

ROUND 12A

TOSS-UP

1) Earth and Space – *Multiple Choice* At which of the following locations on the HR diagram would one find Betelgeuse?

- W) Top right
- X) Top left
- Y) Bottom right
- Z) Bottom left

ANSWER: W) TOP RIGHT

BONUS

1) Earth and Space – *Short Answer* What are the two main non-oxygen elements in coal combustion products that are responsible for acid rain?

ANSWER: NITROGEN AND SULFUR

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### TOSS-UP

2) Physics – *Short Answer* A car is traveling around a circular track in uniform circular motion. Identify all of the following three quantities that are constant for the car: 1) Angular velocity; 2) Acceleration; 3) Radial velocity.

ANSWER: 1

### BONUS

2) Physics – *Short Answer* What is the name of the principle that states that the lowest energy orbitals of an atom are filled before higher energy ones?

ANSWER: AUFBAU PRINCIPLE

**TOSS-UP**

3) Energy – *Short Answer* What U.S. university was the site of the first ever sustained nuclear reaction?

ANSWER: UNIVERSITY OF CHICAGO (ACCEPT: CHICAGO)

**BONUS**

3) Energy – *Short Answer* Recent experiments regarding antimatter at the Relativistic Heavy Ion Collider determined that what fundamental force demonstrates no asymmetry within nuclei [*NEW-klee-eye*]?

ANSWER: STRONG NUCLEAR FORCE (ACCEPT: STRONG, STRONG NUCLEAR)

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TOSS-UP

4) Math – *Multiple Choice* Consider the polynomial equation $6x^3 - 20x + 15 = 0$. According to the rational root theorem, which of the following is NOT a possible rational root of this equation?

- W) -5
- X) 1/3
- Y) 1/2
- Z) 6/5

ANSWER: Z) 6/5

BONUS

4) Math – *Short Answer* If the sides of a triangle have lengths 5, 7, and 8, what is the cosine of the largest angle?

ANSWER: 1/7

TOSS-UP

5) Biology – *Multiple Choice* What aspect of a reaction does an enzyme change?

- W) Free energy
- X) Entropy [*EN-troh-pee*]
- Y) Enthalpy [*EN-thul-pee*]
- Z) Activation energy

ANSWER: Z) ACTIVATION ENERGY

BONUS

5) Biology – *Multiple Choice* What do amoebas use in order to move around?

- W) Cilia [*SILL-ee-ah*]
- X) Flagella [*Flah-JEL-ah*]
- Y) Pseudopodia [*soo-dah-POH-dee-ah*]
- Z) Asters

ANSWER: Y) PSEUDOPODIA

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### TOSS-UP

6) Chemistry – *Multiple Choice* Which of the following statements concerning crystal structure is NOT true?

- W) HCP lattices are more space-filling than FCC lattices
- X) Cesium [*SEEZ-ee-um*] chloride lattices form when anions [*AN-eye-ons*] and cations [*CAT-eye-onz*] are of roughly equal size
- Y) Rock-salt lattices have (6,6)-coordination
- Z) The crystal structure of a metal is dependent on pressure and temperature

ANSWER: W) HCP LATTICES ARE MORE SPACE-FILLING THAN FCC LATTICES

### BONUS

6) Chemistry – *Short Answer* Identify all of the following four species that have a square planar geometry:

- 1) Sulfur tetrafluoride [*tetrah-FLOOR-ide*];
- 2) Carbon tetrachloride [*tetrah-KLOOR-ide*];
- 3) Xenon [*ZEE-non*] tetrafluoride;
- 4) Iodine tetrabromide [*tetrah-BROH-mide*] anion [*AN-eye-on*] with a 1<sup>-</sup> charge

ANSWER: 3 AND 4

### TOSS-UP

7) Earth and Space – *Multiple Choice* Much of the information we have about the center of the Milky Way was collected in the radio wavelengths of the electromagnetic spectrum. Which of the following telescopes could be used to make these images?

- W) Hubble Space Telescope
- X) Keck Observatory
- Y) Chandra Observatory
- Z) Very Large Array

ANSWER: Z) VERY LARGE ARRAY

### BONUS

7) Earth and Space – *Short Answer* Ground astronomy must be conducted in wavelengths of light that can pass through Earth's atmosphere. Aside from visible light, to what other form of electromagnetic radiation is our atmosphere mostly transparent?

ANSWER: RADIO

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TOSS-UP

8) Chemistry – *Multiple Choice* Consider the gas-phase decomposition of PCl_5 into PCl_3 and Cl_2 . If the reaction begins with 5 atmospheres of PCl_5 , and if the partial pressure of chlorine is x atm at equilibrium, which of the following expressions for K_p is correct?

- W) The fraction with numerator x and denominator $5 \text{ minus } x$
- X) The fraction with numerator x and denominator open parenthesis 5 minus x close parenthesis squared
- Y) The fraction with numerator x squared and denominator $5 \text{ minus } x$
- Z) The fraction with numerator x squared and denominator open parenthesis 5 minus x close parenthesis squared

ANSWER: Y) THE FRACTION WITH NUMERATOR x SQUARED AND DENOMINATOR $5 \text{ MINUS } x$

BONUS

8) Chemistry – *Short Answer* What is the name of the analytic method in chemistry that uses the spin-flip transitions of nuclei to identify the unique electronic bonding environments for a given compound?

ANSWER: NMR (ACCEPT: NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY)

TOSS-UP

9) Energy – *Short Answer* Identify all of the following three options that would increase the resistance of a wire:
1) Increasing the temperature; 2) Increasing the radius; 3) Increasing the length.

ANSWER: 1 AND 3

BONUS

9) Energy – *Short Answer* Hydrogen fuel cells use a membrane to separate the electrodes and allow what particles to pass from the anode [*ANN-ode*] to the cathode [*CATH-ode*]?

ANSWER: PROTONS

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**TOSS-UP**

10) Math – *Short Answer* If angle ABC is inscribed in a circle and measures 15 degrees, what is the degree measure of arc ABC?

ANSWER: 330

**BONUS**

10) Math – *Short Answer* A triangular right prism has each edge of length 10. To the nearest ten, what is its volume?

ANSWER: 430

### TOSS-UP

11) Energy – *Multiple Choice* What is the typical co-electrolyte in Vanadium [*vah-NAY-dee-um*] redox [*REE-dox*] flow batteries?

- W) Zinc nitrate
- X) Sulfuric acid
- Y) Sodium hydroxide
- Z) Copper chloride

ANSWER: X) SULFURIC ACID

### BONUS

11) Energy – *Short Answer* Biodiesel produces less particulates, carbon oxides, sulfur dioxide, and unburnt carbons than fossil-based diesel. However, biodiesel does result in greater emissions of what ozone-generating pollutant?

ANSWER: NITROUS OXIDES (ACCEPT: NOX)

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TOSS-UP

12) Biology – *Multiple Choice* Which of the following statements about monocots and dicots is NOT correct?

- W) Monocots have three holes in their pollen, while dicots only have one
- X) Monocots have scattered vascular bundles, while dicot bundles are in a ring
- Y) Monocots lack a pith region in the stem, while dicots have a pith
- Z) Monocots have parallel venation in their leaves while dicots have netted veins

ANSWER: W) MONOCOTS HAVE THREE HOLES IN THEIR POLLEN, WHILE DICOTS ONLY HAVE ONE

BONUS

12) Biology – *Multiple Choice* Which of the following pairs of terms referring to the life cycle of land plants is mismatched with the correct ploidy?

- W) Megasporangium [*mega-spor-AYN-gee-um*] and diploid
- X) Sporocyte and diploid
- Y) Egg and haploid
- Z) Integument and haploid

ANSWER: Z) INTEGUMENT AND HAPLOID

TOSS-UP

13) Math – *Short Answer* To the nearest whole number, what is the slant height of a right circular cone with radius 6 and height 9?

ANSWER: 11

BONUS

13) Math – *Short Answer* How many zeros occur at the right of the number of permutations of 100 objects taken 80 at a time?

ANSWER: 5

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**TOSS-UP**

14) Biology – *Short Answer* What virus causes mononucleosis [*mono-new-kee-OH-sis*] in humans?

ANSWER: EPSTEIN-BARR VIRUS

**BONUS**

14) Biology – *Short Answer* In a developing root, there are three regions: the region of cell division, the region of cell elongation, and the region of maturation. What external feature of the epidermis allows one to know they have located the region of maturation?

ANSWER: ROOT HAIRS

**TOSS-UP**

15) Earth and Space – *Multiple Choice* Which variable affecting the speed of sound in the ocean dominates at very large depths?

- W) Water Pressure
- X) Salinity
- Y) Temperature
- Z) Biologic density

ANSWER: W) WATER PRESSURE

**BONUS**

15) Earth and Space – *Short Answer* Plutinos are Kuiper belt objects whose orbits are locked in a 3-to-2 resonance with what planet?

ANSWER: NEPTUNE

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TOSS-UP

16) Math – *Short Answer* In base 8, what is 6 times 7?

ANSWER: FIVE-TWO

BONUS

16) Math – *Short Answer* Rounded to the nearest integer, what is the area of a circle of circumference 15?

ANSWER: 18

TOSS-UP

17) Physics – *Multiple Choice* A swinging door is opened to +80 degrees, and released. It swings to -40 degrees, then back to +20 degrees and so on before eventually reaching rest at 0 degrees. This oscillatory behavior can be best described as which of the following?

- W) Underdamped
- X) Critically damped
- Y) Overdamped
- Z) Undamped

ANSWER: W) UNDERDAMPED

BONUS

17) Physics – *Short Answer* Protons and neutrons are made up of what two quarks?

ANSWER: UP AND DOWN

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### TOSS-UP

18) Chemistry – *Multiple Choice* Which of the following compounds has the highest vapor pressure at 25 degrees Celsius?

- W) Water
- X) Ethanol
- Y) Methanol
- Z) Diethyl [*dye-eh-thyl*] ether [*EE-thur*]

ANSWER: Z) DIETHYL ETHER

### BONUS

18) Chemistry – *Short Answer* Consider the heating of anhydrous [*an-HIGH-drus*] solid calcium carbonate to form gaseous CO<sub>2</sub> and solid calcium oxide. Identify all of the following three changes that would shift this reaction to the right:  
1) Adding more calcium carbonate; 2) Adding more calcium oxide; 3) Increasing the temperature.

ANSWER: 3

### TOSS-UP

19) Chemistry – *Multiple Choice* Which of the following correctly explains why oxygen exists in a double-bonded diatomic [*dye-ah-TOM-ik*] form whereas sulfur forms S8 chains?

- W) Sulfur is too electropositive to form strong pi [*pie*] bonds
- X) Sulfur's 3p orbitals have less overlap for pi bonding
- Y) Oxygen is paramagnetic whereas sulfur is diamagnetic [*dye-ah-mag-NET-ik*]
- Z) Sulfur can expand its valence [*VAY-lense*] shell to hold more than eight electrons

ANSWER: X) SULFUR'S 3P ORBITALS HAVE LESS OVERLAP FOR PI BONDING

### BONUS

19) Chemistry – *Short Answer* Identify all of the following three statements that are TRUE concerning carbon monoxide: 1) It is a high-field ligand [*LIH-gund*]; 2) It often forms complexes with neutral metal atoms; 3) It is a pi [*pie*] donor ligand.

ANSWER: 1

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TOSS-UP

20) Physics – *Short Answer* What compound of uranium in the uranium fuel cycle is polyfluorinated [*polly-FLOOR-in-ated*] and gaseous?

ANSWER: UF6 (ACCEPT: URANIUM HEXAFLUORIDE, HEX)

BONUS

20) Physics – *Short Answer* A square conducting loop that has sides of length 10 centimeters is pulled out of a 5-tesla magnetic field at 1 meter per second. What is the magnitude of the induced EMF, in volts, in the loop while it is leaving the magnetic field?

ANSWER: 0.5

TOSS-UP

21) Earth and Space – *Multiple Choice* A necessary conclusion of Hubble's law is that very-distant galaxies are moving away from us at speeds faster than the speed of light. Which of the following correctly explains this observation?

- W) Hubble's law becomes non-linear for very large distances
- X) The Hubble constant was originally miscalculated
- Y) Due to the metric expansion of space, faraway objects can recede from us faster than the speed of light
- Z) The proper distance to faraway galaxies does not scale linearly with the Hubble constant

ANSWER: Y) DUE TO THE METRIC EXPANSION OF SPACE, FARAWAY OBJECTS CAN RECEDE FROM US FASTER THAN THE SPEED OF LIGHT

BONUS

21) Earth and Space – *Multiple Choice* Cosmologists have recently reembraced the cosmological constant as a quantity in the Einstein field equations. Which of the following could be a physical explanation for the cosmological constant?

- W) Vacuum energy
- X) Morse energy
- Y) Cosmic microwave background
- Z) Dark matter

ANSWER: W) VACUUM ENERGY

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### TOSS-UP

22) Physics – *Short Answer* How many vibrational degrees of freedom does a linear triatomic gas molecule possess?

ANSWER: FOUR

### BONUS

22) Physics – *Short Answer* For an ideal gas, identify all of the following 3 properties that, when increased alone, would increase the mean free path of a gas molecule: 1) Pressure; 2) Temperature; 3) Collision area.

ANSWER: 2

### TOSS-UP

23) Chemistry – *Short Answer* Identify all of the following three quantities in reaction kinetics that are dimensionless:  
1) Rate constant; 2) Steric [*steh-rik*] factor; 3) Collision frequency.

ANSWER: 2

### BONUS

23) Chemistry – *Short Answer* Identify all of the following three changes that would shift the equilibrium of the Haber [*HAH-bur*] process to the right: 1) Adding hydrogen gas; 2) Adding an inert gas; 3) Increasing the volume of the container at constant temperature.

ANSWER: 1 ONLY