1) **Physical Science** – *Short Answer*   Niels Bohr developed a model of the atom that explained why different elements burn in different colors. In this model, the light emitted by burning is due to changes in what subatomic particle?

ANSWER: ELECTRON

BONUS

1) **Physical Science** – *Short Answer*   Identify all of the following three properties of matter that are extensive: 1) Mass; 2) Volume; 3) Density.

ANSWER: 1, 2

2) Earth and Space – *Multiple Choice*   Which of the following minerals will be a source of phosphate to the environment when it is weathered?

W) Quartz
X) Apatite
Y) Gypsum
Z) Pyrite

ANSWER: X) APATITE

BONUS

2) Earth and Space – *Short Answer*   Rank the following three elements in order of increasing abundance in Earth's crust: 1) Iron; 2) Silicon; 3) Carbon.

ANSWER: 3, 1, 2

3) Energy – *Short Answer*   Ames Lab researchers are determining the physical properties of AuNPs *[A. U. N. P's]*. What metallic element are these nanoparticles made of?

ANSWER: GOLD

BONUS

3) Energy – *Multiple Choice*   Researchers at Fermi National Accelerator Lab are designing a new kind of qubit *[Q-bit]*. Which of the following best describes the difference between a qubit and a classical bit?

W) Qubits use quantum tunneling to move data more quickly
X) Qubits can exist in a superposition of classical states
Y) Qubits exploit quantum interference to become more energy efficient than classical bits
Z) Qubits use quantum decoherence to simulate multiple classical bits

ANSWER: X) QUBITS CAN EXIST IN A SUPERPOSITION OF CLASSICAL STATES

4) Life Science – *Short Answer*   From time to time, arthropods must shed their exoskeletons to continue growing. What is the term for this process?

ANSWER: MOLTING (ACCEPT: ECDYSIS)

BONUS

4) Life Science – *Short Answer*   During prophase I, what process results in the exchange of DNA between homologous *[ha-MAWL-uh-gus]* chromosomes?

ANSWER: CROSSING OVER (ACCEPT: SYNAPSIS; do not accept: RECOMBINATION)

5) Math – *Short Answer* $x/2 + x/4$ is what percent of x?

ANSWER: 75

BONUS

5) Math – *Short Answer*   Solve the following equation for x:
<u>open parenthesis $7x – 6$ close parenthesis squared</u> = 64.

ANSWER: –2/7 OR 2 (must give both answers)

6) Physical Science – *Short Answer*   What is the term for double-replacement reactions between acids and bases?

ANSWER: NEUTRALIZATION

BONUS

6) Physical Science – *Short Answer*   In the combustion of ethane, how many water molecules are produced for every oxygen molecule used?

ANSWER: 6/7

7) Earth and Space – *Multiple Choice*   Which of the following best describes the direction in which a comet's gas tail points?

W) Ahead of the comet's motion
X) Behind the comet's motion
Y) Away from the Sun
Z) Towards the Sun

ANSWER: Y) AWAY FROM THE SUN

BONUS

7) Earth and Space – *Short Answer*   Which of the terrestrial planets has the largest number of natural satellites?

ANSWER: MARS

8) Energy – *Short Answer*   Brookhaven National Lab scientists are investigating materials that decrease in volume when heated, instead of increasing in volume. What is the term for the physical effect where the volume of a material is dependent on temperature?

ANSWER: THERMAL EXPANSION (ACCEPT: THERMAL CONTRACTION)

BONUS

8) Energy – *Multiple Choice*   Brookhaven National Lab is researching how to tether catalysts to chromophores for artificial photosynthesis. Which of the following is most similar in function to a chromophore?

W) Enzyme
X) Fuel
Y) Solvent
Z) Dye

ANSWER: Z) DYE

9) Life Science – *Multiple Choice* Which of the following is NOT found in an animal cell?

W) Mitochondrion
X) Cytoskeleton
Y) Endoplasmic reticulum *[reh-TIK-yoo-lum]*
Z) Cell wall

ANSWER: Z) CELL WALL

BONUS

9) Life Science – *Short Answer* In a multicellular organism, cells in different tissues have very different functions. Identify all of the following three features that are typically different between two such cells: 1) DNA sequence; 2) Transcriptomic *[trans-krip-TOH-mik]* profile; 3) Proteomic *[pro-tee-OH-mik]* profile.

ANSWER: 2, 3

10) Math – *Short Answer*   A trapezoid has height 6 and one base of length 16. If the area is 72, what is the length of the other base?

ANSWER: 8

BONUS

10) Math – *Short Answer*   Express the following in scientific notation rounded to two significant digits: the fraction with numerator 5.7×10^5 and denominator 8.9×10^{-4}.

ANSWER: 6.4×10^8

11) Physical Science – *Short Answer*   While Newton's first law deals with linear motion, spinning objects also have a tendency to remain spinning in the absence of external torques *[torks]*. This is due to the conservation of what quantity?

ANSWER: ANGULAR MOMENTUM (ACCEPT: ROTATIONAL MOMENTUM, MOMENT OF MOMENTUM)

BONUS

11) Physical Science – *Short Answer*   In most organic compounds, how many covalent bonds does nitrogen make to other atoms?

ANSWER: THREE

12) Earth and Space – *Short Answer*   What two phases of the Moon come directly before and after waxing gibbous *[GIH-bus]*, respectively?

ANSWER: BEFORE = FIRST QUARTER, AFTER = FULL (ACCEPT: FULL MOON for after)

BONUS

12) Earth and Space – *Short Answer*   Rank the following three stellar spectral classes by increasing temperature: 1) G; 2) M; 3) A.

ANSWER: 2, 1, 3

13) Energy – *Short Answer*   Scientists at Pacific Northwest National Lab are studying antibiotic resistance in the bacterial genus *Mycobacterium*. What human lung disease, which can be diagnosed with a PPD skin test, is caused by bacteria in this genus?

ANSWER: TUBERCULOSIS (ACCEPT: TB)

BONUS

13) Energy – *Short Answer*   Scientists at Pacific Northwest National Lab are developing NWChem, a computational chemistry software capable of Hartree-Fock, DFT, and TD-DFT calculations. These calculations are primarily concerned with the behavior of what subatomic particle?

ANSWER: ELECTRON

14) Life Science – *Short Answer*   What is the term for sequence alterations within DNA that may result from errors in replication, exposure to radiation or chemicals, or viral infection?

ANSWER: MUTATIONS

BONUS

14) Life Science – *Short Answer*   What is the general term for viruses that infect prokaryotes *[PRO-care-ee-oats]*?

ANSWER: BACTERIOPHAGES (ACCEPT: PHAGES)

15) Math – *Short Answer*   What is the slope of a line perpendicular to the line with equation $9x + 4y = 36$?

ANSWER: 4/9

BONUS

15) Math – *Short Answer*   What is the volume of a circular cone formed by rotating a right triangular region with legs of length 13 and 9 about its longer leg?

ANSWER: 351π