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- The solubility of mercury(II) oxalate in water is 3.2×10^{-4} M. Calculate the K_{sp} of mercury(II) oxalate. For your information: The oxalate ion is $C_2O_4^{2-}$. (15B)
A. 3.2×10^{-11} B. 4.3×10^{-2} C. 1.3×10^{-10} D. 1.8×10^{-2} E. 1.0×10^{-7}

- What is the pH of a solution prepared by adding 60.0 mL of 0.20 M barium hydroxide and 30.0 mL of 0.25 M nitric acid? (14B,15A)
A. 1.30 B. 0.74 C. 12.78 D. 13.26 E. 12.70

- A certain reaction is found to be exothermic and to proceed in such a way that its randomness decreases. Which of the following correctly describes the reaction? (16)
A. The reaction is spontaneous at all temperatures.
B. The reaction is spontaneous at high temperatures but not at low.
C. The reaction is spontaneous at low temperatures but not at high.
D. The reaction is not spontaneous at any temperature.
E. There is no way to choose an answer from the data given.

- What is the solubility of manganese(II) sulfide in 0.00010 M sodium sulfide? (15B)
A. 1.4×10^{-15} B. 1.4×10^{-13} C. 1.4×10^{-19} D. 1.0×10^{-4} E. 1.4×10^{-11}



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5. What is the pH of a 0.20 M solution of potassium benzoate? **(14B)**
A. 8.74 B. 5.26 C. 11.56 D. 10.52 E. 2.44
6. The K_{sp} of cobalt(III)hydroxide is 1.6×10^{-44} . Calculate the solubility of cobalt(III)hydroxide in water in moles/liter. **(15B)**
A. 2.5×10^{-15} M B. 2.6×10^{-88} M C. 1.3×10^{-22} M D. 1.6×10^{-15} M E. 4.9×10^{-12} M
7. What is the molarity of a 18.1% solution of hydrobromic acid if the solution has a specific gravity of 1.12? **(11A)**
A. 1.16 M B. 86.0 M C. 108 M D. 0.927 M E. 2.51 M
8. If 2.8 grams of an unknown nonelectrolyte is dissolved in 68.0 grams of water, the melting point of the resulting solution is -0.630°C . What is the molecular weight of the substance? (K_f for water = $1.86^{\circ}\text{C}/\text{m}$ and K_b for water = $0.51^{\circ}\text{C}/\text{m}$.) **(11B)**
A. 64.8 g/mole B. 153 g/mole C. 122 g/mole D. 34.0 g/mole E. 82.3 g/mole



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9. Calculate the emf for the reaction, $2 \text{Fe}^{3+}(\text{aq}) + \text{Ni}(\text{s}) \rightarrow 2 \text{Fe}^{2+}(\text{aq}) + \text{Ni}^{2+}(\text{aq})$. (17)
A. -1.79 volts B. 1.79 volts C. 1.02 volts D. 0.52 volts E. -1.02 volts
10. What is the sum of the coefficients of the reactants if the equation $\text{H}_2\text{O}_2(\text{aq}) + \text{Cr}(\text{OH})_3(\text{s}) \rightarrow \text{CrO}_4^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l})$ (basic solution) is balanced? (17)
A. 5 B. 7 C. 9 D. 2 E. 8
11. What is the maximum number of milliliters of 0.23 M calcium chloride solution which could be prepared from 1.8 g of calcium chloride? (11B)
A. 7.0×10^1 mL B. 7.8×10^1 mL C. 7.0×10^{-2} mL D. 8.2×10^1 mL E. 3.7 mL
12. What is the pH of a 0.52 M solution of formic acid? (15A)
A. 2.01 B. 4.03 C. 11.99 D. 5.27 E. 9.97



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13. How many milliliters of 0.23 M hydrochloric acid is needed to prepare 64 mL of 0.12 M hydrochloric acid? (11B)
- A. 2.0×10^{-1} mL B. 8.2×10^1 mL C. 3.0×10^1 mL D. 1.2×10^2 mL E. 3.3×10^1 mL
14. At a certain temperature, it is found that 4.0 moles of nitrogen, 2.0 moles of hydrogen, and 5.0 moles of ammonia are in equilibrium in a 100.0 liter container. What is the equilibrium constant for the reaction, $3 \text{H}_2(\text{g}) + \text{N}_2(\text{g}) = 2 \text{NH}_3(\text{g})$? (13)
- A. 7.8×10^3 B. 1.6×10^4 C. 1.6×10^0 D. 1.3×10^{-4} E. 7.8×10^{-1}
15. If 194.3 mL of 0.16 M barium hydroxide are needed to completely neutralize 50.0 mL of a solution of hydrobromic acid, what is the concentration of the hydrobromic acid? (4-10)
- A. 1.2 M B. 0.082 M C. 0.62 M D. 0.31 M E. 0.16 M
16. What would be the expected boiling point of a solution prepared by adding 3.00 grams of urea (gfw = 60.0) to 45 mL of water? (K_f for water = $1.86^\circ\text{C}/\text{m}$ and K_b for water = $0.52^\circ\text{C}/\text{m}$.) (11B)
- A. 0.58°C B. 0.20°C C. 100.58°C D. 134.70°C E. 101.20°C



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17. The balanced equation for a given reaction is $2A + 3B \rightleftharpoons C$. The following data regarding the rate at which the reaction occurs were collected in the lab.

Expt.	Rate*	(A)	(B)
1	2.1×10^2	0.01 M	0.02 M
2	4.2×10^2	0.01 M	0.04 M
3	4.2×10^2	0.02 M	0.02 M

*rates are in M/sec

What is the order of the reaction with respect to A? (12A)

- A. 0 B. 1 C. 2 D. 3 E. 4
18. At a certain temperature the equilibrium constant for the reaction, $2X(g) \rightleftharpoons Y(g) + 2Z(g)$, is 0.43. If 0.25 moles of Z are mixed with 0.45 mole of X and 1.50 mole of Y in a 3.4 liter container, then (13)
- A. $Q = 0.46$ and the system reaches equilibrium by decreasing the amount of Y.
 B. $Q = 0.46$ and the system reaches equilibrium by increasing the amount of Y.
 C. $Q = 0.14$ and the system reaches equilibrium by decreasing the amount of Y.
 D. $Q = 0.14$ and the system reaches equilibrium by increasing the amount of Y.
 E. None of the above.
19. What is the age of a piece of bone in which the activity of ^{14}C is 4.5 disintegrations per second? The activity of ^{14}C in modern bone of a similar kind is 14.7 disintegrations per second and the half-life of ^{14}C is 5,730 years. (21)
- A. 1.75×10^3 years B. 4.25×10^3 years C. 2.70×10^4 years D. 9.79×10^3 years E. 5.38×10^3 years



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20. Will a precipitate form if 20.0 mL of 1.3×10^{-4} M silver(I) nitrate is mixed with 30.0 mL of 3.5×10^{-5} M sodium sulfide? (15B)
- A. Q value is 1.1×10^{-10} , so precipitate will form.
 - B. Q value is 1.1×10^{-10} , so precipitate will not form.
 - C. Q value is 5.7×10^{-14} , so precipitate will form.
 - D. Q value is 5.7×10^{-14} , so precipitate will not form.
 - E. None of the above are correct.
21. How long would it take (in hours) to deposit 1.60 grams of aluminum from a solution of aluminum nitrate through which a current of 0.120 amps is passing? (17-7)
- A. 7.94×10^2 hrs
 - B. 1.43×10^1 hrs
 - C. 2.38×10^3 hrs
 - D. 1.32×10^1 hrs
 - E. 3.97×10^1 hrs
22. What is the mole fraction of calcium nitrate in a solution prepared by adding 78.0 grams of the substance to 68.0 grams of water?
- A. 0.888
 - B. 0.534
 - C. 0.126
 - D. 0.112
 - E. 0.954
23. A certain reaction is found to proceed with an enthalpy change of 210 kcal and an entropy change of 20.0 cal/K. What is the free energy change for the reaction at 127°C? (16)
- A. -2.3 kcal
 - B. -7.8 kcal
 - C. 218 kcal
 - D. 207 kcal
 - E. 202 kcal



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24. Which of the following indicates what happens if zinc condenses at 478°C ? Its melting point is 420°C and its boiling point is 907°C . (16)
- A. Free energy decreases, enthalpy decreases, and entropy increases.
 - B. Free energy decreases, enthalpy increases, and entropy decreases.
 - C. Free energy increases, enthalpy increases, and entropy decreases.
 - D. Free energy decreases, enthalpy decreases, and entropy decreases.
 - E. Free energy increases, enthalpy increases, and entropy increases.
25. What is the pH of a solution which is 0.10 M in benzoic acid and 0.20 M in potassium benzoate? (15A)
- A. 3.88
 - B. 10.12
 - C. 2.59
 - D. 4.48
 - E. 9.52



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No. in Q-Bank	No. on Test	Correct Answer
38	7 1	E
19	7 2	D
33	7 3	C
47	7 4	E
32	7 5	A
37	7 6	E
16	7 7	E
135	7 8	C
40	7 9	C
44	7 10	C
2	7 11	A
31	7 12	A
1	7 13	E
9	7 14	A
67	7 15	A
136	7 16	C
51	7 17	B
11	7 18	D
58	7 19	D
46	7 20	C
41	7 21	E
3	7 22	D
35	7 23	E
36	7 24	D
28	7 25	D



Each correct answer is worth 3 pts. Record your answers on the back of the Scantron sheet.

51. If a reaction were found to reach completion in 3 hours and 20 minutes at 45°C, at what temperature would the same reaction reach completion in 6 hours and forty minutes? (12B)

A. 45°C B. 22°C C. 55°C D. 65°C E. 35°C

52. What is the pH of a solution with a hydroxide ion concentration of 10^{-2} M?

A. 1 B. 13 C. 12 D. 8 E. 2

53. If 13 moles of H_2 and 18 moles of P are mixed and allowed to react according to the equation

$3 H_2 + 2 P = 2 PH_3$, how many moles of H_2 remain when 8 moles of PH_3 are present in the container? (11A)

A. 10 B. 6 C. 7 D. 1 E. 0

54. **K-TYPE Answer Format:** Mark *a* if A, B, C are correct; *b* if A, C; *c* if B, D; *d* if D only; *e* otherwise. (16)

A. The larger the free energy change, the more rapidly a reaction reaches equilibrium.
B. According to the 3rd Law of Thermodynamics, entropy of a perfect crystal at 0°C is zero.
C. All exothermic reactions are always spontaneous at all temperatures.
D. The minimum work needed to cause a nonspontaneous reaction to occur is equal to the change in entropy for the reaction.



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55. Given the reaction $2 \text{Co(s)} + \text{Sn}^{4+}(\text{aq}) \rightarrow 2 \text{Co}^{2+}(\text{aq}) + \text{Sn(s)}$ choose the correct statements using **K-TYPE** Answer Format: *Mark a if A, B, C are correct; b if A, C; c if B, D; d if D only; e otherwise.* (17)
- A. According to the equation above, Co(s) loses electrons.
 - B. Co(s) is the oxidizing agent in the reaction above.
 - C. $\text{Sn}^{4+}(\text{aq})$ is reduced as the reaction above proceeds.
 - D. If the reaction $\text{W(s)} + \text{X}^{2+}(\text{aq}) \rightarrow \text{W}^{2+}(\text{aq}) + \text{X(s)}$ proceeds spontaneously, then $\text{W}^{2+}(\text{aq})$ is a better oxidizing agent than $\text{X}^{2+}(\text{aq})$.
56. A certain reaction is third order in terms of (Cl). If the rate of the reaction is 1.6×10^{-3} M/sec when (Cl) is 0.1 M, what is the rate of the reaction when (Cl) is 0.2 M? (12A)
- A. 1.3×10^{-2} M/sec
 - B. 3.2×10^{-3} M/sec
 - C. 6.4×10^{-3} M/sec
 - D. 1.6×10^{-3} M/sec
 - E. 8.0×10^{-4} M/sec
57. Choose the correct statements from the following using K-TYPE answer format. **I.E. Mark "A" if a, b, and c are correct; "B" if a and c are correct; "C" if b and d are correct; "D" if d only is correct; and "E" if any other pattern is correct.** (13,14)
- A. If the K for a reaction is 10^{13} , then you would expect to find a relatively large amount of reactants in the system at equilibrium.
 - B. A reaction with a K of 10^{-14} would react very slowly.
 - C. Potassium hydroxide would totally break apart into ions if dissolved in water.
 - D. CH_3OH would probably be more soluble than $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ in water.
58. What is the pH of a 0.052 M solution of strontium hydroxide? (14B)
- A. 7.00
 - B. 0.98
 - C. 1.28
 - D. 12.72
 - E. 13.02

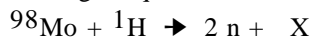


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59. **K-TYPE** answer format: Mark **a** if A,B,C are correct; **b** if A,C; **c** if B,D; **d** if D only; **e** otherwise. (11B)

- A. The vapor pressure of a 0.2 m solution of sugar would be higher than that of a 0.3 m solution of sugar.
- B. The osmotic pressure of a 0.2 m solution of sodium chloride would be the same as that of a 0.2 m solution of sugar.
- C. The boiling point of a 0.2 m solution of urea is the same as the boiling point of 0.2 m solution of sugar.
- D. The freezing point of a 0.05 m solution of sodium sulfate would be lower than that of a 0.1 m solution of sodium sulfate.

60. Which of the following is equivalent to X in the following nuclear equation? (21)



- A. ${}^{97}\text{Mo}$ B. ${}^{97}\text{Nb}$ C. ${}^{97}\text{Tc}$ D. ${}^{98}\text{Mo}$ E. ${}^{98}\text{Tc}$

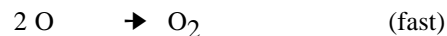
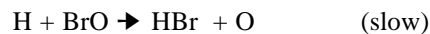
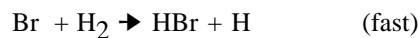
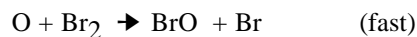
61. **K-TYPE** answer format: Mark **a** if A,B,C are correct; **b** if A, C; **c** if B, D; **d** if D only; **e** otherwise. (15B)

- A. CaF_2 would be more soluble in pure water than in a solution of 0.1 M KF.
- B. $\text{Cr}_2(\text{SO}_3)_3$ is probably soluble in water.
- C. Ag_2S would be more soluble in acidic solution than in pure water.
- D. If it appears in an aqueous reaction alone, Pt^{2+} would have to be a solid, i.e. could not be in solution.



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62. The mechanism for a certain reaction is



Choose the correct statements using

K-TYPE answer format: Mark *a* if A,B,C are correct; *b* if A, C; *c* if B, D; *d* if D only; *e* otherwise.

A. O₂ is a catalyst in the mechanism.

B. The overall reaction is $\text{H}_2 + \text{Br}_2 \rightarrow \text{HBr} + \text{H} + \text{Br}$

C. O and BrO are intermediates in the reaction.

D. If a reaction is zero order with respect to (D) and second order with respect to (F), then its rate expression would be $\text{rate} = k(\text{D})(\text{F})^2$.

63. Choose the substances which are correctly described using **K-TYPE** answer format: Mark *a* if A,B,C are correct; *b* if A, C; *c* if B, D; *d* if D only; *e* otherwise. (12B)

A. LiOH is a weak base.

B. HNO₃ is a weak acid.

C. HCl is a polyprotic acid.

D. HPO₄²⁻ is a stronger base than CH₃COO⁻.

64. Given the reaction, $4 \text{NH}_3(\text{g}) + 5 \text{O}_2 = 4 \text{NO}(\text{g}) + 6 \text{H}_2\text{O}(\text{g})$, what happens overall if NO is removed from a system at equilibrium? (13)

A. The amounts of NH₃, O₂, and H₂O increase and NO decreases.

B. The amount of H₂O increases while NH₃, O₂, and NO decrease.

C. The amounts of NH₃ and O₂ decrease while H₂O and NO increase.

D. The amounts of NH₃, O₂, and NO increase while H₂O decreases.

E. The amounts of NH₃ and O₂ increase while NO and H₂O decrease.



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65. Choose the correct statements from the following using K-TYPE answer format. I.E. Mark "A" if a, b, and c are correct; "B" if a and c are correct; "C" if b and d are correct; "D" if d only is correct; and "E" if any other pattern is correct.

- A. The HBrO_3 and $\text{Ca}(\text{OH})_2$ react to produce the $\text{Ca}(\text{BrO}_2)_2$.
- B. A solution prepared by adding 0.2 moles of acetic acid and 0.1 moles of sodium hydroxide would have buffer properties.
- C. A solution prepared by adding 0.50 moles of hydrochloric acid and 0.50 moles of sodium chloride to water would have buffer properties.
- D. The base $\text{NH}_3(\text{aq})$ is the base related to the salt NH_4Cl .

66. Choose the correct statements from the following using K-TYPE answer format. I.E. Mark "A" if a, b, and c are correct; "B" if a and c are correct; "C" if b and d are correct; "D" if d only is correct; and "E" if any other pattern is correct. (14A)

- A. In the reaction, $6 \text{Br}^- + \text{Ni}^{2+} \rightarrow [\text{NiBr}_6]^{4-}$, Ni^{2+} acts as a Lewis acid.
- B. In the equation $\text{BF}_3 + \text{NH}_3 \rightarrow \text{BF}_3\text{NH}_3$, BF_3 acts as a Lewis acid.
- C. In the reaction $[\text{CoI}_6]^{4-} + \text{H}_2\text{O} \rightarrow [\text{CoI}_5(\text{H}_2\text{O})]^{3-} + \text{I}^-$, H_2O functions as a Lewis base.
- D. A Lewis acid always donates H^+ during a reaction.

67. The half-life for the reaction of a substance X by a first order process is 2 weeks. If one has 100 grams of the substance today, how much will remain in two months (=8 weeks)? (12A)

- A. 100 g
- B. 0 g
- C. 50 g
- D. 3.1 g
- E. 6.2 g

68. X reacts with Y according to the equation, $2 \text{X} + 1 \text{Y} \rightarrow 3 \text{Z}$. What is the rate of the reaction of X when that of Z is $1.6 \times 10^{-3} \text{ M/sec}$?

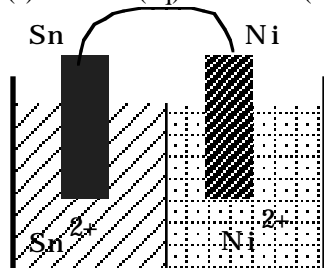
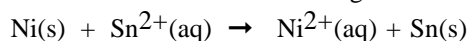
- A. $1.6 \times 10^{-3} \text{ M/sec}$
- B. $5.3 \times 10^{-4} \text{ M/sec}$
- C. $3.2 \times 10^{-3} \text{ M/sec}$
- D. $1.1 \times 10^{-3} \text{ M/sec}$
- E. $2.4 \times 10^{-3} \text{ M/sec}$



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69. **K-TYPE Answer Format:** Mark *a* if A, B, C are correct; *b* if A, C; *c* if B, D; *d* if D only; *e* otherwise.

Choose the correct statements concerning the cell diagrammed below using K-TYPE answer format. (17)



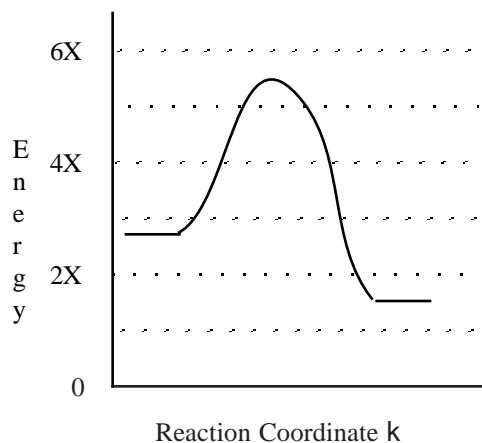
- A. The Sn electrode is the anode.
 B. The electrons move from the Ni electrode to the Sn electrode through the wire as the battery operates.
 C. The Ni^{2+} would move toward the Ni electrode as the reaction proceeds.
 D. If water is added to the Sn half-cell, the voltage of the cell decreases.
70. Choose the correct statements from the following using K-TYPE answer format. **I.E. Mark "A" if a, b, and c are correct; "B" if a and c are correct; "C" if b and d are correct; "D" if d only is correct; and "E" if any other pattern is correct. (14A)**
- A. If Li_2CO_3 were dissolved in water, the resulting solution would turn litmus blue.
 B. If HBr dissolves in water, the resulting solution has more HBr molecules than Br^- ions.
 C. If the pH of a solution is 6.8, its pOH would be 7.2 .
 D. A solution with a $[\text{H}^+] = 1.6 \times 10^{-7} \text{ M}$ is basic.
71. Choose the correct statements from the following using K-TYPE answer format. **I.E. Mark "A" if a, b, and c are correct; "B" if a and c are correct; "C" if b and d are correct; "D" if d only is correct; and "E" if any other pattern is correct. (14A)**
- A. According to Bronsted-Lowry, a base is a substance which accepts an electron pair .
 B. HCOOH is the conjugate acid of HCOOH_2^+ .
 C. In the equation $\text{HI} + \text{H}_2\text{O} \rightarrow \text{HO}^- + \text{H}_2\text{I}^+$, HI acts as a Bronsted-Lowry acid.
 D. In the equation $\text{CH}_3\text{COOH} + \text{HClO}_3 \rightarrow \text{CH}_3\text{COOH}_2^+ + \text{ClO}_3^-$, CH_3COOH acts as a Bronsted-Lowry base.



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72. Choose the correct statements from the following using K-TYPE answer format. I.E. Mark "A" if a, b, and c are correct; "B" if a and c are correct; "C" if b and d are correct; "D" if d only is correct; and "E" if any other pattern is correct. (14A)
- A. H_2SO_4 is less acidic than H_2SO_3 .
 - B. HClO_4 is more acidic than HBrO_4 .
 - C. H_2S is less acidic than PH_3 .
 - D. H_2S is more acidic than H_2O .

73. $X = 50 \text{ J}$ in the diagram. Choose the correct statements regarding the reaction represented by the diagram using K-TYPE answer format: Mark a if A, B, & C are correct; b if A & C are correct; c if B & D are correct; d if D only is correct; e otherwise. (12B)



- A. The energy of the reactants is approximately 65 J.
- B. The energy change for the reaction is approximately -37 J.
- C. The activation energy for the reaction is approximately 73 J.
- D. The energy of the activated complex is approximately 73 J.



Each correct answer is worth 3 pts. Record your answers on the back of the Scantron sheet.

74. **K-TYPE Answer Format:** Mark *a* if A, B, C are correct; *b* if A, C; *c* if B, D; *d* if D only; *e* otherwise. (17)

- A. Cl_2 is a better oxidizing agent than NO_3^- .
- B. Zn is a better reducing agent than Al.
- C. O_2 , MnO_4^- , and H_2O_2 are common oxidizing agents.
- D. The oxidation number of Cl in KClO_3 is - 5.

75. How does the $[\text{H}^+]$ of the solution change when the pH of the solution is increased by 3? (14B-3)

- A. It decreases to 1/3 of its original value.
- B. It becomes 3 times larger.
- C. It becomes 1,000 times its original value.
- D. It decreases to 1/1,000 of its original value.
- E. It is not affected.



Each correct answer is worth 3 pts. Record your answers on the back of the Scantron sheet.

No. in Q-Bank	No. on Test	Correct Answer
49	7	51 E
29	7	52 C
8	7	53 D
34	7	54 D
42	7	55 B
54	7	56 C
5	7	57 B
24	7	58 E
14	7	59 B
57	7	60 C
39	7	61 B
56	7	62 B
18	7	63 D
10	7	64 B
27	7	65 C
21	7	66 A
64	7	67 E
50	7	68 D
45	7	69 C
23	7	70 B
22	7	71 D
20	7	72 C
55	7	73 A
43	7	74 B
25	7	75 D