

1. **This quantity is equal to the square root of the dielectric relaxation time multiplied by Einstein's relation. Strong Landau damping occurs when wavelength is comparable to this quantity. It can be derived by calculating the change in number density due to a positive point charge, using that value to find the charge density and then solving the (\*) Poisson equation. That calculation shows that this quantity is proportional to the square root of temperature divided by electron density. For 10 points, name this characteristic length in plasma physics over which significant charge separation can occur.**

ANSWER: Debye length

2. **With Bert Hölldobler, this man conducted a comprehensive analysis of the genus *Lasius*. With his student Daniel Simberloff, this man removed all of the arthropod species from six mangrove islands in the Florida Keys in order to experimentally prove that recolonization of an island is proportional to distance from the "mainland". This man rejected kin selection and argued that group selection is the evolutionary origin of eusociality and altruism. Along with Robert MacArthur, he formulated the theory of island biogeography and he wrote *The Social Conquest of the Earth*. For points, name this so-called (\*) "father of sociobiology", a Harvard professor and the world's foremost expert on ants.**

ANSWER: Edward Osborne Wilson

3. *Description acceptable.* **Programs designed for accomplishing this task often use Forsyth-Edwards notation to save current states to external storage. The 0x88 method uses an array of size 16 by 8 to store information concerning the present state when accomplishing this task. Claude Shannon proposed two types of programs for accomplishing this task; Type A evaluates every possibility using a minimax procedure, while Type B only looks at a few possibilities and uses a quiescence search. Shannon introduced a crude evaluation function for this task that uses coefficients like (\*) 3, 5, and 9 to represent relative worth. Shannon argued that it was impossible for a computer to ever accomplish this task perfectly due to the number of possible positions being about 10 to the power of 43. For 10 points, name this task that Deep Blue was able to perform so well that it beat Garry Kasparov.**

ANSWER: play chess [accept reasonable equivalents]

4. **The "bottleneck" effect named for these particles inhibits the relaxation of excited electrons. A wave vector can be transformed to a different Brillouin zone by the anharmonic scattering of these particles in Umklapp processes. A model that treats these particles like they're in a (\*) box predicts that heat capacity is proportional to temperature cubed. That model is the Debye model. According to BCS theory, superconductivity is a result of these particles' interactions with electrons. These particles propagate at the speed of sound. For 10 points, name these quasiparticles used to quantize the vibrational modes of a lattice.**

ANSWER: phonons

5. **The alpha 12 and 13 subunits of this class of protein control the rate of disassembly of dorsal ruffles, which are actin-rich membrane projections involved in cell migration. The 2012 Nobel in Chemistry was awarded for discovering that 7 helices make up beta-adrenergic receptors, which are (\*) coupled to these proteins. These proteins' gamma subunit is prenylated; and they come in two classes, heterotrimeric and small, the latter of which is exemplified by the Ras superfamily. These proteins can stimulate phospholipase C to produce DAG and IP3, but more often they stimulate adenylyl cyclase to produce cAMP. For 10 points, name these membrane-bound proteins which are activated by GTP.**

ANSWER: G proteins

6. A 2013 paper introduced the idea of a type of number named for F and this adjective, which are equal to the product of two Fibonacci numbers. The existence of a certain type of numbers described by this adjective, whose cardinality is unknown, is the subject of Sylvester's web of conditions. All known numbers described by this adjective are of the form  $(*) 2$  to the power of  $p$  minus 1 times the difference of two to the  $p$  and 1. That result is known as the Euler-Euclid theorem. 6, 28, and 496, are examples of, for 10 points, numbers described by what adjective meaning that the number is equal to the sum of its proper divisors.  
ANSWER: perfect numbers [prompt on "odd" after "Sylvester's web of conditions" and while still in power, since that clue is about odd perfect numbers]
7. The FFC Cambridge process was first used to produce this element via reduction in molten calcium chloride. Ketones or aldehydes can be coupled into alkenes using a chloride of this element in the McMurry reaction. This metal and aluminum are present in  $(*)$  Tebbe's reagent. The Hunter process for producing this metal was replaced by a process in which its tetrachloride is reduced by liquid magnesium at about 850 degrees Celsius. This metal is produced in the Kroll process and its dioxide is used as a white pigment. For 10 points, name this metal that is often used in aircraft due to it being light but strong, with atomic number 22 and symbol Ti.  
ANSWER: titanium [accept Ti until mention]
8. This task can be accomplished on a small mirror using three Fabry-Perot cavities. Arthur Ashkin developed a technique for accomplishing this task that relies on radiation pressure from lasers. Earnshaw's theorem can be used to show that this task cannot be accomplished using paramagnetic materials due to a lack of stability, but it is possible to accomplish this task using diamagnetic materials.  $(*)$  The London equations describe an effect that can be used to accomplish this task on a magnet using a superconductor. Accomplishing this task requires canceling out the force of gravity without mechanical support. For 10 points, name this task, whose magnetic form can be used to make really fast trains.  
ANSWER: levitation [accept anything including levitation or its word forms, e.g. "making something levitate", prompt on "floating something in the air" or equivalents]
9. A paper that appeared in *Nature* by Swain et al. reported the first detection of this compound in the atmosphere of an exoplanet. The near-infrared spectrum of Gliese 229B is dominated by the absorption band of this compound. SpaceX plans to power their Raptor engines with liquid oxygen and this compound, since it would be possible to refuel at certain locations in our solar system. Ligeia and  $(*)$  Kraken Mare consist mostly of the liquid form of this compound. Curiosity detected a spike in this compound on Mars in December 2014, and this hydrocarbon is often sought after as a possible sign of life. For 10 points, name this hydrocarbon found in lakes on Titan, with chemical formula  $\text{CH}_4$ .  
ANSWER: methane [accept CH<sub>4</sub> until mention]
10. The return coefficient of these systems is equal to the difference of exposure time and residence time divided by exposure time. The Fjord-types of these systems are found in valleys formed by glaciers and have relatively low circulation. An example of the bar-built type of these systems is the Pamlico Sound, which is found to the west of the  $(*)$  Outer Banks. The salt-wedge types of these systems have higher salinity at deeper depths. The Chesapeake Bay is a notable example of these bodies consisting of brackish water. For 10 points, name these bodies of water where freshwater meets saltwater.  
ANSWER: estuaries

11. **Neuromodulation induced by this hormone occurs after norepinephrine causes cyclic AMP to build up in the hippocampus. In the central nervous system, this hormone generally exerts the opposite effect to oxytocin; thus it may be involved in long-term maintenance of a learned response and in avoidance behavior. This hormone can be used as an alternative to (\*) epinephrine to stimulate vasoconstriction for patients with cardiac arrest due to ventricular fibrillation or pulseless ventricular tachycardia. In its main role, this hormone increases the permeability of the distal convoluted tube and collecting duct. For 10 points, name this hormone which promotes water retention in the kidney.**  
ANSWER: vasopressin [accept antidiuretic hormone or ADH]
12. **Mansuripur's paradox can be resolved by considering the "hidden" momentum of a dipole so-named due to the relevance of this law. Using this law alongside one of the London equations can be used to calculate the London penetration depth of the Meissner effect. Taking the divergence of this law and then noting that the divergence of the curl is equal to zero allows one to derive the continuity equation of electromagnetism. You can switch between the two forms of this law by using the (\*) Kelvin-Stokes theorem, and the Biot-Savart law has to be used instead of this one when current density isn't constant. For 10 points, name this law corrected by Maxwell, which states that the line integral around a closed loop is proportional to the current passing through it.**  
ANSWER: Ampere's circuit law [accept Ampere-Maxwell law]
13. **This computer scientist names an extension of "Hello world"-like programs with Trabb Pardo. He created a test to distinguish compilers in the ALGOL 60 programming language named the "man or boy" test. "Dancing Links" is an implementation of an algorithm he created to find solutions to the exact cover problem named Algorithm X. Along with two less famous people he names an algorithm that makes use of a failure function or (\*) partial match table. Annoyingly large integers can be compactly written using his up-arrow notation. This computer scientist created an algorithm for searching strings with Morris and Pratt. He developed Metafont and a typesetting language called TeX ["tek"]. For 10 points, name this Stanford computer scientist who wrote *The Art of Computer Programming*.**  
ANSWER: Donald Knuth
14. **Skoda found a "twisted" form of this operator for enveloping algebras. If the difference of two closed forms is equal to this operator applied to some other form, then the two closed forms are referred to as cohomologous. If this operator applied to some  $p$ -form beta yields zero, then there exists some  $p-1$  form gamma such that, locally, this operator applied to gamma equals beta. That result is known as Poincare's lemma. One property of this operator is that squaring it always yields zero. Applying this operator to a 0-form, or scalar function, yields the gradient. For 15 points, name this operator that maps  $p$  forms to  $p+1$  forms, which is denoted by a  $d$  and obeys the Leibniz rule. (\*)**  
ANSWER: exterior derivative [prompt on "derivative" or "gradient"]
15. **One character in this film receives a recorded message from his parents for his birthday and is told he is "a big celebrity in the second grade". In this film, Dr. Floyd is questioned by a fellow scientist if an epidemic has afflicted Clavius. A character in this film originated from Urbana, Illinois and was instructed by Mr. Langley to learn the song "Daisy Bell", which became that character's last words. A murder in this film's first part (\*) The Dawn of Man is committed using a newly found tool, which after being tossed is used as a match cut to satellites turning to Strauss's Blue Danube Waltz. HAL 9000 antagonizes Dr. Poole and Bowman while aboard a spaceship bound for Jupiter. For 10 points, name this film about an expedition to investigate the presence of a black monolith, directed by Stanley Kubrick.**  
ANSWER: 2001: A Space Odyssey

16. The software TagFinder is used to fingerprint and profile the results of these two techniques. These techniques are preferred over NMR spec to study metabolism with carbon-13-labelled substrates. In order to perform these techniques with volatile compounds, the purge and trap method is used. As compounds (\*) elute from the first part of these techniques, they are fragmented by electrons in preparation for the second part. An inert gas such as helium carries the sample mixture through the mobile phase in these techniques, whose products are then sorted by their mass-to-charge ratio. For 10 points, name this combination of two analytical techniques, abbreviated GC-MS.

ANSWER: gas chromatography-mass spectrometry [accept "GC-MS" until mention; prompt on partial]

17. A 2015 paper by Zhang *et al.* detailed how a lethal form of this process could be used to protect crops from insect pests. The PIWI domain of a protein central to this process is responsible for anchoring the guide RNA to a highly conserved basic pocket where the first nucleotide is unpaired and stacks over a conserved tyrosine residue. The endonuclease argonaute in the (\*) RISC complex cleaves the target molecule of this process after dsRNA is fragmented by the enzyme Dicer. Fire and Mello won the 2006 Nobel for studying this process in *C. elegans*. For 10 points, give this gene-silencing process in which miRNA and siRNA bind to mRNA after transcription.

ANSWER: RNA interference [accept RNAi]

18. A proposed way to test whether our Universe is a bubble located in a multiverse is to search for a form of this effect resulting from bubble collisions. In the non-relativistic limit, this effect can be described by the Kompaneets equation. The kinematic variety of this effect, which is independent of (\*) redshift, is due to the high-energy bulk motion of electrons. This effect was used to catalogue galaxy clusters thanks to the results of the Planck spacecraft. For ten points, name this effect that causes a distortion of the CMB due to inverse Compton scattering, and is named for two Soviet physicists.

ANSWER: Sunyaev-Zel'dovich effect [prompt on "inverse Compton" scattering]

19. Carreira proposed a model for the enantioselective reaction of this type between silyl ketene acetals and aldehydes. Claisen and Schmidt name a type of this reaction which produces dibenzylideneacetone. In the first step of the Krebs cycle, oxaloacetate and acetyl-coA undergo this type of reaction to form citryl-coA, which is quickly dehydrated to form citrate. This reaction follows (\*) Michael addition in the Robinson annulation sequence. The alpha carbon of a carbonyl is deprotonated to form an enolate, which then attacks another carbonyl in, for 10 points, what reaction that forms beta-hydroxy ketones?

ANSWER: aldol condensation

20. This statement can be used to show that planetary systems and atoms can't exist in dimensions greater than three due to a lack of binding energy. Deriving the scalar G function with respect to time and choosing n equals negative one reduces this statement to Lagrange's identity for gravitating systems. That scalar G function is equal to one half the time derivative of the moment of inertia, and is also equal to the sum over N point particles of each particle's momentum vector dotted with its position vector. For systems with a (\*) potential energy, this theorem states that two times the average kinetic energy equals n times the average total potential energy. For 10 points, name this theorem, which relates the average kinetic and potential energies of a system.

ANSWER: Virial theorem

21. The now supplanted theory of turbulence that this man names with Hopf states that fluids become turbulent when they start flowing faster and develop more Fourier modes. This man introduced the idea of quasiparticles in his theory of Fermi liquids. He and one of his students developed a formula describing the precession of magnetization, which was later modified by (\*) Gilbert. He developed a theory of second-order phase transitions, which provided inspiration for a theory of superconductivity that he names with Ginzburg. For 10 points, name this Soviet physicist who won a Nobel for his theory of superfluidity.

ANSWER: Lev Landau