1. Which of the following statements would be consistent with the "Collision Theory" of reactions between gas molecules?
   A. As temperature decreases, the energy of molecular collisions increases.
   B. All collisions between reactant molecules will lead to the formation of products.
   C. Molecules do not have to collide with a certain orientation for a reaction to occur.
   D. As temperature decreases, the number of molecular collisions decreases.
   E. All of these are consistent with "Collision Theory".

2. The Activation Energy of a reaction is

   A. the energy difference between products and reactants.
   B. the kinetic energy of gas molecules at a given temperature.
   C. the minimum energy required to form a catalyst.
   D. the minimum energy required for reactants to form products.
   E. the minimum energy required to accelerate a gas molecule at a given temperature.

3. Which of the following will generally increase the rate of a chemical reaction?

   A. increasing temperature
   B. adding a catalyst
   C. decreasing reactant concentrations
   D. Both A and B
   E. A, B, and C

4. The average rate of disappearance of O_3 in the reaction

   $$2\ O_3\ (g) \rightarrow 3\ O_2\ (g)$$

   is found to be 9.0×10^{-3} M/s at a given point in time. What is the rate of appearance of O_2 at that same point in time?

   A. 1.4×10^{-2} M/s
   B. 9.0×10^{-3} M/s
   C. 6.0×10^{-3} M/s
   D. 3.0×10^{-5} M/s
   E. 2.7×10^{-5} M/s

5. Radioactive decay is a good example of

   A. a zero order process B. a first order process C. a second order process
   D. a third order process E. a last order process

6. Given the reaction:

   $$2MnO_4^-\ (aq) + 5H_2C_2O_4\ (aq) + 6\ H^+\ (aq) \text{ ---> } 2\ Mn^{2+}\ (aq) + 10\ CO_2\ (g) + 8H_2O\ (l)$$

   At a given point in time the rate of loss of MnO_4^- is 0.328 M/s. What is the rate of loss of $H_2C_2O_4$ at this same point in time?

   A. 0.164 M/s
   B. 0.0656 M/s
   C. 0.656 M/s
   D. 0.820 M/s
   E. 0.131 M/s

For Questions 7 - 8 use the following data:

$A(g) + 2B(g) \text{ ------> } 2\ C\ (g)$

Experiment	$[A]_0$	$[B]_0$	Rate of Loss of A $^-$
#1	0.16 M	0.15 M	8.0×10^{-2} M/s
#2	0.16 M	0.30 M	3.2×10^{-1} M/s
#3	0.080 M	0.30 M	8.0×10^{-2} M/s

7. What is the rate law for this reaction?

A. Rate = k[A][B]

B. Rate = k $[A]^2[B]$

C. Rate = k $[A][B]^2$

D. Rate = k $[A]^2[B]^2$

E. Rate = k [B]

8. What is the numerical value for the rate constant in this reaction?

A. 140
B. 79
C. 3.3
D. 164
E. 21

For Questions 9 - 10 use the following data:

$2NO(g) + 2H_2(g) \text{ ------> } N_2\ (g) + 2\ H_2O\ (g)$, Rate = k $[NO]^2[H_2]$

Experiment	$[NO]_0$	$[H_2]_0$	Rate of Loss of NO $^-$
#1	0.10 M	0.20 M	1.50×10^{-2} M/s
#2	0.10 M	0.30 M	2.25×10^{-2} M/s
#3	0.20 M	0.20 M	6.00×10^{-2} M/s

9. What is the numerical value of the rate constant for this reaction?

A. 7.5
B. 0.0030
C. 380
D. 0.75
E. 0.00030

10. What will be the <u>rate of loss</u> of NO (g) when $[NO]_0 = 0.30$ M and $[H_2]_0 = 0.15$ M?

A. 1.35×10^{-2} M/s
B. 8.00×10^{-2} M/s
C. 1.01×10^{-1} M/s
D. 5.13 M/s
E. 3.38×10^{-1} M/s

11. Of the types of radioactive decay discussed in class, which of the following types of radiation was least likely to be able to pass through body tissues?

A. alpha B. beta C. gamma D. all were about the same.

Use the following information for questions 12 through 14:

A new drug, SHAZZAM, decomposes in aqueous solution by a first order process with a rate constant of $k = 1.28 \times 10^{-3}\ s^{-1}$.

12. What is the half-life of SHAZZAM in minutes?

A. 541 min
B. 781 min
C. 25.0 min
D. 13.0 min
E. 9.02 min

13. A 500. mg tablet of SHAZZAM is placed into a beaker of water. How many mg of SHAZZAM will remain (undissolved) after 35.0 minutes?

A. 34.0 mg
B. 62.3 mg
C. 121 mg
D. 466 mg
E. 478 mg

14. How long will it take a tablet of SHAZZAM to decay to 35.0% of its of it original amount?

A. 128 s
B. 820 s
C. 781 s
D. 813 s
E. 273 s

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15. Which of the following statements about equilibrium is FALSE?

A. A system that is disturbed from equilibrium responds in a manner to restore equilibrium.

B. Equilibrium is a dynamic process, with two opposing processes balancing each other.

C. The equilibrium constant is independent of the initial mixture of reactants and products.

D. The equilibrium constant is independent of temperature.

E. None of the statements above are true.

Use the following reaction for questions 16 - 18:

$$4\ NH_3\ (g)\ +\ 5\ O_2\ (g) \rightleftharpoons 4NO\ (g)\ +6\ H_2O\ (g)\ ,\ \Delta H = -\ 910\ kJ$$

16. Given that the gases in the reaction above are initially <u>in equilibrium</u>, which of the following will cause the reaction to <u>shift to the right</u>?

A. adding NO (g) to the equilibrium mixture
B. removing NH_3 (g) from the the equilibrium mixture
C. decreasing the temperature of the equilibrium mixture
D. Both A and B
E. A, B, and C

17. Given that the gases in the reaction above are initially <u>in equilibrium</u> in a 2.00 L container, what will happen if the the container is suddenly "compressed" to 1.00L?

A. The reaction will shift to the right.
B. The reaction will not shift.
C. The reaction will shift to the left.

18. Which of the following represents the relationship between K_c and K_p in the reaction given above?

A. $K_c = \frac{K_p}{(RT)^2}$ B. $K_c = \frac{K_p}{(RT)}$ C. $K_c = K_p$

D. $K_c = K_p(RT)$ E. $K_c = K_p(RT)^2$

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19. "When a stress is applied to a system that is in equilibrium, it will shift to come back to equilibrium" is a statement of

A. the Arrhenius Rate Equation
B. Le Chatelier's Principle
C. the Equilibrium Constant Expression
D. the Rate Law
E. the Stress Hypothesis

20. What is the equilibrium constant expression for the reaction:

$$H_2\ (g)\ +\ I_2\ (s) \rightleftharpoons 2HI\ (g)$$

A. $K = \frac{[H_2]\,[I_2]}{[HI]}$ B. $K = \frac{[H_2]\,[I_2]}{[HI]^2}$ C. $K = \frac{[HI]}{[H_2]}$

D. $K = \frac{[HI]^2}{[H_2]\,[I_2]}$ E. $K = \frac{[HI]^2}{[H_2]}$

Consider the following equilibria (at 298K) for questions 21 through 23:

I.	$N_2\,(g) + 3\,H_2\,(g) \rightleftharpoons 2\,NH_3\,(g)$	$K_I = 2.1 \times 10^{2}$
II.	$N_2\,(g) + 2\,O_2\,(g) \rightleftharpoons N_2O_4\,(g)$	$K_{II} = 6.9 \times 10^{-8}$
III.	$NH_3\,(g) + H_2O\,(l) \rightleftharpoons NH_4^+\,(aq) + OH^-\,(aq)$	$K_{III} = 1.8 \times 10^{-5}$
IV.	$2\,H_2O_2\,(l) \rightleftharpoons 2H_2O\,(l) + O_2\,(g)$	$K_{IV} = 9.0 \times 10^{40}$

21. For which of the reactions above are the presence of reactants "favored" at equilibrium?

A. I only
B. I and IV
C. II only
D. II and III
E. all of the reactions favor the presence of reactants at equilibrium.

22. Which of the following represents the equilibrium constant expression for Reaction I?

A. $K = \dfrac{[N_2]\,[H_2]}{[NH_3]}$
B. $K = \dfrac{[N_2]\,[H_2]^3}{[NH_3]^2}$
C. $K = \dfrac{[NH_3]}{[N_2]\,[H_2]}$
D. $K = \dfrac{[NH_3]^2}{[N_2]\,[H_2]^3}$
E. $K = \dfrac{[NH_3]^2}{[H_2]^3}$

23. Using the equilibrium constants above, calculate the value of K for the following reaction?

$$N_2\,(g) + 3\,H_2\,(g) + 2H_2O\,(l) \rightleftharpoons 2\,NH_4^+\,(aq) + 2\,OH^-\,(aq)\ ,\quad K = ?$$

A. 3.8×10^{-3}
B. 7.6×10^{-3}
C. 4.2×10^{-4}
D. 2.1×10^{2}
E. 6.8×10^{-8}

24. According to the reaction below, if $[N_2O_4]_{eq} = 2.5 \times 10^{-6}$ M and $[O_2]_{eq} = 0.80$ M at equilibrium, then $[N_2]_{eq}$ must equal _____.

$$N_2\,(g) + 2\,O_2\,(g) \rightleftharpoons N_2O_4\,(g) \qquad K = 6.9 \times 10^{-8}$$

A. 5.7×10^{1} M
B. 1.8×10^{-2} M
C. 7.8×10^{-2} M
D. 3.5×10^{-2} M
E. 2.7×10^{-13} M

25. Consider the following equilibrium;

$$2\,A\,(g) + B\,(g) \rightleftharpoons C\,(g), \qquad K = 0.89 \text{ at } 298 \text{ K}$$

If 0.500 moles of A, 2.00 moles of B, and 0.150 moles of C are mixed in a 1.00 L container, which of the following will be true when equilibrium is established?

A. [A] will be greater than [B].
B. [C] will have decreased.
C. [A] will have increased.
D. [B] will have decreased.
E. No change will have occurred.

26. Given the following equilibrium at a certain temperature:

$$N_2\,(g) + O_2\,(g) \rightleftharpoons 2NO\,(g)\ , \qquad K = 0.560$$

If 2.00 moles of N_2 and 2.00 moles of O_2 are placed in a 1.00 L flask, what concentration of NO will be present at equilibrium?

A. 0.856 M
B. 1.02 M
C. 1.71 M
D. 0.529 M
E. 1.06 M

27. Given the following equilibrium at a certain temperature:

$$NH_4Br\,(g) \rightleftharpoons NH_3\,(g) + HBr\,(g), \qquad K = 1.6 \times 10^{-5}$$

If 2.50 moles of $NH_4Br\,(g)$ is placed in a 1.00 L flask, what concentration of NH_3 will be present at equilibrium?

A. 1.6×10^{-5} M
B. 6.3×10^{-3} M
C. 4.0×10^{-3} M
D. 2.5×10^{-3} M
E. 4.0×10^{-5} M