

Chemistry 12
Worksheet 2-2
LeChatelier's Principle

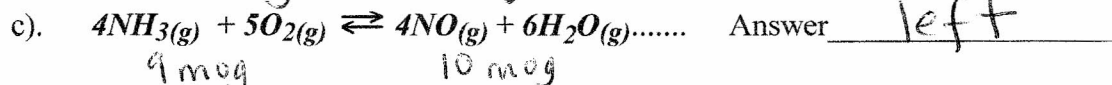
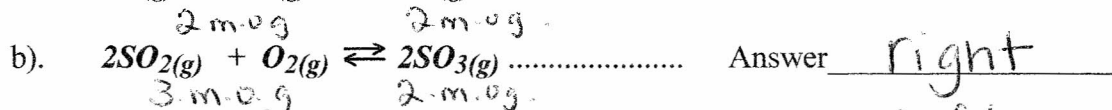
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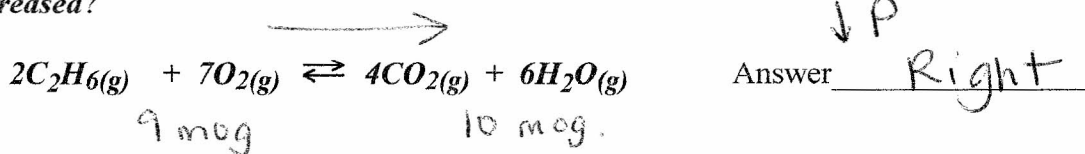
1. In order to decide what effect a **change in total pressure** will have on an equilibrium system with gases, what is the first thing you should do when given the balanced equation?

Add up the moles of gas (m.o.g.) on both sides of the equation.

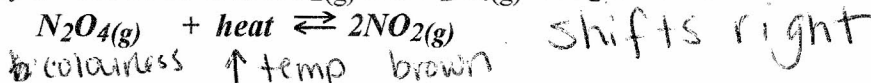
2. Predict which way the following equilibrium systems will shift when the **total pressure is increased**. (NOTE: Some may have no shift)



3. Which way will the following equilibrium shift if the **total pressure** on the system is **decreased**?



4. Explain why a flask filled with $NO_2(g)$ and $N_2O_4(g)$ will get **darker** when heated. Use the equation:

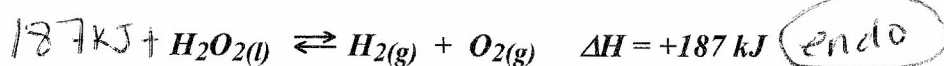


Heating causes the equilibrium to shift right which will produce more NO_2 gas. This is brown so flask will show a darker colour.

5. State **Le Chatelier's Principle**.

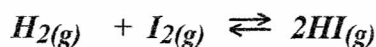
When a stress is applied to a system at equilibrium, the equilibrium will SHIFT to counteract the imposed stress.

6. *Hydrogen peroxide* is decomposed as follows:



Predict the *direction of equilibrium shift* by each of the following imposed changes:

- a) **Increase** the $[\text{H}_2]$ Answer left shifts
- b) **Decrease** the $[\text{O}_2]$ Answer right
- c) **Decrease** the **total pressure** Answer right
- d) **Increase** the **temperature** Answer right
- e) Add MnO_2 as a *catalyst* Answer no shift
7. Consider the following reaction at equilibrium:



- a) Addition of more H_2 gas to the container will do what to the rate of the forward reaction?

Answer increase rate.

- b) If, for a while, the rate of the *forward* reaction is **greater than** the rate of the *reverse* reaction, what will happen to the $[\text{HI}]$?

Answer $[\text{HI}]$ increase

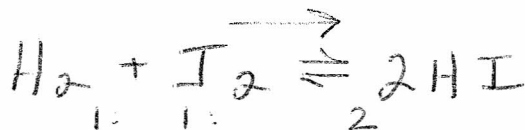
- c) As the $[\text{HI}]$ is increased, what will happen to the rate of the *reverse* reaction?

Answer increase rate

- d) When the rate of the *reverse* reaction once again becomes **equal** to the rate of the *forward* reaction, a new equilibrium has been reached.

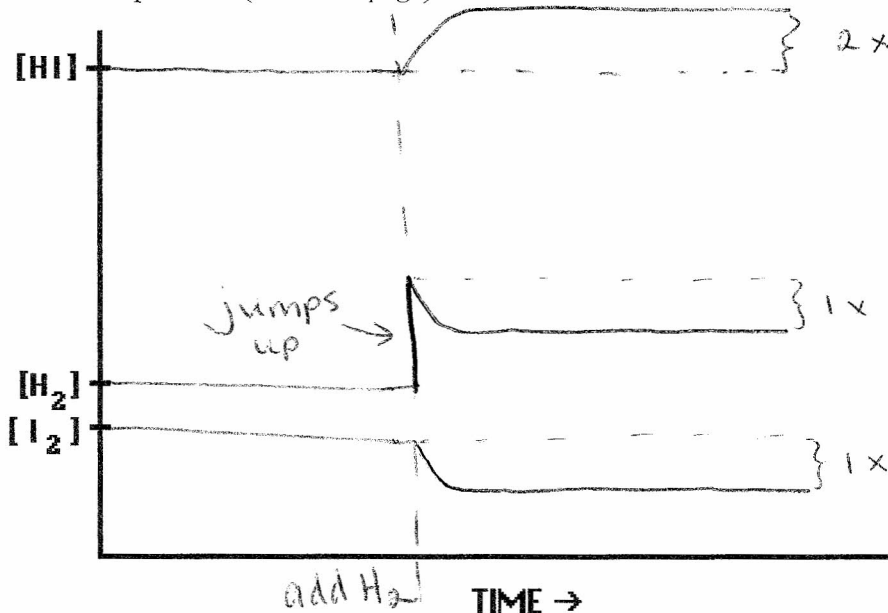
- e) Since the rate of the *forward* reaction was, for a while, greater than the rate of the *reverse* reaction, the new equilibrium will have a slightly higher concentration of

$[\text{HI}]$ and a slightly lower concentration of $[\text{H}_2]$ & $[\text{I}_2]$

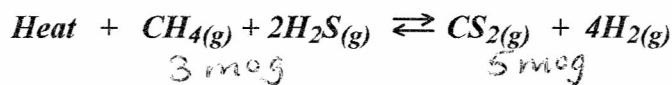


x added H₂

f) Sketch a graph of the relative concentrations of each species as the process outlined in a-e of this question (on the last page) is carried out.

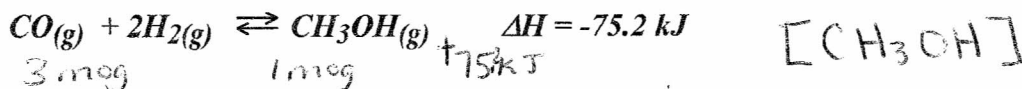


8. Consider the following equilibrium and state which way (left or right) the equilibrium shifts when each of the changes below are made.

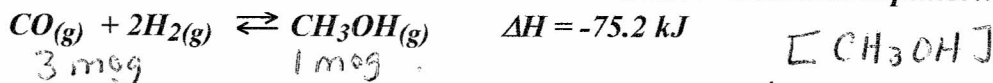


- a) CH₄ gas is added Answer Right
- b) CS₂ gas is removed..... Answer Right
- c) H₂ gas is added Answer Left
- d) The total volume of the container is decreased $\downarrow V, \uparrow P$ Answer Left
- e) The temperature is increased Answer Right
- f) The total pressure is decreased $\downarrow P, \uparrow V$ Answer Right
- g) Helium gas is added to increase the total pressure.... Answer no shift
(volume has not changed).

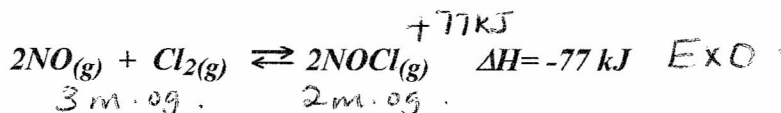
9. Using the following equilibrium, state what would happen to the equilibrium partial pressure of CH₃OH gas when each of the following changes are made:



- a) CO gas is added to the container Answer increases
- b) The temperature is increased Answer decreases
- c) The total pressure of the system is increased..... Answer increases.

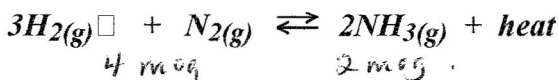


- d) H₂ gas is removed from the system..... Answer decreases
- e) A catalyst is added..... Answer no change in []
- f) The total volume of the container is increased..... Answer decreases
10. For the reaction:



state the **optimal pressure and temperature conditions** necessary for maximum production of NOCl. (high or low?) want a shift to the RIGHT.

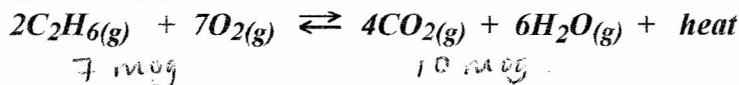
1. High pressure 2. LOW temperature
11. For the reaction:



state the **optimal conditions** for a **high yield** of ammonia (NH₃). (high or low?) want a shift to the RIGHT

1. HIGH pressure 2. LOW ~~HIGH~~ temperature

12. Given the following equilibrium system, state which way the equilibrium will shift when the changes below are made:



- a) The volume of the container is halved..... Answer left
- b) The temperature is decreased Answer right
- c) CO₂ is added to the container..... Answer left
- d) The total pressure is increased Answer left
- e) O₂ gas is removed from the system Answer left
- f) Neon gas is added to increase the total pressure Answer no change/shift
no change in volume.
- h) A catalyst is added..... Answer no change/shift

13. Using the equilibrium: $\text{N}_2\text{(g)} + \text{O}_2\text{(g)} + \text{heat} \rightleftharpoons 2\text{NO(g)}$ ENDO
- NO Explain why nitric oxide (NO) does **not** generally form in the atmosphere but **is** formed in the internal combustion engine of an automobile or during a lightning storm.

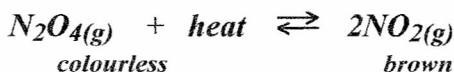
min H favours reactants, max entropy favours neither side. So this rxn is not spontaneous. At high temps, the rxn shifts RIGHT

14. Explain why a syringe containing NO₂ gas will first get *darker* and *then lighter* in colour when compressed. Use the equilibrium equation:



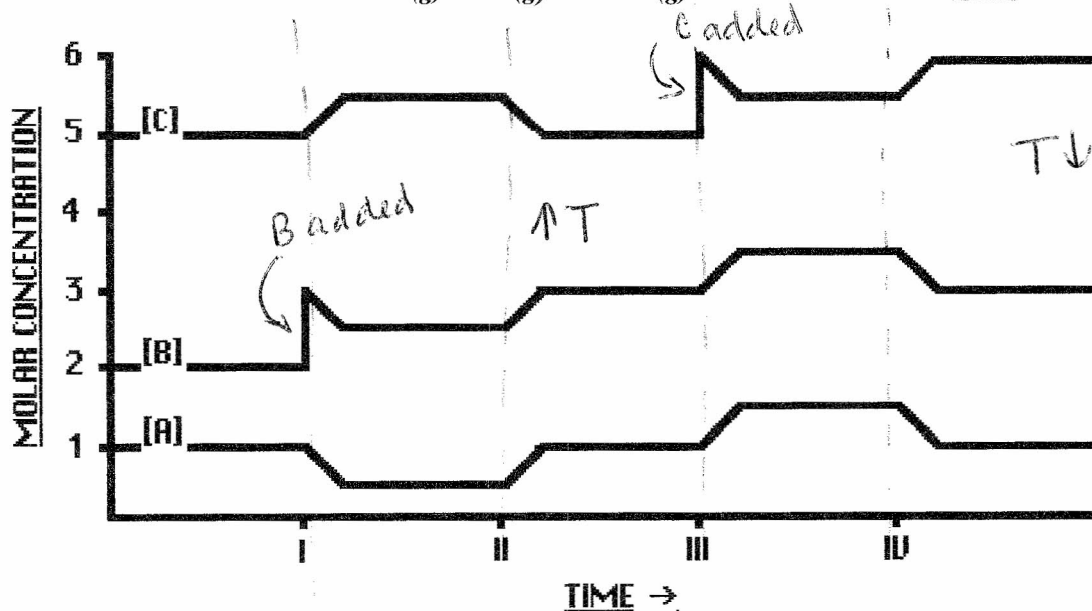
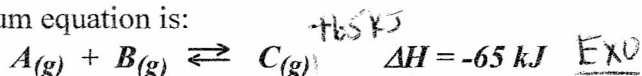
at first, ↑P, ↓V = shifts RIGHT (darker, more NO₂)
 then equilibrium is reestablished as reverse rate picks up. The colour will lighten.

15. Explain why a flask containing NO₂ will get *lighter* in colour when put into ice water. Use the equation:



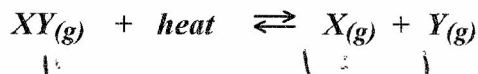
heat is removed (lost to surroundings) so the equilibrium shifts LEFT.

16. Given the following graph showing the concentrations of species A, B and C, state what changes in **temperature** or **concentration** are responsible for each of the shifts shown on the graph. The equilibrium equation is:



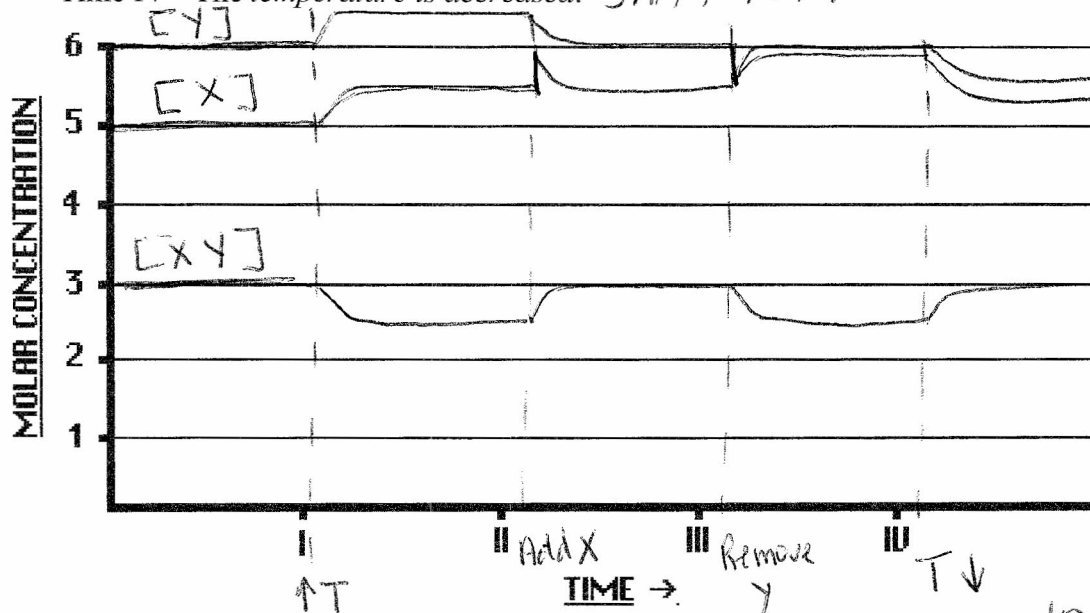
- a) At time I, the B is added
- b) At time II, the temp is increased (shift left)
- c) At time III, the C is added
- d) At time IV, the temp is decreased (shift right).

17. Given the equilibrium equation:

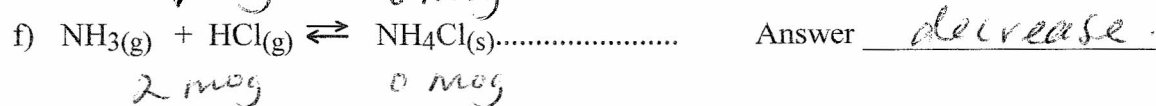
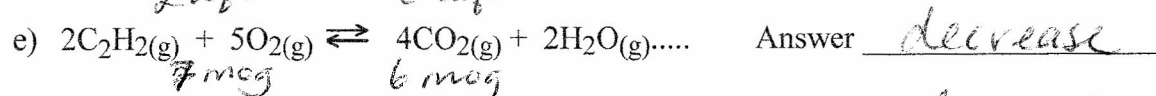
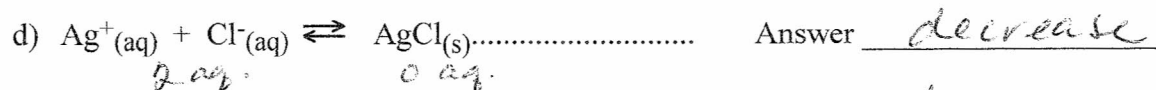
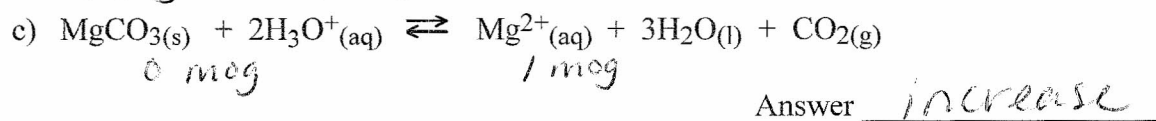
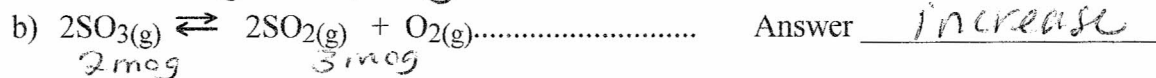
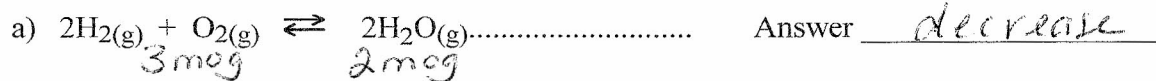


If initially, at equilibrium, the $[XY] = 3.0 \text{ M}$, the $[X] = 5.0 \text{ M}$ and the $[Y] = 6.0 \text{ M}$, draw a graph similar to the one in question 16 showing qualitatively what happens to the concentrations of each species as the following changes are made to the system:

- Time I - The temperature is increased. *Shift Right*
- Time II - Some $X(g)$ is added to the system *Shift left*
- Time III - Some $Y(g)$ is removed from the system *Shift right*
- Time IV - The temperature is decreased. *Shift left*



18. For each of the following reactions, predict whether the **entropy** increases or decreases.



19. On the basis of **enthalpy** and **entropy**, predict whether each of the following reactions would be *spontaneous as written* or not at room temperature.

