

The 61st Annual Merck State Science Day Competition May 17, 2011

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 calorie = 4.184 joules $1/f = 1/d_o + 1/d_1$ C = 2f $h_i/h_o = d_i/d_o$ E = hf speed of light in vacuum = 3.0×10^8 m/sec Planck's constant, $h = 6.63 \times 10^{-34}$ joule-sec $v = c \sqrt{1 - v^2/c^2}$ Avogadro's Number = 6.02×10^{23} Q = $mc\Delta T$ KE_{ave} = $1/2mv^2$ PE_{grav} = mgh W = $F \times S$

W = Vq $v_{avg} = s/t$ $s = v_o t + 1/2at^2$ $v_f^2 = v_i^2 + 2as$ $v_f = v_i + at$ $c = f\lambda$ $P_1V_1/T_1 = P_2V_2/T_2$ I = V/R1 C = 6.25 X 10¹⁸ e⁻¹ D = M/V $v = f \lambda$ P = W/t K_f water = -1.86 °C/m K_h water = 0.51°C/m

Universal gas constant: R = 8.31 kPa-liter/(mole-K) = 0.0821 atm-liter/(mole-K)

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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. BONE CANCER

When breast cancer cells migrate to bone tissue, the cancer is generally fatal. Researchers have discovered that a protein called transforming growth factor beta (TGF-B) is involved in this process. The protein stops cells in the G1 stage and promotes differentiation and apoptosis. TGF-B can also convert effector T-cells into suppressor T-cells.

- 1. The type of cell signaling described here is
 - A) synaptic.

D) inflammatory.

B) paracrine.

E) neuromodulatory.

- C) endocrine.
- 2. If a cancerous cell mutates so that it can no longer receive the TGF-B signal, then
 - A) the cells would proliferate.
 - **B)** the cells would delf-destruct.
 - C) the cells would synthesize their DNA.
 - **D)** the cells would migrate to other sites.
 - E) the cells would attack neighboring cells.
- **3.** The effect of TGF-B on T cells would cause
 - A) an increase in the inflammatory response.
 - **B)** an increase in the cell-mediated response.
 - C) a decrease in the inflammatory response.
 - **D)** a decrease in the cell-mediated response.
 - E) an increase in both the inflammatory and cell-mediated response.
- 4. The action of TGF-B on the normal cell is similar to a
 - A) tumor-promoter gene.
 - **B)** tumor-supressor gene.
 - C) both a tumor-promoter and a tumor-supressor gene.
 - **D)** neither a tumor-promoter nor tumor-supresson gene.
 - E) it cannot be determined from the information given.
- 5. The most obvious next step for researchers is to find ways to
 - A) block cell receptors for TGF-B.
 - **B)** increase cell production of TGF-B.
 - C) mutate TGF-B genes in animal models.
 - **D)** mimic the action of TGF-B on bone cells.
 - E) remove the suppressor T cells from the bone tissue.
- **6.** TGF-B is a protein that is chain of 380 amino acids. What kind of bond connects these amino acids together?

A) ionic

D) peptide

B) ester

E) ether linkage

- C) hydrogen
- 7. An amino acids consists of which functional groups?
 - **A)** -N and -H

D) -NO₂ and -COOH

B) -NH and -OH

E) -NH₂ and -COOH

C) -NH₃ and -OH

- **8.** Cis-platin is a compound used in chemotherapy for some kinds of cancer. It consists of hydrogen, 2.02%, nitrogen, 9.34%, chlorine, 23.6%, and platinum, 65.0%. What is the formula of this compound?
 - **A)** Pt₆₅Cl₂₄H₂N₉

D) (PH)₆(NCl)₂

 $\textbf{B)} \quad Pt_{32}Cl_{12}HN_5$

E) $PtCl_2(NH_3)_2$

- C) $Pt_3H_7(NCl)_5$
- 9. Amino acids can act as cellular fluid buffers. This means that the
 - A) amino group neutralizes bases, and the carboxalate neutralizes acids
 - **B)** amino group neutralizes acids, and the carboxalate neutralizes bases
 - C) lowers the activation energy in the Kreb's Cycle
 - **D)** acts as an intermediate in an enzymatic system
 - E) amino acid is a zwitterion

II. DIAMONDS

Diamonds have been revered for their beauty and rarity for centuries. From myths about valleys of diamonds protected by snakes, to the production of millions of carats in rough diamonds each year, the history of diamonds is one of mystical power, beauty and commercial expertise. The first recorded history of the diamond dates back some 3,000 years to India, where it is likely that diamonds were first valued for their ability to refract light. In those days, the diamond was used in two ways-for decorative purposes, and as a talisman to ward off evil or provide protection in battle. In modern times it has inspired countless songs, novel, movies, and, unfortunately, wars.

- **10.** What type of bonding is found in diamonds?
 - **A)** *sp*

D) sp^4

B) sp^2

E) ionic

- C) sp^3
- 11. Natural diamonds are formed under what conditions?
 - **A)** low temperature, low pressure
 - **B)** low temperature, high pressure
 - C) high temperature, low pressure
 - **D)** high temperature, high pressure
 - E) high velocity impacts by meteorites on the earth's surface
- **12.** What are the two conductive properties of diamonds?

I. electrical insulator

II. electrical conductor

III. thermal insulator

IV. thermal conductor

- **A)** I & III
- **B)** I & IV
- C) II & III
- **D)** II & IV
- E) varies depending on the size of the diamond
- 13. Natural color in diamonds is due to:
 - A) impurities of iron, copper, and nickel.
 - **B)** impurities of nitrogen, hydrogen, or boron.
 - C) voids created by cationic anionic interactions.
 - **D)** structural stresses created in cutting them to shape.
 - E) irradiation by uranium atoms trapped in the crystal structure.

14.	 Diamonds are commonly mined via open-pit mines. Which of the following is N environmental impact of open-pit mines? A) lowering of water table B) acid mine drainage C) habitat destruction D) ground subsidence E) tailings piles 	OT a common negative
15.	 Which of the following would be the most likely formation in which to find diam A) Volcanic plumes B) Sedimentary rock C) Metamorphic rock E) Shallow lake bottoms 	onds?
16.	 16. When light from the air enters a diamond at an angle of less than 90° to the normal A) is equal to the angle of incidence. B) is less than the angle of incidence. C) is greater than the angle of incidence. D) can be less or greater than the angle of incidence depending upon the size. E) can be less or greater than the angle of incidence depending upon the number. 	
17.	 When compared to cubic zirconium (a synthetic gemstone resembling diamond) I. diamonds are harder II. diamonds have greater refractive index III. diamonds are denser 	
	 A) I only B) II only C) III only D) I and II only E) I, II and III 	
	Hydroelectric Pumped Storage is a way to store water at an elevation so it can times of larger than ordinary demand. Water is pumped from a lower elevation during times of less than average demand, times when electric supply grids have through a generator to the lower reservoir during times when there is an absence gry. The method allows electric grid operators to compensate for the variabil and season. Of the electric power delivered in the United States about 2.5 percentage almost all of which is pumped storage. In the United States the equipment and pump in one direction of rotation and as a turbine and generator in operators.	n reservoir to an upper reservoir we surplus capacity. It flows back ove average demand for electric lity in demand throughout the day not of it goes through some form of ment is designed to function as a
	The Yard's Creek Pumped Storage Facility located in Blairstown, NJ has a capacity. The upper reservoir holds approximately 6.2×10^6 m ³ of water. Mo about 250 m ³ /s. It flows through a 549 m long pipe which is 0.457 m in diameter per m ³ .	aximum flow rate of the water is
18.	18. The storage of energy by the pumped storage method is in a form.	
	A) nuclear B) Martinized C) kinetic energy D) chemical energy E) potential energy	

19.	The pumped storage method for storing energy is only 70 to 85 percent efficient. Given four possible reasons folloss in efficiency. I. Pumping is not 100 % efficient. II. Generators are not 100 % efficient. III. Some water evaporates, depending on surface area and temperature. IV. Combined pumps and generators are more than 100% efficient.				
	Which are true sta A) all four B) only I and II C) only I and III			aly II and III aly I, II and III	
20.			operation were 100 lbe approximately		t were operating at maximum output, the
	A) 170	B) 250	C) 333	D) 439	E) 549
21.			ervoir at the Yard's		ould be drained to the lower reservoir, the
	A) 1.2 secondsB) 21 minutesC) 3.4 hours		D) 5. E) a	•	
22.	I. hydrogen II. temperatu III. molecular	bonding ire	liquid will flow the	rough a pipe?	
	A) I & II onlyB) I & III onlyC) I, II & III onl	у		III & IV only l of them	
23.	What is the energ	y consumed by H ₂	O if this movement	changes its temp	erature by 0.5°C?
	A) $-2.1 \times 10^3 \text{ kJ}$	B) $2.1 \times 10^3 \text{ kJ}$	C) $1.3 \times 10^6 \text{ kJ}$	D) 1.3×10 ⁹ l	E) 2.6×10 ⁹ kJ
24.	I. cheaper to b	uild 1ght on line when 1 e reused	ored compared to c	ther storage meth	ods because;
	A) I and II		D) II	and III	
	B) II and IIIC) I and IV		E) al	selections	
25.			e to decompose wat H = +286 kJ/mol H ₂		
	How much energy		d to decompose a c	ubic meter (m ³) c	f water?
	A) $-2.8 \times 10^8 \text{ kJ}$ B) $-1.6 \times 10^7 \text{ kJ}$,	6×10 ⁷ kJ 8×10 ⁸ kJ	
	C) 5.1 kJ		,		

II. storage of O₂ III. chemical reaction efficiency IV. impurities in the water **A)** I **D)** I and II **B)** II E) III and IV C) III Table 1. Species composition and relative abundance of fish collected during the 2009 boat electrofishing surveys in the Project area. (http://ka.sharepointsite.net/YardsCreek/public/Initial%20Study%20Report/Aquatic%) **Lower Reservoir Auxiliary Reservoir** Number Relative Number Relative Nest habitat food **Species** Abundance Abundance builder? Bluegill 0.2% 342 63.0% 1 littoral Algae, yes aquatic insects Brown 1 Molluscs, 0.2% 1 0.2% benthic yes Bullhead insects, catfish algae 2 Chain 0.5% 8 1.5% littoral Small no Pickerel fish, frogs Killifish 1 0 Aquatic 0.2% 0.0% Some littoral

160

26

0

1

5

543

26. What other issues would need to be addressed to use this as a storage method?

2.5%

0.9%

0.2%

20.6%

74.6%

100%

11

1

89

323

433

Largemouth

Pumpkinseed

Rock Bass

Smallmouth

Yellow Perch

Total Catch

Bass

Bass

I. storage of H₂

27. From the information in Table 1, one reason for the differences in abundance and types of species found in the lower reservoir versus the auxiliary (upper) reservoir would be the of the fish.

29.5%

4.8%

0.0%

0.2%

0.9%

100%

- A) habitat
- **B)** lifespan
- C) adult size

D) food requirements

species

yes

yes

yes

yes

no

insects

fish, other bass

Small

prey

Aquatic

insects

Small

prey

Small

prey, fish

littoral

littoral

Rocky

littoral

varies

littoral

Crayfish,

E) reproductive habits

- 28. What can be deduced about the water levels of the lower and auxiliary reservoirs?
 - A) Both reservoir water levels are held constant.
 - **B)** The water levels of both reservoirs vary occasionally.
 - C) The water levels of both reservoirs vary consistently.
 - **D)** Only the lower reservoir water level varies consistently.
 - **E)** Only the auxiliary reservoir water level varies consistently.
- **29.** The top predator in these ecosystems is most likely the

A) bluegill.

D) chain pickerel.

B) killifish.

E) brown bullhead catfish.

C) rock bass.

IV. GUANO

John Maron (2006) studied the effect of introduced species on the ecosystems of the Aleutian Islands of Alaska. Historically, these islands were the home to millions of seabirds. Bird guano supported the growth of dense stands of graminoid grasses. Arctic foxes were introduced in the early 1900's to create a base for fur trading. Norway rats also migrated there from various ships. The US Fish and Wildlife Service removed the foxes from many islands by the 1980's. Maron compared islands that had never had foxes with islands that had had their foxes removed. His findings are summarized in Table 1 below. Lifestyle information about the animals is found in Table 2.

parameter	Historically Fox-free islands	Islands with foxes removed
Number of seabirds	687,812 +/- 399,909	15,867 +/- 5289
Graminoid biomass g/m ²	361 +/- 9	5 +/- 7
% cover by graminoids	45 +/- 7	10 +/- 5
Dominant vegetation	graminoids	Mosses, lichens, shrubs

Table 2. Lifestyle information for representative Aleutian Island animals

animal	Gestation/incubation period (days)	Litter size	Litters/yr.	Age at sexual maturity	Lifespan (yrs)
Arctic fox	53	5-25	1	10 months	3
Norway rat	21-23	6-12	24-6	3 months	2-3
Puffin	74	1	1	3-5 years	15-40
(seabird)					

- **30.** The population of seabirds was lower on islands with foxes removed because
 - **A)** the seabirds had a K-strategist style.
 - **B)** the seabirds had lost their food source.
 - C) the seabirds had lost their nesting sites.
 - **D)** the rats were still present on those islands.
 - E) human interference had caused the seabirds to migrate away.
- **31.** Bird guano is an important source of
 - I. carbon
 - II. nitrogen
 - III. phosphorus
 - IV. sulfur
 - A) I and II

D) all of the above

B) II and III

E) only one of the above.

C) 3 of the above

32.	The birds most vu A) seed eaters. B) ground nester C) predatory birds	rs.	D) 1	nd rats would have migratory birds. brightly colored b		
33.		ilized the gramino e pollinators of the ad the seeds of the rats tunneled und	oids. e graminoids.	, destroying their		
34.	The islands with f because		d species	richness compare	ed to the historically fox-fre	ee islands
	A) increasedB) increasedC) equal of reD) decreasedE) decreased	of decreased pred moval of invasive of competitive inl	lation. e foxes. nibition			
35.	Which of the follo	owing nutrient cy	cles is primarily a	sedimentary cycle	e?	
	A) the rock cycle			the nitrogen cycle		
	B) the water cycC) the carbon cy		E) 1	the phosphorus cy	rcle.	
	•					
36.	A) nitrogen is anB) nitrogen is anC) nitrogen is anD) nitrogen is an	toxic substance for indicator of speci limiting factor for indicator of the p	or many plants.	s. d foxes.	of the islands. He measured	d this because
37.	In major productinitrogen?	ve agricultural ard	eas of the USA, wh	nich of the follow	ing are anthropogenic source	ces of soil
		I. fertilizers				
		II. burning				
		III. burning ; IV. dairy far				
		J				
	A) I and II.		,	all of the above.		
	B) II and III.C) 3 of the above	e.	E)	only one of the ab	ove.	
20	,		oo in haaa 1-111	5 10 10 This	of mumbous mafas to the	
38.	A) expiration da			5-10-10. This set	of numbers refer to the	
	B) settings for ye					
	C) ratio of fertili					
	D) interval, in da		s to be reapplied. orus-potash in the	miyture		
	, ,		•			
39.	The smell of fresh molecule?	nly cut grass is ma	ainly due to cis-3-l	nexenal. How ma	ny double bonds are found	in this
	A) none	B) 1	C) 2	D) 3	E) 6	
	,	,	,	,	,	
40.	Guano also contai	ins some oxalic a	cid, a diprotic orga	nic acid. Which f	formula best represents this	molecule?

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- **A)** CH₂O
- **B)** (CHO)₂
- C) $(COOH)_2$
- D) CH₃COOH
- E) OCH-O-COOH

V. CYSTIC FIBROSIS

Cystic fibrosis is an autosomal recessive, lethal genetic disorder occurring in 1 of every 2500 European and American Caucasian children. People with cystic fibrosis create mucus that is very thick and sticky. The gene responsible (cystic fibrosis transmembrane regulator or CFTR) normally creates chloride ion channels in cell membranes. These channels are important for removing bacteria and mucus, helping enzymes mix with food, and conserving salt.

Scientists have wondered why this lethal mutation has persisted so long in these Caucasian populations. One hypothesis links the mutant gene with the ability to survive the lethal strain of Cholera. Vibrio cholera causes extreme diarrhea by opening all transmembrane chloride ducts in the small intestine. Another hypothesis notes that Salmonella typhi, the bacterium that causes typhoid fever, uses the normal CFTR protein for entry into the gastrointestinal tract.

41.	Which of the following	g organ systems w	ould be expected to	have high expression	on of the CFTR gene?
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- i. the respiratory system
- ii. the digestive system
- iii. the sweat glands
- iv. the nervous system

A) I and II only
B) II and III only
E) Only 3 of the above

- **C)** II and IV only
- **42.** A cell physiologist tested the cholera hypothesis with a mouse model that carried the CFTF mutation. The results were that
 - A) male CF mice died from cholera.
 - **B)** homozygous dominant mice survived cholera.
 - C) homozygous recessive mice died from cholera.
 - **D)** heterozygous mice secreted half the expected amount of fluid.
 - E) there was no significant difference in survival based upon genotype.

43. Cystic fibrosis is rare in Blacks, Hispanics and Asians. It is estimated that 1 of 8100 Blacks are born with CF. What is the approximate frequency of carriers in the Black population?

44. If the frequency of CFTR heterozygotes is 1/150 in the Asian population, what is the probability that a child born of a Caucasian mother and an Asian father will have CF?

- 45. One explanation for the fact that the CFTR mutation is less frequent in the Hispanic, Black, and Asian populations is that
 - A) this is an example of genetic drift.
 - **B)** these populations were at greater risk for intestinal diseases.
 - C) the thicker mucus in heterozygotes conferred an advantage at high altitudes.
 - **D)** the loss of salt due to sweat in heterozygotes is a disadvantage in hot climates.
 - E) these three populations had cleaner water sources and did not need the CFTR mutation.
- **46.** The best argument against the hypothesis that the CFTR mutation confers an adaptive advantage for heterozygotes against cholera is that
 - A) cholera is a disease found only in Africa.
 - **B)** human CF heterozygotes have a lessened life span.
 - C) the mouse model did not display the same advantage.
 - **D)** cholera epidemics in Europe began during the Industrial Revolution.
 - E) lethal recessive mutations eventually are removed from a population by natural selection.
- 47. The CFTR protein is in the ATP-binding cassette (ABC) family. This means that the movement of chloride through the channel is a type of
 - A) osmosis.

D) simple diffusion.

B) co-transport.

E) facilitated diffusion.

- C) active transport.
- **48.** The mutation in the CFTR is a deletion three nucleotides that results in a loss of the amino acid phenylalanine at the 508th position on the protein. Which represents phenylalanine?

E)

B)

- **49.** People with CF have less thiocyanate and hypothiocyanite in their saliva. What are the formulas of these ions?
 - **A)** TiCy¹⁻, HTiCy¹⁻ **B)** SCN¹⁻, OSCN¹⁻

D) CN¹⁻, HCN¹⁻

 \mathbf{E}) CNO_3^{1-} , CNO^{1-}

C) SCNO₃¹, HSCNO₂¹

50. The most common non-pulmonary complication of cystic fibrosis is diabetes. This is due to damage to the pancreas. Thus, less of the , is produced. A) digestive juice, bile **D)** vitamin, ascorbic acid **B)** protein, insulin E) neurotransmitter, seratonin C) enzyme, amylase VI. ROCKET On March 4, 2011 the NASA Glory mission carrying the Total Irradiance Monitor (TIM); and the Aerosol Polarimetry Sensor (APS) was launched on a Taurus XL rocket from the Vandenberg Air Force Base. A protective covering called a fairing failed to separate, and the rocket that was to carry the satellite was unable to accomplish its mission. 51. Several factors contribute to the difficulty of achieving orbit. Which of these is most dependent on the additional mass of the fairing? A) the rate of fuel burned **B)** the inertia of the rocket C) the thrust force provided by the rocket **D)** the extra force of gravity on the rocket E) the drag force exerted by the atmosphere 52. In terms of the planet's mass M, the rocket's mass m, the planet's radius R, and the universal gravitational constant G, which equation would be used to calculate the escape speed, which is the speed needed to escape from a gravitational field without further propulsion, from a planet? A) $mv^2/R = GMm/R^2$ **B)** $mv^2/R = mG$ C) $\frac{1}{2}v^2 = GM/R$ **D)** $\frac{1}{2}mv^2/R = GMm$ E) $\frac{1}{2}$ mv² = GMm/R² 53. The escape speed from Earth's gravitational field 11.2 km/s. In order for the payload to be inserted into low earth orbit the velocity after the burnout of stage 3 A) must be exactly 11.2 km/s. **B)** must be less than 11.2 km/s. C) must be greater than 11.2 km/s. **D)** will be either greater or less than 11.2 km/s depending upon the mass of the rocket. E) will be either greater or less than 11.2 km/s depending upon the trajectory of the rocket. **54.** Earth's surface gravity is 9.8 m/s² and the moon's surface gravity is 1.6 m/s². If an astronaut had a mass of 50 kg on earth her mass on the moon would be **A)** 8.2 kg. **D)** 300 kg. **B)** 41.8 kg. E) 410 kg. **C)** 50 kg. 55. In low earth orbit Earth's gravitational acceleration for the satellite **A)** is 0 m/s^2 . **B)** is 9.8 m/s^2 . C) is greater than 9.8 m/s^2 . **D)** is less than 9.8 m/s^2 , but greater than 0 m/s^2 . E) depends upon the mass of the rocket.

- **56.** The orbital velocity for a satellite in elliptical orbit
 - **A)** is greatest at apogee (the point most distant from the Earth).
 - **B)** is greatest at perigee (the point closest to the Earth).
 - C) is greatest at some point between apogee and perigee.
 - **D)** is greatest at some point between perigee and apogee.
 - E) is the same at apogee and perigee.
- **57.** The Taurus delivery system has the capability to spin the payload with an angular rate of 0 to 355 degrees per second prior to deployment. The actual spin rate depends on the
 - I. payload mass
 - II. center of gravity
 - III. composition of the payload

A) I only

D) I and II onlyE) I, II and III

B) II only

C) III only

- **58.** As a satellite is deployed and its solar panels are extended, its spin rate
 - A) increases

D) increases, then decreases

B) decreases

E) decreases, then increases

C) remains the same

VII. OIL SPILL

A newly discovered type of oil-eating microbe is suddenly flourishing in the Gulf of Mexico and gobbling up the BP spill at a much faster rate than expected, scientists reported. Also, the microbe works without significantly depleting oxygen in the water... A report just last week described a 22-mile-long underwater mist of tiny oil droplets. They found that the dominant microbe in the oil plume is a new species, closely related to members of Oceanospirillales. This microbe thrives in cold water, with temperatures in the deep recorded at 5° C (41°F).

Researcher Terry Hazen, a microbial ecologist at Lawrence Berkeley National Lab in Berkeley, California, said that within two weeks of the capping [of the oil rig], the plume could not be detected, but there was a phenomenon called marine snow that indicated microbes had been feasting on hydrocarbons.

Adapted From http://www.msnbc.msn.com/id/38834330/ns/disaster in the gulf/

- **59.** These findings are in stark contrast with the prolonged presence of oil after the Exxon Valdez oil spill in Alaska. Why might there be more oil-eating microbes in the Gulf than in Alaskan waters?
 - A) Alaskan waters have lower iron levels than Gulf waters.
 - **B)** Alaskan waters are too cold for these microbes to survive.
 - C) Oil-eating microbes are consumed by Alaskan fish, such as salmon.
 - **D)** Oil companies planted these microbes in an effort to mitigate the effects of oil spills.
 - E) Periodic leaks and natural seeps of oil in the Gulf have caused the evolution of oil-eating microbes.
- **60.** Common effects of ocean oil spills include all of the following EXCEPT:
 - A) Algal/phytoplankton blooms
 - **B)** Destruction of shoreline habitat
 - C) Death of sea birds and mammals
 - **D)** Contamination of commercial fishing stock
 - E) Respiratory and intestinal diseases in workers.
- 61. Scientists also had been concerned that oil-eating activity by microbes would quickly

- A) create an anoxic dead zone.
- **B)** interfere with other clean-up efforts.
- C) out-compete normal ocean microbes.
- **D)** contaminate organisms higher in the food chain.
- E) release greater quantities of ozone-depleting gases.
- **62.** Why is it significant that the oil plume was in a "mist of tiny oil droplets"?
 - A) This finding showed that microbes were already at work.
 - **B)** This finding meant that the rig had been effectively capped.
 - C) This finding showed that the oil was still present in the Gulf.
 - **D)** This finding meant that microbes could work more efficiently.
 - E) This finding meant that less oil had been spilled than previously announced.
- **63.** Scientists hypothesized that the microbes needed iron from the seawater in order to degrade the oil. One reason for this hypothesis is that
 - A) iron helps to maintain the low temperatures required by these microbes.
 - **B)** iron is needed to attract magnetic components of crude oil.
 - C) iron is needed for the microbes to replicate their DNA.
 - **D)** iron is needed for hydrocarbon degrading enzymes.
 - **E)** iron is needed for microbial protein synthesis.
- **64.** Various chemical dispersants were used to treat the oil spill. What is the nature of these dispersants?
 - **A)** They are both polar and non-polar.
 - **B)** They are non-polar molecules so they can dissolve in the oil.
 - C) They are highly polar molecules so that they can dissolve in water.
 - **D)** They chemically react with the oil molecules and decompose them into tiny fragments.
 - E) They are ionic molecules that allow the salt in the sea water to coat the surface of the oil droplets.
- **65.** What happened to most of the petroleum that reached the surface?
 - A) It evaporated into the atmosphere
 - **B)** It was picked up by boats using skimmers.
 - C) It is still in the Gulf of Mexico as giant oil slicks.
 - **D)** It floated on the Gulf Stream out into the Atlantic Ocean.
 - **E)** It came ashore onto the beaches and into the tidal marshes and was removed by shore workers.
- **66.** Petroleum is considered *sweet* if
 - A) the drilling well erupts as a gusher.
 - **B)** it contains large amounts of aromatics.
 - C) it contains a higher percentage of octane.
 - **D)** has a low percentage of sulfur compounds.
 - E) it is pumped from a land based well rather than from an ocean platform well.
- **67.** Petroleum is refined in order to:
 - I. remove unwanted sulfur
 - II. separate it into its useful components
 - III. break large hydrocarbon molecules into smaller ones
 - IV. mix engine performance additives into the gasoline
 - A) I & II only
 - B) I & IV only
 - C) II & III only
 - **D)** I, II, & III only
 - **E**) all 4
- **68.** Which most affects the density of the water at the depth of the wellhead?

I. temperature

II. pressure

III. light

A) I only

D) I and II only

B) II onlyC) III only

E) I, II and III

VIII. NSAIDs

NSAIDs are nonsteroidal anti-inflammatory drugs with analgesic (pain-reducing), antipyretic (fever-reducing), and anti-inflammatory effects. As analgesics, NSAIDs are unusual in that they are non-narcotic. The most prominent members of this group of drugs are aspirin (acetylsalicylic acid or ASA), ibuprofen (Advil, Motrin, Nuprin, etc.) and naproxen (Aleve, Midol Extended Relief, Naprosyn, etc.). All can be purchased OTC or over-the-counter, i.e., no doctor's prescription is required. The structures for the three are below. Acetaminophen (Anacin, Pediacare, Tylenol, etc.) has analgesic and antipyretic effects but is not a very good anti-inflammatory.

- **69.** Aspirin, ibuprofen, and naproxen are generic drugs. This means that they:
 - A) are derived from natural sources.
 - **B)** are mostly taken by elderly (geriatric) patients
 - C) were first made many generations ago
 - **D)** are available to the general public through Medicare
 - E) can be made by any pharmaceutical company after the original brand-name drug patent has expired.

	B) C) D)	A NSAID molecule will fill the active site They work faster than COX. The normal substrate of COX is prevented NSAIDs denature COX by competing with The substrate of COX is locked in the active from leaving.	fron the	n being made. formation of hydrogen bonds.
72.		search has shown that L-ibuprofen is an effecteralization can be drawn from this information		pain reliever but D-ibuprofen is not at all effective. What
	•	Only the L-isomer can be microencapsulate is responsible for differences in biochemical	al ac	tivity.
	B)	These two structural isomers behave exactl L-ibuprofen blocks the pain signal.	y the	e same in biological systems, but only
	C)	The difference in behavior illustrates the m site.	olec	ular specificity of a substrate for its binding
	D)	The L-isomer is heavier than the D-isomer molecular weight of a drug.	, and	biochemical activity is related to the
	E)	Only the L-isomer is found in nature, so ad evolved.	apta	tions for use of the D-isomer have not
73.				tomach lining, platelets and kidney function. COX2 is active as of NSAIDs include which of the following:
	B)	Only one of the above. I and II. I and III.		III and IV. Three of the above.
74.	A) B) C) D)	participation in release of prostaglandins. participation in the cellular respiration path interference with protein synthesis. interference with antibody-antigen recognition interference with propagation of the action	tion.	
75.	I. h III. l IIV. A) B)	profen (patented in 1961) and naproxen (patave similar size and shape have similar functional groups have similar molar masses are both obtained from natural materials. IV only I & II only I, II, & III only	D)	I, II, & IV only all of them
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70. In 1897, Felix Hoffmann, working for Bayer AG in Germany, first produced aspirin from salicylic acid. What

D) ether

71. NSAIDs act in a cell by being competitive inhibitors of the enzyme cyclooxygenase (COX). What does this

E) ketone

functional group is found in aspirin?

A) aldehyde B) amino

C) ester

IX. NUCLEAR FISSION

Nuclear fission is the process whereby a heavy nucleus captures a slow moving neutron and undergoes splitting into smaller daughter nuclei. American designed nuclear reactors use "fuel rods" that are about 4 or 5 % uranium 235. The daughter products of the fission are radioactive and typically continue to decay. Control rods absorb neutrons and thereby control the number of neutrons available to cause fission. They are in the fuel rod reactor area. The farther into the core they are inserte, the more neutrons they absorb. Spent fuel rods are usually stored in pools of water after removal from a reactor core.

76.	In an atom of the	electrically neut	ral isotope of urani	ım, $\frac{238}{92}$ U (chemica	al valence +6) there are	eelectrons.
	A) 327	B) 235	C) 143	D) 92	E) 6	
77.			h of the following f D)		arough a series of collisi d be the best moderator	
78.	I. Heat is prII. Radiation	oduced in radioa is still being pro	-	handler just to wea	ar asbestos gloves.	
	Spent fuel rods and A) I only B) II only C) only III	re referred to as '	D)	only I and II only I and III		
79.		ium. This then e	mits a beta particle		ubsequently emits a be	
	A) halfB) doubleC) less than		,	more than the same as		
80.	reactors" when the 235. The half-life	e uranium ore ve of U-235 is app	vas about 3% U-23	5. Uranium ore to lion years. (ignor	been some "naturally day is about 99.3% Ure the isotope U-234 for	238 and 0.7% U-
	A) 0.1	B) 0.5	C) 1	D) 5	E) 100	
81.	Fukushima Dai-IoA) It indicates tB) It indicates thC) Cadmium is aD) Cd-106 is a	chi Nuclear Pow hat there is a pos ne level of power a rare and expen- high energy gam		ne isotopes that is l n. batteries. be hard to replace is especially hazar	dous to humans.	

absorber.

82.	one of the products of the fission of U-235 can be some I-131. I-131 has a half-life of slightly over 8.0 days. Ho many days would it take to reduce the I-131 to 10% of the original amount? A) 15.2 days B) 32.0 days E) can not be determined unless you know the original amount of I-131.
	C) 26.7 days
83.	I-131 undergoes decay by beta (β) emission. What is the daughter nuclide? A) I-130 D) Sb-127 B) I-132 E) Te-132 C) Xe-131
84.	The Dai-Ichi Nuclear Power Station had at least two hydrogen explosions. What is the source of this hydrogen gas? A) Hydrogen is used as a fuel in the fusion process. B) Hydrogen is a by-product of the fission process. C) Hydrogen gas is used as the coolant in the reactor. D) At high temperatures, water will decompose into its elements. E) Hydrogen is used to enrich the uranium fuel by changing U-235 into U-238.
85.	Plutonium is another fuel used in nuclear power plants. Pu-240 has a half-life of 6561 years. What is its rate constant? Eliminated A) 1.06x10 ⁻³ M ⁻¹ yr B) 4.55x10 ⁺³ Myr E) 9.47x10 ⁺³ M ⁻¹ yr C) 4.55x10 ⁺³ M ⁻¹ yr
86.	One advantage of generating power from nuclear power plants as opposed to coal power plants is A) nuclear power plants create fewer toxic residues. B) the United States has more uranium reserves than coal reserves. C) nuclear power plants are cheaper to build and operate than coal plants. D) less CO ₂ is generated as a result of using nuclear power versus using coal. E) a higher net energy yield is generated by nuclear plants than by coal plants.
87.	After the earthquake in Fukushima, Japan, people in that area were advised to take iodine pills. These pills help protect against cancer which may be caused by exposure to radiation. A) skin B) lung C) colon D) breast E) thyroid
88.	Which of the following is NOT an early symptom of radiation poisoning? A) bleeding B) diarrhea C) nausea D) fatigue E) rashes
89.	 Nuclear power plants produce electricity by A) heating steam to spin turbines. B) concentrating ions to charge molten salt batteries. C) generating x-rays, which accelerate electrons in wires. D) channeling alpha particles to charge photovoltaic cells. E) emitting high energy neutrons which charge magnetic sheets.
90.	 A partial meltdown occurred at the Fukushima power plant because the A) tsunami swept through the pool of spent fuel rods. B) backup electric power supply system was damaged. C) earthquake cracked the walls of the containment building. D) operators fled the damaged building to escape the tsunami. E) reactor was working at a higher capacity to compensate for other damage.

Merck State Science Day 2011 Answer Section

ADVANCED INTEGRATED SCIENCE

MULT

TIPLE CHOICE						
1.	В					
2.	Α					
3.	С					
4.	В					
5.	Α					
6.	D					
7.	E					
8.	E					
9.	В					
10.	С					
11.	D					

12. B 13. A 14. D 15. A 16. B 17. D 18. E 19. E 20. A 21. C 22. C 23. D 24. A 25. D 26. A 27. E 28. D 29. D 30. A 31. B 32. B 33. A 34. A 35. E 36. C 37. D 38. E 39. C 40. C

41. Ε 42. D 43. В 44. C **45**. D 46. D 47. C 48. D 49. В **50**. В 51. С C **52.** 53. В 54. C **55**. В 56. В **57**. D **58**. В Ε 59. 60. Α

81. Α 82. C 83. C 84. D 85. A Eliminated 86. Ε 87. E 88. Ε 89. Α 90.