



Public Health Training Network

Lesson 2

## SELF-STUDY COURSE 3010-G

# Water Supply



## **Environmental Health Sciences Self-Study Course SS3010**

### **Lesson 2: *Water Supply***

#### **I. Lesson Consists of**

- A. Part I: 25 multiple choice questions
- B. Part II: 25 multiple choice questions
- C. Part III: 25 multiple choice questions
- D. Part IV: 25 multiple choice questions

Note: These questions are not in sequence due to the interrelated nature of the subject. The student must complete the reading assignment before attempting to complete the questions.

#### **II. Reference**

Salvato, J. A. *Environmental Engineering and Sanitation*. 4th ed. New York: John Wiley & Sons, 1992.

#### **III. Topics and Reading Assignments**

	<b>(Page No.)</b>
Chapter 3 - <i>Water Supply</i>	
A. Introduction	214 to 218
B. Travel of Pollution Through the Ground	218 to 222
C. Water Quantity and Quality	222 to 294
D. Source and Protection of Water Supply	294 to 324
E. Desalination	324 to 331
F. Treatment of Water - Design and Operation Control	331 to 406
G. Water System Design Principles	406 to 445
H. Examples	445 to 459
I. Cleaning and Disinfection	459 to 464
J. Emergency Water Supply and Treatment	464 to 471

#### **IV. Suggested Supplementary Readings**

Gilbert, C. and Calabrese E., *Regulating Drinking Water, Regulating Drinking Water Quality*, Lewis Publishers, 1992.

Holfkes, E. H., Huisman, L. *International Reference Center for Community Water Supply and Sanitation*. Small community water supplies. New York: John Wiley and Sons, 1983.

Hunter, J. et al., *Parasitic Diseases in Water Resources Development*, WHO, 1993.

*Manual of Individual Water Supply System*. Washington, D.C.: U.S. Environmental Protection Agency, Office of Drinking Water, 1982; EPA-570/9-82-004.

#### **References of Historical Significance:**

Baker, M. H. *The Quest for Pure Water*. New York: American Water Works Association, 1948, second edition 1981. (Historical chronology of water treatment; strongly suggested reading for professional development. This text is very useful if you are involved in instruction or education about the development of drinking water systems.)

*Cross-connection Control Manual*. Washington, D.C.: U.S. Environmental Protection Agency, 1970.

Winslow, C. E. A. *The Conquest of Epidemic Disease: a Chapter in the History of Ideas*. Princeton, New Jersey: Princeton University Press, 1943. (Reprinted 1980, University of Wisconsin Press). (This public health classic is highly recommended for reading.)

#### **V. Objectives**

Upon successful completion of Lesson 2, students should be able to correctly

- demonstrate a basis understanding of the relationship of demand, design, distribution, and economics of water service
- recognize the principles involved in conducting a sanitary survey of potential or existing water systems and watersheds

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- apply the principles of drinking water supply development to the following: groundwater systems, small treatment systems, large system development, and specialized treatment systems
- demonstrate an understanding of pre-treatment potentials of chemical, physical, and biological contamination of groundwater and surface water
- demonstrate an understanding of the post-treatment potential of contamination of drinking water from backflow, backsiphonage, and construction materials and methods.

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**Part I: Multiple Choice**

1. As you know from previous readings, the composition of soil is very important in the removal of both viruses and bacteria. Which of the following soil conditions is most favorable for removal of viruses?
  - a. sand over gravel
  - b. fine loamy sand over coarse sand and gravel
  - c. gravel over semi-porous clay
  - d. coarse sand and gravel over fine sand or clay.
2. Which of the following organisms are most resistant to unfavorable environmental conditions and indicate past or possibly intermittent pollution?
  - a. fecal streptococci
  - b. escherichia coli
  - c. aerobacter aerogenes
  - d. clostridium sporulates.
3. Which of the following wells is considered the most dependable source of water and is less likely to become contaminated?
  - a. driven well
  - b. bored well
  - c. drilled well
  - d. dug well.
4. Which of the following is not considered a satisfactory solution to the problem of chemical contamination in well systems?
  - a. abandoning the well
  - b. boiling the water
  - c. connecting to a public water system
  - d. building a new, properly constructed, drilled well.

5. Which of the following chemicals is the most widely used to destroy microorganisms?
- a. chlorine
  - b. copper sulfate
  - c. chloramine
  - d. hydrogen sulfate.
6. The control of corrosion in piping requires all of the following steps **except**
- a. development of protective coating inside pipes
  - b. the use of corrosion-resistant pipe materials or pipe coatings
  - c. an increase in water velocity
  - d. control of electrochemical action.
7. Which of the following is the best methods of backflow control?
- a. air gap separation
  - b. vacuum breaker
  - c. backflow preventer
  - d. barometric loops.
8. Microscopic photosynthetic plants of the simplest forms, having neither roots, stems, nor leaves, that are associated with taste and odor, filter clogging, and other water problems are known as
- a. yeasts
  - b. algae
  - c. protozoa
  - d. rotifiers.
9. Control of infectious, intestinal diseases of humans requires
- a. provisions of safe water supplies
  - b. proper waste disposal
  - c. personal hygiene
  - d. all of the above.



10. Drinking water standards generally specify that a water is safe provided that testing in a specified manner does not reveal more than an average of
- a. 10 positive samples out of 100 samples taken
  - b. 50 coliform organisms per 100 ml
  - c. 1 positive sample out of 40 samples taken
  - d. 50 coliform organisms per 200 ml.
11. What does it mean when a body of water has a high Jackson Turbidity Units (JTU)?
- a. it has a low amounts of organic matter
  - b. it has no bacteria
  - c. no one is swimming at this time
  - d. it has high turbidity.
12. The presence of which of the following is most easily identified by laboratory analysis in water contaminated by feces?
- a. shigella dysenteriae
  - b. coliform
  - c. entamoeba histolytica
  - d. salmonella typhosa.
13. Nephelometric Turbidity Units (NTU) are most commonly used to
- a. determine the type of pollution or contamination present in natural waters
  - b. estimate the amount of dissolved oxygen in surface waters
  - c. define the strength of waste waters
  - d. determine turbidity.
14. The safe distance between a well and a waste disposal system is dependant on
- a. chemical processes
  - b. physical processes
  - c. biological processes
  - d. all of the above.

15. The geophysical methods used to identify and investigate the extent and characteristics of ground water pollution include
- a. geomagnetics
  - b. electromagnetics
  - c. electrical resistivity
  - d. all of the above.
16. What is the first step in evaluating the safety of a potential water system?
- a. the frequency with which source and distribution system water samples are collected
  - b. a detailed sanitary survey of the water supply
  - c. the standard plate count for bacterial examination
  - d. the results of a bacterial chemical examination.
17. What are examples of groundwater systems?
- a. dug, bored, driven, and drilled wells, rock and sand or earth springs, and infiltration galleries
  - b. water located no deeper than 400 feet
  - c. direct municipal wastewater systems
  - d. lake, reservoir, stream, pond, river, and creek supplies.
18. What causes water hardness?
- a. high concentrations of iron
  - b. pond, creek, or other surface water
  - c. well-water supplies that are improperly constructed, protected, or located
  - d. dissolved calcium and magnesium bicarbonates, sulfates, and chlorides in groundwater.
19. What is desalination?
- a. the detection of detergents in water by laboratory examination
  - b. the process of removing undesirable tastes and odors from domestic water supplies
  - c. one of the classifications for springs
  - d. the conversion of seawater or brackish water to fresh water.



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20. The quality of surface water depends on
- the use of chemicals for disinfection of drinking water
  - the elimination of coliform organisms
  - the watershed area drained, land use, location and sources of pollution, and the natural agencies of purification
  - the injecting of a chlorine solution into water at its source.
21. Which of the following is not commonly used for disinfection of water?
- chlorine
  - silver nitrate
  - chlorine-ammonia compounds
  - ozone.
22. Hydropneumatic or pressure-tank water systems are suitable for
- providing sufficient water to meet peak demands for domestic, commercial, and industrial purposes
  - small communities, housing developments, private homes and estates, camps, food service operations, and hotels
  - water storage requirements
  - helping to control watershed runoff.
23. The hydropneumatic tank typically contains \_\_\_\_\_ of its volume as water.
- 50 percent
  - 80 percent
  - 20 percent
  - does not contain water only compressed air.
24. Water containing nitrates generally indicates
- a nearby cesspool
  - evidence of previous pollution
  - a chemical leak
  - a nearby slaughterhouse.

25. Diatomaceous earth filters

- a. should be integrated into pressure-tank systems
- b. can be used for public water supplies
- c. should be augmented by chlorination
- d. can be left unattended for long periods of time.

**Part II: Multiple Choice**

1. In a stratified reservoir, the best quality water is usually contained in the zone called
  - a. metalimnion
  - b. euphotic
  - c. epilimnion
  - d. hypolimnion.
2. Hydrogen sulfide can be fatal at exposure of
  - a. 100 ppm
  - b. 150 ppm
  - c. 225 ppm
  - d. 300 ppm.
3. The most practical method for removing nitrates from water is
  - a. reverse osmosis
  - b. ion exchange
  - c. reverse osmosis
  - d. double reverse osmosis.
4. Which of the following is not a practical method for removal of cadmium?
  - a. ion exchange
  - b. lime softening - *work*
  - c. reverse osmosis
  - d. iron coagulation. - *work*
5. Backsiphonage may be prevented by all of the following methods **except**
  - a. barometric loop
  - b. vacuum breakers
  - c. air gap separation
  - d. backpressure units.

6. The formula  $Q=AIR$  is used to determine
  - a. trihalomethane formation
  - b. amount of oxygen in quarry wastewater
  - c. rate of runoff in a watershed
  - d. area of education pipe in air lift pump.
7. Of the following, which is not a variable to be considered when deciding upon a safe distance between a well and a sewage disposal system?
  - a. well construction, tightness of pump connection, depth of well casing and sealing of the annular space
  - b. the number of individuals utilizing the well
  - c. the volume, strength, type and dispersion of the polluted material
  - d. the soil structure and texture.
8. Microbial pollution travels only a short distance through
  - a. solution channels in limestone
  - b. fissured rock
  - c. dried-out, cracked clay
  - d. sandy loam or clay.
9. Typically, an abundant supply of groundwater may be yielded from
  - a. sedimentary rocks
  - b. molten rocks
  - c. igneous rocks
  - d. metamorphic rocks.
10. An example of a surface water supply would be
  - a. a well
  - b. a rock and sand spring
  - c. an earth spring
  - d. a reservoir.



11. Which of the following is used to properly seal a drilled well to prevent contamination of the water supply?
  - a. epoxy
  - b. A mixture of sand and mud
  - c. grouting
  - d. a rubber seal with silicone adhesive.
  
12. Which of the following compounds would not contribute to water hardness?
  - a. calcium sulfate
  - b. magnesium sulfate
  - c. calcium chloride
  - d. sodium chloride.
  
13. The quiescent settling of water such as would occur in a reservoir, lake or basin without the aid of chemicals is known as
  - a. plain sedimentation
  - b. coagulation
  - c. settling
  - d. flocculation.
  
14. Which of the following is not a commonly accepted method or device to prevent backsiphonage?
  - a. vacuum breakers
  - b. cross-connections
  - c. air gap separation
  - d. back pressure units.
  
15. Centrifugal pumps are of several types depending on the design of the
  - a. volute
  - b. shaft
  - c. impeller
  - d. mechanical seal.



16. Which of the following disinfecting compounds can be used full strength for disinfection?
- a. perchloron
  - b. calcium chloride
  - c. chlorinated lime
  - d. sodium hypochlorite.
17. The type of filter that is recommended for use at small communities and rural places is the
- a. rapid sand filter
  - b. pressure filter
  - c. slow sand filter
  - d. diatomaceous earth filter.
18. All of the following will generally vary directly with the quantity of water used for domestic purposes **except**
- a. availability of water
  - b. habits of the people
  - c. cost of water
  - d. amount of minerals in the water.
19. Groundwater in the soil travels up through a plant's root system and then comes out from the leaf structure as
- a. transpiration
  - b. sublimation
  - c. evaporation
  - d. condensation.
20. The type of water that makes it difficult to produce suds or to rinse laundry, dishes or food equipment is
- a. soft water
  - b. hard water
  - c. spring water
  - d. distilled water.

21. A sanitary survey of a water system is necessary for what reason?
- a. to determine the safety and the adequacy of the water supply
  - b. to determine how much iron is in a water supply
  - c. to determine what size pump is needed for the water system
  - d. to determine whether the water in the system is hard or soft.
22. The sources of water supply are divided into which of the following major classifications?
- a. spring water and well water
  - b. groundwater and surface water
  - c. rainwater and river water
  - d. demineralized water and lake water.
23. The conversion of seawater or brackish water to fresh water is called
- a. decontamination
  - b. purification
  - c. desalination
  - d. dehydration.
24. The gas causing the distinct "rotten egg" odor in many water sources is
- a. hydrogen sulfide
  - b. carbon dioxide
  - c. chlorine gas
  - d. hydrogen carbonate.
25. High concentrations of nitrates in drinking water are
- a. detrimental to adults
  - b. considered safe to drink
  - c. the cause of a blood disease in teenagers
  - d. a possible cause of methemoglobinemia.

**Part III: Multiple Choice**

1. Turbidity of water will
  - a. interfere with proper disinfection
  - b. harbor viruses
  - c. cause tastes and odor
  - d. all of the above.
  
2. This substance is the first product of the decomposition of organic matter. Its presence in water usually indicates "fresh pollution" of sanitary significance. What is it?
  - a. ammonia
  - b. sugar
  - c. carbon dioxide
  - d. hydrogen sulfide.
  
3. The presence of which of the following elements in water treatment plant effluent is used as a measure of filtration efficiency?
  - a. copper
  - b. aluminum
  - c. zinc
  - d. lead.
  
4. One of the most common reasons for the contamination of wells drilled through rock, clay, or hardpan is
  - a. seepage of pollutants through soil
  - b. failure to seal well casings properly
  - c. porosity of the rock
  - d. use of inferior quality well casings.
  
5. Proper disinfection of water using chlorine depends on the concentration of chlorine plus which of the following?
  - a. temperature of the water
  - b. Ph of the water
  - c. contact period
  - d. all of the above.

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11. The presence of which of the following in water would indicate past or possibly intermittent pollution?
- a. streptococcus fecalis
  - b. escherichia coli
  - c. clostridium perfringens
  - d. enterococci.
12. Which of the following is a measure of the amount of light scattered by particles suspended in a water test sample?
- a. Formazin Turbidity Units (FTU)
  - b. Nephelometric Turbidity Units (NTU)
  - c. Jackson Turbidity Units (JTU)
  - d. Lincoln Turbidity Units (LNU).
13. In testing for residual chlorine, which of the following determines free available chlorine with minimal interference from combined chlorine, iron, nitrates, and nitrites?
- a. leuco crystal violet method
  - b. stabilized neutral orthotolidine (SNORT) method
  - c. DPD-colormetric method
  - d. DPD-titrimetric method.
14. Granular activated carbon (GAC) filters are used to
- a. treat water for soft drinks and bottled drinking water
  - b. remove taste and odor producing compounds
  - c. remove synthetic organic chemicals (suspected carcinogens)
  - d. all of the above.
15. Ozone is effective against
- a. amoebic cysts
  - b. bacteria and phenols
  - c. viruses
  - d. all of the above.





16. Which of the following is (are) fundamental to the control of inorganic chemicals in drinking water?
- a. sanitary survey
  - b. identification of the sources
  - c. determination of amounts of pollutants
  - d. all of the above.
17. Often over 90% of sodium arsenate can be removed by
- a. filtration
  - b. coagulation
  - c. ion exchange
  - d. all of the above.
18. Reduction of the level of fluorides in drinking water can be accomplished by
- a. coagulation
  - b. lime softening
  - c. ion exchange
  - d. all of the above.
19. What are the fundamental steps involved in the control of organic chemicals in drinking water?
- a. conduct sanitary surveys to identify sources, types and amounts of pollutants
  - b. identify pollutants and select treatment methods
  - c. contact higher level regulatory authorities for consultation
  - d. upgrade water treatment plants.
20. Trihalomethanes are synthetic organic chemicals primarily created
- a. during the coagulation process
  - b. during the pre-chlorination process
  - c. during reverse osmosis
  - d. during the post-chlorination process.

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21. The control of man-made pollutants must start with management of
- a. industry
  - b. their manufacturers
  - c. the source
  - d. our lifestyles.
22. The Langelier index is used to determine the point of stability of
- a. aluminum sulfate
  - b. calcium carbonate
  - c. water Ph
  - d. HOCl.
23. A hydraulic ram is used to elevate a quantity of water to a higher elevation. Rams are powered by
- a. wind
  - b. electricity
  - c. water
  - d. heat.
24. A well casing should be equipped with a vent and installed
- a. with a sampling tap
  - b. in a pit to prevent freezing
  - c. with a turbine type pump
  - d. with concrete used as grout.
25. A centrifugal pump is limited to use where the lift of the water is not in excess of
- a. 33.9 feet
  - b. 20 feet
  - c. 15 feet
  - d. 90 feet.

**Part IV: Multiple Choice**

1. The limitation of the lift capability of the centrifugal pump is based on
    - a. the weight of the atmosphere
    - b. the design of the impeller and volute
    - c. the efficiency of the motor
    - d. the effect of friction.
  2. A jet pump will lift water a maximum of
    - a. 500 feet
    - b. 120 feet
    - c. 33.9 feet
    - d. 15 feet.
  3. Cross-connections are frequent causes of disease resulting from
    - a. backsiphonage of contaminated chemicals
    - b. backflow of biologically contaminated liquids
    - c. connection of the water supply to the sewer system
    - d. all of the above.
  4. Backflow of nonpotable materials into the potable water system may occur by
    - a. backpressure
    - b. backsiphonage
    - c. vacuum in the volume
    - d. a and b above.
  5. The flushometer valve is typically protected by
    - a. a non-pressure-type vacuum breaker
    - b. a pressure-type vacuum breaker
    - c. a backflow preventer
    - d. a reduced pressure zone backflow preventor.
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6. Which of the following defines effective porosity or specific yield?
- a. the amount of water that will drain out of saturated rock or soil by gravity
  - b. the rate of flow of water at 60° F in gallons per day
  - c. the actual efficiency of a given water bearing formation
  - d. both a and b above.
7. Which of the following statements is (are) true?
- a. all surface water must be considered unsanitary unless given adequate treatment
  - b. all groundwater supplies may be considered safe as a potable water supply
  - c. when considering surface water as a water supply, the entire watershed must be surveyed
  - d. both a and c above.
8. Which of the following statements is (are) true concerning the presence of coliform organisms in drinking water?
- a. the drinking water may also be used as a varnish remover
  - b. the drinking water should be considered unsanitary
  - c. the drinking water does not contain toxic chemicals
  - d. all of the above.
9. At any given time, the amount of groundwater compared to the amount of all surface water (streams and lakes) is said to be estimated at
- a. 5 times as much
  - b. 20 to 30 times as much
  - c. one-half as much
  - d. one-tenth as much.
10. Which of the following statements should not be a prime consideration in locating a groundwater supply?
- a. the probable travel of pollution through the ground
  - b. the well construction practices and standards
  - c. the sanitary seal provided at the point where the pump lines pass out of the casing
  - d. the distance that the water will need to travel.



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11. It is recommended that a contaminated well be abandoned unless
  - a. all the sources of pollution can be found and removed
  - b. the contaminated stratum from which water is being extracted is effectively sealed off
  - c. the persons drinking the water show no adverse health effects
  - d. a and b above.
12. When using presettling reservoirs to eliminate heavy turbidity or pollution before treatment, what is the desirable retention time?
  - a. 8 hours
  - b. 1 week
  - c. 2 to 3 days
  - d. 1 month or longer.
13. Direct filtration can produce a good quality water at a lower cost provided that the water being treated is
  - a. low in suspended matter and turbidity
  - b. low in color, coliform organisms, and plankton
  - c. free of paper fiber
  - d. all of the above.
14. If sufficient amounts of activated carbon in the powdered form are used, practically all tastes and odors are removed from water by
  - a. absorption
  - b. polymerization
  - c. adsorption
  - d. oxidation.
15. When considering water storage requirements, which of the following is not considered a recommended practice?
  - a. the water storage should equal not less than half of the daily consumption
  - b. the retention time for the stored water should not be over 8 hours
  - c. at least half of the stored water should be in elevated tanks
  - d. capacity should equal the maximum daily usage plus fire requirements.



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16. It has been estimated that waterborne disease worldwide accounts for in excess of
- a. 250 million illnesses per year
  - b. 20 million illnesses per year
  - c. 150 million illnesses per year
  - d. 400 million illnesses per year.
17. Residential cesspool and septic tank soil absorption systems discharge
- a. 400 billion gallons of sewage into the ground each year
  - b. 800 billion gallons of sewage into the ground each year
  - c. 800 million gallons of sewage into the ground each year
  - d. 2 billion gallons of sewage into the ground each year.
18. In a test conducted in North Carolina by the PHS in sandy soil, sewage organisms traveled
- a. only 10 feet
  - b. 450 feet
  - c. in excess of 200 feet
  - d. 1,200 feet.
19. Leaching from a garbage dump has been found to pollute wells
- a. 2,000 feet away
  - b. 1,400 feet away
  - c. 100 feet away
  - d. 50 feet away.
20. Hardness in drinking water is desirable at levels of
- a. 80 to 150 mg/l
  - b. 50 to 80 mg/l
  - c. 0 to 50 mg/l
  - d. 600 to 800 mg/l.

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21. Alkalinity of water is desirable at levels of
- a. 0 to 30 mg/l
  - b. 0 to 500 mg/l
  - c. 30 to 100 mg/l
  - d. 0 to 5 mg/l.
22. Domestic community water system pumps should be of such capacity as to deliver the average daily water demanded to the storage tank in
- a. 4 to 8 hours
  - b. 14 to 18 hours
  - c. 6 to 12 hours
  - d. 18 to 24 hours.
23. In distillation, sea water is heated to the boiling point and then into steam, usually under pressure, at a starting temperature of
- a. 278° F
  - b. 260° F
  - c. 250° F
  - d. 258° F.
24. Barium is a muscle stimulant and in large quantities may be harmful to the nervous system and heart. The fatal dose is
- a. 150 to 250 mg
  - b. 550 to 600 mg
  - c. 400 to 475 mg
  - d. 800 to 1000 mg.
25. The amount of color in water should be less than
- a. 5 color units
  - b. 10 color units
  - c. 20 color units
  - d. 15 color units.

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## **Answer Keys**



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**Answer Keys (Page No.)**

**Lesson 2: Part I**

1. B (220)	6. C (267)	11. D (257)	16. B (295)	21. B (333)
2. D (253)	7. A (424)	12. B (251)	17. A (297)	22. B (428)
3. C (304)	8. B (259)	13. D (257)	18. D (270)	23. C (428)
4. B (312)	9. D (222)	14. D (219)	19. D (325)	24. B (250)
5. A (334)	10. C (252)	15. D (218)	20. C (331)	25. C (360)

**Part II**

1. A (376)	6. C (407)	11. C (330)	16. D (333)	21. A (243)
2. D (379)	7. B (313)	12. D (270)	17. C (348)	22. B (244)
3. B (399)	8. D (313)	13. A (344)	18. D (394)	23. C (325)
4. C (399)	9. A (297)	14. B (424)	19. A (223)	24. A (270)
5. A (426)	10. D (445)	15. C (435)	20. B (270)	25. D (274)

**Part III**

1. D (258)	6. D (340)	11. B (251)	16. D (397)	21. D (logic)
2. A (268)	7. B (387)	12. B (257)	17. B (397)	22. B (391)
3. B (262)	8. B (469)	13. C (336)	18. D (399)	23. C (438)
4. B (304)	9. C (333)	14. D (374)	19. A (401)	24. D (311)
5. D (337)	10. A (226)	15. <del>D</del> (378) C 435	20. B (402)	25. C (435)

**Part IV**

1. A (435)	6. A (226)	11. D (295)	16. A (216)	21. C (261)
2. B (438)	7. D (331)	12. C (345)	17. A (216)	22. C (411)
3. D (424)	8. B (230)	13. D (356)	18. C (219)	23. C (327)
4. D (425)	9. B (297)	14. C (374)	19. A (220)	24. B (264)
5. A (425)	10. D (logic)	15. B (412)	20. B (270)	25. D (258)

