Round 17

TOSSUP

1) ENERGY *Short Answer* This phenomenon limits the functioning of transistors today. Name this phenomenon that is also observed in alpha decay of nuclei.

ANSWER: QUANTUM TUNNELING.

BONUS

1) ENERGY *Short Answer* Alpha decay is used in smoke detectors, which use Americium-241 as an alpha particle source. What other isotope, the decay product of Americium would also be found in smoke detectors?

ANSWER: NEPTUNIUM-237

TOSSUP

2) EARTH AND SPACE *Short Answer* What object is the most geologically active body in the solar system, due to its proximity to the planet it orbits?

ANSWER: IO

BONUS

2) EARTH AND SPACE *Short Answer* The interior of Jupiter is mostly composed of what peculiar, conductive liquid.

ANSWER: METALLIC HYDROGEN

TOSSUP

3) CHEMISTRY *Short Answer* At constant volume and a constant number of particles, the inverse of temperature can be expressed as the partial derivative of what quantity with respect to internal energy?

ANSWER: ENTROPY

BONUS

3) CHEMISTRY *Short Answer* Giving your answer in scientific notation to one place after the decimal, find the entropy of a system, in joule/kelvin if Boltzmann's constant is given as 1.4 times 10 to the negative 23rd joule/kelvin and if there are 20 microstates.

ANSWER: 4.2×10^{-23}

TOSSUP

4) BIOLOGY *Short Answer* Which organelle would you expect to proliferate in the liver cells of an organism that has been treated with phenobarbital?

ANSWER: SMOOTH ENDOPLASMIC RETICULUM (ACCEPT ER)

BONUS

4) BIOLOGY *Multiple Choice* Zidovudine, or azidothymidine, is a common antiretroviral medication. It is used to inhibit which one of the following?

W) Capsid Protein
X) Protease
Y) Reverse Transcriptase
Z) Transposase

ANSWER: Y) REVERSE TRANSCRIPTASE

TOSSUP

5) MATH *Short Answer* What is the largest 3-digit palindrome divisible by 7?

ANSWER: 959

BONUS

5) MATH *Short Answer* What is the largest value of x, such that 3^x divides 100!(Read as 100 factorial).

ANSWER: 48

TOSSUP

6) PHYSICS *Short Answer* Given that a sound source produces 5 Watts of power, giving your answer in Watts per square meter, what is the intensity of a sound wave at 20 meters from the source.

ANSWER: 1/(320 * pi)

BONUS

6) PHYSICS *Short Answer* The solution to the brachistochrone is one of these shapes. This solution makes sense when one considers the parametric equations of this shape, which are $x = a(t - \sin(t))$ and $y = a(1 - \cos(t))$.

ANSWER: CYCLOID

TOSSUP

7) ENERGY *Short Answer* Researchers at the IceCube Observatory study cosmic rays by detecting and analyzing the millions of particles that are formed in the upper atmosphere. These cosmic rays notably produce what unstable isotope from interactions with nitrogen in the upper atmosphere?

ANSWER: CARBON-14

BONUS

7) ENERGY *Multiple Choice* Ames National Labs plans on opening the first Dynamic Nuclear Polarization NMR spectrometer, which will be able to overcome standard NMRs weakness of intrinsically low sensitivity. Which of the following best describes how this will be overcome?

W) The spectrometer will use shorter wavelengths of light as well as increasing the intensity, resulting in higher resolution.
X) Much more powerful magnets will be used to align the atomic nuclei, resulting in a much more powerful response from atomic nuclei
Y) Microwaves will be used to excite unpaired electrons which will transfer spin polarization to the nuclei, resulting in stronger responses
Z) Specific wavelengths of light will be used to raise the energy level of electrons in the atoms, these excited state atoms give a stronger response in NMR.

ANSWER: Y) MICROWAVES WILL BE USED TO EXCITE UNPAIRED ELECTRONS WHICH WILL TRANSFER SPIN POLARIZATION TO THE NUCLEI, RESULTING IN STRONGER RESPONSES

TOSSUP

8) EARTH AND SPACE *Multiple Choice* What mineral is abundant in the lower portion of many ophiolites, in addition to crucially comprising a major portion of the mantle?

W) Orthoclase
X) Calcite
Y) Olivine
Z) Forsterite

ANSWER: Y) OLIVINE

BONUS

8) EARTH AND SPACE *Short Answer* Order the following four periods of the Paleozoic era in chronological order: 1) Silurian, 2) Permian, 3) Devonian, 4) Cambrian

ANSWER: 4, 1, 3, 2 (CAMBRIAN, SILURIAN, DEVONIAN, PERMIAN)

TOSSUP

9) CHEMISTRY *Multiple Choice* A Grignard reagent most often consists of what group attached to an alkyl or aryl group.

W) Ketone
X) Potassium alkoxide
Y) Magnesium Bromide
Z) Copper lithium

ANSWER: Y) MAGNESIUM BROMIDE

BONUS

9) CHEMISTRY *Short Answer* By name or number, identify all of the following four classes of compounds that could be the result of a Grignard reaction

1) Primary Alcohol
2) Diol
3) Aldehyde
4) Glycol

ANSWER: 1, 2, AND 4 (PRIMARY ALCOHOL, DIOL, GLYCOL)

TOSSUP

10) MATH *Multiple Choice* Which of the following is not a way to represent the number e?

W) The limit as n approaches infinity of quantity 1 plus 1/n raised to the n-th power.
X) The limit as n approaches infinity of the difference between the n-th harmonic number and the natural log of n
Y) The sum from n is equal to zero to infinity of 1 over n factorial

Z) The limit as n approaches infinity of the fraction with numerator n and denominator the n-th root of quantity n factorial

ANSWER: X) THE LIMIT AS N APPROACHES INFINITY OF THE DIFFERENCE BETWEEN THE N-TH HARMONIC NUMBER AND THE NATURAL LOG OF N

BONUS

10) MATH *Short Answer* Find the last two digits in the expansion of 71^2020

ANSWER: 01 (0 AND 1)

TOSSUP

11) PHYSICS *Short Answer* Neutrinos are currently being studied to find out if they have this property, where in a particle is its own antiparticle?

ANSWER: MAJORANA

BONUS

11) PHYSICS *Multiple Choice* Sphaleron processes, which would have been essential to leptogenesis, are processes that violate the conservation of which of the following

W) CPT Symmetry
X) Lepton and Baryon number
Y) Energy and information
Z) Color and charge

ANSWER: X) LEPTON AND BARYON NUMBER

TOSSUP

12) ENERGY *Multiple Choice* Researchers at Argonne National Lab are studying myosin in tarantulas using APS. Which of the following accurately compares how myosin is activated in tarantulas versus how it is activated in humans.

W) Myosin is activated by phosphorylation in tarantulas, and mechanical stress in humans
X) Myosin is activated by phosphorylation both in tarantulas and in humans
Y) Myosin is activated by mechanical stress in tarantulas, and phosphorylation in humans
Z) Myosin is activated by mechanical stress both in tarantulas and in humans

ANSWER: W) MYOSIN IS ACTIVATED BY PHOSPHORYLATION IN TARANTULAS, AND MECHANICAL STRESS IN HUMANS

BONUS

12) ENERGY *Short Answer* Researchers at CERN are using the Large Hadron Collider to search for what particle type of particles, a leading candidate for the composition of dark matter?

ANSWER: WIMPS (WEAKLY INTERACTING MASSIVE PARTICLES)

TOSSUP

13) EARTH AND SPACE *Short Answer* Order the following four colors of classifications of stars from LEAST to GREATEST surface temperatures: 1) Yellow; 2) Blue; 3) Red; 4) White.

ANSWER: 3, 1, 4, 2 (RED, YELLOW, WHITE, BLUE)

BONUS

13) EARTH AND SPACE *Multiple Choice* Which of the following best describes why population III (three) stars have been predicted to have very large masses.

W) The higher metallic content leads to higher density cores that are able to attract and hold more matter in the star
X) Population III stars form in areas that are very rich in hydrogen and helium, so the stars are able to grow larger
Y) The lower metallic content allows the stars to survive longer and fuse more hydrogen, so they can accumulate more mass
Z) The lower metallicity and warmer interstellar medium shortly after the Big Bang allowed larger stars to form than would be possible later in the universe

ANSWER: Z) THE LOWER METALLICITY AND WARMER INTERSTELLAR MEDIUM SHORTLY AFTER THE BIG BANG ALLOWED LARGER STARS TO FORM THAN WOULD BE POSSIBLE LATER IN THE UNIVERSE

TOSSUP

14) CHEMISTRY *Short Answer* The Fenske equation is used to calculate the minimum number of plates to be used in what process.

ANSWER: FRACTIONAL DISTILLATION (ACCEPT DISTILLATION)

BONUS

14) CHEMISTRY *Short Answer* By name or number, identify all of the following three compounds that form a negative azeotrope with water

1) Pyridine
2) Ethanol
3) Acetonitrile

ANSWER: NONE

TOSSUP

15) BIOLOGY *Multiple Choice* Disulfide bridges form in which of the following kinds of environments?

W) Reducing
X) Phosphatasing
Y) Oxidizing
Z) Neutral

ANSWER: Y) OXIDIZING

BONUS

15) BIOLOGY *Multiple Choice* The pKa of Histidine's imidazole ring at physiological pH is numerically closest to which of the following?

W) 0
X) 3
Y) 7
Z) 14

ANSWER: Y) 7

TOSSUP

16) MATH *Short Answer* What function is used to model an ideal point mass or point charge, with an integral equal to 1 on the real number line, and is equal to zero at almost every point?

ANSWER: (DIRAC) DELTA (FUNCTION)

BONUS

16) MATH *Short Answer* If the sum to infinity of the series 1+2r+3r^2+4r^3+... is 9/4, then what is the value of r?

ANSWER: 1/3

TOSSUP

17) PHYSICS *Multiple Choice* 2 telephone poles of equal height are connected by a 20 m wire. A bird flies over and lands in the middle of the wire. When it lands, the bird sinks, stretching the wire until it makes an angle of 120°. If the bird weighs 10 N, how much horizontal force does each side of the wire exert on the bird?

W) 0 N
X) 5 N
Y) 10 N
Z) 20 N

ANSWER: W) 0 N

BONUS

17) PHYSICS *Multiple Choice* The voltage gap on a wheatstone bridge is measured to be 0. Which of the following sets of resistors could NOT make a Wheatstone bridge with 0 voltage gap?

W) 5, 10, 10, and 20 ohm resistors
X) 9, 10, 12, and 13 1/3 ohm resistors
Y) 1, 2, 4, and 8 ohm resistors
Z) 6, 12, 18, and 24 ohm resistors

ANSWER: Z) 6, 12, 18, AND 24 OHM RESISTORS

TOSSUP

18) BIOLOGY *Short Answer* Herceptin is a chemotherapy drug used to block HER2, which is often overexpressed in around 20% of breast cancer tumors. HER2 is an example of which of the following kinds of cellular receptors?

W) G Protein Coupled Receptors
X) Receptor Tyrosine Kinases
Y) Janus Kinases
Z) Ligand Gated Ion Channels

ANSWER: X) RECEPTOR TYROSINE KINASES

BONUS

18) BIOLOGY *Multiple Choice* A seed is flashed with several types of light in the sequence red, red, far red, far red, red, red, red, far red. Based on this, what will most likely occur in the germination of this seed?

W) Germination will occur the full length of the flashes.
X) Germination will fail to occur.
Y) Germination will have a 3/8 probability of occuring.
Z) Germination will have a 5/8 probability of occuring.

ANSWER: X) GERMINATION WILL FAIL TO OCCUR

TOSSUP

19) EARTH AND SPACE *Multiple Choice* Of the following, which is not a variety of quartz?

W) Citrine
X) Amethyst
Y) Carnelian
Z) Lepidolite

ANSWER: Z) LEPIDOLITE

BONUS

19) EARTH AND SPACE *Short Answer* In this process small ice crystals in clouds collect the available water vapor and grow in size, then water droplets release more water vapor to reach equilibrium which is again collected by ice crystals. What is this process by which precipitation can form in very cold, high altitude clouds?

ANSWER: (WEGENER-) BERGERON (-FINDEISEN) PROCESS

TOSSUP

20) CHEMISTRY *Multiple Choice* Which of the following pairs of compounds is made by the transesterification of a fat or vegetable soil?

W) Biodiesel and glycerine
X) Biodiesel and glycerol
Y) Bioethanol and glycerine
Z) Bioethanol and glycerol

ANSWER: X) BIODIESEL AND GLYCEROL

BONUS

20) CHEMISTRY *Short Answer* Order the following three steps of a transesterification chronologically.

1) The double bond is regenerated, and one of the side chains is expelled
2) The base removes the hydrogen from the alcohol

3) The alkoxide's oxygen attacks the carbonyl carbon

ANSWER: 2, 3, 1

TOSSUP

21) BIOLOGY *Short Answer* What electron transporter, which may be found as quinone, hydroquinone, or semiquinone, is utilized in the brain and serves as an energy carrier to generate ATP in cellular respiration?

ANSWER: FAD+ TRANSPORTER (ACCEPT: FLAVIN ADENINE DINUCLEOTIDE, FAD, FAD TRANSPORTER, FLAVIN ADENINE DINUCLEOTIDE TRANSPORTER)

BONUS

21) BIOLOGY *Short Answer* What molecule is a precursor of a vital coenzyme that helps to convert carbohydrates into ATP, providing energy for cellular processes such as the Krebs Cycle.

ANSWER: RIBOFLAVIN

TOSSUP

22) MATH *Short Answer* Quadrilateral ABCD circumscribes circle O. Side AB is 10, BC is 13, and AD is 17, what is the length of side CD.

ANSWER: 20

BONUS

22) MATH *Short Answer* Find the value of the local minima of the function $18\tan^2(\theta) + 2\tan^2(pi/2 - \theta)$

ANSWER: 12

TOSSUP

23) PHYSICS *Multiple Choice* In which of the following harmonic oscillators does the system reach equilibrium the fastest?

W) Undamped

X) Underdamped

Y) Critically damped

Z) Overdamped

ANSWER: Y) CRITICALLY DAMPED

BONUS

23) PHYSICS *Multiple Choice* Given that a damped harmonic oscillator has a spring constant of 10 Newtons / meter, a mass of 1 kg placed in it, and a viscous damping coefficient of 2 Newton seconds / meter, calculate the angular frequency, in radians per second, of the oscillator.

ANSWER: 3 (RADIANS / SECOND)
