LOST ROUND 10

TOSS-UP

1) PHYSICS – *Short Answer* Expressing your answer in terms of time t, what is the power of a 2F capacitor at a given time if the current at any given time is $4t^2$?

ANSWER: 8/3 t^5

BONUS

1) PHYSICS – *Short Answer* Ashish put some glowing dots on the moon which glow at 820 nm. If we want to see these dots from earth, which are 0.001 radians apart in our field of view, what diameter should we make the aperture of our telescope? Give your answer to 1 significant figure.

ANSWER: 1 mm

TOSS-UP

2) BIOLOGY – *Short Answer* The myelencephalon in the fetus develops into what structure in the adult brain?

ANSWER: MEDULLA OBLONGATA (ACCEPT: MEDULLA)

BONUS

2) BIOLOGY – *Short Answer* 2,4-dichlorophenoxyacetic acid, an auxin based herbicide, is sprayed into a field containing multiple different plants. By name or number, identify all the following three plants in the field that would die: 1) Roses; 2) Corn; 3) Sugarcane.

ANSWER: 1 ONLY (Roses)

TOSS-UP

3) CHEMISTRY – *Multiple Choice* What functional group is produced when an amide is heated in the presence of thionyl chloride?

W) Amine
X) Acid chloride
Y) Nitrile
Z) Imine

ANSWER: Y) NITRILE

BONUS

3) CHEMISTRY – *Short Answer* Order the following three halide substituents in increasing rate of reaction for nucleophilic aromatic substitution: 1) Fluoride; 2) Chloride; 3) Iodide.

ANSWER: 2, 3, 1

TOSS-UP

4) MATH – *Short Answer* An arithmetic sequence of positive integers has first term x and xth term x^3. If the common difference between terms is 30, what is the first term of the sequence?

ANSWER: 5

BONUS

4) MATH – *Short Answer* Consider the 2 by 2 matrix with first row 4, 7, and second row –6, 2. What is the trace of the inverse of this matrix?

ANSWER: 3/25

TOSS-UP

5) EARTH AND SPACE – *Short Answer* Order the following three minerals in increasing stability against chemical weathering: 1) Anorthite; 2) Albite; 3) Gibbsite.

ANSWER: 2, 1, 3

BONUS

5) EARTH AND SPACE – *Short Answer* When plutons rise, they can dislodge pre-existing blocks of rock that sink down into the magma and eventually become xenoliths. What is this process called?

ANSWER: STOPING

TOSS-UP

6) ENERGY – *Multiple Choice* Scientists at Oak Ridge National Lab have been using various spectroscopic techniques to examine a range of materials, including both geological and

biological materials. Which of the following spectroscopic techniques would the scientists be most likely to use to study the iron-57 composition of a sample of kaolinite?

W) Nuclear magnetic resonance spectroscopy
X) Electron paramagnetic resonance spectroscopy
Y) Infrared spectroscopy
Z) Mossbauer spectroscopy

ANSWER: Z) MOSSBAUER SPECTROSCOPY

BONUS

6) ENERGY – *Short Answer* Scientists at Thomas Jefferson National Laboratory are studying the beta decay in tritium. Tritium is weakly radioactive because it has too many neutrons compared to protons in its nucleus. Identify all the following four nuclear processes that would occur in an atom below the nuclear dripline: 1) Beta minus decay; 2) Beta plus decay; 3) Electron capture; 4) Alpha decay.

ANSWER: 1 ONLY

TOSS-UP

7) PHYSICS – *Multiple Choice* In the Debye model for the heat capacity of solids at low temperatures, solids can be modeled as vibrating phonons trapped in a 3D box. The energy of a phonon in the Debye model is dependent on what power of the length of the box?

W) -2
X) -1
Y) 0
Z) 1

ANSWER: X) -1

BONUS

7) PHYSICS – *Short Answer* What is the moment of inertia of a long rod whose length is the cube root of the quantity pi/2 about an axis perpendicular to its endpoint if its linear mass density as a function of distance to the endpoint is $\cos(x^3)$?

ANSWER: 1/3

TOSS-UP

8) BIOLOGY – *Short Answer* What metal is the cofactor for lignin-biosynthetic enzymes in plants?

ANSWER: COPPER

BONUS

8) BIOLOGY – *Short Answer* Identify all of the following locations in which one would NOT expect the predominant component of the cytoskeleton to be an intermediate filament: 1) Nuclear lamina; 2) Cell cortex; 3) Filopodia.

ANSWER: 2 AND 3

TOSS-UP

9) CHEMISTRY – *Short Answer* What effect explains the greater stability of oximes and hydrazones compared to normal imines ***[i-meens]*** against hydrolysis due to the stronger nucleophilicity of hydrazine and hydroxylamine compared to normal amines?

ANSWER: ALPHA EFFECT

BONUS

9) CHEMISTRY – *Short Answer* Identify all of the following three quantum models for which the energy gap between consecutive energy levels remains constant with increasing quantum number: 1) Particle in a box; 2) Quantum harmonic oscillator; 3) Rigid rotor.

ANSWER: 2 ONLY

TOSS-UP

10) MATH – *Short Answer* For how many integer values of x is $x^3 + 2x - 1$ evenly divisible by $x - 2$?

ANSWER: 2

BONUS

10) MATH – *Short Answer* Alice, Brett, and Charlie each pick a real number on the open interval from 0 to 1 uniformly and at random. What is the probability that the sum of the squares of Alice and Brett's numbers is less than the square of Charlie's number?

ANSWER: π/12

TOSS-UP

11) EARTH AND SPACE – *Multiple Choice* What type of Karst topography do landscapes consisting of a maze of isolated steep-sided hills that rise abruptly from the ground demonstrate?

W) Interstratal
X) Tower
Y) Cockpit
Z) Polje ***[pol·YEH]***

ANSWER: X) TOWER

BONUS

11) EARTH AND SPACE – *Multiple Choice* Where along the Earth's interior does the geotherm plateau?

W) Asthenosphere
X) Moho
Y) Transition zone
Z) Lower mantle

ANSWER: X) MOHO

TOSS-UP

12) ENERGY – *Short Answer* Scientists at Pacific Northwest National Laboratory are studying the gut microbiome. One common gram-positive probiotic, Lactobacillus, is left a deep violet after applying a gram stain. What element added during gram-staining acts as a mordant to fix the crystal violet onto the peptidoglycan?

ANSWER: IODINE

BONUS

12) ENERGY – *Short Answer* Scientists at Princeton Plasma Physics Laboratory are using interferometry to measure Langmuir waves, rapid oscillations of the electron density in conducting media such as plasmas. What quasiparticle is used to quantize the oscillations within the plasma?

ANSWER: PLASMON

TOSS-UP

13) PHYSICS – *Short Answer* Kaons are a group of mesons that are predicted to be unstable without accounting for the conservation of what quantity?

ANSWER: STRANGENESS

BONUS

13) PHYSICS – *Short Answer* Classify each of the following four particles as either fermions, scalar bosons or vector bosons: 1) Kaon; 2) Top quark; 3) Tau antineutrino; 4) Photon

ANSWER: 1) VECTOR BOSON, 2) FERMION, 3) FERMION, 4) VECTOR BOSON.

TOSS-UP

14) BIOLOGY – *Multiple Choice* During what phase of meiosis is a secondary oocyte frozen until ovulation?

W) Prophase I
X) Prophase II
Y) Metaphase I
Z) Metaphase II

ANSWER: Z) METAPHASE II

BONUS

14) BIOLOGY *Short Answer* Identify all of the following three statements that are true concerning vision: 1) The optic nerve synapses with the lateral geniculate nuclei on the way to the cerebellum; 2) Vision is integrated in the occipital lobe; 3) Opponent color cells are sensitive to a wide range of colors in contrast to being excitable by specific wavelengths of colors.

ANSWER: 1 AND 2

TOSS-UP

15) CHEMISTRY – *Multiple Choice* Which of the following explains why the endo product is kinetically favored over the exo product in a Diels–Alder reaction?

W) The *endo* transition state is formed more rapidly by quantum tunneling
X) The *endo* transition state is formed more rapidly by a higher steric factor
Y) The *endo* transition state is stabilized by secondary orbital interactions
Z) The *endo* transition state is stabilized by decreased steric hindrance

ANSWER: Y) THE *ENDO* TRANSITION STATE IS STABILIZED BY SECONDARY ORBITAL INTERACTIONS

BONUS

15) CHEMISTRY – *Short Answer* The Mitsunobu reaction is a powerful one-pot reaction that can be used to substitute hydroxyl groups with nucleophiles such as acetate. Identify all of the following three statements that are true about the Mitsunobu reaction: 1) The azodicarboxylate acts as a catalyst; 2) The phosphine acts as an reducing agent; 3) The stereochemistry of an alpha chiral center in the alcohol is retained.

ANSWER: 2 ONLY

TOSS-UP

16) MATH – *Short Answer* Evaluate the remainder when 201 choose 100 is divided by 101.

ANSWER: 1

BONUS

16) MATH – *Short Answer* An isosceles trapezoid is circumscribed around a circle with radius 5. Given one of the bases has length 8, what is the length of the opposite base?

ANSWER: 25/2

TOSS-UP

17) EARTH AND SPACE – *Short Answer* Thought to have resulted from the fragments of past asteroid collisions, what term is given to families of asteroids that share similar semimajor axis, eccentricity, and orbital inclination, and as a result do not collide?

ANSWER: HIRAYAMA FAMILIES

BONUS

17) EARTH AND SPACE – *Short Answer* Identify all of the following three statements that are true about forbidden lines: 1) They are the result of metastable levels; 2) They only occur in low density gas; 3) They are emission spectra.

ANSWER: ALL

TOSS-UP

18) ENERGY – *Multiple Choice* Scientists at Ames National Laboratory selectively hydrogenated nitrate to ammonia using a binary nickel phosphide catalyst. Which of the following is the most likely rate determining step of this process?

W) Adsorption of hydrogen on the catalyst surface
X) Dissociation of hydrogen on the catalyst surface
Y) Adsorption of nitrate on the catalyst surface
Z) Addition of hydrogen to nitrate on the catalyst surface

ANSWER: X) DISSOCIATION OF HYDROGEN ON THE CATALYST SURFACE

BONUS

18) ENERGY – *Multiple Choice* Scientists at Oak Ridge National Laboratory are studying the strength of biomaterials to advance the manufacturing of synthetic materials. The cross-linking of what amino acid gives lignin its strength?

W) Phenylalanine
X) Cysteine
Y) Methionine
Z) Proline

ANSWER: W) PHENYLALANINE

TOSS-UP

19) PHYSICS – *Multiple Choice* Which of the following expressions is equal to the relativistic energy of a particle with mass m, velocity v, and Lorentz factor γ ***[gamma]***?

W) γmv
X) γmc
Y) γmv^2
Z) γmc^2

ANSWER: Z) γmc^2

BONUS

19) PHYSICS – *Short Answer* A spring has a potential energy function -e^(-x^2) ***[negative e to the power of open parentheses negative x squared close parentheses]***. At x=0, what is the angular frequency of oscillation if a mass of 9 kg is attached?

ANSWER: 1/3

TOSS-UP

20) BIOLOGY – *Short Answer* What hormone within amphibians signal for metamorphosis?

ANSWER: THYROXINE (ACCEPT: T4)

BONUS

20) BIOLOGY – *Multiple Choice* Exposure of what phospholipid on the extracellular leaflet signals for apoptosis in humans?

W) Phosphatidylserine ***[fos-fa-tye-dil-SER-een]***
X) Phosphatidylcholine ***[fos-fa-tye-dil-co-leen]***
Y) Phosphatidylethanolamine ***[fos-fa-tye-dil-eh-thuh-naal-a-meen]***
Z) Phosphatidylinositol ***[fos-fa-tye-dil-i-know-suh-taal]*** 4,5-bisphosphate

ANSWER: W) PHOSPHATIDYLSERINE

TOSS-UP

21) CHEMISTRY – *Short Answer* Identify all of the following three statements that are true about hard soft acid-base theory: 1) Hard acids have lower LUMOs than soft acids; 2) Hard

bases favor conjugate addition when reacted with unsaturated carbonyls; 3) Hard bases prefer elimination over substitution at saturated carbons.

ANSWER: 3 ONLY

BONUS

21) CHEMISTRY – *Short Answer* Cyclohexa-1,3-dione reacts with methyl vinyl ketone in the presence of catalytic sodium hydroxide and is heated. Identify all of the following three statements that are true: 1) A 5 membered ring is formed as the major product of this reaction; 2) The first step of the reaction mechanism is an aldol condensation; 3) Heating the reaction favors the thermal cyclic product over the kinetic cyclic product.

ANSWER: 3 ONLY

TOSS-UP

22) MATH – *Multiple Choice* Which of the following is equivalent to $ln(-3)$ ***[the natural logarithm of negative 3]***?

W) $ln(3) + \pi i$ ***[the natural logarithm of 3 plus pi i]***
X) $ln(3) - \pi i$ ***[the natural logarithm of 3 minus pi i]***
Y) $ln(3) * ln(\pi i)$ ***[the natural logarithm of 3 times the natural logarithm of pi i]***
Z) $ln(3) / ln(\pi i)$ ***[the natural logarithm of 3 divided by the natural logarithm of pi i]***

ANSWER: W) $ln(3) + \pi i$

BONUS

22) MATH – *Short Answer* Five members of a science bowl team are sitting around a circular table that contains 12 seats. Abiding with social distancing guidelines, no two team members are allowed to sit adjacent to one another. How many ways are there for the team to sit around the table, given rotations are not considered distinct?

ANSWER: 504

TOSS-UP

23) EARTH AND SPACE – *Multiple Choice* Which of the following pairs does NOT include two minerals which are polymorphs of each other?

W) Calcite and aragonite
X) Beryl and malachite
Y) Andalusite and sillimanite
Z) Sphalerite and wurtzite

ANSWER: X) BERYL AND MALACHITE

BONUS

23) EARTH AND SPACE – *Short Answer* Identify all of the following three statements that are true concerning T-Tauri stars: 1) They are often surrounded by stellar cocoons; 2) They are variable stars with very irregular intervals of pulsation; 3) They are found in globular clusters containing T associations.

ANSWER: 1 AND 2

TOSS-UP

24) ENERGY – *Short Answer* Scientists at Ames National Laboratory mapped the quantum phase transitions in a superconductor. Using a nitrogen vacancy magnetoscope, the scientists accurately measured what distance, which characterizes the depth at which a magnetic field becomes $\frac{1}{e}$ ***[one over e]*** times as strong as the magnetic field at the surface?

ANSWER: LONDON PENETRATION DEPTH

BONUS

24) ENERGY – *Short Answer* Scientists at Los Alamos National Laboratory used photocathodes covered by a one atom thick graphene layer to increase the efficiency of quantum semiconductors, such as quantum dots. Identify all of the following three statements that are true about quantum dots: 1) The bandgap is directly proportional to the radius of the quantum dot; 2) The absorption spectrum is redshifted due to stokes shift; 3) Quantum dots display quantum confinement due to their small size.

ANSWER: 2 AND 3

TOSS-UP

25) BIOLOGY – *Multiple Choice* Daniel arrives in the emergency room suffering from histotoxic hypoxia. Which of the following is a plausible explanation for his histotoxic hypoxia?

W) A thrombus was dislodged and occluded some of his coronary arteries, causing an infarction and reduced stroke volume
X) He ingested too many apple seeds and is suffering from cyanide poisoning
Y) He has prolonged exposure to competitive inhibitors of hemoglobin that are not O_2 or CO_2
Z) He is suffering from deep vein thrombosis and thus has a lowered end diastolic volume

ANSWER: X) HE INGESTED TOO MANY APPLE SEEDS AND IS SUFFERING FROM CYANIDE POISONING

BONUS

25) BIOLOGY – *Short Answer* During potocytosis, what group of vesicles form from invaginations of lipid rafts on the plasma membrane to deliver their contents directly into the cytosol?

ANSWER: CAVEOLAE