

ROUND 11A

TOSS-UP

1) Energy – *Short Answer* E10 fuel can produce what low atmosphere pollutant that serves as a UV protectant in the upper atmosphere?

ANSWER: OZONE

BONUS

1) Energy – *Short Answer* The Daya [**DIE-ah**] Bay Collaboration is currently on the hunt for a hypothetical type of neutrino [**new-TREE-no**] that does not interact with other particles except through gravity. What is the term for this neutrino?

ANSWER: STERILE NEUTRINO (ACCEPT: INERT NEUTRINO)

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### TOSS-UP

2) Physics – *Short Answer* In classical optics, diffraction is a phenomenon that can be described as interference according to what principle?

ANSWER: HUYGEN'S PRINCIPLE

### BONUS

2) Physics – *Short Answer* What rule states that if an energy level contains several degenerate orbitals, the orbitals must all be singly filled before any of them can be doubly filled?

ANSWER: HUND'S RULE

**TOSS-UP**

3) Earth and Space – *Multiple Choice* The Black Hills of South Dakota is a large dome that has been exposed due to upwarping followed by erosion. Which of the following rocks would we expect to find in the innermost core of the Black Hills?

- W) Shale
- X) Gypsum
- Y) Pegmatite
- Z) Limestone

ANSWER: Y) PEGMATITE

**BONUS**

3) Earth and Space – *Short Answer* How many times greater, in terms of energy, is a magnitude 6 earthquake than a magnitude 4 earthquake?

ANSWER: 961

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TOSS-UP

4) Biology – *Multiple Choice* Which of the following correctly explains why fish cannot breathe outside of water?

- W) Air contains less oxygen than water
- X) Their gas exchange systems are tuned to dissolved oxygen
- Y) In air, their gills collapse
- Z) Air provides more structural support to the fish

ANSWER: Y) IN AIR, THEIR GILLS COLLAPSE

BONUS

4) Biology – *Short Answer* Identify all of the following three items that are considered rhizopods: 1) Kelp; 2) Amoeba; 3) Euglenid [*you-GL EE-nids*].

ANSWER: JUST 2 (ACCEPT: AMOEBA)

TOSS-UP

5) Chemistry – *Multiple Choice* Which of the following is the most plausible first step in the solvolysis [*sawl-VAWL-eh-sis*] of tert-butyl [*turt-BYU-til*] iodide in water?

- W) Concerted substitution
- X) Attack of water to form a pentavalent [*penta-VAY-lent*] intermediate
- Y) Decomposition to form positively-charged intermediate
- Z) Decomposition to form negatively-charged intermediate

ANSWER: Y) DECOMPOSITION TO FORM POSITIVELY-CHARGED INTERMEDIATE

BONUS

5) Chemistry – *Short Answer* Rank the following three acids in terms of increasing pKa: 1) Chlorous [*KLOR-us*] acid; 2) Hydroiodic [*HIGH-droh-eye-AW-dik*] acid; 3) Acetic [*ah-SEE-tik*] acid.

ANSWER: 2, 1, 3

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**TOSS-UP**

6) Math – *Short Answer* What is the area of a kite with diagonals of lengths 5 and 8?

ANSWER: 20

**BONUS**

6) Math – *Short Answer* If  $a_{1} = 3$  and, for  $n$  greater than one,  $a_{n} = 2a_{n-1} - 1$ , what is the value of  $a_{5}$ ?

ANSWER: 33

**TOSS-UP**

7) Biology – *Multiple Choice* Which of the following is an example of a Chrysophyten [*Cris-AW-fih-tan*]?

W) Amoeba [*ah-MEE-bah*]

X) Trypanoma [*trih-pan-OH-ma*]

Y) Plasmodium [*plazz-MOH-dee-um*]

Z) Diatom [*DYE-ah-tom*]

ANSWER: Z) DIATOM

**BONUS**

7) Biology – *Short Answer* Given that hemoglobin is 144 amino acids long, identify all of the following three numbers of nucleotides that can be in the primary mRNA transcript of hemoglobin at different stages of processing:

1) 144; 2) 432; 3) 1356.

ANSWER: JUST 3 (ACCEPT: 1356)

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TOSS-UP

8) Math – *Multiple Choice* The graph of a continuous function f contains the points $(4, -5)$ and $(7, -1)$. The intermediate value theorem guarantees an x -value such that f of x equals which of the following?

W) -6

X) -2

Y) 2

Z) 6

ANSWER: X) -2

BONUS

8) Math – *Short Answer* How many positive integral factors does 936 have?

ANSWER: 24

TOSS-UP

9) Chemistry – *Multiple Choice* Which of the following compounds has the lowest boiling point?

- W) Water
- X) Hydrogen sulfide
- Y) Hydrogen selenide [*SELL-en-ide*]
- Z) Hydrogen telluride [*TELL-ur-ide*]

ANSWER: X) HYDROGEN SULFIDE

BONUS

9) Chemistry – *Short Answer* Identify all of the following three statements that are TRUE of the Nernst equation:

- 1) The equation does not use the Faraday constant;
- 2) The standard redox [*REE-dox*] potential for a concentration cell is negative;
- 3) The Nernst equation accounts for overpotential.

ANSWER: NONE OF THEM

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### TOSS-UP

10) Earth and Space – *Multiple Choice* The Global Positioning System consists of several operational satellites in spatially separated orbits around the earth. How many different satellite signals are required for accurate position, velocity, and time data?

- W) 2
- X) 3
- Y) 4
- Z) 6

ANSWER: Y) 4

### BONUS

10) Earth and Space – *Multiple Choice* Kepler's second law states that in any given period of time, a planet will have what orbital property stay constant?

- W) Distance traveled
- X) Angular distance traveled
- Y) Area swept
- Z) Number of rotations

ANSWER: Y) AREA SWEPT

**TOSS-UP**

11) Energy – *Short Answer* Renewable diesel is produced via multiple methods. Biodiesel, however, is only produced via what chemical process?

ANSWER: TRANSESTERIFICATION (ACCEPT: METHANOLYSIS)

**BONUS**

11) Energy – *Short Answer* Scientists at Argonne National Lab recently published a paper regarding the potential use of certain microbes as a method for recovering natural gas from depleted oil and coal mines. What specific fuel molecule do these microbes produce?

ANSWER: METHANE (ACCEPT: CH<sub>4</sub>)

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TOSS-UP

12) Math – *Short Answer* What is the dot product of the vectors $4\mathbf{i} - 2\mathbf{j} + \mathbf{k}$ and $3\mathbf{i} - \mathbf{k}$?

ANSWER: 11

BONUS

12) Math – *Short Answer* An isosceles trapezoid with integer side lengths has bases of length 12 and 26. What is the minimum length of its shortest side?

ANSWER: 8

TOSS-UP

13) Physics – *Short Answer* What dimensionless physical constant is equal to the square of the ratio of the charge of the electron to the Planck charge?

ANSWER: FINE STRUCTURE CONSTANT

BONUS

13) Physics – *Short Answer* A cyclist is decelerating at 2.5 meters per second squared. If at point A, she is traveling at 8 meters per second and at point B, she is traveling at 5 meters per second, how long, in seconds, did it take her to travel from point A to B?

ANSWER: 1.2

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**TOSS-UP**

14) Energy – *Short Answer* DOE scientists at Brookhaven National Lab are using the Relativistic Heavy Ion Collider to study color confinement within protons. What group of elementary particles are they studying?

ANSWER: QUARKS (ACCEPT: GLUONS AND QUARKS)

**BONUS**

14) Energy – *Short Answer* Many redox [*REE-dox*] flow batteries use acidic electrolytes. Electrodes in these devices must necessarily be immune to acid attack as well as electronically conductive. What element is used for almost all flow battery electrodes?

ANSWER: CARBON (ACCEPT: CARBON FIBER)

### TOSS-UP

15) Chemistry – *Multiple Choice* Which of the following titrations would have an equivalence point with a pH closest to 9?

- W) Titration of sodium hydroxide with hydrochloric acid
- X) Titration of hydrochloric acid with ammonia
- Y) Titration of acetic acid with sodium hydroxide
- Z) Titration of barium hydroxide with sulfuric acid

ANSWER: Y) TITRATION OF ACETIC [*ah-SEE-tik*] ACID WITH SODIUM HYDROXIDE

### BONUS

15) Chemistry – *Short Answer* Identify all of the following three statements that are TRUE of the permanganate [*pur-MAYNG-en-ate*] ion: 1) It is reduced to  $Mn^{2+}$  in neutral solution; 2) It contains manganese [*MAYN-gan-ez*] in the +7 oxidation state; 3) It can be used as an indicator and titrant [*TIE-trant*] in a potentiometric [*poh-ten-shee-oh-MEH-tric*] titration [*tie-TRAY-shun*].

ANSWER: 2 AND 3

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TOSS-UP

16) Biology – *Short Answer* What structural molecule do Gram positive bacteria possess in large quantities?

ANSWER: PEPTIDOGLYCAN

BONUS

16) Biology – *Short Answer* Identify all of the following three types of ion channels that are open during the falling phase of the action potential: 1) Voltage gated sodium; 2) Voltage gated potassium; 3) Ligand [*LIH-gund*] gated sodium.

ANSWER: JUST 2

TOSS-UP

17) Earth and Space – *Multiple Choice* What arises in space, thought to be from particle pairs that blink into existence and promptly annihilate?

- W) Gravitational potential energy
- X) Vacuum energy
- Y) Cherenkov radiation
- Z) Bremsstrahlung radiation

ANSWER: X) VACUUM ENERGY

BONUS

17) Earth and Space – *Short Answer* What type of stellar object lies fully within its own Schwarzschild radius?

ANSWER: BLACK HOLE

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### TOSS-UP

18) Physics – *Short Answer* An ideal ammeter is connected to a 1.5-volt battery and it reads 2 amps. How much power, in watts, is dissipated by the internal resistance of the battery?

ANSWER: 3

### BONUS

18) Physics – *Short Answer* How much more power does a 40-decibel sound deliver than a 20-decibel sound?

ANSWER: 100

**TOSS-UP**

19) Earth and Space – *Multiple Choice* Ganymede is more massive than Titan, but only Titan has an atmosphere. Which of the following correctly explains this?

- W) Titan's atmosphere is mostly made of heavy gases, like sulfur dioxide, which cannot escape its gravitational pull
- X) Titan is significantly colder than Ganymede, preventing its atmosphere from escaping
- Y) Titan actively replenishes its atmosphere, while Ganymede does not
- Z) Titan absorbs atmospheric gases from Saturn, while Ganymede does not absorb gases from Jupiter

ANSWER: X) TITAN IS SIGNIFICANTLY COLDER THAN GANYMEDE, PREVENTING ITS ATMOSPHERE FROM ESCAPING

**BONUS**

19) Earth and Space – *Multiple Choice* The eruption of El Chicon had a greater effect on global temperatures than the eruption of Mount Saint Helens despite being a smaller eruption. Which of the following best explains why?

- W) El Chicon emitted much more sulfur dioxide
- X) El Chicon deposited more heavy ash
- Y) El Chicon was located more centrally in the hemisphere
- Z) El Chicon was a more prolonged eruption

ANSWER: W) EL CHICON EMITTED MUCH MORE SULFUR DIOXIDE

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TOSS-UP

20) Physics – *Multiple Choice* Which of the following circuits with two components will behave as an electrical resonator?

- W) resistor and capacitor
- X) resistor and inductor
- Y) capacitor and inductor
- Z) capacitor and capacitor

ANSWER: Y) CAPACITOR AND INDUCTOR

BONUS

20) Physics – *Short Answer* The temperature is 27 degrees Celsius outdoors and 17 degrees Celsius indoors. To the nearest whole number, what is the maximal coefficient of performance that could be attained by an ideal air conditioner?

ANSWER: 30

TOSS-UP

21) Chemistry – *Short Answer* Identify all of the following three compounds that are a stronger base than sodium hydride: 1) T-butyl [*t-byu-til*] lithium; 2) Ammonia; 3) Sodium tert-butoxide [*tert-byu-tox-eyed*].

ANSWER: JUST 1

BONUS

21) Chemistry – *Short Answer* Identify all of the following three compounds that are most likely to undergo electrophilic [*ee-lektroh-FILL-ik*] aromatic substitution at the meta position: 1) Nitrobenzene; 2) Toluene [*TAWL-you-een*]; 3) Ethyl benzoate [*BEN-zoh-ate*].

ANSWER: 1 AND 3

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### TOSS-UP

22) Biology – *Short Answer* In the spinal cord, cell bodies of sensory neurons are grouped together to form what structures?

ANSWER: DORSAL ROOT GANGLIA (ACCEPT: DORSAL ROOTS)

### BONUS

22) Biology – *Short Answer* Identify all of the following three responses that are actions of the sympathetic nervous system: 1) Pupil constriction; 2) Increased heart rate; 3) Vasodilation [*vay-zoh-dye-LAY-shun*] in muscles.

ANSWER: 2 AND 3

**TOSS-UP**

23) Math – *Short Answer* If the difference between two prime numbers is 27, what is their sum?

ANSWER: 31

**BONUS**

23) Math – *Short Answer* A custom mixture of nuts is composed of cashews worth \$16 a pound and almonds worth \$10 a pound. May purchases 8 pounds of the mixture for \$113. How many of these 8 pounds are cashews?

ANSWER: 5.5 (ACCEPT:  $5\frac{1}{2}$ ,  $11/2$ )