

HIGH SCHOOL - ROUND 13A

TOSS-UP

1) Energy – *Multiple Choice* Researchers at the DOE’s Joint Genome [*JEE-nome*] Institute recently performed a transcriptomic [*trans-krip-TAWN-ik*] analysis on mycorrhizal [*MY-koh-RYE-zul*] fungi [*fun-ji*] to understand their mechanisms of drought adaptation. Which of the following procedures was integral to this analysis?

- W) Measured numbers of RNAs for all of the fungal [*FUN-gul*] genes
- X) Sequenced the fungi’s [*fun-jize*] DNA
- Y) Measured the levels of every fungal protein
- Z) Sequenced all of the fungi’s [*fun-jize*] proteins

ANSWER: W) MEASURED NUMBERS OF RNAS FOR ALL OF THE FUNGAL GENES

BONUS

1) Energy – *Short Answer* SLAC [*slack*] scientists recently published a surprising study in which they discovered that applying small amounts of pressure to platinum or lithium cobalt oxide increased the material’s catalytic efficiency. Identify all of the following three devices to which this discovery is relevant:

- 1) Fuel cells; 2) Batteries; 3) Capacitors.

ANSWER: 1 AND 2

~~~~~

### TOSS-UP

2) Physics – *Multiple Choice* One vector has a magnitude of six meters, and the other has a magnitude of three meters. The magnitude of their vector product is 0.556. Which of the following is true of this system?

- W) The angle between the vectors is 33.7 degrees
- X) The angle between the vectors is 146.3 degrees
- Y) The scalar product is 19.9 meters
- Z) There is not enough information to determine the angle or the scalar product

ANSWER: Z) THERE IS NOT ENOUGH INFORMATION TO DETERMINE THE ANGLE OR THE SCALAR PRODUCT

### BONUS

2) Physics – *Short Answer* The root-mean-square voltage of AC power in the United States is 120 volts. In volts and to two significant figures, what is its amplitude?

ANSWER: 170

**TOSS-UP**

3) Math – *Short Answer* What is the sum of the largest prime number less than 50 and the smallest prime number greater than 50?

ANSWER: 100

**BONUS**

3) Math – *Multiple Choice* A regular 15-sided polygon is inscribed in a circle with radius 6. Which of the following is the length of one of its sides?

- W)  $6 \sin 24^\circ$
- X)  $6 \cos 24^\circ$
- Y)  $12 \sin 12^\circ$
- Z)  $12 \cos 12^\circ$

ANSWER: Y) 12 SINE  $12^\circ$



**TOSS-UP**

4) Biology – *Short Answer* What cells in plants function similarly to embryonic [*em-bree-ON-ic*] stem cells in animals?

ANSWER: MERISTEMATIC (ACCEPT: TOTIPOTENT)

**BONUS**

4) Biology – *Short Answer* The adenovirus [*AD-an-oh-virus*] capsid is shaped like what platonic solid?

ANSWER: ICOSAHEDRON (ACCEPT: REGULAR ICOSAHEDRON)

### TOSS-UP

5) Chemistry – *Multiple Choice* Nylon is a polymer formed by condensation reactions of diamines [*DYE-ah-meens*] and dicarboxylic [*dye-car-box-IHL-ik*] acids. What functional group is formed by this reaction?

- W) Alcohol
- X) Nitrile
- Y) Ester
- Z) Amide [*AM-ide*]

ANSWER: Z) AMIDE

### BONUS

5) Chemistry – *Short Answer* Identify all of the following three organic compounds that can be used as strong bases in a chemical reaction: 1) Pyridinium chloro-chromate; 2) Oxolane; 3) DMSO.

ANSWER: NONE

~~~~~

TOSS-UP

6) Earth and Space – *Multiple Choice* Which of the following methods of determining distances to celestial objects is useful for the greatest distances?

- W) Stellar parallax
- X) Hubble's law
- Y) Variable stars
- Z) Radar ranging

ANSWER: X) HUBBLE'S LAW

BONUS

6) Earth and Space – *Short Answer* As a planet with a circular orbit revolves around a star, how many of its five Lagrangian [*lah-**GRAHN**-jee-in*] points will also move?

ANSWER: FIVE (ACCEPT: ALL OF THEM)

TOSS-UP

7) Energy – *Short Answer* Researchers at Lawrence Berkeley National Lab are studying how mechanical tension from proteins anchored at the nuclear membrane changes gene expression by imaging what collection of external fibrous glycoproteins that provide structural and biochemical support to an animal cell?

ANSWER: EXTRACELLULAR MATRIX (ACCEPT: ECM)

BONUS

7) Energy – *Multiple Choice* Scientists at Pacific Northwest National Lab tested theoretical predictions of the rate of crystallization of metastable liquid water at temperatures well below 0 °C. Which of the following is true of the crystallization of supercooled water in this regime?

- W) Water gains enthalpy [*EN-thul-pee*] and entropy [*EN-troh-pee*], but loses Gibbs free energy
- X) Water gains enthalpy, but loses entropy and Gibbs free energy
- Y) Water gains entropy, but loses enthalpy and Gibbs free energy
- Z) Water gains entropy, loses enthalpy, and its Gibbs free energy stays constant

ANSWER: Y) WATER GAINS ENTROPY, BUT LOSES ENTHALPY AND GIBBS FREE ENERGY

~~~~~  
**TOSS-UP**

8) Math – *Short Answer* The graph of the function  $f$  of  $x$  lies in the third quadrant. The function  $g$  of  $x$  equals  $-2$  times  $f$  of  $x$ . In what quadrant does the graph of the function  $f$  of  $x + g$  of  $x$  lie?

ANSWER: SECOND (ACCEPT: 2)

**BONUS**

8) Math – *Short Answer* Two complex numbers have absolute values of  $\sqrt{2}$  and  $3\sqrt{2}$ , and angles of 57 degrees and 35 degrees, respectively. What are the absolute value and the angle degree measure of their product?

ANSWER: ABSOLUTE VALUE = 6; ANGLE = 92

**TOSS-UP**

9) Earth and Space – *Multiple Choice* Which of the following is NOT true of stellar evolution and the HR diagram?

- W) White dwarfs occupy the lower left region of the HR diagram
- X) The sun falls on the main sequence
- Y) The instability strip falls below the main sequence
- Z) The Hayashi track is a pre-main-sequence phase of stellar evolution

ANSWER: Y) THE INSTABILITY STRIP FALLS BELOW THE MAIN SEQUENCE

**BONUS**

9) Earth and Space – *Short Answer* Identify all of the following three statements that are true of neutron stars: 1) The paired neutron material can be considered a superfluid; 2) Neutron star crust contains degenerate electrons; 3) Neutron stars are supported by degeneracy pressure.

ANSWER: ALL

~~~~~  
TOSS-UP

10) Biology – *Short Answer* In what phylum [*FYE-lum*] is an octopus classified?

ANSWER: MOLLUSCA

BONUS

10) Biology – *Multiple Choice* In an indirect immunofluorescence experiment, which of the following would be most useful for imaging a protein that is first probed with a rabbit antibody?

- W) goat-anti-rabbit RFP
- X) goat-anti-rabbit cAMP
- Y) rabbit-anti-goat GFP
- Z) goat-anti-mouse GFP

ANSWER: W) GOAT-ANTI-RABBIT RFP

TOSS-UP

11) Physics – *Short Answer* Doug pushes a 7-kilogram box up a 30-degree ramp onto the bed of a truck, which is 3 meters above the ground. In joules and rounded to the nearest 10, how much work did he do?

ANSWER: 210

BONUS

11) Physics – *Short Answer* According to Noether's [*Noh-turz*] Theorem, the conservation of angular momentum is related to what kind of spatial symmetry?

ANSWER: ROTATIONAL (ACCEPT: ROTATIONAL INVARIANCE)

~~~~~

### TOSS-UP

12) Chemistry – *Multiple Choice* A student observes the dimerization [*dye-mur-ih-ZAY-shun*] of a solution of cyclopentadiene [*sigh-kloh-penta-DYE-eeen*]. Assuming the reaction is second-order in cyclopentadiene, which of the following will she observe as she continues to monitor the reaction?

- W) The rate increases
- X) The rate remains constant
- Y) The half-life increases
- Z) The half-life remains constant

ANSWER: Y) THE HALF-LIFE INCREASES

### BONUS

12) Chemistry – *Multiple Choice* Consider a gas-phase reaction where  $\Delta H$  is less than  $\Delta U$ . If the reaction is at equilibrium, which of the following changes will ALWAYS shift the reaction mixture to the right?

- W) Increasing the temperature
- X) Decreasing the temperature
- Y) Increasing the volume
- Z) Decreasing the volume

ANSWER: Z) DECREASING THE VOLUME

**TOSS-UP**

13) Biology – *Short Answer* What property is exhibited by genes that have multiple phenotypic [*FEE-no-TIP-ik*] effects?

ANSWER: PLEIOTROPY [*plee-AW-troh-pee*]

**BONUS**

13) Biology – *Multiple Choice* White flowers with a long, narrow corolla tube that flower at night are most likely pollinated by what animals?

- W) Beetles
- X) Birds
- Y) Bats
- Z) Moths

ANSWER: Z) MOTHS



**TOSS-UP**

14) Energy – *Short Answer* EXO-200 is a SLAC [*slack*]-supported experiment attempting to determine if anti-neutrinos [*new-TREE-noze*] and neutrinos are the same particle. They are doing this by observing the double beta [*BAY-tah*] decay of what noble gas?

ANSWER: XENON [*ZEE-non*]

**BONUS**

14) Energy – *Short Answer* Scientists at Oak Ridge National Lab are using computer simulations to better understand the stability of calcium-52, which is inadequately described by current theories. Most surprisingly, despite having completely filled a nucleon shell, calcium-52 does not appear to behave like what set of nuclei?

ANSWER: MAGIC NUCLEI (ACCEPT: MAGIC NUMBER NUCLEI)

**TOSS-UP**

15) Earth and Space – *Multiple Choice* Which of the following pairs of tectonic [*tek-TAWN-ik*] plates does NOT constitute a primarily convergent boundary?

- W) North American and Cocos plates
- X) South American and Nazca plates
- Y) African and Eurasian plates
- Z) Pacific and Antarctic plates

ANSWER: Z) PACIFIC AND ANTARCTIC PLATES

**BONUS**

15) Earth and Space – *Short Answer* Identify all of the following three geologic principles that are Steno's [*STEH-nose*] Laws: 1) Law of original horizontality [*haw-rih-zon-TAL-ih-tee*]; 2) Law of superposition; 3) Law of faunal succession.

ANSWER: 1 AND 2

~~~~~  
TOSS-UP

16) Physics – *Multiple Choice* The statement that magnetic monopoles do not exist in classical physics is most equivalent to which of the following statements?

- W) The magnetic field has a divergence of zero
- X) The electric field has a divergence related to total charge density
- Y) A changing magnetic field will induce an electromotive force in a closed loop
- Z) A moving charge will induce a magnetic field

ANSWER: W) THE MAGNETIC FIELD HAS A DIVERGENCE OF ZERO

BONUS

16) Physics – *Short Answer* Identify all of the following three particles that have a color charge of zero: 1) Free neutron; 2) Free proton; 3) Electron.

ANSWER: ALL

TOSS-UP

17) Chemistry – *Short Answer* What is the IUPAC name for the compound with the chemical formula $\text{Ni}(\text{CO})_4$?

ANSWER: TETRACARBONYL [*carboh-NEEL*] NICKEL ZERO (ACCEPT: TETRACARBONYL NICKEL)

BONUS

17) Chemistry – *Short Answer* Consider a zero-order reaction with a single aqueous [*AY-kwee-us*] reactant A. If the initial concentration of A is 1 molar and the half-life at this time is 10 seconds, how many seconds will elapse before the concentration of A is 0.25 molar?

ANSWER: 15

~~~~~  
**TOSS-UP**

18) Math – *Short Answer* What is the integral from  $-3$  to  $6$  of  $4 dx$ ?

ANSWER: 36

**BONUS**

18) Math – *Short Answer* If the probability of event A is 0.4, the probability of event B is 0.6, and the probability of both A and B occurring is 0.3, what is the probability of event A given that B has already occurred?

ANSWER: 0.5 (ACCEPT:  $\frac{1}{2}$ , 50%)

### TOSS-UP

19) Biology – *Short Answer* What is the adjective for the specialized type of fruit in which the fruit develops from several flowers, of which pineapples are an example?

ANSWER: MULTIPLE (ACCEPT: COLLECTIVE)

### BONUS

19) Biology – *Short Answer* Identify all of the following three responses that are activities of the parasympathetic division of the nervous system: 1) Bronchi [**BRONK-eye**] relaxation in lungs; 2) Heart-rate acceleration; 3) Stimulation of the adrenal [**Ah-DREE-nul**] medulla [**meh-DULL-ah**].

ANSWER: NONE

~~~~~

TOSS-UP

20) Chemistry – *Short Answer* Positron-emission tomography is a medical technique that involves the dosing of a patient with a fluorinated analog of what biochemically important molecule?

ANSWER: GLUCOSE

BONUS

20) Chemistry – *Short Answer* Rank the following three types of interactions in increasing order of energy cost in a conformational analysis of the C2-C3 bond in butane: 1) H-H eclipsed overlap; 2) CH₃-CH₃ eclipsed overlap; 3) H-CH₃ eclipsed overlap.

ANSWER: 1, 3, 2

TOSS-UP

21) Earth and Space – *Short Answer* What mineral can be found on the continuous branch of Bowen's reaction series?

ANSWER: PLAGIOCLASE FELDSPAR (ACCEPT: PLAGIOCLASE; DO NOT ACCEPT: FELDSPAR)

BONUS

21) Earth and Space – *Short Answer* Identify all of the following three statements that are true regarding winds: 1) In general, winds at the equator flow west; 2) Air rising from the equator sinks around 5 degrees north and south latitudes; 3) At 30 degrees south latitude, the sinking air generally yields clear skies.

ANSWER: 1 AND 3

~~~~~  
**TOSS-UP**

22) Math – *Short Answer* What is the discriminant of the quadratic function  $y = x^2 - 5x + 9$ ?

ANSWER: -11

**BONUS**

22) Math – *Short Answer* In a circle with radius 6, what is the area of a circular segment defined by an arc of  $60^\circ$ ?

ANSWER:  $6\pi - 9\sqrt{3}$

### TOSS-UP

23) Physics – *Short Answer* A propeller is accelerating at 2.5 radians per second squared. After 4 seconds, it has rotated through 80 radians. What was the initial angular velocity, in radians per second, at the beginning of the 4 seconds?

ANSWER: 15

### BONUS

23) Physics – *Short Answer* A beam of light is traveling inside a solid cube of a material with an index of refraction of 1.414. If the cube is in air, what is the measure, to the nearest degree, of the minimum angle to the normal inside the glass so that the beam of light will not enter the air?

ANSWER: 45