

Finals

Final Round Tossups

(1) **Householder's method for finding these values generalizes to a method co-named for Joseph Raphson if the order "d" equals one. An upper bound on the number of these values is given by Descartes's [[deh-KAHRTS]] rule of signs. According to the (+) fundamental theorem of algebra, a polynomial's degree equals the number of the complex types of these values, which can be found for a parabola using the (*) quadratic equation. For the point, name these values where the X-axis intersects a polynomial.**

ANSWER: **Roots** of a polynomial (accept **Zeroes**; accept **X-intercepts**; prompt on "solutions")

(2) **Otto Lilienthal used the principles of this field to recreate characteristics of animals into his vehicles. Large trucks frequently have a deflector on the top of the cab to reduce this field's (+) namesake property. Vehicles are given this field's namesake property through streamlining. Wind tunnels are used in this field to examine (*) drag in powered flight tests. For the point, name this field, the study of the motion of air around solid objects.**

ANSWER: **Aerodynamics** (prompt on "fluid dynamics" or "gas dynamics")

(3) **This region's Pantheon Fossae [[FAH-say]] includes an impact crater and radiating grabens [[GRAH-bens]] nicknamed for its appearance as "the Spider." The antipodal [[an-TIH-poh-dul]] area of this region consists of grooved hilly terrain colloquially called the (+) "Weird Terrain." After Mariner 10 was unable to take a complete image of this region, the first full photograph of this region was taken by the MESSENGER spacecraft, revealing it to be about 35 percent the width of its (*) host body's diameter. For the point, name this largest impact crater on Mercury, derived from the Latin word for "heat".**

ANSWER: **Caloris** Basin (or **Caloris** Planitia;; prompt on "Mercury," "Mercury's Surface," or any other description of Mercury's surface)

(4) **In mammals, vinculin [[VINK-yoo-lin]] is involved in linking this protein with integrin [[in-TEH-grin]] adhesion molecules. One structure formed from this protein is regulated by thymosin [["THIGH"-moh-sin]] and (+) profilin [[pro-FIH-lin]] and another structure of this protein is regulated by the Arp2/3 [[ARP-2-3]] complex. This protein comes in polymer filamentous and monomer [[MAH-no-mer]] globular varieties. (*) Cytoskeleton microfilaments are composed of this protein. For the point, name this protein that binds to myosin [[MY-oh-sin]] to facilitate muscle contraction.**

ANSWER: **Actin** (accept F-**actin** or G-**actin**)

(5) **Dissolving sulfuric acid causes it to undergo this process to produce hydronium and bisulfate ions. After undergoing this reaction, amides [[AM-ides]] are converted into a carboxylic [[kar-bok-SIH-lik]] acid and an amine [[AM-een]] or ammonia. (+) Glycosidase [[gly-KAH-sih-dase]] enzymes break polysaccharides into monosaccharides via this reaction. Proteases [[PRO-tee-ay-ses]] break down proteins by using this reaction to (*) cleave peptide bonds. For the point, name this reaction that breaks up molecules when they react with water.**

ANSWER: **Hydrolysis**

(6) **The total momentum of these particles is conserved in Umklapp scattering. In non-condensate matter, second sound phenomena occur due to vibrations in these particles. Electron interactions with these particles produce Cooper pairs in (+) superconductors according to BCS theory. The contribution of these particles to a solid's specific heat is estimated with the (*) Debye [[deh-"BY"]] model. For the point, name these quasiparticles representing lattice vibration.**

ANSWER: **Phonons**

(7) **This thinker claimed that the majority of research conducted is "normal science," building on the ideas and theories of those who carry out pre-science. This thinker compared changes in scientific understanding to the gestalt [[geh-SHTAHLT]] switch that occurs when looking at the (+) duck-rabbit illusion. In one book, this thinker claimed that the title events happen when existing theories become incommensurable with observable data, leading to a (*) paradigm shift. For the point, name this American philosopher, the author of *The Structure of Scientific Revolutions*.**

ANSWER: Thomas **Kuhn**

(8) **This constellation names the closest dwarf galaxy to the Milky Way. This constellation's VY star, a red supergiant, was once the candidate for the biggest known star in the universe. The closest white dwarf to Earth is (+) in this constellation. A star in this constellation forms the "winter triangle" with Procyon [[PRO-see-on]] and Betelgeuse [[BEH-tel-"juice"]]. (*)** Sirius, the brightest star in the night sky, is the alpha star of, for the point, what constellation that depicts a "great dog"?

ANSWER: **Canis Major** (prompt on descriptions of a big or large dog before mentioned: do not accept or prompt on partial answers or "Canis Minor")

(9) **These particles are distinguished from their antiparticles by having left-handed chirality [[kai-RAL-ih-tee]]. Sterile, non-interacting forms of these particles have been proposed as a potential explanation of dark matter. Along with a (+) positron, one of these particles is released in Beta plus decay. These particles come in three leptonic flavors (*)** corresponding to the electron, muon [[MYOO-on]], and tau [[TAO]]. For the point, name these nearly massless particles which lack charge.

ANSWER: **Neutrinos** (accept Tau **neutrinos**; accept Muon **neutrinos**; accept Electron **neutrinos**; prompt on "fermions"; do not accept or prompt on "neutrons")

(10) **In an editorial on this case one writer referred to the defense as "theological bilge." One defense witness in this case was asked questions about the population of ancient Egypt as well as Cain's wife. This case involved a violation of the (+) Butler Act and was deliberately staged to bring attention to the small town of Dayton, Tennessee. (*)** Clarence Darrow and William Jennings Bryan debated at, for the point, what court case, in which a teacher was convicted of teaching evolution?

ANSWER: **Scopes trial** (or the Scopes **Monkey** trial; or *The State of Tennessee v. John Thomas Scopes*)

(11) **This problem was used to demonstrate that the "geometry of position" is about something more general than "measurements and calculations." One variation of this problem is the five rooms puzzle. This problem was used to show that the (+) ability to continually move along the edges of a graph was dependent only on the vertices, creating an Euler [[OY-ler]] walk. The real-world inspiration (*)** of this problem was briefly made solvable after allied bombing of modern Kaliningrad. For the point, name this early graph theory problem based on the roads of a city on the Pregel River.

ANSWER: **Seven bridges** of Königsberg (accept **Königsberg Bridge problem**; prompt on "bridge problem" and similar answers)

(12) **Along with two boundary conditions, a straight path, and a steady state, this condition is necessary for shell balance. A 2D layer with this condition is necessary for the Blasius [[BLAY-zee-us]] equation. Incompressible and Newtonian fluids (+) characterized by this condition experience a pressure drop according to the Hagen-Poiseuille [[HAH-gen pwah-ZUHL]] equation. High momentum diffusion and low momentum convection characterize this regime, which notably (*) lacks eddies. This regime occurs in fluids that have a low Reynolds number. For the point, name this flow regime contrasted with turbulent flow.**

ANSWER: **Laminar** flow (or **Streamline** flow)

(13) **Evidence for the existence of these regions includes the presence of primordial helium 3 and massive flood basalts. These structures are bookended by a hot "tail" and a cooler "head." The movement of the crust over (+) one of these regions is the likely cause of volcanic island chains such as Hawaii due to the formation of (*) hotspots. For the point, name these regions in which partially molten rock rises up to the crust from their namesake layer of the earth.**

ANSWER: **Mantle Plume** (prompt on "hotspots" before mentioned; prompt on "mantle")

(14) **The Wolf-Rayet [[RAY-et]] star WR-25 is part of this constellation's Trumpler 16 open cluster. This constellation's brightest star is the current second brightest star in the night sky, Canopus [[KAH-noh-pus]]. This constellation's namesake nebula contains the (+) Keyhole Nebula and the Homunculus [[ho-MUNG-kyoo-luss]] Nebula. A star in this constellation was the second brightest star for several decades after a great eruption in 1837. Puppis [[PUH-piss]] and Vela [[VEE-lah]] form a ship with (*) this constellation, of which this constellation is the hull. For the point, what southern constellation contains a luminous blue variable Eta [[EH-tah]] star?**

ANSWER: **Carina**

(15) **This force is the result of the Pauli exclusion principle at the surface of contact. In Gravitron carnival rides, this force opposes centripetal force to hold riders to the wall. Cosine of slope angle times mass times gravitational (+) field strength yields this force. Friction is equal to the product of this quantity multiplied by (*) mu [[MYOO]]. For the point, name this component of the contact force, which is always perpendicular to the plane of contact.**

ANSWER: **Normal** force (prompt on "contact force" before mentioned; do not accept or prompt on "inertia")

(16) **Grubbs catalysts cleave bonds in these molecules in a reaction called their namesake "metathesis." Hydroboration-oxidation reactions convert one of these functional groups into an alcohol. The stereochemistry of these functional groups is described by E/Z (+) notation. These molecules follow the general formula "C_nH_{2n}" and have sp² hybridized orbitals. A polymer made from the simplest example of these molecules is the most common plastic in the world due to its use in packaging. (*) Ethylene is an example of, for the point, what hydrocarbons with a carbon-carbon double bond?**

ANSWER: **Alkenes** (or **Olefins**; accept Carbon-carbon **Double Bonds**; prompt on "Hydrocarbons"; do not accept or prompt on "Alkanes" or "Alkynes")

(17) **With his first wife, Barbara de Mey, this man opened a self-run draper's shop before spending 40 years as a chamberlain at the City Hall in Delft. After this man's development of a method to create powerful lenses, his friend, Reiner de (+) Graaf, helped induct him into the Royal Society of London. Throughout his scientific career, this man created over 500 microscopes and discovered infusoria [[in-"few"-SOH-ree-ah]], the (*) vacuole [[VAK-yoo-ole]] of a cell, and spermatozoa [[sper-mah-tah-ZOH-ah]]. For the point, name this Dutch scientist recognized as the "Father of Microbiology."**

ANSWER: Antonie van **Leeuwenhoek** [[LEH-ven-hohk]]

(18) **Tropical varieties of these structures cause flows towards the equator. The intensity on one side of these structures is described by "western intensification." Despite its name, the Sargasso Sea is one of these structures. One of these structures in the (+) Indian Ocean reverses direction during monsoons. There are five major structures of this type around the world, two of which (*) rotate clockwise and three counter-clockwise. For the point, name these regions of rotating ocean currents.**

ANSWER: Ocean **Gyres** (prompt on "currents")

(19) **This phenomenon allows Pluto's motion to remain stable despite crossing Neptune's path. The Laplace [[lah-PLAHSS]] variety of this phenomenon occurs with successive two-to-one ratios, yielding a four-to-two-to-one ratio. In the (+) asteroid belt, Kirkwood gaps are formed due to this phenomenon with (*) Jupiter. For the point, name this phenomenon in which orbiting bodies influence each other due to having orbital periods that are integer multiples of each other.**

ANSWER: Orbital **resonance**

(20) **This scientist's concept of "fitness" was applied to society in the book *Social Statics*. This scientist replaced Carl Linnaeus's category of "Vermes" [[VEHR-mess]] by coining the term "invertebrate." This scientist wrote the *Philosophie zoologique* [[fee-loh-soh-FEE zoh-oh-loh-ZHEEK]] and (+) illustrated one of his ideas by citing a giraffe acquiring a long neck through multiple (*) generations of stretching. For the point, name this biologist, who proposed a discredited theory of evolution that involved inheritance of acquired characteristics.**

ANSWER: Jean-Baptiste **Lamarck** (or Jean-Baptiste Pierre Antoine de Monet, chevalier de **Lamarck**)

(21) **Enzyme inhibitors that mimic these configurations include the antiviral drug Tamiflu. The structures of these entities resemble intermediates of similar energy according to Hammond's postulate. These entities are symbolized by a "double (+) dagger" symbol and represent saddle points on a potential energy surface. The activation energy is the difference between the reactants and (*) this state on a reaction coordinate. For the point, name these temporary states of high potential energy along a reaction's path.**

ANSWER: **Transition States** (accept **Activated Complexes**; prompt on "intermediate")

(22) **The Yukawa interaction describes interactions governed by this force in a scalar and Dirac [[dee-RAHK]] field. This is the only force affected by asymptotic freedom, causing this force to diminish over time. This force is currently best understood through (+) quantum chromodynamics. This force allows quarks to be confined into hadrons, preventing the existence of free quarks. This force is mediated by the (*) gluon, holding neutrons and protons together in the atomic nucleus. For the point, name this most powerful of the four elementary forces.**

ANSWER: **Strong** nuclear force (or **Strong** interaction; or **Color** force)

(23) **This enzyme uses repeated cycles of "scrunching" to stop and restart during the process of "abortive initiation." In bacteria, this enzyme binds a sigma factor before recognizing the minus 35 and minus 10 elements, which are analogous to the eukaryotic (+) TATA box. This enzyme binds a promoter sequence to begin synthesizing a single-stranded product that is later spliced and translated. (*) Transcription is performed by, for the point, what enzyme that produces a certain biologically essential molecule from a DNA template?**

ANSWER: DNA detected (dependent) **RNA polymerase** [[pah-LIM-er-ase]] (accept **RNAP** or **RNAPol**; prompt on "polymerase"; do not prompt on "RNA")

(24) **This equation wrongly predicts that the critical compressibility factor equals three-eighths for all fluids. Maxwell's equal area rule corrects a flaw on P-V isotherms generated by this equation, which truncates the virial [[VEE-ree-ah]] equation at two terms. (+) Attractive forces and particle volumes are accounted for by the parameters "a" and "b" in this equation, making it more accurate than the (*) ideal gas law. For the point, name this equation of state, whose Dutch developer also names a set of weak intermolecular forces.**

ANSWER: Van der Waals Equation (or Van der Waals Equation of State)

(25) **The time to fixation of an allele [[uh-LEEL]] experiencing only this phenomenon is four times the population size according to the Wright-Fisher model. Motoo [[moh-TOH-oh]] Kimura's neutral theory attributes most molecular evolution to (+) this phenomenon, whose effects are corrected for by assuming an infinite population size under Hardy-Weinberg equilibrium. Due to the founder effect, a population undergoing a (*) bottleneck is especially sensitive to this phenomenon. For the point, name this change in allele frequencies due to random sampling.**

ANSWER: Genetic Drift (accept Allelic drift; accept Sewall-Wright effect)

(26) **Spin trapping often requires reacting these molecules with nitrones before they can be visualized using EPR spectroscopy. These molecules contain a high-energy molecular orbital called a SOMO [[SOH-moh]]. These species are created by homolytic (+) cleavage reactions, which can be drawn using fish-hook arrows. The superoxide example of these molecules is diagrammed with a (*) single dot. For the point, name these species with unpaired electrons that are neutralized by antioxidants.**

ANSWER: Free Radicals (prompt on "Paramagnetic")

(27) **Anonymous inline examples of these objects are known as Lambdas, and a type of language which includes Scheme and Lisp is named for these objects. In Java, the main program is defined using the "public static (+) void main" type of these objects, and recursive versions of these things repeatedly make (*) calls to themselves. For the point, name these objects which can take input parameters and return output.**

ANSWER: Functions (accept Methods, Subroutine, Routine, Subroutine, or Procedure; accept Lambda function; accept Functional language; accept Recursive function)

(28) **Mutations to these genes cause the precancerous condition Barrett's esophagus. The presence of ghost loci [[LOH-kai]] suggests that placozoa [[play-ko-ZO-ah]] once had these genes but later experienced secondary loss. Ctenophora [[tih-NAH-foh-rah]] and (+) porifera [[poh-RIH-feh-rah]] are the only animal phyla to completely lack these genes. Mutations to these genes can cause drosophila [[droh-soh-FEE-lah]] body segments to (*) grow in the wrong places. For the point, name these genes that control anterior-posterior axis layout during embryonic development.**

ANSWER: **Hox** genes (prompt on "homeobox" genes)

(29) **The presence of methane trapped in these structures is the primary evidence for Dansgaard-Oeschger [[DANS-gard ESH-guh]] events. These are the largest structures to experience basal shear stress. One of these structures that formerly (+) covered most of Canada and the United States was named (*) Laurentide. For the point, name these structures that cover Greenland and Antarctica, large masses of frozen water that are larger than glaciers or ice shelves.**

ANSWER: **Ice Sheets** (accept **Continental Glaciers**; prompt on "Glacier"; prompt on "Ice Shelf"; prompt on "Ice")

(30) **One reaction of this type causes Walden inversion at a chiral [[KAI-ral]] center after backside attack. Activating groups favor this type of reaction at "ortho" and "para" positions in the Friedel-Crafts alkylation, which is an example of the "electrophilic (+) aromatic" type of this reaction. The SN1 and SN2 mechanisms for this type of reaction accept a nucleophile (*) and release a leaving group. For the point, name this type of reaction in which one functional group in a molecule is replaced by another.**

ANSWER: **Substitution** reaction (accept Nucleophilic **Substitution**; accept Electrophilic Aromatic **Substitution**; accept **SN1** reaction before mentioned; accept **SN2** reaction before mentioned; accept **Single Displacement** reaction; accept **Single Replacement** reaction; prompt on "displacement"; prompt on "replacement")

(31) **This phylum contains the myxozoans [[miks-oh-ZO-uns]], the only known animals to lack mitochondria and to have single-celled species. When considered to be the sister taxon to bilateria [{"by"}-lah-TEE-ree-uh]], this phylum is placed within Planulozoa [{"plah-noo-loh-ZO-ah}]. (+) Some members of this phylum can cause the sometimes deadly Irukandji [{"ee-roo-KAHN-jee}] syndrome in people. Most members of this radially symmetric phylum have either medusae [{"meh-DOO-say}] or polyp body forms. This phylum is defined by the presence of (*) stinging cells called nematocysts [{"nee-MAH-toh-sists}]. For the point, name this animal phylum that includes anemones [{"ah-NEH-moh-nees}], corals, and jellyfish.**

ANSWER: **Cnidaria** [{"nigh"}-"DARE"-ee-uh] (or **Cnidarians**; be lenient on pronunciation)

(32) **An iridescent example of these minerals first found in Canada is called labradorite [{"LAB-rah-dor-ite}]. A common intrusive example of these minerals is anorthite [{"AN-or-thite}]. Triclinic [{"try"}-KLIH-nik] crystals characterize the (+) plagioclase [{"PLAH-jee-oh-klase}] subclass of these minerals. The continuous branch of Bowen's reaction series is made up of one subclass of these minerals. These aluminum tectosilicate (*) minerals have a Mohs hardness rating of 6. For the point, name these most abundant minerals in the Earth's crust.**

ANSWER: **Feldspar**

(33) **Enzymes named for these entities are used in the tagmentation process of techniques such as ATAC-seq [{"attack"}-"seek"]. Autonomous types of these entities contain their namesake enzyme or reverse transcriptase [{"tran-SKRIP-tase}], while non-autonomous (+) types of these entities lack both. A type of these entities called P elements results in hybrid dysgenesis [{"dis-JEH-neh-sis}] in Drosophila [{"droh-SAH-fih-lah}]. The Activator/Dissociation system was the first of these entities identified, having been done so in (*) maize by Barbara McClintock. For the point, name these DNA sequences named for their ability to move around a genome.**

ANSWER: **Transposons** (or **Transposable elements** or **TEs**; accept **jumping genes**; prompt on "transposase" before "reverse")

(34) **Hetero-varieties of these solutions have phase diagrams with saddle-shaped miscibility [{"miss"}-"ability"}] gaps. One method for separating these solutions involves dissolving salts before distillation. Classic examples of these solutions include mixtures of 68 percent (+) nitric acid and 32 percent water as well as 94 percent water and 6 percent (*) ethanol. For the point, name these solutions which form when the constituent parts have similar boiling points, causing them to violate Raoult's [{"rah-OOLS}] law and resist distillation.**

ANSWER: **Azeotropes** (or **Constant Boiling Point Mixture**)

(35) **By damaging these structures, the monoclonal antibodies bamlanivimab [[bam-lah-NIH-vih-mab]] and etesevimab [[eh-teh-SEH-vih-mab]] disrupt infection. These structures extend from the viral envelope lipid bilayer and are composed of (+) glycoproteins. Adenoviruses are modified to express these structures in the Johnson & Johnson vaccine. Pfizer mRNA vaccines (*) program cells to produce these structures. For the point, name this protein structure that gives coronaviruses their distinctive "crowned" appearance.**

ANSWER: Sars-Cov-19 **Spike** protein (or **Peplomer**; prompt on partial answers)

Extra Questions

(1) **In some structures, this process is managed by the Automatic Depressurization System. High pressure injection systems are used for this process in nuclear reactors. In most nuclear power plants, this process occurs in (+) hyperboloid ["high"-PER-boh-loyd] structures commonly known as this process's "towers." Discharging the material used for this process into local (*) lakes and streams can cause local temperatures to rise, creating anoxic [[an-OKS-ik] environments. For the point, name this process achieved in power plants with flowing water.**

ANSWER: **Cooling** (accept word forms and equivalents; accept **Cooling** towers)

(2) **The root mean square voltage of this phenomenon is equal to the square root of the mean over the square of instantaneous voltage. The voltage equation of this phenomenon can be stated as peak voltage times the sine of the (+) angular frequency times the time traveled. When diode bridges have this phenomenon as an input (*) but not an output, they are known as bridge rectifiers. The voltage of this phenomenon can be "stepped up" or "stepped down" in a transformer. For the point, name this type of electrical current contrasted with direct current.**

ANSWER: **Alternating Current** (or **AC**)