Round 15

TOSSUP

1) ENERGY *Short Answer* Scientists at the Max Planck Institute are researching how to harness fusion energy, which is the energy source that fuels stars. What fusion process is dominant in stars greater than about 1.3 solar masses and produces helium from hydrogen?

ANSWER: CNO (CARBON-NITROGEN-OXYGEN) CYCLE

BONUS

1) ENERGY *Short Answer* Scientists at Lawrence Berkeley National Lab and the Max Planck Institute have collaborated to research a certain decay process. What is this type of radioactive decay that, if observed, would confirm lepton-number violations and the Majorana nature of neutrinos.

ANSWER: NEUTRINOLESS DOUBLE-BETA DECAY

TOSSUP

2) BIOLOGY *Multiple Choice* The urine of people affected by rhabdomyolysis is often dark in color due to the presence of what molecule, which also leads to a positive response for blood from a urine tests strip in the absence of erythrocytes?

W) Hemoglobin
X) Myoglobin
Y) Bilirubin
Z) Insulin

ANSWER: X) MYOGLOBIN

BONUS

2) BIOLOGY *Short Answer* During anaphase of mitosis, what enzyme cleaves the cohesins that are responsible for the adhesion of sister chromatids?

ANSWER: SEPARASE

TOSSUP

3) MATH *Short Answer* What operation cannot be performed on the Weierstrass function at any point, even though it is continuous on the entire real number line.

ANSWER: DIFFERENTIATION OR DERIVATIVE

BONUS

3) MATH *Short Answer* Given that $sinx + sin^2x$ = 1, find the value of $cos^8x + 2cos^6x + cos^4x - 2$

ANSWER: -1

TOSSUP

4) EARTH AND SPACE *Short Answer* The Chandrasekhar limit of white dwarfs, estimated to be about 1.4 solar masses, is analogous to what value for neutron stars?

ANSWER: TOV (TOLMAN-OPPENHEIMER-VOLKOFF) LIMIT

BONUS

4) EARTH AND SPACE *Short Answer* What phenomenon, caused by the Pauli exclusion principle, supports white dwarfs and neutron stars from collapsing under their own gravity.

ANSWER: (ELECTRON/NEUTRON) DEGENERACY PRESSURE

TOSSUP

5) CHEMISTRY *Short Answer* Differentiating this property with respect to the number of particles yields chemical potential. Differentiating it with respect to volume yields pressure. Differentiating it with respect to temperature yields entropy. Name this property.

ANSWER: (GIBBS/HELMHOLTZ) FREE ENERGY

BONUS

5) CHEMISTRY *Short Answer* If the internal energy is 100 Joules and the product of pressure and volume is 50 Joules and the product of entropy and temperature is 75 Joules, find the Helmholtz free energy. Express answer in number of Joules.

ANSWER: 25 (JOULES)

TOSSUP

6) PHYSICS *Multiple Choice* A video has some physical motion in it with acceleration a. Now suppose you watch the video played backward. The acceleration of the motion in the backward played video compared to the forwards played video will be:

W) In the opposite direction
X) In the same direction

Y) Of greater magnitude
Z) Of lesser magnitude

ANSWER: X) IN THE SAME DIRECTION

BONUS

6) PHYSICS *Short Answer* By name or number, identify all of the following 3 elements that could be used as a dopant to create a p-type semiconductor.

1) Phosphorus
2) Arsenic
3) Antimony

ANSWER: NONE

TOSSUP

7) BIOLOGY *Short Answer* What most chemically complex vitamin is based on a corrin ring surrounding a cobalt atom?

ANSWER: VITAMIN B12 OR COBALAMIN

BONUS

7) BIOLOGY *Short Answer* Name both cycles by which viruses can reproduce.

ANSWER: LYSOGENIC AND LYTIC CYCLES

TOSSUP

8) ENERGY *Multiple Choice* The Deep Underground Neutrino Experiment, DUNE, at Fermilab plans to use a high-power neutrino beam in Illinois and a detector in South Dakota 900 miles away to observe differences in the properties of neutrinos and antineutrinos. Which of the following properties, if different between matter and antimatter neutrinos, would provide evidence as to why we live in a matter dominated universe.

W) Mass
X) Charge
Y) Oscillation Rate
Z) Spin

ANSWER: Y) OSCILLATION RATE

BONUS

8) ENERGY *Short Answer* Researchers at Pacific Northwest National Lab have been researching how the microbiome in a person's gut may influence their memory. This could possibly be related to what nerve, which links the digestive tract to the brain?

ANSWER: VAGUS OR PNEUMOGASTRIC NERVE

TOSSUP

9) EARTH AND SPACE *Multiple Choice* Which of the following deserts is NOT a rain shadow desert?

W) Gobi
X) Great Basin
Y) Patagonia
Z) Namib

ANSWER: Z) NAMIB

BONUS

9) EARTH AND SPACE *Multiple Choice* What term is used to refer to a parcel of air whose wet adiabatic rate is greater than the environmental lapse rate?

W) Absolute Stability
X) Absolute Instability
Y) Conditional Stability
Z) Conditional Instability

ANSWER: W) ABSOLUTE STABILITY

TOSSUP

10) PHYSICS *Short Answer* A cannonball is fired off a cliff that is 490 m high horizontally at a speed of 17 m/s. To the nearest whole number, how far away from the cliff will it be when it lands?

ANSWER: 170 METERS

BONUS

10) PHYSICS *Short Answer* Josh throws a 1 kg frisbee flying flat at a speed of 30 m/s. Dipen, who weighs 50 kg, runs at 10 m/s toward the frisbee to catch it. Unfortunately, the frisbee hits his head, colliding elastically. Dipen, however, is a big boy, and he only stops running after getting hit while the frisbee flies off. If Dipen is 2 m tall, how far away will the frisbee land on the

ground from Dipen to the nearest whole number? Assume the acceleration due to gravity is 10 m/s^2.

ANSWER: 297 METERS (297 M)

TOSSUP

11) MATH *Short Answer* What is the coefficient of $x^2 * y^4$ in the expansion of $(x^2+2y)^5$ (quantity x squared plus two y to the fifth power)?

ANSWER: 80

BONUS

11) MATH *Short Answer* What is the area of a triangle with side lengths 15,16, and 17? Express your answer in simplest radical form.

ANSWER: $24\sqrt{21}$

TOSSUP

12) CHEMISTRY *Short Answer* An epoxide is a specific cyclic form of what broader class of organic compounds?

ANSWER: ETHER

BONUS

12) CHEMISTRY *Short Answer* Order the following compounds in order of INCREASING bond angle around the central atom.

1) Dimethylamine
2) Carbon tetrachloride
3) Sulfur Hexafluoride

ANSWER: 3, 1, 2 (SULFUR HEXAFLUORIDE, DIMETHYLAMINE, CARBON TETRACHLORIDE)

TOSSUP

13) BIOLOGY *Short Answer* Thymine dimer formation due to excessive UV exposure in bacteria and archaea can be reverted via which light-utilizing enzymes?

ANSWER: PHOTOLYASES

BONUS

13) BIOLOGY *Multiple Choice* A eukaryotic zygote has a congenital extremely rare recessive mutation that results in a nucleotide sequence change in the gene coding for topoisomerase. What will most likely occur after the zygote forms?

W) Nucleotide excision repair will remove the affected sequence and correct it.
X)The other parental set of DNA with the correct topoisomerase gene will be transcribed and there will be no effect.
Y)The zygote will fail to or find difficulty in replication
Z)The zygote will replicate until enough mutations have accumulated to cause mass apoptosis.

ANSWER: X) THE OTHER PARENTAL SET OF DNA WITH THE CORRECT TOPOISOMERASE GENE WILL BE TRANSCRIBED AND THERE WILL BE NO EFFECT.

TOSSUP

14) EARTH AND SPACE *Short Answer* What is the fine-grained, extrusive equivalent of granite?

ANSWER: RHYOLITE

BONUS

14) EARTH AND SPACE *Multiple Choice* If lava is more felsic in composition, how would this affect the resulting pillow lavas from an underwater eruption?

W) Larger pillows
X) Smaller pillows
Y) Does not affect size
Z) Less rounded pillows

ANSWER: W) LARGER PILLOWS

TOSSUP

15) PHYSICS *Short Answer* What technology was used to detect gravitational waves?

ANSWER: LASER INTERFEROMETRY

BONUS

15) PHYSICS *Short Answer* Given that in a double slit interference experiment, the distance between the slits is 20 meters and and the length from the center of the slits to the first node is

10 meters and the horizontal distance from central maximum to the node is 0.2 meters, find the wavelength of the light, in meters.

ANSWER: 0.8 (METERS)

TOSSUP

16) BIOLOGY *Multiple Choice* Parkinson's disease is characterized by cell death and low levels of dopamine in what brain structure?

ANSWER: SUBSTANTIA NIGRA

BONUS

16) BIOLOGY *Multiple Choice* The early damages of what neurodegenerative disease are most apparent in the brain striatum?

W) Parkinson's
X) Alzheimer's
Y) Huntington's
Z) Lou Gehrig's

ANSWER: Y) HUNTINGTON'S

TOSSUP

17) MATH *Short Answer* What is the largest positive integer value of n less than 100 such that 3^{n-1} is divisible by 97?

ANSWER: 96

BONUS

17) MATH *Short Answer* What's the remainder when (1!+2!+3!+4!+5!+6!+...+80!) is divided by 100?

ANSWER: 13

TOSSUP

18) ENERGY *Short Answer* Researchers at Ames National Lab are researching how to image DNA origami nanostructures, which have many potential uses for nanotechnology. These structures are formed from the interactions between complementary base pairs. What phenomenon is responsible for holding together these base pairs?

ANSWER: HYDROGEN BONDING

BONUS

18) ENERGY *Short Answer* Scientists at Argonne National Lab have implemented centroidal Voronoi tessellation in order to find the optimal placement rain gauges to accurately assess an area's precipitation.By name or number, identify all of the following 4 sets of shapes which are able to tessellate a two-dimensional plane.

1) Regular pentagon
2) Square and isosceles trapezoid
3) Regular hexagon
4) Kite

ANSWER: 2, 3, AND 4 (SQUARE AND ISOSCELES TRAPEZOID, REGULAR HEXAGON, KITE)

TOSSUP

19) CHEMISTRY *Short Answer* To the nearest whole and in seconds, what is the half life at 5 seconds of a first-order reaction with rate constant equal to 6.9 times 10 to the negative third power inverse seconds and initial concentration of the rate determining reactant .4 molar?

ANSWER: 100 SECONDS

BONUS

19) CHEMISTRY *Short Answer* A reaction has three reactants, A, B, and C. Give the order of the reaction relative to each reactant and of the overall reaction if the following changes have the corresponding effects on the rate. Concentration of A is doubled, the reaction proceeds 4 times faster. Concentration of B and C are both doubled and the reaction proceeds 16 times faster. Concentration of A and C are both doubled and the reaction proceeds 4 times faster.

ANSWER: A - 2ND, B - 4TH, C - 0TH, OVERALL - 6TH

TOSSUP

20) MATH *Multiple Choice* What is the area of an equilateral hexagon with side length 4?

ANSWER: 24 (SQRT 3)

BONUS

20) MATH *Short Answer* In how many ways can 9 people be split up into 1 team of 3 and 3 teams of 2?

ANSWER: 1260

TOSSUP

21) EARTH AND SPACE *Multiple Choice* The Hall-Héroult process dissolves bauxite, the primary aluminum ore, into the molten form of what aluminum-containing mineral.

W) Gibbsite
X) Quartzite
Y) Alunite
Z) Cryolite

ANSWER: Z) CRYOLITE

BONUS

21) EARTH AND SPACE *Short Answer* What is the crystal system of cryolite?

ANSWER: MONOCLINIC

TOSSUP

22) CHEMISTRY *Short Answer* Schweizer's Reagent is used to dissolve what polymer. The regenerated form of which is used to produce the synthetic fiber rayon?

ANSWER: CELLULOSE

BONUS

22) CHEMISTRY *Short Answer* By name or number, identify each of the following four ligands which Schweizer's Reagent contains around its central copper two plus ion.

1) Ammine
2) Aqua
3) Carbonato
4) Nitrosyl

ANSWER: 1 AND 2 (AMMINE AND AQUA)

TOSSUP

23) PHYSICS *Short Answer* If a capacitor with capacitance 0.2 farads is connected in series with a battery of 70 volts, how much energy, in joules, is stored in the capacitor?

ANSWER: 490 (JOULES)

BONUS

23) PHYSICS *Short Answer* Capacitors A and B are connected in series. Capacitor C is connected in parallel with both A and B. If A = 4 microfarads, B = 12 microfarads, and C = 10 microfarads, what is the equivalent capacitance, in microfarads, of this arrangement?

ANSWER: 13 (MICROFARADS)
