

1. Calculate the freezing point depression of 100 g of alien snot when 8.4 g of salt NaHCO_3 is added. Pretend that the freezing point depression constant of alien snot is $1.5^\circ\text{C}\cdot\text{kg}/\text{mol}$. (In case you didn't know alien snot is very runny, not so viscous).

- 3.0°C
- 2.0°C
- 1.5°C
- 4.5°C

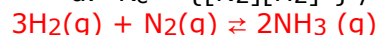
$$\Delta T_f = i K_f m$$

$$m = (8.40 \text{ g}) / (84.01 \text{ g mol}^{-1}) = 0.1 \text{ mol NaHCO}_3$$

$$\Delta T_f = 2 (1.5^\circ\text{C}\cdot\text{kg}/\text{mol alien snot})(0.1 \text{ mol NaHCO}_3 / 0.1 \text{ kg alien snot}) = 3.0^\circ\text{C}$$

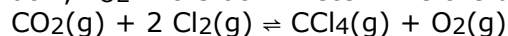
2. Determine the correct equilibrium expression for the reaction of hydrogen gas with nitrogen gas to produce ammonia.

- $K_p = \{P(\text{N}_2) P^2(\text{H}_2)\} / P^3(\text{NH}_3)$
- $K_p = P^3(\text{NH}_3) / \{P(\text{N}_2) P^2(\text{H}_2)\}$
- $K_c = [\text{NH}_3]^2 / \{[\text{N}_2][\text{H}_2]^3\}$
- $K_c = \{[\text{N}_2][\text{H}_2]^2\} / [\text{NH}_3]^3$



Products over reactants. Coefficients are exponents.

3. In the reaction below the partial pressures are $P_{\text{CO}_2} = 2 \text{ atm}$, $P_{\text{Cl}_2} = .20 \text{ atm}$, $P_{\text{CCl}_4} = 10 \text{ atm}$, $P_{\text{O}_2} = 0.5 \text{ atm}$. Determine the direction of the reaction and why. ($K_p = 6.4 \times 10^{-18}$)



- Shift right, $Q < K$
- Shift left, $Q = K$
- Shift left, $Q < K$
- Shift right, $Q > K$
- Shift left, $Q > K$
- No shift, $K < Q$

When $Q > K$ the reaction will shift in the reverse to make more reactants and decrease Q .

$$Q = (P_{\text{CCl}_4} \times P_{\text{O}_2}) / (P_{\text{CO}_2} \times P_{\text{Cl}_2}^2)$$

$$= (10 \times .5) / (2 \times .20^2) = 62.5$$

$$62.5 > 6.4 \times 10^{-18}$$

4. Steel rusting is exothermic. It's mostly made of iron, which when reacted with oxygen will form iron oxide (Fe_2O_3). An increase in which of the following compounds will be seen when the temperature decreases?

- Fe
 - O_2
 - Fe_2O_3
- I
 - I and II
 - I, II and III
 - II
 - II and III
 - III
 - I and III

The reaction is exothermic so a decrease in temperature will shift the reaction towards the products to compensate the heat loss.



5. Consider the following reaction:



Which combination of concentrations of H₂, N₂, and NH₃ will lead to the most ammonia once equilibrium is reached? Assume 1 L of solvent.

- a. 0 M, 0 M, and 1 M
- b. 10 M, 10 M, and 1 M
- c. .1 M, .1 M, and 1 M

$$Q = \frac{[\text{NH}_3]^2}{[\text{H}_2]^6 [\text{N}_2]}$$

For option A, Q approaches infinite, which means that $Q > K$ and the will proceed to the left and the amount of NH₃ will

For option B, Q is equal to 10^{-7} . For option C, Q is equal to 10^7 . Both Q's are less than K, but the Q for option C is closer to K than the Q for option B. This means that more ammonia must be produced with the starting concentrations in option B for equilibrium to be reached.

6. Complete the following table:

R	4 NH ₃ (g)	+	3 O ₂ (g)	⇌	2 N ₂ (g)	+	6 H ₂ O(g)
I	20		11		6		0
C	-8		-6		+4		+12
E	12		5		10		12

What is the value of K?

- a. 2
- b. 1.4
- c. 234.4
- d. 115.2

$$K = \frac{[\text{N}_2]^2 [\text{H}_2\text{O}]^6}{[\text{NH}_3]^4 [\text{O}_2]^3} = \frac{[10]^2 [12]^6}{[12]^4 [5]^3} = 115.2$$

7. Which of the following values for ΔG will result in the largest positive value for K? (No calculations necessary)

- a. -1 kJ/mol
- b. -100 J/mol
- c. 100 J/mol
- d. 1 kJ/mol

K has an exponential relationship with G ($K = e^{-\Delta G/RT}$). So, the ΔG with the lowest value will result in the largest K.

8. Which of the following is a true statement?

- a. As temperature increases, the equilibrium of an exothermic reaction will shift right.
- b. As temperature increases, the equilibrium of an endothermic reaction will shift right.
- c. The equilibrium of any reaction is independent of temperature.
- d. When using the Van't Hoff equation, the sign of ΔH can be ignored

The equilibrium of reactions depends on temperature, and the dependence can be quantified using the Van't Hoff equation. The sign of ΔH will determine which direction a reaction shifts with changes in temperature. Exothermic reactions become less spontaneous as the temperature increases, which means that the equilibrium will shift toward the reactants. The opposite is true for endothermic reactions - as the temperature increases, the equilibrium of a reaction will shift toward the products.

