TOSS-UP

1) Biology *Multiple Choice* The resting membrane potential of a neuronal axon is established by the differing concentrations around the membrane of all of the following except:

W) Flourine

X) Chlorine

Y) Sodium

Z) Potassium

ANSWER: W) FLOURINE

BONUS

1) Biology *Multiple Choice* According to sliding filament theory, the binding of ATP to myosin causes it to release its grip on which protein found in the thin filament of muscles:

W) collagen

X) actin

Y) fibrin

Z) keratin

ANSWER: X) ACTIN

(Notes: Actin slides alongside myosin to produce muscle contractions. Myosin forms the "thick filament", sliding along chains of actin proteins by binding and then detaching, releasing Ca+ ions.)

TOSS-UP

2) Chemistry *Multiple Choice* What type of reaction can be split into half-reactions?

W) Reduction-Oxidation reactions

X) Acid-Base reactions

Y) Single Replacement reaction

Z) Double Replacement reaction

ANSWER: W) REDUCTION-OXIDATION REACTIONS

BONUS

2) Chemistry *Multiple Choice* Which of the following reactions is not a single replacement reaction?

W) $Fe_2O_3 + 2\,Al \longrightarrow 2\,Fe + Al_2O_3$

X) $NH_4^+ + OH^- \longrightarrow NH_3 + H_2O$

Y) $2\,C_2H_4 + 2\,O_3 \longrightarrow 4\,H_2CO + O_2$

Z) $Mg + 2\,H_2O \longrightarrow Mg(OH)_2 + H_2$

ANSWER: Y) $2\,C_2H_4 + 2\,O_3 \longrightarrow 4\,H_2CO + O_2$

TOSS-UP

3) Earth and Space Science *Multiple Choice* Which of the following could NOT be used to determine the distance to a galaxy:

W) The Tully-Fisher relation

X) The Titius-Bode relation

Y) The period-luminosity relation

Z) Hubble's law

ANSWER: X) THE TITIUS-BODE RELATION

(Notes: The Titius-Bode relation erroneously describes the distances to planets.)

BONUS

3) Earth and Space Science *Multiple Choice* The Eddington number, which describes the number of protons in the universe, is closest to:

W) 10^{20}

X) 10^{40}

Y) 10^{60}

Z) 10^{80}

ANSWER: Z) 10^{80}

TOSS-UP

4) Energy *Multiple Choice* Approximately what percentage of energy produced within the United States comes from the burning of coal?

W) 40%

X) 50%

Y) 60%

Z) 70%

ANSWER: W) 40%

(Notes: The actual amount is closer to 42%.)

BONUS

4) Energy *Short Answer* Order the following sources of emissions in order of greatest to smallest percentages of overall greenhouse gas emissions: Agriculture, Transportation, Land Use, Commercial

ANSWER: TRANSPORTATION, COMMERCIAL, AGRICULTURE, LAND USE (ACCEPT 2,4,1,3)

(Notes: http://www.epa.gov/climatechange/ghgemissions/sources.html has the chart of emissions.)

TOSS-UP

5) Mathematics *Multiple Choice* If a triangle can be superimposed on its mirror image, it must be:

W) equilateral

X) isosceles

Y) achiral

Z) scalene

ANSWER: X) ISOSCELES

BONUS

5) Mathematics *Multiple Choice* When a matrix is in Jordan normal form, it

W) is written in a basis of generalized eigenvectors

X) is diagonal

Y) has only one nonzero entry per row

Z) has zero determinant

ANSWER: W) IS WRITTEN IN A BASIS OF GENERALIZED EIGENVECTORS

TOSS-UP

6) Physics *Short Answer* What effect, first described in the book Hydrodynamica, allows for an airfoil to generate lift?

ANSWER: BERNOULLI'S PRINCIPLE

BONUS

6) Physics *Multiple Choice* A stream of water no matter how evenly it is ejected, never comes out in a perfect cylinder, but rather as one with sinusoidal perturbations. This is because of

W) Adhesive Forces

X) Surface Tension

Y) Viscosity

Z) Impurities in the Water

ANSWER: X) SURFACE TENSION

(Notes: The Plateau-Rayleigh instability occurs when the wavelength of these perturbations exceeds the circumference of the stream.)

TOSS-UP

7) Biology *Short Answer* What hemorrhagic fever named after a river in the Republic of Congo, is known for its high mortality rate and widespread symptoms?

ANSWER: EBOLA [OR EBOLA VIRUS, OR EBOLA HEMORRHAGIC FEVER]

BONUS

7) Biology *Multiple Choice* Which of the following is a class of animal included within the phylum Cnidaria:

W) Crinoidea

X) Ascidiacea

Y) Tentaculata

Z) Hydrozoa

ANSWER: Z) HYDROZOA

TOSS-UP

8) Chemistry *Short Answer* By name or number, name all of the following four compounds that are liquids at room temperature: Br_2, NH_3, H_2O_2, ether

ANSWER: Br_2, H_2O_2, ETHER [OR 1, 3, 4]

BONUS

8) Chemistry *Short Answer* Order the following compounds by boiling point from lowest to highest: N_2, Br_2, Cl_2, O_2

ANSWER: N_2, O_2, Cl_2, Br_2 [OR 1, 4, 3, 2]

(Notes: Liquid nitrogen at its boiling point is actually colder than liquid oxygen at its boiling point. Oxygen has stronger intermolecular forces due to its increased number of electrons.)

TOSS-UP

9) Earth and Space Science *Short Answer* What towering type of cloud is commonly associated with thunderstorms and is often shaped like an anvil?

ANSWER: CUMULONIMBUS

BONUS

9) Earth and Space Science *Multiple Choice* When does a 1st quarter moon set?

W) at sunrise

X) at noon

Y) at sunset

Z) at midnight

ANSWER: Z) AT MIDNIGHT

(Notes: The moonrise and moonset times go forward from sunrise and sunset during a new moon. A quarter of a day past sunset is approximately midnight.)

TOSS-UP

10) Energy *Short Answer* What unstable isotope of uranium is formed by bombarding nuclear fuel with neutrons?

ANSWER: URANIUM-236 [OR: U-236]

BONUS

10) Energy *Multiple Choice* What is the most popular method of removing Hydrogen Sulfide and Carbon Dioxide from natural gas?

W) Amine Absorption Treatment

X) Polymeric Membranes

Y) Cryogenic Distillation

Z) Claus Process

ANSWER: W) AMINE ABSORPTION TREATMENT

(Notes: Polymeric membranes are becoming more popular as they are cheaper and pollute less, but do not yet have the popularity of the historically popular Amine Absorption. They are also still in research phases and are not fully developed. Cryogenic Distillation removes hydrocarbons such as ethane and propane, and the Claus process removes Sulfur from natural gas.)

TOSS-UP

11) Mathematics *Multiple Choice* Which of the following functions monotonically increases over its domain, and also has a derivative that monotonically increases over its domain?

W) $\sqrt{x}$

X) x^2

Y) $-1/x$

Z) $xln(x)$

ANSWER: Z) $XLN(X)$

(Notes: The domain of $xln(x)$ is restricted to $x > 0$.)

BONUS

11) Mathematics *Short Answer* What is the normalized vector of [1, 4, 8]?

ANSWER: [1/9, 4/9, 8/9]

TOSS-UP

12) Physics *Short Answer* By what factor would the surface gravity of a planet change if its mass was doubled and its diameter was halved?

ANSWER: 8

(Notes: $g = GM/r^2$)

BONUS

12) Physics *Multiple Choice* The work done on a satellite in an elliptical orbit

W) is always zero

X) averages out to zero

Y) is only zero at the perihelion

Z) is only zero at the aphelion

ANSWER: X) AVERAGES OUT TO ZERO

(Notes: It is zero at the perihelion and at the aphelion.)

TOSS-UP

13) Biology *Multiple Choice* The function of the TATA box is to:

W) Provide a binding site on the ribosome for tRNA during translation

X) Promote a gene by telling RNA polymerase where to start transcribing

Y) Provide a binding site on the ribosome for mRNA during translation

Z) Recruit thymine and adenine from the environment in DNA replication

ANSWER: X) PROMOTE A GENE BY TELLING RNA POLYMERASE WHERE TO START TRANSCRIBING

BONUS

13) Biology *Multiple Choice* Which purine-derived nitrogenous base uses three hydrogen bonds in DNA?

W) Adenine

X) Guanine

Y) Cytosine

Z) Thymine

ANSWER: X) GUANINE

(Notes: The purine-derived nucleobases are Adenine and Guanine. The Adenine binds to Thymine with only 2 hydrogen bonds, as there is only one substituent on adenine (there is a keto and an amine on guanine).)

TOSS-UP

14) Chemistry *Short Answer* According to VSEPR theory, what is the molecular geometry of Sulfur Hexafluoride?

ANSWER: OCTAHEDRAL

BONUS

14) Chemistry *Short Answer* What trigonal pyramidal compound is produced by the Haber-Bosch process?

ANSWER: AMMONIA [OR: NH3]

TOSS-UP

15) Earth and Space Science *Multiple Choice* Which of the following periods is NOT contained within the Mesozoic era?

W) Triassic

X) Jurrasic

Y) Creataceous

Z) Permian

ANSWER: Z) PERMIAN

BONUS

15) Earth and Space Science *Short Answer* During what geologic period was alluvium formed?

ANSWER: QUARTERNARY

TOSS-UP

16) Energy *Short Answer* What is the final carbon product of glycolysis?

ANSWER: PYRUVATE

BONUS

16) Energy *Short Answer* What device is used to experimentally determine the energy released or absorbed in a chemical reaction?

ANSWER: CALORIMETER

TOSS-UP

17) Mathematics *Short Answer* Evaluate the limit as x approaches zero of the function $f(x) = xsin(1/x)$.

ANSWER: 0 (ZERO)

(Notes: $sin(1/x)$ only ranges between -1 and 1.)

BONUS

17) Mathematics *Short Answer* Evaluate the derivative at x = 0 of the function: $f(x) = x^3 sin(1/x^2)$.

ANSWER: UNDEFINED (OR: DOES NOT EXIST)

(Notes: $f'(x) = 3x^2 sin(1/x^2) - 2sin(1/x^2)$, so $f'(0) = 0 - 2sin(\infty)$)

TOSS-UP

18) Physics *Multiple Choice* When a material's Young's modulus no longer applies, it is said to be in the

W) plastic region

X) supercritical region

Y) elastic region

Z) transition region

ANSWER: W) PLASTIC REGION

BONUS

18) Physics *Short Answer* How much stress is required to put a 1% strain on a material with a Young's modulus of 320 Gigapascals?

ANSWER: 3.2 GIGAPASCALS

TOSS-UP

19) Biology *Multiple Choice* An open circulatory system has:

W) No distinction between blood and interstitial fluid

X) Direct gas exchange with its environment

Y) A three-chambered heart, with some mixing of oxygenated and deoxygenated blood

Z) No hemoglobin

ANSWER: W) NO DISTINCTION BETWEEN BLOOD AND INTERSTITIAL FLUID

BONUS

19) Biology *Short Answer* What is the copper-containing oxygen carrier found in insects?

ANSWER: HEMOCYANIN

TOSS-UP

20) Chemistry *Short Answer* What is the common name for group 16, the group of elements containing selenium, sulfur, and oxygen?

ANSWER: CHALCOGENS

BONUS

20) Chemistry *Multiple Choice* Which of the following is FALSE about f-block elements:

W) They have high reduction potentials because of the high-energy f orbitals

X) They are often used in nuclear fission reactors because of their large, unstable nuclei

Y) They make for strong magnets because their shells can hold up to 7 spin-up electrons

Z) They often violate the Aufbau principle by interchanging electrons between d and f orbitals

ANSWER: W) THEY HAVE HIGH REDUCTION POTENTIALS BECAUSE OF THE HIGH-ENERGY F ORBITALS

TOSS-UP

21) Earth and Space Science *Multiple Choice* Approximately where on the Hertzsprung-Russel diagram would Sirius B be found?

W) Top Left

X) Bottom Left

Y) Top Right

Z) Bottom Right

ANSWER: X) BOTTOM LEFT

(Notes: Sirius B is a white dwarf. White dwarfs have high surface temperatures and absolute magnitudes, as they are nearing the end of their stellar lives. As a result, they would be in the bottom left corner of the H-R diagram.)

BONUS

21) Earth and Space Science *Short Answer* Calculate the distance modulus of Rigel, knowing that Rigel's apparent magnitude is 0.12, its absolute magnitude is -7.84, and its surface temperature is 12,000 Kelvin.

ANSWER: 7.96

(Notes: Distance modulus is simply apparent magnitude - absolute magnitude. Temperature has no factor in distance modulus calculation.)

TOSS-UP

22) Mathematics *Short Answer* If x and y are complex numbers, then expressing your answer in as simplified a form as possible, what is the slope-intercept equation for the line that goes through the points (0, i) and (i, -1)?

ANSWER: Y = I + IX (OR: Y = IX + I)

BONUS

22) Mathematics *Short Answer* By name or number, give all of the following complex numbers whose magnitude is at least twice the magnitude their real component: i, 4 + i, -1 + 3i, 0

ANSWER: I, -1 + 3I, 0 (OR: 1, 3, 4)

TOSS-UP

23) Physics *Short Answer* If the temperature of a black body is doubled, and its radius is reduced by a factor of four, by what factors, respectively, do the total energy output and peak wavelength change?

ANSWER: 1 AND 1/2

(Notes: The Stefan-Boltzmann law says $P = T^4 * R^2$ * (const), and Wien's law says that $\lambda_{max} = 1/\mathrm{T}$ * (const).)

BONUS

23) Physics *Multiple Choice* Which of the following best describes the necessary criterion for an object to be a black body?

W) It must reflect none of the light that falls on it

X) It must transmit all of the light that falls on it

Y) It must absorb all of the light that falls on it

Z) It must transmit none of the light that falls on it

ANSWER: Y) IT MUST ABSORB ALL OF THE LIGHT THAT FALLS ON IT

TOSS-UP

24) Biology *Short Answer* What is the scientific name of the 4-chromosomed model organism, studied by Thomas Hunt Morgan, in which the hedgehog homolog genes were discovered?

ANSWER: DROSOPHILA MELANOGASTER [ACCEPT: DROSOPHILA]

(Notes: Drosophila are fruit flies.)

BONUS

24) Biology *Multiple Choice* The function of the protein "sonic hedgehog homolog" is to:

W) rapidly transport certain substrates throughout the bloodstream

X) direct the fetal development of bilateral symmetry

Y) give Drosophila fruit flies wing coloration

Z) restrict hair growth outside of the scalp

ANSWER: X) DIRECT THE FETAL DEVELOPMENT OF BILATERAL SYMMETRY

(Notes: It also controls Drosophila segmentation.)

TOSS-UP

25) Earth and Space Science *Short Answer* Arrange the following three rocks from most felsic to most mafic: quartzite, basalt, obsidian

ANSWER: QUARTZITE, OBSIDIAN, BASALT (OR: 1, 3, 2)

(Notes: quartzite is almost 100% silica (quartz), obsidian is mostly silica, and basalt is a classic mafic rock.)

BONUS

25) Earth and Space Science *Short Answer* What two minerals, containing calcium and sodium in addition to aluminum silicate, comprise the endpoints of the plagioclase feldspar series?

ANSWER: ALBITE AND ANORTHITE