

Playoffs

Bee Semifinals

(1) Mixing borax and glue forms slime because the borax cross-links this type of molecule in the glue. These macromolecules make up materials like teflon, nylon, and rubber. PVC is one of these compounds, whose general name refers to the fact that they are made up of smaller subunits. These compounds are made up of repeating subunits, and are larger than oligomers. For the point, name these molecules made up of many monomers.

ANSWER: polymers

(2) This man proposed a thought experiment that would violate the Second Law of Thermodynamics by allowing entropy to decrease in a system via a door between two gas chambers opened and closed by a small, intelligent being. More notably, this scientist collected the work of Ampère, Faraday, and Gauss into a unified theory of electromagnetism. For the point, name this Scottish scientist who names a hypothetical “Demon” and the set of four electromagnetism equations.

ANSWER: James Clerk Maxwell

(3) This object was independently discovered by its namesake and Johann Listing. Paradromic rings are formed by cutting this object, and joining a pair of them together can form a Klein bottle. These non-orientable objects are chiral; that is, it will look different if a clockwise or counter-clockwise half-twist is made before the two ends of the rectangle are joined together to create this shape. For the point, name this one-sided surface.

ANSWER: Möbius strip (or Möbius band)

(4) This is the maximum number of electrons that can fit in a single orbital. Elements which form molecules with this many atoms are found in the mnemonic BrINCiHOF [Brinkle-hoff]. There are this many protons in an alpha particle. Alkaline earth metals contain this many valence electrons and are found in this numbered column of the periodic table. Oxygen requires this many extra electrons to have a full octet. For the point, give this number, the atomic number of helium.

ANSWER: two

(5) “Twotinos” exist at the far outer edge of this region, orbiting with a period of 330 years in an orbital resonance with the nearest planet. Cubewanos also orbit within this region, which is defined as between 30 and 55 astronomical units from the Sun. Bodies like Haumea, Makemake, and Pluto lie beyond Neptune in, for the point, what disc-shaped region of space beyond the solar system’s planets that is far smaller than the Oort Cloud?

ANSWER: Edgeworth-Kuiper [ky-per] Belt

(6) This disease is caused by a point mutation where a glutamic acid is changed to a valine. This disease, which can cause spleen enlargement, inhibits oxygen transfer by reducing hemoglobin's ability to bind to blood cells. This recessive disease causes blockages in veins, but does provide some immunity to malaria. For the point, name this genetic disease, most frequent among people of African origin, that affects the shape of red blood cells.

ANSWER: sickle cell anemia

(7) Gas deposits in one form of this mineral turn it "milky," and other impurities in this mineral are classified as "smoky" or "rose." Pierre Curie discovered that this mineral is piezoelectric [PYE-ah-zoh-"electric"], and it is commonly found inside geodes. After feldspar, this is the second-most common mineral in the Earth's crust, and it comes in varieties like chalcedony, onyx, citrine, and amethyst. For the point, name this silicon dioxide-based mineral, used to define 7 on the Mohs scale of hardness.

ANSWER: quartz (accept milky, smoky, or rose quartz; accept any of the four named varieties before they are mentioned)

(8) Marian Smoluchovsky proposed that this phenomenon could power a ratchet-and-pawl system as a perpetual motion machine. This phenomenon can be described mathematically as a Wiener process, and it forms a fractal-like curve. This process was first discovered while its namesake was observing the movement of pollen grains in water. For the point, name this seemingly random type of motion of particles in fluids.

ANSWER: Brownian motion

(9) Forms of this mineral include crocidolite, its blue form, and chrysotile, the most commonly used form. According to legend, Charlemagne owned a tablecloth made of this material which was cleaned by throwing it in the fire. This friable material is used in Bunsen burner mats, even though inhalation of the dust of this substance is linked to mesothelioma. For the point, name this substance whose long, white fibers are still used in building insulation even though they are strongly linked to lung cancer.

ANSWER: asbestos

(10) These structures are arranged in a corolla, whose elongation into a tube was studied by Charles Darwin. These structures are accompanied in the perianth by protective green sepals. Monocots usually have these structures in multiples of three, while dicots have either four or five. For the point, name these structures of a flower that promote plant reproduction by providing bright colors to attract pollinators.

ANSWER: petals

(11) D'Alembert's Principle allows the omission of certain inertial components from these diagrams. One of these diagrams with an arrow pointing straight down and another pointing perpendicularly out of a ramp can be used to demonstrate static friction. An object remains at rest when the sum of the vectors on this depiction is zero; those arrows frequently stand for tension and gravity. For the point, name these diagrams that show all of the forces on an object.

ANSWER: free body diagram (accept force diagram before the word "forces" is read)

(12) After this scientist chaired the committee that organized *Voyager's* Golden Record, he requested that *Voyager 1* turn its camera around to take a picture of Earth from 6 billion kilometers away. This man then titled a book after that photograph, *Pale Blue Dot*. This man noted that galaxies are composed of “billions upon billions of stars” in a book and miniseries that was renewed under Neil DeGrasse Tyson in 2014. For the point, name this American astronomer who narrated *Cosmos*.

ANSWER: Carl Sagan

(13) One of these structures, the Farallon, broke up into ones named for Gorda, Juan de Fuca, and the Nazca. They meet at convergent or divergent boundaries, classified by the relative motion. At an underwater divergent boundary between these objects, seafloor spreading may occur. Orogeny can be caused when these bodies, which float on the asthenosphere, collide. For the point, name these large segments of the Earth's crust, whose movement causes earthquakes and the formation of mountains.

ANSWER: tectonic plates

(14) According to the Euclid-Euler [YOO-klid “oiler”] Theorem, there are exactly as many of these numbers as there are Mersenne prime numbers. Every known example of these numbers is even, but it's still unknown whether odd examples of these exist. The third-smallest of these numbers is 496, and numbers that are not this type or either “abundant” or “deficient.” For the point, name this type of number that is equal to the sum of its proper divisors, as seen in adding $1+2+3$ to give 6.

ANSWER: perfect number

(15) This statement was found by Mikhail Lomonosov during his attempts to disprove phlogiston theory. Antoine Lavoisier discovered this statement by reacting metals with oxygen in sealed containers. Modern formulations of this law must consider the central quantity's equivalence to energy. According to this principle, a chemical reaction in a closed environment should not change weight. For the point, name this principle which states that matter cannot be created or destroyed.

ANSWER: law of conservation of mass

(16) On a circuit diagram, these elements are represented by a triangle pointing into a bar. These circuit devices function by using a p-n junction composed of a semiconductor, like silicon. They make use of a depletion zone to prevent current from travelling from the cathode to the anode. For the point, name these circuit elements that only conduct electricity in one direction and which sometimes emit bright light as LEDs.

ANSWER: diodes (accept light-emitting diode or LED)

(17) A mathematician from this country names a formula simplifying exponentiation of complex numbers, and another names a “law of signs” that predicts how many real solutions a polynomial will have. The binomial coefficients are arrayed in a pattern named for another mathematician from this country; that triangle has 1's down both sides. The rectangular coordinate system was developed by a mathematician from, for the point, what home country of Abraham de Moivre [mwahv], Blaise Pascal, and René Descartes [day-CARt]?

ANSWER: France (for reference, the clues refer to de Moivre, then Descartes, then Pascal, then Descartes again)

(18) Some of these creatures possessed coats of pycnofibers similar to hair. These creatures had a patagium connective membrane, once confused for flippers, stretching between various sets of hollow bones. Archaeopteryx is believed to *not* be one of these creatures, but rather a separate transitional species between dinosaurs and modern birds. For the point, name these “winged lizards,” including Quetzalcoatlus, the first vertebrates known to be able to fly under their own power.

ANSWER: pterosaurs (accept pterodactyls)

(19) Overflowing Roche lobes in one of these systems can cause gases to accrete from the more massive to the less massive member. In one of these systems, the first discovered white dwarf orbits in an ellipse around the brightest star in the nighttime sky. Sirius AB is one of these systems in which a common barycenter is the center of mass for both components. For the point, name these systems consisting of two nearby stars affecting each others' orbits.

ANSWER: binary star system

(20) Copals are an intermediate stage in the formation of this substance. Within this substance, terpenes and alcohols serve as dehydrating agents, allowing the preservation of organic material. PCR can sometimes be used to amplify DNA found within this material, as done in science fiction films like *Jurassic Park*. For the point, name this type of fossilized resin in which plant or animal material is often preserved.

ANSWER: amber

(21) The rate of these systems is measured in Sverdrups. One of these systems is responsible for the mild winters in Nantucket. The Kuroshio is one of these systems that forms part of the North Pacific Gyre. The North Atlantic Drift extends one of these to Europe after it accelerates northward on the Eastern Seaboard. The Gulf Stream is a hundred-kilometer wide example of, for the point, what continuously flowing paths of water within an ocean?

ANSWER: ocean currents (or gyres before it is read)

(22) This behavior is exhibited by “divide and conquer” algorithms, as well as the Euclidean algorithm for finding GCDs. The definition of the factorial function as “n factorial equals n times “n minus 1 factorial”” exhibits this property, as does a sequence generated by the rule “multiply the previous term by 2.” For the point, name this circular behavior in which the rule for doing something references itself.

ANSWER: recursion (accept word forms like recursive behavior or recursive function)

(23) A Venturi meter uses this quantity to measure speed. This quantity is sometimes measured in units named for an Italian scientist who used it to study drain rates, Evangelista Torricelli. The speed of a fluid is related to this quantity by Bernoulli's equation. This quantity can be measured in millimeters of mercury, and the atmospheric type is gauged by a barometer. For the point, name this quantity that measures force per unit area.

ANSWER: pressure (accept air pressure)

(24) Nacreous clouds can exist in this region of the atmosphere, which experiences very little convection. Like the thermosphere, the temperature of this range increases with altitude. This layer lies immediately above the tropopause. The ozone layer is found in, for the point, what layer of Earth's atmosphere, found between the troposphere and mesosphere, the highest that can be reached by jet aircraft?

ANSWER: stratosphere

(25) The n th of these numbers is equal to the number of unique handshakes made by everyone in a room with n plus 1 people. The n th of these numbers can be found by multiplying n , n plus 1, and one-half. The sum of two consecutive examples of these numbers is always a square number, a result easily proven geometrically. For the point, name this type of number that can represent an arrangement of objects in a certain simple shape, the first four examples of which are 1, 3, 6, and 10.

ANSWER: triangular numbers (accept word forms of triangle; do not prompt on anything else)

(26) This system was the subject of the Great Debate conducted by Shapley and Curtis. This structure includes the Norma and Orion-Cygnus Arms, and the Great Rift and Coalsack are dark nebula regions formed by interstellar dust in this galaxy. This part of the Laniakea Supercluster is a barred spiral that is centered on Sagittarius A* [A-star], the nearest supermassive black hole to Earth. For the point, name this galaxy which is home to our solar system.

ANSWER: Milky Way (prompt on galaxy before mentioned)

(27) In these cells, the nodes of Ranvier are breaks in a layer of insulation where ion exchange can occur. Those nodes are found in the axon, a part of these cells that is protected by the myelin sheath, which degenerates in multiple sclerosis. These structures consist of a soma with branching dendrites, which pass chemical and electrical signals from across synapses into these structures. For the point, name these cells which perform the major work of the nervous system.

ANSWER: neurons (or nerve cells)

(28) This man introduced a coordinate system to maps in a work titled *Geography*, describing methods of projections later improved by Mercator. This man cataloged 48 known constellations and popularized the theory of epicycles describing planetary orbits in his book *The Almagest*. For the point, name this ancient Roman scientist from Alexandria whose geocentric model of the solar system was revolutionized by Copernicus.

ANSWER: Claudius Ptolemy

(29) The formation of this substance is called vitrification. Trinitite was a green example of this substance that formed after the Trinity nuclear test. This substance is drawn into wires to form optical fibers. This substance does not exhibit long-range order, so it is often considered an amorphous solid. This substance, which is commonly manufactured to be transparent, is primarily made from silicon dioxide. For the point, name this substance which can be made by applying heat to sand.

ANSWER: glass

(30) This function's value at one-half is said to be equal to the square root of pi, though that result is actually produced by the gamma function, which extends this function to non-positive integer inputs. This function at zero is defined as 1, in part because there is one way to order zero people in a line. This function at 10 is 3,628,800, and this function applied to 5 yields 120, or 5 times 4 times 3 times 2 times 1. For the point, name this mathematical function notated by an exclamation point.

ANSWER: factorial function (accept gamma function before it is read)

Bee Finals

(31) On this celestial body, Aeolis Mons rises within the Gale Crater. Acidalia Planitia dominates one of the 30 quadrangles that are used in a mapping of this planet. The tallest volcano in the solar system, Olympus Mons, is on this planet. A probe landing site on this planet was honorarily named Bradbury Landing shortly after the *Curiosity* rover began exploring it. For the point, name this planet orbited by Phobos and Deimos, the fourth planet from the Sun.

ANSWER: Mars

(32) One of this element's sulfates is gypsum, and one of its oxides is lime; each is commonly used in plaster. The decay of argon-40 into potassium-40 would be used in radioactive dating if this element's isotope 40 weren't such a common product of that decay. This element with twenty protons is a very common metal in the human body, due to its role in mineralizing bone. For the point, name this chemical element with atomic symbol Ca ["C A"], which is important for healthy teeth.

ANSWER: calcium (prompt on "Ca" before it is read)

(33) Telomerase lengthens the ends of these structures. Aneuploidy is the state of having an abnormal number of these structures, which are displayed in a karyotype. Down's syndrome is caused by the presence of a third copy of one of the 21st of these structures. Human cells have forty-six of, for the point, what structures, found in the nucleus, which contain an organism's DNA and whose subtypes include X and Y?

ANSWER: chromosomes (accept specific chromosomes before "Down's syndrome" is read; after that, accept chromosome 21)

(34) These phenomena are measured in Britain on a 0-to-11 scale that purely judges wind speed, in contrast with a common American scale that classifies these events based on their damage. That American scale runs from 0-to-5 and was "enhanced" in 2007. The Fujita scales measure the intensity of, for the point, what dangerous, swirling columns of air that commonly spawn from thunderstorms in an "Alley" in the Great Plains?

ANSWER: tornado

(35) This particle can accept a positron in one form of beta decay. Fission is caused by bombarding nuclei with these particles, causing more to be released in a chain reaction. James Chadwick won a Nobel Prize for his discovery of these particles, which are made up of one up and two down quarks. The presence of one of these particles differentiates deuterium from the more common form of hydrogen. For the point, name this chargeless particle found in atomic nuclei with protons.

ANSWER: neutrons

(36) This process fuels the proton-proton chain and the CNO cycle. Performing this process with elements heavier than iron requires energy, which is why it only happens in supernovas. Electrolysis of heavy water was once thought to achieve the “cold” form of this process. This process releases energy when performed on lighter elements, as when done with hydrogen to make helium. For the point, name this type of nuclear reaction in which atomic nuclei combine.

ANSWER: nuclear **fusion** (do not accept “fission”)

(37) A step in this cycle breaks a triple bond and is performed by rhizobia at nodules. An inflow in this cycle was drastically increased after the invention of the Haber-Bosch process. That process produces ammonia for use in explosives and, more crucially, fertilizer that directly affects this cycle. For the point, name this cyclical process in which an element is converted between molecular forms usable by plants and a diatomic gas that makes up the majority of the Earth’s atmosphere.

ANSWER: **nitrogen** cycle

(38) Gilbert Lewis proposed this rule from Richard Abegg’s observations, which supported his model that placed electrons in the vertices of a cube. This statement can be explained by the s and p orbitals fitting up to 2 and 6 electrons respectively. Noble gases besides helium are not reactive due to the fact that they already satisfy this rule. For the point, name this statement which says that atoms wish to have eight valence electrons.

ANSWER: **octet rule** (or **rule of eight** before “eight” is said at the end)

(39) Zeckendorf proved that every positive integer can be written as the sum of one or more numbers in this sequence, even if consecutive numbers are forbidden. Starting with the fifth term, every number in this sequence is the largest value in a Pythagorean triple. This specific case of a Lucas **[loo-kah]** sequence was inspired by a thought experiment involving rabbit breeding. As this sequence progresses, the ratio between its terms approaches the golden ratio. For the point, name this recursive sequence of numbers that begins “1, 1, 2, 3, 5.”

ANSWER: **Fibonacci** sequence

(40) This celestial body’s highest mountain is the Boösaule Montes. This satellite is internally heated by tidal forces, powering over four hundred active volcanoes on its surface. This body is the innermost of the Galilean moons, and it is larger than Europa but smaller than Callisto. For the point, name this third-largest moon of Jupiter, named after a lover of Zeus who was turned into a cow.

ANSWER: **Io**

(41) This technique is often performed with a column packed with silica. This technique was first used by botanist Mikhail Tsvet to analyze plant pigments. The distance that spots travel in this technique is based on how similar in polarity they are to a mobile and a stationary phase. A common setup for this experiment uses a piece of paper suspended above a solvent, which can be used to demonstrate whether an ink is made of one or more dyes. For the point, name this separation technique named for the fact that it commonly separates mixtures of colors.

ANSWER: **chromatography** (accept column **chromatography**; accept paper **chromatography**)

(42) This vesicle's lumen maintains a pH level between 4 and 5. Christian de Duve's Nobel was earned for discovering both peroxisomes and these organelles. Proteases [pro-tee-aces] and lipases are used in this structure, where autophagy, a form of natural cell death, takes place. Some vacuoles have been found to take part in this organelle's primary behavior. For the point, name this cellular organelle that breaks down cell waste.

ANSWER: lysosomes

(43) One type of this phenomenon is called a Foehn. This phenomenon creates regions called ergs, including the Chech in Algeria, and is also responsible for aeolian processes such as abrasive erosion. This meteorological phenomenon is measured by anemometers and is classified on the Beaufort scale, which tracks the motion of smoke, leaves, and objects. For the point, name this weather phenomenon consisting of moving air.

ANSWER: wind

(44) This man determined that the cube of the semi-major axis of an orbit is proportional to the square of its orbital period. He used Platonic solids in an explanation of heliocentrism in his *Mysterium Cosmographicum*. This assistant to Tycho Brahe inspired Newton's theory of universal gravitation with an explanation of Copernicus' work. For the point, name this German astronomer who described elliptical, rather than circular, orbits in the first of his three laws of planetary motion.

ANSWER: Johannes Kepler

(45) This quantity can be computed as the dot product of the force and velocity vectors. The decibel scale is defined with the logarithm of a ratio of two values for the acoustic form of this quantity. When moving a weight with a constant amount of this quantity, doubling the weight requires either doubling the time taken or cutting the distance in half. For the point, name this quantity that measures work done over time, which is measured in Watts or another scale based on horses.

ANSWER: power

Tiebreakers

(46) The determinant of a two-by-two matrix is equal to this quantity for the parallelogram formed by the vectors encoded in that matrix. The definite integral of a function can be interpreted as the net value of this quantity between that function's graph and the x -axis. Heron's formula can find this quantity for a triangle. For the point, name this quantity that expresses how much space a two-dimensional figure takes up, equal to s squared for a square with side length s .

ANSWER: area

(47) A gland that sits on top of this organ secretes aldosterone, which regulates sodium reuptake. The glomerular capillaries are adjacent to the Bowman's capsule of this organ. Nephrons perform the basic function of this organ, which is connected by ureters to the bladder. Patients with renal failure, or the failure of these organs, may undergo dialysis. For the point, name these bean-shaped organs that are used to remove waste products.

ANSWER: kidney

(48) Ken Mattingly was prevented from participating in this program due to German measles. Ed White, Roger Chaffee, and Gus Grissom died in what was retroactively deemed the first mission of this project. James Lovell commanded another mission in this program that suffered an oxygen tank explosion, less than a year after this program's goal was achieved by Buzz Aldrin and Neil Armstrong. For the point, name this NASA program that brought humans to the Moon.

ANSWER: **Apollo** program (accept Apollo 13; accept Apollo 1 after "Ed White" is said; accept Apollo 11 after "Buzz Aldrin" is said)

(49) This element's +1 ion oddly exists as two atoms bonded with a net +2 charge. A column of this element can be used to find atmospheric pressure, with 760 millimeters equaling one atmosphere. This element's most common ore is cinnabar, and mixtures of this element are called amalgams. This element, like alcohol, is sometimes placed in the bulb of a thermometer. For the point, name this toxic element, a liquid at room temperature, whose chemical symbol is Hg.

ANSWER: mercury (or Hg before mentioned)

(50) These geographical features are called meromictic when their layers don't mix; if that status persists, a limnic eruption may occur, as happened at Nyos in 1986. One of these bodies under Antarctica is named Vostok. Like basins, these features are called endorheic if they do not have an outflow, and the "oxbow" type of these structures is formed when a meander is cut off from a river. For the point, name these bodies of water, such as five "Great" ones in North America.

ANSWER: lakes (prompt on general descriptions of bodies of water; do not accept ponds or other specific types)