DOUBLE ELIMINATION 1

TOSS-UP

1) X-Risk - *Short Answer* In order to make any scientific observations, one must first be in a universe that supports life. Thus, the fact that we can make observations at all gives us evidence about the universe, regardless of what those observations are. This is an example of what philosophical principle?

ANSWER: Anthropic principle

BONUS

1) X-Risk - *Multiple Choice* Which of the following does the scaling hypothesis NOT imply?

W) There are very few problems for which overfitting is a serious concern for neural networks
X) Increasing the size of neural networks will advance AI capabilities to potentially dangerous levels
Y) Logic-based AI systems will be harder to align than neural networks
Z) Progress in AI capabilities is largely dependent on progress in computer hardware

ANSWER: Y) Logic-based AI systems will be harder to align than neural networks

TOSS-UP

2) Math - *Multiple Choice* Which of the following polar numbers has the largest x value in rectangular coordinates?

W) $(5, \frac{\pi}{5})$ [5 comma pi over 5]
X) $(5, \frac{\pi}{6})$ [5 comma pi over 6]
Y) $(5, \frac{\pi}{7})$ [5 comma pi over 7]
Z) $(5, \frac{\pi}{8})$ [5 comma pi over 8]

ANSWER: Z) $(5, \frac{\pi}{8})$

BONUS

2) Math - *Multiple Choice* Use implicit differentiation to solve for dy/dx of $x^2 + y^2 = r^2$.

W) $-x/y$
X) x/y
Y) $-y/x$
Z) y/x

ANSWER: W) $-x/y$

TOSS-UP

3) Chemistry - *Multiple Choice* In the limit of an infinite chain, polyacetylene [pol-ee-uh-SEE-tul-een] is observed to have a decreasing change in resistivity with temperature. Which of the following phases of condensed matter does polyacetylene exist in the limit of an infinite chain?

W) Metal
X) Semiconductor
Y) Superconductor
Z) Insulator

ANSWER: X) Semiconductor

BONUS

3) Chemistry - *Short Answer* What is the ratio of the energy of a photon released when an electron transitions from the $n = 3$ to the $n = 2$ state to the energy of a photon released when an electron transitions from the $n = 4$ to the $n = 3$ state in a hydrogen atom?

ANSWER: $20/7$

TOSS-UP

4) Earth and Space - *Short Answer* Identify all of the following three processes that may result in crustal rebound: 1) Deglaciation; 2) Lithospheric delamination; 3) Orogenesis.

ANSWER: 1 and 2

BONUS

4) Earth and Space - *Multiple Choice* At a constant depth, which of the following aluminosilicate minerals would form at the highest temperature?

W) Kyanite
X) Sillimanite
Y) Andalusite
Z) Kaolinite [KOW-lin-ite]

ANSWER: X) Sillimanite

TOSS-UP

5) Biology - *Multiple Choice* Larry breathes in the contents of a bomb calorimeter and his lower airways start collapsing due to multiple burns. Which of the following is he likely experiencing?

W) Emphysema
X) Increased vital capacity
Y) Increased partial pressure of oxygen in his lungs
Z) Increased stimulation of J receptors

ANSWER: W) Emphysema

BONUS

5) Biology - *Short Answer* Which enzyme is responsible for the conversion of trypsinogen [trip-SIN-oh-jin] into trypsin [TRIP-sin]?

ANSWER: Enterokinase

TOSS-UP

6) Physics - *Short Answer* The cyclotron frequency of an electron in a vacuum is a quantity defined in a way such that what constant is scaled linearly by the strength of the magnetic field?

ANSWER: Charge-to-mass ratio

BONUS

6) Physics - *Short Answer* If the moment of inertia of a uniformly dense sphere of radius R and mass M is I about its central axis, what is the moment of inertia of the same sphere but with all of the mass from 0 to $\frac{R}{2}$ hollowed out, as a fraction of I?

ANSWER: $\frac{31}{32}I$

TOSS-UP

7) X-Risk - *Multiple Choice* Due to restrictions on ozone-depleting chemicals, which family of strong greenhouse gases is now commonly used as refrigerants?

W) Hydrofluorocarbons
X) Hydrochlorofluorocarbons
Y) Chlorofluorocarbons
Z) Hydrofluoroolefins

ANSWER: W) Hydrofluorocarbons

BONUS

7) X-Risk - *Short Answer* Human civilization on earth will have to learn to adapt to the increasing temperature of the Sun as it evolves through its main sequence phase. In stars as massive as the Sun, what event separates the red giant branch and the horizontal branch?

ANSWER: Helium flash

TOSS-UP

8) Math - *Short Answer* A triangle is inscribed in a circle with a circumradius of 24. What is the largest possible area of the incircle of the triangle?

ANSWER: 144π

BONUS

8) Math - *Multiple Choice* Which of the following pieces of information does the r^2 value convey in the context of statistical models?

W) The proportion of variation in the dependent variable that is predictable from the independent variables
X) Whether there is any causal relationship between the independent variables and the dependent variable
Y) Whether the correct regression was used
Z) Whether the most appropriate set of independent variables was chosen

ANSWER: W) The proportion of variation in the dependent variable that is predictable from the independent variables

TOSS-UP

9) Chemistry - *Multiple Choice* While barium ions can be used to precipitate sulfate ions out of aqueous solutions, barium sulfides are significantly more soluble. Which of the following best explains this effect according to hard-soft acid-base theory?

W) Oxide ions are harder bases than sulfide ions
X) Oxide ions are softer bases than sulfide ions
Y) Sulfur six ions are harder bases than sulfide ions
Z) Sulfur six ions are softer bases than sulfide ions

ANSWER: W) Oxide ions are harder bases than sulfide ions

BONUS

9) Chemistry - *Short Answer* The reaction A yields 2B is second-order in A. The first half-life is 5 seconds when the reaction starts using 2 moles of A. How many seconds after the reaction begins will it take until there are 3.5 moles of B present?

ANSWER: 35

TOSS-UP

10) Earth and Space - *Short Answer* Around a rotating black hole, general relativity predicts that light moving in the direction of rotation will move past the black hole faster than light moving against the direction of rotation. What effect is this known as?

ANSWER: Frame dragging

BONUS

10) Earth and Space - *Short Answer* Identify all of the following three astronomical features that can be sustained by recombination: 1) HII [H-two] regions; 2) Stromgren spheres; 3) Neutral molecular dust.

ANSWER: 2 and 3

TOSS-UP

11) Biology - *Short Answer* How many molecules of sodium dodecyl [do-DES-ul] sulfate would bind to a protein composed of 36 amino acids?

ANSWER: 18

BONUS

11) Biology - *Short Answer* Malabsorption can occur from what disease that decreases the surface area of the brush border due to an autoimmune loss due to sensitivity to proteins known as gluten?

ANSWER: Celiac disease

TOSS-UP

12) Physics - *Short Answer* What technique is used to probe inside hadrons, and was used as the first piece of evidence that quarks exist?

ANSWER: Deep inelastic scattering

BONUS

12) Physics - *Multiple Choice* A wheel separated into four equal quadrants by two diagonal lines is numbered 1, 2, 3, 4 counter-clockwise from the 12 o'clock position. The wheel is then set to rotate at 300 revolutions per minute. If a dart is fired towards the topmost quadrant of the wheel from 35 meters away while flying at 10 meters per second, which of the quadrants will it land on?

W) 1
X) 2
Y) 3
Z) 4

ANSWER: Y) 3

TOSS-UP

13) X-Risk - *Multiple Choice* Which of the following groups of asteroids has the highest number of potentially hazardous objects?

W) Apollo asteroids
X) Hilda asteroids
Y) Trojans
Z) Plutinos

ANSWER: W) Apollo asteroids

BONUS

13) X-Risk - *Short Answer* In a thermonuclear weapon, the tamper on the primary and the secondary cores are a dense layer used to delay explosion of the fissioning core before all the fuel has been used up. This requires a dense, inert material that can also reflect neutrons. These tampers are usually made of what radioactive isotope, which is lacking in clean bomb tampers?

ANSWER: Uranium-238

TOSS-UP

14) Math - *Short Answer* Order the following three functions from lowest to highest growth rate in their big O notation: 1) $n^{\log(n)}$ [n to the power of log n]; 2) $n^2 \log(n)$ [n squared times log n]; 3) $n^{2.5}$ [n to the 2.5].

ANSWER: 2, 3, 1

BONUS

14) Math - *Short Answer* Evaluate the double integral with the outer bound from 0 to 1 and the inner bound from y to $y+2$ of the quantity $4x-3y$, dx, dy.

ANSWER: 9

TOSS-UP

15) Chemistry - *Short Answer* What is the molecular geometry of the metal center in nickel tetracarbonyl [tet-ruh-CAR-buh-nul]?

ANSWER: Tetrahedral

BONUS

15) Chemistry - *Multiple Choice* The equilibrium between the dissolution and precipitation of an ionic compound with chemical formula AB in water is necessarily shifted toward dissolution by which of the following changes?

W) Adding more AB to the solution
X) Adding an ionic compound CD to the solution
Y) Increasing temperature of the solution
Z) Decreasing temperature of the solution

ANSWER: X) Adding an ionic compound CD to the solution

TOSS-UP

16) Earth and Space - *Multiple Choice* Which of the following devices would provide the best vertical resolution of the current state of the atmosphere?

W) Radiosonde [RAY-dee-oh-sond]
X) Geostationary satellite
Y) Land-based radar
Z) Air-based radar

ANSWER: W) Radiosonde

BONUS

16) Earth and Space - *Multiple Choice* What best describes the origin of deep-focus earthquakes found below usual crustal depths?

W) Hydration of down-going subducted plates
X) Metamorphism of subducted slabs
Y) Diversion of mantle flow due to subducted slabs
Z) Lithospheric heating from generation of lithospheric windows

ANSWER: X) Metamorphism of subducted slabs

TOSS-UP

17) Biology - *Multiple Choice* Which of the following eicosanoids [eye-COH-suh-noids] would be deficient in a person possessing a knockout mutation for the lipoxygenase [luh-POK-suh-jin-ase] enzyme?

W) Thromboxanes [throm-BOX-anes]
X) Prostacyclins [pros-tuh-SIKE-lin]
Y) Leukotrienes [loo-koh-TRI-eens]
Z) Cyclic endoperoxides

ANSWER: Y) Leukotrienes [loo-koh-TRI-eens]

BONUS

17) Biology - *Short Answer* Because of the presence of gamma carboxyglutamate residues on fibrin, blood clotting cannot occur without the presence of which ion?

ANSWER: Ca^{2+} (ACCEPT: Calcium)

TOSS-UP

18) Physics - *Short Answer* A single photon is introduced into an otherwise closed system of 200 helium electrons in the first excited state. Based on this information alone, identify all of the following results that are possible after the photon is introduced: 1) The number of photons present at a given time is more than one; 2) The number of photons present at a given time is zero; 3) The number of electrons at a given time is less than 200.

ANSWER: 1 and 2

BONUS

18) Physics - *Short Answer* Identify all of the following three vector quantities associated with a particle that will remain unchanged under parity flip: 1) Spin; 2) Orbital angular momentum; 3) Magnetic torque.

ANSWER: All

TOSS-UP

19) X-Risk - *Multiple Choice* Which of the following techniques is not generally used by astronomers to detect exoplanets around their host star?

W) Transit photometry
X) Doppler spectroscopy
Y) Stellar parallax
Z) Gravitational lensing

ANSWER: Y) Stellar parallax

BONUS

19) X-Risk - *Short Answer* Search engine results and social media platforms have been observed to have what type of bias in which systematic and repeatable errors lead to unfair outcomes?

ANSWER: Algorithmic bias

TOSS-UP

20) Math - *Short Answer* Calculate the eigenvalues of the 2×2 matrix with first row 4, 5 and second row 0, -2.

ANSWER: 4, -2

BONUS

20) Math - *Multiple Choice* The graph of $r = 1 + \cos\theta$ in polar coordinates is which of the following shapes?

W) Cardioid
X) Convex limacon
Y) Dimpled limacon
Z) Looped limacon

ANSWER: W) Cardioid

TOSS-UP

21) Chemistry - *Multiple Choice* Carnelley's rule states that highly symmetric molecules tend to have high melting points. Which of the following best explains this observation?

W) Symmetric molecules have a large heat of fusion and large entropy of fusion
X) Symmetric molecules have a large heat of fusion and small entropy of fusion
Y) Symmetric molecules have a small heat of fusion and large entropy of fusion
Z) Symmetric molecules have a small heat of fusion and small entropy of fusion

ANSWER: X) Symmetric molecules have a large heat of fusion and small entropy of fusion

BONUS

21) Chemistry - *Short Answer* What compound is the anhydride of perchloric acid?

ANSWER: Cl_2O_7

TOSS-UP

22) Earth and Space - *Multiple Choice* The Faber-Jackson power law for luminosity and velocity distributions is applied to which of the following galaxy types?

W) Ring
X) Spiral-barred
Y) Elliptical
Z) Lenticular

ANSWER: Y) Elliptical

BONUS

22) Earth and Space - *Short Answer* After contracting as a pre-main sequence object, massive protostars enter the main sequence via what horizontal pathway?

ANSWER: Henyey track

TOSS-UP

23) Biology - *Short Answer* Identify all of the following three effects that would result from altitude acclimation: 1) Increased hematocrit [huh-MAT-oh-crit]; 2) Increased production of 2,3 BPG; 3) Increased release of endothelin-1 in the peripheral capillaries.

ANSWER: 1 and 2

BONUS

23) Biology - *Short Answer* Cytochrome P450 and hemoglobin both contain what characteristic macrocyclic ring that coordinates iron?

ANSWER: Porphyrin

TOSS-UP

24) Physics - *Short Answer* What two vector fields are introduced in order to account for the total observed electric field inside a dielectric due to the presence of bound charges?

ANSWER: Polarization and displacement fields

BONUS

24) Physics - *Short Answer* Identify all of the following three wavevector magnitudes that would cause a plane electromagnetic wave to attenuate when in a non-vacuum medium: 1) $2\pi^2$ 2) $2\pi^2 + 3i$ 3) $2\pi^2 - 3i$

ANSWER: 2 only