DOUBLE ELIMINATION 4

TOSS-UP

1) Chemistry - *Multiple Choice* Adding 0.1 moles of which of the following acids to 1 kilogram of water would cause the freezing point of the solution to decrease the most?

W) H_3PO_3
X) H_2SO_4
Y) CH_3COOH
Z) $HClO_4$

ANSWER: X) H_2SO_4

BONUS

1) Chemistry - *Short Answer* Order the following four 0.1 molar solutions in water from lowest to highest pH: 1) Acetic acid; 2) Trichloroacetic acid; 3) Butanoic **[BYOO-tuh-no-ik]** acid; 4) Trifluoroacetic acid.

ANSWER: 4, 2, 1, 3

TOSS-UP

2) Math - *Short Answer* What is the sum of i^{5k} **[i to the power of quantity 5k]** for all positive integers k less than or equal to 2025, where $i = \sqrt{-1}$?

ANSWER: i

BONUS

2) Math - *Short Answer* In a square grid of 25 dots, what is the probability that the center of the grid is strictly inside a rectangle defined by randomly choosing 2 rows and 2 columns?

ANSWER: $\frac{4}{25}$ (ACCEPT: 0.16, 16%)

TOSS-UP

3) Physics - *Short Answer* A planet is in circular orbit around of star of mass M. In terms of the planet's kinetic energy K, what is the sum of the kinetic energy and gravitational potential energy of the planet?

ANSWER: $-K$

BONUS

3) Physics - *Multiple Choice* An ideal superconducting ring of area A, initially in the non-superconducting phase, is placed in the xy-plane. A magnetic field of magnitude B is turned on in the $+z$ direction. The temperature is then lowered so that the ring becomes a superconductor before the magnetic field is turned off. Which of the following is the resulting current and magnetic flux through the loop?

W) No current, no magnetic flux
X) No current, magnetic flux of BA
Y) Counter-clockwise current, no magnetic flux
Z) Counter-clockwise current, magnetic flux of BA

ANSWER: Z) Counter-clockwise current, magnetic flux of BA

TOSS-UP

4) Biology - *Multiple Choice* Which of the following coreceptors is most important in the binding of MHC Class I **[one]**?

W) CD4
X) CD8
Y) CCR5
Z) CCR6

ANSWER: X) CD8

BONUS

4) Biology - *Multiple Choice* Which of the following is NOT true regarding water transport inside the xylem **[ZY-lum]**?

W) Xylem sap ascends in the plant when the outside air is drier than the interior of the leaf
X) Both cohesion and adhesion facilitate the transport of water in the xylem
Y) The transport of water inside the xylem is an example of bulk flow
Z) Cavitation blocks water transport from ice crystals puncturing holes in the xylem sclereids **[SKLAIR-ee-ids]**

ANSWER: Z) Cavitation blocks water transport from ice crystals puncturing holes in the xylem sclereids

TOSS-UP

5) Energy - *Short Answer* Scientists in the Irwin group at Stanford are attempting to detect axions, hypothetical particles that could explain the presence of dark matter. Identify all of the following three statements that are true of axions: 1) They are bosons; 2) They have zero mass; 3) They have zero charge.

ANSWER: 1 and 3

BONUS

5) Energy - *Short Answer* Scientists at Stanford's Doerr School of Sustainability are studying the role fungal networks play in tackling climate change. Identify all of the following three statements regarding fungi that are true: 1) Fungi are considered both autotrophs and heterotrophs; 2) Fungal spores can be produced sexually and asexually; 3) A zygote is produced when the cytoplasms of two fungal spores of opposite mating types fuse.

ANSWER: 2 only

TOSS-UP

6) Earth and Space - *Multiple Choice* Which of the following rocks would most likely be formed due to the action of turbidity currents?

W) Slate
X) Greywacke **[GRAY-wack-ee]**
Y) Limestone
Z) Mudstone

ANSWER: X) Greywacke

BONUS

6) Earth and Space - *Multiple Choice* Which of the following best characterizes the typical pressure tendency of a region during the passage of an occluded front?

W) Rising steadily
X) Rising, then falling
Y) Falling steadily
Z) Falling, then rising

ANSWER: Z) Falling, then rising

TOSS-UP

7) Physics - *Multiple Choice* Given an object of fixed mass in an elliptical orbit with semimajor axis length a and semiminor axis length b, which of the following values of a and b result in the highest total energy for the system?

W) a = 15 meters, b = 10 meters
X) a = 10 meters, b = 5 meters
Y) a = 14 meters, b = 14 meters
Z) a = 6 meters, b = 6 meters

ANSWER: W) a = 15 meters, b = 10 meters

BONUS

7) Physics - *Short Answer* Identify all of the following three circuit elements that have purely imaginary impedance **[im-PEE-dance]** values: 1) Resistor; 2) Capacitor; 3) Inductor.

ANSWER: 2 and 3

TOSS-UP

8) Chemistry - *Multiple Choice* A multi-step equilibrium reaction takes place in a container. The first reaction involves A reversibly going to B with $K = 10$, and the second reaction involves B reversibly going to C with $K = 5$. What is the equilibrium constant for the overall reaction?

W) 2
X) 5
Y) 10
Z) 50

ANSWER: Z) 50

BONUS

8) Chemistry - *Short Answer* Identify all of the following three molecular compounds that are predicted to be paramagnetic by molecular orbital theory: 1) B_2 2) O_2^+ 3) F_2^-.

ANSWER: All

TOSS-UP

9) Earth and Space - *Multiple Choice* Which of the following stellar spectral types has the lowest average temperature?

W) M
X) L
Y) Y
Z) T

ANSWER: Y) Y

BONUS

9) Earth and Space - *Short Answer* Order the following three stages of cosmological history from first to last to occur: 1) Recombination; 2) Inflation; 3) Planck epoch.

ANSWER: 3, 2, 1

TOSS-UP

10) Energy - *Short Answer* Scientists in the Kavli Institute at Stanford are studying the early life cycle of galaxies. When the fast-moving jets of matter produced by galatic nuclei are seen from Earth, they often appear to be moving faster than the speed of light. What term is given to this specific type of motion?

ANSWER: Superluminal motion

BONUS

10) Energy - *Short Answer* Researchers in the Radio Glaciology group at Stanford are using techniques developed on Earth to study water-ice crusts above subsurface oceans on different moons. Identify all of the following three moons that these researchers could be studying: 1) Europa; 2) Ganymede; 3) Titan.

ANSWER: All

TOSS-UP

11) Math - *Short Answer* Luka and Lebron initially stand on the xy-plane at the origin and (3, 4), respectively. After each second, they independently move in any of the 4 cardinal directions with equal probability. What is the probability that after 5 seconds, the two players are standing at the same spot?

ANSWER: 0

BONUS

11) Math - *Short Answer* Sheldon is drawing rectangles on a 4×4 grid in the xy-plane. He will not draw rectangles that are squares and will only draw rectangles with sides parallel to the coordinate axes. How many possible rectangles can Sheldon draw?

ANSWER: 22

TOSS-UP

12) Biology - *Multiple Choice* Thyroid tissue is destroyed by autoimmune attacks in Hashimoto's disease, yet enlargement of the thyroid is a characteristic sign of the disease. Which of the following best explains this phenomenon?

W) Decreased T_3 and T_4 secretion leads to an increase in circulating TSH
X) A rapid inflammation response within the thyroid causes immense swelling
Y) Released iodine from traps in the thyroid colloid stimulates abnormal cell growth
Z) A fall in metabolism from thyroid nonfunction leads to a rise in growth hormone secretion

ANSWER: W) Decreased T_3 and T_4 secretion leads to an increase in circulating TSH

BONUS

12) Biology - *Short Answer* Identify all of the following three statements regarding sickle cell anemia that are true: 1) At the molecular level, the trait exhibits codominance; 2) At the organism level, the trait exhibits incomplete dominance; 3) At the population level, the trait exhibits an autosomal recessive inheritance pattern.

ANSWER: All

TOSS-UP

13) Chemistry - *Multiple Choice* Which of the following reaction types can convert chloromethane to bromomethane in one step?

W) SN1
X) SN2
Y) E1
Z) E2

ANSWER: X) SN2

BONUS

13) Chemistry - *Short Answer* Tollens' test for reducing sugars uses the silver complex $Ag(NH_3)_2^+$ **[Ag, open parentheses, NH3, close parentheses, 2, plus]**. Given that the solution is exposed to air for an extended period of time, what is the chemical formula of the brown-colored precipitate that forms?

ANSWER: Ag_2O

TOSS-UP

14) Earth and Space - *Short Answer* Identify all of the following three features that commonly form at mid-ocean ridges: 1) Pillow lavas; 2) Black smokers; 3) Serpentinite **[sur-PEN-tin-ite]**.

ANSWER: All

BONUS

14) Earth and Space - *Multiple Choice* Which of the following best explains why on a hot summer day, small cumulus clouds that form are usually surrounded by a region of blue sky?

W) The air near cloud edges has lower humidity, preventing condensation in those areas
X) The air near cloud edges has higher temperature, preventing condensation in those areas
Y) The convection cycle is directed downward near the cloud edges and inhibits cloud formation
Z) The air near cloud edges lacks turbulence, resulting in clearer skies

ANSWER: Y) The convection cycle is directed downward near the cloud edges and inhibits cloud formation

TOSS-UP

15) Biology - *Short Answer* What is the term for the outer layer of the blastocyst **[BLAS-toh-sist]**, which grows outwards into the endometrium **[en-doh-MEE-tree-um]** to access nutrients and eventually help form the placenta?

ANSWER: Trophoblast

BONUS

15) Biology - *Multiple Choice* The ribose of a nucleotide connects to the RNA backbone. Which of the following are the atoms directly bonded to the 5' **[5 prime]** and 3' carbons of ribose sugars, respectively?

W) Carbon and carbon
X) Carbon and oxygen
Y) Oxygen and oxygen
Z) Oxygen and carbon

ANSWER: Y) Oxygen and oxygen

TOSS-UP

16) Physics - *Short Answer* Identify all of the following three phenomena that are correctly explained by the Bohr model: 1) Energy spectra of single-electron atoms; 2) Finite-time decay of electron orbits; 3) Orbital angular momentum of ground state electrons equal to zero.

ANSWER: 1 and 2

BONUS

16) Physics - *Short Answer* Puja sleds down a frictionless hill and around a vertical circular loop-de-loop of radius 10 meters. To the nearest meter, what is the minimum height of the hill that would allow Puja to travel around the loop without entering free fall?

ANSWER: 25

TOSS-UP

17) Energy - *Short Answer* Scientists in the Jacobs-Wagner Group at Stanford are studying the activity of cyclin **[SY-klin]**-dependent kinase **[KY-nase]** in cancer cells. Identify all of the following three statements that are true of cyclin-dependent kinases in the cell: 1) Maturation-promoting factor activity is inversely related with cyclin concentration; 2) Cyclin-dependent kinases directly regulate the transcription of cyclin genes; 3) Cyclin-dependent kinases are degraded following mitosis.

ANSWER: None

BONUS

17) Energy - *Short Answer* Researchers at SLAC are using soft X-rays to study charge density waves in superconductors. Identify all of the following three quantities that are greater in soft X-rays compared to hard X-rays: 1) Wavelength; 2) Frequency; 3) Energy.

ANSWER: 1 only

TOSS-UP

18) Math - *Short Answer* Britney starts at 0 on the real number line and hops 1 unit left or right with equal probability n times. She then takes her final position and squares it. In terms of n, what is the expectation of the result?

ANSWER: n

BONUS

18) Math - *Short Answer* A 6-sided die is rolled 5 times. How many distinct sequences of rolls result in a total sum of 28?

ANSWER: 21

TOSS-UP

19) Chemistry - *Multiple Choice* For a gas with compression factor greater than 1, which of the following must be true about the gas?

W) Hydrogen bonding is the primary type of bonding
X) The gas does not have any hydrogen bonds
Y) Attractions in the gas overpower the repulsions
Z) Repulsions in the gas overpower the attractions

ANSWER: Z) Repulsions in the gas overpower the attractions

BONUS

19) Chemistry - *Multiple Choice* Which of the following methods is NOT a valid way to protect iron from corrosion?

W) Passivation with Fe_2O_3
X) Cathodic protection with Zn
Y) Differential aeration
Z) Reducing its temperature to below 0° Celsius

ANSWER: Z) Reducing its temperature to below 0° Celsius

TOSS-UP

20) Physics - *Short Answer* What theorem in Hamiltonian mechanics states that a physical system with continuous symmetry has a corresponding conservation law?

ANSWER: Noether's theorem

BONUS

20) Physics - *Short Answer* Unpolarized light of intensity I is incident on three stacked polarizers with angles 0°, 30°, and 90°, in that order. What is the intensity of light that is transmitted through the last polarizer, in terms of I?

ANSWER: $\frac{3}{32}I$

TOSS-UP

21) Earth and Space - *Multiple Choice* Which of the following observations provided the first evidence for the existence of dark matter?

W) Gravitational lensing of distant galaxies
X) Rotation curves of spiral galaxies
Y) Cosmic microwave background fluctuations
Z) Type Ia **[one-A]** supernovae redshifts

ANSWER: X) Rotation curves of spiral galaxies

BONUS

21) Earth and Space - *Short Answer* By name or number, order the following three galactic distance-determination techniques from lowest to highest maximum distance: 1) Tully-Fisher relation; 2) RR Lyrae variables 3) Type 1a **[one-A]** supernovae.

ANSWER: 2, 1, 3

TOSS-UP

22) Biology - *Multiple Choice* Which of the following organisms uses positive pressure breathing?

W) Salamander
X) Turtle
Y) Bird
Z) Mouse

ANSWER: W) Salamander

BONUS

22) Biology - *Short Answer* Albert is observing the equilibrium potential of sodium ions in mammalian neurons. Identify all of the following three changes that he could make to shift the Na^+ equilibrium potential to become more positive: 1) Inhibit the sodium-potassium pump; 2) Block potassium leak channels; 3) Depolarize the neuron.

ANSWER: None of them

TOSS-UP

23) Math - *Short Answer* Identify all of the following three values of n for which the value $n^3 - n$ must be divisible by 6: 1) 13, 2) 30; 3) 47.

ANSWER: All

BONUS

23) Math - *Short Answer* Let r and s be the roots of the quadratic $x^2 - 3x + 6$. What is the value of $r^3 + s^3$?

ANSWER: -27