1. **This molecule's namesake kinases are exemplified by envZ and cheA, and use four-helix bundle motifs to relay phosphoryl groups from ATP. AICAR is a byproduct of the biosynthesis of this molecule, which involves the Amadori rearrangement of 5'ProFAR in order to produce its unique side chain. In a particular catalytic triad, the acidic residue, aspartate, polarizes this molecule, which in turn activates (*)** nucleophilic cysteine. At the oxygen binding site of hemoglobin, iron is bound to this amino acid's imidazole side chain. For 10 points, name this slightly basic amino acid which is decarboxylated to form histamine.
ANSWER: **histidine** [accept **His**; do not accept or prompt on "histamine"]

2. **A mathematician from this country proved a theorem that extended Ptolemy's theorem to the case of four non-intersecting circles that lie tangentially inside a larger circle. A mathematician from this country applied biquaternion algebra to special relativity and helped a leader of this country, who was earlier one of his students, found the DIAS. The first director of that institute in this country was Erwin Schrodinger, who fled to this country to escape the Nazis. One mathematician from this country discovered the (*)** icosian calculus and names a theorem stating that matrices satisfy their own characteristic equation with Arthur Cayley. Éamonn De Valera was a math teacher here before becoming the Taoiseach of this country. For 10 points, name this country in which the equation describing quaternions was carved into the Bloom Bridge by William Hamilton while on a walk through Dublin.
ANSWER: Republic of **Ireland**

3. **An equation important to these devices assumes that drift, diffusion, and thermal recombination-generation are the only significant processes creating current in them. That equation states that the saturation current times the quantity exponential of voltage divided by the thermal voltage and ideality factor all minus one equals the current passing through these devices. That equation is named for (*)** Shockley. Quantum tunneling causes negative resistance in the Esaki version of these devices, and one type of them can conduct in the reverse bias direction and is named for Zener. For 10 points, name these devices that allow current to only pass in one direction, an example of which is the light-emitting type.
ANSWER: **diode**s [prompt on "semiconductors" until "Shockley"]

4. **Margules functions can be added to correct this equation, and Köhler theory is used to study cloud droplets by combining the Kelvin effect with this equation. Obeying this equation leads to a straight line on P-x-y diagrams, and this law can be extended via multiplying by (*)** fugacity and activity coefficients on different sides of the equation. It can be used to calculate the bubble and dew points, and this law is only valid for ideal solutions. This law is violated by azeotropes. For 10 points, name this law which states that partial vapor pressure can be calculated as the product of the vapor pressure of a pure component and its mole fraction.
ANSWER: **Raoult**'s Law

5. **This number divided by any integer greater than or equal to 2 is equal to the sum of the reciprocals of three positive integers according to the Erdos-Straus conjecture. Frobenius proved that real division algebras have a maximum of this many dimensions. The smallest non-cyclic group has this many elements and is called the (*)** Klein group. Any integer can be expressed as the sum of this many square numbers. The Abel-Ruffini theorem states that this is the highest degree of a polynomial for which a general solution in radicals can be found. Cousin primes are a distance of this number apart. For 10 points, name this number of colors required for map coloring, which is equal to the square root of 16.
ANSWER: **four**

6. **A compound in this substance activates the lipid derivatives anandamide and 2-arachidonylglycerol, which mediate depolarization-induced 'suppression of inhibition' in the hippocampus and cerebellum. Another active ingredient in it contains a 5-HT1A receptor agonist, which explains its anti-anxiety effect. Indica and Sativa are the primary strains of this drug; examples of the former include the prized (*)** "purple" variety. Medical uses of this plant include treating chemotherapy-induced nausea and vomiting as well as glaucoma. For 10 points, THC is the main psychoactive ingredient in what drug, whose effects are mimicked by synthetic cannabinoids?
ANSWER: **cannabis** [accept **marijuana**; accept **THC** or **tetrahydrocannabinol** until "5-HT1A", anti-prompt on it after; prompt "weed" and other street names]

7. *Description acceptable.* **Jacobsen used the Hf-W isotopic system to try to predict when this process occurred. A theory put forth by researchers at Caltech proposes that following this process a silicate vapour atmosphere formed allowing for isotopic equilibration. Cuk and Stewart published a paper explaining how angular momentum could have been lost following this process due to evection resonance. (*)** Problems with the mainstream theory of this process include near identical ratios of Titanium-50 to Titanium-47 and the relative lack of volatile elements. The dislodgement of Theia from L4 or L5 may have caused this process. The Giant Impact Theory predicts that it resulted from a collision with a Mars-sized object. For 10 points, name this event that led to the creation of the object that causes our tides.
ANSWER: **formation of the moon**

8. **Fossils from this period can be found in the Paleorrota geopark, which includes the Santa Maria formation. Monte San Giorgio contains the best marine fossils from this period. The earth saw major climate change in the Carnian Pluvial Event that occurred during this period. Plesiosaurs and (*)** ichthyosaurs were the only marine reptiles to survive the extinction occurring at the end of this period. An event preceding this period led to a lack of coal originating from it and the only known mass extinction of insects. Explosions from the Siberian traps may have caused the massive extinction that occurred right before this period. For 10 points, name this period, the first of the Mesozoic, which witnessed the emergence of dinosaurs and preceded the Jurassic.
ANSWER: **Triassic** period

9. **A variant of this reaction named for Chen and Mapp generates a phosphite in place of an alcohol and works because the P=O double bond is favored over P=N. The allyl ester of a carboxylic acid is converted to its enolate in a variant co-named for (*)** Ireland, while other variants of this reaction are named for Johnson, Bellus, and Eschenmoser. This reaction can be viewed as a variant of the Cope Rearrangement with oxygen substituted for the R-group. This heat-catalyzed reaction is highly susceptible to solvent effects - with polar solvents accelerating it by 10-fold. For 10 points, name this [3,3]-sigmatropic rearrangement in which an allyl vinyl ether is converted to an unsaturated carbonyl compound.
ANSWER: **Claisen rearrangement**

10. **Charles Richet named a substance whose presence indicates the formation of these entities, the production of which is attributed to the emission of "ectenic force". The presence of these entities can be detected by infrared thermometers by identifying cold spots. Another method of detecting these entities indicate their presence by spikes in EMF. Audio recordings in the presence of these entities can produce an (*)** EVP, or an electronic voice phenomenon and photographic evidence of them are identified by the presence of "orbs". Early methods of detecting these entities saw their formation from a slimy substance called ectoplasm emitted from a human host known as a "medium". For 10 points, identify these supernatural manifestations commonly believed to be the spirits of the deceased.
ANSWER: **ghost**s [accept "spirits" until read; accept specters or anything indicating these are spirits of some kind; DO NOT accept demons]

11. **BLADE is an API developed at Stanford by Terei and Levy that allows users to have more control over this process. An example of a "two-finger" approach to this task is done by splitting a heap into two and only using one at a time, which is referred to as Cheney's algorithm. White, black, and grey sets are created in the (*)** tri-color marking approach to accomplishing this task. It is desirable to lower the pause time of programs accomplishing this process. Joseph McCarthy developed the mark-sweep method for accomplishing this task in LISP. This process can be used to avoid dangling pointers and double free bugs. For 10 points, name this process of automatic memory management in which a program disposes of unused data to give itself more space.
ANSWER: **garbage collection** [accept word forms]

12. **Zel'dovich predicted a gravitational analogue of this effect, in which it doesn't depend on the properties of the system. The Breit-Rabi formula is used to correct the calculations of quantities important to this effect in the presence of hyperfine interactions. The energy of this effect is proportional to the Bohr Magneton and the Landé g-factor. A (*)** perturbative term is added to the Hamiltonian for a system experiencing this effect, which can be used to explain the Lyman alpha transition. In the presence of strong fields this effect is instead named for Paschen and Back, while its electric analogue is called the Stark effect. For 10 points, name this effect in which spectral lines are split by a magnetic field.
ANSWER: **Zeeman** effect

13. **An April, 2015 paper in Science by Huang *et al.* reported that this process could occur by placing polyhedral oligomeric silsesquioxane molecular nanoparticles at the vertices of a rigid tetrahedral framework. Legrain *et al.* created a material out of silicon nitrate that undergoes this process when exposed to water. Researchers at Georgia Tech showed that cyanuric acid and a modified triaminopyrimidine could have undergone this process in water to form the first RNA-like polymers. One type of this process is thought to undergo a fast step of adsorption followed by a longer period of (*)** monolayer organization. 4D-printing is a technique developed by an MIT lab that specifically studies this process. Protein folding is an example of this type of process. For 10 points, name this process in which disordered parts form an ordered structure without the aid of external mechanisms.
ANSWER: molecular **self-assembly** [accept word forms; since this has a common name, prompt on things that sound like they know what they're talking about but don't include the words **self** and **assembly**]

14. **The inverse of this operation can be found through Mellin's inverse formula. For any a greater than negative one, applying this operation to x raised to the power of a yields the gamma function of $a+1$, divided by s to the power of $a+1$. Applying this operation to a probability density function can be used to find the moment generating function. This operation is defined as the integral from zero to infinity of (*)** e to the power of negative st multiplied by the relevant function of t with respect to dt. This operation can be used to convert differential equations into algebraic equations. For 10 points, name this transform that takes a function from the time domain to the complex frequency domain.
ANSWER: **Laplace** transform

15. **The first ever professor of theoretical physics at this private university names a wave function describing the propagation of an electron in a crystalline lattice. A current professor at this American university connected string theory with the idea that our three dimensional universe may be the manifestation of a two-dimensional information surface on the cosmological horizon. That same professor at this university used the aforementioned (*)** "holographic principle" to take down Stephen Hawking in the Black Hole War. Martin Perl discovered the tau lepton at this university's accelerator, which along with Brookhaven was the site of the discovery of the J/psi meson causing the November Revolution. For 10 points, name this university home to Leonard Susskind and a namesake linear accelerator center called SLAC.
ANSWER: **Stanford** University

16. **Drugs that target poly-ADP ribose polymerase shut down this process in cancer cells. In one type of this process, amide/imidic acid tautomerizations on the hemimethylated strand are resolved by Mut proteins. Bacteria deficient in uvr genes lack the ability to perform this process on thymine dimers. The simplest type of this process occurs when MGMT (*)** converts O6-methylguanine back to guanine. These processes occur after SOS response arrests the cell cycle when mutations are detected. For 10 points, name these processes, which come in "mismatch" and "nucleotide-excision" varieties, in which a cell identifies and corrects damage to its genome.
ANSWER: **DNA repair** [accept specific types of repair such as **mismatch repair**, **nucleotide excision repair**, and direct **DNA repair**]

17. **In quantum gravity, this object can be represented as the gravitational limit of truncated Fourier-transformed vacuum expectation values of time-ordered products of field operators. The overall residue of poles of time-ordered two point functions can be used to construct this object. This object can be calculated in terms of time-ordered correlation functions in momentum space by the LSZ reduction. Geoffrey Chew tried to replace quantum field theory with his "bootstrap" model based off this object. This object can be thought of as the unitary operator that governs the evolution of asymptotic states from time equals negative infinity to positive infinity. For 10 points, name this operator that is used to predict the results of (*)** scattering processes.
ANSWER: **S-matrix** [accept **scattering matrix**]

18. **The continuous Bachmann process is the most common way to make one of these compounds, and yields another of them as a byproduct. Termite-derived endosymbionts and the manganese peroxidase system in fungi are being investigated for their capacity to break down and mineralize the nitroamine class of these compounds. The industrial process to manufacture a type of these compounds involves reacting a (*)** benzene derivative with a mixture of sulfuric acid and nitric acid three times, and that process also yields the pollutants pink water and red water. The discovery that absorbent, solid cellulose can make one of these - liquid nitroglycerin - safer was made by Alfred Nobel. For 10 points, TNT and dynamite are examples of what type of chemical that causes things to go BOOM?
ANSWER: chemical **explosive**s [accept **RDX** or **HMX** first line, anti-prompt thereafter; anti-prompt "trinitrotoluene" or "TNT" until mention; anti-prompt "dynamite" until mention; anti-prompt on "bombs"]

19. **The Regge-Wheeler equation describes the axial perturbations of this model, and the Aichelburg-Sexl ultraboost is used when travelling past a body described by it. When working in the tetrad formalism it is often convenient to use Gullstrand-Painlevé coordinates to study this model, and Flamm's paraboloid can be used to visualize it. Birkhoff's theorem states that this solution is the only one of its kind. The quantity (*)** 1 minus $2GM$ divided by r appears in the line element for this solution. This solution has to be replaced with the Kerr metric and the Reissner Nordstrom metric for rotating and charged black holes, respectively. For 10 points, name this metric named for a German who also has a namesake radius.
ANSWER: **Schwarzschild** metric [accept **Schwarzschild** solution or black hole]

20. **This scientist and Sanson name four reflections of an object–off of the inner and outer cornea and the inner and outer lens. In this man's namesake "shift", the eye becomes more sensitive to blue light under scotopic conditions, as vision becomes dominated by rods. Basket cells may restrict this man's namesake cells, which modulate the level of excitation caused by mossy and climbing fibers, and are the only output cells of the (*)** cerebellar cortex. Specialized muscle cells in the subendocardium relay cardiac impulses from the atrioventricular bundle to the ventricles; those cells are this man's namesake "fibers". For 10 points, name this Czech physiologist.
ANSWER: Jan Evangelista **Purkyně** [accept Johann Evangelist **Purkinje**]

21. **The opacity of graphene was found to be approximately equal to pi times this quantity, according to Nair *et al.*, which works presumably because graphene is only one atom thick. Data from the 128 quasars of varying redshift support the hypothesis that its value has changed by 6 parts per million, and the (*)** Lamb shift is proportional to the 5th power of this quantity. First calculated from the electron magnetic moment anomaly, this value is equal to *e* squared over h-bar *c*. For 10 points, name this coupling constant of electromagnetic interactions, which is equal to approximately one over 137 and is symbolized alpha.
ANSWER: **fine-structure** constant