LOST ROUND 6

TOSS-UP

1) PHYSICS – *Multiple Choice* A T-S diagram can be used to visualize the changes in temperature and specific entropy that take place during a thermodynamic cycle. Which of the following quantities can be calculated as the area enclosed by a clockwise cycle on a T-S diagram?

W) Entropy change
X) Heat released
Y) Heat absorbed
Z) Thermal efficiency

ANSWER: Y) HEAT ABSORBED

BONUS

1) PHYSICS – *Short Answer* By name or number, list all of the following circuit components that have a non-linear relationship between voltage and current: 1) Transistor; 2) Resistor; 3) Diode.

ANSWER: 1 AND 3

TOSS-UP

2) BIOLOGY – *Multiple Choice* Anka is suffering from abnormal sleeping patterns where she wakes up during the night multiple times and experiences narcolepsy. Anka most likely has damage to which of the following?

W) Suprachiasmatic nucleus ***[sup-rah-qi-az-matic]***
X) Substania nigra ***[sub-stan-XIA-ni-gra]***
Y) Amygdala ***[uh-meh-G-duh-la]***
Z) Basal nuclei

ANSWER: W) SUPRACHIASMATIC NUCLEUS

BONUS

2) BIOLOGY – *Short Answer* Allen grows a plant belonging to the Cactaceae ***[kak-ta-SEE-ey]*** family. After measuring the pH of the central vacuole, he realizes that the pH decreases during the day and increases during the night. Identify all of the following three statements that are true

of his plant: 1) It lacks photosystem II in its bundle-sheath cells; 2) It likely uses PEP carboxylase to fix CO_2 during the day; 3) It likely possesses a high stomatal density.

ANSWER: NONE

TOSS-UP

3) CHEMISTRY – *Short Answer* What type of isomerism is exhibited by S and R BINAP, which arise as different enantiomers due to steric hindrance preventing free rotation around a single bond?

ANSWER: ATROPISOMERISM

BONUS

3) CHEMISTRY – *Short Answer* Identify all of the following three statements that are true about the transition state of S_N2 reactions: 1) It displays 3 center 4 electron bonding; 2) The leaving group and nucleophile display positive partial charges; 3) The nucleophile attacks at a 180 degree angle to the leaving group.

ANSWER: 1 AND 3

TOSS-UP

4) MATH – *Short Answer* A particle moving in the x-y plane has its velocity defined parametrically such that $v_x(t) = 3t$ and $v_y(t) = 4t$. How far does the particle travel between the times $t = 0$ and $t = 4$?

ANSWER: 40

BONUS

4) MATH – *Short Answer* Two real numbers are chosen independently and uniformly at random between 0 and 1. What is the probability that the two numbers differ by no more than ⅓?

ANSWER: 5/9

TOSS-UP

5) EARTH AND SPACE – *Short Answer* By name or number, identify all the following four groups of organisms that would form siliceous ooze: 1) Foraminifera; 2) Diatoms; 3) Radiolarians; 4) Coccolithophores.

ANSWER: 2 AND 3 (ACCEPT: DIATOMS AND RADIOLARIANS)

BONUS

5) EARTH AND SPACE – *Short Answer* A binary system is composed of Star A and star B. The binary system has a period of 12 years and an average distance of 12 AU. If the ratio of the distances from the center of mass for stars A and B is 2:1, what are the masses of star A and B respectively in solar masses?

ANSWER: 4 AND 8

TOSS-UP

6) ENERGY – *Multiple Choice* Scientists at Los Alamos National Laboratory recently imaged heart RNA—long, non-coding RNA critical to stem cell programming—using small-angle X-ray scattering. What group of small non-coding RNA have a strong function in endogenous gene expression?

W) miRNA
X) siRNA
Y) piRNA
Z) giRNA

ANSWER: W) miRNA

BONUS

6) ENERGY – *Multiple Choice* Scientists at the Joint Genome Institute are attempting to manipulate bacterial colonies to change nitrogen concentrations in ecosystems. Which of the following genera of bacteria do NOT engage in nitrogen fixation?

W) Anabaena
X) Nitrosomona
Y) Rhizobium
Z) Campylobacter

ANSWER: Z) CAMPYLOBACTER

TOSS-UP

7) PHYSICS – *Multiple Choice* Which of the following combinations of circuit components will take the longest to lose half of its energy after it is disconnected from a battery?

W) 2 ohm resistor and 6 microfarad capacitor
X) 3 ohm resistor and 12 microhenry inductor
Y) 4 ohm resistor and 2 microfarad capacitor
Z) 5 ohm resistor and 10 microhenry inductor

ANSWER: W) 2 OHM RESISTOR AND 6 MICROFARAD CAPACITOR

BONUS

7) PHYSICS – *Short Answer* Identify all of the following three changes that would increase the physical separation between intensity peaks on the screen in a double-slit diffraction setup: 1) Increasing the distance between the slits; 2) Increasing the distance between the occluding slits and the screen; 3) Decreasing the wavelength of light.

ANSWER: 2 ONLY

TOSS-UP

8) BIOLOGY – *Multiple Choice* Which of the following is a proto-oncogene?

W) HER2
X) BRCA1
Y) APC
Z) p53

ANSWER: W) HER2

BONUS

8) BIOLOGY – *Short Answer* What organ do invertebrates such as insects use to detect gravity and maintain equilibrium?

ANSWER: STATOCYST

TOSS-UP

9) CHEMISTRY – *Multiple Choice* Which of the following alkene addition reactions is NOT a syn addition?

W) Catalytic hydrogenation
X) Oxymercuration
Y) Hydroboration-oxidation
Z) Osmium tetroxide dihydroxylation

ANSWER: X) OXYMERCURATION

BONUS

9) CHEMISTRY – *Short Answer* Identify all of the following three statements that are true about crystal field theory: 1) All d orbitals are lowered in energy upon formation of a metal complex; 2) Octahedral complexes experience larger splitting than tetrahedral complexes; 3) Almost all tetrahedral complexes are low spin.

ANSWER: 2 ONLY

TOSS-UP

10) MATH – *Short Answer* By number, identify all of the following three scenarios that are examples of a type II error: 1) A doctor testing the efficacy of a new drug incorrectly concludes that the drug does not improve a patient's symptoms; 2) A researcher testing a new sports drink incorrectly concludes that the sports drink significantly enhances performance; 3) A car manufacturer evaluating a new engine incorrectly concludes that the engine decreases fuel efficiency.

ANSWER: I ONLY

BONUS

10) MATH – *Short Answer* How many two digit positive integers have the property that they are divisible by their units digit?

ANSWER: 41

TOSS-UP

11) EARTH AND SPACE – *Short Answer* What term is given to the icy core of the comet that releases dust to form the dust tail?

ANSWER: NUCLEUS

BONUS

11) EARTH AND SPACE – *Short Answer* The double-exhaust model describes what group of astronomical objects that emit strong radio waves from twin-lobed hotspots?

ANSWER: DOUBLE-LOBED RADIO GALAXY (ACCEPT: RADIO GALAXIES)

TOSS-UP

12) ENERGY – *Short Answer* Scientists at Argonne National Laboratory are studying the molecular orbitals of Fe-complexes. In hemoglobin and cytochromes, iron is bound to what heterocyclic macrocycle complexes?

ANSWER: PORPHYRIN RING

BONUS

12) ENERGY – *Multiple Choice* Scientists at Brookhaven National Labs have been using Lanthanide Binding Tags to bind proteins and become a fluorescent locator during 3D and 2D X-Ray imaging. What is the likely use of these tags?

W) To help purify the protein by increasing its affinity for pellets during gel filtration chromatography
X) To increase the efficiency of protein binding during IC-PMS
Y) To allow the protein to be localized with electron paramagnetic resonance spectroscopy
Z) To determine the subcellular localization of the tagged proteins.

ANSWER: Z) TO DETERMINE THE SUBCELLULAR LOCALIZATION OF THE TAGGED PROTEINS

TOSS-UP

13) PHYSICS – *Short Answer* A convex lens has a focal length of 40 cm. What distance would an object have to be placed in front of the lens in centimeters such that the image distance is equal to the object distance?

ANSWER: 80

BONUS

13) PHYSICS – *Short Answer* By name or number, list all the combinations of colors that the two quarks in a pion could have: 1) Red, anti-green; 2) Green, blue; 3) Anti-green, anti-red.

ANSWER: NONE

TOSS-UP

14) BIOLOGY – *Multiple Choice* Angiotensin-converting-enzyme inhibitors are used to treat which of the following conditions?

W) Hypertension
X) Beriberi
Y) Diabetes insipidus
Z) Pernicious anemia

ANSWER: W) HYPERTENSION

BONUS

14) BIOLOGY – *Short Answer* By name or number, identify all the following three cellular junctions that are stabilized by cadherins: 1) Desmosome; 2) Adherens junction; 3) Gap junction.

ANSWER: 1 AND 2 (ACCEPT: DESMOSOME AND ADHERENS JUNCTION)

TOSS-UP

15) CHEMISTRY – *Multiple Choice* Which of the following describes the spontaneity of the autoionization of water?

W) Spontaneous at all temperatures
X) Non-spontaneous at all temperatures
Y) Spontaneous at low temperatures
Z) Spontaneous at high temperatures

ANSWER: X) NON-SPONTANEOUS AT ALL TEMPERATURES

BONUS

15) CHEMISTRY – *Short Answer* Order the following three elements in increasing third ionization energy: 1) Indium; 2) Calcium; 3) Chlorine.

ANSWER: 1, 3, 2

TOSS-UP

16) MATH – *Short Answer* Express the complex number $(1 + i)^{-6}$ ***[the quantity 1 plus i to the power of negative 6]*** in standard form.

ANSWER: $i/8$

BONUS

16) MATH – *Short Answer* Determine the number of ordered triplets (x, y, z) of odd positive integers such that $x + y + z = 99$.

ANSWER: 1225

TOSS UP

17) EARTH AND SPACE - *Multiple Choice* The drainage of Lake Agassiz led to the widespread deposition of lacustrine clays enriched with vermiculites. The fine grained materials lead to increase in boreal forest development due to the high potassium concentrations and high acidity. What basic soil order resulted from the drainage of Lake Agassiz?

W) Mollisol
X) Alfisol
Y) Spodosol
Z) Vertisol

ANSWER: Y) SPODOSOL

BONUS

17) EARTH AND SPACE – *Short Answer* Identify all of the following three objects that are supported solely by neutron degeneracy pressure: 1) Black hole; 2) O type star; 3) Neutron star.

ANSWER: 3 ONLY

TOSS-UP

18) ENERGY – *Short Answer* Scientists at Fermi National Accelerator Laboratory constantly detect muons formed from cosmic rays as they collide with Earth's atmosphere. However, the

half-life calculated in laboratories is too short for these muons to reach Earth's surface. What effect predicted by special relativity must be accounted for to predict these muons that survive longer than they should?

ANSWER: TIME DILATION (ACCEPT: LENGTH CONTRACTION)

BONUS

18) ENERGY – *Short Answer* Scientists at Fermilab have been studying the fluctuations of synchrotron photons and found that their oscillations closely model a poisson distribution. They produced these photons via what device, which is composed of alternating dipole magnets that rapidly oscillate electrons?

ANSWER: UNDULATOR

TOSS-UP

19) PHYSICS – *Short Answer* Quantum nonlocality is a direct conclusion of which theorem that disproves the existence of local, hidden variable theories if quantum mechanics is to be considered?

ANSWER: BELL'S THEOREM

BONUS

19) PHYSICS – *Short Answer* By name or number, identify all of the following three quantities that approach infinity as velocity approaches the speed of light: 1) Momentum; 2) Mass energy; 3) Total energy.

ANSWER: 1 AND 3

TOSS-UP

20) BIOLOGY – *Short Answer* What specialized hyphae do arbuscular mycorrhizal fungi use to extract nutrients from, or exchange nutrients with, their plant host?

ANSWER: HAUSTORIA

BONUS

20) BIOLOGY – *Short Answer* What specific enzyme is responsible for the cleavage of phospholipids into arachidonic acid and lysophosphatidic acid?

ANSWER: PHOSPHOLIPASE A_2

TOSS-UP

21) CHEMISTRY – *Multiple Choice* Which of the following molecules does NOT display 3 center 4 electron bonding?

W) Phosphorus pentachloride
X) Allyl anion
Y) Tin tetrachloride
Z) Triiodide

ANSWER: Y) TIN TETRACHLORIDE

BONUS

21) CHEMISTRY – *Short Answer* According to the Debye model, the entropy of a solid at very low temperatures is proportional to the temperature raised to what power?

ANSWER: 3

TOSS-UP

22) MATH – *Short Answer* 16 teams participate in a double elimination tournament. If the probability of each team winning each individual game is ½, what is the probability that the winner of the tournament will be undefeated?

ANSWER: ½

BONUS

22) MATH – *Short Answer* Isosceles triangle ABC has AB = AC. The angle bisector of angle ABC intersects AC at point D. Given triangle ABD is also isosceles, determine the smallest possible value of angle ABC in degrees.

ANSWER: 360/7

TOSS UP

23) EARTH AND SPACE - *Multiple Choice* Which of the following best describes how ocean cores can be utilized for proxy climate data?

W) Inclusions of pollen grains
X) Variation in settling rates of particulates
Y) Carbon isotope ratios in fossilized detritus
Z) Oxygen isotope ratios in carbonate shells

ANSWER: Z) OXYGEN ISOTOPE RATIOS IN CARBONATE SHELLS

BONUS

23) EARTH AND SPACE – *Short Answer* What specific ocean zone is characterized by being above the open ocean and having enough light for photosynthesis?

ANSWER: EPIPELAGIC

TOSS-UP

24) ENERGY – *Multiple Choice* Researchers at the SLAC National Accelerator Laboratory have been studying stomata mediated bacterial infections of plants. They discovered that some plants can provide immunity for other plants by activating their stomatal regulation pathways that are dependent on which of the following hormones?

W) Gibberellins
X) Auxins
Y) Abscisic acid
Z) Strigolactones

ANSWER: Y) ABSCISIC ACID

BONUS

24) ENERGY – *Short Answer* Researchers at Argonne National Lab have been working with orthorhombic pseudo-perovskite crystals. While cooling, negative magnetization was discovered. They measured the magnetization via the backscattering of what particle, used because it can measure events in the nanosecond time scale?

ANSWER: NEUTRON

TOSS-UP

25) PHYSICS – *Multiple Choice* Which of the following potential energy functions does not have a stable equilibrium?

W) cos(x)
X) $x^2 - 8x + 3$
Y) $x^3 - x^2 + x$
Z) $e^x - x$

ANSWER: Y) $x^3 - x^2 + x$

BONUS

25) PHYSICS – *Short Answer* A tank of water with density 1000 kg/m^3 is filled to a height of 15 meters. A hole is drilled in the side so that a jet of water streams out a horizontal distance *d*. In meters, what is the maximum possible value of *d*?

ANSWER: 15