1. **The first detection of periclase and this mineral in the dust of quasars was found by the Spitzer Space Telescope in quasar 2112+059. Most asterisms appear on gemstones of this mineral. Chromium oxide or ferric oxide can be used in the flame fusion production of this mineral in the (*)** Verneuil process. The first working laser utilized a synthetic form of this mineral as its gain medium.When mixed with compounds containing iron, this mineral is called Emery. Another variety of this mineral sometimes has a color described as "pigeon's blood." This mineral's chemical formula is $Al_2O_3$. For 10 points, name this mineral that makes up rubies and sapphires and has a value of 9 on the Mohs hardness scale.
ANSWER: **corundum**

2. **L. N. Vaquelin first isolated this element from its crocoite ore. Adding hydrogen peroxide to solutions containing this element causes its dark blue peroxide to form. This element is complexed to two pyridine molecules in a reagent that catalyzes the oxidation of alcohol, however a combination of this element's (*)** trioxide, sulfuric acid and acetone is more commonly used for that reaction. This is the only anti-ferromagnetic element at room temperature. This element's +6 oxidation state forms two anions which exist in equilibrium and will appear orange in the presence of an acid, and yellow in the presence of a base. For 10 points, name this toxic metal present with iron in stainless steel, with atomic number 24 and chemical symbol Cr.
ANSWER: **chromium** [accept **Cr** until mention]

3. **Solutions to an equation named for him are bi-characteristics of a 1-form called the integral invariant of Poincaré-Cartan. His namesake vector field is defined on Poisson manifolds, and he is the first namesake of an equation that states that the partial derivative of S with respect to time plus H equals zero. That equation is analogous to (*)** Schrodinger's equation and allows the motion of classical objects to be treated as waves. His namesake equations relate the time derivative of each canonical coordinate to the derivative of his namesake quantity with respect to the other coordinate. His namesake quantity is the Legendre transform of the Lagrangian. For 10 points, name this physicist whose namesake quantity is equal to T plus V and represents the total energy of a system.
ANSWER: William **Hamilton**

4. **This condition results when L-methylmalonyl-CoA is not converted to succinyl-coA. A form of this is caused by glucose-6-phosphate dehydrogenase deficiency, while Coombs test can be used to diagnose an autoimmune form. which is related toThe mean corpuscular volume can determine whether this condition is (*)** macro- or micro-cytic. Cobalamin deficiency impairs methionine synthase, which in turn prevents proper DNA-methylation in the megaloblastic form of this condition. A glutamic acid to valine substitution in hemoglobin causes the "sickle-cell" form of this condition. Iron-deficiency is the most common cause of, for 10 points, what condition marked by a shortage or deformation of red blood cells?
ANSWER: **anemia** [accept **acidemia** if someone actually buzzes with that on the first clue; accept specific types of **anemia** including megaloblastic **anemia**, hemolytic **anemia**, pernicious **anemia**, sickle-cell **anemia**, and iron-deficient **anemia**; prompt on "low red blood cell count" and other descriptions of anemia]

5. **One value important to these devices is equal to 2 times surface tension over the difference between external pressure and vapor pressure; that value is called the critical radius. Large versions of these devices containing heavy elements like xenon may be able to be used to detect WIMPs. Electroweak unification theory was supported by the detection of (*)** neutral weak currents in these devices. These devices quickly reduce their pressure to allow the fluid inside them to become superheated before the arrival of a beam of charged particles. For 10 points, name these devices invented by Donald Glaser, which have largely been replaced by wire and spark chambers.
ANSWER: **bubble chamber**s

6. **Nate Silver introduced the "quick" variety of this statistic. Bill James showed that the catcher's variety of this value isn't statistically significant. The "plus" variety of this value sets the league average equal to 100 and accounts for differences in ballparks. The "component" variety of this statistic is calculated using hits and walks instead of the traditional variables. (*)** Mariano Rivera has the lowest career value for this statistic in the live-ball era. If a pitcher gave up 2 runs in 6 innings, his value for this statistic would be 3. For 10 points, name this baseball statistic that tells you how many runs a pitcher is responsible for giving up in nine innings.
ANSWER: **earned run average** [accept **ERA**]

7. **Huang introduced a constraint function in his improved version of this algorithm, and Schutz introduced a partition based improvement of it. Fredman and Tarjan developed the fastest version of this algorithm using a min-priority queue implemented with a Fibonacci heap. An extension of this algorithm that utilizes a knowledge-plus-heuristic cost function contains this algorithm as a special case of setting the heuristic to zero. That extension is the (*)** A-star algorithm.The first step of this algorithm is to pick an initial node, set its tentative distance value to zero, and then set the tentative distance value of all the other nodes to infinity. The Bellman-Ford algorithm is more versatile than this one in that it can handle negatively weighted edges. For 10 points, name this algorithm that finds the shortest path between two nodes and is named for a Dutchman.
ANSWER: **Dijkstra**'s algorithm [anti-prompt on "A-star" algorithm]

8. **Unrelated to all of his other work, this scientist showed that coral was not a plant like his contemporaries had believed. He observed that the polar ice caps of Mars change in size throughout the seasons. Despite this scientist's great discovery that the Milky Way is disk shaped, he incorrectly believed that the sun was at the center of it. The largest crater on any body relative to its size is a crater on (*)** Mimas named for this guy. This scientist was the first to realize that the sun gives off radiation that isn't in the visible spectrum. He was able to confirm that Newton's law of gravity applied outside of our solar system by his discovery of binary star systems. This man discovered Titania, Oberon, and the planet they orbit. For 10 points, name this astronomer who discovered Uranus.
ANSWER: William **Herschel**

9. **This protein's function is inhibited when LMO3 binds to its DNA-binding domain. The potential for this protein in gene therapy is limited by the fact that it forms hetero-tetramers with its mutant analog. A proline rich domain in this protein alters sequence-specific transactivation of the PIG3 gene, which in turn reduces the ability to induce (*)** apoptosis. A germline mutation in the gene that codes for this protein is responsible for causing Li-Fraumeni syndrome. This protein activates the expression of p21, which inhibits cyclin-dependent kinase activity at the G1 to S checkpoint. For 10 points, name this tumor-suppressing protein known as the "guardian of the genome".
ANSWER: **p53** [accept **TP53**]

10. **Deviation of the chemical potential from the standard state equals negative RT times the natural log of this quantity. pH can be calculated by replacing the reaction quotient by this quantity in the Nernst equation. They can be found for single ions using the Pitzer equation and for (*)** strong electrolytes in dilute solutions using the Debye-Huckel rule. Concentration is multiplied by, for 10 points, what coefficient symbolized gamma that accounts for variation in microscopic interactions between species in a non-ideal mixture?
ANSWER: **activity coefficient**s [accept activity after "coefficients", prompt before]

11. **Wald's equation finds this quantity for a random number of random independent events. Daniel Bernoulli solved a paradox concerning a lottery at a casino in St. Petersburg with an infinite value for this quantity. Fisher information can be defined as this value of the derivative of the log-likelihood function squared. For a continuous distribution, this quantity is equal to the integral from negative to positive infinity of (*)** x times the probability distribution function of x with respect to dx. This quantity is equal to 3.5 for a dice roll. For 10 points, name this statistical quantity that tells you what payoff you should get in the long run, which is often negative for casino games.
ANSWER: **expected value** [accept **expectation**, **first moment**, or **mean**, prompt on average]

12. **One principle of this framework is the ability to replace expressions with their values and not change a program's behavior, which is called referential transparency. The Hindley-Milner type system is often used in this framework, and introducing monads allows one to use (*)** lazy evaluation in this paradigm. The Curry-Howard correspondence allows one to "prove" programs in this paradigm. The "pure" examples of languages in this paradigm have no side effects, and most languages in this paradigm are based on lambda calculus. For 10 points, name this programming paradigm contrasted with imperative programming and exemplified by Lisp and Haskell.
ANSWER: **functional** programming

13. **A 2002 experiment by Carugno *et al.* was able to observe this effect, in the scenario that it was originally predicted to occur, with 15 percent precision. The "dynamical" form of this effect produces real photons by using work to make something accelerate. This effect can be interpreted simply as the relativistic van der Waals force. This effect can be described in terms of the zero-point energy resulting from the quantized field between two objects. Since only certain (*)** wavelengths of photons can be produced between the objects involved in this effect, the greater number of photons outside the objects pushes them together. For 10 points, name this effect in which two uncharged plates in a vacuum are attracted to each other.
ANSWER: **Casimir**-Polder effect [accept **Casimir**-Polder force]

14. **The H-DLVP theorem concerns possible values of this function, which can be modified by the Gram-Backlund extension. Using Laurent series to expand this function around 1 gives the Stieltjes constants. This function can be used to approximate non-zero holomorphic functions since it exhibits universality, which is a result known as (*)** Voronin's theorem. At s equals 3 this function returns Apéry's constant, and at s equal 2 it returns pi squared over 6. It has yet to be proven whether or not all nontrivial zeros of this function have a real part of one half. For 10 points, name this function named for a German guy who also has a hypothesis related to this function and primes.
ANSWER: **Riemann-Zeta** function [prompt on partial]

15. **This compound binds to a tetranuclear copper sulfide cluster at the active site of its namesake reductase; and acetylene is the most specific inhibitor of that enzyme. This compound is a byproduct of adipic acid synthesis, which the company Solutia used along with a zeolyte catalyst to produce phenols. This compound's high specific impulse makes it a strong monopropellant candidate to replace (*)** hydrazine. Two water molecules are also produced when this compound is manufactured by heating ammonium nitrate until it decomposes; adding small amounts of free ammonia in that process prevents the synthesis of other oxides of nitrogen. For 10 points, name this compound, also known as "laughing gas".
ANSWER: **nitrous oxide** [accept **$N_2O$**, promt on "laughing gas" before mention]

16. **This structure is the target of the parasite *Neoparamoeba perurans*. Sirens retain a form of these structures that consists of a stalk lined with fimbriae. The (*)** Eustachian tubes, parathyroid, and thymus have the same embryonic origin as these structures. They're not taste buds, but echinoderms have primitive analogs of this organ called papulae. In some organisms, a bony operculum covers these structures. Rakers in this organ help separate food from water. Oxygen is passed to the blood via a countercurrent exchange system in, for 10 points, what organ that enables aquatic animals to breathe?
ANSWER: **gill**s

17. *Description acceptable.* **One way to test the accuracy of theories of this type is to measure their PPN parameters, which are measures of deviation popularized by Clifford Will. Allowing a nonlinear function of R in the action introduces a whole class of these theories. Schiff's conjecture states that any complete, self-consistent theory of this type that includes the WEP must necessarily include the EEP. The Lagrangian for the Lovelock variety of these theories depends on higher order contractions of the Riemann tensor. Some theories of this type have been proposed as a way to solve the (*)** galaxy rotation problem without needing to introduce dark matter. MOND is a classic example of, for 10 points, what general class of theories that attempt to replace Einstein's.
ANSWER: **alternatives to general relativity** [accept "**alternate theories of gravity**" and any reasonable equivalents, prompt on "theories of gravity", do NOT accept just "general relativity"]

18. **This quantity divided by the number of particles all raised to the 3/2 power appears in the Sackur-Tetrode equation. The differential of this quantity is given as TdS minus pdV. This quantity is the Legendre transform of the Helmholtz free energy, which is equal to (*)** this quantity minus the product of temperature and entropy. This quantity plus the product of pressure and volume gives enthalpy. Heat added to a system plus work done by that system equals the change in this quantity according to the first law of thermodynamics. For 10 points, name this quantity symbolized U that gives the total amount of kinetic and potential energy in a system.
ANSWER: **internal energy**

19. **When analyzing the results of this technique, gating is often used to isolate a specific sub-population. An argon-ion laser can be used to excite FITC ["fit-Z"] and PE, which are two common markers used in this technique. Increasing the sample pressure allows more particles to enter the stream in a process known as hydrodynamic focusing, which is used to line the cells up one-by-one. In this technique, forward-scattered light is proportional to cell surface-area or size, while side-scattered light is proportional to cell granularity. For 10 points, name this technique used to sort (*)** fluorescently-labeled cells by physical properties as they pass through a beam of light.
ANSWER: **flow cytometry** [accept **fluorescent activated cell sorting** or **FACS** before "fluorescently"]

20. **One star in this constellation with a notable circumstellar disk is the so-called Butterfly star. One object within this constellation has a band containing a lot of helium spanning its center. This constellation names a star formation complex with Auriga. The RV star of this constellation serves as a prototype for certain variable stars. Another star in this constellation serves as the prototype for stars slowly contracting along the (*)** Hayashi track; that infant star is this constellation's T star. The Pleiades are located in this constellation, whose alpha star is Aldebaran. For 10 points, name this constellation that contains the Crab Nebula and looks like a bull.
ANSWER: **Taurus**

21. **The Gramian is found by applying this operation to a bunch of inner products. This operation can be thought of as the exterior product of column vectors. For a minus, plus, plus, plus metric signature, the proper volume element is found by taking the square root of negative one times this operation applied to the metric tensor. Copying the first two columns of a (*)** 3 by 3 matrix to the right of the last column and drawing diagonals is used in the Rule of Sarrus to calculate this value. The Jacobian type of this value is used to switch between coordinate systems, and if this value is zero for a matrix, then it doesn't have an inverse. For 10 points, name this value, which is equal to AD minus BC for 2 by 2 matrices.
ANSWER: **determinant**