HIGH SCHOOL - ROUND 13A

TOSS-UP

1) Energy − *Short Answer* Scientists at the National Energy Technology Lab recovered pressurized cores from the Gulf of Mexico. When these cores were depressurized, they released what gas trapped on the ocean floor as a hydrate?

ANSWER: METHANE (ACCEPT: NATURAL GAS, CH_4)

BONUS

1) Energy – *Multiple Choice* Argonne National Lab researchers are using X-rays from the Advanced Photon Source to study the self-healing properties of nanoparticles. Which of the following techniques are they using to image these particles?

W) Atomic force microscopy
X) Coherent diffraction imaging
Y) Convergent beam electron diffraction
Z) Focused ion beam microscopy

ANSWER: X) COHERENT DIFFRACTION IMAGING

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TOSS-UP

2) Physics − *Short Answer* What phenomenon occurs when fluids flow up or down thin channels due to the difference between cohesive and adhesive forces between a liquid and another boundary?

ANSWER: CAPILLARY ACTION (ACCEPT: CAPILLARY EFFECT, CAPILLARY MOTION, CAPILLARITY)

BONUS

2) Physics − *Short Answer* Planet X orbits a star at a distance of 2.5 times 10^7 meters with an orbital period of 4 years. If planet Y orbits the same star with an orbital period of 32 years, in meters and in scientific notation with 2 significant figures, how far is planet Y from the star?

ANSWER: 1.0 TIMES 10^8
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TOSS-UP

3) Math − *Short Answer* To the nearest whole number, what is the slant height of a right circular cone with radius 7 and height 6?

ANSWER: 9

BONUS

3) Math − *Short Answer* At what x-value does the maximum value of the function f of $x = -2x^3 - 3x^2 + 36x + 9$ occur on the closed interval from –8 to 8?

ANSWER: –8

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TOSS-UP

4) Biology − *Short Answer* Diastole ***[dye-ASS-tuh-lee]*** and systole ***[SIS-tuh-lee]*** correspond to the phases of what organ?

ANSWER: HEART

BONUS

4) Biology – *Short Answer* Identify all of the following three statements that are true of starches: 1) In branched glycogen, the branch begins with an alpha-1,4-glycosidic linkage; 2) Amylopectin is more branched than amylose; 3) Cellulose is more branched than glycogen.

ANSWER: 2
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TOSS-UP

5) Chemistry – *Short Answer* Rank the following three aqueous solutions in terms of increasing electrolyte strength: 1) One-molar sucrose; 2) One-molar hydrochloric acid; 3) One-molar acetic acid.

ANSWER: 1, 3, 2

BONUS

5) Chemistry – *Short Answer* Identify all of the following three reagents that can be used to oxidize an alcohol: 1) Potassium permanganate ***[pur-MAYNG-en-ate]***; 2) Chromium trioxide ***[try-OX-ide]***; 3) Sodium borohydride ***[boar-oh-HIGH-dride]***.

ANSWER: 1, 2

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TOSS-UP

6) Earth and Space − *Multiple Choice* Arkose contains quartz and at least 25 percent of what other mineral group?

W) Carbonate
X) Feldspar
Y) Mica ***[MY-kah]***
Z) Clay

ANSWER: X) FELDSPAR

BONUS

6) Earth and Space − *Multiple Choice* Which of the following statements is NOT true about Lagrange ***[lah-GRAHNJ]*** points associated with two large bodies in orbit?

W) Lagrange points are solutions to the general three-body problem
X) There can be as many as 6 Lagrange points to describe a system
Y) Unstable Lagrange points lie on a straight line
Z) There are fewer stable Lagrange points than unstable points

ANSWER: X) THERE CAN BE AS MANY AS 6 LAGRANGE POINTS TO DESCRIBE A SYSTEM
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TOSS-UP

7) Energy − *Multiple Choice* Scientists at Thomas Jefferson National Accelerator Facility collide electrons with nuclei, generating particle showers that are measured by detectors. Which of the following particles is likely to be directly measured by a particle detector at Jefferson Lab?

W) Bottom quark
X) Gluon
Y) Z boson
Z) Proton

ANSWER: Z) PROTON

BONUS

7) Energy – *Multiple Choice* Scientists at Ames Lab have developed solvent-free techniques to synthesize alkali metal hydrides. Which of the following techniques do they use to unambiguously determine that the hydrogen atoms have bound to the metal?

W) Gravimetric analysis
X) Infrared spectroscopy
Y) UV/Vis spectroscopy
Z) Solid-state NMR spectroscopy

ANSWER: Z) SOLID-STATE NMR SPECTROSCOPY

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TOSS-UP

8) Math − *Short Answer* If the definite integral from 2 to 6 of *f* of *x* d*x* = 26, then what is the definite integral from 2 to 6 of *f* of *x* minus 4 d*x*?

ANSWER: 10

BONUS

8) Math − *Short Answer* Rounded to the nearest integer, what is the geometric mean of 6 and 85?

ANSWER: 23
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TOSS-UP

9) Earth and Space − *Multiple Choice* Which of the following values, in kelvins, is closest to the temperature of the Sun's photosphere?

W) 5,800
X) 8,000
Y) 2,000,000
Z) 15,000,000

ANSWER: W) 5,800

BONUS

9) Earth and Space − *Multiple Choice* Which of the following is the term for a pair of stars that are not physically close to each other but appear as a single star when viewed from Earth?

W) Optical double
X) Visual double
Y) Spectroscopic ***[spek-troh-SCAW-pik]*** binary
Z) Astrometric binary

ANSWER: W) OPTICAL DOUBLE

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TOSS-UP

10) Biology – *Short Answer* Of what class are sharks and rays members?

ANSWER: CHONDRICHTHYES ***[KON-drik-theez]***

BONUS

10) Biology − *Short Answer* Identify all of the following three statements that are true of the circadian clock: 1) It is autonomous; 2) It can be modulated by behavioral cues; 3) It evolved to manage energy use corresponding to the light-dark cycle caused by Earth's rotation.

ANSWER: ALL OF THEM
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TOSS-UP

11) Physics − *Short Answer* In an ideal gas, the average translational kinetic energy is linearly proportional with what power of the temperature of the gas?

ANSWER: ONE (ACCEPT: FIRST)

BONUS

11) Physics − *Short Answer* To the nearest whole hertz, what is the frequency of the second mode of a fixed string of length 0.08 meters, mass 0.125 kilograms, and tension 200 newtons?

ANSWER: 141

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TOSS-UP

12) Chemistry – *Short Answer* Identify all of the following three changes that increase the entropy of the system involved: 1) Dry ice sublimates into gas; 2) Nitrogen is pressurized from 0.01 atmospheres to 1 atmosphere; 3) Sugar is dissolved in a cup of tea.

ANSWER: 1, 3

BONUS

12) Chemistry – *Short Answer* What is the monomer used to synthesize teflon?

ANSWER: TETRA-FLUORO-ETHYLENE (ACCEPT: C_2F_4)
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TOSS-UP

13) Biology − *Short Answer* In rod cells, what protein is photobleached when exposed to light?

ANSWER: RHODOPSIN

BONUS

13) Biology – *Short Answer* Several important evolutionary features only evolved once in history. Identify all of the following three features that are known to have evolved a single time: 1) C4 photosynthesis; 2) Amniotic egg; 3) Feathers.

ANSWER: 2, 3

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TOSS-UP

14) Energy – *Short Answer* Scientists at Fermi National Accelerator Lab are attempting to detect WIMPs as a part of the SuperCDMS experiment. WIMPs are particles that are thought to primarily interact with ordinary matter via what two fundamental forces?

ANSWER: GRAVITY AND WEAK (ACCEPT: GRAVITY AND WEAK NUCLEAR, GRAVITY AND WEAK INTERACTION)

BONUS

14) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are developing methods to engineer the rhizosphere ***[RYE-zoh-sfeer]***. This is the area of soil that interacts with what part of the plant?

ANSWER: ROOTS
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TOSS-UP

15) Earth and Space − *Multiple Choice* A stream's competence is a measure of which of the following?

W) Water discharge rate
X) Flooding frequency
Y) Maximum transportable particle size
Z) Erosion rate

ANSWER: Y) MAXIMUM TRANSPORTABLE PARTICLE SIZE

BONUS

15) Earth and Space − *Short Answer* A phreatic ***[free-AT-ik]*** eruption can occur when magma interacts with what?

ANSWER: WATER (ACCEPT: GROUNDWATER)

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TOSS-UP

16) Physics − *Multiple Choice* Which of the following capacitor configurations for four identical capacitors would yield the largest stored charge for a given voltage?

W) All four capacitors connected in series
X) Two parallel branches of two series capacitors
Y) Three capacitors in parallel, in series to a fourth
Z) All four capacitors connected in parallel

ANSWER: Z) ALL FOUR CAPACITORS CONNECTED IN PARALLEL

BONUS

16) Physics − *Short Answer* Andrew finds a length of ideal rope with finite mass on the ground. He picks up one end by applying a constant force upward. Identify all of the following three statements that are true of this system: 1) Until he has lifted the entire rope off the ground, any given point on the rope has a constant velocity; 2) Until he has lifted the entire rope off the ground, any given point on the rope has a constant acceleration; 3) The total momentum of the rope increases as he pulls on the rope.

ANSWER: 3
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TOSS-UP

17) Chemistry – *Short Answer* What is the bond order of the diatomic species N_2 two minus?

ANSWER: TWO

BONUS

17) Chemistry − *Short Answer* Rank the following three nuclides in terms of increasing binding energy per nucleon: 1) Deuterium ***[doo-TEER-ee-um]***; 2) Helium-4; 3) Lithium-6.

ANSWER: 1, 3, 2

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TOSS-UP

18) Math – *Short Answer* The science and chess clubs at a school have a total of 60 students in them. If 37 are in the science club and 28 are in the chess club, how many are in both?

ANSWER: 5

BONUS

18) Math − *Short Answer* What is the slope-intercept equation of the oblique asymptote of the function *f* of *x* equals the fraction with numerator $2x^2 – 5$ and denominator $x + 3$?

ANSWER: $y = 2x – 6$
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TOSS-UP

19) Biology – *Short Answer* In the *lac* operon in *E. coli*, CAP acts as an activator protein. What second messenger must bind to CAP to activate transcription of the DNA?

ANSWER: CYCLIC AMP (ACCEPT: cAMP)

BONUS

19) Biology – *Multiple Choice* John Gurdon studied totipotency ***[toh-TIH-pah-ten-see]*** by implanting a nucleus from a fully-differentiated frog cell into enucleated egg cells. Which of the following best describes what he observed about the egg?

W) It continued to divide, but stopped development prior to forming a tadpole
X) It continued to divide and developed into a tadpole as normal
Y) It did not begin to divide after nucleation
Z) It continued to divide, but skipped the tadpole stage and formed a frog

ANSWER: W) IT CONTINUED TO DIVIDE, BUT STOPPED DEVELOPMENT PRIOR TO FORMING A TADPOLE

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TOSS-UP

20) Chemistry – *Short Answer* What named pericyclic reaction is classically the reaction of a di-ene ***[DYE-een]*** with a dienophile ***[dye-EENOH-file]*** in a single, concerted step?

ANSWER: DIELS-ALDER REACTION

BONUS

20) Chemistry – *Short Answer* Identify all of the following three changes to an organic reaction that would increase its rate constant: 1) Decreasing the energy of the nucleophile HOMO; 2) Decreasing the energy of the electrophile LUMO; 3) Decreasing the overlap between nucleophile HOMO and electrophile LUMO.

ANSWER: 2
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TOSS-UP

21) Earth and Space – *Short Answer* Astronomers sometimes notice that spectral lines can be broadened due to the presence of strong magnetic fields. What is the name for this effect?

ANSWER: ZEEMAN EFFECT

BONUS

21) Earth and Space – *Short Answer* Arrange the following three atmospheric boundaries in order of increasing pressure: 1) Mesopause; 2) Tropopause; 3) Stratopause.

ANSWER: 1, 3, 2

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TOSS-UP

22) Math – *Short Answer* The line with equation $y = 2x - 7$ is reflected across the y-axis. What is the slope-intercept equation of its image?

ANSWER: $y = -2x - 7$

BONUS

22) Math – *Short Answer* How many two-digit positive integers have the tens digit strictly less than the ones digit?

ANSWER: 36
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TOSS-UP

23) Physics – *Short Answer* What principle posits the requirement that the laws of physics must be equivalent in all inertial ***[in-UR-shul]*** reference frames?

ANSWER: RELATIVITY (ACCEPT: SPECIAL RELATIVITY; DO NOT ACCEPT: GENERAL RELATIVITY)

BONUS

23) Physics – *Short Answer* Consider a relativistic spaceship moving at 0.6 times the speed of light *c* relative to Earth. If this spaceship fires a particle that moves at 0.6*c* relative to the spaceship in the same direction as the spaceship, what is the ratio of particle's velocity to the speed of light as seen by an observer on Earth?

ANSWER: 15/17