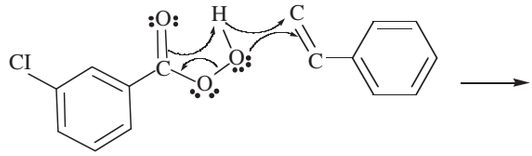
98. (C)

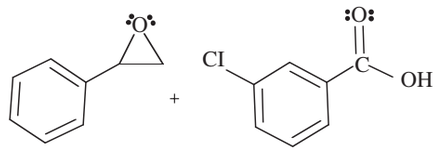
A quaternary carbon is one which bears four substituted groups (non-hydrogen). From the structure of the compound, only two of the carbon atoms bear four alkyl groups. Choice **(C)** is the correct answer.



99. (C)

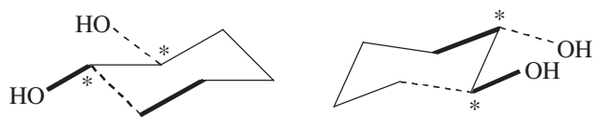
The OH group in peroxycarboxylic acids contains an electrophilic oxygen. Therefore, peroxycarboxylic acids react with alkenes by adding the electrophilic oxygen to the double bond to form oxacyclopropanes. The other product of the reaction is a carboxylic acid. The transfer of the oxygen is stereospecifically *cis*, the stereochemistry of the starting alkene being retained in the final product. The mechanism of this oxidation (called epoxidation) involves a cyclic transition state in which the peroxy carboxylic acid proton is transferred to its own carbonyl group at the same time as the electrophilic oxygen is added to the pi bond.



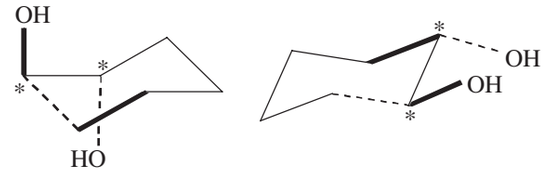


100. (A)

The first step to solving this problem is determining whether the connectivity is the same in the two compounds, as they are both 1,2-dihydroxy cyclohexane. Therefore, they are definitely not constitutional isomers [eliminate choice **(B)**]. Visual assessment tells us that cyclohexane is in the chair conformation in each compound, so choice **(E)** is also incorrect.



Each molecule contains two chiral centers (*), so choices **(A)**, **(C)**, and **(D)** are possible answers. Examination of the positions of the hydroxyl groups, however, tells us that the molecules are identical [choice **(A)** is correct]. In each case, both hydroxyl groups are in the equatorial positions (note the parallel dashed and bold lines). If any of the hydroxyls were in axial positions, they would be pointed downward and upward instead of parallel to the C–C bond "once removed."



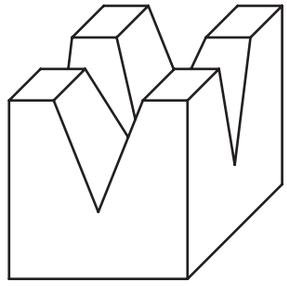
PERCEPTUAL ABILITY TEST

ANSWER KEY

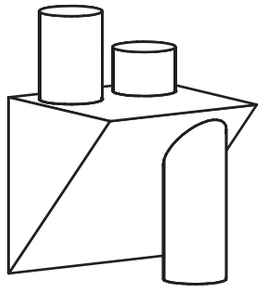
1. (A)	16. (B)
2. (E)	17. (D)
3. (C)	18. (A)
4. (A)	19. (E)
5. (B)	20. (C)
6. (B)	21. (E)
7. (A)	22. (D)
8. (C)	23. (D)
9. (C)	24. (D)
10. (A)	25. (A)
11. (D)	26. (C)
12. (A)	27. (C)
13. (D)	28. (B)
14. (B)	29. (B)
15. (C)	30. (D)

PERCEPTUAL ABILITY TEST

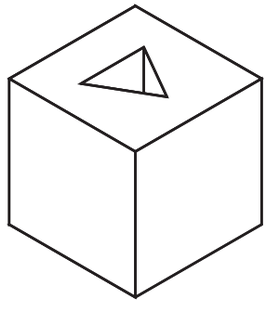
6. (B)



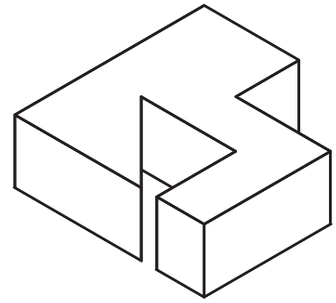
7. (A)



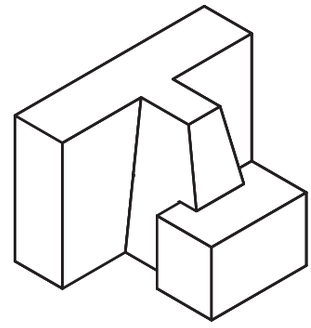
8. (C)



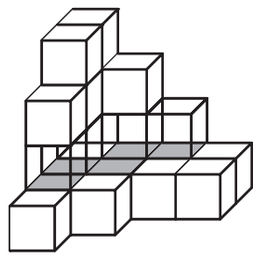
9. (C)



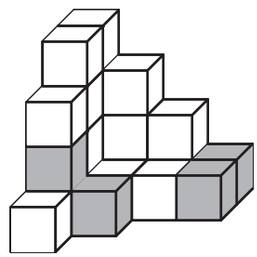
10. (A)



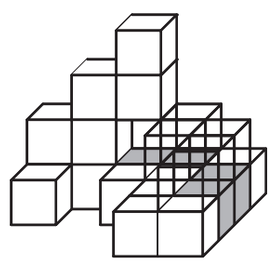
21. (E)
One side varnished (5 cubes):



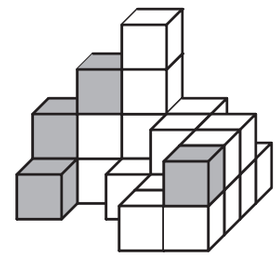
22. (D)
Three sides varnished (4 cubes):



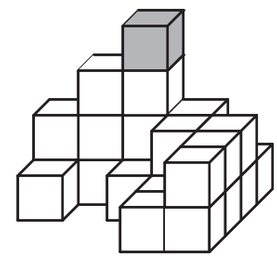
23. (D)
One side varnished (4 cubes):



24. (D)
Four sides varnished (4 cubes):



25. (A)
Five sides varnished (1 cube):



READING COMPREHENSION

ANSWER KEY

1. (D)	8. (A)	15. (E)	22. (A)	29. (C)
2. (B)	9. (E)	16. (C)	23. (D)	30. (C)
3. (E)	10. (D)	17. (D)	24. (A)	31. (B)
4. (A)	11. (B)	18. (B)	25. (B)	32. (E)
5. (B)	12. (B)	19. (E)	26. (B)	33. (A)
6. (C)	13. (A)	20. (D)	27. (A)	34. (E)
7. (B)	14. (C)	21. (B)	28. (E)	

READING COMPREHENSION

1. (D)

In MG, autoantibodies bind the active site of the AChR where ACh normally binds (competitive binding). They do not bind the ion channel.

2. (B)

MG is an autoimmune disease and, as such, could theoretically be treated by suppressing the level of activation of the immune system. Increasing the outflow of calcium pre-synaptically would not address the main problem in MG; furthermore, it may decrease the release of ACh from vesicles in the motor neuron. You could increase the transcription (production) of AChR in the hopes of expressing more AChR, but this would not best address the immune dysregulation in MG; the AChR and the post-synaptic membrane would still be attacked. Also, the passage mentions that there already exists a high-density of AChR on the membrane. Increasing the activity of acetylcholinesterase would only work to decrease the amount of ACh available at the NMJ. Finally, increasing the threshold for action potential at the motor end plate would make it harder for signals to be transmitted under any condition.

3. (E)

Transmission of signals at the NMJ is *always* blocked in MG, for this is the defining characteristic of the disease. The other choices may or may not be features of the disease. The passage states that autoantibodies are present in the serum of *most* patients. Progression of the disease may be slow or fast; some patients do not have rapid involvement of the respiratory muscles. The passage states that 75 percent of the individuals with MG also have disease of the thymus. Lastly, while the disease often does start with ocular abnormalities, it may present with different symptoms, as well.

4. (A)

The order of the events is as follows: (1) action potential is propagated in the motor neuron; (2) calcium influx; (3) vesicle fusion; (4) release of ACh with diffusion across the synapse; (5) binding of ACh to its receptor with ensuing opening of Na channels in the receptor; leading to (6) membrane depolarization.

5. (B)

T cells mature in the thymus. Privileged sites harbor cryptic antigens and ignorant lymphocytes and try to keep activated immune cells out. Examples of such sites mentioned in the passage are the brain and testes.

6. (C)

Exposure to normally sequestered self-antigen is a form of endogenous autoreactivity, while the other options are those mentioned in the passage as exogenous sources.

7. (B)

The passage mentions myoid cells in the thymus as the possible source of autoantigen in MG. B cells are the source of antibodies but are not thought to be specifically involved in initiating the autoimmune process. The motor neuron itself is not directly affected by the MG immune attack. Specific CD4+ T cells, not CD8+ T cells, have been shown to transfer the disease in some animal models, providing evidence of a role for these cells in the autoimmune process. Anergic cells are characteristic players in the normal tolerant individual and help to prevent autoimmunity, not instigate it.

8. (A)

According to the passage, the bungarotoxin studies helped to demonstrate the high density of AChR on the post-synaptic membrane.

9. (E)

Cross-reactivity with bacterial proteins following an infection is actually a cause of autoimmune phenomena. All of the other options were listed in the passage as processes believed to be involved in maintaining self-tolerance.

10. (D)

The passage says that the antibodies demonstrated at the NMJ are IgG type, not IgM. The other options are all listed as ways that the number of AChR is reduced on the post-synaptic membrane.

11. (B)

The passage states that the clonal deletion theory was abandoned for a more comprehensive model once post-infectious, self-limited autoimmune phenomena were documented.

12. (B)

All of the statements are true except for **(B)**—75% of those with MG have disease of the thymus, not 50%.

13. (A)

When enough ACh binds AChR on the post-synaptic membrane, the membrane is depolarized, and an action potential is generated. This binding occurs on the post-synaptic membrane (not pre-), and involves the influx of sodium ions. Acetlycholinesterase then hydrolyzes unbound ACh to assist in clearing it from the area of the NMJ.

14. (C)

As mentioned in the passage, the thymus is thought to play a major role in autoimmune MG.

15. (E)

As mentioned in the passage, ACh is normally synthesized and stored in vesicles at the motor nerve terminal.

16. (C)

Electron microscopic immunocytochemistry demonstrates the presence of both IgG and the complement "attack complex" at the NMJ.

17. (D)

In some experimental models of MG, the disease can be transferred to normal animals with AChR –specific CD4+ T cells.

18. (B)

James Cleaver cultured cells from people with XP, a disease characterized by exquisite sensitivity to UV rays, a.k.a. sunlight.

19. (E)

Photoreactivation is a method of direct reversal of dimerization due to UV radiation. It is common to yeast, *E. coli*, and some species of plants and animals, but is not found in humans.

20. (D)

Damage to DNA often distorts the DNA strand such that further replication and transcription are hindered if there is no repair. When damage is so severe that repair is ineffective, a cell may initiate the process of programmed cell death to protect against the accrual of dangerous mutations. Otherwise, an un-repaired mutation may lead to accumulation of other mutations that result in the deregulation of the cell cycle that leads to cancer. Conversely, proper repair of DNA preserves the integrity of the genome.

21. (B)

The cyclobutane ring joins pyrimidines that are adjacent on the same strand of DNA when cells are exposed to UV radiation. It results from UV light exposure but is not a component of UV light. Photoreactivation is the mechanism for reversing this type of damage in yeast and *E. coli*; there is a different mechanism employed by humans. However, the damage is the same in all cell types (dimerization) regardless of the repair mechanism. Individuals with XP are extraordinarily susceptible to the damaging effect of UV radiation because of mutations in the genes normally involved in repairing pyrimidine dimers; XP is not due to mutation of cyclobutane itself.

22. (A)

The first sentence of the second paragraph states that the most efficient method of repair of common types of damage is direct reversal of the damage. The passage then gives two examples of such reversible damage: pyrimidine dimers and guanine methylation. Methylation of a guanine residue results in damage to a single base and can be directly repaired using the enzyme methylguanine methyltransferase.

23. (D)

Cleavage of pyrimidine dimers is the mechanism of direct repair known as photoreactivation. Photoreactivation never occurs in humans. On the other hand, human repair of pyrimidine dimers involves the XP proteins that participate in dimer recognition, DNA unwinding, DNA cleavage, and excision of an oligonucleotide.

24. (A)

HNPCC affects one in 200 people. This represents a prevalence (expressed as a percentile) of 0.5%.

25. (B)

MutS and *MutL* are involved in mismatch repair, which is a repair mechanism that acts as a back-up to the proofreading of DNA polymerase.

26. (B)

In the discussion of mismatch repair, the passage mentions that *E. coli* are able to distinguish the new DNA strand from the parental strand by the presence of methylated adenine residues within the parental strand. When there is a mismatch, it is the aim of the repair system to correct the mistake in the newly synthesized strand, which is represented by the un-methylated strand in *E. coli*.

27. (A)

The nucleotide-excision repair system acts to remove an oligonucleotide, as opposed to the removal of a single base in base-excision repair. The passage presents the XP proteins as components of this system in humans, which results in the excision of a 30-base long oligonucleotide. This process involves the 3' and 5' nucleases, *XPF* and *XPG*, not the AP endonuclease used in base-excision repair.

28. (E)

The key point here is that proofreading by DNA polymerase during DNA replication is the first line of defense against DNA damage; it is the first attempt at DNA repair when there is a mismatch. The other choices listed are elements of post-replication recovery. Choices **(A)** through **(C)** represent (or state) homologous recombination, while choice **(D)** represents the effort to secure genomic integrity for the organism by deleting a unsound cell.

29. (C)

Coupling of nucleotide-excision repair (not base-excision repair) with transcription was demonstrated in experiments involving both mammalian cells and *E. coli*. These experiments revealed that DNA being actively transcribed is repaired more quickly than is non-transcribed DNA. In *E. coli* alone, this was found to involve RNA polymerase recognition. Nowhere does it state that repair actually initiates DNA transcription, but merely that the two processes are connected. Earlier in the passage, the ability of *E. coli* to reverse UV-induced pyrimidine dimers is discussed, but this mechanism is not found in mammalian cells.

30. (C)

Both XP and HNPCC are characterized by deficiencies in systems meant to repair DNA before the completion of replication (pre-replication repair). XP results from a failure of nucleotide-excision repair, while HNPCC results from a failure of mismatch repair. Only nucleotide-excision repair is both involved in fixing the pyrimidine dimers attributable to UV radiation, and coupled to transcription. While XP is a relatively rare disease, occurring in one in 250,000 people, HNPCC is much more common, occurring in one in 200.

31. (B)

As stated in paragraph 8 of the passage, *XPB* and *XPD* proteins are subunits of the basal transcription factor TFIIH.

32. (E)

In recombinational repair, the undamaged strand of parental DNA undergoes homologous recombination to fill the gap in the daughter molecule opposite the site of damage. This is mentioned in paragraph 10 of the passage.

33. (A)

As stated in the passage (paragraph 7), the *XPA* protein recognizes damaged DNA. The *XPB* and *XPD* proteins complex with *XPA* and unwind the region surrounding the damaged DNA. *XPF*, a 5' nuclease, and *XPG*, a 3' nuclease, are then recruited to cleave the 5' and 3' sides of the damaged site, respectively.

34. (E)

Both *E. coli* and mammalian cells have mechanisms for recognizing the parental DNA strand. Mismatch repair in *E. coli* differs from mismatch repair in mammalian cells in that *E. coli* recognizes the parental DNA strand by the presence of methylated adenine, while mammalian cells recognize the parental DNA strand by the presence of single-strand breaks in newly replicated DNA. This distinction is noted in paragraph 9 of the passage.

QUANTITATIVE REASONING

ANSWER KEY

1. (D)	6. (A)	11. (D)	16. (E)
2. (C)	7. (E)	12. (E)	17. (B)
3. (B)	8. (A)	13. (C)	18. (A)
4. (E)	9. (A)	14. (C)	19. (D)
5. (D)	10. (B)	15. (B)	20. (D)

QUANTITATIVE REASONING

1. (D)

First, group the numbers 3.4 and 8 together and group the powers 10^8 and 10^{-5} together. Then, $3.4 \times 10^8 \bullet 8 \times 10^{-5} = (3.4 \times 8) \times (10^8 \times 10^{-5})$. Now $3.4 \times 8 = 17.2$. To work with $10^8 \times 10^{-5}$, you need to know the following law of exponents: Whenever you multiply powers with the same base, you add the exponents. Algebraically, $b^x \bullet b^y = b^{x+y}$. So, $10^8 \times 10^{-5} = 10^{8+(-5)} = 10^{8-5} = 10^3$. So $3.4 \times 10^8 \bullet 8 \times 10^{-5} = 27.2 \times 10^3$. This matches none of the answer choices; however, each answer choice contains 2.72. Let us divide the 27.2 by 10 in order to obtain 2.72; to keep the value of 27.2×10^3 the same, multiply 10^3 by 10:

$$27.2 \times 10^3 = \left(\frac{27.2}{10}\right) \times (10^3 \times 10)$$

$$= \left(\frac{27.2}{10}\right) \times (10^3 \times 10^1)$$

$$= 2.72 \times 10^{3+1}$$

$$= 2.72 \times 10^4.$$

This is answer choice **(D)**. The last step is a useful trick to remember when you need to shift the decimal place when using scientific notation.

2. (C)

The perimeter of a square is 4 times the length of a side. To find the perimeter, we need the length of a side of the square. We are given the area of the square: 4,900. The area of a square is the length of a side squared. If we call the length of a side s, then $s^2 = 4{,}900$. Taking the square root of both sides, $s = 70$. Since lengths are nonnegative, we do not work with the value $s = -70$. Since the length of side is 70, the perimeter of the square is answer choice **(C)**.

3. (B)

A quick way to answer this question is to look at the decimal equivalents of the fractions. $\frac{7}{10}$ has a decimal representation with just one digit to the right of the decimal point while the other four of these fractions have infinite repeating decimal equivalents. Perform long division on the remaining four fractions, writing down only the digits to the right of the decimal point in the decimal equivalents of the fractions that will enable you to make the comparison:

$\frac{7}{10} = 0.7$

$\frac{20}{23} = 0.8\ldots$

$\frac{5}{7} = 0.7\ldots$

$\frac{27}{35} = 0.7\ldots$

$\frac{25}{33} = 0.7\ldots.$

The fraction $\frac{20}{23}$ is greater than 0.8 whereas the other four fractions are less than 0.8. The correct answer is choice **(B)**.

4. (E)

Since the ratio of juniors to seniors is 9 to 14, we can write the ratio of seniors to the total number of people as 14 to (9 + 14) = 23. Consequently, $\frac{14}{23}$ of the students present are seniors:

$$\frac{14}{23}(1{,}840) = 14 \times 80 = 1{,}120$$

Therefore, answer choice **(E)** is correct.

5. (D)

Before substituting the values, the expression $c \div \frac{3}{d}$ can be rearranged. Remember that when you divide by a fraction, you invert the fraction and multiply. So $c \div \frac{3}{d} = c \times \frac{d}{3} = \frac{1}{3}cd$.

Now we can make the substitutions. We are told that $c = \frac{16}{15}$ and $d = \frac{75}{30}$. Notice that $\frac{75}{30}$ can be reduced to $\frac{5}{2}$.

Now substitute $\frac{16}{15}$ for c and $\frac{5}{2}$ for d:

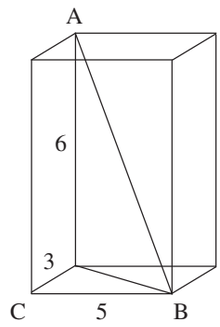
$$c + \frac{3}{d} = \frac{1}{3}cd = \frac{1}{3} \times \left(\frac{16}{15}\right) \times \left(\frac{5}{2}\right) = \frac{1}{3} \times \frac{8}{3} \times \frac{1}{1} = \frac{8}{9},$$

which is choice **(D)**.

6. (A)

$\frac{100}{4} = 25$ and $\frac{85}{5} - \frac{72}{6} + \frac{56}{8} = 17 - 12 + 7 = 12$. So the real question is, 12 is what percentage of 25? A percentage is just a fraction. Once we have the fraction, we can then convert that fraction to a percentage. To convert the fraction $\frac{12}{25}$ to a percentage, multiply that fraction (or decimal) by 100%. So $\frac{12}{25} = \frac{12}{25} \times 100\% = 12 \times 4\% = 48\%$. Therefore, the answer is **(A)**.

7. (E)



In the drawing above, the length of line segment *AB* is an instance of the greatest possible distance between any two corners. Let's find the length of *AB*. In right triangle *ADB* side *AB* is the hypotenuse and sides *AD* and *DB* are the legs. We know that *AD* has a length of 6. We need the length of *DB* in order to be able to find the length of *AB*. Now, triangle *BCD* is also a right triangle. In this right triangle, leg *DC* has a length of 3 and leg *CB* has a length of 5, and *DB* is the hypotenuse. We can use the Pythagorean theorem: $DB^2 = DC^2 + CB^2$, $DB^2 = 3^2 + 5^2$, $DB^2 = 9 + 25$, $DB^2 = 34$, and $DB = \sqrt{34}$. Since lengths are nonnegative, we do not work with the value $DB = -\sqrt{34}$. Now that we know the lengths of legs *AD* and *DB* in right triangle *ADB*, we can use the Pythagorean theorem to find the length of hypotenuse *AB*. We know that $AD = 6$ and $DB = \sqrt{34}$. So we have that $AB^2 = AD^2 + DB^2$, and then $AB^2 = 6^2 + \left(\sqrt{34}\right)^2$, $AB^2 = 36 + 34$, and $AB^2 = 70$. So, $AB = 70$.

Whenever you are asked to find the diagonal of a rectangular prism (like the one in this question), you should feel free to use the "extended" Pythagorean theorem. In this case, $AB^2 = AD^2 + BC^2 + CD^2 = 6^2 + 5^2 + 3^2 = 36 + 25 + 9 = 70$. So, $AB = \sqrt{70}$.

8. (A)

In distance, rate (or speed), and time problems, we use the formula Distance = Rate × Time. It will be convenient to work with this formula in the forms Rate = $\frac{\text{Distance}}{\text{Time}}$ and Time = $\frac{\text{Distance}}{\text{Rate}}$ when solving this problem.

It is important to keep in mind that the average speed for an entire trip is always the total distance divided by the total time. Never take the average of the speeds. In this question, a greater amount of time was spent traveling the first half of the distance from Town A to Town B at an average speed of 48 miles per hour than was spent traveling the second half of the distance from Town B to Town A at the greater average speed of 96 miles per hour. So, the average speed (in miles per hour) must be closer to 48 than to 96—it must be less than $\frac{48 + 96}{2}$. Just realizing this enables you to eliminate choices **(C)**, **(D)**, and **(E)**.

One way to solve this problem is to pick a value for the distance between Towns A and B. Always pick a number that is easy to work with. Here, we should pick a number that is a multiple of 48 and 96. Let's use 96 for the distance in miles between the towns. Let's now state what the total distance traveled is. We know that 96 miles were traveled when going from Town A to Town B and 96 miles were traveled when going from Town B to Town A. So, the total distance traveled was 192 miles. Now let us find the total time traveled. The time taken to travel from Town A to Town B was $\frac{96 \text{ miles}}{48 \text{ miles per hour}}$, which is $\frac{96}{48} = 2$ hours. The time taken to travel from Town B to Town A was $\frac{96 \text{ miles}}{96 \text{ miles per hour}} = 1$ hour. The total time traveled was 2 + 1 = 3 hours. The total distance traveled was 192 miles, so the average speed for the round trip was $\frac{192 \text{ miles}}{3 \text{ hours}} = 64$ miles per hour, answer choice **(A)**.

9. (A)

When the product of a group of numbers does not equal 0, none of the numbers can equal 0. Here the product of $x + 4v$, $y - 5 + wz$, and v is not 0. So, $x + 4v$, $y - 5 + wz$, and v all cannot equal 0. Since v cannot equal 0, choice **(A)** is correct. At this point, you should move on to another question.

When you see multiple numbers multiplied together and are asked to think about whether any of them might be zero, remember: if $abc \neq 0$, then $a \neq 0$, $b \neq 0$, and $c \neq 0$.

10. (B)

Begin by solving the inequality $7x + 12 < 5x - 16$ for x.

$$7x + 12 < 5x - 16$$

Subtract 5x from both sides: $2x + 12 < -16$

Subtract 12 from both sides: $2x < -28$

Divide both sides by 2: $x < -14$.

Looking at the answer choices, we see that choice **(B)** is −14.

11. (D)

Use the fact that $\sin(x + \pi) = -\sin x$.

Here, $\sin\frac{8\pi}{7} = \sin\left(\frac{7\pi + \pi}{7}\right) = \sin\left(\frac{\pi + \pi}{7}\right) = -\sin\frac{\pi}{7}$.

You will want to have a handle on the basic properties of sin, cosine, and tangent by Test Day.

12. (E)

Solve the equation $y = \frac{4x - 5}{3x + 7}$ for x in terms of y:

$$y = \frac{4x - 5}{3x + 7}$$

Multiply both sides by $3x + 7$: $y(3x + 7) = 4x - 5$

Multiply out the left side: $3xy + 7y = 4x - 5$

Subtract $4x$ from both sides: $3xy + 7y - 4x = -5$

Subtract $7y$ from both sides: $3xy - 4x = -7y - 5$

Factor out an x from the left side: $x(3y - 4) = -7y - 5$

Divide both sides by $3y - 4$: $x = \frac{-7y - 5}{3y - 4}$.

None of the answer choices is $x = \frac{-7y - 5}{3y - 4}$. However, if we multiply the numerator and denominator of $x = \frac{-7y-5}{3y-4}$ by -1, we have $x = \frac{-7y-5}{3y-4} = \frac{(-7y-5)\times(-1)}{(3y-4)\times(-1)} = \frac{7y+5}{-3y+4} = \frac{7y+5}{4-3y}$, which is choice **(E)**.

Remember that when you are solving for one variable in terms of another, your goal is always to isolate the variable you are solving for.

13. (C)

The absolute value of a number is the distance of that number from 0 on the number line. It is also the number without its sign. For example, $|-4| = 4$ and $|12| = 12$. Indeed, to look at these examples in a way that will help us remember that the absolute value of a number is the number without its sign, let's also say that $|-4| = 4$ and $|12| = 12$.

Now, let's look at the expression that we want to simplify:

$$\frac{|7 - 35| + 4|2 \times 3 - 1|}{|12 - 30| - |7 - 3|}.$$

First, simplify what is inside each absolute value symbol:

$$|7 - 35| = |-28|$$

$$|2 \times 3 - 1| = |6 - 1| = |5|$$

$$|12 - 30| = |-18|$$

$$|7 - 3| = |4|$$

So $\frac{|7 - 35| + 4|2 \times 3 - 1|}{|12 - 30| - |7 - 3|} = \frac{|-28| + 4|5|}{|-18| - |4|}$

Now, use the definition of the absolute value symbol.

$$|-28| = 28$$

$$|5| = 5$$

$$|-18| = 18$$

$$|4| = 4$$

So, $\frac{|-28| + 4|5|}{|-18| - |4|} = \frac{28 + 4(5)}{18 - 4} = \frac{28 + 20}{14} = \frac{48}{14} = \frac{24}{7}$,

and choice **(C)** is correct.

You do not need to write out all these steps the way this was done here. The better you get at absolute values, the more quickly you'll be able to work through more complicated problems like this one.

14. (C)

Call David's age, D and Jane's age, J. Since Jane's age is $2\frac{1}{2}$ times David's age, we have that $J = 2\frac{1}{2}D$, or $J = \frac{5}{2}D$. "In 15 years Jane's age will be twice David's age" is translated into $J + 15 = 2(D + 15)$. Be careful when translating from English to algebra—make sure you understand exactly what everything means. Now, we have the two equations: $J = \frac{5}{2}D$ and $J + 15 = 2(D + 15)$. It looks like substituting $\frac{5}{2}D$ for J would lead to an easier equation to solve. Now, substituting $\frac{5}{2}D$ for J into the equation $J + 15 = 2(D + 15)$, we have that $\frac{5}{2}D + 15 = 2(D + 15)$. Now, solve this equation for D:

$\frac{5}{2}D + 15 = 2(D + 15)$.

Multiply out the right side: $\frac{5}{2}D + 15 = 2D + 30$.

Subtract $2D$ from both sides: $\frac{1}{2}D + 15 = 30$.

Subtract 15 from both sides: $\frac{1}{2}D = 15$.

Multiply both sides by 2: $D = 30$.

David's age is 30. We want Jane's age 8 years ago. Let's first find Jane's age now and then subtract 8 from that. Let's use the equation $J = \frac{5}{2}D$ to find Jane's current age: since $D = 30$, $J = \frac{5}{2}D = \frac{5}{2}(30) = 5(15) = 75$. As Jane's current age is 75, Jane's age was eight years ago. The correct answer is choice **(C)**.

Notice how the wrong answer choices are traps. If you added 8 to 75 by accident, answer choice **(E)** was waiting for you; and if you mistakenly used Jane's current age, you chose choice **(D)**. If you used David's current age, you chose choice **(A)**. On math questions, always be sure to solve for exactly what the question is asking for.

15. (B)

First find the values of $a^2 + b^2$ and $3a + b$ when $a = 8$ and $b = 4$ and then find what percent $3a + b$ is of $a^2 + b^2$. When $a = 8$ and $b = 4$, $a^2 + b^2 = (8)^2 + (4)^2 = 64 + 16 = 80$ and $3a + b = 3(8) + (4) = 24 + 4 = 28$. All that remains to be done is to answer the question "28 is 80 percent of what number?" Let's find what fraction 28 is of 80 and then convert that fraction to a percent. $\frac{28}{80}$ can be reduced to $\frac{7}{20}$ by dividing the numerator and denominator by 4. Now convert $\frac{7}{20}$ to a percent: $\frac{7}{20} \times 100\% = 7 \times 5\% = 35\%$. Choice **(B)** is correct.

16. (E)

Solve the equation $\sqrt{2\left(\frac{5}{x+3}\right)} = 10$ for x.

$\sqrt{2\left(\frac{5}{x+3}\right)} = 10$.

Square both sides: $\left[\sqrt{2\left(\frac{5}{x+3}\right)}\right]^2 = 10^2$.

Simplify both sides: $2\left(\frac{5}{x+3}\right) = 100$.

Divide both sides by 2: $\frac{5}{x+3} = 50$.

Subtract 3 from both sides: $\frac{5}{x} = 47$.

Multiply both sides by x: $5 = 47x$.

Divide both sides by 47: $\frac{5}{47} = x$.

Thus $x = \frac{5}{47}$, and choice **(E)** is correct.

17. (B)

Let us begin by converting the 7,200 inches into feet. There are 12 inches in a foot, so there is $\frac{1}{12}$ of a foot in an inch. Then 7,200 inches = 7,200 inches $\times \frac{1 \text{ feet}}{12 \text{ inches}}$ $= \frac{7{,}200}{12 \text{ inches}} = 600$ feet.

Now, let's convert 600 feet into yards. Since a yard equals 3 feet, a foot equals $\frac{1}{3}$ of a yard. 600 feet = 600 feet $\times \frac{1 \text{ yard}}{3 \text{ feet}} = \frac{600}{3}$ yards = 200 yards.

18. (A)

When one of the 16 people is selected, 15 people remain that can then also be selected to join the committee. So, there are $16 \times 15 = 240$ different ways to select one person and then a second. However, a committee is made up of a pair of people. It does not matter if the committee is considered to be made up of person A and person B or made up of person B and person A. So we must divide 240 by 2 to find the number of possible committees. So, the number of possible committees is $\frac{240}{2} = 120$. The lesson to be learned: when counting the number of possible ways to do something, be sure not to double-count.

19. (D)

A line parallel to the y-axis is a vertical line, so every point on this line must have the same x-coordinate. Look for an equation that describes coordinate pairs always having the same x-coordinate. The equation $x = 14$ is an equation of a line that always has an x-coordinate of 14. Therefore, choice **(D)** is correct.

Answer choice **(A)**, $y = 14$, is a horizontal line, parallel to the x-axis. All the other answer choices are lines that are neither horizontal nor vertical.

20. (D)

To find the probability of two events occurring, multiply the probability of one event occurring by the probability of the second event occurring, given that the first event occurred. For a single event, we use the formula

$$\text{Probability} = \frac{\text{Number of favorable outcomes}}{\text{Number of possible outcomes}}.$$

Let's first consider the probability that the first coin chosen is gold. Here, there are 5 gold coins and a total of 5 + 1 = 6 coins. So, the number of favorable outcomes is 5, and the number of possible outcomes is 6. Consequently, the probability that the first coin chosen is gold is $\frac{5}{6}$. Now, let's find the probability of the second coin chosen being gold, given that the first coin chosen was gold. There are 4 gold coins remaining and a total of 5 coins remaining. The probability that the second coin chosen is gold *given that the first coin chosen is gold* is $\frac{4}{5}$. So, the probability that both coins chosen are gold is $\frac{5}{6} \times \frac{4}{5} = \frac{4}{6} = \frac{2}{3}$.