

National Science Bee Finals

Regulation Tossups

(1) **One of these structures in Iceland named Surtshellir is believed to be home to ghosts and the spirit of the fire giant Surtr. Speleothems uniquely found in these structures include so-called (+) shark teeth. Some varieties of these structures form when their namesake substance crusts over the top of an existing channel. (*) Skylights form in these structures after a crust formed from pāhoehoe flows solidifies and collapses. For the points, name these conduits that transfer the magma expelled by volcanoes beneath the surface.**

ANSWER: **Lava tube** (or **Pyroducts**; prompt on “Cave”; prompt on “Volcanic cave” or “Lava cave”)

(2) **Due to the electron’s lower cellular toxicity, a form of cancer therapy in accordance with this phenomenon utilizes electrons instead of alpha and beta particle emitters. A special case of this phenomenon is called the (+) Coster-Kronig transition, in which a vacancy within an atom is filled with an electron in a higher subshell. An atom undergoing this phenomenon loses an electron in its (*) innermost K shell. First discovered by Lise Meitner, this is, for the points, what effect that results from an emission of an electron, named after a French physicist?**

ANSWER: **Auger** Effect (or **Auger**-Meitner Effect; accept **Auger** Process; accept **Auger** Therapy)

(3) **These compounds are produced by the oxidation of arachidonic acid and essential fatty acid eicosapentaenoic acid by ALOX5. The slow reacting substance of anaphylaxis is composed of the Cysteinyl types of these compounds. The (+) B4 type of these compounds are primarily responsible for attracting neutrophils to areas of tissue damage. The asthma and allergic rhinitis drug (*) Singulair works by antagonistically competing for receptors for these compounds. For the points, name this family of eicosanoids whose overproduction causes asthma attacks by triggering smooth muscle contraction, which are named for their production in white blood cells.**

ANSWER: **Leukotrienes** (prompt on “Eicosanoids”; prompt on “Fats” or “Lipids”)

(4) **This man financed a Norwegian expedition to study North American ocean currents, which he recorded in a book with Johan Hjort titled *The Depths of the Ocean*. In the essay “The State of Ocean Science,” this man became the first scientist to document the (+) Mid-Atlantic Ridges and ocean trenches, which he labeled “deeps.” After succeeding (*) Charles Wyville Thomson, this man become responsible for the scientific reports for the *Challenger Expedition*. For the points, name this Canadian born Scottish scientist, the father of modern oceanography.**

ANSWER: Sir John **Murray**

(5) **Some of these compounds can be modified by using metal nodes in an unsaturated environment and altering the environment’s characteristics. These compounds’ 3-d structure can be modified through postsynthetic modifications such as (+) stratified synthesis. Ligands within these compounds are sometimes named struts and linkers and the formation of them is the focus of (*) reticular chemistry. When these compounds are isomorphic to zeolites, they are known as zeolitic imidazolate. For the points, name this porous coordination polymers characterized by possessing large numbers of voids.**

ANSWER: **Metal-Organic Frameworks** (or **MOFs**; prompt on “Organic Frameworks”)

(6) **The vertical portion of these systems are largely maintained through so-called “hot towers.” The return portion of these systems terminates at the Intertropical Convergence Zone. The (+) northern and southern examples of these systems are separated by a low pressure zone near the equator and bound by the west to east (*) subtropical jet streams. These systems were proposed to explain the trade winds by their namesake, an English lawyer. For the points, name this system that exchanges air in the tropics and subtropics.**

ANSWER: **Hadley** Cell (or **Hadley** Circulation)

(7) **In the Standard Model, this man names a coupling interaction that describes how the Higgs field to the massless lepton and quark fields through spontaneous symmetry breaking. This scientist names a (+) potential that in SI units is 1 over meters and is also known as the screened Coulomb potential. This scientist predicted the existence of the (*) lighted hadron, a meson made from a quark and an antiquark called the pion. For the points, name this first Japanese Nobel laureate.**

ANSWER: Hideki **Yukawa** (or Hideki **Ogawa**)

(8) **A stationary phase with this property is used to separate molecules in reverse phase chromatography. A form of "collapse" named for this property energetically drives (+) protein folding, because amino acids with this property like leucine and alanine are often found on the (*) interior of globular proteins. The fatty acid tails of phospholipids have this property, causing them to orient inwards in the cell membrane. For the points, name this property exhibited by fats and other organic molecules that repel water.**

ANSWER: **Hydrophobic** (or **Hydrophobicity**; prompt on "Water-Fearing" or "Organic" or "Nonpolar")

(9) **The formula $L\text{-squared over two mu r-squared}$ is incorporated into this system's centrifugal term as a component of its rotational energy. Unlike a more complex counterpart, this system can typically be reduced to a (+) "central-force problem" and be solved with first integrals. A special case of this system that involves a force F that varies (*) inversely with distance is known as the Kepler problem. For the points, name this problem of the ways that a pair of bodies orbit each other.**

ANSWER: **Two-body** problem (or **Kepler** problem before read; prompt on "Orbits")

(10) **This man used the phrases "gulf of execution" and "gulf of evaluation" to describe common problems in computer-human interactions. This man described the visceral, behavioral, and reflective levels to describe reactions to objects in *Emotional Design*. This man adopted (+) Rob Kling's idea of "user centered design" to describe how devices can be engineered to match the psychology of users. This man used the concept of (*) perceived affordances to describe things that users think are possible but which are not using the example of door handles. For the points, name this cognitive scientist and usability engineer, the author of *The Design of Everyday Things*.**

ANSWER: Donald "Don" **Norman**

(11) **Two B vitamins bind to this nitrogenous base to form the cofactors NAD and FAD. This nucleobase forms the end of a (+) coenzyme whose acetyl- form is used in the first step of the Krebs cycle. A "tail" containing many repeats of this base is added to the (*) 3' [[three-prime]] end of a mature mRNA after splicing. In RNA, this purine base can form two hydrogen bonds with uracil. For the points, name this nitrogenous base which pairs with thymine in DNA.**

ANSWER: **Adenine** (accept **Adenosine**; prompt on "A")

(12) **The singular variety of these phenomena occur to systems which cannot be uniformly approximated with asymptotic expansion. When a binary system is affected by this phenomenon it is known as the Kozai mechanism. (+) Neptune was the first body to be discovered by observing these phenomena. A method named for these phenomena is often defined as using known changes in one system caused by a defined (*) third object to detect changes in energy. For the points, name these small deviations in the Hamiltonian of a system.**

ANSWER: **Perturbation**

(13) **In a 1921 letter to *Nature*, this scientist wrote that the sea's blue color was a reflection of the sky. This man once told a prime minister "everything that glitters is not gold" after he shined (+) ultraviolet light on a piece of copper. This man studied light scattering with his student, (*) K. S. Krishnan. For the points, name this Indian physicist who names an effect that occurs when a light beam is deflected by molecules, resulting in the change in the wavelength of light.**

ANSWER: C. V. **Raman** (or Chandrasekhara Venkata **Raman**; accept **Raman** Effect)

(14) **Due to what may be the most distal horizontal gene transfer from diatoms, some types of these organisms can utilize silicon in their body structure. These organisms use farnesol to break down food cell walls in a very similar way to how sperm cells use calcium ions to break down the egg cell. These organisms possess a (+) ring of microvilli filled with actin that surround a single flagella. These organisms closely resemble and are the namesake of a type of cell used by (*) sea sponges to induce regular water flow. For the points, name these single celled Eukaryotes, the closest relatives of animals.**

ANSWER: **Choanoflagellates**

(15) **This phenomenon was first formulated in response to Alfred Russel Wallace's criticism of Darwin's *The Descent of Man*. This phenomenon was postulated in *The Genetical Theory of Natural Selection* and is closely related to the (+) sexy son hypothesis. This phenomenon is believed to account for supposedly ostentatious male (*) secondary sex characteristics such as peafowl tail feathers. For the points, name this phenomenon that can produce adaptations to attract mates that reduces the individual's overall fitness, commonly described as sexual selection gone out of control.**

ANSWER: **Runaway Selection** (or **Fisherian Runaway**; prompt on "Runaway"; prompt on "Sexual Selection" or "Selection" or "Natural Selection")

(16) **Because this set is closed under composition, it can be shown to be self-low. In an article titled "Primes is in" this class, Agarwal, Kayal, and Saxena showed that primality testing is in this complexity class. The problem of whether a given set of (+) Horn clauses is satisfiable or not is in this class, which that problem's Boolean counterpart likely is not. As shown by Karmarkar's algorithm, (*) linear programming falls in this class, which is either a subset or equal to its nondeterministic counterpart. For the points, name this complexity class consisting of all problems that can be solved by a deterministic Turing machine in polynomial time.**

ANSWER: **P** (or **P**TIME or **D**TIME)

(17) **This hypothesis was proposed because the Kerr metric forbids spacetime from being globally hyperbolic. Shahar Hod claimed to defeat one challenge to this hypothesis by proposing that a black hole could not have enough (+) angular momentum added to it to cause a violation of it. The validity of this hypothesis was the subject of a wager between Kip Thorne and Stephen Hawking. The weak form of this hypothesis was made by (*) Roger Penrose to forbid the existence of "naked" singularities. For the points, name this hypothesis that holds singularities are unobservable from the rest of spacetime due to event horizons.**

ANSWER: **Cosmic Censorship** Hypothesis (or **Cosmic Censorship** Principle)

(18) **While at Yale, this scientist was the first to crystallize and solve the structure of the Group I ribozyme. A biography by Walter Isaacson titled (+) *The Code Breaker* describes this scientist's rivalry with Feng Zhang and her initial use of a programmable single (*) guide RNA. This scientist shared the 2020 Nobel Prize in Chemistry with Emmanuelle Charpentier for developing a technique that uses the Cas9 endonuclease to induce double-strand breaks. For the points, name this developer of the CRISPR gene editing system.**

ANSWER: Jennifer **Doudna**

(19) **A pair of cases of this disease from the 1980s were described in Richard Preston's book *The Hot Zone*. Unlike the closely related Ebola virus disease, rates of this disease do not increase after droughts that are followed by (+) heavy rains. Two fatal cases of this disease among European tourists occurred to visitors of Kenya's Kitum cave, who may have inhaled powdered (*) guano from Egyptian fruit bats. For the points, name this viral hemorrhagic fever caused by either R-A-V-V or M-A-R-V, which is named for the German city it was discovered in.**

ANSWER: **Marburgh** Virus Disease (or **MVD**; accept **Marburgh** Hemorrhagic Fever; prompt on viral "Hemorrhagic Fever")

(20) **For a theoretical fluid satellite, this value can be approximated by changing the 2R term to 2.44R. This value can be calculated for spherical bodies as the 2 times the density ratio raised to the one third power times the radius of the primary. (+)** Planetary rings can form when a moon's orbital radius falls beneath this value. This value is defined as the distance at which self-gravitation is (*) overcome by another body's tidal forces, causing disintegration. For the points, name this distance at which an orbiting body will be ripped apart.

ANSWER: **Roche** Limit (or **Roche** Radius)

(21) **This scientist discovered that higher crystallization temperatures were related to lower concentrations of aluminum, sodium, potassium, and silica. A sequence named for this scientist is divided into (+) continuous and discontinuous branches and starts with plagioclase or olivine and ends with quartz. This scientist names a (*) crystallization sequence followed by silicate minerals formed from basaltic magma. For the points, name this Canadian geologist who names a mineral reaction series.**

ANSWER: Norman Levi **Bowen** (accept **Bowen**'s Reaction Series)

(22) **Adding one percent of this element to silver produces the tarnish-resistant alloy, Argentium. The ore of this element can be found in the sulfide mineral (+) argyrodite, and along with cadmium, gallium, zinc, and indium, this element is mined from sphalerite. (*)** Clemens Winkler discovered this element, which was placed by Dmitri Mendeleev on the periodic table between silicon and tin. For the points, name this metalloid with atomic number 32 commonly used in transistors.

ANSWER: **Germanium** (accept **Ekasilicon**)

(23) **Brown and Houk's twist-asynchronicity model applies to the intramolecular form of this reaction. Like the McLafferty rearrangement, a retro form of this reaction commonly occurs in mass spectrometers. Because it is locked in the (+) s-cis configuration, cyclopentadiene undergoes this reaction quickly. This concerted reaction occurs faster when the electron-withdrawing groups of one reactant are pointed (*) underneath and inward. This reaction follows both the cis principle and the endo rule. For the points, name this pericyclic creation that produces cyclohexene derivatives from dienophiles and dienes.**

ANSWER: **Diels-Alder** Reaction (prompt on "Cycloaddition")

(24) **The moment-area theorem can be used to describe these structures when they have segments with differing moments of inertia. The behavior of thick or sandwich composite types of these structures can be described by considering the shear deformation and rotational bending effects with the (+) Timoshenko-Ehrenfest equation. The Euler-Bernoulli theory of these structures uses a simplification of the linear theory of elasticity to calculate their (*) load-bearing and deflection characteristics.** For the points, name these elementary structural components used in civil engineering, whose length is much greater than their width.

ANSWER: **Beams**

(25) **This law is used to quantify mixtures of two molecules that share an isosbestic point. NanoDrop devices use this law to measure the concentration of proteins by finding a solution's (+) OD280 value, which is then compared to a standard curve obtained from a blank. The molar extinction coefficient is multiplied by (*) cuvette path length and concentration in this law to give a sample's absorbance.** For the points, name this law that underlies spectrophotometry and describes the attenuation of light through a medium.

ANSWER: **Beer's** Law (or **Beer-Lambert** Law; or **Beer-Lambert-Bouguer** Law; or Lambert-**Beer** Law)

(26) **The regression hypothesis of this result holds that macroscopic disturbances are governed by the same laws as microscopic spontaneous fluctuations. A special case of this result applied to wavelength specific emission and absorption is known as (+) Kirchhoff's law.** This result shows that the Seebeck and the Peltier coefficients of a material are equivalent. This result is sometimes known as the (*) "fourth law of thermodynamics" and is named for a Norwegian chemist and physicist. For the points, name this set of statements that describe forces and flows in reversible non-equilibrium processes.

ANSWER: **Onsager** Reciprocal Relation

(27) **This principle formally states that no injective function exists whose codomain is smaller than its domain. This statement underlies the inevitability of hash collisions, as well as the fact that in a group of (+) 367 people, at least two will share a birthday. Dirichlet's box principle is an alternate name for this statement, which says that if (*) n items are placed into m containers, and n is greater than m, then at least one container will have more than one item.** For the points, name this counting argument named for its use in sorting birds.

ANSWER: **Pigeonhole** Principle (accept **Dirichlet's Box** Principle before mention; accept **Dirichlet's Drawer** Principle before "Dirichlet")

(28) **In many quadrupedal domestic animals, these cells begin to die off shortly after birth in a type of abiotrophy caused by mutations to TOE1. These large cells are characterized by possessing an elaborate dendritic structure consisting of a large number of branching (+) dendritic spikes that are crossed by parallel fibers. These cells are linked to the medulla through the (*) climbing fibers. Glutamate is passed across these cells synapses with granule cells in the cerebellum. For the points, name these GABAergic neurons named for a Czech anatomist.**

ANSWER: **Purkinje** cells (or **Purkinje** neurons; prompt on “neuron” before read)

(29) **An elementary example of these constructs called Rule 90 arises from the "exclusive or" function and is numbered using a system developed by Stephen Wolfram. Patterns within one of these constructs include (+) Methuselaha, spaceships, and the glider gun discovered by Bill Gosper. That example of these systems functions using the rule that any (*) live cell with two or three live neighbours survives. Conway's Game of Life is an example of, for the points, what mathematical grids of cells that evolve through generations under a set of rules?**

ANSWER: **Cellular Automata** (or **Cellular Automaton**; accept **CA**s; accept **Cellular Spaces**; accept **Tessellation Automata**; accept **Homogeneous Structures**; accept **Cellular Structures**; accept **Tessellation Structures**; accept **Iterative Arrays**; prompt on "Automata" or "Games" or "Zero-Player Games")

(30) **Lower than expected levels of the F2 mechanism in this region during the Summer is known as its "Winter anomaly." This region's D layer can release massive amounts of (+) radio radiation when bombarded by X-rays from a solar flare as part of its "sudden disturbances." This region causes (*) reflection of high wavelength photons, allowing AM radio waves to be broadcast over long distances. For the points, name this layer of the atmosphere characterized by the presence of charged particles.**

ANSWER: **Ionosphere** (prompt on “Thermosphere”)

(31) **This scientist expanded on the law of definite proportions by proving that elements did not have relative masses in terms of hydrogen atoms, thus disproving Prout's hypothesis. Elements discovered by this scientist include (+) cerium and selenium, and he was also the first person to isolate silicon. This scientist developed a notation system that abbreviated the names of elements and appended them with (*) superscripts and subscripts. Chemistry terms coined by this scientist include catalyst, allotrope, and polymer. For the points, name this Swedish scientist who developed modern chemical notation standards.**

ANSWER: Jons Jacob **Berzelius**

(32) **In proton NMR, molecules with this property cause deshielding via a namesake "ring current." The Friedel-Crafts alkylation substitutes onto molecules with this property such as (+) arenes. Hydrocarbons are called aliphatic if they lack this property, which is possessed by molecules with (*) "4 n plus 2" pi electrons according to Huckel's rule. For the points, name this property of organic molecules that are cyclic, planar, and have resonance, whose simplest example is benzene.**

ANSWER: **Aromatic** (or **Aromaticity**; prompt on "Cyclic")

(33) **This theory was dubbed the "Jewel of Physics" for being able to predict the Lamb shift and the value of the anomalous magnetic moment with a very high accuracy. One consequence of this theory is that (+) positrons are considered to be electrons moving backwards in time. The 1965 Nobel Prize in physics was awarded to Tomonaga, Schwinger and (*) Feynman for their work on this theory. For the points, name this field theory that describes the interactions of matter and photons.**

ANSWER: **Quantum Electrodynamics** (or **QED**)

(34) **While this scientist was a lieutenant colonel during World War Two, he assisted in the development of a vaccine against Japanese encephalitis. This scientist discovered a virus he coined the (+) "B" virus, which was named after a Dr. William Brebner, a colleague who died from a monkey bite. In 1959, Dr. Mikhail Chumakov administered this scientist's most notable development to (*) 10 million Russian children. For the points, name this medical researcher who developed the oral polio vaccine.**

ANSWER: Albert **Sabin** (or Albert Bruce **Sabin**; or Abram **Saperstein**)

(35) **Signs in this law can be determined using its namesake's right hand grip rule. Both the integral and differential form of this law are exactly equivalent according to the (+) Kelvin-Stokes theorem. Adding a displacement current to this law correctly demonstrated that light was a type of (*) electromagnetic wave. This law was derived by James Maxwell, and not its namesake, in the paper "On Physical Lines of Force" and makes up one of Maxwell's laws. For the points, name this magnetic equivalent of Gauss' law.**

ANSWER: **Ampere's** Law

Extra Questions

(1) **Murty and Loomis developed a potential energy scale for the magnitude of these phenomena. New Zealand's Project Seal was a weapons program aiming to cause these phenomena. Early detection of these phenomena is hampered by (+) shoaling effects. Unlike similar phenomena, these events maintain tidal bore by failing to break. Immediately before one of these events, (*) drawback can occur when water recedes from the shore. For the points, name these massive waves that are caused by volcanic eruptions or earthquakes.**

ANSWER: **Tsunami** (prompt on "Tidal Wave")

(2) **For a constant force, this scalar quantity can be found with the formula F times s times cosine of theta. This quantity is measured with non-SI [[S-I]] units such as foot-pounds or (+) kilowatt-hours. This quantity is equal to the negative change in potential energy for (*) conservative forces acting on an object. This quantity is defined as the force transferred to an object along the path of displacement. For the points, name this quantity equal to force times distance.**

ANSWER: **Work** (prompt on "Energy" before "potential" is mentioned)

(3) **A short-lived research institute named after this process was opened in 1989 by the University of Utah. An attempt to achieve this process involved a palladium cathode submerged in (+) heavy water within a calorimeter. That experiment was notably conducted by Martin (*) Fleischmann and Stanley Pons, who were heavily criticized by other scientists after multiple failed replication attempts. For the points, name this theoretical process that would allow for a nuclear reaction to occur at room temperature.**

ANSWER: **Cold Fusion** (accept National **Cold Fusion** Institute; prompt on "Fusion")