ROUND 5

TOSS-UP

1) Chemistry – *Multiple Choice* Which of the following is true regarding electrolytic cells?

W) The anode is the site of oxidation and is labeled positive
X) The anode is the site of oxidation and is labeled negative
Y) The cathode is the site of oxidation and is labeled positive
Z) The cathode is the site of oxidation and is labeled negative

ANSWER: W) THE ANODE IS THE SITE OF OXIDATION AND IS LABELED POSITIVE

BONUS

1) Chemistry – *Short Answer* Given that the pKa of hydrofluoric acid is 3.1, what is the pH, to one decimal place, of a solution made by adding 100 milliliters of 3 molar sodium hydroxide to a 110-millititer solution of 3 molar hydrofluoric acid?

ANSWER: 4.1

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TOSS-UP

2) Math – *Multiple Choice* According to the Rational Root Theorem, which of the following polynomials could have $x = 5$ as a root?

W) $x^2 + 5x + 6$
X) $2x^2 + 9x - 15$
Y) $5x^2 - 12x - 13$
Z) $5x^2 + 12x + 12$

ANSWER: X) $2x^2 + 9x - 15$

BONUS

2) Math – *Short Answer* A fair coin is flipped 9 times. What is the probability that the number of tails is a multiple of 3?

ANSWER: 85/256
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TOSS-UP

3) Physics – *Multiple Choice* Which of the following magnifications cannot be produced using a single converging lens?

W) 1/2
X) –1/2
Y) 2
Z) –2

ANSWER: W) 1/2

BONUS

3) Physics – *Multiple Choice* Which of the following does not increase when a dielectric is added between the plates of a capacitor that is connected to a voltage source?

W) Charge on the plates
X) Electric field
Y) Energy stored
Z) Capacitance

ANSWER: X) ELECTRIC FIELD

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TOSS-UP

4) Biology – *Multiple Choice* For a population in Hardy-Weinburg equilibrium, if 10% of males display symptoms of an X-linked recessive disease, what percent of females are expected to be affected by the disease?

W) 1%
X) 5%
Y) 10%
Z) 20%

ANSWER: W) 1%

BONUS

4) Biology – *Short Answer* What is the small opening of an ovule through which the pollen tube deposits sperm for fertilization?

ANSWER: MICROPYLE
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TOSS-UP

5) Earth and Space – *Short Answer* An inland sea actively builds layers of sedimentary rock until the sea level drops and an erosion surface forms. After twenty million years, the inland sea forms again and begins forming new sedimentary rock. What type of unconformity has formed?

ANSWER: DISCONFORMITY

BONUS

5) Earth and Space – *Short Answer* Identify all of the following three locations in the Earth's interior where the geotherm intersects the solidus curve: 1) Lithosphere-asthenosphere boundary; 2) Core-mantle boundary; 3) Inner-core-outer-core boundary

ANSWER: 3 ONLY

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TOSS-UP

6) Energy – *Short Answer* Scientists at Brookhaven National Laboratory have successfully grown crystals of a lanthanum barium copper oxygen system, a high-temperature superconductor. What transition metal is the most popular alternative to lanthanum in making high-temperature superconductors with barium, copper, and oxygen?

ANSWER: YTTRIUM

BONUS

6) Energy – *Short Answer* Scientists at SLAC National Accelerator Lab used the Linac Coherent Light Source to examine the structure of metalloporphyrins after being excited by a laser. The metal center in a metalloporphyrin is coordinated to four atoms of what element?

ANSWER: NITROGEN
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TOSS-UP

7) Biology – *Short Answer* The interstitial cells of Leydig, found adjacent to the seminiferous tubules in the testicle, produce what steroid in response to stimulation from luteinizing hormone?

ANSWER: TESTOSTERONE

BONUS

7) Biology – *Multiple Choice* Which of the following is not physiologically formed from tryptophan?

W) Serotonin
X) Auxin
Y) Melanin
Z) Niacin

ANSWER: Y) MELANIN

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TOSS-UP

8) Math – *Multiple Choice* Jeremy wants to see if a prep book really increases test scores. He decides to perform a significance test with an alpha value of 0.05. The p-value for his data was 0.03. Which of the following conclusions is correct?

W) The null hypothesis should be rejected and the prep book does not increase test scores
X) The null hypothesis should be rejected and the prep book does increase test scores
Y) The null hypothesis should not be rejected and the prep book does not increase test scores
Z) The null hypothesis should not be rejected and the prep book does increase test scores

ANSWER: X) THE NULL HYPOTHESIS SHOULD BE REJECTED AND THE PREP BOOK DOES INCREASE TEST SCORES

BONUS

8) Math – *Short Answer* What is the fraction with numerator 3 + 4i and denominator 5 + 12i in standard a + bi form?

ANSWER: 63/169 – 16i/169
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TOSS-UP

9) Chemistry – *Multiple Choice* Which of the following would have the largest retention factor in a thin layer chromatography experiment where the mobile phase is hexane and the stationary phase is silica gel?

W) Water
X) Benzene
Y) Acetone
Z) Diethyl ether

ANSWER: X) BENZENE

BONUS

9) Chemistry – *Short Answer* What theorem in thermodynamics states that kinetic energy is distributed evenly among rotational and translational modes?

ANSWER: EQUIPARTITION THEOREM

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TOSS-UP

10) Earth and Space – *Short Answer* Identify all of the following three statements regarding stellar populations that are true: 1) Globular clusters contain old, metal-rich Population II stars; 2) The galactic disk of spiral galaxies typically contains more Population I stars than Population II stars; 3) The metallicity of Population II stars is much greater than that of Population I stars.

ANSWER: 2 ONLY

BONUS

10) Earth and Space – *Short Answer* What theory describes the quasistatic spiral structure of spiral galaxies, by proposing that stars orbit at different speeds depending on their distance from the galactic center?

ANSWER: DENSITY WAVE THEORY (ACCEPT: LIN-SHU DENSITY WAVE THEORY)
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TOSS-UP

11) Physics – *Multiple Choice* What circuit component is used for tuning frequency-dependent equipment?

W) Variable resistor
X) Variable capacitor
Y) Schottky diode
Z) Transformer

ANSWER: X) VARIABLE CAPACITOR

BONUS

11) Physics – *Short Answer* How many times as energetic is a photon emitted from an electron falling from principal energy level $n = 4$ to $n = 1$ in a hydrogen atom when compared to one emitted from an electron falling from energy level $n = 3$ to $n = 1$?

ANSWER: 135/128

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TOSS-UP

12) Energy – *Short Answer* Scientists at Oak Ridge National Lab are measuring the weak nuclear force between nucleons. Identify all of the following three statements regarding the weak force that are true: 1) It can mediate flavor changes in quarks; 2) It violates CPT symmetry; 3) It is mediated by the W and Z bosons.

ANSWER: 1 AND 3

BONUS

12) Energy – *Short Answer* Scientists at Argonne National Lab are studying how the pathological biochemical process leading to brain hypoxia can be redirected to induce biosynthesis of gold nanoparticles. What physiological condition is traditionally the main consequence of brain hypoxia?

ANSWER: STROKE
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TOSS-UP

13) Chemistry – *Multiple Choice* A sample of water ice at –30 degrees Celsius is heated to the gaseous phase while the temperature of the sample is plotted against the heat supplied to the sample. At 0 degrees Celsius and 100 degrees Celsius, the heating curve is flat. However, the flat region at 100 degrees Celsius is much wider than that at 0 degrees Celsius. Which of the following best accounts for this phenomenon?

W) Liquid water has a greater specific heat capacity than ice
X) Liquid water has a greater specific heat capacity than water vapor
Y) The heat of fusion for water is greater than the heat of vaporization
Z) The heat of vaporization for water is greater than the heat of fusion

ANSWER: Z) THE HEAT OF VAPORIZATION FOR WATER IS GREATER THAN THE HEAT OF FUSION

BONUS

13) Chemistry – *Multiple Choice* Quantum dots can be described as analogs to which of the following?

W) Three dimensional potential wells
X) Simple harmonic oscillators
Y) Quantum harmonic oscillators
Z) P-n junctions

ANSWER: W) THREE DIMENSIONAL POTENTIAL WELLS

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TOSS-UP

14) Biology – *Multiple Choice* Which of the following amino acids is most easily identifiable by its absorption spectrum under exposure to UV light?

W) Glycine
X) Alanine
Y) Serine
Z) Tryptophan

ANSWER: Z) TRYPTOPHAN

BONUS

14) Biology – *Short Answer* What is the name for the mechanism by which an action potential propagates along a myelinated axon by hopping from one node of Ranvier to the next?

ANSWER: SALTATORY CONDUCTION
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TOSS-UP

15) Earth and Space – *Multiple Choice* Which of the following best explains why observing stars in the galactic bulge is easier with infrared light than visible light?

W) Blue light is scattered more easily than red light in the interstellar medium
X) Red light is scattered more easily than blue light in the interstellar medium
Y) Stars in the galactic bulge have peak wavelength emission at around 900 nm
Z) Most stars in the galactic bulge are protostars that are best seen through infrared light

ANSWER: W) BLUE LIGHT IS SCATTERED MORE EASILY THAN RED LIGHT IN THE INTERSTELLAR MEDIUM

BONUS

15) Earth and Space – *Short Answer* What are porphyroblasts that contain inclusions of smaller minerals?

ANSWER: POIKILOBLASTS

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TOSS-UP

16) Physics – *Short Answer* A solenoid is made by wrapping a coil of wire in a helical shape many times around a cylinder. When a certain current is passed through the coil, a magnetic field of strength B is formed. If, while all other variables are kept constant, the same amount of wire was wrapped around a cylinder half as long, what would be the strength of the new magnetic field in terms of B?

ANSWER: 2B

BONUS

16) Physics – *Short Answer* The motion of a block on a spring can be modeled by the equation $x(t) = 3$ times the sine of the quantity $\underline{2t + \pi/6}$. If the mass of the block is 5 kilograms, what is the spring's spring constant in newtons per meter?

ANSWER: 20
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TOSS-UP

17) Math – *Short Answer* What is the derivative with respect to x of $f(x)$ = cosine x tangent x?

ANSWER: COSINE x

BONUS

17) Math – *Short Answer* What is the radius of the circle inscribed in a triangle with side lengths of 8, 9, and 9?

ANSWER: 4 SQUARE ROOT 65 OVER 13

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TOSS-UP

18) Chemistry – *Short Answer* Heterogeneous alloys often possess a distinct melting point that is lower than either of the starting materials at a certain relative component composition. What is the name for this type of mixture?

ANSWER: EUTECTIC

BONUS

18) Chemistry – *Multiple Choice* Which of the following is an intensive property?

W) Enthalpy
X) Gibbs free energy
Y) Heat capacity
Z) Standard reduction potential

ANSWER: Z) STANDARD REDUCTION POTENTIAL
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TOSS-UP

19) Biology – *Multiple Choice* What portion of the brain contains the group of neurons responsible for controlling involuntary breathing?

W) Medulla Oblongata
X) Hypothalamus
Y) Forebrain
Z) Pons

ANSWER: W) MEDULLA OBLONGATA

BONUS

19) Biology – *Short Answer* Skeletal muscle triads are composed of what organelle on either side of a T-tubule?

ANSWER: SARCOPLASMIC RETICULUM (ACCEPT: TERMINAL CISTERNAE, ENDOPLASMIC RETICULUM)

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TOSS-UP

20) Energy – *Short Answer* Scientists at Lawrence Berkeley National Laboratory have discovered a novel method of stopping cancer cells from spreading and developing secondary tumors far away from the original tumor. What is the name for this propagation of cancer cells?

ANSWER: METASTASIS

BONUS

20) Energy – *Short Answer* Scientists at Oak Ridge National Laboratory are attempting to reach new levels of efficiency for hydrogen fusion inside a metal fusion reactor. Because fusion requires extremely high temperatures, what metallic element with the highest melting point should the inner wall of the fusion reactor be made out of?

ANSWER: TUNGSTEN
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TOSS-UP

21) Math – *Short Answer* Two metal spheres with integer radii are melted down and recast into a larger sphere. What theorem states that this sphere will not have an integer radius?

ANSWER: FERMAT'S LAST THEOREM

BONUS

21) Math – *Short Answer* Simplify the following trigonometric expression: sine 15 cosine 15 tangent 15 plus sine 75 cosine 75 tangent 75

ANSWER: 1

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TOSS-UP

22) Physics – *Multiple Choice* Light is traveling from air into sapphire with an index of refraction of 1.76. At what angle will the reflected ray be maximally polarized?

W) 30 degrees
X) 45 degrees
Y) 50 degrees
Z) 60 degrees

ANSWER: Z) 60 DEGREES

BONUS

22) Physics – *Short Answer* A 3-kilogram object traveling at 8 meters per second collides perfectly elastically with a 12-kilogram object initially at rest. At the same time, a constant force of 6 newtons starts to be applied to the 3-kilogram object in the direction of its previous velocity. How much time, in seconds, elapses from the initial collision to their next collision?

ANSWER: 8 SECONDS
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TOSS-UP

23) Earth and Space – *Short Answer* Pingos and polygon wedge ice are examples of what structures that form due to freeze-thaw cycles of permafrost?

ANSWER: PERIGLACIAL LANDFORMS

BONUS

23) Earth and Space – *Short Answer* A star with radius R, luminosity L, and flux density F, suddenly shrinks to one-half R. Assuming temperature stays constant, what is the new luminosity and flux density of the star in terms of L and F, respectively?

ANSWER: NEW LUMINOSITY IS *L*/4, FLUX DENSITY STAYS AS *F*