TOSS-UP

1) Chemistry – *Multiple Choice* Which of the following statements is NOT true regarding d-orbitals?

W) They can overlap to form delta bonds
X) They have an azimuthal quantum number of 3
Y) They possess planar symmetry
Z) They can be involved in metal-ligand bonding

ANSWER: X) THEY HAVE AN AZIMUTHAL QUANTUM NUMBER OF 3

BONUS

1) Chemistry – *Multiple Choice* In which of the following functional groups is sulfur found in the lowest oxidation state?

W) Thiol
X) Sulfone
Y) Sulfoxide
Z) Sulfonamide

ANSWER: W) THIOL

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TOSS-UP

3) Math – *Short Answer* What is the greatest integer x such that $x - 1$ divides $x + 1$?

ANSWER: 3

BONUS

3) Math – *Short Answer* There are seven cowboys, each having a different number of pigs from 0 to 6 inclusive. What is the sample variance of the number of pigs?

ANSWER: 14/3

TOSS-UP

4) Biology – *Short Answer* Identify all of the following three amino acids that commonly destabilize alpha helices: 1) Glycine; 2) Alanine; 3) Leucine.

ANSWER: 1 ONLY

BONUS

4) Biology – *Multiple Choice* Glycosaminoglycans are derivatized carbohydrates containing a high density of negative charges. The negative charges force individual molecules apart, conferring significant lubricity to glycosaminoglycan solutions. In which of the following substances are glycosaminoglycans likely to be found in the highest concentration?

W) Blood
X) Cytosol
Y) Synovial fluid
Z) Cerebrospinal fluid

ANSWER: Y) SYNOVIAL FLUID

TOSS-UP

5) Physics – *Multiple Choice* Which of the following would occur if the earth were reshaped into a perfect sphere without changing its density?

W) The force of gravity would increase at the poles
X) The force of gravity would increase at the equator
Y) The force of gravity would decrease at the equator
Z) The force of gravity would not change anywhere

ANSWER: X) THE FORCE OF GRAVITY WOULD INCREASE AT THE EQUATOR

BONUS

5) Physics – *Short Answer* In an RGB pixel, what color subpixels are illuminated to produce yellow light?

ANSWER: RED AND GREEN

TOSS-UP

6) Energy – *Multiple Choice* Scientists at Argonne National Lab are determining the structure of aminoglycoside residues which play key roles in recognizing certain ribosomes. Which of the following types of ribosomal subunits are found exclusively in eukaryotes?

W) 30S
X) 50S
Y) 70S
Z) 80S

ANSWER: Z) 80S

BONUS

6) Energy – *Short Answer* Researchers at Argonne National Lab and SLAC National Accelerator Lab have been finding solutions to produce a cavity free electron laser able to provide high energy pulses of X rays. In their solution, they utilized what device in order to reach the high repetition rates of the laser via a periodic structure of alternating dipole magnets?

ANSWER: UNDULATOR

TOSS-UP

7) Biology – *Short Answer* Receptor mediated endocytosis relies on clathrin proteins to create coated pits and involute target molecule-filled vesicles. Conversely, what proteins in motor neurons are required for vesicle docking in exocytosis?

ANSWER: SNARE PROTEINS

BONUS

7) Biology – *Multiple Choice* Which of the following molecules is NOT an intermediate in the biosynthesis of cholesterol?

W) Mevalonate
X) Malonyl-CoA
Y) Squalene
Z) HMG-CoA

ANSWER: X) MALONYL-COA

TOSS-UP

8) Physics – *Multiple Choice* Which of the following types of radiation curves most sharply in a magnetic field?

W) Alpha
X) Beta
Y) Gamma
Z) Neutrino

ANSWER: X) BETA

BONUS

8) Physics – *Multiple Choice* Which of the following is true about the root mean square displacement of a particle undergoing Brownian motion?

W) It is proportional to temperature
X) It is proportional to the square of temperature
Y) It is proportional to time
Z) It is proportional to the square root of time

ANSWER: Z) IT IS PROPORTIONAL TO THE SQUARE ROOT OF TIME

TOSS-UP

9) Earth and Space – *Multiple Choice* Which of the following will likely lead to the biggest increase in net primary productivity along a western coast in the Northern Hemisphere?

W) A northerly wind
X) An easterly wind
Y) A southerly wind
Z) A westerly wind

ANSWER: W) A NORTHERLY WIND

BONUS

9) Earth and Space – *Multiple Choice* Which of the following best explains the origin of the helium flash in medium mass red giant stars?

W) The reinitiation of hydrogen fusion in the core produces excess helium, which glows incandescently on a timescale of about 10 years
X) The core mass exceeds the Chandrasekhar limit and leads to a short but intense brightening
Y) After reaching a critical temperature, the inert helium core begins fusion and loses its degeneracy in a short runaway fusion event
Z) Large amounts of helium-4 are produced by the photon-induced splitting of beryllium-8, which produces a tremendous amount of energy and causes a short brightening

ANSWER: Y) AFTER REACHING A CRITICAL TEMPERATURE, THE INERT HELIUM CORE BEGINS FUSION AND LOSES ITS DEGENERACY IN A SHORT RUNAWAY FUSION EVENT

TOSS-UP

10) Chemistry – *Short Answer* Order the following three metals in their +3 oxidation states according to increasing ligand field stabilization energy in their hexa-aquo-complexes: 1) Chromium; 2) Molybdenum; 3) Tungsten.

ANSWER: 1, 2, 3

BONUS

10) Chemistry – *Short Answer* An octahedral titanium centered complex forms with three triphenyl phosphine ligands, two chloride ligands, and one cyanide ligand. Given that the net charge on the complex is +1, determine the electron count on titanium.

ANSWER: 12

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Commented [3]: yes ik it's insane ffs

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TOSS-UP

11) Math – *Short Answer* A coin is flipped 20 times. What is the most likely number of tails flipped?

ANSWER: 10

BONUS

11) Math – *Short Answer* The point (3, 8) undergoes a dilation of a factor of 3 with center of dilation at the point (8, 3). What are the coordinates of the resultant point?

ANSWER: (–7, 18)

TOSS-UP

12) Energy – *Multiple Choice* Researchers at Idaho National Lab are using a neutron radiography reactor to perform neutron tomography. Before the neutrons hit the imaging sample, they must be slowed down by a moderator to produce thermal neutrons. Which of the following is NOT an effective neutron moderator?

W) Xenon-135
X) Heavy water
Y) Graphene
Z) Polyethylene

ANSWER: W) XENON-135

BONUS

12) Energy – *Short Answer* Researchers at Pacific Northwest National Lab are developing models for groundwater flow. In porous strata, groundwater flow can be impeded by what layers of relatively impermeable rock?

ANSWER: AQUITARDS (ACCEPT: AQUICLUDE)

TOSS-UP

13) Biology – *Multiple Choice* Which of the following structures may be found in gametophyte mosses as the threadlike chain of cells that divides?

W) Protonema
X) Integument
Y) Haustoria
Z) Cork cambium

ANSWER: W) PROTONEMA

BONUS

13) Biology – *Short Answer* Identify all of the following three cells that possess MHC class II: 1) Dendritic cell; 2) Killer-T Cell; 3) Virgin B Cell.

ANSWER: 1 AND 3

TOSS-UP

14) Physics – *Multiple Choice* Which of the following fundamental interactions is described by quantum chromodynamics?

W) Electromagnetic
X) Gravitational
Y) Strong
Z) Weak

ANSWER: Y) STRONG

BONUS

14) Physics – *Short Answer* A uniform ball floats freely in a pool of water, with exactly three quarters of its volume immersed. Then, a mystery liquid is poured on top of the pool, so that the ball is entirely below its surface. Now, one quarter of the volume of the ball is immersed in water. What is the specific gravity of the mystery liquid?

ANSWER: 2/3

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TOSS-UP

15) Math – *Short Answer* One of the angles in a parallelogram is 60 degrees. What is the area of the parallelogram if two adjacent sides measure 3 and 4?

ANSWER: 6 ROOT 3

BONUS

15) Math – *Short Answer* What is the least number of local extrema in a quartic polynomial?

ANSWER: 1

TOSS-UP

16) Earth and Space – *Multiple Choice* Which of the following features is indicative of a deposition-dominated coast?

W) Sea stacks
X) Uplifted marine terraces
Y) Sea arches
Z) Barrier islands

ANSWER: Z) BARRIER ISLANDS

BONUS

16) Earth and Space – *Multiple Choice* Which of the following best describes Love seismic waves?

W) Horizontal shear waves at the surface
X) Ripples that propagate via circular motions at the surface
Y) Transverse waves that travel through the Earth
Z) Longitudinal waves that travel through the Earth

ANSWER: W) HORIZONTAL SHEAR WAVES AT THE SURFACE

TOSS-UP

17) Chemistry – *Short Answer* What quantity is given by the partial derivative of enthalpy with respect to temperature?

ANSWER: Cp (ACCEPT: CONSTANT PRESSURE HEAT CAPACITY)

BONUS

17) Chemistry – *Short Answer* Katie prepares a 1 L solution of the divalent cation A with concentration 0.03M. Given the solubility product of ASO_4 to be $4 * 10^{-7}$, to 1 significant digit and in scientific notation, what is the concentration of A^{2+} following the addition of 2 mol of sodium sulfate?

ANSWER: $2*10^{-7}$ ($[M^{2+}] = K_{sp}/[SO_4^{2-}]$; $[SO_4^{2-}] \approx 2$ M)

TOSS-UP

18) Math – *Multiple Choice* Triangle ABC has integer side lengths. Which of the following values must be rational?

W) Sine of angle ABC
X) Cosine of angle ABC
Y) Tangent of angle ABC
Z) Cosecant of angle ABC

ANSWER: X) COSINE OF ANGLE ABC

BONUS

18) Math – *Short Answer* Compute the line integral of $x + y$ over the arc defined by $x^2 + y^2 = 1$ and x and y both greater than 0.

ANSWER: 2

TOSS-UP

19) Physics – *Multiple Choice* A block slides down a large hill, onto a flat surface, and up a smaller hill. Neglecting friction, at which of the following points is the block's gravitational potential energy maximized?

W) When the block has minimal magnitude of velocity
X) When the block has maximal magnitude of velocity
Y) When the block has minimal magnitude of acceleration
Z) When the block has maximal magnitude of acceleration

ANSWER: W) WHEN THE BLOCK HAS MINIMAL MAGNITUDE OF VELOCITY

BONUS

19) Physics – *Multiple Choice* Which of the following quantities is minimized by solutions to the Euler–Lagrange equation?

W) Lagrangian
X) Hamiltonian
Y) Action
Z) Momentum

ANSWER: Y) ACTION

TOSS-UP

20) Earth and Space – *Multiple Choice* Which of the following statements does not accurately describe the ideal Ekman spiral in the Southern Hemisphere?

W) Water at the surface is deflected 45 degrees to the left of prevailing wind direction
X) Deeper water is deflected further to the left relative to water above it by drag forces
Y) The overall Ekman transport is about 90 degrees to the left of prevailing wind direction
Z) The depth of maximum Ekman transport is at about 50 meters deep

ANSWER: Z) THE DEPTH OF MAXIMUM EKMAN TRANSPORT IS AT ABOUT 50 METERS DEEP

BONUS

20) Earth and Space – *Short Answer* Identify all of the following three types of mass-wasting that are coherent: 1) Slump; 2) Rockfall; 3) Earthflow.

ANSWER: 1 AND 3

TOSS-UP

21) Biology – *Multiple Choice* Which of the following techniques would best be used to analyze mRNA?

W) Restriction fragment analysis
X) Northern blotting
Y) SDS-PAGE
Z) UPGMA

ANSWER: X) NORTHERN BLOTTING

BONUS

21) Biology – *Short Answer* The Renin Angiotensin Aldosterone System, or RAAS, is an endocrine pathway initiated in the kidney which is responsible for regulating blood pressure and electrolyte balance in the human body. Identify all of the following three physiological responses that may be incurred by the RAAS system: 1) Increase in blood volume; 2) Increase in blood pressure; 3) Vasodilation.

ANSWER: 1 AND 2

TOSS-UP

22) Energy – *Short Answer* Scientists at Lawrence Livermore National Lab are studying capacitive deionization which is a promising water desalination technology that is effective for removing ionic contaminants. This method is poised to replace what current expensive desalination technique that relies on a hydrostatic pressure to pass water through a selectively permeable membrane?

ANSWER: REVERSE OSMOSIS

BONUS

22) Energy – *Short Answer* Scientists at Idaho National Labs are working to understand the physical and chemical processes in lithium-ion batteries. In particular, they are studying the growth of what harmful structures that reduce the efficiency of these batteries?

ANSWER: DENDRITES

TOSS-UP

23) Chemistry – *Multiple Choice* Two gaseous chlorine radicals are in equilibrium with a single molecule of chlorine gas at standard temperature and pressure. Which of the following statements is correct regarding this reaction?

W) The equilibrium constant for the reaction is close to 1
X) The reaction is endothermic
Y) Adding chlorine radical to the reaction mixture will shift the equilibrium to the left
Z) Increasing the volume of the container will shift the equilibrium to the left

ANSWER: Z) INCREASING THE VOLUME OF THE CONTAINER WILL SHIFT THE EQUILIBRIUM TO THE LEFT

BONUS

23) Chemistry – *Short Answer* Acetals are important functional groups in synthetic organic chemistry. From slowest to fastest, arrange the following three carbonyl-containing molecules according to their rate of acetal formation: 1) Acetaldehyde; 2) Acetone; 3) 2-Butanone.

ANSWER: 3, 2, 1