

## ROUND 7

### TOSS-UP

1) Biology – *Short Answer* Which of the following four statements are true of cytoplasmic determinants during embryogenesis?

- 1) They are encoded solely by maternal genes
- 2) They are found in the cytoplasm of all germ cells
- 3) They are homogenous in the cytoplasm
- 4) They regulate gene expression and differentiation

ANSWER: 1 AND 4

### BONUS

1) Biology – *Short Answer* Beginning with a  $2n$  zygote, order the following four stages of the fungal life cycle.

- 1) Germination
- 2) Karyogamy
- 3) Meiosis
- 4) Plasmogamy

ANSWER: MEIOSIS, KARYOGAMY, GERMINATION, PLASMOGAMY (3, 2, 1, 4)

### TOSS-UP

2) Math – *Short Answer* Find the area of the region bounded by the curves y equals x squared and y equals 4 times x.

ANSWER: 32/3

### BONUS

2) Math – *Multiple Choice* Which of the following matrix operations is equivalent to transposing a matrix and then taking its conjugate?

W) Inverse

- X) Adjoint
- Y) Rotation
- Z) Eigenvalue

ANSWER: X) Adjoint

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### TOSS-UP

3) Physics – *Short Answer* Identify all of the following four charge distributions that have an electric potential function that is inversely proportional to the distance from the center: 1) A point charge, 2) An infinite line of charge, 3) An infinite plate of charge, 4) Inside a conducting sphere

ANSWER: 1 ONLY

### BONUS

3) Physics – *Short Answer* An infinitely long rod with a charge density of 4 Coulombs per meter. If the rod is moving at 3 meters per second, what is the magnitude of the magnetic field 6 meters away from the wire, in nanoteslas?

ANSWER: 400, 400 nanoteslas

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### TOSS-UP

4) Chemistry – *Multiple Choice* Which of the following compounds readily form highly reactive free radical species that initiate a polymerization reaction?

- W) Ketones
- X) Peroxides
- Y) Alcohols
- Z) Aldehydes

Answer: X) Peroxides

### BONUS

4) Chemistry -- *Multiple Choice* Which of the following is closest to the pKa of an alpha hydrogen of a beta diketone?

- W) 5

- X) 9
- Y) 13
- Z) 17

ANSWER: X) 9

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### TOSS-UP

5) Earth and Space – *Short Answer* Order the following four layers of an ophiolite from shallowest to deepest: 1) Sheeted Dikes; 2) Gabbro; 3) Pillow Lavas; 4) Peridotite;

ANSWER: 3, 1, 4, 2 [SP]

### BONUS

5) Earth and Space – *Short Answer* What is the redshift of a star that is moving away from a viewer at 0.75c in radical form?

ANSWER:  $\sqrt{7} - 1$  [SP]

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### TOSS-UP

6) Earth and Space – *Multiple Choice* The earth experiences glacial maximums consistently almost every 100,000 years. Which of the following changes are the major contributing factor to this phenomenon?

- W) Axial Precession
- X) Axial Obliquity
- Y) Sunspot Cycle
- Z) Eccentricity

ANSWER: Z) ECCENTRICITY [SP]

### BONUS

6) Earth and Space – *Short Answer* If the environmental lapse rate is greater than the dry adiabatic lapse rate, what atmospheric condition has occurred?

ANSWER: ABSOLUTE INSTABILITY [SP]

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**TOSS-UP**

7) Physics – *Multiple Choice* The bright point in the center of a circular object's shadow is called the Arago spot. This effect occurs due to what physical phenomenon?

- W) Refraction
- X) Reflection
- Y) Diffraction
- Z) Dispersion

ANSWER: Y) Diffraction

**BONUS**

7) Physics – *Short Answer* For a circuit consisting of an initially charged capacitor and an inductor, charge oscillates between the capacitor and the inductor. If the capacitor has capacitance  $4\pi$  milli Farads and the inductor has inductance  $16\pi$  milli Henries, what is the period of the oscillation of charge between the capacitor and inductor, to the nearest hundredth of a second?

ANSWER: 0.16, 0.16 seconds

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**TOSS-UP**

8) Chemistry – *Short Answer* Which rule conveys that no two electrons can have the same set of quantum numbers in an atom?

Answer: Pauli Exclusion Principle

**BONUS**

8) Chemistry -- *Short Answer* In a Jablonski diagram, what radiationless transition occurs between electronic states of the same spin multiplicity?

ANSWER: INTERNAL CONVERSION

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**TOSS-UP**

9) Biology – *Short Answer* Keshav pickaxed a fetus with a gestational age of 20 weeks, spilling blood everywhere. Which hematopoietic organ most likely produced this spilled blood?

ANSWER: LIVER (ACCEPT: SPLEEN)

### BONUS

9) Biology – *Multiple Choice* Which of the following diseases is most likely caused due to neural crest cells failing to migrate completely during fetal development?

- W) Thalassemia, which is caused by body not producing sufficient hemoglobin
- X) Hirschsprung disease, which is caused by missing enterochromaffin cells in the gut
- Y) Spina bifida, which is caused by incomplete closure of the neural tube
- Z) Cerebral palsy, which is caused by abnormal brain development, often before birth

ANSWER: X) HIRSCHSPRUNG DISEASE, WHICH IS CAUSED BY MISSING ENTEROCHROMAFFIN CELLS IN THE GUT

### TOSS-UP

10) Math – *Multiple Choice* Which of the following theorems permit interchanging the order of integration for double integrals over a region?

- W) Green's Theorem
- X) Stokes' Theorem
- Y) Fubini's Theorem
- Z) Taylor's Theorem

ANSWER: Y) Fubini's Theorem

### BONUS

10) Math – *Short Answer* How many binary sequences of length 10 have no two consecutive zeroes?

ANSWER: 144

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### TOSS-UP

11) Earth and Space – *Multiple Choice* In which of the following time frames does Venus appear the brightest to us?

- W) When its phase is full
- X) When it is at superior conjunction
- Y) About a month before or after inferior conjunction
- Z) When it is at opposition

ANSWER: Y) ABOUT A MONTH BEFORE OF AFTER INFERIOR CONJUNCTION [SP]

### BONUS

11) Earth and Space – *Multiple Choice* Which of the following is the only other object in the solar system apart from Earth known to harbor hydrothermal activity?

- W) Io
- X) Callisto
- Y) Enceladus
- Z) Triton

ANSWER: Y) ENCELADUS [SP]



### TOSS-UP

12) Math – *Multiple Choice* A student wants to conduct a hypothesis test to compare two fertilizers. Specifically, to see if either fertilizer is more effective than the other. Which of the following best describes her hypothesis test if she uses a 5% significance level?

- W) One-tailed with 90% equivalent confidence
- X) One-tailed with 95% equivalent confidence
- Y) Two-tailed with 90% equivalent confidence
- Z) Two-tailed with 95% equivalent confidence

ANSWER: Y) Two-tailed with 90% equivalent confidence

### BONUS

12) Math – *Short Answer* Identify all of the following three random variables that are Gaussian or nearly Gaussian:

- 1) The sum of two Gaussian random variables
- 2) The product of two Gaussian random variables
- 3) The sum of squares of two Gaussian random variables

ANSWER: 1 ONLY

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**TOSS-UP**

13) Chemistry – *Multiple Choice* Which of the following elements has a green flame test color?

- W) Sodium
- X) Barium
- Y) Strontium
- Z) Rubidium

Answer: X) Barium

**BONUS**

13) Chemistry -- *Multiple Choice* If Potassium Tertbutoxide is used as a reagent in the elimination of 2-bromo, 3-phenyl propane, what is the IUPAC name of the resulting major product

Answer: 3-phenyl, 1-propene

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**TOSS-UP**

14) Physics – *Multiple Choice* A circuit consisting of a charged capacitor, lightbulb, and an inductor is originally open. What could exactly describe the current going through the lightbulb after the circuit is closed?

- W) Exponential Increase
- X) Exponential Decrease
- Y) Simple Harmonic Oscillation
- Z) Constant

ANSWER: X) Exponential Decrease

### BONUS

14) Physics – *Multiple Choice* Analogies are commonly seen when studying physics. In a circuit consisting of a resistor, inductor, and capacitor, the inductor is analogous to what element in a spring-mass-block system?

- W) Spring Constant
- X) Mass
- Y) Displacement
- Z) Damping Force

ANSWER: X) Mass



### TOSS-UP

15) Biology – *Multiple Choice* Which of the following statements is best supported by the ecological species concept?

- W) *E. Coli* and *D. immitis* are different species since they usually infect different hosts
- X) *Canis lupus* and *Homo sapiens* are different species since they have different morphologies
- Y) *E. Coli* and *D. immitis* are different species since they cannot produce viable offspring
- Z) *Canis lupus* and *Homo sapiens* are in the same domain since they are in the same kingdom

ANSWER: W) *E. COLI* AND *D. IMMITIS* ARE DIFFERENT SPECIES SINCE THEY USUALLY INFECT DIFFERENT HOSTS

### BONUS

15) Biology – *Multiple Choice* Which of the following best exemplifies an example of an exaptation?

- W) Darwin's finches adapted different beaks, but their structure depended on their diet
- X) Owls eyes evolved larger concentration of rods to help with nocturnal hunting
- Y) Feathers evolved for insulation, but over time co-opted for flight
- Z) Cavefish evolved eyes, but they evolved to subsequently degenerate after development

ANSWER: Y) FEATHERS EVOLVED FOR INSULATION, BUT OVER TIME CO-OPTED FOR FLIGHT



### TOSS-UP

16) Biology – *Short Answer* Which subgroup of proteobacteria lives in close association with eukaryotes and includes *Rhizobium* and *Agrobacterium*?

ANSWER: ALPHAPROTEOBACTERIA (ACCEPT: ALPHA)

### BONUS

16) Biology – *Multiple Choice* Which of the following culture media is characterized by containing natural compounds of which precise chemical compositions aren't known, and may vary between batches, thus affecting the process reproducibility?

- W) Defined media
- X) Differential media
- Y) Selective media
- Z) Complex media

ANSWER: Z) COMPLEX MEDIA

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### TOSS-UP

17) Earth and Space – *Multiple Choice* Which of the following types of rock are the Lunar Highlands primarily composed of?

- W) Basalt
- X) Gabbro
- Y) Anorthosite
- Z) Migmatite

ANSWER: Y) ANORTHOSITE [SP]

### BONUS

17) Earth and Space – *Short Answer* What type of melting occurs due to the upward movement of mantle and the rapid decrease in pressure caused by it?

ANSWER: DECOMPRESSION MELTING [SP]

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### TOSS-UP

18) Chemistry – *Multiple Choice* When compared to insulators, what is the the band gap in semiconductors

- W) The band gap in semiconductors is smaller than that in insulators
- X) The band gap in insulators is smaller than that in semiconductors
- Y) The band gap difference depends on the element
- Z) The band gap in semiconductors and insulators is the same

Answer: W) The band gap in semiconductors is smaller than those in insulators

18) Chemistry -- *Multiple Choice* What is not one of the differences between p-type and n-type semiconductors

- W) The number of free electrons available
- X) Conductivity level
- Y) Size of band gap
- Z) None of the above

Answer: Z) None of the above



### TOSS-UP

19) Physics – *Multiple Choice* An infinite conducting plate and a point charge are placed 5 meters apart. At a point 10,000 meters away on the perpendicular line connecting the plate and the charge, the electric field is proportional to what power of distance to the plate?

ANSWER: -3

### BONUS

19) Physics – *Short Answer* A solid sphere has a moment of inertia about its central axis of 10 kg m<sup>2</sup> (Read: kilogram times meters squared). If the radius of this sphere is tripled while keeping its density constant, what will be the new moment of inertia of the sphere, in kg m<sup>2</sup> (Read: kilogram times meters squared)?

ANSWER: 2430, 2430 kg m<sup>2</sup>

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### TOSS-UP

20) Math – *Short Answer* Determine all of the following three pairs of vectors that are linearly independent:

- 1) open bracket, 2 comma 3, close bracket and open bracket, 3 comma -2, close bracket
- 2) open bracket, 3 comma 5, close bracket and open bracket, 6 comma 10, close bracket
- 3) open bracket, 4 comma 6, close bracket and open bracket, 2 comma 3, close bracket

ANSWER: 1 ONLY

### BONUS

20) Math – *Short Answer* Sequence  $a$  is defined by a sub  $n$  equals 1 over open parenthesis,  $n$  squared plus  $n$ , close parenthesis for  $n$  greater than 0. What is the sum of the first 100 terms of this sequence?

ANSWER: 100/101

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