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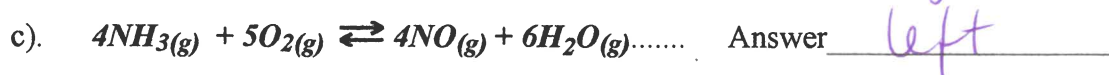
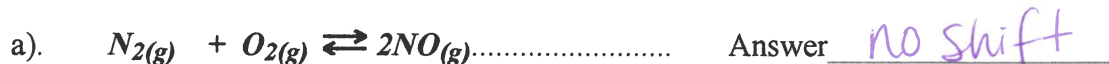
Chemistry 12
LE CHATELIER'S PRINCIPLE

KEY

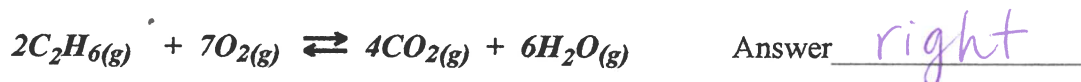
1. In order to decide what effect a **change in total pressure** will have on an equilibrium system with gases, what is the first thing you should do when given the balanced equation?

count moles of gas on each side

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:

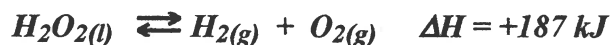


-heating causes shift to right
=> more NO_2 => darker

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

When a stress is applied to a system at equilibrium, the system readjusts (shift right or left) to counteract the stress & establish a new equilibrium

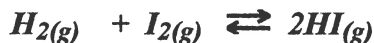
6. *Hydrogen peroxide* is decomposed as follows:



-endo

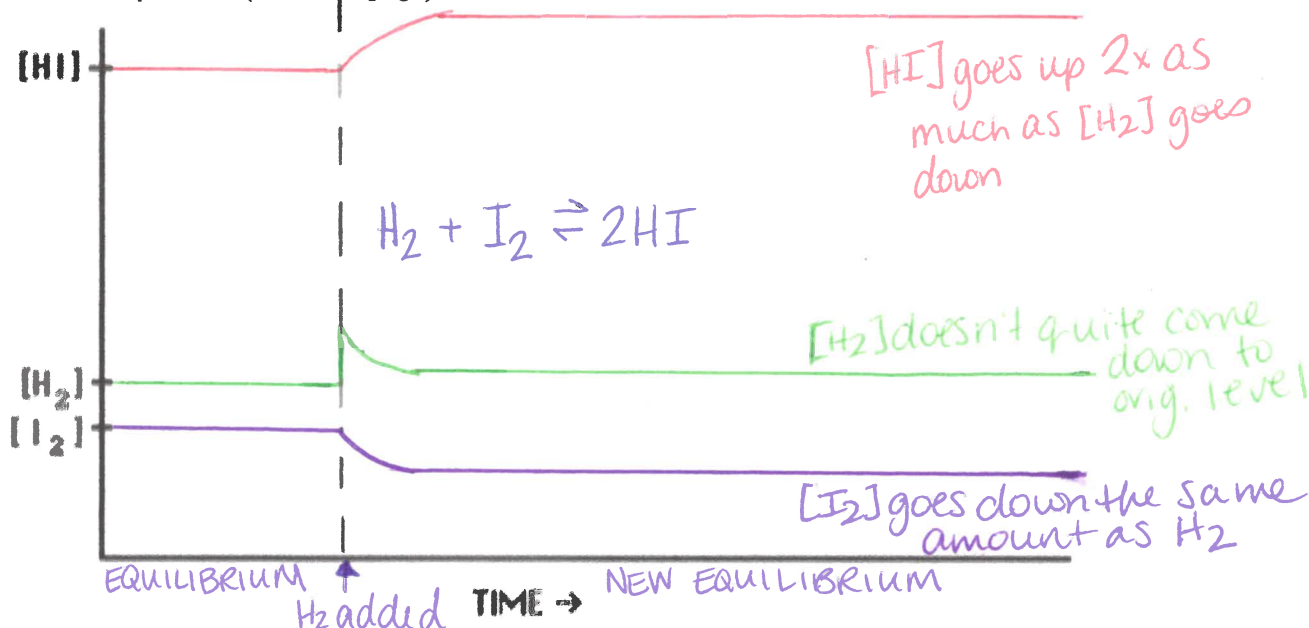
Predict the *direction of equilibrium shift* by each of the following imposed changes:

- a) *Increase* the $[\text{H}_2]$ Answer left
- 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:

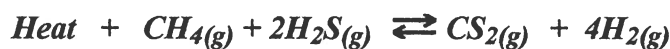


- a) Addition of more H_2 gas to the container will do what to the rate of the forward reaction?
Answer increase it
- b) If, for a while, the rate of the *forward* reaction is *greater than* the rate of the *reverse* reaction, what will happen to the $[\text{HI}]$?
Answer increase
- c) As the $[\text{HI}]$ is increased, what will happen to the rate of the *reverse* reaction?
Answer increase
- 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 H_2 & I_2

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 Answer left
- e) The temperature is increased Answer right
- f) The total pressure is decreased Answer right
- g) Helium gas is added to increase the total pressure.... Answer no shift

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 Answer ↓
- c) The total pressure of the system is increased..... Answer ↑



- d) H₂ gas is removed from the system..... Answer ↓
- e) A catalyst is added..... Answer no Δ
- f) The total volume of the container is increased..... Answer ↓

10. For the reaction:



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

1. high pressure (causes shift right) 2. low temperature (shifts right)

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:



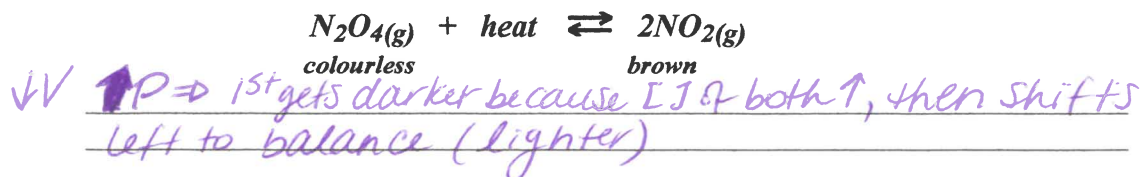
- a) The volume of the container is halved..... Answer left
- b) The temperature is decreased Answer right
- c) CO₂ is added to the container..... Answer left
- d) The total pressure is increased Answer left
- e) O₂ gas is removed from the system Answer left
- f) Neon gas is added to increase the total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

13. Using the equilibrium: $\text{N}_{2(g)} + \text{O}_{2(g)} + \text{heat} \rightleftharpoons 2\text{NO}_{(g)}$

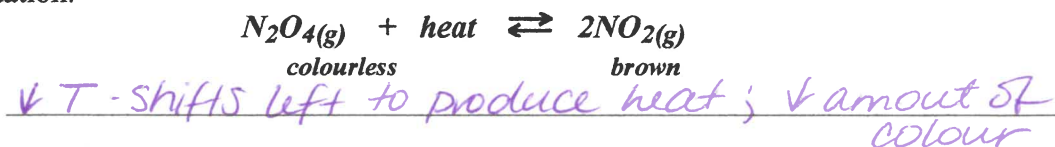
Explain why nitric oxide (NO) does **not** generally form in the atmosphere but **is** formed in the internal combustion engine of an automobile or during a lightning storm.

min enthalpy → favours reactants
entropy → equal
BUT, @ ↑T (engine, lightning) shifts right
& NO is formed

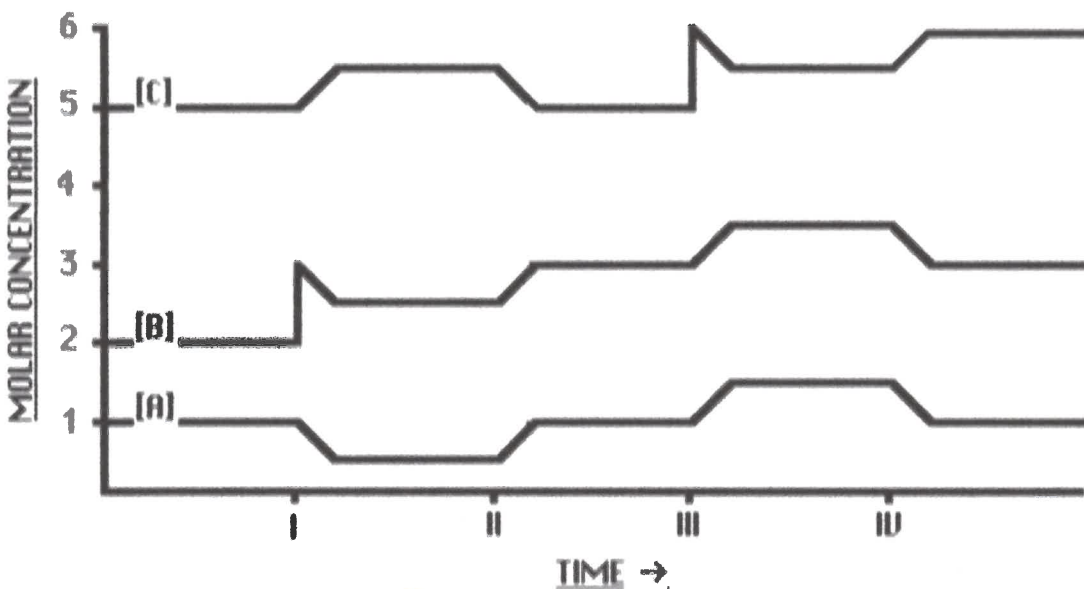
14. Explain why a syringe containing NO_2 gas will first get *darker* and *then lighter* in colour when compressed. Use the equilibrium equation:



15. Explain why a flask containing NO_2 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:



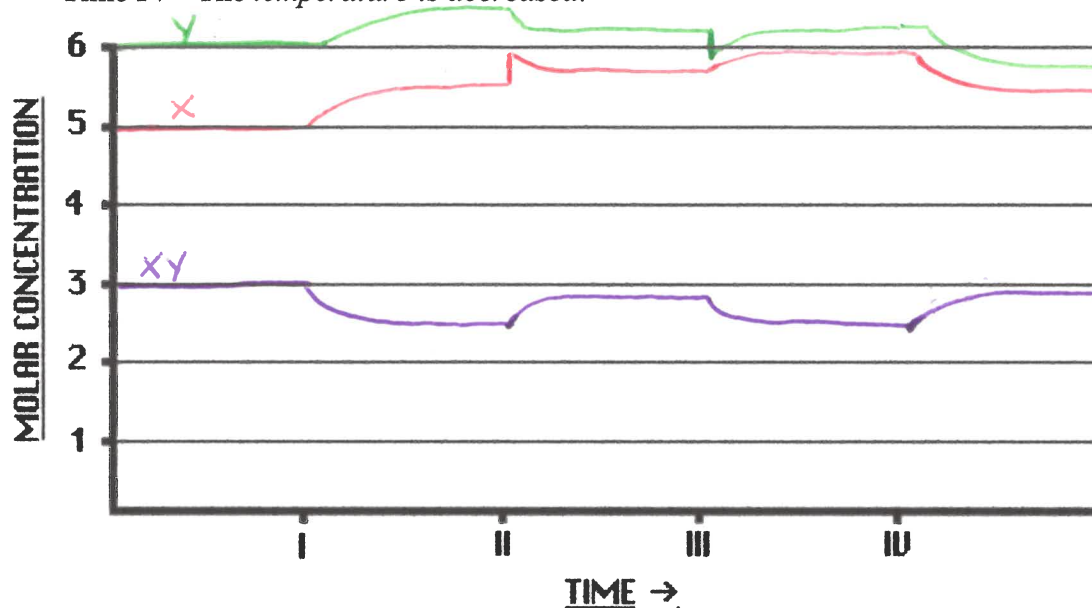
- a) At time I, the B is added
- b) At time II, the T is \uparrow
- c) At time III, the C is added
- d) At time IV, the T is \downarrow

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.

- a) $2H_{2(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(g)}$ Answer ↓
- b) $2SO_{3(g)} \rightleftharpoons 2SO_{2(g)} + O_{2(g)}$ Answer ↑
- c) $MgCO_{3(s)} + 2H_3O^+_{(aq)} \rightleftharpoons Mg^{2+}_{(aq)} + 3H_2O_{(l)} + CO_{2(g)}$
Answer ↑
- d) $Ag^+_{(aq)} + Cl^-_{(aq)} \rightleftharpoons AgCl_{(s)}$ Answer ↓
- e) $2C_2H_2_{(g)} + 5O_{2(g)} \rightleftharpoons 4CO_{2(g)} + 2H_2O_{(g)}$ Answer ↓
- f) $NH_{3(g)} + HCl_{(g)} \rightleftharpoons NH_4Cl_{(s)}$ Answer ↓

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.



Minimum enthalpy favours (reactants/products) reactants

Maximum entropy favours (reactants/products) reactants

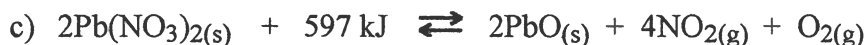
Spontaneous as written? (yes/no) Answer no



Minimum enthalpy favours (reactants/products) products

Maximum entropy favours (reactants/products) products

Spontaneous as written? (yes/no) Answer yes



Minimum enthalpy favours (reactants/products) reactants

Maximum entropy favours (reactants/products) products

Spontaneous as written? (yes/no) Answer yes - but would reach a state of equilibrium (not go to completion)