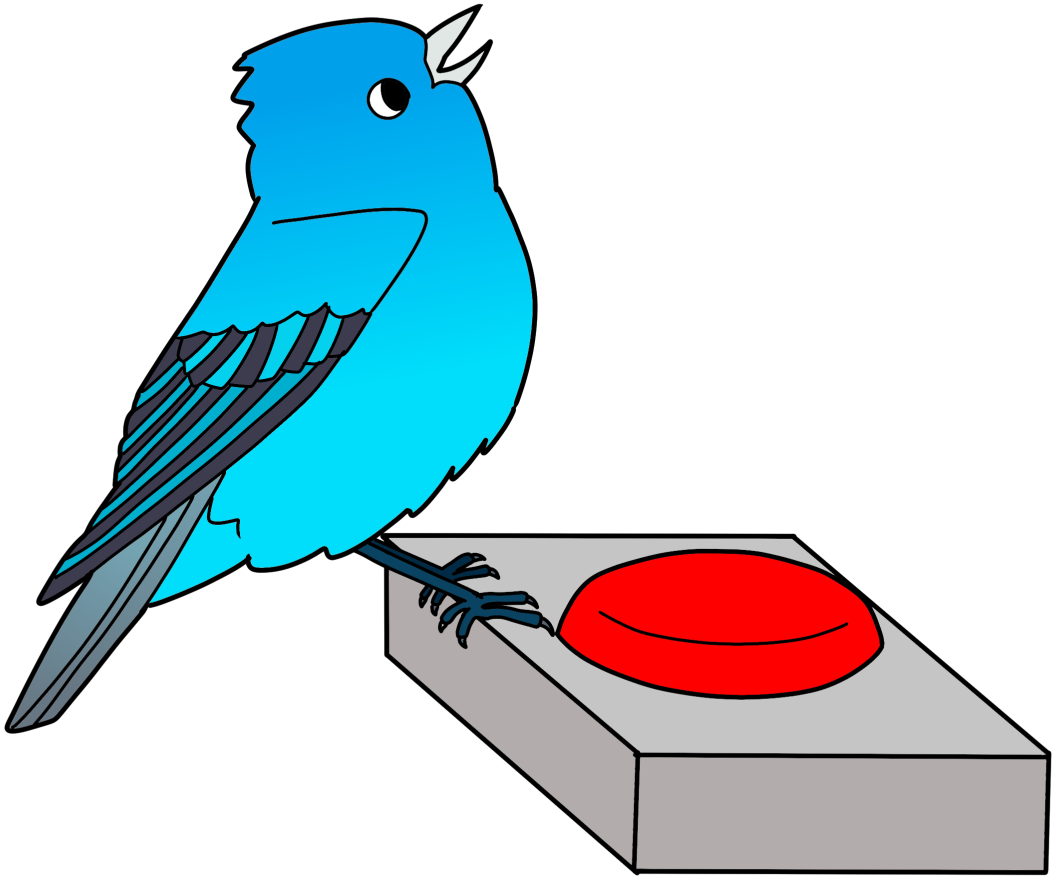
2021 BirdSO Science Quiz Bowl Division C – Buzzer Round



1. **The wavefunction of this particle is written as the product of the usual spatial part and a spin part sigma, where sigma is usually alpha or beta. When two of these subatomic particles are exchanged with each other in a many-body wave function, the sign of the Slater determinant changes. The Hartree wavefunction is limited (*)** by the fact that it does not reflect the anti-symmetric nature of this particle as required by the Pauli principle. A vacuum tube can use these particles to excite phosphors and create an image. This particle was discovered by Thomson in 1897. For 10 points, name this subatomic particle with a charge of negative electricity.
<CHEMISTRY>

2. **The beginning of this geologic time period is partially obscured by Romer's gap. The Uralian and Alleghanian Orogenies both started in this time period, marking the start of the formation of the Appalachian Mountains. This time period saw the formation of (*)** Pangea, as well as massive atmospheric oxygen levels, which probably explains the massive arthropods and amphibians who lived in this time period. This geologic time period also suffered a minor extinction event due to a rapid climate shift and a steep drop in Carbon Dioxide levels, which wiped caused a collapse in rainforests. For 10 points, name this geologic time period, named for the massive coal deposits formed in its swamps which is often also referred to as the age of amphibians.
<EARTH SCIENCE>

3. **In mathematics, a continuous generalization of the factorial function utilizes this symbol**. **In thermodynamics, the ratio between the heat capacity at a constant pressure (*)** and at a constant volume is represented by this symbol. This symbol represents the Euler–Mascheroni constant, the limiting difference between the harmonic series and the natural logarithm. For 10 points, name this Greek letter that is used to denote a photon.
<MISCELLANEOUS>

4. **The free energy barrier in antiparallel beta sheets is due to constraining of this structural motif onto which a third strand can coalesce. This structural motif can be divided into four (*)** classes depending on the amount of amino acids which it contains, commonly found in globular proteins. Forming a type of tertiary structure, these regions are known for forming small loops between antiparallel beta strands. For 10 points, name this structure which you could stick in your hair.
<BIOLOGY>

5. **These regions were discovered by determining that the square root of a certain phenomenon's energy was related to its strain increment. That discovery was first made in the Kermadec-Tonga region, though a second scientist independently discovered them contemporaneously. These regions' dips are affected the temperature of the underlying (*)** mantle, and the "double" version of these regions can be identified by dual lines of earthquake concentration. For 10 points, name these regions found in subduction zones, where deep focus earthquakes occur and are useful for mapping the surface of a subducting plate, usually named for two scientists.
<EARTH SCIENCE>

6. **Hungarian physicist Leo Szilard in his 1929 paper, "On the Reduction of Entropy in a Thermodynamic System by the Intervention of Intelligent Beings", argued that this controversial thought experiment is not a violation of the laws of physics. Scientists have been recently working on single-atom traps (*)**, which mimic what occurs in this thought experiment. Although it was Boltzmann whose work helped contribute to this paradox, it was Kelvin that coined its present-day name. For 10 points, name this 1867 thought experiment proposed that a being controls an opening between two gas

compartments, selectively allowing gas molecules to pass through the opening and causing a decrease the entropy of a system.
<PHYSICS>

7. **This mathematician discovered a set of rational functions that are defined based on a corresponding set of polynomials discovered by the same person. This mathematician's constant, which describes the asymptotic behavior of the prime counting function (*)**, is equal to one. The symbols named for this mathematician are used in the law of quadratic reciprocity. The form of an elliptic curve named after this mathematician is denoted $y^2 = x(x-1)(x-\lambda)$ "y squared is equal to x times the quantity x minus one times the quantity x minus lambda". For 10 points, name this French mathematician, who famously showed that certain integers cannot be written as the sum of three perfect squares.
<MISCELLANEOUS>

8. **The S672R mutation in these proteins is associated with sinus bradycardia, and "heart rate reducing agents" like ivabradine work by inhibiting these proteins. These structures are sometimes known as HCN because they are both voltage and cAMP activated. Sympathetic nerves increase heart rate by increasing the (*)** permeability of the sodium type of these structures in the SA node. Similar structures of this type for Calcium are known as T-type. For 10 points, name this laughable type of ion channel that can be contrasted with L-type channels.
<BIOLOGY>

9. **The first one of this object was discovered by Abraham Ihle in 1665, and is among the oldest objects in the universe. In 1939, Pieter Oosterhoff noticed there were two populations of this object, thus forming the Oosterhoff groups. (*)** Compared to the sun, this object contains a much lower proportion of metals to Hydrogen and Helium. A famous example of one of these objects is 47 Tucanae, which is the second brightest one of these objects in the night sky. A Hertzsprung-Russell diagram of this object will display a main-sequence turnoff point, which can be used to estimate the age of this object. For 10 points, name this spherical collection of old Population II stars, which the Milky Way contains approximately 150 of.
<EARTH SCIENCE: Astronomy>

10. **Replacement of the carboxy group of this compound with sulfonic acid yields PSP. Derivatives of this compound inhibit 5'-monodeiodination of rT3 with enhanced inhibition when bromine substitution is at the ortho position of this compound's derivatives. (*)** Indicated by orange to colorless to pink to colorless, the color changes of this phenol-containing chemical compound are displays of the varying degrees of conjugation that result from protonation and deprotonation. The compound is a member of a class of dyes formed by the reaction between various phenols and phthalic anhydride. For [n] points, name this particular compound.
<CHEMISTRY>

11. **Eccentricity, Obliquity, Precession. Long ago, variations in these three factors would cyclically impact the amount of insolation received by Earth. These cycles are theorized to cause variations in Earth's climate (*)**, including glacial and interglacial periods. Although first hypothesized in the 1800s, it was not until the 1920s that the evidence became sufficient to prove the idea. Even still, the theory encountered some problems with conflicting evidence regarding the length and influence of certain cycles, many of which have been explained with changes on Earth rather than its motion in space. For 10 points, give the collective name of the cyclical change of Earth's motion, named after the Serbian mathematician who assembled the theory.
<EARTH SCIENCE>

12. **Named after its creators, this algorithm was originally published in the paper *New Directions in Cryptography* in November 1976. (*)** Commonly implemented in TLS handshakes, one version of this protocol relies on elliptic curves to keep network traffic secure. The security of this algorithm relies on the difficulty of computing logarithms over a finite field GF(q) “G F, Q”, such that q is prime. For [n] points, what is the name of this popular algorithm which allows Alice and Bob to exchange cryptographic keys over an insecure channel?
<MISCELLANEOUS>

13. **This vitamin serves as a key prosthetic group for Acyl Carrier Protein (ACP). A derivative of this molecule possesses a sulfhydryl group capable of bonding with malonyl Coenzyme A (CoA) (*)**, allowing for the transfer of malonate from malonyl CoA to ACP by Malonyl CoA: ACP Transacylase. This vitamin participates in CoA synthesis along with 4 molecules of ATP and 1 molecule of cysteine. This vitamin can be synthesized from pantoic acid and beta-alanine. Among humans, it is rarely deficient, and is found in many foods. For 10 points, name this B-vitamin named for its prevalence, from the Greek word "pantos" meaning "from everywhere".
<BIOLOGY>

14. **The contour integral of the differential of entropy over this quantity is equal to 0 in the Clausius statement. By the equipartition theorem, each degree of freedom has an average energy of ½ Boltzmann’s Constant times this quantity, and the emittance of a black body is related to the fourth power of this quantity by the (*)** Stefan-Boltzmann Law. Below the Curie variety of this quantity, materials lose their ferromagnetic properties. This state function is multiplied by change in entropy when calculating Gibbs Free Energy and is a measure of the average kinetic energy. For 10 points, name this quantity that is measured in Kelvins.
<PHYSICS>

15. **A mutant of Chlamydomonas lacks the ability to synthesize the large subunit, RbcL, of this enzyme. Carbonic anhydrase is a part of the supermolecular complex containing this enzyme. Increasing specificity to its substrate requires either tighter binding (*)** of the carboxylase transition state intermediate or an increase in the binding ratio of the carboxylase to oxygenase transition state intermediates to this enzyme. This enzyme is known to rapidly degrade during the initial phase of senescence and is a major enzyme of the stroma. This enzyme catalyzes the carboxylation of ribulose-1,5-bisphosphate (RuBP) by CO2 and produces 3-phosphoglyceric acid (PGA). For 10 points, name this most abundant enzyme on Earth.
<BIOLOGY>

16. **Dating back to the first century A.D., this word’s typographical symbol originated as a ligature of the letters “E” and “T”. (*)** This word is the reverse of a certain acid that carries genetic material. The ASCII representation of this word’s typographical symbol is 0x26. The corresponding operation to this word is displayed in LaTeX using the command \cap (“backslash cap”). This word is used in English to cumulatively combine clauses. For 10 points, identify this logical operator that is equivalent to the product of two bits.
<MISCELLANEOUS>

17. **This class of compounds forms both the reactants and the products in Dieckmann condensations. Nitrate varieties of these compounds, such as nitroglycerin, are known for their explosive nature. DMAP catalyzes a reaction named for Steglich that forms these compounds. (*)** Saponification cleaves a bond named for these compounds that connect glycerol and fatty acids. One of these compounds is

formed by the reaction of a carboxylic acid with an alcohol in a process named for Fischer. For 10 points, name these sweet-smelling compounds characterized by an alkyl-substituted carboxyl with the formula RCOOR'.
<CHEMISTRY>

18. **One version of this quantity for a material can be related to the single free parameter and incident angle by the Heyney-Greenstein phase function. This quantity's V-band and Bond variants can refer to different things in astronomy, while a high radar value of this quantity for an asteroid can be indicative of high (*)** metallic content. This quantity's increase can lead to a positive feedback loop with ice, and Saturn's moon Enceladus has the highest value of this quantity of any body in the Solar System due to its white, icy surface. For 10 points, name this quantity, the percentage of incident radiation which is reflected, for which a perfect blackbody has a value of 1.
<PHYSICS>

19. **This compound, which is a popular reagent in organic synthesis for forming new carbon-carbon bonds as a complex connected by 2 coordination bonds. (*)** In a lab setting they must be used in solutions of diethyl ether or tetrahydrofuran as they are very moisture sensitive. Another use they have is to form alcohols by attacking carbonyls such as aldehydes or ketones. These reagents are often compared to organolithium reagents due to their similar properties. For 10 points, name this organomagnesium compound.
<CHEMISTRY>

20. **When this wave moves in two opposite directions in V2-3, it can present as Wellen's Syndrome. This feature can be characterized by various properties such as its symmetry, skewness, and amplitude. (*)** With a typical duration of 100 ms, this single-letter feature references a peak in electrical signal corresponding to ventricular repolarization.The duration, amplitude, and morphology of this feature on an electrocardiogram can be used for diagnosing cardiac abnormalities, and in a classic arrest, elevation of this segment may be observed. For [n] points, name this feature.
<BIOLOGY>

21. **These active analog devices, first implemented with vacuum tubes, can be used to implement a gyrator (*),** creating a simulated inductance from a capacitance. They often contain current mirrors as part of their construction. These devices are frequently approximated with an ideal model with infinite input impedance and zero output impedance. For 10 points, what is the name of the electronics integrated circuit that was originally used to perform operations with analog electronics?
<MISCELLANEOUS>

22. **Rates of this process are measured most easily by the acetylene reduction method. Trichodesmium is noted to carry out a majority of this process (*)** in tropical waters. This process is done under anoxic conditions due to oxidation of Fe and Mo needed for this process. Some organisms make use of the ability of leghemoglobin to reversibly bind oxygen in order to generate favorable conditions for this process. This process is synonymous with diazotrophy. This process is reduced if large concentrations of free ammonium are available. Heterocysts have the enzyme, nitrogenase, to do this process. For 10 points, name this process that reduces N2 to ammonia.
<BIOLOGY>

23. **This quantity of a material can be related to its wavelength in both the Sellmeier and Cauchy equations for a transparent material. When an electric field is applied to a material, this quantity will change in the Kerr effect. Brewster's angle** (*) is found by taking the arctangent of the ratio of two

of these quantities, and polarization of this quantity is responsible for a phenomenon observed in certain minerals, birefringence. For 10 points, name this quantity which can be used to relate angles of incidence and refraction in Snell's Law, the ratio of the speed of light in a material to that of light in a vacuum.
<PHYSICS>

24. **This form of sea ice, most commonly found around the polar regions, is formed with the breakdown of grease ice. The same name is given to an unusual form of a lava dome found on Venus, roughly 10 to 100 times larger than volcanic domes on Earth. In graph theory, this describes a graph whose vertices are the permutations of n symbols and generated by prefix reversals. In 1970, Soviet physicist Yakov Zeldovich showed that a supergalactic ellipsoid of gas collapses upon its shortest axis, resembling this object. A sorting problem named for this food famously had its upper bound lowered by (*)** Bill Gates in 1979, a bound that stood for over thirty years. A 2003 paper used the flattening ratio as a metric to determine that Kansas was considerably flatter than one of these. For 10 points, name this food you can get at IHOP.
<MISCELLANEOUS>

25. **The Takai olefination reacts one of these groups with a chromium containing compound to form alkenes. Pyridinium chlorochromate converts primary alcohols to this functional group, and Ribose and ribulose differ in that ribose contains one of these groups. (*)** Sodium Borohydride, NaBH4, reduces this functional group into a primary alcohol. Tollen's test detects this functional group by forming a silver mirror. For 10 points, name this functional group characterized by a terminal carbonyl group.
<CHEMISTRY>

26. ***Description acceptable.*** **The term for these rocks was partially coined by Concordia University visual arts professor Kelly Jazvac. The largest example of these rocks is most likely the meter long and 50 centimeter wide piece owned by the Museon in The Hague. They were first discovered by Charles Moor on Hawaii's Kamilo beach. (*)** Somewhat surprisingly, they are generally not formed by lava flows, but are instead most commonly generated by campfires. This type of rock has been proposed as a marker horizon for the Anthropocene and they are primarily formed through agglutination of their namesake melted material. For 10 points, name this type of rock, whose technical name is a portmanteau between "plastic" and "conglomerate."
<Earth and Space, Geology>

27. **This element bonded to zinc is formed as a byproduct in the Simmons-Smith reaction. It is bonded to four oxygens and a carbon in the Dess-Martin reagent. (*)** With carbonyl, it is bound to iridium in the catalyst for the Cativa process. It forms a pale yellow precipitate with silver ions in solution that is used in cloud seeding. A common method for developing TLC plates involves formation of brown spots by exposing them to sublimated vapors of this element. A polyatomic ion consisting of three atoms of this element has linear geometry and participates in a classical clock reaction in which it forms a deep blue complex with starch. For 10 points, name this heaviest stable halogen with atomic number 53.
<Chemistry, Laboratory>

28. **A "reactive center loop" alongside a "breach" and "shutter" region are found in a class of inhibitors partially named for this amino acid. An unusually stable octamer of this amino acid has been hypothesized to be the origin of amino acid homochirality. Fibroin, the primary component of spider silk, consists primarily of glycine, alanine, and these residues**. (*) They function as nucleophiles via a proton shuttling mechanism in their namesake proteases, examples of which include thrombin and chymotrypsin and often feature a catalytic triad consisting of this amino acid, histidine, and aspartate.

Threonine and this amino acid are modified in O-linked glycosylation. For 10 points, name this nonessential amino acid with a hydroxymethyl side chain and one-letter abbreviation S.
<Biology, Biochemistry>

29. **The Gershgorin Circle Theorem bounds these within namesake discs. Methods for finding them may rely on transforming their input into Hessenberg form. (*)** Specific algorithms for finding these quantities include the Lanczos algorithm and Rayleigh quotient iteration. It's not the Jacobian but analyzing the signs of these quantities for a system can be used to identify the presence of fixed points. In quantum mechanics, (*) creation and annihilation operators raise and lower these quantities. They are always real for Hermitian matrices and their sum equals the trace. Matrix diagonalization involves finding, for 10 points, what scalars, symbolized lambda, that are the roots of their characteristic polynomial?
<MISCELLANEOUS>

30. **The climbing image and synchronous transit methods are computational techniques for locating these entities. For two conformers in equilibrium, their relative distribution depends on the difference in energy between two of these entities. Phi value analysis is used to study their structure in protein chemistry. (*)** The 1999 Nobel Prize was awarded for the development of techniques that allowed for the observation of these species using femtochemistry. A factor of kappa k T over h appears in an equation central to their namesake theory named for Eyring and Polanyi. For an SN2 reaction, this species has trigonal bipyramidal geometry. For 10 points, name these chemical species represented with a double dagger symbol that reside on saddle points of potential energy surfaces.
<Chemistry, Kinetics>

31. **Interacting pairs of these structures may lead to long-wave Crow instabilities and short-wave Widnall instabilities. Helmholtz's theorems describe the dynamics of their namesake "filaments". A quantum analog of these phenomena named for Abrikosov was predicted using Ginzburg-Landau theory.** (*) Moving a cylinder through water is a common demonstration of their namesake induced vibrations. Theodore von Karman names a pattern formed from the shedding of these structures, which occurs at a frequency that may be calculated from the flow velocity, characteristic length, and Strouhal number. They often appear in turbulent regimes and are partially characterized by the curl of the velocity field. For 10 points, name these regions of circular fluid flow.
<Physics, Fluids>

32. **Q-balls are a non-topological form of these phenomena characterized by their conservation of Noether charge. The elastic ribbon model visualizes a set of solutions of this type; those solutions may be calculated by applying a Bäcklund transform to the trivial sine-Gordon equation. (*)** The existence and stability of these phenomena resolved a paradox named for Fermi, Pasta, Ulam and Tsingou while also launching the field of nonlinear systems. Applying an inverse scattering transform to solve the KdV equation yields these waves as solutions. They arise in mathematical and physical models as a result of nonlinearity and dispersion effects. For 10 points, name these self-reinforcing waves that maintain their shape as they propagate.
<Physics, Waves>

33. **The Streeter-Phelps equation estimates variations in this quantity with distance. "Rugged" probes for measuring this variable may utilize Clark electrode or luminescence quenching methods. One procedure for determining a variable associated with this quantity utilizes glucose-glutamic acid solution as a reference; that procedure involves storing 300 mL incubation bottles in the dark for a five day period**. (*) Low levels of this substance characterize the region below the chemocline in meromictic environments. Strong acid and thiosulfate are used in the latter half of an iodometric

back-titration to measure levels of this substance, a procedure called the Winkler test. For 10 points, name this water quality variable that is low in dead zones as a result of hypoxia.
<Earth and Space, Oceanography>

34. **The results of this analytical technique may be used in conjunction with the Forouhi-Bloomer dispersion relations to measure the optical properties of semiconductor wafers. The characterization of host-guest complexation equilibria via the Benesi-Hildebrand method most commonly uses this lab technique. (*)** A 280 nm peak in this technique may indicate the presence of tyrosine and tryptophan residues in a protein sample. The Woodward-Fieser rules predict the absorption maxima of spectra generated from this technique. A "blank" may be used for calibration in this procedure, whose samples are loaded into cuvettes. For 10 points, what lab technique may be utilized in conjunction with Beer's law to estimate the concentration of a colored solution.
<Chemistry, Laboratory>

35. **This quantity for a diatomic ideal gas gives the expected occupancy ratio between adjacent vibrational energy levels in the RRHO approximation. In negative temperature regimes, these values increase with energy. (*)** Dividing this quantity for a given state by the partition function of the system gives the probability of the system being in that state. The partition function is itself calculated as a sum of these values. For a state of energy epsilon, this quantity equals e to the negative beta epsilon, where beta equals one over the product of temperature and a namesake constant. For 10 points, what "factors" are named for an Austrian physicist who also names a probability distribution with Maxwell?
<Physics, Thermodynamics>

36. **Inhomogeneous distribution of atoms in these substances may result in Gaussian spectral line broadening. Miedema's approach to estimating the heat of formation of these substances is frequently used to provide inputs for CALPHAD calculations. (*)** The unified numbering system or UNS specifies the chemical composition of these materials in North America. They're not polymers but, as a result of temperature-induced hysteresis, these materials may exhibit shape memory. The Hume-Rothery rules outline requirements for the atomic radii and crystal structures of the components of these materials, which may be classified as substitutional or interstitial depending on the relative arrangement of these components. For 10 points, name these mixtures of metals, examples of which include bronze and steel.
<Chemistry, Solutions>

37. **This process may be modeled using the equation "lambda-E equals R-sub-n minus G minus H," which forms the basis for the METRIC energy balance algorithm. Lysimeters may be used to measure the rate of this process through weighing or non-weighing methods**. (*) Its "potential" form is commonly estimated using the Thornthwaite equation from air temperature and daylight hour values, which may then be used in conjunction with average annual precipitation to calculate the aridity index. Due to greater canopy interception, conifer forests typically have higher measured rates of this process than deciduous forests. For 10 points, name this process, the total water loss to the atmosphere from Earth's surface, including from plants.
<Earth and Space, Meteorology>

38. **A 2020 paper by Paraan et al showed that beta-propellers on these proteins are cross-linked by the beta-2 appendages of a related protein. Auxilin binds to lattices of these proteins and recruits Hsc70 in the process, leading to their disassembly. These proteins halt their primary function during mitosis and stabilize the kinetochore of the mitotic spindle alongside TACC3 and CKAP5**. (*) They were first observed in mosquito oocytes yolk proteins by Roth and Porter. Dynamin is responsible for membrane scission towards the end of a process partially named for these proteins. AP180 and epsin are examples of

adaptins that aid in the polymerization of these proteins into their characteristic triskelion shape. For 10 points, name these proteins that mediate endocytosis by coating the outside of vesicles.
<Biology, Cells>

39. **A form of microscopy named for this phenomenon has a penetration depth governed by the Goos-Hanchen shift; that technique utilizes the evanescent waves generated by this process to excite fluorophores. It's not polarization, but this process is the working principle behind the Fresnel rhomb. Its "frustrated" form is utilized in simple beam splitters and optical fingerprinting. (*)** Gemstones such as diamond are frequently faceted at an angle that allows this process to occur, which can be calculated by setting the angle of refraction in Snell's law to 90 degrees. It occurs at the interface between two media when the media in which the wave enters has a greater index of refraction than the other. For 10 points, name this phenomenon that occurs above the critical angle and is exploited in fiber optic cables.
<Physics, Optics>

40. **In evolutionary algorithms, this letter is commonly used to symbolize the mutation rate. The standard gravitational parameter is denoted using this letter and is equal to the product of the universal gravitational constant and mass. (*)** The Gibbs-Duhem equation describes changes in a quantity symbolized by this letter, which is also the conjugate variable of particle number. It denotes a function that equals zero for non-squarefree integers. This letter precedes the name of bridging ligands found in coordination complexes containing and the Debye is a unit for a variable symbolized with this letter. When used as a prefix, it represents the SI factor of ten to the negative sixth. For 10 points, name this Greek letter that represents the coefficient of friction.
<MISCELLANEOUS>

41. **The name of these stars may be followed by a "+OB" or "+abs" suffix if their spectra contain companion absorption lines. "Slash stars" are examples of these stars with similar characteristics to Class O stars and they also name a class of luminous starburst galaxies. (*)** Planetary nebulae with these stars at their center are often associated with large astrospheres. The prototypical example of these stars is found within the Gamma Velorum system. They are characterized by a set of strikingly broad helium, carbon, nitrogen and oxygen emission lines and extremely strong stellar winds. For 10 points, name these doubly-eponymous stars that make up Class W in the extended Harvard classification system.
<Earth and Space, Astronomy>

42. **The ribonucleotide reductase enzyme of a species in this genus has a unique dATP-induced homotetramer structure with two catalytic domains. Another of its species was mistakenly identified as the causative agent of typhoid before being renamed after the rice fields it was originally discovered in. (*)** Several members of this genus have been genetically engineered for bioremediation applications, one of which was the first organism to be patented. It's not *Streptococcus* but another member of this genus is a common model organism due to its involvement with many biofilm-related infectious diseases like cystic fibrosis. For 10 points, name this bacterial genus that includes species such as *putida* and *aeruginosa* and whose name is partially derived from the Greek word for "false."
<Biology, Pathology>

43. **Interactions between these particles can be used to approximate static force fields in scattering calculations. These particles are considered "off shell" because they do not satisfy the energy-momentum relation. Particles of this type are responsible for roughly 3% of the Lamb shift. (*)** "Boosting" of these particles by black hole gravitation provides a model for Hawking radiation and their fluctuations are responsible for the Casimir effect. These particles can only exist within time frames shorter

than that governed by the energy-time Heisenberg uncertainty relation. Exchange of photons with this property mediate the electromagnetic force. For 10 points, name these types of particles that are sometimes contrasted with “real” particles.
<Physics, Modern>

44. **In 2012, the Pirate Bay created a “physible” section containing files for users of these devices. A model affectionately named Benchy is used as a popular benchmark for testing the accuracy of these devices, which may be improved by using adaptive slicing to minimize staircase effects. (*)** They may take AMF or STL files as an input and often contain a Bowden or direct extruder through which ABS may be guided. A common method for smoothing their outputs utilizes acetone vapor to melt their thermoplastic (*) filament material. Companies known for manufacturing these devices include Stratasys and MakerBot. For 10 points, name these devices that facilitate computer controlled additive manufacturing and rapid prototyping.
<MISCELLANEOUS>

45. **These devices are central to non-volatile random access memory systems, examples of which include RRAM. An early prototype of these devices consisted of a titanium dioxide thin film sandwiched between titanium and platinum electrodes and was created at Hewlett-Packard labs. (*)** Their current voltage plots exhibit a pinched Lissajous curve hysteresis loop as predicted by Leon Chua, who, in 1971, highlighted the theoretical symmetry between resistors, capacitors, inductors and these circuit elements. Their namesake quantity is the charge derivative of magnetic flux linkage and has units of Webers per Coulomb. For 10 points, name these circuit components whose resistance varies depending on the history of current flow through them.
<Physics, Electricity and Magnetism>

46. **Chaotic mélanges in this state composed of blueschist and graywacke breccias were the subject of the Franciscan-Knoxville paradox. The majority of North American serpentine soil is located in this state. The Gorda plate, a northern remnant of the Farallon plate, partially forms the Mendocino Triple Junction located off the coast of this state. (*)** A transpressional fold and thrust belt in this state contains a system with a “Big Bend” feature; that system, studied by geologists Thomas Dibblee and Andrew Lawson, is a canonical example of strike-slip faulting. Lagerstätten located in this state include the La Brea Tar Pits. For 10 points, name this tectonically-active west coast state home to the San Andreas Fault.
<Earth and Space, Geology>

47. **Low spin complexes with this d-count are generally square planar. It’s not four, but a conjugated ring of this size is a canonical example of the pseudo Jahn-Teller effect. A conjugated ring of this size is the largest with three bonding molecular orbitals in its Frost circle. This is *twice* the number of signals in the carbon-13 NMR spectrum of meta-benzenediol. (*)** Rings of this size frequently adopt crown and tub conformations. It is the coordination number of the body-centered cubic unit cell and the most common allotrope of sulfur consists of a cyclic arrangement of this many atoms. Doubling the concentration of each reactant in a termolecular reaction would increase the rate by this factor. The number of electrons in the full valence shell of a p-block element is equal to this number. For 10 points, name the positive integer whose consumption by seven is the reason that six is afraid of nine.
<Chemistry>

48. **These systems are the title of a journal published by Wiley on behalf of the Geological Society of Japan. These systems may come in ensiatic or ensimatic forms depending on the type of material they lie above. (*)** An inversion of concavity is commonly cited as the reason behind the characteristic shape of

these features under ideal conditions and one side of them is typically associated with a large negative Bouguer anomaly. These structures are generally used by geologists to divide convergent boundaries into three namesake parallel zones and examples of these structures include the Lesser Antilles, Mariana and Aleutians. For 10 points, name these curved chains of active volcanoes most commonly formed through the subduction of oceanic crust.
<Earth and Space, Geology>

49. **A low level of sodium in this pathway has been suggested to be an adaptation to protect young growing tissues from Na+ accumulation. Transcripts for glutamine synthase are upregulated by infestation by some members of the superorder, Sternorrhyncha. In maize, stylectomy using brown plant hoppers** (*) allows measurement of this pathway's contents. This pathway is symplastic where the water flow is pressure driven, but the pressures are positive, with relatively high values in the source regions and relatively lower values at the sinks. This pathway consists of sieve tubes which are an end-to-end arrangement of sieve elements joined at a sieve plate. For 10 points, name this structure along with the xylem that are the main two long-distance transport structures in plants.
<Biology>

50. **The Type 931 was the first mass produced example of these devices. Devices of this type that incorporate an Ag-O-Cs surface may exhibit a strong anode dark current, an effect that is minimized when bialkali photodiodes are utilized instead. (*)** These devices may be classified as either head-on or side-on, depending on the location where they receive signals. They are the most common fluorescence detectors used in two-photon excitation microscopy. They are often paired with scintillation counters and work by using high voltages to accelerate electrons across a series of dynodes and anodes. For 10 points, name these high gain, low noise detectors that multiply the current produced by incident photons by several orders of magnitude.
<Physics, Modern>

51. **First run at a Division B Invitational in the 2018 season, this Science Olympiad event is more than 50 minutes long. (*)** With no cheatsheets or binders allowed, this event was last won nationally by Ladue Middle School. Although sometimes extremely difficult, after adding an “-ing” ending to a word in the name of this event, you may be spared. Topics in this event range from pancakes to the word “and”. For 1 point, how dumb do you feel right now?
<MISCELLANEOUS>