Representative Questions—Exam 3

1. The kinetic-molecular theory of gases assumes which of the following?
   a. gas samples are mostly empty space
   b. the average kinetic energy is proportional to the Kelvin temperature
   c. when gas particles collide with each other, they do so without losing energy
   d. a and b
   e. all of the above

2. A fixed amount of gas occupies a flask with a volume of 2.55 L. What is the effect on the pressure of the gas if the temperature is increased?
   a. The pressure increases.
   b. The pressure decreases.
   c. The pressure remains the same.
   d. The pressure might increase or decrease depending on the number of moles present.
   e. There is not enough information to determine the effect on the pressure.

3. Which of the following best represents the behavior of V and n for an ideal gas when both pressure (P) and amount (T) are fixed?

   I
   \[ \frac{V}{n} \]

   II
   \[ \frac{V}{n} \]

   III
   \[ \frac{V}{n} \]

   IV
   \[ \frac{V}{n} \]

   a. I
   b. II
   c. III
   d. IV
   e. none of the above

4. Which is/are true?
   a. \( P \propto T \) with fixed n, V
   b. \( V \propto T \) with fixed n, P
   c. \( V \propto \frac{1}{P} \) with fixed n, T
   d. \( V = kT \) with fixed n, P
   e. all of the above

5. A fixed amount of gas occupies a flask with a volume of 2.55 L. What is the effect on the pressure of the gas if the temperature is increased?
   a. The pressure increases.
   b. The pressure decreases.
   c. The pressure remains the same.
   d. The pressure might increase or decrease depending on the number of moles present.
   e. There is not enough information to determine the effect on the pressure.
6. A gas occupies 2.0 L at 800 torr and 30°C. Which of the following is true if the volume is held constant and the pressure is reduced to 600 torr?
   a. Temperature decreases by less than 100 K.
   b. Temperature decreases by more than 100 K.
   c. Temperature increases by less than 100 K.
   d. Temperature increases by more than 100 K.
   e. Temperature does not change.

7. Calculate the pressure when 3.0 moles of an ideal gas occupy a volume of 3.0 L and the temperature is 400 K?
   a. 33 atm
   b. 67 atm
   c. 296 atm
   d. $3.1 \times 10^{-2}$ atm
   e. $3.1 \times 10^{2}$ atm

8. What is the volume of 2 moles of neon gas at 0°C and 1 atm?
   a. 22.4 L
   b. 44.8 L
   c. 67.2 L
   d. 11.2 L
   e. 33.6 L

9. What is the volume of a half mole of nitrogen gas at 0°C if the pressure is 760 torr?
   a. 22.4 L
   b. 44.8 L
   c. 11.2 L
   d. 67.2 L
   e. 33.6 L

10. Assume n and P are fixed for a sample of gas that occupies 200. mL at 350. K. What is the temperature if the volume is 300. mL?
    a. 300. K
    b. 233 K
    c. 350. K
    d. 525 K
    e. 200. K

11. A balloon occupies 2 L at 1 atm at 200 K. What is the volume at 6 atm and 1200 K?
    a. 0.056 L
    b. 1 L
    c. 72 L
    d. 18 L
    e. 2 L
12. A gas (4.0 mol) occupies 3.00 L at 200.0 K. What is the pressure?
a. 12 atm  
b. 22 atm  
c. 90 atm  
d. 273 atm  
e. 4.9 \times 10^{-3} \text{ atm}

13. Suppose a 4.00 L flask contains 21.45 g of a gas at 400.0 K and a pressure of 2.00 atm, what is the molecular weight of the gas? Hint: Substitute mass/molar mass for n in the ideal gas equation.
a. 22.4 g/mol  
b. 42.9 g/mol  
c. 86.0 g/mol  
d. 88.1 g/mol  
e. 176 g/mol

14. A syringe contains a gas that has a volume of 20.0 cc at 11.5 psi. If the tip is blocked so that the gas can't escape, what pressure is required to decrease the volume to 1.50 cc?
a. 0.863 psi  
b. 345 psi  
c. 153 psi  
d. 230 psi  
e. 2.61 psi

15. The gases in this problem are all at the same temperature. Which of the following shows the gases listed correctly in order of increasing average velocity?
a. Ne < H_{2} < Ar < Cl_{2} 
b. Cl_{2} < Ar < Ne < H_{2} 
c. Ar < Ne < Cl_{2} < H_{2} 
d. Cl_{2} < Ne < H_{2} < Ar 
e. Cl_{2} < Ne < Ar < H_{2}

16. A flask contains the following gases:

<table>
<thead>
<tr>
<th>Xe</th>
<th>CH_{4}</th>
<th>N_{2}</th>
<th>He</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>II</td>
<td>III</td>
<td>IV</td>
</tr>
</tbody>
</table>

Arrange the gases in order of increasing average speed.
a. I < II < III < IV  
b. IV < II I < II < I  
c. III < I < IV < II  
d. IV < II < I < III  
e. I < III < II < IV
17. What is the partial pressure of Ne gas if a closed flask contains 40 g of Ne and 40 g of Ar and the total pressure is 120 torr?
   a. 40 torr  
   b. 80 torr  
   c. 180 torr  
   d. 240 torr  
   e. 360 torr

18. A flask contains 0.80 L of helium and 0.20 L of neon at 2.0 atm. What is the partial pressure of helium? Hint: Remember the total of the partial pressures equals the total pressure.
   a. 2.0 atm  
   b. 1.6 atm  
   c. 1.2 atm  
   d. 0.8 atm  
   e. 0.4 atm

19. A gas in a 2.0 liter container with rigid walls is initially at 300 K and a pressure of 3.0 atm. If the gas is warmed to 400 K, what is the pressure inside the container?
   a. 0.5 atm  
   b. 1.0 atm  
   c. 2.0 atm  
   d. 4.0 atm  
   e. 8.0 atm

20. A sample of gas occupies 200 mL at 300 K. What is the temperature if the gas occupies a volume of 500 mL?
   a. 60.0 K  
   b. 120. K  
   c. 273 K  
   d. 333 K  
   e. 750 K

21. Since pressure and temperature are directly proportional to each other (for a fixed amount of gas at constant volume) we mathematically say that
   a. $P = k(1/T)$  
   b. $P = kT$  
   c. $PT = k$  
   d. $1/k = (P)(T)$  
   e. $P_1T_1 = P_2T_2$

22. Suppose that the pressure on a sample of gas is 0.0250 atm when the temperature is 80.0 K and the gas occupies a volume of 24.00 L. If the pressure increases to 10.0 atm and the temperature increases to 200.0 K, what is the new volume occupied by this gas sample?
   a. 0.0240 L  
   b. 15.0 L  
   c. 0.00417 L  
   d. 0.150 L  
   e. 2.40 L
23. A flask contains 4 g of helium at 0 °C and 1 atm. What is the volume of the gas?
   a. 0.0100 L
   b. 0.0500 L
   c. 2.30 L
   d. 22.4 L
   e. 89.6 L

24. What is the temperature of 5.0 moles of argon gas occupying 8.00 L at 3 atm?
   a. 0.0170 K
   b. 0.390 K
   c. 273 K
   d. 162 K
   e. 58.5 K

25. Assuming that the temperature and pressure remain constant, how much water will be produced from 2.5 L of hydrogen?

   \[2 \text{H}_2 (g) + O_2 (g) \rightarrow 2 \text{H}_2\text{O} (g)\]

   a. 10 L
   b. 5.0 L
   c. 2.5 L
   d. 1.3 L
   e. 0.63 L

26. Three liters of nitrogen and 6 L of oxygen reacted and produced 3 L of product (all gases at the same temperature and pressure). Which equation best describes what must have occurred?
   Hint: This is an application of Avogadro’s Law.
   a. \(\text{N}_2 + \text{O}_2 \rightarrow \text{N}_2\text{O}_2\)
   b. \(\text{N}_2 + 2 \text{O}_2 \rightarrow 2 \text{NO}_2\)
   c. \(2 \text{N}_2 + \text{O}_2 \rightarrow 2 \text{N}_2\text{O}\)
   d. \(\text{N}_2 + 2 \text{O}_2 \rightarrow \text{N}_2\text{O}_4\)
   e. \(\text{N}_2 + 3 \text{O}_2 \rightarrow 2 \text{NO}_3\)

27. Which intermolecular forces are present within a pure sample of CH₃F?
   a. only dipole-dipole forces
   b. only hydrogen-bonding forces
   c. only London dispersion forces
   d. London dispersion forces and dipole-dipole forces
   e. London dispersion forces and dipole-dipole forces and hydrogen-bonding forces

28. All of the following molecules experience London dispersion forces. Which of these is also capable of dipole-dipole interactions?
   a. BH₃
   b. NH₃
   c. CH₄
   d. CCl₄
   e. CO₂
29. The ability of water to form intermolecular hydrogen bonds is responsible for
   a. its surprisingly low specific heat.
   b. its low heat of vaporization.
   c. its surprisingly high boiling point.
   d. the increase in density when liquid water freezes.
   e. all of the above

30. What types of intermolecular forces exist between molecules of compound A and molecules of compound B?

   a. London dispersion forces
   b. dipole-dipole forces
   c. hydrogen bonding
   d. a and b
   e. all of the above

31. Place the following in order of increasing boiling point.

   \[ \text{NH}_3 \quad \text{H}_2\text{O} \quad \text{Ne} \quad \text{NO} \]
   I     II    III   IV

   a. I < II < III < IV
   b. IV < III < II < I
   c. III < II < I < IV
   d. III < IV < I < II
   e. II < I < III < IV

32. Which of the following is capable of hydrogen-bonding?

   a. CBr\textsubscript{4}
   b. CH\textsubscript{3}OH
   c. CHCl\textsubscript{3}
   d. HCN
   e. H\textsubscript{2}

33. Which of the following is capable of dipole-dipole interactions, but can’t H-bond?

   a. BH\textsubscript{3}
   b. CH\textsubscript{3}OH
   c. H\textsubscript{2}S
   d. SiH\textsubscript{4}
   e. NH\textsubscript{3}
34. Molecules of pentane, CH₃CH₂CH₂CH₂CH₃, interact with each other via which type(s) of intermolecular forces?
   a. London dispersion forces
   b. Dipole-dipole forces
   c. Hydrogen bonding forces
   d. London dispersion forces and dipole-dipole forces
   e. London dispersion forces, dipole-dipole forces, and hydrogen bonding forces

35. Which of the following intermolecular forces are present in a sample of acetone?

![Acetone structure](image:https://example.com/acetone.png)

   a. only hydrogen-bonding forces
   b. only dipole-dipole forces
   c. only London dispersion forces
   d. hydrogen-bonding and dipole-dipole forces
   e. London dispersion and dipole-dipole forces

36. Predict the order of increasing boiling point based on the intermolecular forces present.

<table>
<thead>
<tr>
<th>Compound</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₂CH₂Cl</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CH₃CH₃</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

   a. I < II < III
   b. III < I < II
   c. II < III < I
   d. III < II < I
   e. I < III < II

37. Which is an endothermic transformation?
   a. liquid to solid
   b. solid to liquid
   c. gas to solid
   d. gas to liquid
   e. none of the above

38. How much heat is needed to melt 22.4 g of ice at 0°C to form liquid water at 0°C? **Caution: Units!**
   a. 3.56 cal
   b. 22.4 cal
   c. 99.2 cal
   d. 1.79 kcal
   e. 12.1 kcal
Steam (36 grams at 120.0°C) is cooled until the entire sample condenses to liquid at 100.0°C. How much heat is released? The specific heat for H₂O in the vapor phase is 0.480 cal/g°C.

Note: Some additional useful information is available on the front of the exam.

   a. 0.346 kcal
   b. 1.43 kcal
   c. 19.1 kcal
   d. 19.8 kcal
   e. 734 kcal

What is the total amount of heat needed to boil and vaporize 10.0 g of water that is initially at 50.0°C? (Hint: Two separate calculations are necessary! See the front of the exam for useful data.)

   a. 0.50 kcal
   b. 1.3 kcal
   c. 4.9 kcal
   d. 5.4 kcal
   e. 5.9 kcal

Which illustrates the “like dissolves like” principle for a solid solute and a liquid solvent?

   a. a polar compound is soluble in a polar solvent
   b. a nonpolar compound is soluble in a nonpolar solvent
   c. an ionic compound is soluble in a very polar solvent
   d. all of the above
   e. none of the above

Which of the following is likely to be a soluble combination (at least to some significant extent)?

   a. CCl₄ and water
   b. CaCl₂ and CCl₄
   c. KCl and octane (C₈H₁₈)
   d. K₂SO₄ and CCl₄
   e. CBr₄ and CCl₄

The volume of solute in mL, divided by the volume of solution in mL, expressed as a percent, is the concentration unit that is abbreviated

   a. M
   b. w/v %
   c. v/v %
   d. w/w %
   e. ppm

Suppose 250 mL of a solution contains 20. g of CaO. What is its w/v %?

   a. 8% (w/v)
   b. 16% (w/v)
   c. 24% (w/v)
   d. 32% (w/v)
   e. 64% (w/v)
45. What is the v/v % of a 500 mL solution containing 75 mL of methanol?
a. 0.75 %
b. 38 %
c. 67 %
d. 75 %
e. 15 %

46. How would you correctly prepare 500.0 mL of a solution that is 2.0% (w/v) Na₂SO₄?
a. dissolve 2.0 g Na₂SO₄ in water and dilute to a total volume of 500.0 mL.
b. dissolve 4.0 g Na₂SO₄ in water and dilute to a total volume of 500.0 mL.
c. dissolve 10.0 g Na₂SO₄ in water and dilute to a total volume of 500.0 mL.
d. combine 2.0 g Na₂SO₄ and 500.0 g of water.
e. combine 2.0 g Na₂SO₄ and 500.0 mL of water.

47. Suppose 15.0 g of methanol (CH₃OH) and 85.0 g of water are combined. What is the concentration of the solution that is produced?
a. 1.76 % (w/w)
b. 0.176 % (w/w)
c. 17.6 % (w/w)
d. 0.15 % (w/w)
e. 15.0 % (w/w)

48. What is the approximate molarity of a solution of NaOH that is 5.0% w/v?
a. 1.6 M
b. 0.80 M
c. 12.5 M
d. 0.039 M
e. 1.25 M

49. How many grams of salt are needed to make 300. mL of a solution that is 3.0% (w/v)?
a. 0.18 g
b. 0.90 g
c. 3.0 g
d. 9.0 g
e. 15 g

50. What is the molarity of a solution prepared by dissolving 80.0 g of NaOH in water and diluting until the total volume is 1.0 L?
a. 0.5 M
b. 1 M
c. 2 M
d. 4 M
e. 8 M
51. If 500 mL of water were added to 500 mL of 0.50 M silver nitrate, what would be the approximate concentration of the resulting solution?
   a. 0.05 M
   b. 0.25 M
   c. 0.50 M
   d. 0.75 M
   e. 1.0 M

52. A sample collected from a lake is found to contain 3.6 ppm mercury. What is the concentration if 150 mL of the sample is diluted to a total volume of 600 mL?
   a. 50 ppm
   b. $1.8 \times 10^2$ ppm
   c. 14 ppm
   d. 0.25 ppm
   e. 0.90 ppm

53. If 400.0 mL of 10.0 % (w/v) fructose ($C_6H_{12}O_6$) solution were evaporated to dryness, how many grams of the fructose would we have?
   a. 2.5 g
   b. 4.0 g
   c. 25.0 g
   d. 40.0 g
   e. 72.0 g

54. If 100 mL of 1.0 M CaCl$_2$ and 300 mL of water are combined, what is the approximate chloride ion concentration in the resulting solution?
   a. 0.33 M
   b. 0.25 M
   c. 0.50 M
   d. 3.0 M
   e. 4.0 M

55. Which one of the following, when prepared as a 0.1M solution in water, would have its freezing point depressed the most relative to pure water?
   a. NaCl
   b. glucose
   c. CaCl$_2$
   d. KI
   e. CsI

56. If 500 mL of 2.5 M KF solution were evaporated to dryness, how many grams of the KF salt would be recovered?
   a. 2.5 g
   b. 7.3 g
   c. 11.6 g
   d. 73 g
   e. 130 g
57. Sodium bicarbonate is only somewhat soluble in water, such that a solution of NaHCO$_3$ in water that is 9.6% (w/v) is a saturated solution. Which of the following is (are) true?
   a. A solution prepared by combining 5 g of NaHCO$_3$ and 100 mL of water is saturated.
   b. Adding sodium chloride to a NaHCO$_3$ solution will increase the Na$^+$ concentration in the solution.
   c. Adding additional sodium bicarbonate to an already saturated solution will cause a further reduction in the vapor pressure of the solution.
   d. A saturated solution always has excess solid present.
   e. all of the above

58. If 2.0 L of 0.40 M LiCl and 2.0 L of 0.60 M LiNO$_3$ are combined, what is the lithium ion concentration in the resulting solution?
   a. 0.2 M
   b. 0.4 M
   c. 0.5 M
   d. 0.6 M
   e. 1.0 M

59. How much potassium chloride is needed to prepare 500 mL of a KCl solution that is 30 w/v%?
   a. 30. g
   b. 150 g
   c. 6.0 g
   d. 0.17 g
   e. 0.67 g

60. If 400 mL of water are added to 0.40 mole of potassium nitrate, what would be the approximate concentration of the resulting solution?
   a. 1.0 M
   b. 0.75 M
   c. 0.50 M
   d. 0.10 M
   e. 0.050 M

61. Which of the following is 40. ppm?
   a. 4.0 mL in 1.0 \times 10^2 mL of solution
   b. 4.0 mL in 1.0 \times 10^4 mL of solution
   c. 4.0 mL in 1.0 \times 10^5 mL of solution
   d. 4.0 mL in 1.0 \times 10^6 mL of solution
   e. 4.0 mL in 1.0 \times 10^9 mL of solution

62. What mass of barium chloride is needed to prepare 500 mL of 0.28 M BaCl$_2$ solution?
   a. 7.3 g
   b. 48.4 g
   c. 29.2 g
   d. 116.6 g
   e. 372 g
63. A solution is prepared by dissolving 25.0 g of SrCl\(_2\) in water and diluting to a volume of 500 mL. What is the concentration of the resulting solution?
   a. 13.0 M  
   b. 5.00 M  
   c. 0.0500 M  
   d. 0.315 M  
   e. 31.5 M

64. What is the concentration if 200 mL of a 4.0 M salt solution is diluted with water until the total volume is 800 mL?
   a. 32 M  
   b. 0.2 M  
   c. 0.3 M  
   d. 0.5 M  
   e. 1.0 M

65. Which solution has the highest concentration of sodium ions?
   a. 0.1 M NaBr  
   b. 0.2 M Na\(_2\)SO\(_4\)  
   c. 0.2 M Na\(_3\)PO\(_4\)  
   d. 0.3 M NaCl  
   e. All of the solutions have the same concentration of sodium ions.

66. A solution containing 50 g of sugar in 500 g of water would:
   a. have a higher vapor pressure than pure water  
   b. have a vapor pressure less than pure water  
   c. boil at a temperature below 100°\(C\)  
   d. freeze at a temperature above 0°\(C\)  
   e. none of the above

67. Relative to pure solvent, a solution containing a non-volatile solute has a ______ vapor pressure and a ______ boiling point.
   a. lower, higher  
   b. lower, lower  
   c. higher, lower  
   d. higher, higher  
   e. none of the above

68. Decreasing the total pressure above a liquid (for example: by taking the liquid to a higher elevation) will cause the boiling point of the liquid to
   a. increase.  
   b. decrease.  
   c. remain the same.  
   d. depends on the density of the liquid (could increase, decrease or stay the same)  
   e. depends on the molar mass of the liquid (could increase, decrease or stay the same)
69. The addition of a soluble, non-volatile solute, such as KI, to water
   a. lowers its boiling point.
   b. raises its freezing point.
   c. decreases its conductivity.
   d. increases its vapor pressure.
   e. decreases its vapor pressure.

70. Which of the following, when placed in water, is a strong electrolyte?
   a. CH₃OH
   b. BaSO₄
   c. Na₃PO₄
   d. PbCl₂
   e. sugar

71. Which of these aqueous solutions would have the lowest freezing point?
   a. 1.0 M Al₂(SO₄)₃
   b. 2.5 M NaCl
   c. 5.0 M sucrose (table sugar)
   d. 1.5 M BaCl₂
   e. 1.5 M AlCl₃

72. Compared to pure water, a 1.0 M solution of CsCl will have a
   a. higher boiling point and a higher freezing point.
   b. higher boiling point and a lower freezing point.
   c. lower boiling point and a higher freezing point.
   d. lower boiling point and a lower freezing point.
   e. none of the above

73. Which of the following is true when a non-volatile solute, such as MgSO₄, is added to water?
   a. Freezing point increases
   b. Boiling point decreases
   c. Conductivity increases
   d. all of the above
   e. none of the above

74. When a liquid evaporates
   a. entropy increases and heat is absorbed.
   b. entropy increases and heat is released.
   c. entropy decreases and heat is absorbed.
   d. entropy decreases and heat is released.
   e. ΔS and ΔH are both zero.

75. An exothermic reaction is one where heat is ______ and ΔH is ______ zero.
   a. absorbed, less than
   b. released, less than
e. Don’t mark E!
76. Which would have a negative value for $\Delta S$?
   a. $\text{CO}_2 (s) \rightarrow \text{CO}_2 (g)$
   b. $\text{Ag}^+ (aq) + \Gamma (aq) \rightarrow \text{AgI} (s)$
   c. $\text{N}_2 (g) + 3 \text{H}_2 (g) \rightarrow 2 \text{NH}_3 (g)$
   d. a and b
   e. b and c

77. Which would have a negative value for $\Delta S$? In other words, which involves entropy decreasing?
   a. nitrogen gas and hydrogen gas reacting to form $\text{NH}_3 (g)$
   b. a new deck of playing cards being shuffled
   c. a few drops of water evaporating
   d. a and b
   e. b and c

78. Based on the reaction shown, which of the following is true?
   $\text{N}_2 (g) + \text{O}_2 (g) \rightarrow 2 \text{NO} (g)$  $\Delta H = 43.2$ kcal
   a. 43.2 kcal are consumed when 1.00 g of $\text{N}_2$ reacts.
   b. 43.2 kcal are consumed when 1.00 g of $\text{O}_2$ reacts.
   c. 43.2 kcal are consumed when 1.00 mol of $\text{N}_2$ reacts.
   d. 43.2 kcal are consumed when 1.00 mol of NO is produced
   e. 43.2 kcal are released when 1.00 mol of NO is produced.

79. About how much heat is released when 16.0 grams of $\text{SO}_2$ is converted into $\text{SO}_3$ in the following reaction?
   $2 \text{SO}_2 (g) + \text{O}_2 (g) \rightarrow 2 \text{SO}_3 (g) + 198.2$ kJ
   a. 793 kJ
   b. 396 kJ
   c. 49.6 kJ
   d. 203 kJ
   e. 24.8 kJ

80. What is the value of $\Delta G$ at 27°C for a reaction if $\Delta H = -17.4$ kcal and $\Delta S = 0.0272$ kcal/K.
   a. 25.6 kcal
   b. -25.6 kcal
   c. -8100 kcal
   d. -9.24 kcal
   e. -16.7 kcal

81. What is the value of $\Delta G$ at 25°C for the reaction of 2 moles of bismuth and 3 moles of sulfur according to the equation: 2 $\text{Bi} (s) + 3 \text{S} (s) \rightarrow \text{BiS}_3 (s)$? Caution: Watch your units!
   For this reaction, $\Delta H = -43.7$ kcal and $\Delta S = -15.2$ cal/K.
   a. -39.2 kcal
   b. 39.2 kcal
   c. 43.3 kcal
   d. -43.3 kcal
   e. -48.2 kcal
Refer to the following energy diagram for problems 82 through 84.

82. What is $\Delta G$ for this reaction?
   a. +6 kcal  
b. +10 kcal  
c. +19 kcal  
d. −6 kcal  
e. −15 kcal

83. What is the activation energy ($E_a$) for this reaction?
   a. +4 kcal  
b. +6 kcal  
c. +10 kcal  
d. +15 kcal  
e. +19 kcal

84. In the reverse direction, this reaction is _________ and $\Delta G$ is _________.
   a. not spontaneous, +9 kcal  
b. not spontaneous, +15 kcal  
c. spontaneous, −6 kcal  
d. spontaneous, −9 kcal  
e. spontaneous, −15 kcal

85. **Exothermic** means
   a. heat is a product and $\Delta H < 0$.  
b. heat is a reactant and $\Delta H < 0$.  
c. heat is a product and $\Delta H > 0$.  
d. heat is a reactant and $\Delta H > 0$.  
e. $\Delta G > 0$.  

86. Which of the following is likely true for the reaction below?

   \[ C_6H_5OH(g) + 7 O_2(g) \rightarrow 6 CO_2(g) + 3 H_2O(g) \]
   a. exothermic and entropy increases  
b. endothermic and entropy increases  
c. exothermic and entropy decreases  
d. endothermic and entropy decreases  
e. $\Delta H = 0$ and $\Delta S = 0$
87. Which of the following conditions will result in a spontaneous reaction regardless of the temperature?
   a. $\Delta H < 0$ and $\Delta S < 0$
   b. $\Delta H > 0$ and $\Delta S < 0$
   c. $\Delta H < 0$ and $\Delta S > 0$
   d. $\Delta H > 0$ and $\Delta S > 0$
   e. $\Delta H > 0$ and $\Delta S = 0$

88. A reaction is *certainly* spontaneous if
   a. $\Delta S$ is positive.
   b. $\Delta S$ is negative.
   c. $\Delta H$ is positive.
   d. $\Delta G$ is positive.
   e. $\Delta G$ is negative.

89. An endothermic reaction is one where heat is ______ and $\Delta H$ is ______ zero.
   a. absorbed, less than
   b. released, less than
   c. absorbed, greater than
   d. released, greater than
   e. Don’t mark E!

90. The enthalpy change is $-43.2$ kcal for the reaction: $2 \text{NO} \rightarrow \text{N}_2 + \text{O}_2$
    Formation of 84 g of nitrogen gas will result in ______ kcal being ______.
    Hint: nitrogen gas, $\text{N}_2$, is 28 g/mol.
   a. 43.2 kcal; released
   b. 130 kcal; released
   c. 14.4 kcal; released
   d. 43.2 kcal; absorbed
   e. 130 kcal; absorbed

Consider the following diagram when answering questions 91–94. Each “tick mark” on the y-axis represents an energy difference of 1 kcal.
91. Which line segment ( ΔG ) represents the free energy change, ΔG, for this reaction?
   a. A
   b. B
   c. C
   d. D
   e. E

92. Which line segment ( ΔG ) could represent Ea for this reaction if a catalyst was present?
   a. A
   b. B
   c. C
   d. D
   e. E

93. Which line segment ( ΔG ) represents the activation energy for the reverse reaction?
   a. A
   b. B
   c. C
   d. D
   e. E

94. Based on the energy diagram shown, which of the following could be the values for ΔG and Ea?
   a. ΔG = +6 kcal and Ea = +5 kcal
   b. ΔG = −6 kcal and Ea = +5 kcal
   c. ΔG = +5 kcal and Ea = −6 kcal
   d. ΔG = +11 kcal and Ea = +6 kcal
   e. ΔG = −6 kcal and Ea = +11 kcal

95. Consider the reversible reaction 2A ⇌ 3B. What is the value of the equilibrium constant if the equilibrium concentration of A is 0.124 M and the equilibrium concentration of B is 0.327 M?
   a. 2.27
   b. 0.440
   c. 2.64
   d. 21.3
   e. 4.05 × 10⁻²

Use the following reaction for problems 96–98.

Heat + 2 NOCl (g) ⇌ 2 NO (g) + Cl₂ (g)

96. The equilibrium expression for the above reaction is:
   a. \( \frac{[\text{NOCl}]^2}{[\text{NO}]^2[\text{Cl}_2]} \)
   b. \( \frac{[\text{NOCl}]^2[\text{Cl}_2]}{[\text{NO}]^2} \)
   c. \( \frac{[\text{NO}]^2[\text{Cl}_2]}{[\text{NOCl}]} \)
   d. \( \frac{2[\text{NOCl}]}{2[\text{NO}][\text{Cl}_2]} \)
   e. \( \frac{[\text{NO}]^2[\text{Cl}_2]}{[\text{NOCl}]^2} \)
97. Which of the following would result from decreasing the temperature in the reaction vessel?
   a. The equilibrium shifts to the right.
   b. The equilibrium shifts to the left.
   c. More NO will form.
   d. More chlorine will form.
   e. none of the above

98. Increasing the concentration of NO has which of the following consequences?
   a. NOCl will decompose to form chlorine and nitric oxide.
   b. The equilibrium shifts to the right.
   c. More Cl\(_2\) will form.
   d. Heat will be released.
   e. all of the above

Use the following reaction for problems 99 – 100.
\[ 2 \text{N}_2 (g) + 5 \text{O}_2 (g) \rightleftharpoons 2 \text{N}_2\text{O}_5 (g) \]

99. In the above equilibrium, increasing the pressure in the reaction vessel has which of the following consequences?
   a. More oxygen will form.
   b. More nitrogen will form.
   c. The equilibrium shifts to the left.
   d. The equilibrium shifts to the right.
   e. The value of the equilibrium constant is increased.

100. In the above equilibrium, removing N\(_2\)O\(_5\) from the reaction vessel has which of the following consequences?
   a. More oxygen will form.
   b. More nitrogen will form.
   c. The equilibrium shifts to the left.
   d. The equilibrium shifts to the right.
   e. The value of the equilibrium constant is increased.

101. In which of the following reactions would increasing the pressure cause a shift in the equilibrium so that more products are produced? Note: All reactants and products are gases.
   a. 2 CO + 2 NO ⇌ N\(_2\) + 2 CO\(_2\)
   b. 4 NH\(_3\) + 5 O\(_2\) ⇌ 4 NO + 6 H\(_2\)O
   c. 2 N\(_2\)O\(_5\) ⇌ 2 N\(_2\) + 5 O\(_2\)
   d. 2 NBr\(_3\) ⇌ N\(_2\) + 3 Br\(_2\)
   e. none of the above