



# The 65<sup>th</sup> Annual Merck State Science Day Competition May 19, 2015

# **Advanced Integrated Science**

## DIRECTIONS

The "answer panel" at the bottom of the window is pre-set to show 10 answer boxes per page.

- 1. The current question has a black border.
- 2. Enter your answer choice using the keyboard.
- 3. Click Confirm to record your answer.
- 4. Questions that have been answered will be

## tinted Green

- 5. Any answer can be edited. Confirm the correction.
- 6.> moves to the next set of questions ( <moves back)
- 7.Click on any number to answer that question.
- 8. Confirm all entries. Each answer is recorded only when Confirm is used.
- 9. When finished, use **FINISHED TEST** in lower left.

Hint: The size of the lettering in the bottom answer panel can be adjusted using CTRL + to magnify the browser view.

The test has **100 items** that will be scored. You have <u>**90**</u> minutes in which to answer all the questions.

There is only one correct answer per question. Do not spend too much time on any one question. Do the items you find easier first, and then go back to those you find more difficult or time consuming during the time you have remaining. Your individual score will be computed on the basis of the number of correctly answered items.

## General Information:

<b>Proton mass,</b> $m_P = 1.67 \times 10^{-27} kg$	<b>Electron charge,</b> $e = 1.60x10^{-19}C$					
<b>Electron mass,</b> $m_e = 9.11x10^{-31}kg$	<b>1</b> electron volt, $1eV = 1.60x10^{-19} J$					
Avogadro's Number, $N_o = 6.02 x 10^{23} mole^{-1}$	Speed of light, $c = 3x10^8 \frac{m}{s}$					
Universal gas constant,	Universal gravitation constant,					
$R = 8.31 \frac{J}{(mol \cdot K)} = 0.0821 \frac{atm \cdot liter}{(mole \cdot K)}$	$G = 6.67 \times 10^{-11}  \frac{m^3}{(kg \cdot s^2)}$					
Boltzmann's constant, $k_p = 1.38 \times 10^{-23} J/_{H}$	Acceleration due to gravity at Earth surface:					
	$g = 10 \frac{m}{s^2}$					
1cal = 4.184J						

Unified atomic mass unit, $u = 1.66 x 10^{-19} kg = 931 \frac{MeV}{c^2}$
Planck's constant, $h = 6.60x10^{-34} J \cdot s = 4.14x10^{-15} eV \cdot s$
Coulomb's Law constant, $k = 9x10^9 N \cdot m^2 / C^2$
<b>1</b> earth atmosphere pressure, $1atm = 1.0x10^5 \frac{N}{m^2}$

**Equations**:

$v_f = v_i + at$	$2ad = v_f^2 + v_i^2$
$d = v_i t + \frac{1}{2}at^2$	$\Sigma F = ma$
$a_c = \frac{v^2}{r}$	$K = \frac{1}{2}mv^2$
$P_g = mgh$	W = Fd
$P = \frac{W}{t} = \frac{\Delta E}{t}$	$F_g = G \frac{M_1 M_2}{R^2}$
$F_B = DVg$	$A_1 v_1 = A_2 v_2$
$P + Dgy + \frac{1}{2}Dv^2 = Constant$	$v = \lambda f$
$n_i \sin i = n_r \sin r$	$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$
$f = \frac{R}{2}$	E = hf = pc
$\Delta E = \Delta mc^2$	$Q = mc\Delta T$
$\frac{P_1V_1}{P_1V_1} = \frac{P_2V_2}{P_2V_2}$	PV = nRT
$T_1$ $T_2$	
V = IR	P = VI

# The Periodic Table of the Elements

1																]	2
Η																	He
Hydrogen 1.00794		_															Helium 4.003
3	4											5	6	7	8	9	10
Li	Be											В	С	Ν	0	F	Ne
Lithium 6.941	Beryllium 9.012182											Boron 10.811	Carbon 12.0107	Nitrogen 14.00674	Oxygen 15.9994	Fluorine 18.9984032	Neon 20.1797
11	12											13	14	15	16	17	18
<b>Na</b> Sodium 22.989770	Magnesium 24.3050											Al Aluminum 26.981538	Silicon 28.0855	P Phosphorus 30.973761	Sulfur 32.066	Cl Chlorine 35.4527	Ar Argon 39.948
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K Potassium 39.0983	Calcium 40.078	<b>Sc</b> Scandium 44.955910	<b>Ti</b> <sup>Titanium</sup> 47.867	V Vanadium 50.9415	Cr Chromium 51.9961	Manganese 54.938049	Fe <sup>Iron</sup> 55.845	<b>Co</b> Cobalt 58.933200	Ni <sub>Nickel</sub> 58.6934	<b>Cu</b> <sup>Copper</sup> 63.546	Zn <sup>Zinc</sup> 65.39	Gallium 69.723	Germanium 72.61	<b>As</b> Arsenic 74.92160	Selenium 78.96	Bromine 79.904	Krypton 83.80
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Мо	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	Ι	Xe
Rubidium 85.4678	Strontium 87.62	Yttrium 88.90585	Zirconium 91.224	Niobium 92.90638	Molybdenum 95.94	Technetium (98)	Ruthenium 101.07	Rhodium 102.90550	Palladium 106.42	Silver 107.8682	Cadmium 112.411	Indium 114.818	<sup>Tin</sup> 118.710	Antimony 121.760	Tellurium 127.60	Iodine 126.90447	Xenon 131.29
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
<b>Cs</b> <sub>Cesium</sub> 132.90545	<b>Ba</b> Barium 137.327	Lanthanum 138.9055	Hafnium 178.49	Ta Tantalum 180.9479	W <sup>Tungsten</sup> 183.84	Re Rhenium 186.207	Osmium 190.23	Ir Iridium 192.217	Platinum 195.078	Au <sub>Gold</sub> 196.96655	Hg Mercury 200.59	Tl Thallium 204.3833	<b>Pb</b> Lead 207.2	<b>Bi</b> Bismuth 208.98038	Polonium (209)	At Astatine (210)	Rn Radon (222)
87	88	89	104	105	106	107	108	109	110	111	112	113	114				
Francium (223)	Ra Radium (226)	Actinium (227)	Rf Rutherfordium (261)	Dubnium (262)	Seaborgium (263)	Bh Bohrium (262)	Hassium (265)	Mt Meitnerium (266)	(269)	(272)	(277)						
				58	59	60	61	62	63	64	65	66	67	68	69	70	71
				<b>Ce</b> Cerium 140.116	Praseodymium 140.90765	Nd Neodymium 144.24	Promethium (145)	Samarium 150.36	Europium 151.964	Gadolinium 157.25	<b>Tb</b> Terbium 158.92534	Dy Dysprosium 162.50	<b>Ho</b> Holmium 164.93032	Erbium 167.26	<b>Tm</b> Thulium 168.93421	Yb Ytterbium 173.04	Lu Lutetium 174.967
				90	91	92	93	94	95	96	97	98	99	100	101	102	103
				<b>Th</b> Thorium 232.0381	Protactinium 231.03588	U Uranium 238.0289	Np Neptunium (237)	Pu Plutonium (244)	Am Americium (243)	<b>Cm</b> Curium (247)	Bk Berkelium (247)	Californium (251)	Es Einsteinium (252)	Fermium (257)	Mendelevium (258)	No Nobelium (259)	Lr Lawrencium (262)

1995 IUPAC masses and Approved Names from http://www.chem.qmw.ac.uk/iupac/AtWt/ masses for 107-111 from C&EN, March 13, 1995, p. 35 112 from http://www.gsi.de/z112e.html

## Merck State Science Day 2015

## **Advanced Integrated Science**

#### **Multiple Choice**

Identify the choice that best completes the statement or answers the question and place your selection ON THE ANSWER PANEL, then "Confirm."

## I. CLIFF SWALLOWS

Over the last several decades, cliff swallows began to nest on highway bridges and overpasses. In the 1980's scientists observed that there was a decline in the cliff swallows population because many of them were being killed by cars. Recently, researchers found the road-kill numbers were going down. They hypothesize that this is due to shorter average wing lengths. These petite wings allow the birds to take off quickly and maneuver deftly through the air. (Reference: www.sciencenews.org)

- 1. Based on the principle of natural selection, how would Darwin explain these results?
  - A) Populations fluctuate according to the season

**B)** The unequal ability of individuals to survive and reproduce will lead to gradual changes in an organism

- C) Species have an innate drive to become more complex
- D) Body parts that are used extensively become larger and stronger
- E) A new species changes most as it buds from a parent species and then changes little over time
- 2. The difference in wing length would be likely be described as:
  - A) Discrete characters
  - **B)** Quantitative characters
  - **C)** Genetic variation
  - **D)** Both A and C are correct
  - **E)** Both B and C are correct
- **3.** Hypothetically speaking, let's assume that the cliff swallows who nest near highways tend to have shorter wing lengths than those that nest in the cliffs. This would illustrate which term below:
  - A) Founder effect
  - **B)** Cline
  - C) Bottleneck effect
  - **D)** Balancing selection
  - E) Pseudogenes

- 4. Which of the following processes could be responsible for the shorter wing length in these birds?
  - A) Genetic variation
  - **B**) Mutation
  - **C)** Sexual reproduction
  - **D)** Crossing over
  - E) All of the above could potentially be responsible
- 5. Assuming that having a shorter wing span is autosomal recessive affecting every 1 in 250. What is the approximate frequency of heterozygotes?
  - **A)** .94
  - **B)** .06
  - **C)** .11
  - **D)** .011
  - **E)** .004
- **6.** Birds excrete waste with a high content of uric acid rather than urea, as do *Homo sapiens*. Why these different forms?
  - A) Uric acid requires less water.
  - B) Bird kidneys are acidic while human kidneys are slightly alkaline.
  - C) Birds have too small a fat content to convert lipoproteins in urea.
  - **D)** Humans have two kidneys with more highly developed nephrons.
  - E) Humans are mainly carnivores while birds are mainly herbivores.
- 7. Bird droppings have been used for centuries as agricultural fertilizer. What soil nutrient can be found in high concentrations in bird droppings?
  - A) potassium
  - **B**) nitrogen
  - C) phosphorus
  - **D**) iron
  - E) calcium

- 8. Why were small songbirds, such as a canary, brought into coal mines?
  - A) Miners liked to hear song birds sing.
  - B) They could show avenues of escape after mine collapses.
  - C) They are more sensitive to hazardous mine gases than humans.
  - D) Leftover scraps from miners' lunches could be economically scavenged.
  - E) The birds eat small insects attached to the donkeys that were used to haul the coal cars.
- 9. Why do cliff swallows tend to nest in colonies?
  - A) Availability of local food supplies.
  - B) Cooperative defense against predators.
  - C) Male swallows tend to have large broods of females.
  - D) Females move their eggs to nearby nests for others to hatch and breed again.
  - E) Adult males cooperate in making a common kill of their prey.
- 10. According to research by biologists at North Carolina and Longwood Universities, The Mechanics and Behavior of Cliff Swallows, a large-winged swallow has an average mass of 24-g and can accelerate in a straight line from rest at 7 m/s<sup>2</sup>. The short-winged swallow has an average mass of 19-g. Assuming the wings on both types of swallow can generate the same force, what is the acceleration of the short-winged swallow under the same conditions?

(Reference: http://jeb.biologists.org/content/early/2014/05/08/jeb.101329.full.pdf)

- A)  $4.8 \text{ m/s}^2$
- **B)**  $6.8 \text{ m/s}^2$
- C) 7.8  $m/s^2$
- **D**)  $8.8 \text{ m/s}^2$
- **E)** 9.8 m/s<sup>2</sup>
- 11. Also according to the researchers at North Carolina and Longwood Universities, while in flight, the small-winged swallow can turn through a circular evasive path quickly. With a constant maximum flying speed of 15.6 m/s, these swallows experience a turning force of an astonishing 7.8 times their weight. Under these conditions and using the mass of the small-winged swallow mentioned above, what is the radius of turn?
  - **A)** 0.3 m
  - **B**) 3.1 m
  - **C)** 4.6 m
  - **D)** 6.2 m
  - E) 9.2 m

- **12.** What is the Newtonian relationship between the larger winged swallows slower turning capabilities and the shorter winged swallows quicker maneuverability.
  - A) Newton's First Law: A smaller mass object doesn't need an external force to change its velocity.
  - **B)** Newton's First Law: An object at rest will remain at rest unless acted upon by an external force.
  - **C)** Newton's Second Law: The acceleration of a mass is proportional to the force applied. Thus, the smaller mass can give rise to a larger force.
  - **D)** Newton's Second Law: The acceleration of a mass is inversely proportional to that mass. Thus a smaller mass gives rise to a larger acceleration.
  - E) Newton's Third Law: For every action there exists an equal and opposite reaction.
- **13.** You are driving a car at the posted speed limit of 55 MPH (90 Km/hr) as you approach this bridge. A cliff sparrow lands on the pavement at a distance of 104 m from you. What is the minimum deceleration your car must have in order to stop your car in time so the sparrow can walk away unharmed?

A) 
$$\frac{3m}{s^2}$$
  
B)  $\frac{4.5m}{s^2}$   
C)  $\frac{6m}{s^2}$   
D)  $7.5m/s^2$   
E)  $\frac{9m}{s^2}$ 

- 14. The decline in cliff swallow population was the result of
  - A) natural selection at work.
  - **B)** habitat fragmentation.
  - C) background extinction rates.
  - **D)** air pollution toxicity.
  - E) climate change.
- 15. Excessive use of fertilizer results in
  - A) climate change.
  - B) industrial smog.
  - C) acid deposition.
  - **D**) cultural eutrophication.
  - E) ozone hole depletion.

## II. TRUVIA

A research team at Drexel University published a study in PLoS One that was the brainchild of a 12year-old. <u>Daniel R. Marenda, Sean O'Donnell</u>, and colleagues reported that erythritol, the main ingredient of the sweetener <u>Truvia</u>, is toxic to Drosophila melanogaster fruit flies.



Simon D. Kaschock-Marenda went to his dad three years ago to pitch an idea. Knowing that his father had access to a supply of fruit flies, the sixth-grader proposed a science fair project: He wanted to feed a variety of sugars and sweeteners to flies and see how the insects fared. He purchased a number of sweeteners, including Truvia and mixed this sweetener and a number of others with Drosophila food, put each in a container with adult fruit flies, and waited. In the Truvia container the fruit flies had died within 6 days, while the ones feeding off the other sweeteners were still alive.

Truvia is marketed as a natural sweetener extracted from the South American Stevia rebaudiana plant, so the scientists suspected that the ingredient killing the fruit flies was coming from the plant. But fruit flies given food laced with <u>Pure Via</u>, another sweetener derived from the stevia plant, didn't react as they had to Truvia.

Analysis showed that more than 90% of the Truvia was erythritol, a zero-calorie sweetener found in fruits and fermented foods, which acts as a bulking agent in Truvia. Further testing show that this was the toxic substance for the fruit flies, even though it is non-toxic to humans. (DOI: <u>10.1371/journal.pone.0098949</u>).

- 16. What is the predominate intermolecular force in erythritol?
  - A) hydrogen bonding
  - **B)** covalent bonding
  - C) polar-colvalent bonding
  - **D**) ionic bonding
  - E) coordinate-covalent bonding

- 17. What is the formula for erythritol?
  - **A)** C<sub>4</sub>O<sub>4</sub>H<sub>4</sub>
  - **B)**  $C_4O_4H_{10}$
  - **C)** C<sub>6</sub>O<sub>4</sub>H<sub>4</sub>
  - **D)**  $C_6O_4H_{10}$
  - **E)** C<sub>6</sub>H<sub>8</sub>O<sub>4</sub>

18. Which substances would likely dissolve erythritol?

- I. water
- II. ethyl alcohol
- III. vegetable oil
- IV. corn syrup
- A) only I
- **B**) only III
- C) I and II only
- **D)** I, II, & IV
- E) all of them
- **19.** Which substance is NOT presently approved by the Food & Drug Administration (FDA) for use as a sweetener?
  - A) sucralose
  - B) aspartame
  - C) saccharin
  - **D)** cyclamate
  - E) mogrosides
- 20. A substance can be considered a zero-calorie sweetener if it:
  - I. is over 100 times sweeter than sugar and is used in micro quantities.
  - II. is not absorbed by the body.
  - III. doesn't cause tooth decay.
  - IV. has a negative heat of combustion,  $\Delta H^{\circ}_{comb.}$
  - A) I & II only
  - **B)** I & III only
  - C) II & IV only
  - **D)** II, III, & IV
  - E) all of them

- **21.** Erythritol can be found in fermented foods. From a biological standpoint, why are fermented foods usually considered a healthy option for humans?
  - A) Fermented food increase the digestibility of food
  - B) Fermented food does not require oxygen to make so it is easier to break down
  - C) Fermented food has been shown to increase the nutrient content in certain foods
  - **D)** Fermented food requires carbon dioxide therefore more organic compounds are present
  - **E)** Both A and C are correct
- 22. Which of the following statement (s) are correct about fermentation?
  - I. Many cells use fermentation to produce ATP by substrate level phosphorylation
  - II. The **only** difference between alcoholic fermentation and lactic acid fermentation are the end products
  - III. FADH is used as an electron acceptor in fermentation
  - IV. Glucose is the only organic compound that begins fermentation
  - A) I only
  - **B)** II only
  - C) II & IV
  - **D)** I, II, III
  - E) III & IV
- 23. Erythritol was determined to be non-toxic, with an LD-50 of 5 g/kg in dogs. An LD-50 is
  - A) the legal minimum dose determined by the FDA.
  - **B)** the dose at which half of organisms can detect the substance.
  - C) the maximum dose allowable by law.
  - **D)** the dose at which half of tested organisms die.
  - E) half of the allowable dose for adults.
- 24. The USFDA calculated that the average adult would consumer 13 g erythritol per day. The average American adult has a mass of 87 kg. Assuming that the LD-50 of 5g/kg in dogs applies directly to humans, then the adult would consume \_\_\_\_\_\_ erythritol than the LD-50.
  - A) much less
  - **B)** about the same amount of
  - C) much more
  - **D)** a little bit less
  - E) a little bit more

#### **III. BOUND BROOK**

By one measure, the Bound Brook might be the most polluted body of water in New Jersey: The state says you shouldn't eat fish – not even one per year – from its depths. A new report by the federal Environmental Protection Agency says that a plume of contaminated groundwater, sitting under a Superfund site in South Plainfield, is flowing straight into the waterway that runs through northern Middlesex County. That means that the cleanup of the Bound Brook, the final stage of a federal project that has already totaled more than \$100 million, will be complicated and costly. Dangerous pollutants have been detected in the surface water, the floodplains, the sediments and the fish along several miles of the waterway, from Spring Lake to New Market Pond, and continuing west all the way to the confluence with the Green Brook.

The total amount of pollution in the waterway has remained constant since the 1990s, according to Prince. But before the latest report, EPA had not fully reckoned with the presence of PCBs, or polychlorinated biphenyls, in the toxic groundwater flowing into the Bound Brook.

The new report in 2014 said that the PCBs in the Bound Brook are probably able to spread more readily than previously acknowledged because they're mixing with volatile organic compounds, a different type of pollutant that makes PCBs more mobile. From 1936 until 1962, the Cornell-Dubilier Electronics company operated at the Hamilton Boulevard site. The company made, among other things, a mess. The company allegedly dumped materials contaminated with PCBs directly into the ground. Sediments of the Bound Brook are laced with pollution from capacitor debris.

Previous stages of the cleanup, dating to 1997, have addressed contamination of homes in the surrounding area. About 540 people live within a quarter-mile of the Superfund site, but investigators found little reason to believe the public was in imminent danger. The EPA ordered the demolition and paving of much of the Superfund site, relocating businesses that were still there. And the EPA said that it was not feasible to clean up the groundwater itself, and decided to monitor it instead.

*On a late spring early evening, it's hard to tell that the brook is choked with pollutants -- harmful toxins with names like Arcolor 1254, trichloroethene, benzidine and heptachlor epoxide.* 

The birds seem oblivious -- waterbound mallards paddle along near the Cornell-Dubilier site, where the heaviest concentrations of pollution can be found, and songbirds like yellow warblers, cedar waxwings and a Baltimore oriole sing pertly from the trees along the banks. A hazy golden sun reflects off New Market Pond.

#### **25.** Groundwater is

- A) water flowing in any small creek or stream.
- **B)** water running off the land after a storm.
- C) water flowing in underground caves.
- **D)** water flowing in porous soil horizons.
- E) all of the above.

**26.** PCB's are dangerous because

*i. they are carcinogenic.ii. they are volatile.iii . they are flammable.* 

- A) only one of the above.
- **B**) i and ii only
- C) i and iii only
- **D)** all of the above
- E) none of the above
- 27. Superfund sites are established under which of the following pieces of legislation?
  - A) CERCLA
  - **B)** RCRA
  - C) Endangered Species Act
  - **D)** National Earth Day
  - E) Clean Water Act
- **28.** New Jersey ranks \_\_\_\_\_\_ in the United States for number of Superfund sites.
  - A) first
  - B) fifth
  - C) tenth
  - **D)** twentieth
  - E) last
- **29.** Recommended way(s) to deal with contaminated groundwater is (are)

*i. create a well and pump the water out to be treated.ii. install a clay or vinyl barrier.iii. allow natural bacteria to detoxify the water.* 

- A) only one of the above.
- **B**) i and ii only
- **C)** i and iii only
- **D)** all of the above
- E) none of the above

- **30.** The article above mentions the yellow warbler. Many scientists have researched the yellow warbler and found that this species live in swampy areas from Canada to South America. Which term below would <u>best</u> describe this species of bird?
  - A) Specialist
  - B) Fundamental Niche
  - C) Realized Niche
  - D) Scavenger
  - E) Generalist
- **31.** Yellow Warblers often have their nest parasitized by Brown-headed Cowbirds, which lay their eggs in the nests of other birds. The warbler has developed a strategy to cope with unwanted eggs. If the cowbird eggs are discovered, the warbler will build a new nest layer on top of the cowbird eggs. Researchers found that warbler nests located in areas with red-winged populations have less cowbird eggs in their nests. Why would this occur?
  - A) Red winged birds may eat the warblers so they are unable to make nests
  - B) Red winged birds may eat warblers eggs so the warblers no longer make nests
  - C) Cowbirds may feed on the red winged birds and no longer bother the warblers
  - **D)** Red winged birds may feed on the cowbirds limiting their populations in those areas
  - E) None of the above are correct
- **32.** The general structure for a polychlorinated biphenyl (PCB) is given below. The numbers in the drawing indicate where one or more chlorine atoms are attached. What is the mass percentage of chlorine in a PCB if it has five (5) attached chlorine atoms?



- **A)** 22.7%
- **B)** 35.5%
- **C)** 41.7%
- **D**) 54.4%
- E) 55.2%

- 33. In the United States, what was the main use of PCBs?
  - A) sunscreens
  - **B)** disinfecting water
  - C) electrical transformers
  - **D**) automatic transmission fluid
  - E) medicated soap for treating acne
- **34.** "…PCBs in the Bound Brook are probably able to spread more readily than previously acknowledged because they're mixing with volatile organic compounds (VOC), a different type of pollutant that makes PCBs more mobile." Why are they more mobile?
  - A) Volatile compounds evaporate more easily.
  - B) Both are non-polar and dissolve in each other.
  - C) PCBs are made more polar by the presence of other organics.
  - D) VOCs can dissolve more minerals in the soil.
  - E) The presence of PCB can be more easily detected when mixed with VOCs.
- **35.** Why are PCBs considered so dangerous?
  - A) They readily penetrate the skin.
  - **B)** They disrupt the endocrine system.
  - C) PCBs are very stable and do not decompose readily.
  - **D)** They are highly lipophilic.
  - E) All of the above.
- 36. Below is the structure for benzidine. What is the pH of a saturated solution of this compound in water?



- A) Weakly acidic
- **B)** Strongly acidic
- C) Weakly alkaline
- D) Strongly alkaline
- E) Neutral

## **IV. Fusion Milestone 2014**

Physicists at Lawrence Livermore National Laboratory announced in February 2014 that they reached an important milestone in nuclear fusion. At the National Ignition Facility, 192 simultaneous laser pulses blasted tiny hydrogen pellets, and the resulting fusion reactions emitted slightly more energy than was initially absorbed — a key first step in inertial confinement fusion. However, there is still a long way to go before the machine produces a net gain in energy, since the pellets absorbed only a small fraction of the incoming laser energy.

Nuclear fusion reactions produce many times more energy than their nuclear fission counterparts and ultimately result in essentially no radioactive waste. (Source:http://www.aps.org/publications/apsnews/201501/stories.cfm)

- **37.** Which one of the following statements is the best explanation as to why *nuclear fusion* is not at present used to generate electric power?
  - A) Fusion processes can result in nuclear explosions.
  - **B)** Fusion requires isotopes that are scarce.
  - C) Fusion results in large amounts of radioactive waste.
  - D) Fusion requires very high temperatures that are difficult to contain.
  - E) Fusion produces too much radiation.
- **38.** Determine the amount of energy released in the following typical H+H fusion reaction:  ${}_{1}^{2}H + {}_{1}^{2}H \rightarrow {}_{2}^{4}He$

Use the following information for your calculation:  ${}_{1}^{2}H$  has a mass of 2.014 102 u,  ${}_{2}^{4}He$  has a mass of 4.002 603 u, and 1 u = 931.5 MeV. A) 0.2 MeV B) 11.9 MeV C) 23.8 MeV D) 257 MeV E) 7480 MeV

**39.** How many kilowatt-hours of energy are released from 25 g of deuterium  ${}_{1}^{2}H$  fuel in the fusion reaction:  ${}_{1}^{2}H + {}_{1}^{2}H \rightarrow {}_{2}^{4}He + \gamma$ 

where the masses are  ${}_{1}^{2}H = 2.014 \ 102 \ u \ and {}_{2}^{4}He = 4.002 \ 603 \ u.$ 

*Note*: Ignore the energy carried off by the gamma ray, *y*.

- A)  $1x10^{6} kWh$
- **B)**  $2x10^{6}kWh$
- **C)**  $3x10^{6}kWh$
- **D)**  $4x10^{6}kWh$
- **E)**  $5x10^{6}kWh$

**40.** In the following tritium-tritium fusion reaction, what is the "X"?

 ${}^3_1H + {}^3_1H \rightarrow {}^4_2He + X$ 

- A) an electron
- **B**) a neutron
- C) two electrons
- **D)** two neutrons
- E) one gamma photon
- **41.** What is the mass of the products of a nuclear fusion reaction compared to the mass of the original components?
  - A) the same.
  - **B)** less.
  - C) more.
  - **D**) depends on the type of components that fuse together.
  - E) depends on the amount of energy released.
- 42. One of the fusion reactions that are currently taking place in the Sun is  ${}_{2}^{3}He + {}_{2}^{3}He \rightarrow {}_{2}^{4}He + {}_{1}^{1}H + {}_{1}^{1}H$ The following are the masses known:  ${}_{1}^{1}H = 1.007825u$ ,  ${}_{2}^{3}He = 3.016029u$ , and  ${}_{2}^{4}He = 4.002603u$ .

How much energy in MeV s released in one reaction of this type?

A) 11 B) 13 C) 15 D) 17 E)	19

- **43.** Energy is an important feature that is required for life to exist. Many times energy can be found in the form of ATP. How is the synthesis of ATP by oxidative phosphorylation powered?
  - A) Conversion of glucose to citric acid
  - B) Redox reactions of the Electron Transport Chain
  - C) Conversion of glucose to pyruvate
  - D) Redox reactions of glycosis
  - E) None of the above are correct
- **44.** Nuclear power plants have the potential for great destruction if a meltdown occurs. Which of the following is NOT a location of a nuclear power plant accident?
  - A) Fukushima
  - B) Chernobyl
  - C) Oyster Creek
  - D) Three Mile Island
  - E) all of the above have had serious accidents.

### 45. Which of the following are environmental problems associated with nuclear power plants?

- I. release of greenhouse gases II. disposal of nuclear waste III. thermal pollution IV. increase in the ozone hole V. industrial smog
- A) only one of the above.
- **B**) only two of the above.
- C) only three of the above.
- **D**) all of the above.
- E) none of the above.

**46.** Nuclear power plants generate about \_\_\_\_\_\_ percent of the electricity in New Jersey.

- **A)** 5
- **B**) 10
- **C)** 25
- **D**) 50
- **E)** 75

47. New Jersey has the \_\_\_\_\_\_ nuclear power plant(s) of all the states in the United States.A) fewest

- B) most
- C) oldest
- **D**) newest
- E) most dangerous
- **48.** The most practical nuclear fusion reaction for power generation seems to be the deuterium-tritium reaction, the sources of these fuels are important. What would be the most economical source for deuterium?
  - A) seawater
  - **B)** methane gas
  - C) dismantled H-bombs
  - D) reacting an active metal with an acid
  - E) extraction from deep underground coal mines

- **49.** Besides laser-implosion of hydrogen pellets another design of confinement is a tokomak. What method does this employ to achieve confinement?
  - A) gamma rays
  - **B**) electrostatics
  - C) magnets
  - **D**) heavy ion beams
  - E) neutron bombardment
- 50. The Plasma Physics Laboratory is the nearest tokomak. Where is it located?
  - A) NJIT
  - **B)** Princeton University
  - **C)** Rutgers University
  - D) Massachusetts Institute of Technology (MIT)
  - E) Harvard University
- **51.** What is the general shape of a tokomak?
  - A) alpha helixsphere
  - **B)** circular base pyramid
  - C) horseshoe magnet
  - **D)** sphere
  - E) torus (donut)
- **52.** In 1989 Martin Fleischmann and Stanley Pons reported that their apparatus had produced anomalous heat ("excess heat"), of a magnitude they asserted would defy explanation except in terms of nuclear processes.[1] They further reported measuring small amounts of nuclear reaction byproducts. Their process was nicknamed "cold fusion". What kind of process was involved?
  - A) room temperature electrolysis of heavy water
  - B) cryogenic confinement via slow neutron beams
  - C) slow neutrons captured by a cold electron beam
  - D) fusion of helium ions just a few degrees above absolute zero
  - E) laser beams boring holes in uranium nuclei cooled by liquid helium

- 53. Why was Fleischmann and Pons's cold fusion never made into a practical reactor?
  - A) It produced too much background radiation.
  - B) Nobody was able to reproduce the results of their experiment.
  - C) Maintaining temperatures near absolute zero proved too impractical.
  - **D)** They both died in a tragic lab accident that also destroyed all of their notes.
  - E) The raw materials and equipment were too expensive to obtain, design, and manufacture.

#### V. DNA

The central dogma from DNA-RNA-Proteins may need to be modified according to researchers in 2015. These scientists recently discovered that 60% of RNA transcripts in squids have been edited, which is significantly higher than other organisms such as fruit flies and humans. (Reference: Squid enrich their DNA blueprint through prolific DNA editing. sciencedaily.com)

- 54. Which of the following statement(s) is correct about the primary transcript of a gene?
  - I. RNA polyermase II transcribes only exons from DNA
  - II. RNA polymerase II transcribes only interons from DNA
  - III. RNA splicing involves cutting out introns from the transcript
  - IV. RNA splicing involves cutting out exons from the transcript
  - V. The mRNA molecule that enters the cytoplasm is an abridged version of the original
  - VI. The mRNA molecule that enters the cytoplasm is unchanged
  - A) I only
  - **B)** III only
  - C) II, VI
  - **D)** III,V
  - E) I, III, IV
- 55. Which of the following is correctly matched?
  - A) snRNA- plays structural and catalytic roles in spliceosomes
  - **B)** SRP RNA- serves as a precursor to mRNA
  - C) tRNA- plays catalytic roles
  - D) siRNA-aids in the processing of pre-rRNA
  - E) snoRNA-involved in regulation of gene expression

- 56. Based on the researchers findings about the squid, what could these results potentially indicate?
  - A) Tremendous amount of protein diversity
  - **B)** Allow the squid to "fine tune" their physiological responses to environmental variables
  - **C)** Illustrate the intense similarities between transcription and translation in prokaryotic and eukaryotic cells
  - D) How features such as telomeres are created
  - E) Both A and B are correct
- 57. Why are interons important?
  - A) They code for the genes of an organisms
  - **B)** They increase the probability of potentially beneficial crossing over between the exons
    - of alleles
  - C) They signal the synthesis of poly-A tails
  - D) They reduce the amount of redundancy in a RNA transcript
  - E) None of the above are correct
- 58. In 1962, the Nobel Prize in Physiology or Medicine was awarded to James Watson, Francis Crick, and Maurice Wilkins for their discovery of the double helix structure of DNA. At the basis of this time-honored discovery was an item called *Photo 51*. It was part of Rosalind Franklin's research, taken by Raymond Gosling in 1952, a PhD student working for Franklin. Gosling then went to work for Maurice Wilkins and showed him *Photo 51*. Wilkins shared this image with his colleagues, Watson and Crick, and the rest is Nobel Prize history. Rosalind Franklin died four years before the Nobel Prize was awarded and received no accolades for her contributions to the discovery of the double helix nature of the DNA molecule.

Photo 51 is:

- A) a visible light photograph.
- **B)** a visible light diffraction pattern.
- C) a radio diffraction pattern.
- **D)** a microwave diffraction pattern.
- E) an X-Ray diffraction pattern.

- **59.** In the human DNA molecule, each sugar-base unit of DNA contains one phosphate with an overall charge of -e. There are two units per sugar-base pair, there are thus 2 negative charges, -e each, in the space of 0.34 nm. What is the electrostatic force associated with this double negative pair assuming no dielectric effects from the surrounding environment?
  - **A)** 2*x*10<sup>−9</sup>*C*
  - **B)** 2*x*10<sup>−6</sup>*C*
  - C) 4*x*10<sup>−9</sup>C
  - **D)** 8x10<sup>−6</sup>C
  - E) 8x10<sup>-9</sup>C
- 60. What is/are the main difference(s) between DNA and RNA?
  - I. RNA has a uracil in place of DNA's thymine
  - II. RNA is a single strand, DNA is a double strand
  - III. different sugars
  - A) I only
  - **B)** I & II only
  - C) I & III only
  - D) II & III only
  - **E)** I, II, & III

61. Within a cell DNA is organized into chromosomes. What helps in the organization?

- A) deoxyriboses
- **B)** nucleotides
- C) histones
- D) ergonics
- E) codons
- **62.** When proteins are made from RNA they must fold into precise 3D structures. Which force(s) contribute to this folding?
  - I. disulfide bridges
  - II. hydrophobic bonding
  - III. hydrogen bonding
  - IV. ionic attractions
  - A) III only
  - **B)** I & III only
  - C) II & III only
  - **D)** II, III, & IV only
  - **E)** I, II, III, & IV

- 63. In human cells, where are most proteins created?
  - A) cytoplasm
  - **B)** ribosomes
  - C) nucleus
  - **D)** endoplasmic reticulum
  - E) golgi bodies
- **64.** What are proteins?
  - A) chains of monosaccharides held together by ether linkages
  - **B)** chains of amino acids held together by peptide bonds
  - C) chains of nucleotides held together by glucophosphate linkages
  - **D)** chains of protons connected by nuclear forces
  - E) strands of purines and pyrimidines bound together in the form of a double helix
- **65.** Most plastics today are made from
  - A) oil.

**D**) other plastics.

- **B)** plants.
- C) inorganics.

- E) animal tissues.
- 66. The reason(s) that thermoplastics from the squid genes might be more eco-friendly than current thermoplastics is/are:

*I. the squid thermoplastics are more likely to be biodegradable. II. less energy would be needed to make the squid thermoplastics.* III. the squid thermoplastics would be more durable.

- **A)** I **D**) all of the above
- **B**) II E) none of the above
- C) III

#### **VI. SPICE**

Curcumin, the compound that gives turmeric spice its characteristic bright color, has well-known antimicrobial properties. Researchers have now put curcumin to work to create a food-safe antibacterial surface. Packaged inside nanosized vesicles attached to glass, the curcumin kills bacteria on contact.



Southern Illinois University researchers packed curcumin inside custom-built nanovesicles consisting of a membrane bilayer constructed from diacetylene fatty acids and a phospholipid. Some of the diacetylene molecules were tagged with N-hydroxysuccinimide groups, which the researchers used to attach the nanovesicles to the glass. The vesicles also have molecules of glucose hanging on their surface, which stick to bacterial cell walls. The glass-bound vesicles, stocked with curcumin, can then nab passing bacteria. Surfaces coated with curcumin were immersed for 48 hours in flasks spiked with E. coli, less than 0.5% of the bacteria survived, while no significant decline occurred in the flasks without curcumin. (Reference: J. Agric. Food Chem. 2015, DOI: 10.1021/jf505442w)

67. What functional groups can be found in curcumin?

- I. hydroxyl II. phenol III. methoxy IV. carbonyl
- A) I & II only
- **B**) I & III only
- **C)** I, III, & IV only
- D) II & IV only
- E) all of them

68. What would be the approximate size of a nanovesicle?

- **A)** 10<sup>-6</sup> m
- **B**)  $10^{-9}$  m
- **C)**  $10^{-12}$  m

- **D)** 1 milli-microcentimeter
- E) 1 centi-picometer

- 69. What is the number of chiral centers in a curcumin molecule?
  - **A)** 0
  - **B**) 2
  - **C)** 6
  - **D**) 8
  - **E)** 12
- 70. What is the color of curcumin?
  - A) red
  - B) yellow
  - C) green
  - **D**) blue
  - E) white
- 71. Bacteria are a very diverse group of organisms. Which statement(s) below is correct about bacteria?
  - I. Gram positive bacteria have a large amount of peptidoglycan in their cell walls.
  - II. All bacteria are considered anaerobes.
  - III. Bacteria that are considered chemoautotrophs need carbon dioxide as a carbon source
  - IV. Examples of chemoautotrophs include cyanobacteria
  - A) I only
  - B) IV only
  - **C)** II & IV
  - **D**) I & III
  - E) II, III, IV
- **72.** Many bacteria are considered pathogenic to humans. Which of the following diseases below are caused by bacteria?
  - A) Lyme Disease
  - B) Ebola
  - C) HIV
  - **D)** Elephantiasis
  - E) None of the above are caused by bacteria

- 73. If these nanovesicles come into widespread use, we would expect
  - A) some bacteria to become resistant to curcumin.
  - **B)** many people to become allergic to curcumin.
  - C) curcumin toxicity at higher trophic levels.
  - **D)** a dramatic decrease in food poisoning.
  - E) none of the above.
- 74. The advantage of using curcumin is
  - A) this is a natural molecule and therefore safer than current antiseptics.
  - **B**) it derives from plant sources and therefore fewer people will be allergic.
  - C) fewer bacteria would be expected to be resistant to this new application.
  - **D)** this is less expensive than current antibiotics.
  - E) this is a natural chemical and therefore less toxic to the environment.

## **VII. DESALINATION**

As surely as the hot, dry Santa Ana winds bring blue skies to the coast and wildfires to the hills, severe California droughts bring calls to build desalination plants up and down the seashore. ... That's not only because the current drought is the longest and most severe in memory, but because a \$1-billion desalination project scheduled to start operating in Carlsbad this fall will be attracting lots of attention. The plant, the largest of its kind in the U.S., is designed to provide San Diego County with about 50 million desalinated gallons a day, about 7% of its water needs. Enthusiasm for desalination tends to overlook its high costs, which stem in part from its enormous energy demand and weighty environmental footprint. The modern process {is} known as reverse osmosis. Let's take a look at the hard realities. As big industrial facilities, desalination plants can't be plunked down just anywhere on the coast without destroying the qualities that attract people to the shoreline. Yet the plants need to be close to customers, with room for pumps, pipelines, inflows and outfalls. Assertions that desalination is an easy answer to California's water crisis should be taken with more than a grain of, well, salt. (Reference: abridged from http://touch.latimes.com/#section/-1/article/p2p-83383753/)

- 75. San Diego is in which of the following biomes?
  - A) temperate deciduous forest
  - **B)** temperate rain forest
  - C) savanna
  - D) chapparal
  - E) tropical rain forest

- **76.** The salt or brine solution left over from desalination is usually pumped back into the ocean. A possible result of this action is
  - *i. increased salinity of the local area, resulting in loss of some species.*
  - *ii. decreased salinity of the local area, resulting in loss of some species.*
  - *iii. increased pH of the local area, resulting in loss of some species.*
  - *iv. decreased pH of the local area, resulting in loss of some species*
  - **A)** only one of the above
  - **B)** i and iii
  - C) ii and iv
  - **D)** i and iv
  - E) ii and iii
- 77. Desalination plants require a large amount of energy. California recently shut down the San Onofre nuclear power plant. Which of the following fuels is most likely to be used to power the desalination plant?
  - A) nuclear
  - B) solar
  - C) hydroelectric
  - **D**) natural gas
  - E) wind
- **78.** Various locations were considered for the desalination plant, but ultimately the Carlsbad site, which is next to NRG Energy's Encina Power Station, was chosen. A good reason for this decision was
  - A) there would be less habitat destruction.
  - **B**) the two facilities could share water pipes.
  - C) the site was not in a populated area.
  - **D)** the land was less expensive.
  - E) the intake water was less salty.
- 79. Desalination plants harm marine life by
  - A) killing larvae sucked up by the intake pipes, thus threatening species.
  - B) killing organisms due to increased temperatures of the water
  - C) reducing the amount of fresh water in ecosystems, thus destroying habitat.
  - **D**) generating noises which alter migration routes of marine mammals.
  - E) none of the above; desalination plants only harm freshwater organisms.

- 80. Which of the following is NOT an environmental problem associated with desalination plants?
  - A) habitat destruction.
  - **B**) biomagnification.
  - C) climate change.
  - **D)** harmful waste.
  - E) reduced biodiversity.
- **81.** Sodium chloride (salt) is an important nutrient to sustain life. However, too much sodium chloride can cause health issues. What is one potential health issue that it can cause?
  - A) Liver damage
  - **B)** High blood pressure
  - C) High cholesterol
  - **D)** Kidney damage
  - E) Lysis of red blood cells
- 82. In which biological reaction could salt be a potential product?
  - A) Redox Reactions
  - **B)** Hydrolysis
  - C) Neutralization Reactions
  - **D**) Dehydration Synthesis
  - E) None of the above create salt
- **83.** Reverse osmosis is the process that occurs when:
  - A) the solution is subjected to an external pressure greater than its osmotic pressure
  - B) the solution is subjected to an external pressure less than its osmotic pressure
  - C) the semipermeable membrane provides the pressure to move the solution
  - **D**) the movement is from the pure solvent to the solution
  - E) the osmotic process is reversed to produce the original solution
- 84. Osmosis and reverse osmosis are considered colligative properties which also include:
  - I. boiling point elevation
  - II. freezing point depression
  - III. enthalpy of solution
  - A) I only
  - **B)** III only
  - C) I and II
  - **D)** I and III
  - E) I, II, and III

- **85.** Another suggestion to relieve the drought in California is to tow icebergs down from Antarctica to provide water. Which statement is true?
  - A) Using icebergs would be less expensive than desalinized water.
  - B) Using the icebergs would help to increase the water levels in California.
  - C) This is just another example of the crazy ideas which come from California.
  - **D)** The icebergs would provide the water for the desalination plant instead of using local seawater.
  - E) Icebergs are fresh water so would provide drinking water without having to build a desalination plant.
- 86. What is the chemical process by which icebergs form?
  - A) distillation
  - **B**) desalination
  - C) osmosis
  - **D**) crystallization
  - E) evaporation

#### **VIII. HUBBLE**



The Hubble Space Telescope. Image courtesy of WikiCommons.

April 2015 marks the 25th anniversary of the launch of NASA mission that has changed the way we look at and understand the Universe. The Hubble Space Telescope, HST, data has yielded tens of thousands of scientific papers and the powerful cameras it contains continue to beam back breathtaking images of the universe.

One of the highlights of the HST is the Ultra Deep Field. In late 2003, after pointing Hubble at a seemingly blank section of sky just above the constellation Fornax for more than 100 hours, astronomers discovered 10,000 distant galaxies and a dozen Quasars (active galaxies where the supermassive black hole at the center is actually "eating" the matter of the galaxy); all in a patch of sky no larger than a grain of sand held at arm's length. Not only does it hint at the unexpected richness of the Universe, but that abundance suggests that small irregular galaxies merge to form the larger ones more familiar in our own cosmic neighborhood.

Each and every dot, smudge, of blob in this image is an entire galaxy of its own each containing billions of stars.



Hubble Ultra Deep Field: Courtesy WikiCommons.

A few details about Hubble itself: Orbital radius: 7000 km (approximately 550 km above the surface) Orbital velocity: 7200 m/s (16,000 MPH) Mass: 11,000 kg

- 87. In a few years, the James Webb Space Telescope will replace the Hubble as our most powerful space telescope. The Webb will have a mass of roughly 6,000 kg. If  $\mathbf{R}$  is the orbital radius of the Hubble, at what orbital radius relative to  $\mathbf{R}$  must the Webb be injected to obtain a stable circular orbit about the Earth?
  - A) <u>6R</u>
  - 11
  - **B**) *R*
  - C)  $\frac{11R}{6}$
  - **D**) 2*R*
  - E) Anywhere the astronomers need to because the mass of the satellite is independent of the orbital properties.
- **88.** The Webb will actually orbit the Sun with an orbital period of exactly one full Earth year. This is accomplished by injecting the Webb into one of the *Lagrange* points, L2 specifically, which is located  $1.5 \times 10^6$  km from Earth directly opposite the Sun. What must the orbital speed be of the Webb in order to attain this period?
  - A) 0.3 km/s
  - **B)** 3 km/s
  - C) 30 km/s
  - **D)** 300 km/s
  - E) Exactly the orbital speed of the Earth.
- **89.** The Hubble's Ultra Deep Field image, shown above, shows an estimated 10,000 galaxies. What is the primary tool astrophysicists use to determine the distance to these galaxies?
  - A) Redshift of visible light
  - **B)** Blueshift of visible light
  - C) Parallax
  - D) Supernovae Type II light emissions
  - E) Variable Cepheids

**90.** The Cosmic Microwave Background Radiation (CMBR) has a redshift of z = 1089, corresponding to an age of approximately 379,000 years after the Big Bang and a comoving distance of more than 46 Billion light years (Bly). This means the Universe is at least 46 Bly in radius, not the often reported 13.8 Bly, although both numbers can be considered accurate and true. What causes this seeming huge discrepancy in numbers?



Image courtesy of NASA/Planck Mission

- A) 46 Bly is the distance as measured by Hubble red shifting, the time it takes light to reach us from the far reaches of the visible Universe.
- **B)** Each measurement is valid when considering the vastly different methodology used to derive it and indicates the uncertainty of the size of the Universe.
- C) 13.8 Bly is the "old" value and has been replaced in the last couple of years by 46 Bly, but the media and common person hasn't caught on yet.
- **D)** 13.8 Bly is the distance as measured by Hubble red shifting, the time it took light from a distant object to reach us from the far reaches of the visible Universe. The 46 Bly is the calculated distance to where those far away objects are now; 13.8 Bly after we received the light.
- **E)** 13.8 ly is the distance as measured physically by parallax and other "tried & true" methods, whereas the 46 Bly is calculated using redshift.

#### Scroll down for more

- **91.** Beyond the "edge" of the visible Universe, some 13.8 Billion light years away, accepted astrophysics theories state that there are objects that travel "faster than light" away from us. This seems to break the basic premise of Einstein's *Special Theory of Relativity* that states nothing can travel faster than the speed of light, not even light. So, how can this accepted astrophysics construct of "faster than light" travel be reconciled with the unbreakable Special Theory of Relativity?
  - A) There are exceptions to every "theory."
  - **B)** Due to the accelerated expansion rate of the Universe, the photons of light beyond the visible Universe are moving at the exact speed of light, but the space they are traveling in is expanding at such an incredible rate that the distance between two measurable points continues to increase.
  - **C)** Einstein's Special Theory of Relativity does not apply to objects or light outside the realm of the visible Universe.
  - **D)** This is only a "theory" that has no observational or mathematical evidence.
  - E) Beyond the "visible" Universe, there is no light so objects can travel as fast as they want to unimpeded by any disturbances.
- **92.** Joseph-Louis Lagrange was an 18th century mathematician who found the solution to what is called the *three-body problem*; is there any stable configuration in which three bodies could orbit each other, yet stay in the same position relative to each other? As it turns out, there are. NASA takes advantage of the Lagrange solution today in order to place satellites in stable orbits while remaining at the same relative distance from each the Earth and the Sun. How many Lagrange points exists in the Sun-Earth system.
  - **A)** 2
  - **B**) 3
  - C) 4D) 5
  - D) 3 F) 6
  - **E)** 6
- **93.** The HST, when placed in orbit, suffered from a common optical problem. Its main camera was out of focus. The below images are of galaxy M100 before and after a corrective operation by Shuttle astronauts. The first image is obviously out of focus. What do physicists call the inherent problem with mirrors that caused this?



- A) Chromatic aberration
- **B)** Spherical aberration
- C) Paraxial aberration
- **D**) Focal aberration
- **E)** Principle axis aberration
- **94.** Technological advances like the Hubble Telescope are essential to understanding the world around us. In biology, scientists have perfected the microscopes in order to study living organisms more thoroughly. Which of the following statement (s) are correct about the electron microscope?

I. Resolution is inversely related to the wavelength of the radiation.

- II. Electron beams have wavelengths much shorter than the wavelengths of visible light.
- III. Electron microscopes are approximately 100 times more sophisticated than a light microscope
- IV. Electron microscopes focuses on a beam of electrons through the specimen.
- A) I only
- **B)** IV only
- C) II & IV
- **D)** I,II,III
- E) I,II, III, IV
- **95.** Besides visible light, Hubble can "see" in the near infrared (IR) region of the spectrum. Why is this an important part of the spectrum to chemists?
  - A) Water becomes opaque when measured in IR.
  - **B)** IR energy is released when a C-H bond is broken.
  - C) IR spectra will show the 3D structures of pure crystals.
  - D) Absorbed IR energy changes the rotational-vibrational motion of molecules.
  - E) IR spectra of a star can indicate the type of fusion reaction taking place in the core.
- **96.** Interstellar and circumstellar molecules have been detected in space by various kinds of spectroscopy. What molecule has NOT yet been detected?
  - A)  $H_2O$ , water
  - **B)** N<sub>2</sub>O, nitrous oxide
  - **C)** SiC<sub>3</sub>, silicon tricarbide
  - **D)**  $H_2SO_4$ , sulfuric acid
  - E) CH<sub>3</sub>CH<sub>2</sub>OH, ethyl alcohol

- 97. What important discovery has the HST has been invaluable in determining?
  - A) The exact distance of the orbit of the earth.
  - **B)** A more accurate age of our sun.
  - C) A more precise determination of the Hubble constant.
  - D) The most accurate measure of the speed of light in a vacuum.
  - E) The best determination of absolute zero.
- **98.** In March 2015, researchers using the HST announced that measurements of aurorae around Ganymede, the largest moon of Jupiter, revealed a subsurface ocean. What do they think is the composition of this ocean?
  - A) saltwater
  - **B**) hydrogen
  - C) molten iron
  - **D**) methane
  - E) ammonia
- **99.** Astrobiologists look for worlds suitable for life to exist. A primary compound that they search for on such worlds is
  - A) water.
  - **B)** oxygen gas.
  - C) methane.
  - D) carbon dioxide.
  - E) DNA.
- **100.** Science fiction writers dreamed of these far away universes, where life might have evolved. A popular theme was life forms based on the element
  - A) carbon.
  - B) oxygen.
  - **C)** sulfur.
  - **D**) silicon.
  - E) helium.

End of test