

2020 National Science Bee – Varsity and Junior Varsity

Round 4

Regulation Questions

1. This element was the largest concern for incorporation into fallout enhancing nuclear weapons known as "salted bombs." Catterite is structurally similar to pyrite but replaces iron with this element. This element's name comes from a German word which roughly translates to "mischievous goblin" since it either refused to smelt or would cause sickness by releasing arsenic fumes. The red-blood cell formation promoting Vitamin B12 uses this metal and gets its common name from it. This metal sits between the other two naturally ferromagnetic elements, iron and nickel. For the point, name this element with atomic number 27 and symbol Co.

ANSWER: **cobalt** [prompt on Co]

2. The *Samosely* are a group of "self-settlers" who live within a 30 kilometer radius from where this event took place. In April 2020, wildfires raised concerns that material settled from this event would kick back-up again in the Red Forest. Electrical testing before this event required a drop in energy to 700 megawatts — unaware of potential poisoning due to Xenon-135. A Zone of Alienation that stretches over the abandoned town of Pripyat was a necessary consequence of this event caused by removing nearly all of the control rods, including 10 of the 28 fail-safe rods. For the point, name this disaster that occurred in Ukraine in 1986 caused by a nuclear reactor meltdown

ANSWER: **Chernobyl** nuclear reactor disaster [accept equivalents mentioning **Chernobyl** like "**Chernobyl** nuclear meltdown" or "nuclear accident at **Chernobyl**"]

3. Samuel Schwabe suggested that the number of these features reaches a maximum every ten years, an idea that fascinated Rudolf Wolf into studying these features and characterizing their daily index via his namesake Wolf number. The variation in the latitude of these features was empirically predicted by Richard Christopher Carrington using the work of Gustav Spörer. These features, whose total during the Maunder minimum may have caused the cooling temperatures of the Little Ice Age, are defined by a dark umbra region surrounded by a yellowish-orange penumbra. For the point, name these dark regions found on the surface of the sun.

ANSWER: **sunspots** [accept **starspots**]

4. Sclerenchyma serves as a structural support to this tissue while parenchymal cells in this tissue serves as a buffer and facilitates transfer to SE/CC complex. Ernst Munch proposed that sugar sinks and sugar sources create a concentration gradient in this tissue that creates turgor pressure allowing for movement of material, an idea referred to as the pressure-flow hypothesis. This bidirectional transport tissue contains companion cells which form complexes to support this tissue's sieve elements. For the point, name this tissue that transports nutrients and sap to the plant, contrasted with water-transporting xylem.

ANSWER: **phloem**

5. This function evaluated at three equals Apery's constant. This function of x equals the infinite product over each prime number p of one minus one over p to the power x . Euler solved the Basel problem by showing that this function evaluated at two gives $\pi^2/6$. This function of s can be defined as the infinite sum over n using terms of the form $1/n^s$. This function evaluated at negative even integers returns its "trivial zeros." Nontrivial zeros of this function lie on the critical strip. For the point, name this function, the subject of Riemann's hypothesis.

ANSWER: **Riemann zeta** function [prompt on zeta function before "Riemann," accept afterwards]

6. These entities when present cause a decrease in the Racah interelectronic repulsion parameter due to the nephelauxetic effect. The way these entities interact with a central element can be analyzed with the CBC Method for determining whether a label of L, X or Z should be assigned to them. The number of contiguous atoms needed to coordinate one of these entities determines hapticity. Coordination chemistry studies the way these entities bind to a central complex. For the point, name these molecules and ions that bind to and form coordination complexes with metals

ANSWER: **ligand**

7. This force only manifests on scales above 246 Giga electron volts and was supported by the Gargamelle collaborations discovery of neutral currents. Glashow, Salam and Weinberg won the 1979 Nobel Prize in Physics for their contribution to the unification of the two fundamental forces that underlie this force. One of the two fundamental forces in the theory of this force is mediated by W and Z Bosons while the second fundamental force was earlier unified by James Clerk Maxwell. For the point, name this force, a combination of the force carried by the photon and the force that causes radioactivity, with the latter being contrasted with the strong force.

ANSWER: **electroweak** force [or **electroweak** interaction; prompt on electromagnetic force or electromagnetism; prompt on weak force]

8. Carl Størmer tracked over 12,000 of these events and helped determine their altitude of occurrence. The namesake ovals of this phenomenon are most prominent at the time referred to as "magnetic midnight." Birkeland currents driven by solar wind and the earth's magnetic field help stir the electrons and protons in the ionosphere to emit photons of various colorful wavelengths, creating curtains and wavy patterns over the arctic and antarctic. For the point, name these light shows caused by ionization of gas in the earth's atmosphere, which, in the northern hemisphere, are referred to with the additional word *borealis*.

ANSWER: **auroras** [accept **aurora borealis**; accept **magnetosphere storms** or **substorms** of the **magnetosphere**; prompt on northern lights]

9. An inability to identify where Sally will look for her marble after Anne has moved it is linked with this disorder; that Sally-Anne test implementation was spearheaded by Simon Baron-Cohen who hypothesized this disorder could be caused by development of an "extreme-male brain." In a book titled *Infantile* [This Disorder], Bernard Rimland attacked Bruno Bettelheim's hypothesis that "Refrigerator Mothers" who are emotionally distant from their child can spur on this disorder. Asperger's syndrome is considered a "high functioning form of," for the point, what spectrum disorder characterized by difficulties socially interacting and communicating?

ANSWER: **autism** spectrum disorder [accept **ASD**]

10. Rijndael S-boxes are used during the SubBytes step of an algorithm that performs this task; that algorithm then performs a ShiftRows step followed by a MixColumns step. 14 rounds of the AES algorithm for this task is required for 256-bit keys. Because it can find a prime factorization in polynomial time, Shor's algorithm may make the RSA algorithm for performing this task obsolete. In the RSA algorithm, the public key performs this task while the private key performs the inverse operation. For the point, name this task of rendering plaintext into ciphertext so that only those with a key can read the information.

ANSWER: **encryption** [accept word forms such as **encrypting**]

11. Transforming these objects can be accomplished using the Gram-Schmidt process. Addition and scalar multiplication following eight axioms define spaces named for these objects. In a given metric space, the metric relates the contravariant and covariant forms of these rank-1 tensors. Matrices describe linear transformations on these objects, which can be represented three dimensionally using \hat{i} , \hat{j} , and \hat{k} , which are themselves unit varieties of these objects with magnitude of one. For the point, name these mathematical objects which differ from scalars since they have both magnitude and direction.

ANSWER: **vectors**

12. Solexa developed one method of this task before being bought out by Illumina, who have been pioneering the "next gen" form of this task. Walter Gilbert shared the 1980 Nobel prize in chemistry with two time winner Frederick Sanger for developing a "Plus and Minus" technique for this task. This task is typically done on the order of 100-1000 bp's (*plural of bp*) and assembly is performed to obtain the final product. Chargaff's rules allow scientists to perform this task on a single strand and pair up bases for the other strand. For the point, name this process of reading out adenine, guanine, cytosine and thymine nucleotides from a fundamental molecule to life.

ANSWER: **DNA Sequencing** [accept answers mentioning **reading DNA**; accept answers mentioning determination of base **sequences** in **nucleic acids** (or nucleotides); or determining base **sequences** in **DNA**]

13. A spherical device utilizing this substance has a Troyon limit expressed in terms of the device's inverse aspect ratio. This substance follows field lines that can be modelled by the equation $d\theta/dz$ equals one over the safety factor times resistance. They're not liquid metals, but these substances, which may experience Rayleigh Taylor instabilities, are principally studied using magnetohydrodynamics. Alfvén waves can occur in these substances which screen out electric fields below the Debye (*duh-bai*) length.. Tokamaks confine these substances to a toroidal field for nuclear fusion. For the point, name this form of matter, an ionized gas often informally referred to as "the fourth state of matter."

ANSWER: **plasma**

14. Dynamic programming is an alternative to algorithms employing this technique via a memoization structure and/or a bottom-up approach. When a function using this technique employs it at the beginning, it is called head-[this technique] and if at the end, tail-[this technique]. A simple, exponential solution to determining the nth fibonacci number uses this technique by calling f of n minus 1 plus f of n minus two. This technique, commonly employed by divide and conquer algorithms, will usually require a base case to terminate. For the point, name this computational technique of having a function call itself.

ANSWER: **recursion** [or word forms like **recursive**]

15. A vaccine approved for this virus genus in the United States in December 2019 made use of vesicular stomatitis virus with modified glycoproteins. A discovery of a filovirus that shared characteristics of this virus genus was named for Reston, Virginia and is fortunately nonpathogenic. The antibody cocktail ZMapp was created to curtail this virus genus. In addition to the Marburg virus, which is in the same family as this virus genus, old world fruit bats are considered a natural reservoir for this hemorrhagic fever disease. For the point, name this genus of viruses whose Zaire strain caused a major epidemic in West Africa from 2013 to 2016.

ANSWER: **Ebola** Virus Disease [prompt on EVD; accept **ebolaviruses**; accept specific strains like Zaire **Ebola**]

16. The primary Seidel terms of the Zernike circle polynomials are often sufficient to describe the majority of defects due to this phenomenon. The Schmidt corrector plate introduces an equal and opposite form of this phenomenon in front of spherical primary mirrors and was used in the Schmidt-Cassegrain telescope design. Field curvature, chromatic, and coma are forms of this phenomenon. This phenomenon commonly occurs when parallel rays of light do not converge. For the point, name this phenomenon in optics where light is spread out over a region of a lens instead of focusing at a single point.

ANSWER: optical **aberrations**

18. Detection of this property in quinine at 8 micromolars is used as a reference index when measuring the concentration at which a compound gains this property. Arthur L. Fox realized a minority of people who took phenylthiocarbamide couldn't detect this property. Today, people who react strongly to this property in "propylthiouracil" are referred to as supertasters. In the debunked "taste areas" of the tongue, this flavor was considered to be localized to the back of the tongue. This flavor is associated with compounds like caffeine which is why unsweetened dark chocolate primarily has this flavor. For the point, name this flavor of coffee and most dark greens.

ANSWER: **bitterness**

19. One of these quantities for n and x multiplies p raised to n multiplied by quantity one minus p raised to quantity n minus x in a Bernoulli process. Pascal's theorem expresses these numbers recursively. The name for these numbers comes from the polynomial quantity x plus y raised to the n , and they can be found for a given n using Pascal's triangle. These numbers can be computed by the formula n factorial over k factorial times quantity n minus k factorial. For the point, name these numbers commonly expressed by n choose k

ANSWER: **binomial coefficients**

20. Arthephius and Nicholas Flamel are widely known to students of this practice; both of whom appear in documents written by Isaac Newton who argued in favor of this practice since Diana's Tree showcases that silver is capable of forming dendrites that seem to give the metal some "lively properties." Women scientists in this practice include Mary the Jewess and the 3rd century Greek Cleopatra; Cleopatra's contributions to this practice include her book on *Chrysopoeia* which discusses the transmutations of metal. This practice's goals include discovery of an alkahest that could dissolve anything and a panacea that could cure any disease. For the point, name this early form of chemistry that largely experimented with trying to turn various substances into gold or elixirs of immortality.

ANSWER: **Alchemy**

21. Parathyroid hormone stimulates the production of the activated form of this vitamin via upregulation of 1-alpha-hydroxylase. An electrocyclic reaction converts 7-Dehydrocholesterol to cholecalciferol, one form of this vitamin. Kyphosis, bowed legs, and a large forehead are common symptoms in a deficiency in this vitamin that affects children. Deficiency in this vitamin can cause rickets. For the point, name this vitamin obtained from sunlight that helps with the absorption of calcium, which is why it is often used to fortify milk.

ANSWER: Vitamin **D** [accept **D3**; accept **D2**; prompt on cholecalciferol; prompt on ergocalciferol]

22. After co-inventing a cyclic one of these devices with Vladimir Veksler, Edwin McMillan went on to use this kind of device in element hunting for which he would win the 1951 Nobel Prize in Chemistry. At UC Lawrence Radiation Laboratory, Glenn T. Seaborg used this kind of device to discover transuranic elements like seaborgium and plutonium. The world's largest one of these devices is a 27-kilometer ring of superconducting magnets that CERN uses as the end of a series of these devices capable of taking protons up to energies of 6.5 Teraelectronvolts. For the point, name these devices like cyclotrons and synchrotrons that speed up atomic components and collide them to gather data.

ANSWER: **particle accelerators** [accept cyclotron or synchrotron before mentioned]

23. For human drug trials, this property is important to the upper portion of the ratio used to calculate Therapeutic Index. Chemicals with this property that localize to the intestines include SEB and are named for this property, prefixed with entero. Another chemical named for this property is a sodium channel blocker and prefixed tetrodo. Due to a compound with this property, the fugu pufferfish must be prepared carefully. Arsenic naturally has this property giving it use as a rat pesticide. For the point, name this property of biological hazards that can cause death in humans.

ANSWER: **toxicity** [do NOT accept or prompt on lethality]

24. This structure is wrapped three times by a filament of stars known as Monoceros. The galaxies Dwingeloo 1 and 2 were discovered behind this galaxy using radio wavelengths, since this galaxy obscures a portion of the nighttime sky behind a so-called "Zone of Avoidance." Large and small Magellanic clouds orbit this galaxy, at the center of which is the black hole Sagittarius A* ("*A*" star). This second largest galaxy in the Local group is 2.5 million light years away from the largest — the Andromeda galaxy. For the point, name this spiral galaxy where the Solar System is located.

ANSWER: **Milky Way** galaxy

26. The biopharmaceutical etanercept is approved to treat plaque psoriasis and this condition. Targeting tumor necrosis factor with inhibitors like adalimumab and infliximab are among the DMARDs used to treat a form of this condition. Colchicine is used to treat one form of this condition caused by build up of uric acid crystals. This overarching condition includes gout and an "osteo-" form where cartilage between bones grinds away. White blood cells invade synovial tissue in a form of this condition characterized by high levels of rheumatoid factor. For the point, name this condition of painful and inflamed joints.

ANSWER: **arthritis** [accept specific forms like **gout**; or **osteoarthritis**; or **rheumatoid arthritis**]

27. On August 23rd, 2019, Jet Propulsion Laboratory activated a "Deep Space" mercury-ion variant of this type of device. Isidor Rabi used magnetic resonance to propose the first use of these devices. Two instances of this device were used to test special relativity in the Hafele-Keating experiment. A modern version of this device can be made using the over 9 billion cycle transition between the two hyperfine energy levels in the ground state of cesium-133 which is used to define the SI unit of the second. For the point, name these devices that use electron energy levels to keep time.

ANSWER: **atomic clock** [prompt on clock]

28. Midland, Michigan is home to a three-way example of one of these structures. The Anji one in China is the oldest of these to make use of an open-spandrel design. Labels such as "fracture critical" and "structurally deficient" are labels used by the NBI to categorize these structures. Donald Bailey designed movable versions of these structures that bear his name to help Allied war efforts in World War II. John Augustus Roebling received help from his wife Emily in designing one of these structures in Brooklyn. The Akashi Kaikyo is the longest example of a suspension one of these. Arch, beam, cable-stayed, truss, and cantilever are other design variants of these structures. For the point, name these structures that span geographical obstacles like rivers, valleys, and roads.

ANSWER: **bridges**

29. Thermal-stress events can cause *Symbiodinium* to disassociate from these organisms or lose their chlorophyll. Zooxanthellae are dinoflagellates that preferentially interact with these organisms. Charles Darwin's first monograph discusses the structure and distribution of these organisms' habitats. Some stony members of these anthozoans use calcium carbonate to strengthen their colonies which are subject to threat from ocean acidification resulting in these organisms' namesake bleaching. For the point, name these marine polyp invertebrates which live in reefs like the Great Barrier Reef.

ANSWER: **coral**

30. According to Robert Merton, studies under this classification break one of the five norms of originality, detachment, universality, skepticism or public accessibility. In his contributions to the demarcation problem, Karl Popper argued that this classification should be given to studies that are non-falsifiable. Studies under this classification do not have experimental means of reproducibility or verification. Examples of studies that fall under this classification include phrenology and astrology. For the point, name this questionable form of science often fueled by superstition or fraud that has little compatibility with the scientific method or scientific reasoning.

ANSWER: **pseudoscience** [accept **non-science**; prompt on fake science; do not accept or prompt on science]

Extra Question

31. A power series solution can be constructed for this kind of equation using the Frobenius method. The Wronskian can help find the final solution to this type of equation while other approaches to solving them include the method of undetermined coefficients. Many times the solution to this sort of equation has an e to the x term due to the namesake operation being idempotent on e to the x . The two principal kinds of this equation are partial and ordinary. For the point, name this type of equation that contains a namesake calculus operation more commonly used than integral equations.

ANSWER: **differential** equation