Indronil Ghosh

Science Bowl – Full Team Round – 2/27/13

**TOSS-UP**

1) PHYSICS *Short Answer* If the tension in the string of a simple pendulum is $\frac{1}{2}mg$ when the pendulum is displaced 60°, by what multiplicative factor will the period of the pendulum change if the tension in the string becomes $50\sqrt{3}mg$ when the pendulum is displaced 30°?
ANSWER: $1/10$

**BONUS**

1) PHYSICS *Short Answer* What is the amplitude of a spring with a spring constant of 10 N/m, and an attached mass of 10 kg that has a velocity of 1 m/s when it is displaced 10 m?
ANSWER: $\sqrt{101}$ m

**TOSS-UP**

2) CHEMISTRY *Short Answer* What is the name of the assumption that supposes that the nuclei, being so much heavier than an electron, move relatively slow and may be treated as stationary while the electrons move in their field?
ANSWER: BORN-OPPENHEIMER APPROXIMATION

**BONUS**

2) CHEMISTRY *Short Answer* What is the hybridization scheme of a molecule with trigonal prismatic molecular geometry?
ANSWER: $spd^4$ , $pd^5$

**TOSS-UP**

3) BIOLOGY *Multiple Choice* Which of the following is true of circulatory systems?
W) Amphibians 3-chambered heart, with 1 atria and 2 ventricles
X) Reptiles (excluding birds) have a 3-chambered heart, with a septum partially dividing the atria into separate right and left chambers
Y) Mammals and birds have a 4-chambered heart, with 2 atria and 2 ventricles
Z) arthropods and most mollusks have closed circulatory systems
ANSWER: Y) MAMMALS AND BIRDS HAVE A 4-CHAMBERED HEART, WITH 2 ATRIA AND 2 VENTRICLES

**BONUS**

3) BIOLOGY *Short Answer* What is the name of the cluster of cells located in the wall of the right atrium that set the rate and timing at which cardiac muscles contract, and the cluster of cells located in the wall between the left and right atria that form a relay point, respectively?
ANSWER: SINOATRIAL NODE, ATRIOVENTRICULAR NODE

**TOSS-UP**

4) EARTH/SPACE *Multiple Choice* What is the name given to winds that are created when air descends the leeward side of a mountain and warms by compression, generally less than 10°C in temperature and occurring mostly in the winter and spring?
W) mountain breeze
X) chinook
Y) country breeze
Z) valley breeze
ANSWER: X) CHINOOK

**BONUS**

4) EARTH/SPACE *Short Answer* What is the name of the great curved cliffs on Mercury, as high as 3 kilometers and reaching hundreds of kilometers across the surface, that seem to have formed when the planet cooled and shrank in diameter, wrinkling its crust?
ANSWER: LOBATE SCARPS

**TOSS-UP**

5) MATH *Short Answer* In the year 2001, North Hollywood won the National Science Bowl. If $N$, $S$, and $B$ are distinct positive integers such that the product $N \times S \times B = 2001$, what is the largest possible value of the sum $N + S + B$ ?
ANSWER: 671

**BONUS**

5) MATH *Short Answer* A beam of light of intensity $L$ hits a pane of glass. Half of the light is reflected, and a third of the light is transmitted; the rest is absorbed. When a beam of light of intensity $L$ hits two parallel panes with an air gap between them, how much light is transmitted through both panes, in terms of $L$?
ANSWER: $4L/27$
[Hint: infinite geometric series]

**TOSS-UP**

6) ENERGY *Multiple Choice* Used uranium fuel stored in a fuel pool will lose what percent of its radiation in one year?
W) 100
X) 80
Y) 50
Z) 10
ANSWER: X) 80

**BONUS**

6) ENERGY *Short Answer* Rank the following four sources of radiation from lowest to highest, according to the amount of radiation the average American is exposed to.
1: medical X-rays
2: mineral mining, burning fossil fuels, color TV sets
3: natural sources of radiation, such as soil, rocks, food, and water
4: radiation emitted from nuclear power plants
ANSWER: 4, 2, 1, 3

**TOSS-UP**

7) PHYSICS *Short Answer* If the density of a body is multiplied 100 times, by what multiplicative factor does its Schwarzschild radius change?
ANSWER: $1/10$

**BONUS**

7) PHYSICS *Short Answer* If unpolarized light traveling through a medium with an index of refraction of 2.0 encounters a different medium at an angle of $\pi/6$ radians and all of the light is reflected, at what angle is the light perfectly polarized? Approximate $\arctan x$ as $x - \frac{x^3}{3}$ and leave your answer in radians.
ANSWER: $11/24$

**TOSS-UP**

8) CHEMISTRY *Multiple Choice* In any chemical reaction, a quantity that decreases to a minimum is
W) free energy
X) entropy
Y) temperature
Z) enthalpy
ANSWER: W) FREE ENERGY

**BONUS**

8) CHEMISTRY *Multiple Choice* What is the ratio of the probability of finding an electron in a small region a distance *d* from the nucleus to the probability of finding it in the same small region located at the nucleus?
W) $e/\pi$
X) $1/e$
Y) $1/(2e)$
Z) $1/e^2$
ANSWER: Z) $1/e^2$

**TOSS-UP**

9) BIOLOGY *Short Answer* Identify all of the following 4 which are major centers that develop from the diencephalon.
1: cerebrum
2: thalamus
3: medulla oblongata
4: hypothalamus
ANSWER: 2 AND 4

**BONUS**

9) BIOLOGY *Short Answer* What is the name given to the group of neurons in the hypothalamus that coordinate circadian rhythms in mammals?
ANSWER: SUPRACHIASMATIC NUCLEUS

**TOSS-UP**

10) EARTH/SPACE *Multiple Choice* Which of the following is a large, step-like fold in horizontal sedimentary strata, that appears to be the result of the reactivating of steeply dipping fault zones located in basement rocks beneath the Colorado Plateau?
W) anticline
X) syncline
Y) monocline
Z) plunge
ANSWER: Y) MONOCLINE

**BONUS**

10) EARTH/SPACE *Short Answer* Identify all of the following 4 which are good estimates of the age of the universe.
1: decay times of uranium-238 and thorium-232 in metal poor stars
2: ages of the hottest main-sequence stars in distant galaxies
3: ages of the faintest white dwarfs
4: isochrone fits for globular clusters
ANSWER: 1, 3, AND 4

**TOSS-UP**

11) MATH *Short Answer* Yash, Roger, Sid, and Jack are tutors at the school math lab. Their schedule is as follows: Yash works every 4$^{th}$ school day, Roger works every 3$^{rd}$ school day, Sid works every 6$^{th}$ school day, and Jack works every 7$^{th}$ school day. Today they are all working in the math lab. In how many school days from today will they next be together tutoring in the lab?
ANSWER: 84

**BONUS**

11) MATH *Short Answer* Recall that the kinetic energy of a body is $K = \frac{1}{2}mv^2$ where *m* is mass and *v* is velocity. Compute the relative change of kinetic energy $\frac{dK}{K}$, given that the relative rate of change of mass is -7 and the relative rate of change of velocity is +5.
ANSWER: 3

**TOSS-UP**

12) ENERGY *Multiple Choice* Compared to photovoltaic cells, fossil fuel plants are about
W) 8 to 24 percent more energy efficient
X) 8 to 24 percent less energy efficient
Y) 25 to 50 percent more energy efficient
Z) 25 to 50 percent less energy efficient
ANSWER: W) 8 TO 24 PERCENT MORE ENERGY EFFICIENT

**BONUS**

12) ENERGY *Short Answer* Assume that Tsiolkovsky's rocket equation states that the maximum change in velocity of a rocket is equal to the natural logarithm of the quantity with numerator "initial total mass including fuel" and denominator "final total mass". Given a rocket with an initial total mass that is 90% fuel and a rocket with an initial total mass that is 99% fuel, compute the ratio of the final kinetic energy of the rocket that is 90% fuel to the final kinetic energy of the rocket that is 99% fuel.

ANSWER: $5/2$

**[**Explanation: $\Delta v = \ln\left(\frac{\text{initial total mass}}{\text{final total mass}}\right)$

$\Delta v_{90} = \ln\left(\frac{100}{10}\right) = \ln(10) \qquad \Delta v_{99} = \ln\left(\frac{100}{1}\right) = \ln(100)$

$2\ln(10) = \ln(100) \quad \rightarrow \quad 2\Delta v_{90} = \Delta v_{99}$

$KE_{90}/KE_{99} = \left[\frac{1}{2}(10)(1^2)\right]/\left[\frac{1}{2}(1)(2^2)\right] = 5/2$ **]**

**TOSS-UP**

13) PHYSICS *Multiple Choice* By what multiplicative factor does the resonant frequency of an LC circuit change if both the inductance and capacitance are quadrupled?

W) $1/16$

X) $1/4$

Y) $1/2$

Z) 1

ANSWER: X) $1/4$

**BONUS**

13) PHYSICS *Short Answer* What states that the laws of physics should be the same if a particle were interchanged with its antiparticle, and then left and right were swapped? The violation of this was discovered in 1964 in the decay of neutral kaons, and resulted in the Nobel Prize in Physics in 1980 for its discoverers.

ANSWER: CP-SYMMETRY

**TOSS-UP**

14) CHEMISTRY *Short Answer* The melting point of MgO is higher than that of NaF. Identify all of the following 3 that are explanations for this observation.

1: $Mg^{2+}$ is more positively charged than $Na^{+}$

2: $O^{2-}$ is more negatively charged than $F^{-}$

3: the $O^{2-}$ ion is smaller than the $F^{-}$ ion

ANSWER: 1 AND 2

**BONUS**

14) CHEMISTRY *Multiple Choice* A yellow precipitate forms when 0.5 *M* $NaI_{(aq)}$ is added to 0.5 *M* solution of which of the following ions?

W) $Zn^{2+}_{(aq)}$

X) $CrO_4^{2-}{}_{(aq)}$

Y) $Pb^{2+}_{(aq)}$

Z) $SO_4^{2-}{}_{(aq)}$

ANSWER: Y) $Pb^{2+}_{(aq)}$

**TOSS-UP**

15) BIOLOGY *Multiple Choice* Sickle-cell anemia results from a point mutation in the HBB gene. The mutation results in the replacement of an amino acid that has a hydrophilic R-group with an amino acid that has a hydrophobic R-group on the exterior of the hemoglobin protein. Such a mutation would most likely result in altered
W) DNA structure as a result of abnormal hydrogen bonding between nitrogenous bases
X) fatty acid structure as a result of changes in ionic interactions between adjacent fatty acid chains
Y) protein secondary structure as a result of abnormal hydrophobic interactions between R-groups in the backbone of the protein
Z) properties of the molecule as a result of abnormal interactions between adjacent hemoglobin molecules
ANSWER: Z) PROPERTIES OF THE MOLECULE AS A RESULT OF ABNORMAL INTERACTIONS BETWEEN ADJACENT HEMOGLOBIN MOLECULES

**BONUS**

15) BIOLOGY *Multiple Choice* The chemical reaction for photosynthesis is $6CO_2+12H_2O+$light energy $\rightarrow C_6H_{12}O_6+6O_2+6H_2O$. If the input water is labeled with a radioactive isotope of oxygen, $^{18}O$, then the oxygen gas released as the reaction proceeds is also labeled with $^{18}O$. Which of the following is the most likely explanation?
W) During the light reactions of photosynthesis, water is split, the hydrogen atoms combine with the CO2, and oxygen gas is released
X) During the light reactions of photosynthesis, water is split, removing electrons and protons, and oxygen gas is released
Y) During the Calvin cycle, water is split, regenerating NADPH from $NADP^+$, and oxygen gas is released
Z) During the Calvin cycle, water is split, the hydrogen atoms are added to intermediates of sugar synthesis, and oxygen gas is released
ANSWER: X) DURING THE LIGHT RX. OF PHOTOSYN., $H_2O$ IS SPLIT, REMOVING $e^-$…

**TOSS-UP**

16) EARTH/SPACE *Short Answer* Melting occurs at higher temperatures at depth because of greater confining pressure. When confining pressure drops enough, this type of melting is triggered. It may occur when mantle rock ascends as a result of convective upwelling.
ANSWER: DECOMPRESSION

**BONUS**

16) EARTH/SPACE *Multiple Choice* The primordial abundance of deuterium may be inferred using currently available instruments from careful measurements of
W) absorption lines in the spectra of high-redshift quasars
X) absorption lines in the atmospheres of Population I stars
Y) emission lines from cold hydrogen clouds at high redshift
Z) emission lines from high-metallicity starburst galaxies
ANSWER: W) ABSORPTION LINES IN THE SPECTRA OF HIGH-REDSHIFT QUASARS

**TOSS-UP**

17) MATH *Multiple Choice* Which of the following describes the graph of the equation $(x+y)^2 = x^2 + y^2$ ?
W) circle
X) parabola
Y) two lines
Z) one point
ANSWER: Y) TWO LINES

**BONUS**

17) MATH *Short Answer* The base of a cone is centered at a vertex of a square with side length 2. The base has radius $\sqrt{2}$ and the cone's height is $\pi$. The cone is revolved around the center of the square, forming a truncated cone. Find the area of the cone without truncation.
ANSWER: $16\pi^2/3$

**TOSS-UP**

18) ENERGY *Multiple Choice* What type of electric motor works without the need for a commutator, by rotating along a fixed axis parallel to the external magnetic field produced by a permanent magnet?
W) brushless DC
X) reluctance
Y) unipolar
Z) homopolar
ANSWER: Z) HOMOPOLAR

**BONUS**

18) ENERGY *Short Answer* Which of the following four are methods that can be used to produce hydrogen?
1: electrolysis
2: steam reforming
3: hydrocracking
4: biomass gratification
ANSWER: 1, 2, AND 4

**TOSS-UP**

19) PHYSICS *Short Answer* A thin solid disk is rolled down a hill with height $h$, with a velocity $v$. It has mass $m$, radius $r$, and a moment of inertia of $1/2\, mr^2$. In terms of the acceleration due to gravity $g$, what is the velocity of the rim of the disk at the bottom of the hill?
ANSWER: $\sqrt{4gh/3}$

**BONUS**

19) PHYSICS *Multiple Choice* Which of the following describes the phenomenon in which light emitted by a moving object is concentrated conically in the direction of its motion?
W) Trans-Planckian problem
X) relativistic beaming
Y) Unruh Effect
Z) relativistic Doppler effect
ANSWER: X) RELATIVISTIC BEAMING

**TOSS-UP**

20) CHEMISTRY *Short Answer* The molecular mass of a substance can be determined by measuring which of the following three?
1: Osmotic pressure of a solution of the substance
2: Freezing point depression of a solution of the substance
3: Density of the gas phase of the substance
ANSWER: 1, 2, AND 3

**BONUS**

20) CHEMISTRY *Multiple Choice* The ionization constant for acetic acid is $1.8\times10^{-5}$; that for hydrocyanic acid is $4\times10^{-10}$. In 0.1 *M* solutions of sodium acetate and sodium cyanide, it is true that
W) $[H^+]$ equals $[OH^-]$ in each solution
X) $[H^+]$ exceeds $[OH^-]$ in each solution
Y) $[H^+]$ of the sodium acetate solution is less than that of the sodium cyanide solution
Z) $[OH^-]$ of the sodium acetate solution is less than that of the sodium cyanide solution
ANSWER: Z) $[OH^-]$ OF THE SODIUM ACETATE SOLUTION IS LESS THAN THAT OF THE SODIUM CYANIDE SOLUTION

**TOSS-UP**

21) BIOLOGY *Multiple Choice* Which of the following features is common to all gas exchange systems in animals?
W) gases diffuse across a moist membrane
X) an intake system is comprised of a series of tubes
Y) active transport removes $CO_2$ from the respiratory structures
Z) transfer is made by counter-current exchange
ANSWER: W) GASES DIFFUSE ACROSS A MOIST MEMBRANE

**BONUS**

21) BIOLOGY *Multiple Choice* The endocrine system incorporates feedback mechanisms that maintain homeostasis. Which of the following demonstrates negative feedback by the endocrine system?

W) During labor, the fetus exerts pressure on the uterine wall, inducing the production of oxytocin, which stimulates uterine wall contraction. The contractions cause the fetus to further push on the wall, increasing the production of oxytocin.

X) After a meal, blood glucose levels become elevated, stimulating beta cells of the pancreas to release insulin into the blood. Excess glucose is then converted to glycogen in the liver, reducing blood glucose levels.

Y) At high elevation, atmospheric oxygen is more scarce. In response to signals that oxygen is low, the brain decreases an individual's rate of respiration to compensate for the difference.

Z) A transcription factor binds to the regulatory region of a gene, blocking the binding of another transcription factor required for expression.

ANSWER: X) AFTER A MEAL, BLOOD GLUCOSE LEVELS BECOME ELEVATED…

**TOSS-UP**

22) EARTH/SPACE *Short Answer* When talking about clusters, 'rich' and 'poor' refer to the number of member galaxies of that cluster. Which of the following statements about clustering is true?

W) rich clusters tend to contain more spiral galaxies

X) most clusters in the universe are rich; poor clusters are somewhat rare

Y) poor clusters tend to be more spherical than rich clusters

Z) rich clusters tend to cluster more strongly than poor ones

ANSWER: Z) RICH CLUSTERS TEND TO CLUSTER MORE STRONGLY THAN POOR ONES

**BONUS**

22) EARTH/SPACE *Multiple Choice* From duration of a microlensing, event one can determine the mass of the lens only if the distance to the lens is known. Although this is usually not the case for a particular event, the statistics of rates and durations of microlensing events in specialized experiments tell us that the masses of the lenses are

W) on average much greater than typical masses of white dwarfs

X) on average greater than maximum masses of brown dwarfs

Y) large enough to fully account for the invisible matter in the Galactic Halo

Z) too large to explain the rotation curve of the Milky Way

ANSWER: X) ON AVERAGE GREATER THAN MAXIMUM MASSES OF BROWN DWARFS

**TOSS-UP**

23) MATH *Multiple Choice* There are 120 seats in a row. What is the fewest number of seats that must be occupied so that the next person to be seated must sit next to someone?
W) 30
X) 40
Y) 41
Z) 60
ANSWER: X) 40

**BONUS**

23) MATH *Short Answer* Two tiles are marked *N*, three tiles are marked *S*, and two tiles are marked *B*. The seven tiles are randomly arranged in a row. What is the probability that the arrangement reads *NSBSBSN* ?
ANSWER: 1/210

**TOSS-UP**

24) ENERGY *Short Answer* What type of power plant transfers the heat from geothermal hot water to other liquids to produce electricity, and can do so from reservoirs with lower temperatures?
ANSWER: BINARY CYCLE

**BONUS**

24) ENERGY *Multiple Choice* In a radioisotope thermoelectric generator, the heat released by the decay of a suitable radioactive material is converted into electricity by the
W) Peltier effect
X) Thomson effect
Y) Seebeck effect
Z) Joule heating
ANSWER: Y) SEEBECK EFFECT