Assorted Questions 1: RR/Early DE Difficulty

1. TOSS-UP MATH Short Answer Providing your answer in simplest form, what is sec(11π/6)?

ANSWER: 2 SQRT(3)/3

BONUS MATH *Multiple Choice* Which of the following represents all the solutions, in degrees, of the equation 4sin2*x* = 1 in the open interval from 0° to 180°?

W) 30°  
X) 30°, 60°  
Y) 30°, 150°  
Z) 60°, 120°  
ANSWER: Y

1. TOSS-UP PHYSICS Multiple Choice A spaceship moving at 0.9c relative to a stationary observer throws a ball forward. The observer records the ball’s speed as 0.91c. Which of the following statements is TRUE of the ball’s speed relative to the spaceship?

W) The speed of the ball is 0.01c

X) The speed of the ball is zero

Y) The speed of the ball is less than 0.01c but greater than zero

Z) The speed of the ball is greater than 0.01c

ANSWER: Z

BONUS PHYSICS Multiple Choice If an AC circuit incorporating a capacitor, a resistor, and an inductor is operated at its resonant frequency, which of the following must be TRUE?

W) The inductance is proportional to the capacitance

X) The inductance is proportional to the inverse of the capacitance

Y) All three components of the circuit are in phase

Z) The inductor dissipates the maximum amount of power

ANSWER: Y

1. TOSS-UP CHEMISTRY Multiple Choice Which of the following is a mild oxidizing solution that contains silver ions which precipitate out of solution when in contact with aldehydes?

W) Tollens’ Reagent

X) Benedict’s Reagent

Y) Markovnikov’s Reagent

Z) Silver Reagent

ANSWER: W

BONUS CHEMISTRY Multiple Choice Potassium Chromate is slowly added to a solution contain 0.20 M AgNO3 and Ba(NO3)2. Which of the following statements is TRUE?

W) The BaCrO4 precipitates out of solution

X) The Ag2CrO4 precipitates first out of solution, and then the BaCrO4 precipitates

Y) Both BaCrO4 and Ag2CrO4 precipitate simultaneously out of solution

Z) Neither BaCrO4 nor Ag2CrO4 precipitates out of solution

ANSWER: X

1. TOSS-UP MATH *Short Answer* What is the determinant of the 2 by 2 matrix with first row 2, -3 and second row -8, -4?

ANSWER: -32

BONUS MATH *Short Answer* A coin is tossed 10 times. Providing your answer as a fraction in lowest terms, what is the probability that there are 3 heads and 7 tails?

ANSWER: 15/128

1. TOSS-UP BIOLOGY *Multiple Choice* Telomeraseis frequently activated in cancer cells. Which of the following describes the action of telomerase?

W) It cuts the telomeres to make them shorter

X) It inhibits DNA repair

Y) It controls the spindle fibers during cell division

Z) It prevents the telomeres from getting shorter

ANSWER: Z) IT PREVENTS THE TELOMERES FROM GETTING SHORTER

BONUS BIOLOGY *Multiple Choice* Shark livers help with their buoyancy by producing which of the following oily materials?

W) Squalene

X) Isoprene

Y) Oleic acid

Z) Linoleic acid

ANSWER: W) Squalene

1. TOSS-UP ESSC Multiple Choice Which of the following statements is TRUE of the proton-proton chain?

W) The fusion of two protons to produce a deuteron is the slow step

X) A main intermediate of the sequence is tritium

Y) Most of the energy released is in the form of neutrinos

Z) Most of the Helium-3 formed doesn’t react to form Helium-4

ANSWER: W

BONUS ESSC Short Answer When approaching the planet Jupiter, comet Shoemaker Levi-9 fell within this limit, resulting in its disintegration due to tidal forces. What is the name for the radius at which this disintegration took place?

ANSWER: ROCHE LIMIT

1. TOSS-UP MATH Short Answer If a particle has displacement in 1-dimension given the formula s(t) = t^3 + 2t + 1 with t in seconds, when is its velocity equal to zero?

ANSWER: NOWHERE

BONUS MATH Short Answer What point on the function f(x) = x^3 has an instantaneous slope that equals the average slope of the function in the interval (0,3) ?

ANSWER: (sqrt(3), 3sqrt(3))

1. TOSS-UP ENERGY Short Answer The endothermic reaction N2(g) + 2 O2(g) → 2 NO2(g) is at equilibrium. Give, by name or number, the two of the following four statements that are TRUE:
2. ΔS is positive
3. ΔS is negative
4. ΔG is positive
5. ΔG is negative

ANSWER: 2 and 3

BONUS ENERGY Short Answer What theorem in physics states that any differentiable symmetry of the action of a physical system has a corresponding conservation law?

ANSWER: Noether’s Theorem

1. TOSS-UP BIOLOGY Short Answer In cellular conditions, special proteins are often required to help a polypeptide chain fold into its most energetically favored conformation without accidentally associating with other chains and forming protein aggregates. What are these special proteins called?

ANSWER: CHAPERONES (ACCEPT: CHAPERONINS)

BONUS BIOLOGY Short Answer Give, by name or number, all of the following three statements that are true of plant regulation:

1. Phytochrome activates cAMP as a second messenger
2. Zeatin is the most common natural auxin
3. Abscisic acid prevents seeds from germinating within an ovary

ANSWER: 3 ONLY

1. TOSS-UP ENERGY *Multiple Choice* If a utility uses a real-time pricing structure, a residential customer could reduce consumption during the times of peak demand by upgrading all but which of the following?

W) Lighting

X) Air conditioning

Y) Heating

Z) Water heating

ANSWER: W) Lighting

BONUS ENERGY Short Answer Which of the following statements is TRUE regarding the Haber Process?

W) The catalyst used is a mixture of Platinum and Rhodium

X) The reaction is run at a low temperature of 25 C to increase the equilibrium constant

Y) Ammonia produced is used to produce nitric acid in the Ostwald Proccess

Z) Most of the nitrogen used is not isolated from the atmosphere

ANSWER: Y

1. TOSS-UP BIOLOGY Multiple Choice Which of the following proteins in signal transduction are high-affinity cellular receptors which dimerize and autophosphorylate aromatic amino acid residues in the intracellular domain when activated from outside the plasma membrane?

W) G-Protein Coupled Receptors

X) Receptor Tyrosine Kinases

Y) NO Receptors

Z) Ca2+ Receptors

ANSWER: X

TOSS-UP BIOLOGY Multiple Choice Which of the following is the best example of the Allee effect in population ecology?

W) A species nearing its carrying capacity observes a reduction in population growth

X) A k-selected species observes logistic population growth

Y) An r-selected species observes a low reproduction rate after many cycles

Z) A small population observes a proportionality between growth rate and population density

ANSWER: Z

1. TOSS-UP MATH Multiple Choice Assume that a line passes through the point (5,5) and has a positive y-intercept and a negative x-intercept. Which of the following could be a point that the line passes through?

W) (5,7)

X) (1,-1)

Y) (7,6)

Z) (6,7)

ANSWER: Z

BONUS MATH Short Answer What is the only critical point of the function f(x) = x ln(x)?

ANSWER: (1/e, -1/e)

1. TOSS-UP ENERGY Multiple Choice Which of the following statements is FALSE regarding Solar Energy?

W) The current theoretical maximum efficiency for Silicon Photovoltaic is about 29%

X) Solar insolation is approximately 1100 W/m2

Y) Solar thermal energy is generally less efficient that PV

Z) Solar thermal energy is generally less feasible on a large scale than PV

ANSWER: Y

BONUS ENERGY Short Answer Give, by name or number, all of the following three statements that is/are TRUE of hydropower:

1. Hydropower currently accounts for 12% of the US power output
2. Ampere’s Law is used to produce electricity from motion of the turbine
3. Loss of forests make conventional hydropower not entirely carbon-neutral

ANSWER: 1 and 3

1. TOSS-UP MATH Multiple Choice Which of the following correctly solves the differential equation y’’ = -y ?

W) An exponential function

X) A sine function

Y) A log function

Z) A polynomial function

ANSWER: X

BONUS MATH Short Answer Given that f(x) is continuous and twice differentiable on the closed interval *I*, and given that f(x) has at least 4 relative extrema on I, how many roots are guaranteed on *I* for the second derivative of f(x)?

ANSWER: 3

1. TOSS-UP CHEMISTRY Short AnswerGive, by name or number, all of the following three statements that are TRUE of activation energy:
2. The Arrhenius equation relates activation energy to temperature
3. Changing the activation energy of a reaction changes its rate
4. A change in activation energy corresponds to a change in transition state structure

ANSWER: ALL OF THEM

BONUS CHEMISTRY Multiple Choice Which of the following molecules is used by C4 plants, in the NADP- ME pathway, to move fixed carbon from the bundle-sheath cells to the mesophyll, where it is oxidized to pyruvate to repeat the cycle?

W) Citrate

X) Oxaloacetate

Y) Malate

Z) Phosphoenolpyruvate

ANSWER: Y

1. TOSS-UP PHYSICS Multiple Choice Which of the following constants does not necessarily actually stay constant, according to current accepted models of physics?

W) Hubble’s constant

X) Fine structure constant

Y) Mass of top quark

Z) Big G

ANSWER: W: Hubble’s constant

BONUS PHYSICS Short Answer If the scattering intensity of light after passing through a cuvette of gas is A, then what is the scattering intensity of light of three times the frequency, if the primary mechanism of scattering is Rayleigh scattering?

ANSWER: 81A

1. TOSS-UP ESSC Short Answer When an alpine glacier near a coastal area disappears and the sea invades the resulting trough, a deep, steep-sided inlet is fomed. What is the name of this inlet?

ANSWER: FJORD

BONUS ESSC Multiple Choice If the sun sets at 6 PM and the moon rises three hours later, what phase is the moon in?

W) First Quarter

X) Waning Gibbous

Y) Waxing Gibbous

Z) Waning Crescent

ANSWER: X

1. TOSS-UP PHYSICS Multiple Choice Which of the following is ALWAYS TRUE of a one-dimensional collision where two objects with the same mass collide at different velocities?

W) Kinetic Energy is conserved throughout the collision

X) Both objects will move in the direction of the initially faster object

Y) Both objects will move in opposite directions

Z) The sum of the velocity vectors before and after the collision is identical

ANSWER: Z

BONUS PHYSICS Multiple Choice Secretary Chu is riding his bicycle through a ramp that has a vertical loop. If the mass of him and his bicycle is 100 kg and the radius of the loop is 5 m, which of the following is closest to the minimum speed he needs at the start of the loop to remain on the loop at the top?

W) 5 m/s

X) 7 m/s

Y) 10 m/s

Z) 20 m/s

ANSWER: X

1. TOSS-UP ENERGY Multiple Choice Which of the following statements is FALSE regarding cellular metabolism?

W) Aldolase catalyzes the degradation of fructose-1,6-bisphosphate into G3P and DHAP

X) The link reactions to the Krebs Cycle involve a decarboxylation reaction

Y) The Pentose Phosphate pathway is essential to production of precursors of nucleic acids

Z) The ETC produces mainly superoxide radicals as a byproduct of metabolism

ANSWER: Z

BONUS ENERGY Short Answer Name the famous enzyme in the Krebs cycle that contains an iron-sulfur cluster of unknown use and catalyzes the reaction that converts citrate into isocitrate.

ANSWER: ACONITASE

1. TOSS-UP ESSC Multiple Choice What type of fog would one expect to form as cold air settles above a warm body of water or land, such as on Lake Ontario during the wintertime?

W) radiation fog

X) advection fog

Y) steam fog

Z) valley fog

Answer: Y) steam fog

BONUS ESSC Multiple Choice What type of interstellar medium component is hot and dense, can be recognized through its distinctive H-alpha lines, and can promote star formation?

W) HI clouds

X) HII clouds

Y) coronal gas

Z) molecular gas

ANSWER: X

1. TOSS-UP BIOLOGY *Multiple Choice* Most bactericidal antibiotics that act by inhibiting transpeptidases, such as penicillins and cephalosporins, are most active when bacteria are in which of the following phases?

W) Lag phase  
X) Log phase  
Y) Stationary phase  
Z) Death phase

ANSWER: X–LOG PHASE

BONUS BIOLOGY Short Answer What form of cancer is treatable by Gleevec, is slow-growing, and is a result of the Bcr-Abl fusion gene?

ANSWER: Chronic Myelogenous Leukemia (ACCEPT: CML)

1. TOSS-UP CHEMISTRY Short Answer What is the molecular geometry and hybridization of the central Sulfur atom in the compound Sulfur Tetrafluoride, or SF4?

ANSWER: SEE-SAW AND *dsp3*

BONUS CHEMISTRY Short Answer Give, by name or number, all of the following THREE statements that are TRUE of coordination-compounds.

1. Tetrahedral splitting is greater than octahedral splitting in magnitude
2. Strong-field ligands generally increase the splitting of a complex
3. Octahedral coordination compounds cannot possess chirality

ANSWER: 2 ONLY

1. TOSS-UP ESSC Short Answer Give, by name or number, all of the following four features that would be indicative of previous glacial activity:
2. Erratics
3. Paternoster Lakes
4. V-Shaped Valleys
5. Oxbow Lakes

ANSWER: 1 and 2

BONUS ESSC Short Answer What stars are evolved massive stars above 20 solar masses that lose mass rapidly through a stellar wind at a rate of approximately 10-5 solar masses per year?

ANSWER: Wolf-Rayet Stars

1. TOSS-UP CHEMISTRY Short Answer What reaction mechanism occurs in the dehydration of isopropanol, where an oxonium ion decays into a carbocation, which is deprotonated by base to form the propene product?

ANSWER: E1 (ACCEPT: ELIMINATION 1, ELIMINIATION UNIMOLECULAR)

BONUS CHEMISTRY Short Answer Organize the following ions in order of increasing ability as a leaving group, from the worst leaving group to the best leaving group:

1. Iodide
2. Fluoride
3. Chloride
4. Hydroxide

ANSWER: 4, 2, 3, 1

1. TOSS-UP PHYSICS Short Answer Give, by name or number, all of the following statements that is TRUE of the application of Ampere’s Circuital Law:
2. The magnetic field a distance *r* from a wire is directly proportional to 1 over *r*
3. The number of turns in a solenoid is independent of the strength of its magnetic field
4. Two wires carrying a current in the same direction will attract each other

ANSWER: 1 AND 3

BONUS PHYSICS Multiple Choice On a frictionless 2D surface, a block of mass *M* moving at speed *v* collides elastically with another block of the same mass *M* that is initially at rest. After the collision, the first block moves at an angle *θ* to its initial direction and has a speed *v*/2. The second block’s speed after the collision is which of the following?

W) SQRT(3) *v*/4

X) *v*/4

Y) SQRT(3) *v*/2

Z) *v*/2

ANSWER: Y