

ROUND 15A

TOSS-UP

1) Chemistry – *Multiple Choice* Which of the following metals exhibits a strong inert-pair effect?

- W) Thallium
- X) Scandium
- Y) Zinc
- Z) Barium

ANSWER: W) THALLIUM

BONUS

1) Chemistry – *Multiple Choice* Which of the following diatomic ions is isoelectronic with the dioxygen molecule?

- W) N_2^+
- X) OF^+
- Y) OF^-
- Z) NO^+

ANSWER: X) OF^+

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### TOSS-UP

2) Earth and Space – *Short Answer* Coral polyps extract what compound out of seawater to form hard external skeletons?

ANSWER: CALCIUM CARBONATE

### BONUS

2) Earth and Space – *Multiple Choice* Trees growing on the edge of a river's meander are most likely to fall into the river due to:

- W) Deposition on the inside of the meander
- X) Deposition on the outside of the meander
- Y) Erosion on the inside of the meander
- Z) Erosion on the outside of the meander

ANSWER: Z) EROSION ON THE OUTSIDE OF THE MEANDER

### TOSS-UP

3) Energy – *Short Answer* What phenomenon explains why certain metals produce small amounts of electric current when exposed to light at or above a threshold frequency?

ANSWER: PHOTOELECTRIC EFFECT (DO NOT ACCEPT: PHOTOVOLTAIC EFFECT)

### BONUS

3) Energy – *Multiple Choice* At a given temperature, which of the following molecules will have the greatest root mean square speed?

- W) Nitrogen
- X) Oxygen
- Y) Argon
- Z) Carbon dioxide

ANSWER: W) Nitrogen

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TOSS-UP

4) Physics – *Short Answer* What experiment famously used interferometry to search for differences in the speed of light as the earth travelled around the sun?

ANSWER: MICHELSON-MORLEY EXPERIMENT

BONUS

4) Physics – *Multiple Choice* You are standing along the principal axis of a large concave mirror, staring at the vertex 30 feet away. The image point of the mirror is 20 feet in front of you. If you are six feet tall, how tall, in feet, is your image in the mirror?

- W) 2
- X) 4
- Y) 9
- Z) 18

ANSWER: W) 2

TOSS-UP

5) Biology – *Multiple Choice* Which of the following organisms probably uses PEP carboxylase to capture carbon dioxide and keep stomata closed during the day?

- W) Sugar cane
- X) Aloe vera
- Y) Corn
- Z) Sorghum

ANSWER: X) ALOE VERA

BONUS

5) Biology – *Multiple Choice* Which of the following cell types is responsible for generating the extracellular matrix?

- W) Macrophages
- X) Monocytes
- Y) Megakaryocytes
- Z) Fibroblasts

ANSWER: Z) FIBROBLASTS

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### TOSS-UP

6) Math – *Short Answer* What is the 10th term of the arithmetic sequence with first 3 terms -8, 8, 24?

Answer: 136

### BONUS

6) Math – *Multiple Choice* Which of the following is never TRUE?

- W) Absolute value of  $a$  plus absolute value of  $b$  equals absolute value of open parenthesis  $a + b$  close parenthesis
- X) Absolute value of open parenthesis  $a + 1000$  close parenthesis is less than absolute value of  $a$
- Y) Negative absolute value of  $a$  equals absolute value of  $a$
- Z) Absolute value of open parenthesis  $a - b$  close parenthesis is less than absolute value of  $a$  minus absolute value of  $b$

ANSWER: Z) ABSOLUTE VALUE OF OPEN PARENTHESIS  $a - b$  CLOSE PARENTHESIS IS LESS THAN ABSOLUTE VALUE OF  $a$  MINUS ABSOLUTE VALUE OF  $b$

### TOSS-UP

7) Chemistry – *Short Answer* What polymer, consisting of repeating  $C_2H_3Cl$  units, is one of the most widely produced plastics and finds usage in industries from construction to clothing?

ANSWER: POLYVINYLCHLORIDE (Accept: PVC)

### BONUS

7) Chemistry – *Multiple Choice* Which of the following is a network solid at the standard atmospheric temperature and pressure?

- W) Ammonia
- X) Sodium chloride
- Y) Silicon carbide
- Z) Diborane

ANSWER: Y) SILICON CARBIDE

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TOSS-UP

8) Energy – *Multiple Choice* The triple alpha process, a fusion-based reaction, results in the formation of what element in the cores of red giant stars?

- W) Helium
- X) Phosphorous
- Y) Carbon
- Z) Beryllium

ANSWER: Y) CARBON

BONUS

8) Energy – *Short Answer* Order, from least to greatest, the following three hydrocarbons by their octane ratings: 1) Iso-octane; 2) N-octane; 3) 1-Heptene

ANSWER: 2, 3, 1

TOSS-UP

9) Earth and Space – *Multiple Choice* What is the approximate mass of the object Sagittarius A-star in solar masses?

- W) 4×10 to the 2nd power
- X) 4×10 to the 6th power
- Y) 4×10 to the 10th power
- Z) 4×10 to the 16th power

ANSWER: X) 4×10 to the 6th POWER

BONUS

9) Earth and Space – *Multiple Choice* How does the intensity of light passing through an absorbing medium change as a function of optical depth?

- W) It decreases exponentially with the optical depth
- X) It decreases as the sixth power of the optical depth
- Y) It decreases as the cube of the optical depth
- Z) It decreases as the square of the optical depth

ANSWER: W) IT DECREASES EXPONENTIALLY WITH THE OPTICAL DEPTH

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### TOSS-UP

10) Physics – *Short Answer* What type of radiation, also known as braking radiation, is emitted whenever a charged particle is deflected by another charged particle?

ANSWER: BREMSSTRAHLUNG RADIATION

### BONUS

10) Physics – *Multiple Choice* A 75 gram piece of copper is heated to 315 degrees Celsius and dropped into a beaker containing 220 milliliters of water that is at an initial temperature of 18 degrees Celsius. Which of the following temperatures, in degrees Celsius, is closest to the point at which the system is at equilibrium?

- W) 5
- X) 25
- Y) 60
- Z) 115

ANSWER: X) 25

### TOSS-UP

11) Biology – *Multiple Choice* Hybrid breakdown and lack of hybrid robustness are examples of which type of reproductive isolation?

- W) Mechanical isolation
- Y) Allopatric speciation
- X) Prezygotic barriers
- Y) Postzygotic barriers

ANSWER: Z) POSTZYGOTIC BARRIERS

### BONUS

11) Biology – *Multiple Choice* Which of the following is not true regarding mitosis?

- W) Sister chromatids are held together by cohesion [*coh-ee-sin*] complexes
- X) M-Cdk drives entry of the cell into mitosis
- Y) The mitotic spindle is built from actin filaments
- Z) The Golgi apparatus becomes less prominent during metaphase

ANSWER: Y) THE MITOTIC SPINDLE IS BUILT FROM ACTIN FILAMENTS

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TOSS-UP

12) Math – *Short Answer* What is the value of $(\log_2 4)(\log_4 6)(\log_6 8)(\log_8 16)$?

ANSWER: 4

BONUS

12) Math – *Short Answer* The product of three positive consecutive odd integers is 7 times their sum. Find the smallest of the three integers.

ANSWER: 3

TOSS-UP

13) Chemistry – *Multiple Choice* What reagent could be used to transform ethanoic acid into acetyl chloride?

- W) Hydrogen chloride
- X) Sodium chloride
- Y) Thionyl chloride
- Z) Magnesium chloride

ANSWER: Y) THIONYL CHLORIDE

BONUS

13) Chemistry – *Short Answer* What is the oxidation state of chromium in the coordination compound of charge +3 that is formed from the reaction of five ammonia ligands and one chloride ligand with the central chromium ion?

ANSWER: +4



TOSS-UP

14) Energy – *Short Answer* Indicate all of the following three statements that are true regarding biofuels: 1) Used vegetable oil can be processed into biodiesel; 2) Bioethers act as octane rating enhancers; 3) Ethanol contains less energy per unit of volume than gasoline.

ANSWER: ALL OF THEM

BONUS

14) Energy – *Multiple Choice* Suppose you compress a gas in a cylinder with a piston by pushing down on the piston. What is the best explanation for why the gas gets warm?

- W) The decrease in volume at constant pressure increases the temperature
- X) By compressing the gas, you do work on it, which is converted into heat
- Y) By compressing the gas, you increase its entropy, resulting in a negative free energy
- Z) The gas will start to condense, releasing energy

ANSWER: X) BY COMPRESSING THE GAS, YOU DO WORK ON IT, WHICH IS CONVERTED INTO HEAT

TOSS-UP

15) Earth and Space – *Short Answer* What phase of a star's lifetime on the HR diagram involves a hydrogen shell burning around an inert helium core?

ANSWER: SUBGIANT BRANCH

BONUS

15) Earth and Space – *Multiple Choice* The reasons why the Earth's core is believed to be largely molten iron do not include arguments that involve which of following?

- W) Density of iron
- X) Conductivity of iron
- Y) Magnetic properties of iron
- Z) Abundance of iron in the universe

ANSWER: Y) MAGNETIC PROPERTIES OF IRON

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### TOSS-UP

16) Physics – *Multiple Choice* By which of the following decay modes does a proton and an electron turn into a neutron and emit an electron neutrino?

- W) Beta minus decay
- X) Beta plus decay
- Y) Electron capture decay
- Z) Bound-state decay

ANSWER: Y) ELECTRON CAPTURE DECAY

### BONUS

16) Physics – *Short Answer* A particle's position is given by the function  $f(t) = (-t^3 + 3t)$  meters, where  $t$  is in seconds. What are the particle's position, in meters, and velocity, in meters per second, respectively, at  $t = 2$  seconds?

ANSWER: -2 AND -9 (ACCEPT: -2 METERS AND -9 METERS PER SECOND - IN ANY ORDER)



### TOSS-UP

17) Biology – *Multiple Choice* Which of the following instruments would be used to perform a polymerase chain reaction in a molecular biology lab?

- W) Microtome
- X) Autoclave
- Y) Spectrometer
- Z) Thermocycler

ANSWER: Z) THERMOCYCLER

### BONUS

17) Biology – *Multiple Choice* A deficiency in which of the following vitamins causes pernicious anemia?

- W) Thiamine [*thigh-uh-meem*]
- X) Retinol
- Y) Ascorbic Acid
- Z) Cobalamin [*co-bahl-uh-min*]

ANSWER: Z) COBALAMIN

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TOSS-UP

18) Math – *Multiple Choice* The derivative of sine-cubed of 2 theta with respect to theta is equal to which of the following?

- W) Cosine-cubed of 2 theta
- X) 3 sine-squared of 2 theta
- Y) 6 sine-squared of 2 theta cosine of 2 theta
- Z) 6 cosine-cubed of 2 theta sine-squared of 2 theta

ANSWER: Y) 6 sine-squared of 2 theta cosine of 2 theta

BONUS

18) Math – *Short Answer* What is the limit as x approaches 0 of the fraction with numerator $2^x - 1$ and denominator $e^x - 1$?

ANSWER: ln 2

TOSS-UP

19) Chemistry – *Multiple Choice* If molten sodium is burned in a pure oxygen atmosphere, a salt is formed. Which of the following is the likely identity of this salt?

- W) Na_2O
- X) Na_2O_2
- Y) NaO_2
- Z) NaO_3

ANSWER: X) Na_2O_2

BONUS

19) Chemistry – *Multiple Choice* Assuming that none of the following molecules contain any rings, which one contains exactly one carbon-carbon or carbon-oxygen double bond?

- W) $\text{C}_4\text{H}_8\text{O}$
- X) $\text{C}_4\text{H}_8\text{Cl}_2$
- Y) $\text{C}_4\text{H}_4\text{O}$
- Z) $\text{C}_4\text{H}_4\text{Cl}_2$

ANSWER: W) $\text{C}_4\text{H}_8\text{O}$

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### TOSS-UP

20) Earth and Space – *Multiple Choice* According to Bowen's reaction series, which of the following minerals would crystallize at the highest temperature?

- W) Olivine
- X) Quartz
- Y) Muscovite
- Z) Orthoclase

ANSWER: W) OLIVINE

### BONUS

20) Earth and Space – *Short Answer* The Great Basin, Gobi, and Takla Makan are examples of what type of deserts?

ANSWER: RAINSHADOW DESERTS

### TOSS-UP

21) Physics – *Short Answer* A cylinder contains 12 liters of an ideal gas at 280 Kelvin and 15 atmospheres. The temperature is raised to 308 Kelvin and the volume reduced to 8 liters. What is the final pressure of the gas in atmospheres?

ANSWER: 24.75

### BONUS

21) Physics – *Short Answer* Identify all of the following four statements that are true of the Standard Model of particle physics: 1) Color confinement results in quarks being perpetually bound to one another; 2) Leptons can be considered fermions; 3) Quarks have  $\frac{1}{2}$  spin; 4) Pions and kaons are classified as mesons.

ANSWER: ALL OF THEM

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TOSS-UP

22) Biology – *Short Answer* Insects that have two pairs of membranous wings, mobile heads, and chewing or sucking mouthparts, such as ants, bees, and wasps, are classified as part of what order?

ANSWER: HYMENOPTERA

BONUS

22) Biology – *Short Answer* Order the following four organisms from least to greatest in terms of the number of genes in their genomes: 1) *S. cerevisiae* [*sehr-uh-vis-ee-ay*]; 2) *E. coli*; 3) *D. melanogaster*; 4) *H. sapiens*.

ANSWER: 2, 1, 3, 4

TOSS-UP

23) Math – *Short Answer* If $\tan \theta = \frac{3}{4}$, what is $\csc \theta$?

Answer: $\frac{5}{3}$

BONUS

23) Math – *Short Answer* How many positive integers a exist such that $\log_a 15,625$ is a positive integer?

ANSWER: 4