Practice Shifting Equilibrium Problems Name _____

Per _____

1-16: For each of the following systems, tell whether the reaction will shift to the left (reactant side), right (product side), or will experience no shift. State your reasoning. <u>In each case, all reactants and products are gases</u>.

1. $3A + 2B \rightleftarrows C + 2D + 20\ kJ$
   a) pressure is decreased
   b) temperature is raised
   c) D is removed from the system

2. $A + B \rightleftarrows 2C + D + 14.6\ kJ$
   a) pressure is increased
   b) temperature is lowered
   c) D is added to the system

3. $2A + B + 42.5\ kJ \rightleftarrows 2C + 3D$
   a) pressure is increased
   b) temperature is lowered
   c) C is added to the system

4. $2A + 2B + 15.9\ kJ \rightleftarrows C + 2D$
   a) pressure is decreased
   b) temperature is raised

5. $A + 2B \rightleftarrows C + D + 46.0\ kJ$
   a) pressure is increased
   b) temperature is raised
   c) A is added to the system

6. $3A + 3B \rightleftarrows 2C + 2D + 25.2\ kJ$
   a) pressure is decreased
   b) temperature is decreased
   c) A is added to the system

7. $2A + B \rightleftarrows 3C + D \qquad \Delta H = +12.7\ kJ$
   a) pressure is decreased
   b) temperature is decreased
   c) B is removed

8. $2A + B \rightleftarrows C + 3D \qquad \Delta H = -34.6\ kJ$
   a) pressure is increased
   b) temperature is raised
   c) volume of the container is increased

9. $3A + 2B \rightleftarrows 2C + 2D \qquad \Delta H = -13.8\ kJ$
   a) pressure is increased
   b) temperature is lowered
   c) volume of the container is increased

10. $A + 3B \rightleftarrows 2C + 2D \qquad \Delta H = +21.3\ kJ$
    a) B is added to the system
    b) temperature is raised
    c) volume of the container is increased

11. $3A + 3B \rightleftarrows C + D \qquad \Delta H = -19.2\ kJ$
    a) volume of the container is increased
    b) the system is heated

12. $A + 3B \rightleftarrows 2C + 3D$
    The reaction is endothermic
    a) pressure is reduced
    b) the system is cooled

13. $2A + 3B \rightleftarrows 2C + 2D$
    The reaction is endothermic
    a) pressure is decreased
    b) heat is removed from the system
    c) C is removed from the system

14. $A + B \rightleftarrows C + 3D$
    The system is exothermic
    a) volume of the container is increased
    b) heat is added to the system

15. $A + B \rightleftarrows 2C$
    The system is exothermic
    a) pressure is lowered
    b) temperature is lowered

16. $2A + 2B \rightleftarrows C + 3D$
    The system is endothermic
    a) pressure is increased
    b) temperature is lowered
    c) B is added to the system

17 - 18. The following system is at equilibrium:

$$CO(g) + 3H_2(g) \rightleftarrows CH_4(g) + H_2O(g) \qquad \Delta H = -290\ kJ$$

Predict whether the reaction will shift right or left with the application of the following stresses.

17a) H_2 is added
b) CH_4 is added
c) heat is removed
d) pressure is reduced
e) the volume of the container is increased

18a) H_2 is removed
b) CH_4 is removed
c) heat is added
d) pressure is increased
e) the volume of the container is decreased

Practice Shifting Equilibrium Problems Name _____**KEY**_____

Per _____

1-16: For each of the following systems, tell whether the reaction will shift to the left (reactant side), right (product side), or will experience no shift. State your reasoning. <u>In each case, all reactants and products are gases</u>.

1. $3A + 2B \rightleftarrows C + 2D + 20\ kJ$
   a) pressure is decreased **left**
   b) temperature is raised **left**
   c) D is removed from the system **right**

2. $A + B \rightleftarrows 2C + D + 14.6\ kJ$
   a) pressure is increased **left**
   b) temperature is lowered **right**
   c) D is added to the system **left**

3. $2A + B + 42.5\ kJ \rightleftarrows 2C + 3D$
   a) pressure is increased **left**
   b) temperature is lowered **left**
   c) C is added to the system **left**

4. $2A + 2B + 15.9\ kJ \rightleftarrows C + 2D$
   a) pressure is decreased **left**
   b) temperature is raised **right**

5. $A + 2B \rightleftarrows C + D + 46.0\ kJ$
   a) pressure is increased **right**
   b) temperature is raised **left**
   c) A is added to the system **right**

6. $3A + 3B \rightleftarrows 2C + 2D + 25.2\ kJ$
   a) pressure is decreased **left**
   b) temperature is decreased **right**
   c) A is added to the system **right**

7. $2A + B \rightleftarrows 3C + D \quad \Delta H = +12.7\ kJ$
   a) pressure is decreased **right**
   b) temperature is decreased **left**
   c) B is removed **left**

8. $2A + B \rightleftarrows C + 3D \quad \Delta H = -34.6\ kJ$
   a) pressure is increased **left**
   b) temperature is raised **left**
   c) volume of the container is increased **right**

9. $3A + 2B \rightleftarrows 2C + 2D \quad \Delta H = -13.8\ kJ$
   a) pressure is increased **right**
   b) temperature is lowered **right**
   c) volume of the container is increased **left**

10. $A + 3B \rightleftarrows 2C + 2D \quad \Delta H = +21.3\ kJ$
    a) B is added to the system **right**
    b) temperature is raised **right**
    c) volume of the container is increased **no shift**

11. $3A + 3B \rightleftarrows C + D \quad \Delta H = -19.2\ kJ$
    a) volume of the container is increased **left**
    b) the system is heated **left**

12. $A + 3B \rightleftarrows 2C + 3D$
    The reaction is endothermic
    a) pressure is reduced **right**
    b) the system is cooled **left**

13. $2A + 3B \rightleftarrows 2C + 2D$
    The reaction is endothermic
    a) pressure is decreased **left**
    b) heat is removed from the system **left**
    c) C is removed from the system **right**

14. $A + B \rightleftarrows C + 3D$
    The system is exothermic
    a) volume of the container is increased
    b) heat is added to the system
    a) right b) left

15. $A + B \rightleftarrows 2C$
    The system is exothermic
    a) pressure is lowered **no shift**
    b) temperature is lowered **right**

16. $2A + 2B \rightleftarrows C + 3D$
    The system is endothermic
    a) pressure is increased **no shift**
    b) temperature is lowered **left**
    c) B is added to the system **right**

Reasoning: In all cases, the system will shift to reduce the stress applied.

For addition of a reactant or a product, the system will shift to remove or use up the extra substance added, so if a reactant is added, the system shifts to the product side in order to use up the excess reactant. If a product is added, the system shifts to the reactant side (left) in order to use up the excess product and reduce the stress on the system.

For removal of a reactant or product, the system will shift to replace the lost substance. So, if product is removed, the system will shift to the product side (right) to replace the lost product. If a reactant is removed, the system will shift to the reactant side to replace the missing reactant and reduce the stress on the system.

For pressure changes, since pressure is due to the number of particles present per unit area, a reduction in pressure will result in a shift that attempts to restore the pressure by increasing the number of particles present, so the system will shift to the side with the greater number of particles. If the pressure has been increased, the system will shift to decrease the pressure by shifting to the side with fewer particles in order to reduce the stress on the system. If there are equal numbers of reactant and product particles shown in the balanced chemical equation, no side will be favored and no shift will occur.

Volume changes for gases result in pressure changes, so the shift will correlate with the change in pressure. If volume is increased, the number of particles per unit area decreases (pressure decreases), so the system will shift to the side with more particles. If volume is decreased, the particles get closer together (more particles per unit area) and pressure increases, so the system will shift to the side with fewer particles in order to reduce the stress on the system.

For temperature changes, if the system is cooled (temperature decreased) the system will shift to release more energy. If the system is heated, it will shift to absorb the added energy. The direction of shift is dependent on whether it is an endothermic reaction or an exothermic reaction. For an endothermic reaction, the energy involved can be treated as a reactant since it is required in order for the reaction to proceed in the forward direction. If energy is added, the reaction will shift to the product side in order to absorb the excess energy and reduce the stress on the system. If energy is removed (the system is cooled) an endothermic reaction will shift to the reactant side in order to release more energy and reduce the stress on the system. For an exothermic reaction, the energy can be treated as a product, since energy is released as the reaction proceeds in the forward direction. Cooling the system will result in a shift to the product side and heating the system will result in a shift to the reactant side to reduce the stress on the system.

17 - 18. The following system is at equilibrium:

$$\mathbf{CO(}g\mathbf{) + 3H_2\,(}g\mathbf{)} \rightleftarrows \mathbf{CH_4\,(g) + H_2O\,(}g\mathbf{)} \qquad \Delta\mathbf{H = -290\ kJ}$$

Predict whether the reaction will shift right or left with the application of the following stresses.

17a) H_2 is added **right**
b) CH_4 is added **left**
c) heat is removed **right**
d) pressure is reduced **left**
e) the volume of the container is increased **left**

18a) H_2 is removed **left**
b) CH_4 is removed **right**
c) heat is added **left**
d) pressure is increased **right**
e) the volume of the container is decreased **right**