

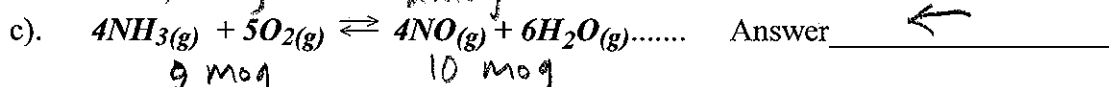
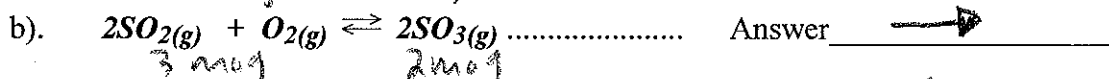
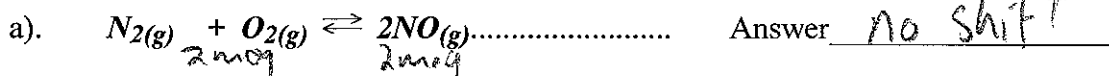
Chemistry 12
Worksheet 2-2
LeChatelier's Principle Name _____

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?

Count the number of moles of gas for reactants/products

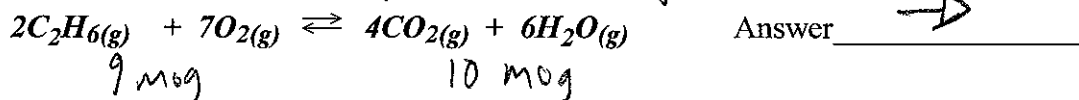
2. Predict which way the following equilibrium systems will shift when the **total pressure is increased**. (NOTE: Some may have no shift)

P ↑ , less moles

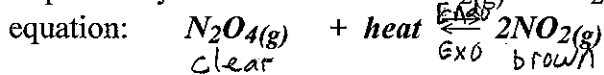


3. Which way will the following equilibrium shift if the **total pressure** on the system is **decreased**?

P ↓ , more moles



4. Explain why a flask filled with $\text{NO}_2(\text{g})$ and $\text{N}_2\text{O}_4(\text{g})$ will get **darker** when heated. Use the equation:

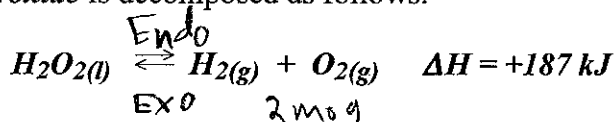


P ↑ , Endo favoured, more NO₂ (brown) produced

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

If a closed system at eqm is subjected to a change, processes will occur to offset that change

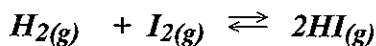
6. Hydrogen peroxide is decomposed as follows:



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

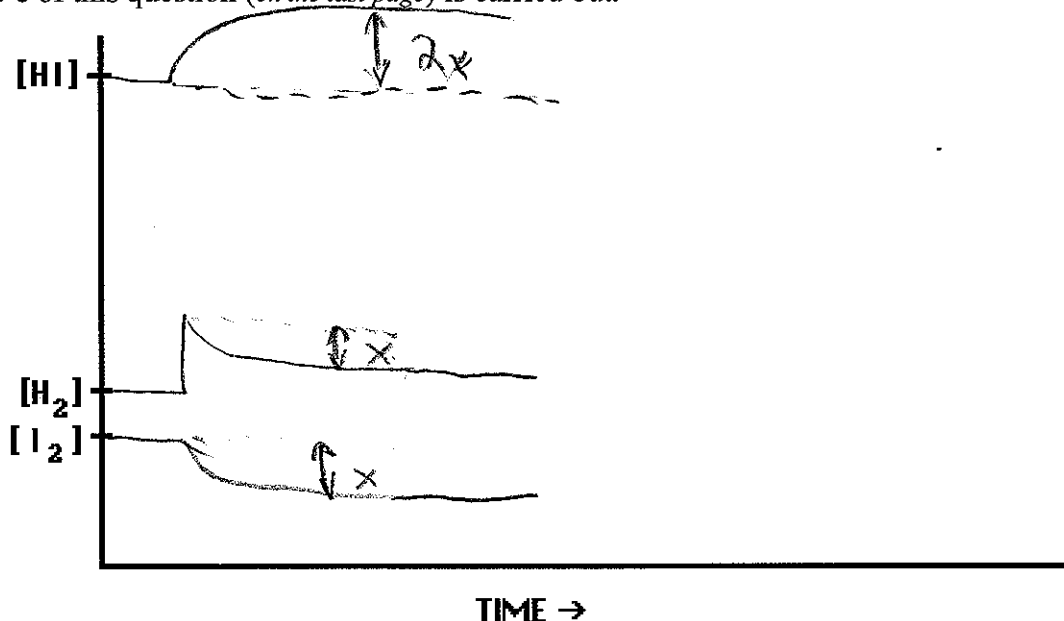
- a) *Increase* the [H₂] Answer ←
- b) *Decrease* the [O₂] Answer →
- c) *Decrease* the *total pressure* More Moles Answer →
- d) *Increase* the *temperature* Endo Answer →
- e) Add MnO₂ as a *catalyst* Answer —

7. Consider the following reaction at equilibrium:

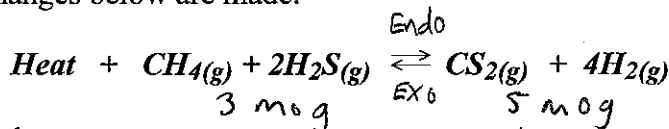


- a) Addition of more H₂ gas to the container will do what to the rate of the forward reaction?
Answer ↑
- b) If, for a while, the rate of the *forward* reaction is *greater than* the rate of the *reverse* reaction, what will happen to the [HI]?
Answer ↑
- c) As the [HI] is increased, what will happen to the rate of the *reverse* reaction?
Answer ↑
- 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 [HI] and a slightly lower concentration of [H₂] & [I₂]

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.

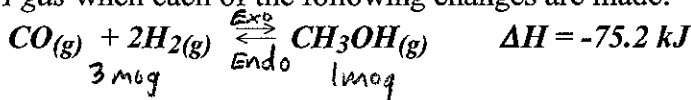


8. Consider the following equilibrium and state which way (left or right) the equilibrium shifts when each of the changes below are made.

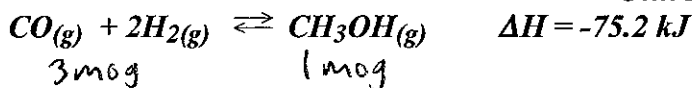


- a) CH₄ gas is added Answer →
- b) CS₂ gas is removed..... Answer →
- c) H₂ gas is added Answer ←
- d) The *total volume* of the container is decreased PA Answer ←
- e) The *temperature* is increased Endo Favoured Answer →
- f) The *total pressure* is decreased more mo g Answer →
- g) Helium gas is added to increase the total pressure.... less mo g Answer ←

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:

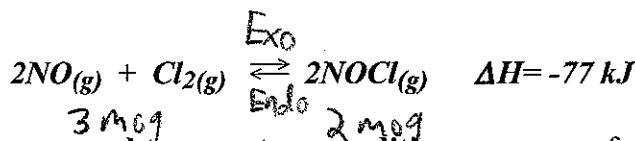


- a) CO gas is added to the container Answer ↑
- b) The *temperature* is increased Endo Favoured Answer ↓
- c) The *total pressure* of the system is increased..... less mo g Answer ↑



- d) H₂ gas is removed from the system..... Answer ←
- e) A catalyst is added..... Answer —
- f) The total volume of the container is increased... P.V. Answer ←

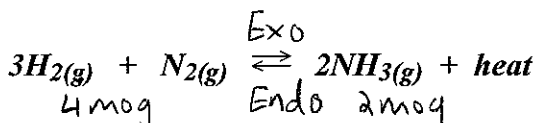
10. For the reaction:



state the optimal pressure and temperature conditions necessary for maximum production of NOCl. (high or low?)

1. high pressure 2. low temperature

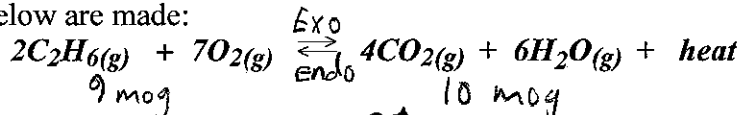
11. For the reaction:



state the optimal conditions for a high yield of ammonia (NH₃). (high or low?)

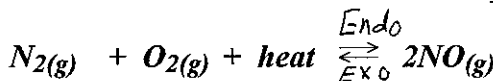
1. high pressure 2. low temperature

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... P.V. Answer ←
- b) The temperature is decreased ... Exo favoured Answer →
- c) CO₂ is added to the container..... Answer ←
- d) The total pressure is increased ... less moles Answer ←
- e) O₂ gas is removed from the system Answer ←
- f) Neon gas is added to increase the total pressure less moles Answer ←
- h) A catalyst is added..... Answer —

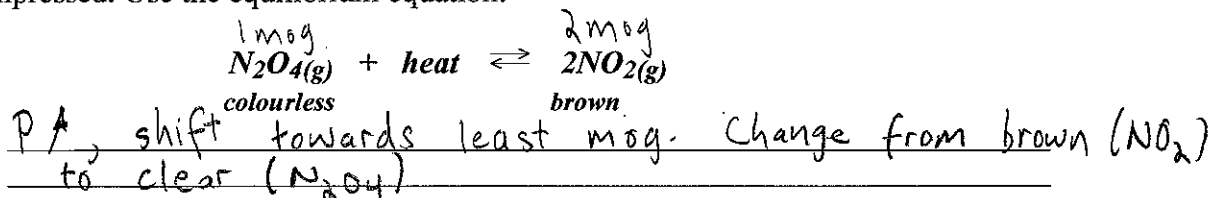
13. Using the equilibrium:



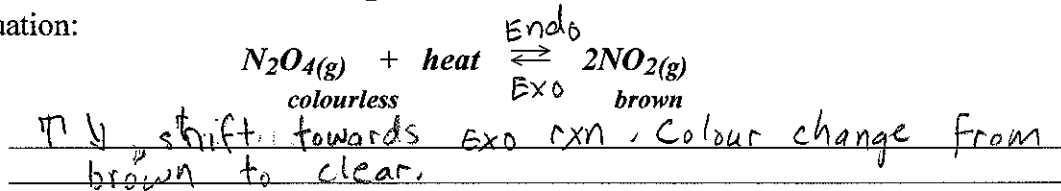
Explain why nitric oxide (NO) does not generally form in the atmosphere but is formed in the internal combustion engine of an automobile or during a lightning storm.

Internal combustion engine / lightning storm: spark = catalyst
Such catalyst will lower E_a by providing an alternate path leading to product formation.

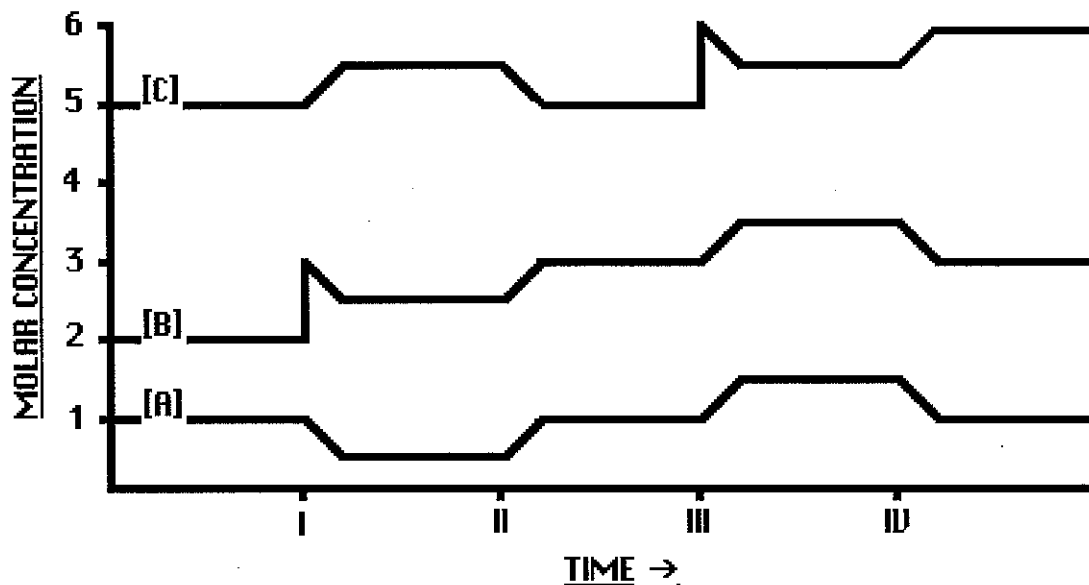
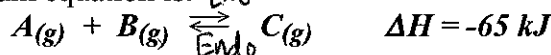
14. Explain why a syringe containing NO₂ gas will first get *darker* and *then lighter* in colour when compressed. Use the equilibrium equation:



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

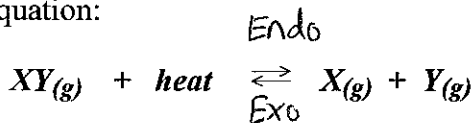


16. Given the following graph showing the concentrations of species A, B and C, state what changes in **temperature** or **concentration** are responsible for each of the shifts shown on the graph. The equilibrium equation is: Exo



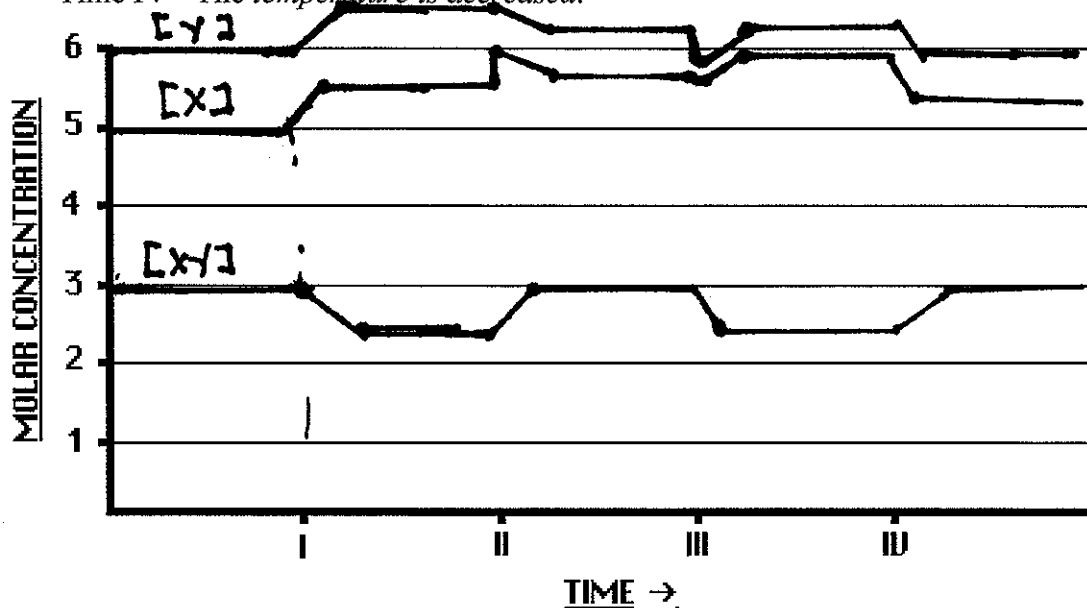
- a) At time I, the [B] ↑
- b) At time II, the T ↓
- c) At time III, the [C] ↑
- d) At time IV, the T ↓

17. Given the equilibrium equation:

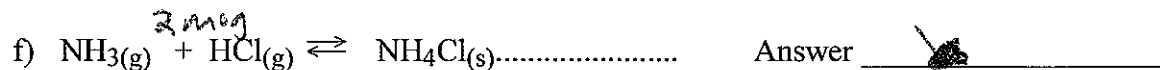
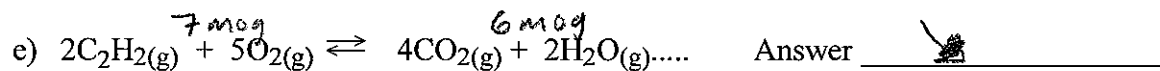
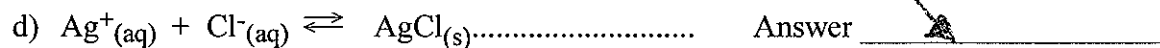
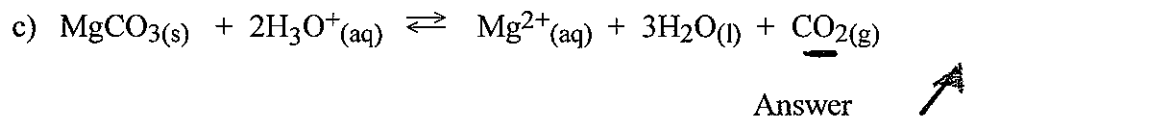


If initially, at equilibrium, the $[XY] = 3.0 \text{ M}$, the $[X] = 5.0 \text{ M}$ and the $[Y] = 6.0 \text{ M}$, draw a graph similar to the one in question 16 showing qualitatively what happens to the concentrations of each species as the following changes are made to the system:

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



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.

- a)
$$\text{N}_2(\text{g}) + 2\text{O}_2(\text{g}) \xrightleftharpoons[\text{Exo}]{\text{Endo}} 2\text{NO}_2(\text{g}) \quad \Delta H = +67.7 \text{ kJ}$$

$$\begin{matrix} 3 \text{ mol} & & 2 \text{ mol} \\ \text{Minimum enthalpy favours (reactants/products)} & \dots & \text{Exo} \end{matrix}$$

$$\text{Reactants}$$

$$\text{Maximum entropy favours (reactants/products)} \dots \dots \dots$$

$$\text{Reactants}$$

$$\text{Spontaneous as written? (yes/no)} \dots \dots \dots \text{ Answer } \underline{\text{No}}$$
- b)
$$2\text{C}(\text{s}) + \text{O}_2(\text{g}) \xrightleftharpoons[\text{Endo}]{\text{Exo}} 2\text{CO}(\text{g}) + 110 \text{ kJ}$$

$$\begin{matrix} 1 \text{ mol} & & 2 \text{ mol} \\ \text{Minimum enthalpy favours (reactants/products)} & \dots & \text{Exo} \end{matrix}$$

$$\text{Products}$$

$$\text{Maximum entropy favours (reactants/products)} \dots \dots \dots$$

$$\text{Products}$$

$$\text{Spontaneous as written? (yes/no)} \dots \dots \dots \text{ Answer } \underline{\text{Yes}}$$
- c)
$$2\text{Pb}(\text{NO}_3)_2(\text{s}) + 597 \text{ kJ} \xrightleftharpoons[\text{Exo}]{\text{Endo}} 2\text{PbO}(\text{s}) + 4\text{NO}_2(\text{g}) + \text{O}_2(\text{g})$$

$$\text{Minimum enthalpy favours (reactants/products)} \dots \text{Exo}$$

$$\text{Reactants}$$

$$\text{Maximum entropy favours (reactants/products)} \dots \dots \dots$$

$$\text{Products}$$

$$\text{Spontaneous as written? (yes/no)} \dots \dots \dots \text{ Answer } \underline{\text{No}}$$