



The 62nd Annual Merck State Science Day Competition May 22, 2012

ADVANCED INTEGRATED SCIENCE

Directions:

PLEASE DO NOT OPEN THE EXAM BOOKLET UNTIL DIRECTED.

Be sure to fill in your name on the answer sheet both by printing it in the correct space and by filling in the corresponding letter in the spaces provided.

Use a #2 pencil only.

Carefully erase any errors, and do not make any extraneous marks on the answer sheet. Do NOT use *White-Out* on any portion of the answer sheet.

The test has **90 items** that will be scored. You have **90** 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. (There is no penalty for guessing.)

In addition to the periodic table, there are several subject-specific items below that you may find useful in answering certain questions. Be sure to read them immediately after you are told to begin. You may refer to them at any time during the test.

INFORMATION THAT MAY BE USEFUL IN SOLVING SOME PROBLEMS

$$1 \text{ calorie} = 4.184 \text{ joules}$$

$$1/f = 1/d_o + 1/d_i$$

$$C = 2f$$

$$h_i/h_o = d_i/d_o$$

$$E = hf$$

$$\text{speed of light in vacuum} = 3.0 \times 10^8 \text{ m/sec}$$

$$\text{Planck's constant, } h = 6.63 \times 10^{-34} \text{ joule-sec}$$

$$v = c \sqrt{1 - v^2/c^2}$$

$$\text{Avogadro's Number} = 6.02 \times 10^{23}$$

$$Q = mc\Delta T$$

$$KE_{\text{ave}} = 1/2mv^2$$

$$PE_{\text{grav}} = mgh$$

$$W = F \times S$$

$$W = Vq$$

$$v_{\text{avg}} = s/t$$

$$s = v_o t + 1/2at^2$$

$$v_f^2 = v_i^2 + 2as$$

$$v_f = v_i + at$$

$$c = f\lambda$$

$$P_1V_1/T_1 = P_2V_2/T_2$$

$$I = V/R$$

$$1 \text{ C} = 6.25 \times 10^{18} \text{ e}^-$$

$$D = M/V$$

$$v = f\lambda$$

$$P = W/t$$

$$K_f \text{ water} = -1.86 \text{ }^\circ\text{C/m}$$

$$K_b \text{ water} = 0.51 \text{ }^\circ\text{C/m}$$

$$\text{Universal gas constant: } R = 8.31 \text{ kPa-liter}/(\text{mole-K}) = 0.0821 \text{ atm-liter}/(\text{mole-K})$$

Periodic Table of the Elements

1 H 1.00794																1 H 1.00794	2 He 4.002602
3 Li 6.941	4 Be 9.012182											5 B 10.811	6 C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797
11 Na 22.989770	12 Mg 24.3050											13 Al 26.981538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6934	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29
55 Cs 132.90545	56 Ba 137.327	57 La 138.9055	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.96655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.98038	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)		114 (289) (287)		116 (289)		118 (293)

58 Ce 140.116	59 Pr 140.90765	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.26	69 Tm 168.93421	70 Yb 173.04	71 Lu 174.967
90 Th 232.0381	91 Pa 231.03588	92 U 238.0289	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

S.E. Van Bramer, 7/22/99

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>

114 from C&EN July 19, 1999

116 and 118 from <http://www.lbl.gov/Science-Articles/Archive/elements-116-118.html>

Multiple Choice

Identify the letter of the choice that best completes the statement or answers the question and place your selection ON THE ANSWER SHEET.

I. ARCTIC

"A large hole [has] appeared in the [Arctic] ozone layer, far bigger than any seen there before.

The Arctic ozone layer suffers a [little damage every winter](#), but the effect is normally short-lived. "This is a clear step beyond that," says [Neil Harris](#) of the University of Cambridge. As the measurements came in, ozone researchers began to debate whether the loss could be compared to that seen over the Antarctic. "It's the first time we've even discussed that question," says Harris.

Between 18 and 20 kilometres up, over 80 per cent of the existing ozone was destroyed. "The loss in 2011 was twice that in the two previous record-setting Arctic winters, 1996 and 2005," says [Nathaniel Livesey](#) of the Jet Propulsion Laboratory in Pasadena, California.

The hole was similar in size to those seen in [Antarctica in the 1980s](#). The Antarctic hole has continued to grow since then, and is [far larger today](#)."

quoted from <http://www.newscientist.com/article/dn20988-arctic-ozone-hole-breaks-all-records.html>

- The Antarctic ozone hole appears in _____ and the Arctic ozone hole appeared in _____.
 - October ... January
 - October ... June
 - October ... October
 - January ... October
 - January ... June
- The most likely cause of the Arctic ozone hole is
 - continued use of CFC's.
 - acid deposition.
 - climate change.
 - habitat destruction.
 - incineration of plastics.
- Ozone is _____ in the troposphere and _____ in the stratosphere.
 - helpful ... helpful
 - helpful ... harmful
 - harmful ... harmful
 - harmful ... helpful
 - helpful ... neutral
- The reason for the answer to **the previous question** is:
 - ozone has different valences in the troposphere than in the stratosphere.
 - ozone has a different molecular formula in the troposphere than in the stratosphere.
 - ozone has different reactivity in lesser oxygen concentrations.
 - ozone is highly reactive in both the troposphere and the stratosphere.
 - ozone is only formed naturally in the troposphere.

5. Conditions for the formation of an ozone hole include
- I. *very cold temperatures*
 - II. *high atmospheric pressure*
 - III. *high altitude clouds*
 - IV. *high water vapor*
 - V. *halogen containing compounds*
- A) only two of the above
B) I, II and III only
C) I, III, and V only
D) I, III, IV and V only
E) all of the above
6. Ground-level ozone is formed as a secondary pollutant in
- A) acid deposition.
B) photochemical smog.
C) industrial smog.
D) climate change.
E) pesticide development.
7. Stratospheric ozone in normal concentrations causes
- A) fewer UV rays to strike the surface of the earth.
B) a reduction in photosynthesis.
C) warming of the Antarctic ice mass.
D) an increase in the greenhouse effect.
E) a cooling of the stratosphere.
8. Which of the following cannot result from the absorption of radiant energy by ozone molecules?
- A) increased vibrational kinetic energy
B) intermolecular bond formation
C) increased angular momentum
D) decreased ozone concentration
E) temporary electronic excitation
9. Ozone can be formed naturally from lightning, which is
- A) plasma capacitance of air.
B) static charge in air.
C) electromagnetic induction through air.
D) dielectric breakdown of air.
E) Coriolis attraction in air.
10. UV rays are dangerous to your health because they
- A) have long wavelengths
B) have large amplitudes
C) are invisible to the naked eye
D) have high frequencies
E) travel at the speed of light
11. An intact ozone layer in the earth's atmosphere is about as thick as
- A) oxide coating on aluminum
B) a piece of paper
C) the diameter of a redwood tree
D) the Empire State Building's height
E) the troposphere

12. The chemical formula for ozone is
- A) O
 - B) O₂
 - C) O₃
 - D) CO
 - E) because it is a mixture, it doesn't have a chemical formula

II. ARSENIC

Dartmouth College researchers reported in early 2012 that many products containing organic brown rice syrup were also contaminated by high levels of arsenic. The arsenic levels in the organic products exceeded the maximum arsenic levels (10 ppb) allowed in bottled water in the U.S. Arsenic is toxic in high doses, targeting the liver, skin, kidney and cardiovascular system.

13. Brown rice syrup would be used in “organic” foods to replace
- A) cane sugar.
 - B) beet sugar.
 - C) artificial sweeteners.
 - D) high fructose corn syrup.
 - E) sucrose.
14. Arsenic contamination of drinking water could come from:
- I. *drilling wells into soils with natural arsenic.*
 - II. *deposition of fumes from coal-burning.*
 - III. *run-off from orchards and farmlands.*
 - IV. *run-off from mining and smelting processes.*
 - V. *leaching from application of commercial fertilizers.*
- A) only one of the above.
 - B) only two of the above.
 - C) only three of the above.
 - D) only four of the above.
 - E) all of the above.
15. Arsenic was used as a subtle murder weapon in the Renaissance because its effects mimicked a common disease at the time. That disease was
- A) tuberculosis.
 - B) pneumonia.
 - C) cholera.
 - D) rabies.
 - E) skin cancer.
16. One reason for arsenic toxicity is its allosteric inhibition of the enzyme pyruvate dehydrogenase. This inhibition would first result in
- A) decreased cellular energy levels.
 - B) decreased DNA replication.
 - C) increased ATP production.
 - D) increased nerve stimulation.
 - E) increased DNA replication.

17. Arsenic is chemically similar to phosphorus. Thus, arsenic is stored in
- A) bones
 - B) fat
 - C) blood
 - D) lymph
 - E) urine
18. Another mechanism of arsenic toxicity is its inhibition of voltage-gated potassium channels. This mechanism would most directly affect
- I. *the nervous system.*
 - II. *cardiac function.*
 - III. *epidermal tissues.*
 - IV. *smooth muscles.*
- A) only one of the above
 - B) only I and II.
 - C) only II and III.
 - D) only II and IV.
 - E) only III and IV.
19. An alternate description of the 10 ppb limit of arsenic in drinking water is:
- A) 10 mg/mL
 - B) 10 $\mu\text{g/mL}$
 - C) 10 $\mu\text{g/L}$
 - D) 10 $\mu\text{g/m}^3$
 - E) 10 ng/m^3
20. A productive use of arsenic is in the compound gallium arsenide. This is most commonly used in which of the following applications?
- A) medical implants
 - B) agricultural fertilizer
 - C) antiviral treatments
 - D) solar cells
 - E) polymer stabilization
21. There are three common *allotropes* of arsenic. How do they differ from one another?
- I. their colors
 - II. their densities
 - III. number of neutrons
 - IV. crystalline structure
- A) only II
 - B) only IV
 - C) II & IV only
 - D) I, II, and IV only
 - E) all 4
22. Gallium arsenide is used in some electronic devices because it is
- A) a nonmetal.
 - B) a metal.
 - C) a metalloid.
 - D) cheaper to produce than silicon.
 - E) easy to recycle.

23. When heated, arsenic sublimates. What is the only other element that does this?
- phosphorus
 - sulfur
 - mercury
 - iodine
 - thallium
24. In 1836 chemist James Marsh first published his highly sensitive method of arsenic detection. Arsenic trioxide had become the favored poison for some killers (“inheritance powder”) because it was odorless, easily incorporated in food or drink, and the poisoning symptoms mimicked that of an endemic disease. In the Marsh Test, tissue from a suspected victim is treated with zinc and sulfuric acid, this produces an arsenic compound in the 3- oxidation state. Which would be the formula for this compound?
- As_2S_3
 - AsH_3
 - AsZnO_3
 - $\text{Zn}(\text{As}_2\text{O}_3)_2$
 - H_3AsO_4
25. Modern methods of forensic detection of arsenic use:
- atomic absorption spectroscopy (AA)
 - X-ray fluorescence spectroscopy
 - nuclear magnetic resonance (NMR)
 - scanning tunneling microscopy (STM)
- I and II only
 - II and III only
 - I and IV only
 - I, III, and IV only
 - all 4

III. BOSON

In December 2011, physicists at CERN announced evidence suggesting possible discovery of the Higgs boson with a mass between 115 GeV and 127 GeV.

26. The existence of the Higgs boson is needed to confirm what theory?
- standard model
 - big bang
 - periodic table
 - nebular hypothesis
 - Cooper pair superconductivity
27. If the Higgs boson has a mass of 127 GeV, its mass in amu can be determined by which of the following calculations? (c = speed of light in vacuum, e = charge of an electron, h = Planck’s constant, N_A = Avogadro’s number)
- $127 * 10^{12} \text{ e}N_A/c^2$
 - $127 * 10^9 \text{ h}N_A/ec^2$
 - $127 * 10^9 \text{ ec}^2/N_A$
 - $127 * 10^{12} \text{ eh}N_A^2/c^2$
 - $127 * 10^9 \text{ N}_A/hc^2$

28. The Higgs boson is believed to explain the existence of mass, particularly why some particles have mass and others do not. Which of the following has *no* mass?
- A) proton
 - B) electron
 - C) photon
 - D) neutrino
 - E) two of the above
29. The Large Hadron Collider at CERN uses alternating magnets to accelerate charged particles. Which of the following *cannot* be accelerated in this type of collider?
- A) proton
 - B) alpha particle
 - C) positron
 - D) antiproton
 - E) neutron
30. The Higgs boson is often referred to as "the God particle" by the media, but many scientists dislike the term. A renaming competition was held, which term was chosen to replace it?
- A) the inclusive recluse
 - B) the champagne bottle boson
 - C) the strange particle
 - D) the groschen boson
 - E) the cardinal particle
31. Even after the confirmation of the Higgs boson, what will still be unanswered about the nature of matter?
- I. the unification of Quantum chromodynamics
 - II. the electroweak interaction and gravity
 - III. the ultimate origin of the universe
 - IV. the evolution of chronotrons and the directional arrow of time
- A) I only
 - B) III only
 - C) I & II only
 - D) I, II, & III only
 - E) all 4
32. Bosons are one of two fundamental classes of subatomic particles. What is the other class?
- A) fermions
 - B) gluons
 - C) mesons
 - D) photons
 - E) baryons
33. The Higgs boson is expected to
- I. have spin
 - II. have an electric charge
 - III. have a color charge
 - IV obey Bose–Einstein statistics
- A) IV only
 - B) I & II only
 - C) I & III only
 - D) II & III only
 - E) all 4

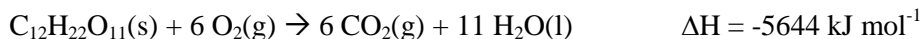
34. Which are not hadrons?
A) protons and neutrons
B) baryons and mesons
C) pions and kaons
D) leptons and photons
E) charmed bottom Omega and quarks
35. Biologists are slightly jealous of the public interest in the search for the Higgs Boson particle. They believe that a particular discovery would serve to incite the same degree of passion for biology. Which of the following is the discovery that would be thought of as the biological equivalent of the Higgs Boson?
A) A confirmed sighting of the Loch Ness monster.
B) A confirmed finding of life on another planet.
C) A successful creation of a formerly extinct dinosaur.
D) The discovery of a new type of primate.
E) The discovery of the cure for cancer.

IV. COTTON CANDY

In a cotton candy machine, sugar crystals are melted by a 900 W heating element inside a cylindrical “spinner head” with a 20-cm diameter. The spinner head rotates at 3450 rpm, and molten sugar leaves the spinner head through small holes with 50- μ m diameter. After leaving the spinner head, the sugar cools quickly to form the amorphous solid floss known as cotton candy.

36. Before leaving the spinner head, the speed of the molten sugar is most nearly
A) 6 m/s
B) 12 m/s
C) 24 m/s
D) 36 m/s
E) 72 m/s
37. How much current does the heating element draw when connected to a standard household circuit?
A) 0.016 A
B) 0.062 A
C) 0.25 A
D) 3.75 A
E) 7.5 A
38. The cooling of molten sugar to form cotton candy is most similar to the formation of which rock?
A) basalt
B) obsidian
C) granite
D) gneiss
E) slate
39. Which of the following is responsible for an outward force on the molten sugar?
A) hydrostatic pressure
B) gravity
C) the rotation of the spinner head
D) convection from the heating element
E) none of these

40. A typical serving of cotton candy has a mass of about 28 grams. Which of the following is closest to the order of magnitude of the total length of floss in that serving?
- 10^2 m
 - 10^4 m
 - 10^6 m
 - 10^8 m
 - 10^{10} m
41. Cane sugar is a disaccharide that is composed of two monosaccharides held together by an ester linkage. What monosaccharides compose this sugar?
- 2 glucoses
 - 2 fructoses
 - glucose and fructose
 - glucose and galactose
 - fructose and galactose
42. Sucrose forms a monoclinic crystal. What is characteristic of this type of crystal?
- square base adjacent to a 90° side
 - parallelogram base adjacent to a 90° side
 - hexagonal base adjacent to a 90° side
 - parallelogram base adjacent to a non- 90° side
 - square base adjacent to a non- 90° side
43. A dramatic demonstration of the energy contained in sugar is done by heating it with potassium chlorate. Which expression would best represent this reaction?
- $C_{12}H_{22}O_{11} + KClO_3 \rightarrow KCl + CO_2 + H_2O$
 - $C_{12}H_{22}O_{11} + KClO_3 \rightarrow KCl + CO_2 + HClO_3$
 - $C_{12}H_{22}O_{11} + KClO_3 \rightarrow KOH + CCl_4 + H_2O$
 - $C_{12}H_{22}O_{11} + KClO_3 \rightarrow C + H_2 + O_2 + K + Cl_2$
 - $C_{12}H_{22}O_{11} + KClO_3 \rightarrow K_2CO_3 + HCl + CH_4 + CO_2$
44. Considering a serving of 28 grams of cotton candy, what is the caloric content (food Calories) of this amount? *1 food Calorie (Cal) = 1 kcal, 1 cal = 4.18 J*



- 7.1 Cal
- 38 Cal
- 48 Cal
- 110 Cal
- 1930 Cal.

45. **Eliminated** Consider the complete combustion of sucrose (at 25°C),

Compound	$\Delta S^\circ, \text{J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$
$\text{C}_{12}\text{H}_{22}\text{O}_{11}(\text{s})$	392
$\text{CO}_2(\text{g})$	213
$\text{H}_2\text{O}(\text{g})$	69.9
$\text{O}_2(\text{g})$	—

_____ What is the ΔG° for this reaction?

- A) -1655
B) 109.1
C) 488 kJ
D) 5160
E) -35700
46. Sugars are produced using products from
I. photosystem I
II. photosystem II
III. substrate level phosphorylation
IV. Krebs cycle
V. Calvin cycle
A) only two of the above
B) I, II, and III only
C) II, III, and IV only
D) I, II, and V only
E) I, II, III, and IV only
47. Overconsumption of sugars has been linked to
I. bulimia
II. diabetes
III. cancer
A) only one of the above
B) I and II only
C) II and III only
D) I and III only
E) all of the above
48. Dieters attempt to lose weight by eating food with low calorie sugar substitutes. Which of the following is NOT a sugar substitute?
A) casein
B) aspartame
C) sucralose
D) saccharine
E) stevia
49. Sucrose is a disaccharide. Which of the following is NOT also a disaccharide?
A) maltose
B) ribose
C) lactose
D) trehalose
E) all of the above ARE disaccharides

50. Sugar is detected by G protein receptors located on the plasma membrane of taste receptor cells. G protein receptors generally use _____ as their second messenger.
- A) GTP
 - B) GDP
 - C) Ca⁺⁺
 - D) cAMP
 - E) Ras

V. FOREST

Scientists studied two remote tropical forests to determine what effects nitrogen pollution was having on the tropical trees. They compared dried leaf specimens from 1968 with specimens from 2007. An increase in both leaf nitrogen concentration and proportion of heavy to light nitrogen isotopes was observed. A similar increase was observed when fertilizer was experimentally applied to the forest floor. Adapted from Science Daily (Nov. 3, 2011).

51. The increase in leaf nitrogen in the remote forests can most likely be attributed to
- A) effects of agriculture.
 - B) burning of fossil fuels.
 - C) nitrogen fixation.
 - D) global climate change.
 - E) ozone depletion.
52. Most of the nitrogen in forest soil normally comes from
- A) bacteria which carry out nitrogen fixation.
 - B) bacteria which carry out denitrification.
 - C) fungi which carry out ammonification.
 - D) weathering of nitrate containing rocks.
 - E) diffusion from atmospheric nitrogen compounds.
53. Most of the nitrogen in the world is found as _____ in the _____.
- A) N₂ ... atmosphere
 - B) NO₂ ... atmosphere
 - C) NH₃ ... soil
 - D) NH₃ ... water
 - E) NO_x ... minerals
54. The most significant reason for loss of N in the soil is
- A) acid rain.
 - B) use of inorganic fertilizers.
 - C) decomposition.
 - D) habitat destruction
 - E) leaching.
55. The scientists predicted that trees in the Fabaceae group could be negatively impacted by this increase in soil nitrogen because
- A) they are harmed by excess amounts of nitrogen
 - B) they are sensitive to changes in soil pH.
 - C) they lose their competitive advantage as nitrogen fixers.
 - D) they will show increased mutations due to the heavier nitrogen.
 - E) their growth rate will slow as global temperatures increase.

56. Nitrogen is one of the most important components of fertilizer. The other two major components are
- A) K and Ca
 - B) C and K
 - C) P and Ca
 - D) S and P
 - E) K and P
57. The stability of molecular nitrogen can be attributed to its
- A) low center of gravity.
 - B) electron spin coupling.
 - C) gravitational attraction to Earth's surface.
 - D) equal numbers of protons and neutrons.
 - E) low electronic potential energy.
58. In order to detect the presence of different nitrogen isotopes, a mass spectrometer is used. This device depends on
- A) fractional distillation, in which lighter isotopes evaporate at lower temperatures.
 - B) magnetic fields, which cause lighter particles to curve more sharply.
 - C) absorption of photons, whose energies are dependent on the energy levels of the nitrogen
 - D) diffraction of electrons, whose wavelength is determined by the mass of the emitting nucleus.
 - E) gravitational attraction, which is greater for heavier isotopes.
59. The molecule N_2 contains
- A) 1 shared pair of electrons, 6 unshared electrons
 - B) 2 shared pairs of electrons, 4 unshared electrons
 - C) 3 shared pairs of electrons, 3 unshared electrons
 - D) 3 shared pairs of electrons, 2 unshared pairs of electrons
 - E) 4 shared pairs of electrons, no unshared pairs of electrons
60. In 1919, Fritz Haber received the Nobel Prize in Chemistry for his process of converting atmospheric nitrogen and hydrogen into ammonia. The balanced equation for this process is
- A) $N + 3 H \rightarrow NH_3$
 - B) $2N + 3 H_2 \rightarrow 2NH_3$
 - C) $N_2 + 4H_2 \rightarrow 2NH_4$
 - D) $N_2 + 3 H_2 \rightarrow N_2H_6$
 - E) $N_2 + 3H_2 \rightarrow 2NH_3$
61. An isotope of nitrogen is ^{15}N . It contains
- A) 7 protons, 8 electrons
 - B) 7 protons, 8 neutrons
 - C) 8 protons, 7 electrons
 - D) 8 protons, 7 neutrons
 - E) 8 neutrons, 7 electrons

VI. IFITM3

Paul Kellam of the Sanger Institute reported in *Nature* (March 2012) evidence linking a gene mutation with increased susceptibility to the 2009 pandemic flu virus. Kellam's group bred mice lacking a working version of IFITM3 (Interferon Inducible Transmembrane) and then exposed the knock-out mice to a low virulence form of the flu virus. The mice became deathly ill with severe pneumonia. Next, the scientists examined the genes of people hospitalized for severe flu infection. The hospitalized population was 17 times more likely than the general European population to carry the mutant allele for IFITM3. Finally, an *in vitro* cell study showed that cells with the mutant allele had poor defenses against H1N1 viruses.

62. The researchers discovered that the IFITM3 mutant allele had CC instead of TT at the normal splicer acceptor site. This mutation would most likely lead to
- I. a change in alternate RNA splicing
 - II. a difference in the length of the final protein product
 - III. an early stop codon
 - IV. an inability for RNA polymerase to bind to the gene
- A) only one of the above
B) I and II only
C) II and III only
D) III and IV only
E) all of the above
63. The designation “interferon inducible” means that this gene is normally part of
- A) innate immunity.
 - B) the complement system.
 - C) acquired immunity.
 - D) antibody recognition.
 - E) the inflammatory response.
64. The “H1N1” name refers to
- I. the type of protein a virus uses to attach to host cells
 - II. the type of enzyme used to release new virus particles from infected cells
 - III. the type of genetic material carried in the virus.
- A) only one of the above
B) I and II only
C) II and III only
D) I and III only
E) all of the above
65. The most infamous H1N1 virus is
- A) rabies.
 - B) measles.
 - C) herpes.
 - D) Spanish flu.
 - E) polio
66. An important difference between animal viruses like H1N1 and bacteriophages is that animal viruses
- A) carry DNA rather than the RNA of bacteriophages.
 - B) are host-specific; bacteriophages are not.
 - C) often have a membranous covering; bacteriophages do not.
 - D) undergo a lysogenic cycle; bacteriophages rarely do.
 - E) contain fewer viral genes than bacteriophages contain.

67. Interferon as well as many proteins contain 1 or more alpha (α) helix structures. These structures can be denatured by:

I	increased temperature
II	freezing
III	pH changes
IV	dilution in water

- A) only I
B) II and III
C) I and III
D) I, III, and IV
E) all of the above
68. Proteins are chains of amino acids. The term *amino-* refers to
A) nitrogen containing
B) hydrogen containing
C) organic base $-NH_2$
D) cyclic compound
E) organic acid, $-COOH$
69. What is a difference between the base pairs of cytosine (C) and thymine (T) in a DNA molecule?
A) Thymine has more stable resonance structures than cytosine.
B) Cytosine has additional amine to create a more alkaline environment.
C) Thymine has additional oxygen which makes a stronger oxidizing agent.
D) Cytosine creates a stronger ionic bond to the substrate molecule in the active site.
E) Cytosine has 3 hydrogen bonds in its base pairing to guanine (G) while T makes only 2 hydrogen bonds to adenosine (A).

VII. POLLUTION

What humans are doing to the atmosphere appears to be leading to climate change and in a direction that could destroy much of what we have created. The water of the planet is also of concern: we often pollute it and we need to purify it. Nature can supply water in abundance as rain, rivers, and lakes but not necessarily where it is most needed. As the world's population increases, many more people will find themselves having to rely on seawater for their supply of freshwater. Through chemistry, we can make it drinkable.

If we are to understand atmospheric pollution and its effects on climate, and to understand water supplies and the need to make them drinkable, then we need to understand the science that is involved.

70. One of the "greenhouse gases" in the atmosphere is carbon dioxide. The amount of CO_2 in the atmosphere has increased dramatically in the last two centuries. What is the primary source of this increase?
A) volcanic eruptions
B) exhaled from humans
C) melting of polar ice caps
D) burning of fossil fuels (coal, oil, gasoline, etc.)
E) increase in the number of cattle and their waste (manure)
71. Another atmospheric pollutant is mixed oxides of nitrogen (NO_x). What is the primary source of these compounds in the atmosphere?
A) lightning
B) volcanoes
C) burning of fossil fuels
D) nitrogen fixation by plants
E) lost into the air during the production of ammonia
72. What method is generally used to convert seawater into drinkable water (desalination)?
A) distillation
B) reverse osmosis
C) precipitation of salt
D) fractional crystallization
E) treatment with ozone (O_3)

73. The commercial source of magnesium metal is seawater. Treatment of seawater with lime water produces insoluble magnesium hydroxide, which is then treated with hydrochloric acid to make MgCl_2 . Mg is obtained by electrolysis of the dried MgCl_2 . What volume of seawater is necessary to make 100. g of Mg if the concentration in seawater is 52 millimol/L?
- A) 79 mL
B) 1.92 L
C) 79 L
D) 1920 L
E) 214000 L
74. What is the third most common atmospheric gas in air after nitrogen and oxygen? [Water vapor varies greatly from place to place, and time to time, and, therefore, is not considered an atmospheric gas.]
- A) helium
B) hydrogen
C) carbon dioxide
D) argon
E) ozone
75. Which of the following is **NOT** a greenhouse gas?
- A) CFCs
B) SO_2
C) H_2O
D) CH_4
E) NO_2
76. Effects of NO_x in the atmosphere include
- I. acid deposition.*
II. ozone hole depletion.
III. industrial smog.
IV. photochemical smog.
- A) only one of the above
B) I and II only
C) I and III only
D) I and IV only
E) all of the above
77. Earth might have been better named “Oceania” because so much of the surface is covered with water, not land. Approximately what percent of Earth’s water is fresh water?
- A) 35%
B) 25%
C) 10%
D) 3%
E) 0.2%
78. Most of that freshwater is found in
- A) lakes
B) rivers
C) groundwater
D) glaciers and ice caps
E) clouds
79. The unique properties of water are important for all of the following biological phenomena EXCEPT:
- A) movement of substances in phloem.
B) movement of substances in xylem.
C) nerve signal propagation.
D) cell membrane structure.
E) temperature homeostasis.

MULTIPLE CHOICE

- 1. A
- 2. C
- 3. D
- 4. D
- 5. C
- 6. B
- 7. A
- 8. B
- 9. D
- 10. D
- 11. B
- 12. C
- 13. D
- 14. E
- 15. C
- 16. A
- 17. A
- 18. B
- 19. C
- 20. D
- 21. D
- 22. C
- 23. D
- 24. B
- 25. A
- 26. A
- 27. A
- 28. C
- 29. E
- 30. B
- 31. D
- 32. A
- 33. A
- 34. D
- 35. B
- 36. D
- 37. E
- 38. B
- 39. A
- 40. B

- 41. A
- 42. D
- 43. B A
- 44. D
- 45. ~~C~~ Eliminate
- 46. D
- 47. C
- 48. A
- 49. B
- 50. D
- 51. B
- 52. A
- 53. A
- 54. E
- 55. C
- 56. E
- 57. E
- 58. B
- 59. D
- 60. E
- 61. B
- 62. B
- 63. A
- 64. B
- 65. D
- 66. C
- 67. C
- 68. C
- 69. E
- 70. D
- 71. C
- 72. B
- 73. ~~C~~ D
- 74. D
- 75. B
- 76. C
- 77. D
- 78. D
- 79. C
- 80. A

- 81. B
- 82. A C
- 83. A
- 84. C
- 85. C
- 86. B
- 87. A
- 88. D
- 89. C
- 90. B