ROUND 12

TOSS-UP

1) PHYSICS Multiple Choice Often some of the strongest spectral lines in cold interstellar gas are produced by:

W) neutral lithium
X) ionized iron
Y) carbon and iron
Z) calcium and sodium

ANSWER: Z) CALCIUM AND SODIUM

BONUS

1) PHYSICS Short Answer The cosmic background radiation discovered by Penzias and Wilson closely matches the radiation from a black body with what temperature Kelvin, to the nearest whole number?

ANSWER: 3

TOSS-UP

2) CHEMISTRY Multiple Choice Which of the following salt solutions, all at 1.0 molar concentration, will have a pH value less than 7:

W) NH₄Cl
X) NaC₂H₃O₂
Y) KCl
Z) LiBr

ANSWER: W) NH₄Cl

BONUS

2) CHEMISTRY Short Answer Name all of the following 4 compounds that exhibit hydrogen bonding: CH₄; H₂S; NH₃; CH₃OH

ANSWER: NH₃; CH₃OH
3) BIOLOGY *Multiple Choice* In early experiments in the mid-1900’s, the source and fate of oxygen involved in photosynthesis was mostly determined through experiments that used:

W) animals in closed containers that would die unless a plant was introduced into the container  
X) a heavy isotope of oxygen as a tracer  
Y) fluorescent labeling of various enzymes and organic products  
Z) simple accounting of the atomic mass of all the reactants and products

**ANSWER:** X) A HEAVY ISOTOPE OF OXYGEN AS A TRACER

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**BONUS**

3) BIOLOGY *Short Answer* By number or name, identify all of the following 4 processes that contribute directly to genetic variation in humans: 1) random fertilization of ova with sperm; 2) crossing over; 3) independent assortment; 4) mitosis

**ANSWER:** 1, 2 AND 3 (ACCEPT: ALL BUT #4)

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**TOSS-UP**

4) MATH *Short Answer* If you roll 2 fair dice simultaneously, what is the probability, given as a fraction, that you will roll the number 6 on AT LEAST one die?

**ANSWER:** 11/36

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**BONUS**

4) MATH *Short Answer* Find the sum of all interior angles, in degrees, in a regular polygon having 14 sides:

**ANSWER:** 2,160

(Solution: \((14 - 2)(180) = 2,160^\circ\))
5) EARTH SCIENCE  *Multiple Choice*  Which of the following is the BEST example of a non-point source pollution:

W) leaching from a landfill
X) a leaking septic tank
Y) fertilizer runoff from agricultural fields
Z) chemical spills at a mining site

**ANSWER:** Y) FERTILIZER RUNOFF FROM AGRICULTURAL FIELDS

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**BONUS**

5) EARTH SCIENCE  *Short Answer*  Arrange the following 4 layers of the Earth’s atmosphere in order of INCREASING air pressure: stratosphere; exosphere; thermosphere; troposphere

**ANSWER:** EXOSPHERE; THERMOSPHERE; STRATOSPHERE; TROPOSPHERE

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6) GENERAL SCIENCE  *Multiple Choice*  Some vitamin tablets contain high concentrations of zinc and must be formulated to include high levels of which of the following minerals in order to prevent an induced anemia:

W) copper
X) calcium
Y) magnesium
Z) boron

**ANSWER:** W) COPPER

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**BONUS**

6) GENERAL SCIENCE  *Short Answer*  What is the most common name for the technique that places a molecule in a strong magnetic field, irradiates the molecule with radio waves, and finally detects changes in the spin of atoms in the molecule?

**ANSWER:** NUCLEAR MAGNETIC RESONANCE  (ACCEPT:  NMR or MAGNETIC RESONANCE SPECTROSCOPY)
TOSS-UP

7) ASTRONOMY Multiple Choice Landform deposits called linear dunes that were recently found on the moon Titan are MOST directly produced by:

W) tectonic activity  
X) wind  
Y) erosion by the retreat and advance of large seas of liquid methane  
Z) streaks in the surface following low-angle meteorite impacts

ANSWER: X) WIND

BONUS

7) ASTRONOMY Short Answer What is the magnifying power of the telescope with a focal length of 5 meters and an eyepiece of 20 millimeters?

ANSWER: 250 (ACCEPT: 250X or 250 TIMES)

(Solution: 5000mm/20mm = 250)

TOSS-UP

8) PHYSICS Multiple Choice The process in which an atom reradiates a photon after interacting with an incident photon of the same energy is called:

W) Rayleigh scattering  
X) the Cherenkov effect  
Y) Bragg’s Law  
Z) Thomson scattering

ANSWER: Z) THOMSON SCATTERING

BONUS

8) PHYSICS Multiple Choice A protanomalous person has decreased sensitivity of the red cones in his or her eyes. Which of the following color pairs will this person have difficulty distinguishing between:

W) red and green  
X) blue and purple  
Y) yellow and turquoise  
Z) dark navy blue and black

ANSWER: X) BLUE AND PURPLE
TOSS-UP

9) CHEMISTRY Multiple Choice Which of the following is typically TRUE of organic compounds:

W) acetylene contains delocalized pi bonds
X) the simplest carboxylic acid is ethanoic acid
Y) ketones have no hydrogen atoms directly attached to the carbonyl group
Z) alcohols contain nonpolar hydroxyl groups

ANSWER: Y) KETONES HAVE NO HYDROGEN ATOMS DIRECTLY ATTACHED TO THE CARBONYL GROUP

BONUS

9) CHEMISTRY Short Answer Rounded to the nearest whole number, what is the percent of magnesium in magnesium carbonate, given the atomic mass of magnesium is 24 grams per mole?

ANSWER: 29

(Solution: \( \text{MgCO}_3 = 24 + 12 + (3 \times 16) = 84; \ 24/84 = 28.57\% \))

TOSS-UP

10) BIOLOGY Multiple Choice In the famous experiment by Hershey and Chase that showed DNA was the genetic material, what did they use to transmit the DNA into \textit{E. coli}:

W) other \textit{E. coli}
X) electric shocks
Y) a blender
Z) bacteriophage

ANSWER: Z) BACTERIOPHAGE

BONUS

10) BIOLOGY Short Answer In the \textit{Amanita} mushroom, what is the name of the cell in which karyogamy and meiosis occur and what is the product of meiosis, respectively?

ANSWER: CELL = BASIDIUM; PRODUCT = BASIDIOSPORE
**TOSS-UP**

11) **MATH Multiple Choice** Which of the following are coterminal angles in standard position (read slowly):

- W) 550° and 185°
- X) 80° and -190°
- Y) 1160° and 800°
- Z) 181° and -118°

**ANSWER:** Y) 1160° AND 800°

(Solution: 80° +3(360°) = 1160°; 80° +2(360°) = 800°)

**BONUS**

11) **MATH Short Answer** Solve the following equation for \(x\), expressing your answer in simplest radical form over the real numbers:

\[x^4 - 9x^2 + 8 = 0\]

**ANSWER:** 
\[\pm 2\sqrt{2} \text{ AND } \pm 1 \text{ (ACCEPT ALL: } +2\sqrt{2}, -2\sqrt{2}, +1, -1)\]

**TOSS-UP**

12) **EARTH SCIENCE Multiple Choice** Which of the following is the BEST example of an ocean current found in the intertidal littoral zone that flows seaward:

- W) rip current
- X) tidal bore
- Y) the Antarctic Circumpolar Current
- Z) equatorial tidal current

**ANSWER:** W) RIP CURRENT

**BONUS**

12) **EARTH SCIENCE Multiple Choice** Which of the following is NOT true of isotherms:

- W) they are more widely spaced over the equatorial regions
- X) they are more closely spaced over North America in the summer than in the winter
- Y) they tend to be linear in form in the Southern Hemisphere south of 40° latitude
- Z) they are lines that connect places with the same average temperature

**ANSWER:** X) THEY ARE MORE CLOSELY SPACED OVER NORTH AMERICA IN THE SUMMER THAN IN THE WINTER
TOSS-UP

13) GENERAL SCIENCE  *Multiple Choice*  Which of the following instruments is BEST used to image small, transparent and fluorescent specimens and obtain optical sections without the need for mechanical sectioning:

W) X-ray microanalyzer  
X) scanning electron microscope  
Y) transmission electron microscope  
Z) confocal laser scanning microscope

**ANSWER:**  Z) CONFOCAL LASER SCANNING MICROSCOPE

BONUS

13) GENERAL SCIENCE  *Short Answer*  A relatively new scourge to the citrus growers in Florida, what is the common name of the citrus disease caused by a species of bacteria called *C. liberibacter* and spread by an introduced non-native insect?

**ANSWER:**  GREENING  (ACCEPT: CITRUS GREENING)

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TOSS-UP

14) ASTRONOMY  *Short Answer*  A sidereal drive is a motor on a telescope that turns it in a certain direction to keep the telescope aimed at a certain celestial object. Giving your answer as north, south, east or west, in what direction does it turn?

**ANSWER:**  WEST

BONUS

14) ASTRONOMY  *Multiple Choice*  The Wilkinson Microwave Anisotropy Probe was specifically designed to:

W) map all matter in the universe down to a resolution of 1 arc second  
X) map the cosmic background radiation to much greater accuracy and precision than previous instruments  
Y) map the size and locations of the Local Group  
Z) map the exact location of the active galactic center of the Milky Way

**ANSWER:**  X) MAP THE COSMIC BACKGROUND RADIATION TO MUCH GREATER ACCURACY AND PRECISION THAN PREVIOUS INSTRUMENTS
15) PHYSICS  *Multiple Choice*  In a compound gearing arrangement where a 40-tooth gear drives an 80-tooth gear which is directly connected to a 50-tooth gear that drives a 100-tooth gear, the total reduction is a factor of:

W) 2  
X) 2.5  
Y) 4  
Z) 5  

**ANSWER:** Y) 4

15) PHYSICS  *Multiple Choice*  Elastic deformation is BEST described as:

W) the linear portion of a stress/strain curve  
X) the ultimate strength of a material  
Y) 0.02% elongation  
Z) permanent deformation  

**ANSWER:** W) THE LINEAR PORTION OF A STRESS/STRAIN CURVE

16) CHEMISTRY  *Multiple Choice*  Which of the following elements has the largest second ionization energy:

W) fluorine  
X) nitrogen  
Y) boron  
Z) lithium  

**ANSWER:** Z) LITHIUM  

(Solution: core electrons must be removed)

BONUS

16) CHEMISTRY  *Short Answer*  Arrange the following compounds in order of INCREASING ionic characteristic: HCl; LiBr; CO; KF

**ANSWER:** CO; HCl; LiBr; KF
TOSS-UP

17) BIOLOGY Multiple Choice Which of the following are MOST often used to introduce foreign genes into mammalian genomes:

W) sliceosomes (read as: sly-see-oh-somz)
X) zinc fingers
Y) plasmids
Z) telomeres

ANSWER: Y) PLASMIDS

BONUS

17) BIOLOGY Multiple Choice Which of the following regulate development in animals, plants and fungi, and were first discovered in Drosophila:

W) homeobox (read as: HOME-ee-oh-box) genes
X) p53
Y) shock genes
Z) oncogenes

ANSWER: W) HOMEOBOX GENES

TOSS-UP

18) MATH Short Answer What function is the inverse of \( y = 3x + 4 \)?

ANSWER: \( y = \frac{x - 4}{3} \)

BONUS

18) MATH Short Answer Giving your answer as an ordered pair, find the solution of the system of the following 2 equations: \( 2x + 3y = 8 \), and \( 3x - 2y = -1 \)

ANSWER: (1, 2) (ACCEPT: 1 AND 2)
TOSS-UP

19) EARTH SCIENCE  *Multiple Choice*  Orthoclase feldspar primarily weathers by which of the following processes to form clay minerals:

W) abrasion  
X) hydrolysis  
Y) exfoliation  
Z) dissolution  

ANSWER: X) HYDROLYSIS

BONUS

19) EARTH SCIENCE  *Short Answer*  What is the name for the sedimentary rock that carries high concentrations of organic material in the form of kerogen, which can yield oil when heated and distilled?

ANSWER: OIL SHALE (ACCEPT: SHALE)

TOSS-UP

20) GENERAL SCIENCE  *Short Answer*  Name all of the following 4 reagents that would NOT be labeled as a highly flammable substance: methanol; diethyl ether; 30% hydrogen peroxide; benzene

ANSWER: 30% HYDROGEN PEROXIDE

BONUS

20) GENERAL SCIENCE  *Short Answer*  What engineering term is MOST commonly used to describe why a shaft with a radius at a transition in diameter is stronger than the same shaft with an abrupt transition in diameter?

ANSWER: STRESS CONCENTRATION (ACCEPT: STRESS CONCENTRATION AT THE CHANGE IN DIAMETER) (DO NOT ACCEPT: STRESS)
21) ASTRONOMY Short Answer If the surface temperature of a given star increased from 20,000K to 60,000K, how many times as much energy would the star release?

ANSWER: 81 (ACCEPT: 3^4)

BONUS

21) ASTRONOMY Short Answer Name all of the following 4 celestial objects that, when viewed from the Earth, CANNOT be in opposition: Moon; Mercury; Mars; Neptune

ANSWER: MERCURY

TOSS-UP

22) PHYSICS Short Answer What specific type of semiconductor is produced by adding phosphorus to silicon?

ANSWER: N-TYPE

BONUS

22) PHYSICS Short Answer How many turns are in the secondary coil of a transformer that has a primary coil with 20,000 turns and is designed to step down 12,000 volts AC to 120 volts AC?

ANSWER: 200

(Solution: 12,000/120 = 20,000/x; x = 200)
TOSS-UP

23) CHEMISTRY  *Short Answer*  The hybridization of one ‘s’ (read as: one <pause> s) orbital and 3 ‘p’ (read as: three <pause> p) orbitals and one ‘d’ (read as: one <pause> d) orbital creates how many *sp*^3^d* hybrid orbitals?

ANSWER:  5

BONUS

23) CHEMISTRY  *Short Answer*  A solution contains 0.50 moles of methanol in 100 grams of water. What is the mole fraction of methanol, to the second decimal place?

ANSWER:  0.08  (DO NOT ACCEPT 8.0%)

(Solution:  100g/18 g mol^−1^ = 5.56 moles;  0.5 mol/(5.56 + 0.5) = 0.0825)

TOSS-UP

24) BIOLOGY  *Short Answer*  Black water fever is a complication of malarial infection. The term black water comes from what oxidized product in the urine of infected individuals?

ANSWER:  HEMOGLOBIN  (ACCEPT:  MET-HEMOGLOBIN)

BONUS

24) BIOLOGY  *Short Answer*  Name all of the following 4 human blood cells that are considered lymphocytes: helper T cells;  CD8 cells;  CD4 cells;  plasma cells

ANSWER:  HELPER T CELLS;  CD8 CELLS;  CD4 CELLS;  PLASMA CELLS  (ACCEPT:  ALL)
25) CHEMISTRY  Short Answer  Calculate the atom percent composition, rounded to the nearest whole number, for each atom in acetic acid:

ANSWER: C = 25%;  H = 50%;  O = 25%

BONUS

25) CHEMISTRY  Short Answer  Calculate the mass percent composition, rounded to the nearest whole number, for each atom in acetic acid:

ANSWER: C = 40%;  H = 7%;  O = 53%

(Solution: C = 24/60 × 100% = 40%;  H = 4/60 × 100% = 6.7%;  O = 32/60 × 100% = 53.3%)