Free Response Practice!

2. Consider the following reaction at chemical equilibrium:

$$N_2(g) + O_2(g) \rightleftharpoons 2\ NO(g) \qquad \Delta H° = 181\ kJ$$

   a. When adding additional N_2 gas to the reaction mixture, what is the effect on O_2?

   b. What is the effect of decreasing the volume of the reaction container?

a) Adding $N_{2(g)}$ increases $[N_2]$, causing the reaction to shift right + make more products to reach equilibrium, which will decrease $[O_2]$.

b) Decreasing the volume of the container will have no effect, b/c the rxn has an equal # of moles of gaseous reactants + gaseous products.

3. Consider the following endothermic reaction at chemical equilibrium:

$$heat + CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

   a. When the temperature of the reaction mixture is increased, what is the effect on $CaCO_3$?

   b. What is the effect of adding an inert gas at constant volume?

a.) ↑T in an endothermic rxn will cause the system to shift right, since heat is the equivalent of a reactant. This will decrease the amount of $CaCO_{3(s)}$, (even though the concentration of $CaCO_{3(s)}$ won't change.)

b.) Adding an inert gas has no effect on the equilibrium position, since only species in the equilibrium constant expression will causes shifts in equilibrium.

4. Consider the following reaction at chemical equilibrium: ∅ mol gas ⇌ 3 mol gas

$$2\ KClO_3(s) \rightleftharpoons 2\ KCl(s) + 3\ O_2(g)$$

   a. What is the effect of increasing the pressure of the reaction mixture?

   b. What is the effect of adding additional KCl to the reaction mixture?

a.) Increasing pressure will cause the rxn to shift to the side w/ the fewest moles of gas to reach equilibrium, so this rxn will shift left towards reactants (∅ mol gas) and away from products (3 mol gas).

b.) Adding more $KCl_{(s)}$ will NOT affect equilibrium position, b/c KCl, a solid, is not part of the equilibrium constant expression, so no shift will occur.

Multiple Choice Practice!

Use the following information to answer questions 1–3.

The following reaction is found at equilibrium at 25°C: $2\ SO_3(g) \rightleftharpoons O_2(g) + 2\ SO_2(g)$ + heat $\Delta H = -198$ kJ/mol

1. Which of the following would cause the reverse reaction to speed up?
   a. Adding more SO_3
   b. Lowering the temperature
   c. Raising the pressure
   d. Removing some SO_2

2. Which of the following would cause a reduction in the value for the equilibrium constant?
   a. Increasing the amount of SO_3
   b. Raising the temperature
   c. Reducing the amount of O_2
   d. Lowering the temperature

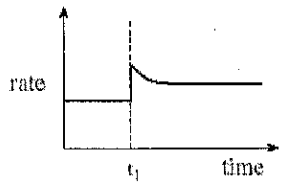
3. If initially only SO_3 was added to the reaction vessel, what is true about the following values as the system approached equilibrium?
   a. $\Delta G > 0$ and $Q > K$
   b. $\Delta G < 0$ and $Q > K$
   c. $\Delta G > 0$ and $Q < K$
   d. $\Delta G < 0$ and $Q < K$

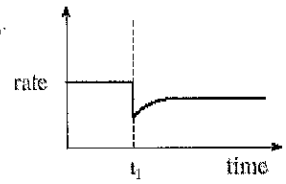
Use the following information to answer questions 4–5.

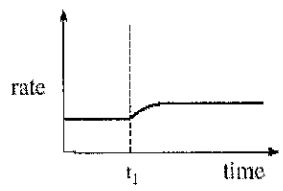
$$CO_2(g) + H_2(g) \rightleftharpoons H_2O(g) + CO(g)$$

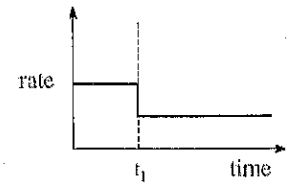
4. Which two stresses will each cause the equilibrium to shift to the left?
   a. increase $[H_2]$, increase $[CO]$
   b. increase $[CO_2]$, decrease $[CO]$
   c. decrease $[H_2]$, increase $[H_2O]$
   d. decrease $[CO_2]$, decrease $[H_2O]$

5. Which of the following graphs represents the forward rate of reaction when $H_2O_{(g)}$ is added to the above equilibrium at time t = 1 ?

A.


B.


C.


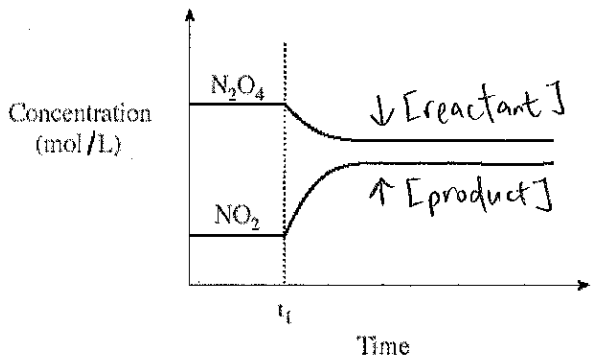
D.


6. Consider the following: $2\ SO_3(g) \rightleftharpoons O_2(g) + 2\ SO_2(g)$. Initially, SO_3 is added to an empty flask. How do the rate of the forward reaction and $[SO_3]$ change as the reaction proceeds to equilibrium?

	Forward Rate	$[SO_3]$		Forward Rate	$[SO_3]$
~~a.~~ a.)	decreases	increases	c.	increases	increases
d. b.)	decreases	decreases	d.	increases	decreases

7. The following reaction is found at equilibrium: $Ni(s) + 4\ CO(g) \rightleftharpoons Ni(CO)_4(l)$ $\Delta H = -160.8$ kJ/mol
   Which of the following will cause this equilibrium to shift to the left?
   a. add some CO
   b. remove some $Ni(CO)_4$
   c. decrease the volume
   d. increase the temperature

8. Consider the following reaction at chemical equilibrium: $N_2O_4(g) \rightleftharpoons 2\ NO_2(g)$. At time t_1. heat is applied to the system. Which of the following best describes the equilibrium reaction and the change in K_c?



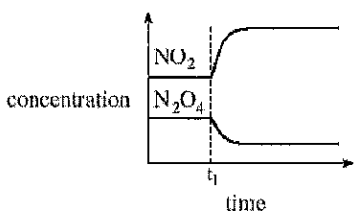
a. exothermic and K_c increases
b. exothermic and K_c decreases
c. endothermic and K_c increases
d. endothermic and K_c decreases

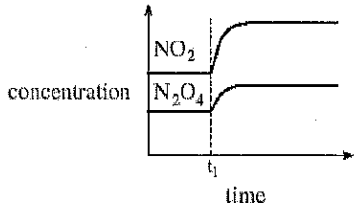
9. A galvanic cell is constructed based on the following reaction: $Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$. The observed voltage was found to be 0.95 volt instead of the standard cell potential, E°, of 1.10 volts. Which of the following could correctly account for this observation?

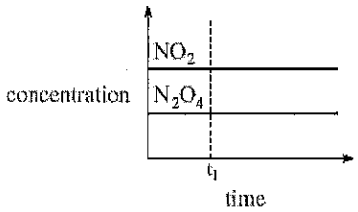
$E_{cell} < E^{o}_{cell}$

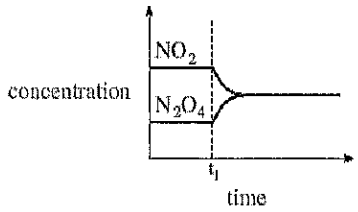
A. The cell had been running for a period of time.
B. The standard free energy of the cell, $\Delta G°$, is negative.
C. The Cu^{2+} solution was more concentrated than the Zn^{2+} solution.
D. The Zn(s) anode had been reduced in mass.

10. Consider the following equilibrium: $N_2O_4(g) \rightleftharpoons 2\ NO_2(g)$. Which of the following shows the relationship between concentration and time as a result of adding a catalyst at time t = 1?

A.


B.


C.


D.


11. The following reaction is found at equilibrium: $N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$. When the volume of the system is decreased, the equilibrium shifts:

a. left since the reverse rate is greater than the forward rate.
b. left since the forward rate is greater than the reverse rate.
c. right since the reverse rate is greater than the forward rate.
d. right since the forward rate is greater than the reverse rate.