ROUND 3

TOSS-UP

1) MATH *Short Answer* If $log\,100^{2x} = 2$ *[log base 10 of 100 to the power of 2x equals 2]*, what is the value of x?

ANSWER: $\frac{1}{2}$ (ACCEPT: 0.5)

BONUS

1) MATH *Short Answer* Simplify the following expression: $\sec^2\frac{3\pi}{4} - \csc^2\frac{\pi}{4} - \cos^2 4\pi$ *[secant squared of 3 pi over 4 minus cosecant squared of pi over 4 minus cosine squared of 4 pi]*.

ANSWER: -1

TOSS-UP

2) CHEMISTRY *Short Answer* What is the electron configuration of chromium?

ANSWER: $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^1\,3d^5$ (ACCEPT: [Ar (argon)] $4s^1\,3d^5$)

BONUS

2) CHEMISTRY *Short Answer* Baeyer-Villiger oxidation is used to transform a ketone into what functional group?

ANSWER: ESTER

TOSS-UP

3) PHYSICS *Multiple Choice* A box is sitting on a ramp with a coefficient of static friction of 0.7. Which of the following is closest to the smallest ramp angle for which the box will begin to slide down the ramp?

W) 30°
X) 35°
Y) 45°
Z) 60°

ANSWER: X) 35°

BONUS

3) PHYSICS *Multiple Choice* Assuming that 1 atmosphere = 1.01×10^5 pascals and the density of water is 1000 kilograms per cubic meter, at what depth of water will the absolute pressure be 10.8 times the atmospheric pressure?

W) 10.1 meters
X) 101 meters
Y) 1,010 meters
Z) 10.1 kilometers

ANSWER: X) 101 METERS

TOSS-UP

4) EARTH AND SPACE *Multiple Choice* Which of the following is closest to the percentage of incoming solar radiation that is absorbed by the ocean and land?

W) 5%
X) 15%
Y) 20%
Z) 50%

ANSWER: Z) 50%

BONUS

4) EARTH AND SPACE *Multiple Choice* In which of the following silicate groups of minerals does olivine belong?

W) Nesosilicates *[nee-soh-SIL-i-kayts]*
X) Inosilicates
Y) Sorosilicates
Z) Phyllosilicates *[fil-oh-SIL-i-kayts]*

ANSWER: W) NESOSILICATES

TOSS-UP

5) BIOLOGY *Multiple Choice* Eukaryotic *[yoo-KAR-ee-oh-tik]* genes are composed of introns and exons. Which of the following eukaryotes *[yoo-KAR-ee-ohts]* would have the shortest intron size?

W) Mice
X) Fruit flies
Y) Humans
Z) Yeast

ANSWER: Z) YEAST

BONUS

5) BIOLOGY *Short Answer* In the production of mammalian proteins, the first amino acid in the polypeptide sequence is almost always the same amino acid. What is this amino acid that is prevalent in almost all proteins?

ANSWER: METHIONINE (ACCEPT: MET AND M)

TOSS-UP

6) ENERGY *Multiple Choice* Which of the following has long been considered the upper theoretical percentage limit for solar cell efficiency?

W) 24.5%
X) 33.7%
Y) 41.2%
Z) 62.8%

ANSWER: X) 33.7%

BONUS

6) ENERGY *Multiple Choice* What property of hydrogen makes water a good neutron moderator?

W) It has a small neutron scattering cross section
X) It has a large neutron scattering cross section
Y) It is fissile
Z) It evaporates at 373 Kelvin

ANSWER: X) IT HAS A LARGE NEUTRON SCATTERING CROSS SECTION

TOSS-UP

7) MATH *Short Answer* What is the probability that at least one head appears in 4 tosses of a fair coin?

ANSWER: 15/16 (ACCEPT: 0.9375)

BONUS

7) MATH *Short Answer* What is the inner product of the vectors $-4i + 3j + 5k$ and $3i - 6j + 7k$?

ANSWER: 5

TOSS-UP

8) CHEMISTRY *Multiple Choice* Which of the following is true of spontaneous processes at constant temperature, volume, and pressure?

W) Gibbs and Helmholtz free energies increase
X) Gibbs free energy increases; Helmholtz free energy decreases
Y) Gibbs and Helmholtz free energies decrease
Z) Gibbs free energy decreases; Helmholtz free energy increases

ANSWER: Y) GIBBS AND HELMHOLTZ FREE ENERGIES DECREASE

BONUS

8) CHEMISTRY *Short Answer* Identify, respectively, the dominant intermolecular force that has the greatest effect on the following four molecules: 1) methane, 2) benzoic acid, 3) hydrogen chloride gas, and 4) ferric sulfide.

ANSWER: 1) LONDON DISPERSION (ACCEPT: INDUCED DIPOLE or VAN DER WAALS), 2) HYDROGEN BONDING, 3) DIPOLE (ACCEPT: DIPOLE-DIPOLE or LONDON DISPERSION), 4) IONIC

9) PHYSICS *Short Answer* In order to play a low C followed by a high C, one octave up, on a violin string, the violinist must increase the frequency of the string by what factor?

ANSWER: 2

BONUS

9) PHYSICS *Short Answer* A large water rocket is in the process of taking off. It is noted that when the rocket weighs 600 newtons and has an exhaust speed of 5 meters per second that it doesn't leave the ground and it also ceases to apply a force on the ground. What must be the volume flow rate of the exhaust in liters per second?

ANSWER: 120

TOSS-UP

10) EARTH AND SPACE *Multiple Choice* Most solar radiation is emitted in short wavelengths. Visible wavelengths fall in which of the following ranges in micrometers?

W) 0.1 - 0.4
X) 0.4 - 0.7
Y) 0.7 - 1.0
Z) 1.0 - 1.3

ANSWER: X) 0.4 - 0.7

BONUS

10) EARTH AND SPACE *Short Answer* What is the word used to describe pebbles in a river that are overlapping and dip in the upstream direction?

ANSWER: IMBRICATION

TOSS-UP

11) BIOLOGY *Short Answer* During which phase of interphase does expression of proteins needed to prepare for DNA replication increase?

ANSWER: G1

BONUS

11) BIOLOGY *Multiple Choice* Brine shrimp are able to survive in wide ranges of salinity. Which of the following phrases is NOT true regarding their osmoregulation when placed in a tank of saline?

W) Osmoconformation, body fluid osmolarity is equivalent to osmolarity of saline in which they are swimming
X) Osmoregulation, body fluid osmolarity is kept at an osmolarity different from the osmolarity of saline in which they are swimming
Y) Hyper-osmoregulation, body fluid osmolarity is kept higher than osmolarity of saline in which they are swimming
Z) Hypo-osmoregulation, body fluid osmolarity is kept lower than osmolarity of saline in which they are swimming

ANSWER: Y) HYPER-OSMOREGULATION, BODY FLUID OSMOLARITY IS KEPT HIGHER THAN OSMOLARITY OF SALINE IN WHICH THEY ARE SWIMMING

TOSS-UP

12) ENERGY *Short Answer* In an isothermal system, what is one way that one can increase the number of interactions of a gas with a solid surface?

ANSWER: INCREASE PRESSURE (ACCEPT: DECREASE VOLUME)

BONUS

12) ENERGY *Multiple Choice* If yellow light has a wavelength of 550 nanometers, which of the following colors and associated wavelengths of light in nanometers is most energetic?

W) Violet, 700
X) Green, 500
Y) Red, 500
Z) Red, 700

ANSWER: X) GREEN, 500

13) MATH *Multiple Choice* What is the general solution to the differential equation:
$dy/dx = 2x + 1$ *[dy dx equals 2x plus 1]*?

W) $y = x^2 + x + c$
X) $y = \frac{1}{2} x^2 + c$
Y) $y = 2 + c$
Z) $y = 2x + c$

ANSWER: W) $y = x^2 + x + c$

BONUS

13) MATH *Short Answer* Simplify: $x^{1/2} (x^{1/2} + x^{1/2})$ *[x to the power of one half times open parenthesis x to the power of one half plus x to the power of one half close parenthesis]*.

ANSWER: $2x$

TOSS-UP

14) CHEMISTRY *Short Answer* In lab, you have patented the creation of a metallic radioactive isotope called Sciencebowlium-23. But, after a period of time, the sample radioactively decays into oxygen-16, where it becomes a gas and dissipates into the atmosphere. You create a sample of Sciencebowlium and weigh it as 500 grams. Exactly four days later, you weigh the sample at 62.5 grams. How many hours long is the half-life of Sciencebowlium-23?

ANSWER: 32

BONUS

14) CHEMISTRY *Short Answer* What is the bond order of the nitrogen-oxygen bond in the nitrate anion?

ANSWER: 1.33 (ACCEPT: 4/3 or 1 1/3)

TOSS-UP

15) PHYSICS *Multiple Choice* Two satellites of masses m_1 and m_2, where $m_1 = 4m_2$, are deployed in circular orbits of the same radius in the gravitational field of Earth. What is the ratio of their linear speeds v_1/v_2?

W) 1/4
X) 1
Y) 2
Z) 4

ANSWER: X) 1

BONUS

15) PHYSICS *Multiple Choice* Assuming h = 6.63×10^{-34} joule seconds, what is the approximate energy of a photon in joules in a 1000 nanometer light beam?

W) 2×10^{-19}
X) 2×10^{-18}
Y) 2×10^{-17}
Z) 4×10^{-18}

ANSWER: W) 2×10^{-19}

TOSS-UP

16) EARTH AND SPACE *Short Answer* What type of front travels at about 30 miles per hour and has a slope of about 1:100?

ANSWER: COLD

BONUS

16) EARTH AND SPACE *Short Answer* What is the name of the deepest lake in Africa that was formed from continental rifting?

ANSWER: LAKE TANGANYIKA

TOSS-UP

17) BIOLOGY *Multiple Choice* A type of albinism in the Hopi Native American population is caused by mutation of the OCA2 gene. If the dominant form of the gene gives a person normal pigmentation, then which of the following genotypes would result in albinism?

W) Heterozygous co-dominance *[het-er-uh-ZY-guhs]*
X) Homozygous dominant *[hoh-muh-ZY-guhs]*
Y) Homozygous recessive
Z) Heterozygous incomplete dominance

ANSWER: Y) HOMOZYGOUS RECESSIVE

BONUS

17) BIOLOGY *Short Answer* Identify all of the following five choices that are diploid: 1) spermatogonium *[spur-mat-uh-GOH-nee-uhm]*, 2) spermatids, 3) secondary spermatocyte *[spuhr-MAT-uh-syt]*, 4) primary spermatocyte, 5) mature sperm cells.

ANSWER: 1, 4 (ACCEPT: SPERMATOGONIUM, PRIMARY SPERMATOCTYE)

TOSS-UP

18) PHYSICS *Multiple Choice* In order to see a full height image of your body, the vertical size of a mirror should be at least which of the following?

W) One-fourth of your height
X) Half of your height
Y) Your height
Z) Twice your height

ANSWER: X) HALF OF YOUR HEIGHT

BONUS

18) PHYSICS *Multiple Choice* A mass spectrometry experiment is performed with a magnetic field of 0.2 newtons per ampere meter and an electric field of 3.0×10^5 volts per meter. What is the speed of the ions?

W) 750 meters per second
X) 1500 meters per second
Y) 150 kilometers per second
Z) 1500 kilometers per second

ANSWER: Z) 1500 KILOMETERS PER SECOND

19) MATH *Multiple Choice* What is the derivative of $y = (3x + 1)^2$ *[y equals 3x plus 1 quantity squared]*?

W) $18x + 6$
X) $18x$
Y) $6x + 1$
Z) $6x + 2$

ANSWER: W) $18x + 6$

BONUS

19) MATH *Short Answer* What is the equation, in slope-intercept form, of the perpendicular bisector of the line segment with endpoints $(4, 10)$ and $(-6, 8)$?

ANSWER: $y = -5x + 4$

TOSS-UP

20) CHEMISTRY *Multiple Choice* At high temperatures, nitrogen (N_2) and oxygen (O_2) gases react to form nitric oxide (NO) in a highly endothermic process. In a closed vessel, the three compounds form an equilibrium *[ee-kwuh-LIB-ree-uhm]*. Which of the following changes to the vessel will result in the production of more NO?

W) Addition of helium at constant volume
X) Adding a catalyst
Y) Increasing the temperature of the vessel
Z) Removing oxygen from the vessel

ANSWER: Y) INCREASING THE TEMPERATURE OF THE VESSEL

BONUS

20) CHEMISTRY *Short Answer* Dinitrogen tetroxide is a powerful oxidizer and can be used with hydrazine fuels to propel rockets. What is the point group of dinitrogen tetroxide?

ANSWER: D_{2h}

21) PHYSICS *Multiple Choice* A light ray passes from air (n_1 = 1.00) to three layers of the human eye: cornea (n_2 = 1.33), lens (n_3 = 1.41), and vitreous humor (n_4 = 1.33). The speeds of light in these mediums are, respectively, v_1, v_2, v_3, v_4. Which of the following must be true about the relationships between the speeds of light in the different media?

W) $v_1 < v_2 < v_3 < v_4$
X) $v_4 < v_3 < v_2 < v_1$
Y) $v_3 < v_2$ and $v_4 < v_1$
Z) $v_2 < v_3$ and $v_1 < v_4$

ANSWER: Y) $v_3 < v_2$ AND $v_4 < v_1$

21) PHYSICS *Short Answer* Two satellites are orbiting in circular orbits of radii r_1 and r_2 around a planet, where $r_1 = 4r_2$. What is the ratio of their periods of revolutions T_1/T_2?

ANSWER: 8

22) EARTH AND SPACE *Short Answer* What international agreement, initially drafted in 1987, was designed to phase out production of chlorofluorocarbons *[klohr-oh-floor-oh-KAHR-buhns]* that cause damage to the stratospheric ozone layer?

ANSWER: MONTREAL PROTOCOL

22) EARTH AND SPACE *Multiple Choice* The shells of which of the following zooplankton groups are used in carbon-14 dating of ocean sediments?

W) Polycistina
X) Foraminifera *[fuh-ram-uh-NIF-er-uh]*
Y) Acantheria *[uh-kan-THUH-ree-uh]*
Z) Ciliata *[sil-ee-AY-tuh]*

ANSWER: X) FORAMINIFERA

TOSS-UP

23) BIOLOGY *Short Answer* If there are two alleles for the gene encoding size, and if the frequency of the big size allele, B *[upper case B],* in a population of warthogs is 0.4, then what is the frequency of the small size allele, b *[lower case b]*, assuming Hardy Weinberg equilibrium *[ee-kwuh-LIB-ree-uhm]*?

ANSWER: 0.6

BONUS

23) BIOLOGY *Short Answer* Arrange the following four groups from the taxa containing the largest number of known living species to the group containing the least: 1) Amphibians, 2) Mammals, 3) Fishes, 4) Birds.

ANSWER: 3, 4, 1, 2 (ACCEPT: FISHES, BIRDS, AMPHIBIANS, MAMMALS)

TOSS-UP

24) ENERGY *Multiple Choice* The Bakken Oil/Gas field is estimated to contain up to 24 billion barrels of oil. In which of the following states, among others, is it located?

W) North Dakota
X) Oklahoma
Y) Pennsylvania
Z) Texas

ANSWER: W) NORTH DAKOTA

BONUS

24) ENERGY *Multiple Choice* A DOE geothermal research project has established the effectiveness of enhanced geothermal systems (EGS) for utilizing geothermal energy for the generation of electricity. Using this approach, which of the following percentages of total U.S. current generating capacity could be generated with EGS?

W) 5%
X)15%
Y) 25%
Z) 50%

ANSWER: Z) 50%

TOSS-UP

25) BIOLOGY *Multiple Choice* Which of the following animals would have the highest levels of myoglobin *[my-uh-GLOH-bin]* in their muscle?

W) American pronghorn
X) Human being
Y) Weddell seal
Z) Kangaroo rat

ANSWER: Y) WEDDELL SEAL

BONUS

25) BIOLOGY *Multiple Choice* Some virus species can infect an individual host more than once because they change the shape of molecules exposed on the surface of their virions *[VY-ree-ons]* so that they are no longer recognized by the host's immunological memory. The influenza virus can make sudden and drastic changes in these molecules due to a phenomenon called reassortment. Which of the following contributes to the process of reassortment?

W) Widely varying strains of influenza
X) The diversity of animals infected by influenza
Y) The segmented genome found in influenza
Z) The lack of effective antivirals against influenza until recently

ANSWER: Y) THE SEGMENTED GENOME FOUND IN INFLUENZA