Finals

Finals Phase 1

(1) The simplex algorithm performs this process in linear programming, a field often alternatively named for this process. The knapsack problem seeks to do this to profit, while the traveling salesman problem seeks to do this to the distance traveled. For the point, give this general term for mathematical processes, including maximization and minimization problems, which try to make some quantity as good as possible.

ANSWER: **optimization** problems (accept word forms and other elaborations; prompt on maximization and/or minimization before mentioned)

(2) Information about higher-order systems is predicted by analyzing this quantity for lower order systems in the CALPHAD method. A similar quantity to this one that holds volume constant is named for Hermann von Helmholtz. The formula for this quantity involves the product of temperature and entropy, subtracted from the enthalpy. For the point, name this measure of a reaction's spontaneity, a type of free energy symbolized G and named for an Englishman.

ANSWER: **Gibbs** free **energy** (accept **Gibbs** alone after "free energy" is read; before then, prompt on energy; prompt on free energy; accept **free enthalpy**, but do not accept or prompt on enthalpy)

(3) During one part of this process, the leptotene and pachytene stages occur, while another part involves the creation of chiasmata. This process increases genetic diversity through homologous recombination. In females, this process produces three polar bodies. This process goes through two of prophase, metaphase, anaphase, and telophase. For the point, name this type of cell division that forms haploid cells, contrasted with mitosis.

ANSWER: **meiosis** (prompt on cell division before mentioned)

(4) In December 1783, a few months after the Montgolfier brothers used hot air to lift their balloon, this Frenchman used hydrogen to lift his manned balloon. Joseph Louis Gay-Lussac verified this man's most famous chemical discovery, which explains the relationship between heat and gas expansion. For the point, name this Frenchman whose namesake law sets temperature directly proportional to volume.

ANSWER: Jacques Alexandre César **Charles** (accept **Charles**'s Law)

(5) Air rising to the upper boundary of this region of the atmosphere causes the circulation of Hadley cells. The lapse rate in this region is roughly 6.5 degrees Celsius per kilometer, given that temperature decreases in this region as the altitude increases. Roughly three-fourths of the mass of the atmosphere is found in this layer, in which airplanes fly. For the point, name this region below the stratosphere, the lowest layer of the atmosphere.

ANSWER: **troposphere**

(6) This person is the namesake of an infrared telescope in the Canary Islands, as well as a crater that makes its body, the moon Mimas, resemble the Death Star. This person discovered the moons Titania and Oberon. His most famous discovery was originally named *Georgium sidus* after King George III, but was later changed to the Greek god of the sky. For the point, name this astronomer who, in 1781, discovered Uranus.

ANSWER: William **Herschel**

(7) To avoid mercury poisoning, this element's compounds with sodium are often used to extract gold, and can also be used in detergents. A silicate glass using this element's trioxide is very heat-resistant and used in Pyrex lab equipment. Group 13 of the periodic table is sometimes named for this element, whose common isotopes have 10 or 11 neutrons. For the point, name this element with atomic number 5 and chemical symbol B.

ANSWER: **boron** (accept **B** before mentioned)

(8) This process replaced the much less efficient "puddling" process, making wrought iron less important for construction use. William Kelly is thought to have independently discovered this process, in which air is blown through a vessel of molten pig iron; the air causes carbon impurities to be oxidized away into slag. Andrew Carnegie was a proponent of, for the point, what 19th century industrial process that revolutionized steel manufacturing?

ANSWER: **Bessemer** process

(9) Three, 5, 17, and 257 are the first few numbers named for this man in the form "2 to the 2 to the n, plus 1." A theorem named for this man was proved when the Taniyama-Shimura conjecture on elliptic curves was solved by Andrew Wiles; that theorem states that there are no positive integer solutions to a to the n plus b to the n equals c to the n, if n is greater than 2. For the point, name this French mathematician who claimed he didn't have enough space for the proof of his "last theorem."

ANSWER: Pierre de **Fermat** (accept **Fermat** numbers, **Fermat** primes, and/or **Fermat**'s Last Theorem)

(10) During this process, sediment can form an accretionary prism. Slab pull occurs during this process, which, in oceans, can lead to the creation of a trench. This process occurs in a Wadati-Benioff zone and may cause a megathrust earthquake. This process takes place at convergent boundaries between two tectonic plates. For the point, name this geologic process in which one tectonic plate is forced under another.

ANSWER: **subduction**

(11) This organelle is the site of O-linked glycosylation. In this organelle, lysosomal proteins are targeted with mannose-6-phosphate. The trans part of this organelle sometimes serves as early endosomes. This organelle consists of flattened stacked disks called cisternae, and it takes products from the endoplasmic reticulum and packages them for secretion out of the cell. For the point, name this organelle, named after its Italian discoverer.

ANSWER: **Golgi** body (apparatus, complex, etc.)

(12) The "bogo" type of this procedure randomly works until it is successful. Tony Hoare invented another algorithm to perform this process that uses a pivot value to partition the array in question. Common types of this procedure include "merge," which runs in Big O of n log n time, as well as "bubble" and "quick." For the point, name this computing task that orders the entries in a list.

ANSWER: **sort**ing (accept descriptive answers that use the word **sort** or the word **order** before it is read; accept additional information like **bogosort**)

(13) The Joule effect is used to calibrate the Calvet type of these devices. An aluminum pan is used in the differential-scanning type of these devices; another type of these devices that holds constant volume under intense pressure is called a bomb. Antoine Lavoisier co-designed an early example of this lab equipment, which typically uses a combustion chamber and a thermometer. For the point, name these devices used to calculate heat capacity and the heat given off by a reaction, thus named for a unit of heat energy.

ANSWER: **calorimeter**s (accept specific types of calorimeters like bomb **calorimeter** or differential-scanning **calorimeter**)

(14) Pingala represented this concept with the word *śunya*. Brahmagupta made an early attempt to systematize this concept, which was represented in a Babylonian system of sexagesimals by a space. Under Wu Zetian in China, an open circle was used to represent this concept, which was described in the Islamic world by a word meaning "empty." For the point, name this concept which quantifies the lack of a numerical value.

ANSWER: **zero** (prompt on empty or word forms before read; prompt on nothing or synonyms)

(15) A mutant copy of the PAX6 gene in fruit flies causes the absence of these structures. This structure's outermost two layers are the fibrous and vascular tunics. Defects of a part of these structures can lead to astigmatism or myopia. Arthropods contain a compound variety of these structures, which contain the iris, cornea, retina, and pupil. For the point, name this primary visual organ.

ANSWER: **eye**s

(16) Leonard Susskind introduced the idea of "landscapes" named for this theory. Edward Witten attempted to connect many of these theories into his own M-theory. The central phenomenon of this type of theory is termed opened or closed based on the presence of endpoints. This theory tries to explain quantum gravity and generally requires supersymmetry. For the point, name this physical theory, named for one-dimensional objects that might make up particles.

ANSWER: **string** theory(s)

(17) This mineral is produced with kyanite in a reaction between magnesium chlorite and quartz. With schist, it is a major component of soapstone, and this often foliated mineral is largely comprised of hydrated magnesium silicate. Welding chalk uses this mineral, which is a common solid lubricant and can be easily scratched by a fingernail. For the point, name this commonly white mineral used in baby powder and as the defining mineral for 1 on Mohs' scale of hardness.

ANSWER: **talc**um (accept **talc**um powder)

(18) In a cube, the perpendicular bisecting plane of a space diagonal cuts a cross-section with this shape. This shape forms 20 of the faces of a truncated icosahedron, along with 12 pentagons. The area of this polygon is equal to three-halves times the square root of 3 times the square of the side length. This polygon can be used to form the honeycomb tiling. For the point, name this polygon with 120 degree interior angles and 6 sides.

ANSWER: regular **hexagon**

(19) A heat press is used in a printing technique in which dyes invoke this process at around 350 degrees Fahrenheit. Mothballs usually contain a hydrocarbon that undergoes this process at around 176 degrees Fahrenheit called naphthalene. The opposite of this process is known as deposition. Solid carbon dioxide undergoes this process at room temperature; as a result, dry ice is often used in smoke machines. For the point, name this phase transition from solid to gas.

ANSWER: **sublimation** (prompt on descriptions of a "solid turning into a gas" before mentioned)

(20) The north polar region of this object contains a dark area which scientists have called "Mordor." This object was discovered by James Christy, whose wife's name influenced its naming. In 2005, two smaller objects were found to orbit the same body as this object; they were named Nix and Hydra. This is the second largest object in the main planetary system visited by the New Horizons spacecraft. For the point, name this largest moon of Pluto.

ANSWER: **Charon**

(21) In 1937, Pyotr Kapitsa discovered that, under certain conditions, helium had a value of zero for this quantity. The forces caused by this property are in the denominator for the Reynolds number. Liquid helium, as a superfluid, has a value of zero for this quantity and can therefore "creep up" the walls of its container. For the point, name this quantity that measures a fluid's resistance to flow.

ANSWER: dynamic **viscosity**

(22) The only subspecies of these animals that can't undergo embryonic diapause, a delaying of pregnancy, is the "musky rat" type. The largest species of these mammals is its "red" type, which has a particularly elastic Achilles tendon. These animals belong to the Macropod family alongside wallabies. The females of this marsupial species raise joeys in their pouch. The Tasmanian forester is an example of, for the point, what hopping mammals found in Australia?

ANSWER: **kangaroo**s (accept musky rat-**kangaroo**s; accept red **kangaroo**s; prompt on marsupials before mentioned)

(23) These regions are the subject of the holographic principle, which notes that all information about objects within the three-dimensional space inside this region is encoded *on* this lower-dimensional space. Objects approaching this region appear, to an external observer, to slow down and become redshifted. Light emitted within this region will never reach an observer outside of this region, due to extreme gravitational pull. For the point, name this boundary surrounding a black hole that, once crossed, cannot be escaped.

ANSWER: **event horizon** (prompt on horizon; prompt on black hole before mentioned)

(24)   Francois Englert co-won a Nobel prize for helping theorize this particle. A mechanism using spontaneous symmetry breaking shares its name with this particle's namesake. An experiment at CERN in 2012 claimed to have discovered this particle, which lacks charge and spin. This particle is thought to explain why W and Z bosons have mass. The "God particle" is a nickname for, for the point, what recently discovered boson?

ANSWER: **Higgs boson** (prompt on boson)

(25)   The gluconeogenesis phase of the Cori cycle takes place in this organ. Along with muscles, the body's supply of glycogen is found in this organ, which sits above the gallbladder. One type of damage of this bile-producing organ is known as cirrhosis, which can be caused by excess alcohol consumption or infection with hepatitis. For the point, name this large human organ found near the stomach in the upper abdomen.

ANSWER: **liver**

(26) This phenomenon's occurrence at the edge of a half-plane can be depicted with a Cornu spiral. One technique for determining crystalline structure involves observing X-ray beams undergoing this process. Fresnel names a type of this phenomenon. It explains why one's shadow becomes more definitely outlined when the person is closer to it. For the point, name this phenomenon in which light bends around an obstacle.

ANSWER: **diffraction**

(27) One proof that the square root of 2 is irrational involves the contradiction that the numerator and denominator would both have this property. This property is held by the number of factors of any integer that is not a perfect square. A real number results whenever the imaginary number i is raised to an exponent with this property. When the size of a data set has this property, the median is the average of the two middle numbers. For the point, name these integers that are divisible by 2.

ANSWER: **even** numbers

(28) A star of this color was revealed to have 7 extrasolar planets in a February 2017 NASA announcement. Exoplanet hosts Gilese 581 and TRAPPIST-1 are stars of this color, which is also the color of the 4th closest star to the Sun, Barnard's Star. This is the color of stars that are predicted to have the longest lifespan. The smallest main sequence stars are dwarfs of this color, which includes the nearby Proxima Centauri. For the point, name this color that gives Mars its nickname.

ANSWER: **red**

(29)   To avoid this phenomenon, some pseudoscientists fire shockwave cannons at the sky. Graupel is sometimes described as the "soft" form of this precipitation because it is composed of rime. Megacryometeors are unusual examples of this phenomenon, which forms around a condensation nucleus as it is lifted by updrafts in a thunderstorm. For the point, name this form of precipitation made up of ice pellets.

ANSWER: **hail**stones (Note: the "theory" behind the cannons is that shockwaves stop the updrafts and keep the hail from forming...but wouldn't thunder take care of that? Right?)

(30) One treatment for this disease is the drug Metformin. Not treating this disease is the primary cause of the production of ketone bodies. A treatment for this disease using a certain protein from the beta cells of the islets in the pancreas won Frederick Banting and Charles Best a Nobel Prize. The adult onset form of this disease, its "Type 2," involves resistance to insulin. For the point, name this disease in which patients suffer from high levels of blood sugar.

ANSWER: **diabetes** mellitus (accept Type 2 **diabetes**; accept Type 1 **diabetes** after "ketone" is read)

Finals Phase 2

(31) These organisms' cell walls lack D-amino acids. These organisms are defined as having ether linked lipids in their cell walls. 16S rRNA [16-S r-R-N-A] was used by Carl Woese to give these organisms their classification, which moved away from a previous tree of life that had 5 kingdoms. Most halophiles and methanogens are part of, for the point, what domain of extremophiles, separate from eukaryotes and bacteria, named for their age?

ANSWER: **archaea**bacteria or **archaeon**s (do not accept or prompt on "bacteria" alone)

(32) This law can be derived from a 1662 principle stating that the least time-intensive path is taken by the central phenomenon; that principle is named for Pierre de Fermat. This law states that the ratio of phase velocities is equal to the sine of the angles of incidence over the sine of the angle of refraction. For the point, name this law that explains the trajectory of light rays through two different mediums, named for a Dutchman.

ANSWER: **Snell**'s Law (accept **Snellius**' Law; accept **Snell**-Descartes law; accept **law of refraction** before "refraction" is read)

(33) This quantity is directly proportional to concentration in the chelate effect. In the law of mass action, this quantity is used to relate the concentrations of products and reactants. The relationship between temperature and this quantity is explained by Le Chatelier's principle. This value, which is symbolized K, is equal to the value of the reaction quotient once the reaction reaches its namesake state. For the point, name this constant, important in studying reactions where the reverse and forward reactions occur at the same, balanced rate.

ANSWER: **equilibrium** constant (accept **K** before said)

(34) This man conducted much of his later research at his observatory at Uraniborg. Manderup Parsberg's injury of this man's face during a duel led this man to wear an artificial nose partly made of gold. This man attempted to combine Copernican and Aristotelian astronomy in a model that had the Sun and Moon orbit Earth while the planets orbit the Sun. For the point, name this astronomer from Denmark whose data was later used by his assistant, Johannes Kepler.

ANSWER: Tycho **Brahe** (accept Tyge Ottesen **Brahe**)

(35)   Researchers first observed the quantum Hall effect in the inversion layer of one type of these devices. The invention of these devices won John Bardeen and William Shockley the Nobel Prize. Moore's law predicts that the number of these entities in a circuit will double each year, thus improving the performance of computer chips. For the point, name these semiconductors that manage electrical signals.

ANSWER: **transistor**s (accept metal-oxide-semiconductor field effect **transistor**s; accept MOS**FET**s; accept **BJT**s; accept bipolar junction **transistor**s)

(36) This space project names the observation that thermal recoil force is unexpectedly slowing down its spacecraft, this project's namesake "anomaly." Two of this project's spacecrafts carried aluminum plaques with the image of a man, woman, and Earth's place in the solar system. The tenth spacecraft of this project was the first to leave the inner solar system. For the point, name this space exploration project that was the first to visit Jupiter and Saturn.

ANSWER: **Pioneer** program

(37) Lacteals are members of this organ system that take up chyle. Infections in this organ system can cause a swelling known as elephantiasis. The largest organ in this system is the spleen. Cancers of this organ system are split into Hodgkin's and Non-Hodgkin. For the point, name this subset of the immune and circulatory system responsible for the filtration of blood, represented by its namesake "nodes."

ANSWER: **lymph**atic system (accept **lymph** nodes)

(38) Molecular weight and a namesake quantity are central to the "size-exclusion" type of this technique. The retention factor relates the amount of time that the central solution of this technique is spent in its mobile and stationary phases, the latter of which is typically a silica gel. There are column and gas types of this technique, which can purify a mixture or simply study its components. For the point, name this class of techniques that separate a mixture, often done in school labs with ink through paper.

ANSWER: **chromatography** (accept additional information, like size-exclusion **chromatography**, etc.)

(39) Most of the debris in these events is created through saltation bombardment; for example, in the Bodélé Depression, winds up to 30 kilometers per hour cause lifted particles to crash back into the ground, lifting up more particles and expanding this event. Simooms and haboobs are examples of these events, which devastated farms in 1930's America. For the point, name these storms, common in deserts, that spread dirt and the namesake material.

ANSWER: **dust storm** (accept **sandstorm**; accept **duster**s; accept **simoom**s or **haboob**s before read)

(40)   This constellation is home to the first discovered quasar, 3C 273, and a galaxy named for its resemblance to a sombrero. This constellation's massive M87 galaxy is the central galaxy of a large cluster. The Milky Way and the rest of the Local Group belong to a supercluster whose center is in this constellation. Spica is the alpha star of, for the point, what constellation that sits between Leo and Libra and depicts a maiden?

ANSWER: **Virgo** (prompt on "maiden" or "virgin" before mentioned)

(41) Blas Cabrera detected one of these particles on Valentine's Day 1982, but none have been detected since. Paul Dirac showed that the existence of these particles would imply that all electric charge is quantized. These particles cannot exist according to one of Gauss' laws. These particles are the magnetic analogue of a point charge. For the point, name these hypothetical particles that would only have either a north or south pole.

ANSWER: magnetic **monopole**s

(42) This value is equal to two times cosine of 36 degrees, and it is also the positive solution to x squared minus x minus one equals zero. A continued fraction consisting entirely of ones evaluates to this value, which is equal to one plus its inverse. For the point, name this mathematical constant that is approximately equal to 1.618, is usually written as the fraction 1 plus root 5 all over 2, and is denoted by the Greek letter phi.

ANSWER: **golden ratio** or **golden mean** (accept any combination of the words [golden or divine] with [ratio, mean, section, cut, or proportion])

(43) The synthesis of this compound is catalyzed by aromatase. The plastic bisphenol A may be unsafe because it can mimic the effects of this compound. Antagonists of this compound include Fulvestrant and Tamoxifen. A small surge in this compound is seen in the luteal phase, while increasing levels of this compound in the follicular phase cause a spike in FSH and LH, leading to ovulation. For the point, name this hormone that is often studied with progesterone, the primary female sex hormone.

ANSWER: **estrogen**

(44) One method of producing this compound relies on an iridium catalyst and avoids the water gas shift; that is the Cativa Process, which adds a molecule of carbon monoxide to a molecule of methanol. An undiluted form of this compound is described as "glacial." This compound, whose chemical formula can be written CH_3COOH [spell it out], is found in a liquid that creates carbonic acid when it reacts with baking soda. For the point, name this acid found in vinegar.

ANSWER: **acetic acid** (accept **ethanoic acid**; accept **CH_3COOH** or other chemical formulas that involve exactly **two carbons, two oxygens, and four hydrogens** before the formula is read)

(45) A theorem that finds this quantity for a rigid body is sometimes named for Huygens [hoy-gens] and Steiner; that theorem involves the distance between two parallel axes, one of which goes through the center of gravity of the object. The torque on a body is equal to its angular acceleration times this value. For the point, name this rotational analogue of mass, symbolized I.

ANSWER: **moment of inertia** (prompt on moment; prompt on "I;" do not prompt on inertia alone)

(46) This element's trichloride is a common Lewis acid catalyst in the Friedel-Crafts reagent. This element's major ore is extracted in the Bayer process. The Hall-Héroult process is used to smelt this element, whose oxide is crystallized in corundum. Bauxite is the main source for this element, whose low density and ability to make durable alloys make it a common component of aircraft frames. For the point, name this element with atomic number 13 and symbol Al.

ANSWER: **aluminum** (or **aluminium**; accept **Al** before mentioned)

(47) A very large one of these entities named Phoebe was not discovered until 2009. The Encke gap is found within these entities. Plumes from Enceladus may act as a source for one of these entities, and Prometheus and Pandora act as "shepherds" for one of them. They aren't moons, but these entities were first observed through a telescope by Galileo, who sometimes referred to them as their host planet's "ears." For the point, name these large features that surround the sixth planet of our solar system.

ANSWER: **rings** of **Saturn**

(48) Description acceptable. A number is raised to a power, then this operation is performed on it to encrypt messages in the RSA system. Fermat's little theorem relates a number a and that number raised to a prime power, a to the p, after performing this operation on a to the p. Two numbers are considered congruent with respect to a modulus if the result of this action is the same for both numbers. For the point, name this action that, when the dividend is 20 and divisor is 6, returns a value of 2.

ANSWER: **finding the remainder** after dividing (accept equivalents; accept **modulo** or **modulus** or equivalent descriptions of modular arithmetic before "modulus" is read)

(49) The most common site for this phenomenon is outside the town of Kifuka in Africa, and it's also highly common at the mouth of the Catatumbo River in Venezuela. One type of this phenomenon triggers colorful high altitude illuminations known as sprites. Fulminology is the study of this phenomenon, whose dry form often triggers wildfires. Ben Franklin's kite proved that this phenomenon was electric. For the point, name this powerful discharge seen during thunderstorms.

ANSWER: **lightning** strikes, storms, etc. (prompt on thunderstorms; prompt on thunder)

(50) A famous one of these structures uses a one-percent grade on much of its journey to Segovia. One of these constructs in France that is made of limestone is known as Pont du Gard. The Tunnel of Eupalinos is an underground construct of this type that served ancient Greece. Roman examples of these maintained latrines and public baths but, unfortunately, used lead piping to prevent evaporation. For the point, name these systems that carry water.

ANSWER: **aqueduct**s