

ROUND 14A

TOSS-UP

1) Chemistry – *Multiple Choice* An alkyne[**AL-kine**] is added to a reaction vessel containing pressurized hydrogen gas and a catalyst consisting of palladium [**pah-LAID-ee-um**] poisoned by traces of lead(II) ions and quinoline [**KWIN-oh-lin**]. Which of the following is the major product of this reaction?

- W) Alkane
- X) Cis-alkene [**sis-al-KEEN**]
- Y) Trans-alkene
- Z) Alcohol

ANSWER: X) CIS-ALKENE

BONUS

1) Chemistry – *Short Answer* Identify all of the following three statements that are true concerning elimination reactions: 1) E2 is a concerted reaction; 2) E1 is substantially accelerated by strong, unhindered bases; 3) Cis-alkenes are often thermodynamically preferred to trans-alkenes.

ANSWER: 1

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### TOSS-UP

2) Biology – *Short Answer* What protein hormone, missing in obese mice with mutations in the ob [**O.B.**] gene, is responsible for controlling satiety [**SAY-sha-tee**]?

ANSWER: LEPTIN

### BONUS

2) Biology – *Short Answer* When fasting, the liver will convert amino acids to glucose. What is the name of this process?

ANSWER: GLUCONEOGENESIS

### TOSS-UP

3) Energy – *Multiple Choice* Which of the following percentages is closest to the level of engine efficiency in a modern gasoline-burning automobile?

- W) 10%
- X) 25%
- Y) 50%
- Z) 90%

ANSWER: X) 25%

### BONUS

3) Energy – *Multiple Choice* A family in Phoenix is considering installing a photovoltaic [*photo-vawl-TAY-ik*] system on their house. Which of the following roof orientations and inclined angles relative to horizontal is best to install the panels?

- W) West-facing at 30 degrees
- X) South-facing at 30 degrees
- Y) South-facing at zero degrees
- Z) East-facing at zero degrees

ANSWER: X) SOUTH-FACING AT 30 DEGREES

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TOSS-UP

4) Physics – *Short Answer* A Wheatstone Bridge is used to measure what property of electrical circuit components?

ANSWER: RESISTANCE

BONUS

4) Physics – *Short Answer* Using the harmonic oscillator model, and assuming the force constant is unchanged between the two molecules, what is the ratio of the fundamental vibrational frequency of hydrogen to that of deuterium?

ANSWER: $\sqrt{2}$ (ACCEPT: $\sqrt{2}$ TO 1)

TOSS-UP

5) Math – *Short Answer* Given f inverse of x equals $2 - x$, what is $f(x)$?

ANSWER: $2 - x$

BONUS

5) Math – *Short Answer* A triangle with integer side lengths has longest side that is 4 times as long as a second side, and the third side has length 20. What is the greatest possible perimeter of the triangle?

ANSWER: 50

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**TOSS-UP**

6) Earth and Space – *Multiple Choice* What radioactive element was produced during nuclear-weapons testing in the mid 1900s and is commonly used by oceanographers to date the age of water masses, but will decay to normal background levels in the coming decades.

- W) Carbon-14
- X) Radon-222
- Y) Uranium-238
- Z) Tritium

ANSWER: Z) TRITIUM

**BONUS**

6) Earth and Space – *Multiple Choice* The key glacier structure formed through annual layering of ice through cycles of melting and snowfall is called what?

- W) Ogives
- X) Primary stratification
- Y) Longitudinal foliation
- Z) Transverse crevasses

ANSWER: X) PRIMARY STRATIFICATION

### TOSS-UP

7) Energy – *Multiple Choice* Why is solar power underutilized in American households?

W) It increases the price of a home by about 5-10%

X) North America is mostly cloudy

Y) Solar technology is currently not very effective

Z) Solar cells are not effective in cold climates

ANSWER: W) IT INCREASES THE PRICE OF A HOME BY ABOUT 5-10%

### BONUS

7) Energy – *Multiple Choice* Nanolithography is a current research interest at Lawrence Livermore National Lab. Which of the following correctly describes nanolithography?

W) The study of fluids confined to nanoscale structures

X) Usage of nanoparticles as medical technology

Y) Depositing residues thinner than 100 nanometers onto surfaces

Z) Fabricating structures smaller than 100 nanometers

ANSWER: Z) FABRICATING STRUCTURES SMALLER THAN 100 NANOMETERS

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TOSS-UP

8) Chemistry – *Multiple Choice* Which of the following methods is LEAST helpful in identifying chiral [*KYE-ruhl*] isomers?

W) X-ray diffraction

X) Quadrupole [*QUAD-roo-pole*] mass spectrometry [*spek-TRAW-metry*]

Y) Nuclear magnetic resonance spectroscopy [*spek-TRAW-scu-h-pee*]

Z) Raman [*RAH-min*] spectroscopy

ANSWER: X) QUADRUPOLE MASS SPECTROMETRY

BONUS

8) Chemistry – *Short Answer* Identify all of the following three statements that are true of a mixture of 96% ethanol and 4% water: 1) The boiling point of the mixture is greater than that of either pure ethanol or pure water; 2) The components can be separated by fractional distillation; 3) The mixture deviates from Raoult's [*rah-OOLZ*] law.

ANSWER: 3

TOSS-UP

9) Earth and Space – *Multiple Choice* Kepler's third law of planetary motion relates what two parameters of the orbiting body?

- W) Solar radiation and distance
- X) Orbital period and semi-major axis
- Y) Orbital eccentricity and solar mass
- Z) Solar mass and mass of orbiting body

ANSWER: X) ORBITAL PERIOD AND SEMI-MAJOR AXIS

BONUS

9) Earth and Space – *Multiple Choice* Magnetite, pyrite, and galena are mineral examples of which of the following crystal system types?

- W) Tetragonal
- X) Cubic
- Y) Triclinic
- Z) Ortho-rhombic

ANSWER: X) CUBIC

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**TOSS-UP**

10) Math – *Short Answer* Consider a bag of 7 marbles, 5 red and 2 white. You draw marbles from the bag until you draw the last white marble, at which point you stop. What is the probability you stop drawing after the second marble is selected?

ANSWER: 1/21

**BONUS**

10) Math – *Short Answer* For the arithmetic sequence with first term 7 and fourth term 19, what is the sum of the first 50 terms?

ANSWER: 5250

**TOSS-UP**

11) Physics – *Multiple Choice* The photoelectric effect reveals what property of photons?

- W) Wave-like nature
- X) Particle-like nature
- Y) Wave-particle duality
- Z) Masslessness

ANSWER: X) PARTICLE-LIKE NATURE

**BONUS**

11) Physics – *Short Answer* In quantum mechanics, the operator for momentum is represented by a derivative with respect to what quantity?

ANSWER: POSITION

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TOSS-UP

12) Biology – *Short Answer* Identify all of the following three genera [*JEN-er-ah*] of bacteria that are Gram positive:

- 1) Escherichia [*eh-she-EE-kee-ah*]; 2) Salmonella; 3) Vibrio [*VIH-bree-oh*].

ANSWER: NONE

BONUS

12) Biology – *Short Answer* Identify the ploidy level for the following three plant life stages: 1) Sporophyte;

- 2) Gametophyte; 3) Spore.

ANSWER: 1) DIPLOID, 2) HAPLOID, 3) HAPLOID

TOSS-UP

13) Math – *Short Answer* What is the absolute value of the complex conjugate of $-4 + 5i$?

ANSWER: $\sqrt{41}$

BONUS

13) Math – *Short Answer* What is the limit as x approaches 3 of the fraction with numerator $x^6 - 81$ and denominator $x^3 - 9$?

ANSWER: 36

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**TOSS-UP**

14) Physics – *Multiple Choice* A 70-kilogram student is walking at 1 meter per second. Which of the following is closest to her de Broglie wavelength, in meters?

W)  $10^{-34}$

X)  $10^{-35}$

Y)  $10^{-36}$

Z)  $10^{-37}$

ANSWER: X)  $10^{-35}$

**BONUS**

14) Physics – *Short Answer* Einstein won the Nobel Prize in Physics for his description of what phenomenon?

ANSWER: PHOTOELECTRIC EFFECT

**TOSS-UP**

15) Chemistry – *Short Answer* Porphyrin [*POOR-feh-rin*] is a chelating [*KEY-lay-ting*] ligand [*LIH-gund*]. How many bonds can it form to a metal center?

ANSWER: 4

**BONUS**

15) Chemistry – *Short Answer* Rank the following four compounds in terms of increasing net dipole moment:

1) Carbon dioxide; 2) Hydrogen chloride; 3) Hydrogen fluoride; 4) Carbon monoxide.

ANSWER: 1, 4, 2, 3

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TOSS-UP

16) Biology – *Short Answer* What second messenger is produced by adenylyl [*ah-DEN-il-il*] cyclase [*SIGH-klayse*]?

ANSWER: CYCLIC AMP (ACCEPT: cAMP, CYCLIC ADENOSINE MONOPHOSPHATE)

BONUS

16) Biology – *Short Answer* In a signalling pathway, a certain step requires the removal of a phosphate group from a protein. What general type of enzyme would perform this reaction?

ANSWER: PHOSPHATASE

TOSS-UP

17) Energy – *Multiple Choice* Researchers are using the Argonne Leadership Computing Facility to design and model peptide therapeutics. Which of the following is NOT a challenge associated with peptide therapeutics?

- W) They are difficult to deliver
- X) They have poor specificity
- Y) They have poor cell penetration
- Z) They are degraded in the circulatory system

ANSWER: X) THEY HAVE POOR SPECIFICITY

BONUS

17) Energy – *Multiple Choice* Researchers at Lawrence Livermore National Lab are studying the conditions under which planet formation occurs by doing which of the following?

- W) Determining the melting point of silica at gigapascal [*gih-gah-pass-KAL*] pressures
- X) Determining the melting point of silica in ultra high vacuum
- Y) Determining the boiling point of silica at gigapascal pressures
- Z) Determining the boiling point of alumina at gigapascal pressures

ANSWER: W) DETERMINING THE MELTING POINT OF SILICA AT GIGAPASCAL PRESSURES

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**TOSS-UP**

18) Earth and Space – *Short Answer* How many planes of cleavage does biotite possess?

ANSWER: ONE

**BONUS**

18) Earth and Space – *Short Answer* Water-saturated surfaces can behave like liquids during earthquakes. What is the term for this phenomenon?

ANSWER: LIQUEFACTION

**TOSS-UP**

19) Chemistry – *Short Answer* Acetylene has a pKa of 25, while hydroxide ions have a pKa of about 16. Expressing your answer to the nearest power of 10, if they were mixed in equimolar amounts, one in how many molecules of acetylene would be deprotonated?

ANSWER: 9 (ACCEPT:  $10^9$ )

**BONUS**

19) Chemistry – *Short Answer* How many unpaired electrons does high-spin open bracket  $\text{CoF}_6$  close bracket to the 3 negative have?

ANSWER: 4

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TOSS-UP

20) Earth and Space – *Multiple Choice* Which of the following is not a unit used by oceanographers to describe sea water salinity?

- W) Parts per thousand
- X) Siemen
- Y) Practical salinity unit
- Z) Grams per kilogram

ANSWER: X) SIEMEN

BONUS

20) Earth and Space – *Short Answer* Prometheus and Pan both create gaps in Saturn's rings due to their gravitational influence. What is the term for this type of satellite?

ANSWER: SHEPHERD

TOSS-UP

21) Math – *Short Answer* An octagon is dilated with scale factor $7/4$. What is the ratio of the areas of the original octagon to the image?

ANSWER: 16/49

BONUS

21) Math – *Short Answer* Other than 2, what is the smallest positive integer that, when divided by 3, 5, 7, or 9, has a remainder of 2?

ANSWER: 317

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**TOSS-UP**

22) Biology – *Short Answer* What enzyme is the major regulation site of glycolysis [*glye-KAWL-eh-sis*]?

ANSWER: PHOSPHOFRUCTOKINASE (ALSO ACCEPT: PFK, PFK-1)

**BONUS**

22) Biology – *Short Answer* In glycolysis [*glye-KAWL-eh-sis*], what enzyme catalyzes the initial phosphorylation [*faws-four-il-AY-shun*] of glucose, preventing it from leaving the cell?

ANSWER: HEXOKINASE (ACCEPT: GLUCOKINASE)

### TOSS-UP

23) Physics – *Short Answer* If the ratio of the lengths of two pendulums is 1:4, what is the ratio of the frequency of the longer to that of the shorter?

ANSWER: 1:2 (ACCEPT:  $\frac{1}{2}$ , 0.5)

### BONUS

23) Physics – *Short Answer* Radiation from a hypothetical blue dwarf is peaked at a wavelength of 250 nanometers. A spaceship travelling away from the star at  $0.6c$  observes a spectrum peaked at what wavelength, in nanometers?

ANSWER: 500