

ROUND 5A

TOSS-UP

1) Chemistry – *Short Answer* In electrochemistry, what equation, named for the 1920 Nobel prize winner in chemistry, gives the redox potential of a galvanic cell as a function of temperature, the reaction quotient, and standard redox potential?

ANSWER: NERNST EQUATION

BONUS

1) Chemistry – *Short Answer* What is the chemical formula for hypophosphorous [*high-poh-fos-fohr-uhs*] acid?

ANSWER: H_3PO_2

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### TOSS-UP

2) Earth and Space – *Multiple Choice* The sun produces energy by what conversion of atomic nuclei?

- W) Hydrogen to helium
- X) Helium to hydrogen
- Y) Oxygen to carbon dioxide
- Z) Dioxide to oxygen

ANSWER: W) HYDROGEN TO HELIUM

### BONUS

2) Earth and Space – *Short Answer* Most sinkholes are caused when what type of sedimentary rock is dissolved?

ANSWER: LIMESTONE

### TOSS-UP

3) Energy – *Short Answer* What process, first proposed by Peter Mitchell, is the movement of protons across a selectively permeable membrane that is coupled to ATP production in respiring animal and plant cells?

ANSWER: CHEMIOSMOSIS

### BONUS

3) Energy – *Short Answer* What stage of aerobic cellular respiration is most closely associated with the mitochondrial matrix?

ANSWER: KREBS CYCLE (ACCEPT: TRICARBOXYLIC ACID CYCLE, CITRIC ACID CYCLE)

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TOSS-UP

4) Physics – *Multiple Choice* You have three equivalent resistors with which to make a circuit. Which of the following combinations would have the least total resistance?

- W) All three resistors in series
- X) All three resistors in parallel
- Y) Two resistors in series to each other and in parallel with the third
- Z) Two resistors in parallel to each other and in series with the third

ANSWER: X) ALL THREE RESISTORS IN PARALLEL

BONUS

4) Physics – *Short Answer* What is the length of a string, in meters, required to produce a fourth harmonic of 200 Hertz if the speed of waves in the string is known to be 400 meters per second and the string is fixed at both ends?

ANSWER: 4

TOSS-UP

5) Biology – *Multiple Choice* Which of the following organelles is the location of post-translation modifications to proteins?

- W) Smooth ER
- X) Golgi body
- Y) Glyoxysome [*gligh-ox-ih-sohm*]
- Z) Mitochondria

ANSWER: X) GOLGI BODY

BONUS

5) Biology – *Short Answer* What is the process by which cells that have reached the end of their functional life span undergo programmed cell death?

ANSWER: APOPTOSIS

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### TOSS-UP

6) Math – *Short Answer* Express the repeating decimal 0.131313, with repeating part 13, as a fraction written in lowest terms.

ANSWER: 13/99

### BONUS

6) Math – *Short Answer* If you made a checkerboard with 23 squares on each side with black squares in every corner and alternating red and black along every row and column, how many red squares do you have on your checkerboard?

ANSWER: 264

### TOSS-UP

7) Chemistry – *Short Answer* What is the name of the process when a heated solid changes directly to gas without going through the liquid state?

ANSWER: SUBLIMATION

### BONUS

7) Chemistry – *Short Answer* Identify all of the following three titrations that would be neutral at the equivalence point: 1) Hydrochloric acid with sodium hydroxide; 2) Hypochlorous acid with sodium hydroxide; 3) Hydrochloric acid with ammonia.

ANSWER: 1

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TOSS-UP

8) Energy – *Short Answer* To provide numerical values for standard potentials in electrochemistry, we must set the standard potential of a certain electrode to zero. What element has a reduction potential that is defined to be zero?

ANSWER: HYDROGEN

BONUS

8) Energy – *Short Answer* Order the following three types of coal from least to greatest in terms of energy density: 1) Anthracite; 2) Lignite; 3) Bituminous.

ANSWER: 2, 3, 1

TOSS-UP

9) Earth and Space – *Multiple Choice* Which of the following is closest to the number of days of the world's supply of precipitation that is stored as water vapor in the Earth's atmosphere at any moment?

- W) 1
- X) 7
- Y) 28
- Z) 365

ANSWER: X) 7

BONUS

9) Earth and Space – *Multiple Choice* The earth is tilted at an angle of 23.5° with respect to the plane of its orbit around the sun. If the amount of tilt were increased to 40° , what would be expected in middle latitudes?

- W) Hotter summers and colder winters than at present
- X) Cooler summers and milder winters than at present
- Y) Hotter summers and milder winters than at present
- Z) Cooler summers and colder winters than at present

ANSWER: W) HOTTER SUMMERS AND COLDER WINTERS THAN AT PRESENT

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### TOSS-UP

10) Physics – *Multiple Choice* A family sits on an 8 meter long see-saw. The daughter, massing 20 kilograms, sits at the left end of the see-saw, and the father, massing 80 kilograms, sits at the middle of the right portion of the see-saw. Where must the mother, massing 60 kilograms, sit in order to make the see-saw in static equilibrium and level with the ground?

- W) 1 meter left of the pivot
- X) 1 meter right of the pivot
- Y)  $4/3$  meter left of the pivot
- Z)  $4/3$  meter right of the pivot

ANSWER: Y)  $4/3$  METER LEFT OF THE PIVOT

### BONUS

10) Physics – *Short Answer* When ultrarelativistic charged particles are accelerated radially, such as those in the Crab nebula, what specific type of radiation is emitted?

ANSWER: SYNCHROTRON RADIATION

### TOSS-UP

11) Biology – *Multiple Choice* Which of the following correctly describes chromatin?

- W) Condensed DNA and associated proteins
- X) Just condensed DNA
- Y) DNA and associated carbohydrates
- Z) Loosely coiled DNA and associated proteins

ANSWER: W) CONDENSED DNA AND ASSOCIATED PROTEINS

### BONUS

11) Biology – *Short Answer* Thomas Hunt Morgan did his inheritance experimentation on red-eyed and white-eyed mutants of which organism?

ANSWER: DROSOPHILA MELANOGASTER (ACCEPT: FRUIT FLY)

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TOSS-UP

12) Math – *Short Answer* How many integers in the closed interval from 0 to 100 are the squares of perfect squares?

ANSWER: 4

BONUS

12) Math – *Short Answer* If $x/2 = y^2$ and $x/4 = 4y$, what is the largest possible value of x ?

ANSWER: 128

TOSS-UP

13) Chemistry – *Short Answer* Ozone is an allotrope of oxygen with formula O₃. What is both the hybridization and molecular geometry of the central oxygen atom in ozone?

ANSWER: SP2 AND BENT

BONUS

13) Chemistry – *Short Answer* Identify all of the following three organic functional groups that, when substituted for a hydrogen on a benzene ring, would further activate that ring towards electrophilic substitution: 1) Amine; 2) Methyl; 3) Nitro.

ANSWER: 1 AND 2

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### TOSS-UP

14) Energy – *Short Answer* When this question was written, the world's fastest computer was China's Tianhe-2 that can perform  $3.4 \times 10^{16}$  computations per second. If it operates at 50% capacity and each calculation requires  $10^{-13}$  joules of energy, what is its operating power in watts and in scientific notation?

ANSWER:  $1.7 \times 10^3$

### BONUS

14) Energy – *Short Answer* What physical constant, equal to the ideal gas constant divided by Avogadro's number, relates particle energy to temperature?

ANSWER: BOLTZMANN CONSTANT

### TOSS-UP

15) Earth and Space – *Multiple Choice* Remnants of the energy released by the Big Bang are now distributed across the Universe as which of the following?

- W) X-rays
- X) Ultraviolet
- Y) Infrared
- Z) Microwaves

ANSWER: Z) MICROWAVES

### BONUS

15) Earth and Space – *Multiple Choice* Under the Cascade Mountains, some upwelling magma has cooled below the surface, forming plutons. Which of the following is true of these plutons?

- W) They are older than the surrounding bedrock
- X) They are younger than the surrounding bedrock
- Y) They are ultra-mafic
- Z) They are fine-grained

ANSWER: X) THEY ARE YOUNGER THAN THE SURROUNDING BEDROCK

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TOSS-UP

16) Physics – *Multiple Choice* When doing mass spectrometry, one will notice that atoms of the same element will have slightly different charge-to-mass ratios. Which of the following particles is responsible for this difference?

- W) Proton
- X) Electron
- Y) Neutron
- Z) Meson

ANSWER: Y) NEUTRON

BONUS

16) Physics – *Short Answer* In Rutherford's nuclear model of the atom, he could not understand why the positive charges in a dense nucleus would not repel each other. Which force was later found to be holding the nucleus together?

ANSWER: STRONG FORCE (ACCEPT: STRONG NUCLEAR FORCE)

TOSS-UP

17) Biology – *Multiple Choice* Which of the following is NOT true regarding aquatic biomes?

- W) Much of the photosynthesis occurring in a coral reef is performed by corals
- X) Intertidal zones are characterized by high levels of oxygen and nutrients
- Y) Oceanic pelagic zones are the largest biome on Earth
- Z) Phytoplankton are the dominant photosynthesizers in pelagic zones

ANSWER: W) MUCH OF THE PHOTOSYNTHESIS OCCURRING IN A CORAL REEF IS PERFORMED BY CORALS

BONUS

17) Biology – *Short Answer* Identify all of the following three hormones that are released by the posterior pituitary gland: 1) Oxytocin; 2) Calcitonin; 3) Luteinizing hormone.

ANSWER: 1



TOSS-UP

18) Math – *Short Answer* Determine the maximum of the function $f(x) = x^2 - 22$ on the closed interval from -3 to 2.

ANSWER: -13

BONUS

18) Math – *Multiple Choice* How many two digit positive integers have at least one 5 as a digit?

- W) 16
- X) 17
- Y) 18
- Z) 19

ANSWER: Y) 18

TOSS-UP

19) Chemistry – *Short Answer* Identify all of the following three formula-name pairs that are correctly matched: 1) $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ and blue vitriol; 2) MgSO_4 and Milk of Magnesia; 3) CaO and limestone.

ANSWER: 1

BONUS

19) Chemistry – *Short Answer* Given that the enthalpy of formation of liquid water is -290 kilojoules per mole, that of gaseous carbon dioxide is -390 kilojoules per mole, and that of gaseous methane is -75 kilojoules per mole, find the enthalpy of combustion of one mole of methane in kilojoules.

ANSWER: -895

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### TOSS-UP

20) Earth and Space – *Short Answer* What element is responsible for the destructive nature of CFCs to ozone molecules?

ANSWER: CHLORINE

### BONUS

20) Earth and Space – *Multiple Choice* According to the Saffir-Simpson scale, a hurricane with maximum sustained winds of 67 meters per second is considered to be what category?

- W) 2
- X) 3
- Y) 4
- Z) 5

ANSWER: Y) 4

### **TOSS-UP**

21) Physics – *Short Answer* What quantum mechanical principle states that no two identical fermions can possess the same quantum numbers simultaneously?

ANSWER: PAULI EXCLUSION PRINCIPLE

### **BONUS**

21) Physics – *Short Answer* What experiment, important in quantum mechanics, involved sending beams of particles through an inhomogeneous magnetic field and observing their deflections, the results of which showed that particles possess an intrinsic angular momentum that takes only certain quantized values?

ANSWER: STERN-GERLACH EXPERIMENT



### **TOSS-UP**

22) Biology – *Short Answer* In the human heart, what chamber contains the SA node?

ANSWER: RIGHT ATRIUM

### **BONUS**

22) Biology – *Short Answer* What type of DNA sequence, an example of which is the TATA box, is required for transcription factor binding and the transcription of DNA to RNA?

ANSWER: PROMOTER

### **TOSS-UP**

23) Math – *Short Answer* Assemblies coming from a plant are inspected for defects. Historical records indicate that 8% have defects in shafts, 6% have defects in bushings, and 2% have defects in both shafts and bushings. One of the assemblies is selected at random. What is the probability, in percentage form, that the assembly has a shaft or bushing defect?

ANSWER: 12

### **BONUS**

23) Math – *Short Answer* What is the greatest common divisor of 132 and 6432?

ANSWER: 12