1. PHYSICS: *Multiple Choice:* A spring that obeys Hooke's law is stretched some distance x. Which of the following gives the relationship between the distance stretched and the work done on the spring?  
  
W) the work is inversely proportional to the distance

X) the work is inversely proportional to the square of the distance

Y) the work is directly proportional to the distance

Z) the work is directly proportional to the square of the distance

ANSWER: Z) the work is directly proportional to the square of the distance

2. CHEMISTRY: *Multiple Choice:* Two liquids, A and B are mixed together in a beaker. It is observed that after some period of time, the beaker is warmer than it was before, but there is no evidence of a chemical reaction occurring. The final solution of the two liquids will

W) have a higher boiling point that either liquid

X) have a lower boiling point than either liquid

Y) have a boiling point higher than only one of the liquids

Z) cannot be predicted

ANSWER: W) have a higher boiling point that either liquid

3. BIOLOGY: *Multiple Choice:* Which of the following statements is false regarding the renin-angiotensin-aldosterone system, or RAAS of the human body?  
  
W) the peptide angiotensin II raises blood pressure by constricting arterioles

X) renin is secreted by the kidneys and is that activator of the RAAS

Y) angiotensin II stimulates the release of aldosterone from the adrenal cortex

Z) angiotensin converting enzyme cleaves angiotensinogen into angiotensin I

ANSWER: Z) angiotensin converting enzyme cleaves angiotensinogen into angiotensin I

4. EARTH AND SPACE SCIENCE: *Short Answer:* The lightness of the lunar highlands as opposed to the basaltic maria is due to the highlands being primarily composed of what intrusive igneous rock dominated by plagioclase feldspar?  
  
ANSWER: ANORTHOSITE

5. MATHEMATICS: *Short Answer:* Find the sum of the series with first three terms are 1, 4, 9 and last term 36.  
  
ANSWER: 91

6. ENERGY: *Multiple Choice:* By name or number, identify all of the following 4 changes to a thermoelectric device that would result in a greater thermodynamic figure of merit, or ZT.  
  
1. increasing electrical conductivity  
2. increasing thermal conductivity

3. increasing the temperature of the cold junction

4. increasing the temperature of the hot junction

ANSWER: ALL BUT 2

7. PHYSICS: *Multiple Choice:* A charged metal ball with charge +q is lowered into an ungrounded hollow metal sphere with radius r. When the ball is at the center of the sphere, the net charge INSIDE the volume of the sphere is  
  
W) +q

X) -q

Y) zero

Z) q/r

ANSWER: Y) ZERO

8. CHEMISTRY: *Multiple Choice:* Which of the following statements best explains why hydrogen fluoride is observed to have entropies close to zero at 0 K while carbon monoxide is observed to have residual entropy:  
  
W) hydrogen fluoride is polar and so has an energy advantage in ordering itself, while almost-nonpolar carbon monoxide does not have a preferred orientation

X) the statistical entropy of hydrogen fluoride is equal to the negative of its residual entropy, canceling it out

Y) hydrogen fluoride can be ordered in less ways than carbon monoxide

Z) hydrogen fluoride has a lower rest energy than carbon monoxide

ANSWER: W) hydrogen fluoride is polar and so has an energy advantage in ordering itself, while almost-nonpolar carbon monoxide does not have a preferred orientation

9. BIOLOGY: *Multiple Choice:* Which of the following statements is NOT TRUE about Gram staining?

W) Gram-positive bacteria are able to retain the crystal violet stain because of their thick peptidoglycan walls

X) archaea stain Gram-variable and cannot by classified into groups by Gram staining

Y) cells that do not retain the crystal violet stain are commonly counterstained with safranin  
 Z) lipidoglycan is present in Gram positive bacteria

ANSWER: W) Gram-positive bacteria are able to retain the crystal violet stain because of their thick peptidoglycan walls

10. EARTH AND SPACE SCIENCE: *Short Answer:* What name is given to the prevailing pattern of easterly surface winds fond in the tropics near the Earth's equator that result as part of the Hedley cell circulation? These winds border the intertropical convergence zone, or doldrums, and have historically been used by captains of sailing ships to cross the oceans, hence their name.

ANSWER: TRADE WINDS

11. MATHEMATICS: *Multiple Choice:* At which of the following x values does the function f(x) = x/(x-1) have a point of inflection?  
  
W) -1

X) 0  
Y) 1  
Z) 2

ANSWER: Y) 1

12. ENERGY: *Short Answer:* What electricity source accounted for about 7% of the electricity produced in the US last year and is the main source of renewable electricity in the United States, ranking ahead of wind, solar power, and geothermal?  
  
ANSWER: HYDROELECTRICITY

13. PHYSICS: *Short Answer:* What problem of classical physics predicts that, according to classical electromagnetism, any blackbody at thermal equilibrium should radiate intense radiation with infinite power and frequency? This problem was solved by Planck's postulation that electromagnetic energy is quanticized and has an energy proportional to the frequency.

ANSWER: ULTRAVIOLET CATASTROPHE

14. CHEMISTRY: *Multiple Choice:* Sulfur tetrafluoride has a molecular geometry that is  
  
W) trigonal pyramidal  
X) seesaw

Y) square planar  
Z) tetrahedral  
  
ANSWER: X) SEESAW

15. BIOLOGY: *Multiple Choice:* In which of the following groups do microtubules form a spindle within the nucleus during mitosis?  
  
W) diatoms and yeast

X) bacteria

Y) archaea

Z) dinoflagellates

ANSWER: W) DIATOMS AND YEAST

16. EARTH AND SPACE SCIENCE: *Short Answer:* What cataclysmic astronomical event is caused by the accretion of gas into the surface of a white dwarf in a binary system which ignites a runoff CNO cycle?

ANSWER: NOVA

17. MATHEMATICS: *Short Answer:* How many petals does the polar rose given by the equation r = cos(6theta)  
  
ANSWER: 3

18. ENERGY: *Multiple Choice:* A refrigerator cools half liter of water from 20 degrees celsius to 0 degrees celsius. Approximating the specific heat of water as 4.2 J/g degress celsius and its density as 1.00 g/mL, if the refrigerator requires 5,000 Joules of energy to complete this task, what is its efficiency to the nearest percent?

W) 42%  
X) 68%  
Y) 76%  
Z) 84%  
  
ANSWER: Z) 84%

19. PHYSICS: *Short Answer:* Sound A is measured to be 100 times as intense as sound B. Hw many decibels louder is sound A relative to sound B?  
  
ANSWER: 20 DECIBELS

20. CHEMSITRY: *Short Answer:* By name or number, identify all of the following 4 pairs of compounds that are isoelectronic  
  
1. CO and CN-

2. N and O+  
3. N2 and O2

4. BF3 and AlF3  
  
ANSWER: 1 AND 2

21. BIOLOGY: *Short Answer:* What specific form of perpetually embryonic tissue is found in the tips of plant roots and shoots and provides additional cells that enable the plant to engage in primary growth?  
  
ANSWER: APICAL MERISTEM

22. EARTH AND SPACE SCIENCE: *Short Answer:* What hypothesis posits that the Earth's surface became entirely or nearly entirely frozen at least once before 650 million years ago. Proponents of the hypothesis argue that it explains sedimentary deposits of glacial origin that have been found at tropical paleoatitudes and other strange features in the geological record.

ANSWER: SNOWBALL EARTH

23. MATHEMATICS: *Short Answer:* What is the largest odd number that is a factor of 860?  
  
ANSWER: 215

24. ENERGY: *Multiple Choice:* A process that is a reversible adiabatic process is also considered to be

W) isothermal

X) isochoric

Y) isobaric

Z) isentropic  
  
ANSWER: Z) ISENTROPIC

25.PHYSICS: *Short Answer:* An organ pipe that is open at both ends has a fundamental frequency of 260 Hertz. One of the ends is then stoppered such that the pipe can be considered to be open on one end and closed on the other. What is the third harmonic of the new organ pipe?

ANSER: 390 Hz