National Science Bee – Finals

Regulation Tossups

(1) **A ladder operator symbolized "A" and named for this process is used to decrease the eigenstate of a quantum harmonic oscillator by one unit. One form of this process produces two gamma photons that travel in opposite directions. (+) Pair production is the inverse of this process, which can occur between an electron and a (*)** positron. For the points, name this process in which a particle collides with its anti-particle, destroying both of them and releasing energy.

ANSWER: **annihilation** (accept word forms; accept electron-positron **annihilation**)

(2) **This disease has caused local extinction of species such as the northern long-eared myotis by causing abnormal arousal from hibernation. This condition affects animals of the order *Chiroptera* across North America, (+) often prompting the closure of caves and caverns. This condition is caused by infections from the *Pseudogymnoascus destructans* fungus. (*)** For the points, name this fatal disease that affects bats and causes a namesake characteristic growth on the muzzle.

ANSWER: **white-nose** syndrome (or **WNS**)

(3) **These functional groups are made from allylic alcohols using a diethyl tartrate ligand and a titanium catalyst in a reaction named for Barry Sharpless. The (+) Prilezhaev reaction for producing these functional groups goes through a so-called "butterfly mechanism." Treating an alkene with a peroxyacid such as mCPBA will produce one of these functional groups, whose simplest example, (*)** ethylene oxide, has very high ring strain. For the points, name this functional group consisting of a three-membered cyclic ether.

ANSWER: **epoxide**s (accept **oxirane**s; prompt on "ethers")

(4) **This company designed an extension called Jazelle, in order to allow for executing Java bytecode, which can operate alongside the compressed Thumb instruction set. This company designed security extensions that contain the ability to switch between worlds, called (+) TrustZone. This company creates designs for microcontrollers and real-time controllers featuring their Cortex cores. (*)** For the points, name this semiconductor computer company that develops CPU designs used in most phones, and was formerly known as Advanced RISC [["RISK"]] Machines.

ANSWER: **Arm** Holdings Plc

(5) **A mechanism developed by this man describes the oxidation of nitrogen into NOX compounds upon combustion. This scientist proposed that density fluctuations after the Big Bang formed flat ellipsoids of gases, which are his namesake (+) "pancakes." In 1966, Igor Novikov and this scientist proposed the concept of primordial black holes (*)** formed after the Big Bang. For the points, name this Soviet physicist who co-names a form of inverse Compton scattering that distorts the cosmic microwave background radiation, along with Rashid Sunyaev.

ANSWER: Yakov **Zeldovich** (or Yakov Borisovich **Zeldovich**; accept **YaB**; accept **Zeldovich** pancake; accept Sunyaev-**Zeldovich** effect; accept **Zeldovich** mechanism)

(6) **This process produces erythrose-4-phosphate, which serves as a precursor to aromatic amino acids such as tryptophan. The non-oxidative phase of this pathway involves a series of isomerization, (+) transaldolase, and transketolase reactions, while its oxidative phase produces two molecules of NADPH from a single unit of glucose-6-phosphate. Running parallel to (*)** glycolysis, this is, for the points, what anabolic pathway that produces precursors for nucleotide synthesis, which is named for its phosphorylated five-carbon sugar intermediates?

ANSWER: **pentose phosphate** pathway (or **pentose phosphate** shunt; accept **hexose monophosphate shunt**; accept **HMP shunt**; accept **phosphogluconate pathway**)

(7) **Adams' catalyst contains the dioxide of this element, which turns black and becomes catalytic when exposed to hydrogen. A square planar cis-complex containing this metal at its center is one of the most commonly used (+) chemotherapy drugs. Reduction potentials are often standardized to this metal, because it makes up the standard hydrogen (*)** electrode. Aqua regia is most commonly used to dissolve both gold and, for the points, what very expensive transition metal with atomic number 78?

ANSWER: **platinum** (accept **Pt**)

(8) **This scientist described his studies of Muriel Bristol's tea-tasting abilities in his book *The Design of Experiments*, which also includes his "exact test" for analysis of contingency tables. The variance of the score equals a type of statistical (+) "information" named for this scientist. This man developed a class of statistical models that analyze differences in means for more than two groups, which is the (*)** ANOVA family of tests. For the points, name this British geneticist and statistician who names the F-test.

ANSWER: Ronald **Fisher** (or Sir Ronald Aylmer **Fisher**; accept **Fisher** information; accept **Fisher**'s exact test)

(9) **Bonding in some molecules with this property can be described using the Pimentel-Rundle, or 3C-4E model. N-X-L notation describes molecules with this property such as Dess-Martin (+) periodinane. Molecules with this property include noble gas compounds and compounds like phosphorus pentachloride and sulfur hexafluoride. (*)** For the points, molecules made up of main group elements are described by what property when they have more than eight electrons in valence shells?

ANSWER: **hypervalence** (or **hypervalent**; or **expanded octet**; prompt on "hypercoordination" or "having extra valence electrons")

(10) **This point for the Solar System is the origin of the International Celestial Reference System. For the Earth-Moon system, this point lies approximately 4,700 kilometers from Earth's center. The (+) wobble of stars around this point can be used to detect exoplanets. For Jupiter, this point lies outside the Sun's surface, while for other bodies like Pluto and Charon, it lies (*)** between them. For the points, name this center of mass around which two or more celestial bodies orbit.

ANSWER: **barycenter** (prompt on "center of mass" or "center of gravity")

(11) **To collect fauna from this region, researchers use a type of sled with a mesh net, which includes a Sherman variety for rough terrain. Organisms in this ecological zone include polychaete worms, (+) and much of the decaying matter in this zone is consumed by detritivores. This region is located below the demersal zone and (*)** part of the profundal zone. For the points, identify this lowest level in a given body of water, a region that includes the sea floor.

ANSWER: **benthic** zone (accept **benthos**; prompt on "sea floor" or "seabed" or "ocean floor" or "lake floor" antiprompt on "hadalpelagic zone")

(12) **This language family's x86 variant uses registers like EAX and EBX, while its instructions include MOV for data transfer and JMP for control flow. Programs written in this language family can directly manipulate the stack pointer and perform (+) bitwise operations using opcodes. RISC [["RISK"]] architectures simplify this language family's instruction set. (*)** For the points, name this low-level programming language family that corresponds directly to machine code.

ANSWER: **assembly** (accept **assembler** or **ASM**; accept specific variants like **x86 assembly** before mentioned)

(13) **In one genus, a type of these genes called "DEFORMED" is involved in regulating "reaper" genes. In chordates, retinoic acid signals to these genes during embryonic development, and in insects, such as *drosophila*, these genes are regulated by the (+) gap and pair-rule genes. Mutations to these genes can cause abnormal body plans such as (*)** extra pairs of legs or wings. For the points, name these genes that code for an animal's body plan along the head-tail axis.

ANSWER: **Hox** genes (or **homeobox** genes)

(14) **William Morris Davis criticized the namesake of these phenomena for not accounting for how an unbalanced flow can turn into geostrophic equilibrium. This phenomenon is contrasted with a "polar" type and one named for William Ferrel, (+) which is centered in the mid-latitudes. In this phenomenon, warm, moist air is drawn into the Intertropical Convergence Zone before moving to the poles and (*)** descending around 30 degrees latitude. For the points, name this "cell," a tropical atmospheric circulation named for an English lawyer.

ANSWER: **Hadley** cells (accept **Hadley** circulation; prompt on "circulation")

(15) **A version of this algorithm that uses a Fibonacci heap improves to "big-O of E plus V log V" runtime. The similar Bellman-Ford or A-star algorithms can be used in place of this algorithm for systems with (+) negative edge weights. This algorithm maintains a priority queue of vertices and updates tentative distances through edge relaxation to find the (*)** shortest path between nodes in a weighted graph. For the points, name this algorithm named for a Dutch computer scientist commonly used in GPS navigation systems.

ANSWER: **Dijkstra**'s [['DIKE'-struh]] algorithm

(16) **A formalism describing this phenomenon uses Airy functions to patch together two solutions at turning points in the WKB approximation. This phenomenon explains the (+) field emission of electrons, which happens at the p-n junction of a Zener diode. George Gamow used this phenomenon to explain (*)** alpha decay, as alpha particles would instead require a large amount of energy to escape the nucleus. For the points, name this phenomenon in which a particle crosses a classically forbidden potential energy barrier.

ANSWER: quantum **tunnel**ing

(17) **The drug tunicamycin blocks a form of this process that targets asparagine residues using a lipid template of dolichol phosphate. This process attaches molecules such as sialic acid and GlcNAc [["glick-nack"]]. The (+) N-linked and O-linked forms of this process take place in the ER and Golgi apparatus, respectively. Proteins are directed to the lysosome by a form of this process that attaches (*)** mannose-6-phosphate. For the points, name this cellular process in which proteins are covalently modified with sugars such as glucose.

ANSWER: **glycosylation** (accept N-linked **glycosylation** or O-linked **glycosylation**; prompt on "adding sugars" or "attaching sugars")

(18) **Changing this quantity can be done by adding barium chloride and sulfuric acid in the McFarland standards. This condition can be found using the Jackson Candle method and it can be measured using (+) Formazin Nephelometric Units. In bodies of water, a disk with alternating black and white quarter circles can be used to measure this condition; that disk is the (*)** Secchi disk. For the points, name this condition in which liquids show haziness, which can be a measure of water quality.

ANSWER: **turbidity** (prompt on "transparency"; prompt on "water clarity" or "water quality" until "water" is read)

(19) **Examples of these things labeled with the letters "A" through "K" are part of a set named for Fraunhofer. These things are shifted in the presence of an electric field, per the Stark effect, (+) while an analogous effect for magnetic fields is the Zeeman [[ZAY-mun]] effect. For the hydrogen atom, examples of these things include the (*)** Balmer and Lyman series. For the points, name these identifying set of features for atoms, occurring at specific wavelengths across the range of electromagnetic radiation.

ANSWER: **spectral lines** (or **spectral absorption lines**; or **emission lines**; or **emission spectra**; or **spectral series**; accept hydrogen **spectral series**; prompt on "lines" or "spectrum" or "spectra")

(20) **Movement proteins were first discovered in studies of this virus. Chemist Wendell Meredith Stanley shared a Nobel Prize for being the first to crystallize this virus. (+) Rosalind Franklin correctly claimed that this virus, with a hollow, rod-like shape, also had a single-stranded RNA, and it was the (*)** first pathogen to be classified as a virus. For the points, name this virus that causes colored blotches on the leaves of a plant that is used to create cigarettes.

ANSWER: **tobacco mosaic** virus (or **TMV**)

(21) **Quasi-periodic sudden relaxation events and drop-offs in temperatures within these devices are known as their sawteeth. These devices rely on both an internal electric current and a powerful, external magnetic coil, unlike a stellarator. (+) These devices can heat hydrogen to several millions of degrees Celsius, making them leading candidates for production of practical fusion energy. (*)** For the points, name these devices that use magnetic fields to confine plasma into a torus shape.

ANSWER: **tokamak**s

(22) **Materials with this property contain phases named for lasagna, spaghetti, and gnocchi and are known as nuclear pasta. Matter with this property is modelled as an ideal (+) Fermi gas. Matter with this property avoids contraction due to gravity by forcing fermions into higher energy states. (*)** For the points, name this property that names a pressure preventing the collapse of a neutron star or white dwarf, which occurs when multiple quantum states share the same energy level.

ANSWER: **degeneracy** (accept word forms like **degenerate**; accept electron **degeneracy pressure**; prompt on answers mentioning "density" or "pressure"; prompt on "fermionic")

(23) **Two sigma bonds and a pi bond are created in the inverse electron-demand form of this reaction, which may involve heteroatoms. A form of this reaction between cyclopentadiene and maleic anhydride favors its (+) "endo" configuration, with electron-withdrawing groups pointed inwards, and is used to produce derivatives of cyclohexene. (*)** For the points, name this four-plus-two cycloaddition reaction between a diene and a dienophile, which is named for two German chemists.

ANSWER: **Diels-Alder** reaction (accept inverse electron-demand **Diels-Alder** reaction)

(24) **The *Rhipidistia* group of this clade evolved a "lymph heart" to circulate bodily fluids. The evolution of this clade is explained by Alfred Romer's "shrinking waterhole hypothesis." This clade is defined by the presence of a (+) fully articulated appendicular skeleton supporting limb buds. In 2004, fossils of Tiktaalik were discovered that showed the transition of this clade to becoming land-dwelling animals. Coelacanths, (*)** lungfish, and tetrapods are the only extant examples of, for the points, what group of bony fish that are contrasted with the ray-finned fish?

ANSWER: **lobe-finned** fish (or **Sarcopterygii**; prompt on "tetrapods" or "lungfish" before read; prompt on "fish")

(25) **This mathematician names a "New Frontiers" prize awarded yearly by the Breakthrough Prize board. With Roya Beheshti Zavareh, this mathematician wrote (+)** ***Elementary Number Theory, Challenging Problems*****. This mathematician, who linked dynamical systems and topology in the "magic wand theorem," (*)** also worked on Teichmuller theory and is best known for her work on moduli spaces of Riemann surfaces. For the points, name this Iranian mathematician, the first woman to win the Fields Medal.

ANSWER: Maryam **Mirzakhani**

(26) **James Hall and James Dwight Dana created a now-unused explanation for this process called geosyncline. Synkinematic events take place as part of this process. (+) Leopold von Buch classified this process as an event by marking the times between the oldest undeformed rock and youngest deformed rock. Creating belts on the crust, convergent plate margins are the site of, (*)** for the points, what process, in which a plate rises upwards to create mountains?

ANSWER: **orogeny** (or **orogenesis**; accept **orogen**ic belt; prompt on "formation of mountains")

(27) **The dynamic variety of this quantity can be measured by placing material inside of a rotating cylinder, while another method involves tilting a box of particles. This quantity can be approximated by a relationship stating that the coefficient of static friction is roughly equal to the tangent of this quantity. (+) This quantity is measured at 40 degrees for ashes. (*)** For the points, name this quantity, which is the largest angle at which granular materials like sand can pile up without slumping downwards.

ANSWER: angle of **repose** (or critical angle of **repose**; accept dynamic angle of **repose**; accept static angle of **repose**)

(28) **This process can be modeled using the Polanyi potential theory, which typically applies at higher pressures than the Brunauer-Emmett-Teller theory. A model for this process calculates the (+) fractional occupancy as a ratio of volumes of gas and is called the Langmuir isotherm. Zeolites and activated carbon have a large (*)** surface area for this process and are used to remove gas particles from the air. For the points, name this process in which molecules adhere to a solid surface.

ANSWER: **adsorption** (accept Langmuir **adsorption** model; do NOT accept or prompt on "absorption")

(29) **This person was nominated for the Nobel Prizes in Chemistry and Physics a combined 49 times but never won. This physicist, the namesake of the element atomic number 109, co-named the element, (+) protactinium. After escaping Nazi Germany, she helped demonstrate that barium isotopes could be generated by bombarding uranium with neutrons to split its nucleus. (*)** For the points, name this Austrian-Swiss physicist who worked with Otto Hahn, Fritz Strassmann, and her nephew, Otto Robert Frisch, to discover nuclear fission.

ANSWER: Elise "Lise" **Meitner** (accept **meitner**ium)

(30) **Three types of this ratite are extant, the Northern, Dwarf, and Southern, or Double-Wattled, species. This animal appears on the coat of arms of West Papua, and one of these animals, which was being held in captivity, once fatally attacked a Florida man with the nails found on the innermost toes of its two feet. One of these (+) birds kicked a tourist off a cliff in its native Southern Hemisphere range in 2012, and like the related emus, these animals fought with (*)** Australians encroaching on their habitat in the early 20th century. For the points, name this type of flightless bird, which along with ostriches, are one of the most dangerous birds in the world to adult humans.

ANSWER: **cassowary** (accept Northern **Cassowary**; accept Dwarf **Cassowary**; accept Southern **Cassowary**; accept Double-Wattled **Cassowary**)

(31) **In a debate, this philosopher disputed Thomas Kuhn's emphasis on scientific revolutions for creating a historical law out of past events. This philosopher criticized induction by stating that no type of logic can ever produce more knowledge than deduction in his (+) principle of critical rationalism. This philosopher claimed that for a statement to be scientific if it must be falsifiable. (*)** For the points, name this Austrian-British philosopher of science, the author of *The Logic of Scientific Discovery*.

ANSWER: Karl **Popper** (or Karl Raimund **Popper**)

(32) **This mission was able to observe line-like features called tiger stripes on Enceladus. This mission captured an image of the Earth and the Moon in a photograph titled (+) *The Day the Earth Smiled*. This mission, which included a landing on the moon Titan, finally ended in a "Grand Finale" when it traveled into a specific planet's atmosphere. (*)** For the points, name this NASA mission that was sent to investigate the rings of Saturn, which was named for a pair of Dutch and Italian astronomers.

ANSWER: ***Cassini*-*Huygens*** [[HOY-genz]] mission

(33) **Dirac cones within this substance produce the chiral half-integer quantum Hall effect. When two pieces of this substance are arranged at the "magic angle" of 1.1 degrees, it exhibits superconductivity. (+) Nanoribbons of this substance can be produced by "unzipping" another material. This substance can be produced by applying a piece of scotch tape to another allotrope and it can be rolled to create (*)** carbon nanotubes. For the points, name this allotrope of carbon that is a single layer of graphite.

ANSWER: **graphene** (do NOT accept "graphite")

(34) **An axiomatic system is complete if every one of these statements is also a theorem. One of these statements is represented by a double turnstile symbol, indicating it is a logical consequence of the empty set. The statement (+) "P or not P" is the simplest example of these statements, which include the law of excluded middle. Contradictions are the opposite of these statements, since they always (*)** evaluate to false. For the points, name these compound logical statements that are always true by virtue of their logical form alone.

ANSWER: **tautology** (or **tautological** statement)

(35) **Rough and smooth strains of a bacterium in this genus were used in Griffith's transforming principle experiments to demonstrate genetic transfer. The *mutans* and (+) *sobrinus* species of this genus cause most instances of dental cavities. An alpha-hemolytic species from this genus is responsible for most cases of bacterial (*)** pneumonia. For the points, name this bacterial genus whose Group A *pyogenes* species causes scarlet fever and a namesake throat infection.

ANSWER: ***Streptococcus*** (or ***Strep***)

Extra Questions

(1) **This technique relies on the chromophore 7-hydroxyphenoxazone, extracted from lichen species like Roccella. Congo red and methyl orange can substitute for the main compound in this test, which (+) changes color at pH 7. Azolitmin is the key component in this classical acid-base indicator that turns substances (*)** red or blue. For the points, name this basic chemical test that determines if a solution is acidic or basic.

ANSWER: **litmus** test (prompt on "pH test")

(2) **To prevent the spread of this genus through contact with pets, the FDA has imposed the "four-inch regulation" on turtle sales. Diseases caused by systemic infections of this genus can be identified by characteristic "rose spots." (+) Drinking water contaminated with members of this genus can cause enteric fever, such as paratyphoid and typhoid fever. Along with campylobacter, this genus of gram-negative bacteria is the most common cause of (*)** food poisoning. For the points, name this bacterial genus associated with raw chicken.

ANSWER: ***Salmonella***

(3) **Radiation sickness is diagnosed by repeated instances of this procedure every three hours after exposure. Automated analyzers for this procedure rely on the Coulter principle, which relates size and volume to changes in electrical impedance. This procedure aids in diagnosing conditions such as (+) thrombocytopenia and_leukemia using metrics like basophil concentration, WBC differential, and platelet concentration. (*)** For the points, name this thorough panel of diagnostic medical tests that includes measures of hemoglobin level and hematocrit.

ANSWER: **complete blood count** (or **CBC**; or **full blood count**; or **FBC**; accept **full hemogram**; accept **FHG**; prompt on "blood test" or "blood count" or "cell counting" or "blood cell count" or "hemogram")