2020 National Science Bee – Middle School
Final Round

Regulation Questions

1. This disease is diagnosed with a hemoglobin A1c test. Along with polycystic ovary syndrome, metformin is commonly prescribed as a treatment to this disease. The leading cause of blindness in young adults is this disease's retinopathy. One form of this disease occurs due to destruction of the Islets of Langerhans. For the point, name this disease caused due to insulin resistance or a lack of insulin production, which requires monitoring of blood sugar levels.
ANSWER: **diabetes**

2. Ozone can be used to split this functional group into carboxylic acids and ketones. No intermediate productions, like a similar functional group, form when these functional groups undergo halogenation. The German words Entgegen and Zusammen lend their names to the E and Z symbols used to label isomers of this functional group. The general formula of acyclic examples of these hydrocarbons have formula C-n, H-2n. The simplest example of these hydrocarbons is ethene. For the point, name this type of functional group consisting of a carbon carbon double bond.
ANSWER: **alkene**s [or olefins]

3. A horizontal approach to the most well known characteristic of this construct occurs along a path named for Henyey. That path for Henyey for this construct can be followed from a different track named for Hayashi. Delta Scuti and SX phoenicis occupy this construct's instability strip. Most data points on this plot are along what is referred to as the main sequence. This diagram typically uses temperature as the x-axis and luminosity as the y axis. For the point, name this color-magnitude diagram named for Danish and American astronomers used for stellar classification.
ANSWER: **Hertzsprung-Russell** Diagram [or **HR** diagram]

4. The equation "A" cosine squared of theta plus B cosine of theta plus C is used in this technique to determine the relation between dihedral torsion angles and the J coupling constant; that equation is the Karplus equation. TMS is used as a reference in this technique which has much larger chemical shifts for its Carbon-13 variant than the proton variant. A medical imaging technique that makes use of this method requires the patient to not have any metal implants due to the use of a giant magnet. For the point, name this technique which makes use of an external magnetic field to make nuclei readings.
ANSWER: **nuclear magnetic resonance** or **NMR** spectroscopy

5. According to the continuum hypothesis, there is no set with cardinality between this set of numbers and the natural numbers. Dedekind cuts are used to construct this set of numbers whose uncountability was proved by Georg Cantor's diagonalization argument. This type of number between 0 and 1 is uncountably infinite. The union of irrational and rational numbers produces this set of numbers. For the point, name these non-complex numbers which do not contain an imaginary component.
ANSWER: **real** numbers [prompt on R]

6. In the United States, types of this material can be identified by a resin identification number between one and seven. Leo Baekeland coined the term for this material and invented the first fully synthetic example of one, bakelite. Because it is likely an endocrine disruptor, the use of BPA as an additive to this material has been called into question. Examples of this material include polypropylene and polystyrene. For the point, name these highly malleable synthetic polymers, which make up water bottles and milk jugs.
ANSWER: **plastic**s [prompt on polymers**]**

7. This language handles input by grouping letters into hboxes which are then put into a vbox with the goal of minimizing badness between lines. Leslie Lamport designed an extension to this language with more user-friendly macros and packages. Donald Knuth designed this language to make beautiful textbooks and has said the X should be pronounced like a Scottish person pronounces "Loch." For the point, name this markup language whose extension shares its spelling with the name for natural raw rubber.
ANSWER: **TeX** [accept **LaTex**]

8. None of these particles are formed during internal conversion while their emission is represented by down arrows on Jablonski diagrams. The equation for these bosons gave rise to the De Broglie hypothesis and is equal to Planck's constant over wavelength. These particles are represented by curvy lines on Feynman diagrams. Young's double slit experiment proved the wave nature of these particles. For the point, name this quantum particle that carries the electromagnetic force and mediates visible light.
ANSWER: **photon**s

9. A gradient caused by this process is reversed by the hormone ADH. This process causes the swelling of a plant's central vacuole creating turgidity. In general, this process stabilizes solute concentrations, which can result in a cell becoming hyper- or hypotonic. Pressure is used to "reverse" this process in a desalination method. Water moves through a semipermeable membrane during, for the point, what diffusive process?
ANSWER: **osmosis** [or **osmotic** flow; prompt on water flow; prompt on water balance; prompt on diffusion]

10. A 50/50 mix of UDMH and NTO is a common hypergolic for these devices. The equation, delta-v equals effective exhaust velocity over the natural logarithm of initial total mass over final total mass, was developed from Newton's second law for these devices by Soviet engineer Konstantin Tsiolkovsky. Oxidizers on board these devices allow for the creation of force despite the presence of a vacuum when these devices travel. That force produced by these devices can be calculated by the thrust equation. For the point, name these devices that help propel satellites into space
ANSWER: **rocket** engines [or **rocket**s; prompt on engine]

11. This program greenlighted AS-204 which ended when a fire caused the death of Ed White, Roger Chaffee, and Gus Grissom. A follow-up program to this one plans to use the Orion spacecraft to set up a station called Gateway. Michael Collins remained in the Command Module during the 11th mission in this program, which landed in the Sea of Tranquility. The follow up to this program is the 2024 Artemis program. For the point, name this program whose 11th mission sent Buzz Aldrin and Neil Armstrong to the moon.
ANSWER: **Apollo** program

12. A white one of these substances forms in the result of a double replacement reaction between silver nitrate and sodium chloride. Double displacement reactions are classified as this type of reaction if the reaction occurs in an aqueous solution and one of the products is insoluble. Sometimes referred to as sediment, this solid component sits below the supernatant. Both referring to the process by which it forms and the solid substance itself, for the point, is what solid that forms out of solution?
ANSWER: **precipitation** [or **precipitate**; prompt on double displacement or double replacement or replacement before "replacement" is mentioned]

13. An effect named for this scientist is mathematically expressed as the magnetic flux density, times the path length times Verdet's *(vayr-DAY)* constant for the material equals the angle of rotation. Maxwell wrote a version of this scientist's law as the curl of electric field equal to the negative partial derivative of the magnetic field with respect to time, where the negative sign was precursored by Lenz's law. This scientist's law describes how an electromotive force is created by a change in flux. For the point, name this English scientist who names an electromagnetic law of induction.
ANSWER: Michael **Faraday**

14. A set of zipper-like proteins that help transport these structures include synaptobrevin and SNAP-25 and can be targeted by botulinum toxin. The fusion of these structures is mediated by SNARE proteins. Triskelion shaped proteins that form a cage like structure around these structures are called clathrin. MPRs are packed onto these structures so that they can be recycled after dropping off mannose-6-phosphate tagged proteins to the lysosome. These structures are similar to micelles and form during endocytosis. For the point, name these structures important in cell transport where a liquid or cytoplasm is surrounded by a lipid bilayer.
ANSWER: **vesicle**s

15. A parameter of this name in thermodynamics is equal to one over Boltzmann's constant times temperature. Penicillin is part of a class of antibiotics named for lactam rings of this letter. Abnormal heart rhythms can be treated with a class of medications named [this letter]-blockers. A form of decay named for this letter releases a particle equivalent to a Helium nucleus. For the point, name this letter that names a sheet motif common in protein folding alongside alpha-helices.
ANSWER: **beta**

16. The coherence length and penetration depth parameterize these materials in Ginzburg-Landau theory. This material is separated by an insulator at a Josephson junction, which gives rise to the Josephson effect where Cooper pairs are able to tunnel across the barrier. John Bardeen, Leon Cooper, and John Robert Schrieffer developed the accurate BCS theory of this material. This material expels magnetic fields in the Meissner effect. For the point, name these materials that at low temperatures have no electrical resistance.
ANSWER: **superconductor**s [accept Type I **superconductor**s or Type II **superconductor**s]

17. One over 2i times quantity e to the i z plus or minus e to the negative i z represents two of this class of functions in their complex form. Two members of this class of functions are used to approximate all periodic functions through the Fourier series. The complex numbers are related to the two most commonly employed of these functions by Euler's formula. The unit circle's radian measurement is commonly used instead of degrees when plugging into these functions to find the ratios of triangles. For the point, name this class of functions that includes the cosine and sine.
ANSWER: **trig**onometric **func**tions

18. A plus three oxidation state salt derivative of one member of these elements is commonly used as an MRI contrast agent. Due to poor shielding of the 4f electrons of these elements, they experience a namesake contraction in atomic radius. Members of this group of elements include Europium, Samarium, and Ytterbium. This group of elements begins at 57 and ends at 71. For the point, name this group of elements that sits below the transition metals on the periodic table above the actinides. .
ANSWER: **lanthanide**s [accept **lanthanoid**s]

19. This species's catabolite activator protein is controlled by cyclic AMP concentration levels which is useful for controlling its production of L-arabinose. François Jacob (*Yah cohb)* and Jacques Monod *(Mo noh)* received the 1965 Nobel Prize in Physiology or Medicine for their work on the Lac operon in this model organism. It isn't S. dysenteriae but Shiga-like toxins are produced by serotypes of this organism, including the enterohemorrhagic strain O157:H7. For the point, name this rod-shaped bacteria whose pathological strains in recent years have caused food poisoning with romaine lettuce.
ANSWER: **E. Coli** [or **escherichia coli**]

20. Containers allow for this task to be done on the heap using pointers in a single operation. Bubble sort works by checking two items and performing this task if the larger item is more to the left in the series. The simplest algorithm for performing this task requires moving one of the two values into a temporary address while assigning the other to the previously assigned address. For the point, name this process of switching two items in memory.
ANSWER: **swap**ping

21. The separation of primary and secondary components was a major breakthrough in the Teller-Ulam design of these devices. The two main designs of this device are the gun-type that impacts into a subcritical load or the implosion type where the outer shell collapses and compresses the core. Uranium-235 and plutonium-239 are radioactive materials used in these devices. For the point, name these explosive devices of war that operate via fission and fusion reactions.
ANSWER: **nuclear weapon**s [accept **thermonuclear weapon**s; accept **hydrogen bomb**; accept **atomic bomb**; accept **H bomb**; accept **A bomb**; accept **fusion weapon**; prompt on warhead; prompt on nukes which are informal terms for the actual device; prompt on weapons]

22. The compressible pressure coefficient due to movement of this phenomenon can be calculated using the Prandtl-Glauert transformation which was predicted to reach a singularity at around 340 meters per second. The Newton-Laplace equation can be used to calculate that speed of this phenomenon. The difference in frequency between two waves of this phenomenon can cause beats. An object travelling faster than the speed of this phenomenon surpasses Mach 1 and is "supersonic." For the point, name these wave phenomena that are biologically perceived by ears.
ANSWER: **sound wave**s [or **sound**s]

23. In this coordinate system, an equation's number of petals is 2k or k if k is an even or odd integer. In this coordinate system, the first parameter times sine of the second parameter results in a horizontal line, whereas swapping sine for cosine results in a vertical line. The first parameter in this coordinate system is obtained from Cartesian coordinates by calculating the square root of x squared plus y squared while the azimuth in this coordinate system can be obtained from arctan of y over x. For the point, name this 2D coordinate system that uses radius and theta coordinates.
ANSWER: **polar** coordinates [accept **polar** notation]

24. Kenneth Livak introduced a delta-delta-CT method for determining the number of cycles needed for fluorescence from dyes like SYBR fluorophores to be detectable. In this technique, an eight-tube strip contains the sample and a portion of the "master mix" of dNTPs, magnesium chloride and enzymes. Kary Mullis was recognized with the 1993 Nobel Prize in Chemistry for inventing this technique whose real time variant makes use of TaqMan probes. Temperature is cycled in this technique during Denaturing, Annealing, and Extension phases, and primers are used to extend nucleotide sequences. For the point, name this technique of amplifying a DNA sample.
ANSWER: **P**olymerase **C**hain **R**eaction

25. NASA expects to discover thousands of these objects via the TESS mission launched in 2018. The first confirmed discovery of one of these objects was Pegasi 51b, which falls under a class of these objects within the frost line known as "Hot Jupiters." Before being retired in 2018, the Kepler space telescope discovered many of these objects by the transit method when they orbited in front of a bright star. If they exist in the habitable zone, these objects are potential sources for life. For the point, name these planets that circle stars other than our Sun.
ANSWER: **extrasolar planet**s [or **exoplanet**s]

26. Early sound detection apparati for submarines made use of either magnetostriction transducers or ultrasonic transducers made with materials that exhibit this effect. The discovery of this effect was first cited in a paper which described it as "Development by compression of polar electricity in hemihedral crystals with inclined faces"; that 1880 paper was written by Pierre and Jacques Curie in their experiments on crystals lacking inversion symmetry which exhibit this effect such as Quartz and Rochelle salts. For the point, name this phenomenon where mechanical stress causes the buildup of electric charge in a material.
ANSWER: **piezoelectricity** [or **piezoelectric effect**]

27. While animal fats are an alternative to producing Fatty Acid Methyl Esters or FAME, transesterification of this class of compounds is usually the most common method to produce FAME. Glycerol ester of wood rosin is a potential alternative to a modification of this class of oils used to prevent citrus flavors from emulsifying that is still classified as "Generally Recognized as Safe" despite concerns of bromine toxicity. Crisco was the first shortening made by hydrogenating this class of oils. Biodiesel is any fuel made from reactions with this class of oils. For the point, name these oils derived from plants such as olive and soy beans.
ANSWER: **vegetable oil** [accept just **vegetable**s after oil is read ; prompt on oil before mentioned;accept specific vegetable oils like **olive oil**]

28. A stopcock is used to control the rate at which these devices function in the dropping variety of this lab equipment. The separatory variety of this lab equipment is used in liquid-liquid extraction. The Buchner variety allows for fast filtration with this piece of lab equipment. This simple piece of plastic, glass, or stainless steel lab equipment in wider scale operations typically has a channel of liquid that feeds into the wide end with filter paper placed near the narrow end. For the point, name this device which can aid in guiding liquid into a narrow opening of a container.
ANSWER: **funnel**

29. Fleischmann and Pons thought they had discovered cold fusion by using this process on heavy water over a palladium substrate. The Tafel equation can be used to calculate the overpotential of water when reacted over a platinum substrate. The Hall-Heroult process uses this method to extract aluminum from aluminum oxide.Water is broken down into hydrogen and oxygen if this process is driven at the correct voltage. For the point, name this process of producing chemical reactions at cathodes and anodes by applying a direct current.
ANSWER: **electrolysis**

30. Given a probability density function f of x, this statistic for the distribution is equal to the integral from negative infinity to infinity of x times f of x d x. This statistic converges to the expected value of a distribution according to the law of large numbers. One Pythagorean type of this statistic can be obtained by multiplying all the numbers in a set together and taking the n-root where n is the total number of data points. Types of this statistic include geometric, harmonic, and arithmetic. For the point, name this statistic, a measure of the average from a set of numbers.
ANSWER: **mean** [before mentioned: accept **expected value** or **ev**, prompt on average]

Extra Questions

31. As a means for taking measurements from this organ, Willem Einthoven invented a namesake Triangle that runs from the wrists to the left ankle. That breakthrough helped him win the 1924 Nobel Prize in Medicine or Physiology for a galvanometer instrument designed for this organ. The Frank-Starling law describes how increase in volume leads to an increase in stroke volume from this organ. A namesake cycle of this organ can be measured from two consecutive R peaks, which makes up the largest spike on a QRS complex measured from this organ on an ECG. This organ cycles between filling diastolic phases and contracting systolic phases. For the point, name this organ that serves as a pump circulating blood throughout the body.
ANSWER: **heart**

32. This material in its molten form is fed through an "isopipe" in a fusion process developed by the Corning company. In that industrial process, this material is then cut from a "mother sheet" to be fed into an ion-exchange process to form this material's sturdy "Gorilla" variety. Using random network theory, W.H. Zachariasen developed four empirical rules for this material. A layer of titanium dioxide added to this material creates a "self-cleaning" variety. The properties of polymers drastically change after undergoing a transition named for this material. These vitreous solids are often formed from the rapid quenching of molten material. Natural varieties of this material include obsidian. For the point, name this amorphous crystalline material that can be formed from the silica in sand.
ANSWER: **glass**