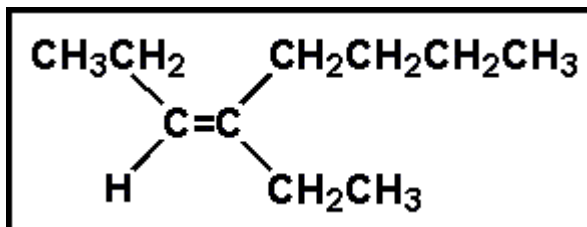


Multiple Choice

Identify the letter of the choice that best completes the statement or answers the question.

- The best way of extinguishing an alkali metal fire is to:
A) use water
B) smother it with a blanket
C) smother it with sand
D) smother it with a plastic bag
E) allow it to burn itself out
- Which one of the following elements occurs as a free metal in the natural environment?
A) mercury B) cadmium C) zinc D) copper E) chromium
- How many carbon atoms are in a one-carat diamond?
[1 Carat = 200 mg]
A) 36.1×10^{23} B) 6.02×10^{23} C) 2.5×10^{23} D) 1.20×10^{23} E) 1.00×10^{22}
- How many atoms of oxygen are required for the complete combustion of one molecule of hexane?
A) 20 B) 19 C) 18 D) 13 E) 12
- Paramagnetism is a property that:
A) is found only in the elements iron, cobalt and nickel in their solid states
B) occurs only in transition elements
C) always occurs when an atom or ion has an even number of electrons
D) is found in substances that have unpaired electrons
E) results from an electric current passing through a conductor
- If 250 g of water at 95°C is poured into a 100 g glass container at 25°C , what will be the maximum resulting temperature of the water and the glass, assuming no significant heat loss to the room?
[Assume the specific heat of glass is $0.50 \text{ J/g}\cdot^{\circ}\text{C}$.]
A) 44 B) 50 C) 66 D) 70 E) 75
- The organic functional group in the following list that does NOT contain oxygen is:
A) ester B) aldehyde C) amine D) ketone E) amide

8. Select the best name for:



- A) 4-ethyl-trans-3-octene D) 5-ethyl-trans-5-octene
B) 4-ethyl-cis-3-octene E) 5-ethyl-cis-5-octene
C) 4-butyl-cis-3-hexene

9. A secondary alcohol containing 4 carbons is shaken with an aqueous solution of KMnO_4 . The resulting organic molecule will be:

- A) an acid D) an ester
B) an aldehyde E) a ketone
C) an amine

10. When two alcohol molecules undergo a self-condensation, the class of molecule that is formed is:

- A) an ether B) a ketone C) an alcohol D) an aldehyde E) an ester

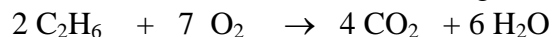
11. The C-C-C bond angle in cyclopropane is:

- A) 60° B) 90° C) 109.5° D) 120° E) 180°

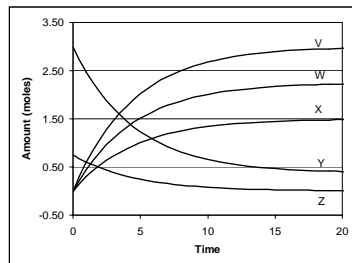
12. Nylon can best be classified as a:

- A) polyester D) polyether
B) polyamine E) polyunsaturate
C) polyamide

13. The complete combustion of ethane occurs according to the following equation.



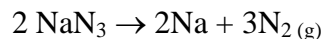
The changes in the amounts of each chemical are plotted on the graph below.



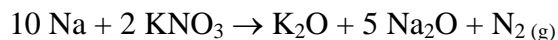
If 3 moles of oxygen were initially available, which statement is true?

- A) Line Z is ethane, line X is water
 B) Line Z is ethane, line W is CO₂
 C) Line Z is ethane, line V is water
 D) Line Y is oxygen, line X is water
 E) Line Y is oxygen, line W is water
14. Wine is an aqueous solution of various flavoring molecules and of alcohol resulting from the fermentation of grape juice. The fermentation process includes the oxidation of sugars to ethyl alcohol. A typical wine is a 12% by weight solution of ethanol with a density of 0.990 gm/mL. What is the molar concentration of ethanol in such a solution?
- A) 0.56 M B) 1.3 M C) 2.6 M D) 3.8 M E) 4.6 M
15. The high efficiency of microwave cooking derives from the ability of water molecules to convert microwave energy to:
- A) energy of rotation D) ionization energy
 B) energy of vibration E) infrared light
 C) energy of translation
16. The half-life of the stimulant caffeine in the average adult human body is 5 hours. How long does it take to metabolize 75% of the caffeine from a cup of coffee?
- A) 5 h B) 10 h C) 12h D) 15h E) 24h

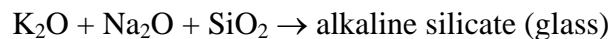
17. The main chemical components in an automobile airbag are sodium azide (NaN_3), potassium nitrate (KNO_3) and silicon dioxide (SiO_2). In the reaction chamber a mixture of NaN_3 , KNO_3 , and SiO_2 is ignited by an electrical impulse and causes a detonation that liberates a precalculated volume of nitrogen gas, which fills the air bag.



The sodium by-product of this reaction combines with the potassium nitrate to generate additional nitrogen for the airbag as:



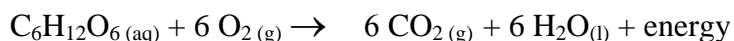
These two reactions leave potassium oxide and sodium oxide to react with the third compound of the mixture, silicon dioxide, forming alkaline silicate ("glass"), which is a safe and stable, non-flammable compound.



About what mass of sodium azide would be required to produce 50 L of N_2 gas at STP?

- A) 62 g B) 97 g C) 145 g D) 208 g E) 280 g

18. Hummingbirds have a very high ratio of surface area to mass which results in a high rate of heat loss from their bodies. In order to maintain their body temperature, they have an extremely rapid metabolic rate. In fact, to maintain their body mass at 5°C they must consume about 0.2 g of sugar per hour. Energy is produced when the sugar is broken down in the following reaction:



Which answer is nearest to the volume of $\text{O}_2(\text{g})$ (measured at 5°C and 100 kPa) that must be consumed per hour by a hummingbird to metabolize this sugar?

- A) 750 mL B) 500 mL C) 300 mL D) 150 mL E) 10 mL

19. For the following chemical reaction: $2 \text{NO}(\text{g}) + \text{Br}_2(\text{g}) \rightarrow 2 \text{NOBr}(\text{g})$
the rate law is given by: $\text{Rate} = k [\text{NO}(\text{g})]^2 [\text{Br}_2(\text{g})]$
If the concentration of NO is doubled and that of Br_2 is tripled, by what factor should the initial rate of reaction increase?

- A) 18 B) 12 C) 6 D) 5 E) 4

20. The equilibrium between chromate (CrO_4^{2-}) ions and the dichromate ($\text{Cr}_2\text{O}_7^{2-}$) ions in aqueous solution is described by the following equation:

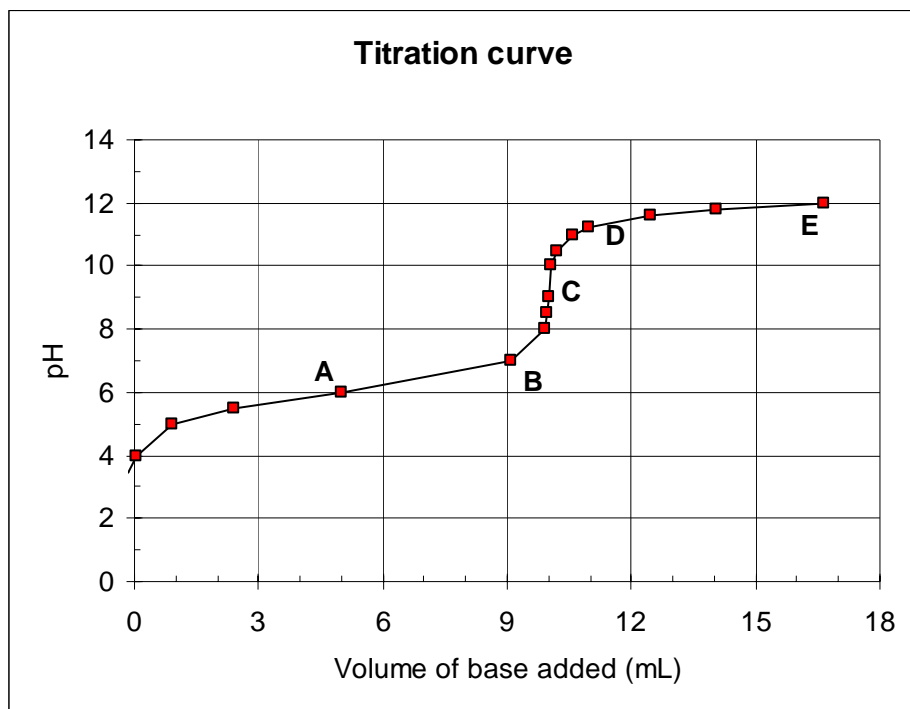


Barium chromate is not very soluble, but barium dichromate is.

What will happen when a neutral solution of $\text{Ba}(\text{NO}_3)_2$ is added to a yellow chromate ion solution?

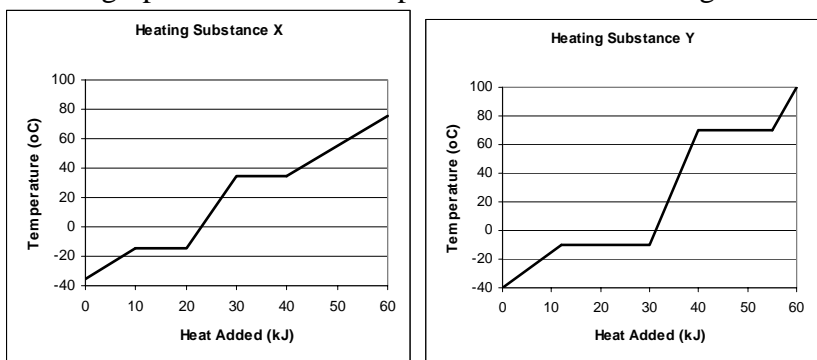
- A) The pH of the solution will remain the same.
B) No precipitate forms and the solution stays yellow.
C) A precipitate forms and the solution turns orange.
D) No precipitate forms and the solution turns orange.
E) The pH of the solution will decrease.
21. The person who made important generalizations about the relationship between the amount of electric current passed through a solution and the amount of chemical reaction produced was:
- A) Henry Cavendish D) Joseph. Priestly
B) Humphrey Davy E) Michael Faraday
C) Alessandro Volta
22. If one mole of sugar molecules is added to 1000 g of distilled water, the freezing point will be -1.86°C .
When 22g of a certain alcohol is added to 1000 g of distilled water, the freezing point of the solution is -0.55°C .
From this information the formula for this alcohol is most likely:
- A) CH_3OH B) $\text{C}_2\text{H}_5\text{OH}$ C) $\text{C}_3\text{H}_7\text{OH}$ D) $\text{C}_4\text{H}_9\text{OH}$ E) $\text{C}_5\text{H}_{11}\text{OH}$
23. Which of the following values is closest to the pH of a solution formed when sufficient ammonia gas is bubbled into pure water such that 0.05 moles of NH_3 remain contained in each liter of water?
[Assume $K_b = 1.8 \times 10^{-5}$ for NH_3]
- A) 3.0 B) 4.7 C) 9.2 D) 10.4 E) 11.0

24. Data for the graph below were recorded by adding 0.1 M NaOH to a 0.1M sample of a weak monoprotic acid (HX). Which labeled point on the graph provides information that allows the calculation of the K_a for the acid to be done the most easily?



- A) A B) B C) C D) D E) E
25. Which one of the following elements usually forms an ion with the same ground-state electron configuration as Ca^{2+} ?
 A) Mg B) Sr C) Na D) Br E) S
26. Which of the following substances has the lowest vapor pressure at 300 K ?
 A) H_2O B) H_2S C) H_2Se D) NH_3 E) CH_4
27. Oxygen gas boils at -183°C . If 22.4 L of O_2 gas (measured at STP) is cooled at constant pressure, what would be the volume of the gas just before it condensed into liquid oxygen?
 A) 22.4 L B) 15.0 L C) 7.4 L D) 6.2 L E) 32.0 mL

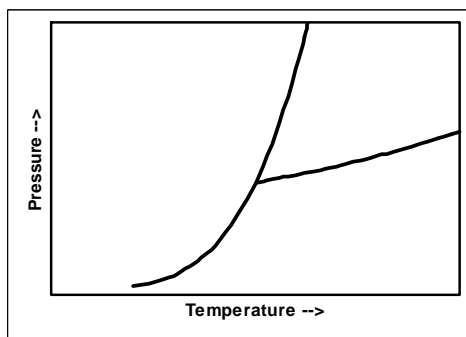
28. The two graphs shown below represent idealized heating curves for one mole of each pure compound.



Based on these graphs, which of the following statements is correct?

- A) The molar heat of fusion of X is *less* than the molar heat of fusion of Y.
- B) The specific heat of X in its liquid state is *less* than the specific heat of Y.
- C) The boiling point of substance X is *greater* than the boiling point of Y.
- D) The molar heat of vaporization of X is *greater* than the molar heat of vaporization of Y.
- E) At room temperature, the vapor pressure of X is *less* than the vapor pressure of Y.

29. The following phase diagram illustrates the behavior of a pure substance. The triple point of the substance is at 400 kPa and 100°C.



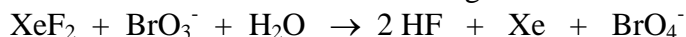
If the pressure on the substance is gradually increased from room pressure at a constant temperature of 80°C, the first change of state that will occur is:

- A) solid to liquid
- B) solid to gas
- C) gas to liquid
- D) gas to solid
- E) liquid to gas

30. Which one of the following molecules is *not* planar ?

- A) BF_3
- B) H_2CO
- C) HNNH
- D) H_2NNH_2
- E) H_2CCH_2

31. Which statement is correct for the following reaction:



- A) fluorine is oxidized, bromine is reduced. D) bromine is oxidized, xenon is reduced.
B) bromine is oxidized, oxygen is reduced. E) fluorine is oxidized, oxygen is reduced.
C) xenon is oxidized, oxygen is reduced.

32. The ground state electron configurations are given for five elements below. Which will have the highest first ionization energy?

- A) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$ D) $1s^2 2s^2 2p^6 3s^2 3p^1$
B) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^1$ E) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
C) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$

33. An element has ionization energies as follows:

$$\text{1st Ionization Energy} = 7.35 \times 10^2 \text{ kJ/mol}$$

$$\text{2nd Ionization Energy} = 1.45 \times 10^3 \text{ kJ/mol}$$

$$\text{3rd Ionization Energy} = 7.72 \times 10^3 \text{ kJ/mol}$$

This element is a member of which of the following groups?

- A) alkali metals D) noble gases
B) alkali earth metals E) metalloids
C) halogens

34. The atomic radii of some elements are listed in the chart below.

Nitrogen	7.5 nm
Phosphorus	10.6 nm
Arsenic	11.9 nm
Bismuth	14.6 nm

Considering these data, the atomic radius of Antimony is closest to:

- A) 9.5 nm B) 11.5 nm C) 13.5 nm D) 15.0 nm E) 20.0 nm

35. Consider the electron configurations for five elements (V,W,X,Y,Z).

Element	Electron Configuration
V	2, 8, 6
W	2, 8, 7
X	2, 8, 8
Y	2, 8, 8, 1
Z	2, 8, 8, 2

The *most electronegative* element in the above list is:

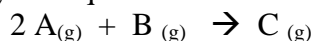
- A) V B) W C) X D) Y E) Z

This information refers to questions 36 to 38 below.

Substance	Boiling Point (°C)	Solubility in Water	Electrical Conductivity in Solid	Electrical Conductivity in Liquid
A	2212	low	high	high
B	78	high	low	low
C	2590	low	low	low
D	-45	low	low	low
E	1890	high	low	high

36. In the table above, the substance that could best be described as a “set of positive particles held together by a pool of valence electrons” is:
- A) A B) B C) C D) D E) E
37. Which substance in the above table may be an organic hydrocarbon consisting of small molecules?
- A) A B) B C) C D) D E) E
38. Which substance in the above table may be an ionic solid?
- A) A B) B C) C D) D E) E

39. A chemical reaction can be described by the equation:



At a constant temperature, the initial rate of the reaction was measured for various initial concentrations of A and B. Data was recorded as follows:

Initial Concentration (mol/L)		Initial Reaction Rate
[A]	[B]	(mol of C /min)
0.50	0.50	0.12
1.0	0.50	0.48
1.0	1.0	0.48
1.5	1.0	1.08
1.0	1.5	0.48

The rate law expression for this reaction is:

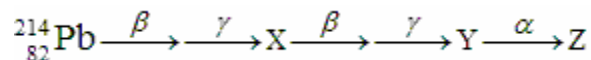
- A) Rate = $k [\text{A}]^2$
- B) Rate = $k [\text{B}]^2$
- C) Rate = $k [\text{A}][\text{B}]$

- D) Rate = $k [\text{A}]^2[\text{B}]$
- E) Rate = $k [\text{A}]^2 [\text{B}]^2$

40. Which of the following scientists is most closely associated with the discovery of radioactivity?

- A) Milliken
- B) Becquerel
- C) Rutherford
- D) Thompson
- E) Einstein

41. In the following nuclear decay sequence, α represents an alpha particle, β represents a beta particle and γ represents a gamma ray.



The correct symbol for element Z in this decay sequence is:

- A) ${}_{82}^{210}\text{Pb}$
- B) ${}_{78}^{210}\text{Pt}$
- C) ${}_{82}^{214}\text{Pb}$
- D) ${}_{84}^{218}\text{Po}$
- E) ${}_{86}^{218}\text{Rn}$

42. A radioactive isotope decays to a stable isotope by emitting beta particles. The half-life is 25 minutes. The isotope is placed in an aluminum container on an electronic balance and the following scale readings are observed.

Mass with empty container 0.00 g (tared)

Mass with container and isotope 1.00 g

After 75 minutes, what reading should be observed on the balance scale?

- A) 0.07 g
- B) 0.13 g
- C) 0.25 g
- D) 0.50 g
- E) 1.00 g

43. A radioactive isotope X has a half-life of 6 h and an isotope Y has a half-life of 12 h. A mixture that has equal numbers of X and Y atoms when prepared, will have what ratio of X atoms to Y atoms after 24 h?

- A) 1:1 B) 1:2 C) 1:3 D) 1:4 E) 1:6

44. In the gaseous state, which molecule has the smallest dipole moment?

- A) NH₃ B) H₂O C) HF D) OF₂ E) CO₂

45. Two wires are connected to a battery and a light bulb in series. When the ends of the wires are touched together, the bulb lights. When the ends of the wires are dipped into a beaker of distilled water, the bulb remains unlit. One gram of a compound is dissolved in the water and the bulb is inspected to see if it is radiating light.

Which of the following compounds would result in the *least* intensity of light radiated from the bulb?

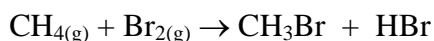
- A) MgSO₄ B) BaSO₄ C) H₂SO₄ D) KOH E) HCl

46. "An acid is a proton donor." By this definition, which of the substances in the following system at equilibrium exhibit acidic behavior?



- A) NH₄⁺ only D) Both H₂O and NH₄⁺
 B) NH₃ only E) Both NH₃ and OH⁻
 C) H₂O only

47. What is the approximate energy released in the reaction:



given these average bond energies in kJ/mol?

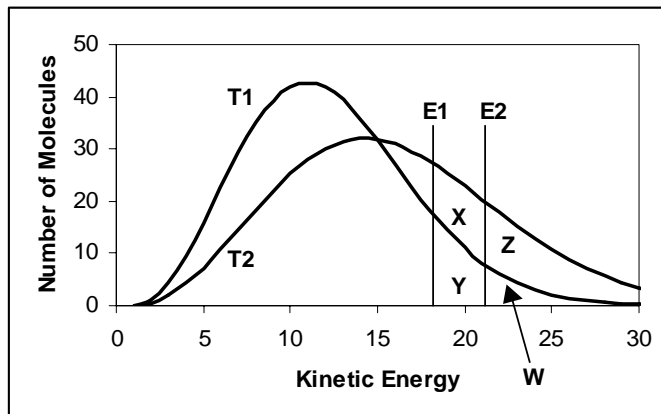
H-H	436	C-Br	288
Br-Br	194	C-H	413
H-Br	366	C-C	348

- A) 685 kJ/mol B) 435 kJ/mol C) 297 kJ/mol D) 141 kJ/mol E) 47 kJ/mol

This information refers to Questions 48 and 49

The following diagram shows the kinetic energy distribution of a fixed sample of a reaction mixture. The curves labeled T1 and T2 refer to the same sample at different temperatures.

The labels E1 and E2 refer to the threshold energy for the reaction with and without the presence of a catalyst.



The label X refers to the molecules populating the area enclosed by the two curves and the two lines. The labels Y, Z, and W refer to similar areas enclosed either by curves or axes.

48. The fraction of molecules able to react without a catalyst in the sample at the higher temperature is in the area(s):
- A) W only B) Z + W C) Y + W D) X + Y E) X + Z
49. The molecules able to react at the lower temperature in the presence of a catalyst are represented in the areas:
- A) W only D) X + Y
 B) W + Z E) W + X + Y + Z
 C) W + Y
50. A mixture of headache pain relievers was separated by paper chromatography. When the solvent front had progressed 15 cm, the ingredient spots had progressed to a maximum of 10.0 cm from the start position. For this solvent/substrate combination the ingredient ASA has an $R_f = 0.64$. As measured from the start position, which spot location most likely contains ASA?
- A) 3.2 cm B) 6.4 cm C) 8.0 cm D) 9.6 cm E) 10.0 cm
51. Orbital hybridization described by sp^3d^2 results in what molecular shape?
- A) trigonal planar D) bent
 B) square planar E) tetrahedral
 C) octahedral

52. Barium chloride crystals are dissolved in a methanol/water solvent and the solution is sprayed into a nearly colorless Bunsen burner flame. [Don't do this at home!]
The color in the flame resulting from the presence of barium ions is:
- A) red B) orange C) green D) blue E) violet
53. Nickel-Cadmium batteries are rechargeable. The reduction potentials for the reactions that occur inside the battery are as follows:
- $$\text{NiO}_2(\text{s}) + 2 \text{H}_2\text{O} + 2e^- \rightarrow \text{Ni}(\text{OH})_2(\text{s}) + 2 \text{OH}^-(\text{aq}) \quad E^\circ = + 0.49 \text{ V}$$
- $$\text{Cd}(\text{OH})_2(\text{s}) + 2e^- \rightarrow \text{Cd}(\text{s}) + 2 \text{OH}^-(\text{aq}) \quad E^\circ = - 0.81 \text{ V}$$
- What material forms at the cathode of the cell when the battery is being discharged?
- A) NiO₂ B) Ni(OH)₂ C) H₂O D) Cd(OH)₂ E) Cd
54. An electrolysis cell is constructed with an iron medallion immersed in a gold(III) chloride solution. How long would it take to deposit 0.5 g of gold metal on the medallion using a current of 2.0 amperes?
[1 Faraday = 96 500 Coulombs]
- A) 0.1 h B) 0.2 h C) 0.6 h D) 1 h E) 12.0 h
55. Chlorine in swimming pools is provided in the form of an aqueous solution of hypochlorous acid in equilibrium with its salt as:
- $$\text{HClO} \rightleftharpoons \text{H}^+(\text{aq}) + \text{ClO}^-(\text{aq}) \quad [K_a = 3 \times 10^{-8}]$$
- The electrically neutral molecule HClO is able to pass through bacterial membranes more easily than the charged ClO⁻ ion and is about 80 times more effective at killing unwanted bacteria. Thus, the control of pH in swimming pools is very important.
What pH would be required in the pool so that 88% of these molecules are in the form HClO ?
- A) 6.6 B) 7.0 C) 7.6 D) 8.0 E) 8.4

End of Test

Answer Section

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

- 41. A
- 42. E
- 43. D
- 44. E
- 45. B
- 46. D
- 47. E
- 48. B
- 49. C
- 50. D
- 51. C
- 52. C
- 53. D
- 54. A
- 55. A