

ROUND 12A

TOSS-UP

1) Math – *Short Answer* If the radius of a right circular cylinder is doubled, by what factor must the height be multiplied in order to keep the volume the same?

ANSWER: $\frac{1}{4}$

BONUS

1) Math – *Short Answer* Find an antiderivative with respect to x for the fraction with numerator e^{2x} and denominator $1 + e^{4x}$.

ANSWER: $\frac{1}{2} \arctan e^{2x}$ (ACCEPT: $\frac{1}{2} \arctan e^{2x} + C$ for any constant C)

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### TOSS-UP

2) Physics – *Multiple Choice* In order for a process to have no change in entropy, which of the following properties must it possess?

- W) Spontaneous
- X) Reversible
- Y) Endothermic
- Z) Exothermic

ANSWER: X) REVERSIBLE

### BONUS

2) Physics – *Short Answer* A circular coil consisting of 100 loops has a cross-sectional area of 0.005 meters squared and a resistance of 3 ohms. If a time-varying magnetic field  $B$  is oriented parallel to the axis of the coil, what is the magnitude of the rate of change of  $B$  that induces a 2.0 ampere current along the wire?

ANSWER: 12

### TOSS-UP

3) Earth and Space – *Multiple Choice* Which of the following is a cloud type that, by definition, produces precipitation?

- W) Stratocumulus
- X) Altostratus
- Y) Nimbostratus
- Z) Altocumulus

ANSWER: Y) NIMBOSTRATUS

### BONUS

3) Earth and Space – *Multiple Choice* Which of the following explains why the number and intensity of wave cyclones is greatest during the late fall, winter and spring months?

- W) Air is drier
- X) Density of the air is greatest
- Y) Temperature contrasts are greater
- Z) Temperatures are below freezing

ANSWER: Y) TEMPERATURE CONTRASTS ARE GREATER

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TOSS-UP

4) Chemistry – *Multiple Choice* Which of the following is not true of oxalic acid?

- W) It is a diprotic acid
- X) It can be oxidized to carbon dioxide
- Y) It contains three oxygen atoms per molecule
- Z) It contains two carbon atoms per molecule

ANSWER: Y) IT CONTAINS THREE OXYGEN ATOMS PER MOLECULE

BONUS

4) Chemistry – *Short Answer* If the equilibrium constant, K , for the reaction $A \rightarrow B$ is 2.0×10^{-5} , then what is the equilibrium constant for the reaction $2B \rightarrow 2A$?

ANSWER: 2.5×10^9

TOSS-UP

5) Biology – *Multiple Choice* Which of the following is NOT a characteristic of chordates?

- W) Notochord
- X) Pharyngeal slits [*fahr-in-jee-uhl*]
- Y) Radial symmetry
- Z) Post-anal tail

ANSWER: Y) RADIAL SYMMETRY

BONUS

5) Biology – *Short Answer* What type of enzyme, produced as part of bacterial immunity against viruses, recognizes palindromic sites on foreign DNA and cleaves them?

ANSWER: RESTRICTION ENZYME

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### TOSS-UP

6) Energy – *Short Answer* What is the thermodynamic cycle that describes the functioning of a sparkless fuel injection piston engine and can be found in certain types of automobiles?

ANSWER: DIESEL CYCLE

### BONUS

6) Energy – *Short Answer* What is the name given to organisms that can use either fermentation or respiration to produce enough ATP to survive?

ANSWER: FACULTATIVE ANAEROBES

### TOSS-UP

7) Math – *Short Answer* A Diophantine equation is a polynomial equation in two or more variables such that the solutions are what type of number?

ANSWER: INTEGERS

### BONUS

7) Math – *Short Answer* If  $x$  is measured in radians, find all values of  $x$  between zero and  $2\pi$  that satisfy the equation  $\sin^2 x = 2 \cos^4 x$ .

ANSWER:  $\pi/4, 3\pi/4, 5\pi/4, 7\pi/4$

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TOSS-UP

8) Physics – *Multiple Choice* The half-life of substance X is 45 years and decomposes to substance Y. A sample from substance Z was taken which contained 1.5% of X and 13.5% of Y by mass. If substance Y is not normally found in substance Z, which of the following is the best estimate of the age, in years, of substance Z?

- W) 45
- X) 100
- Y) 140
- Z) 270

ANSWER: Y) 140

BONUS

8) Physics – *Short Answer* What substance, first postulated by Fritz Zwicky, is thought to be responsible for aberrations between theorized and observed orbital velocities of galaxies?

ANSWER: DARK MATTER

TOSS-UP

9) Earth and Space – *Short Answer* What is the name for the non-dimensional, unitless quantity that indicates how well a surface reflects solar energy?

ANSWER: ALBEDO

BONUS

9) Earth and Space – *Multiple Choice* Which of the following is NOT true regarding the ocean floor?

- W) Continental shelves generally overlay oceanic crust
- X) The continental shelf tends to be fairly featureless
- Y) Continental shelves represent less than 10% of the total ocean area
- Z) Continental shelves are saturated with water

ANSWER: W) CONTINENTAL SHELVES GENERALLY OVERLAY OCEANIC CRUST

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### TOSS-UP

10) Chemistry – *Multiple Choice* Which of the following statements is true for an ideal solution?

- W) The enthalpy of solution is exothermic
- X) The vapor pressure of the solution is directly proportional to the molality of the solvent
- Y) Solvent particles interact more strongly with solute particles than other solvent particles
- Z) Raoult's [*rah-oolt's*] Law is obeyed

ANSWER: Z) RAOULT'S LAW IS OBEYED

### BONUS

10) Chemistry – *Multiple Choice* The rate-limiting step for a reaction involving Reactant X is  $X + X \rightarrow Y$ , where Y is a product. Which of the following quantities plotted against time would produce a straight line?

- W) One over molarity of X
- X) Molarity of X
- Y) Natural log of the molarity of X
- Z) Molarity of X squared

ANSWER: W) ONE OVER MOLARITY OF X

### TOSS-UP

11) Biology – *Short Answer* Identify all of the following three choices that represent dangers to biodiversity: 1) Allowing fallow farmland to regrow with weeds; 2) Importing an Australian moth to deal with pests on farmland; 3) Relocating mountain lions that have moved into human habitats.

ANSWER: 2

### BONUS

11) Biology – *Multiple Choice* In which of the following organisms would you most likely be able to find contractile vacuoles?

- W) Cytomegalovirus
- X) E. coli
- Y) Paramecium
- Z) Xenopus [*zee-noh-pus*]

ANSWER: Y) PARAMECIUM



### TOSS-UP

12) Math – *Short Answer* For what values of  $x$  does the function  $f(x) = \frac{x-2}{x^2-4}$  have a vertical asymptote?

ANSWER: -2

### BONUS

12) Math – *Short Answer* Evaluate the following definite integral: the integral from  $x = -3$  to  $0$  of the square root of open parenthesis  $9 - x^2$  close parenthesis  $dx$ .

ANSWER:  $(9\pi)/4$  (ACCEPT:  $2.25\pi$ )

### TOSS-UP

13) Physics – *Short Answer* What type of early particle accelerator, invented in the 1930s, consists of an evacuated chamber inside of a uniform magnetic field in which particles orbit circularly in and out of D-shaped conductors?

ANSWER: CYCLOTRON

### BONUS

13) Physics – *Short Answer* An ideal refrigerator absorbs heat at  $-23^{\circ}$  Celsius and exhausts it at  $27^{\circ}$  Celsius. Find its coefficient of performance to the nearest integer.

ANSWER: 5

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TOSS-UP

14) Earth and Space – *Short Answer* Detecting signatures of gravitational waves on the cosmic microwave background would lend support to what theory first proposed by Alan Guth?

ANSWER: INFLATION

BONUS

14) Earth and Space – *Multiple Choice* What causes clouds of matter to flatten during the development of a protostar?

- W) Rotation
- X) Energy release
- Y) Gravity
- Z) Diffusion

ANSWER: W) ROTATION

TOSS-UP

15) Energy – *Short Answer* What is the energy range in a solid where no electron states can exist called?

ANSWER: BAND GAP (ACCEPT: ENERGY GAP)

BONUS

15) Energy – *Short Answer* What type of compression, found in the Rankine and Otto cycles, compresses the gas without removing any heat from it?

ANSWER: ADIABATIC

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### TOSS-UP

16) Chemistry – *Multiple Choice* Which of the following is true concerning a chemical system at a state of dynamic equilibrium?

- W) Forward and reverse rate constants are both equal to one
- X) Change in enthalpy for the reaction at standard state is zero
- Y) Change in Gibbs free energy is zero
- Z) Molar entropy of products minus molar entropy of reactants is zero

ANSWER: Y) CHANGE IN GIBBS FREE ENERGY IS ZERO

### BONUS

16) Chemistry – *Short Answer* Approximating copper (II) chloride's molar mass as 133 grams per mole, and assuming that the boiling point elevation constant for water is 0.5 degrees Celsius per molal, calculate the boiling point in degrees Celsius to one decimal place of a solution prepared by dissolving 80 grams of copper (II) chloride in 1 kilogram of water.

ANSWER: 100.9



**TOSS-UP**

17) Math – *Short Answer* If the difference between two prime numbers is 11, what is their sum?

ANSWER: 15

**BONUS**

17) Math – *Short Answer* What is the largest prime factor of the quantity  $4^{2013} + 4^{2014} + 4^{2015}$ ?

ANSWER: 7



**TOSS-UP**

18) Biology – *Short Answer* Complete beta oxidation of odd-numbered saturated fatty acids requires what vitamin that is not required for the beta oxidation of even-numbered saturated fatty acids?

ANSWER: VITAMIN B-12 (Accept: COBALAMIN)

**BONUS**

18) Biology – *Short Answer* Identify all of the following three choices that are pieces of evidence that lend credence to the endosymbiotic theory: 1) Chloroplasts contain their own genomes; 2) Mitochondria contain bacteria-like ribosomes; 3) All mitochondrial proteins are synthesized in the nucleus.

ANSWER: 1 AND 2

### TOSS-UP

19) Physics – *Short Answer* Identify all of the following three statements that explain why the actual acceleration due to gravity at any point on the Earth's surface would be different from the value calculated for that point via Newton's Law of Gravitation: 1) The Earth's mass is not uniformly distributed; 2) The Earth is not perfectly spherical; 3) The Earth is rotating.

ANSWER: 1, 2, AND 3

### BONUS

19) Physics – *Short Answer* A rollercoaster cart slides down a frictionless track and then goes around the inside of a loop-the-loop with radius R. In terms of R, what is the minimum height the rollercoaster cart must start at in order to just make it around the loop?

ANSWER: 2.5R

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TOSS-UP

20) Energy – *Short Answer* The breakdown of glycogen as a source of energy involves the conversion of glycogen to glucose-6-phosphate monomers, which then enter glycolysis. What intermediate is produced by the breakdown of glycogen, that is then converted to glucose-6-phosphate?

ANSWER: GLUCOSE-1-PHOSPHATE (ACCEPT: ALPHA-D-GLUCOSE-1-PHOSPHATE)

BONUS

20) Energy – *Multiple Choice* Which of the following is NOT true of the citric acid cycle?

- W) FADH₂ is produced by the oxidation of succinate
- X) The conversion of malate to oxaloacetate produces NADH
- Y) The production of succinate results in the release of Coenzyme A
- Z) The citric acid cycle produces 4 NADH and 1 FADH₂ per turn

ANSWER: Z) THE CITRIC ACID CYCLE PRODUCES 4 NADH AND 1 FADH₂ PER TURN

TOSS-UP

21) Biology – *Short Answer* What are the mating structures of basidiomycetes [*bah-sid-ee-oh-mye-seets*] called?

ANSWER: MUSHROOMS (ACCEPT: BASIDIOCARPS)

BONUS

21) Biology – *Short Answer* What largely parasympathetic nerve innervates the heart and is responsible for slowing down heart rate and lowering ventricular contractility when in a “rest and digest” state?

ANSWER: VAGUS NERVE (ACCEPT: CN X, CRANIAL NERVE TEN)



TOSS-UP

22) Earth and Space – *Short Answer* Pompeii was destroyed by what volcanic phenomenon, sometimes called “glowing avalanches?”

ANSWER: PYROCLASTIC FLOW (ACCEPT: NUÉE ARDENTE)

BONUS

22) Earth and Space – *Short Answer* What soil horizon is the loosest and is characterized by partly decayed organic matter?

ANSWER: O HORIZON

TOSS-UP

23) Chemistry – *Short Answer* What group 14 element has the highest melting point?

ANSWER: CARBON

BONUS

23) Chemistry – *Short Answer* Identify all of the following three statements concerning electrochemistry that are true: 1) A Faraday is the number of coulombs of charge generated by 1 mole of electrons; 2) The oxidation of copper into copper(II) ions can spontaneously drive the reduction of protons into hydrogen gas at standard state; 3) The oxidation of zinc into zinc(II) ions can spontaneously drive the reduction of protons into hydrogen gas at standard state.

ANSWER: 1 AND 3