EXPLORING THE TEMPERATURE DEPENDENCE OF THE EQUILIBRIUM CONSTANT (K) WITH THE TI-NSPIRE

TEACHER NOTES

Teaching time: One class period

Topic: Thermodynamics and Equilibrium

Level: Honors Chemistry I and/or Advanced Placement Chemistry

Prerequisite Knowledge: The student will be expected to have a working knowledge of Thermodynamics and equilibrium.

Materials: TI-Nspire Calculator

Objectives: Students will learn the following skills:

1. enter data into lists
2. name lists
3. use formulas to populate data
4. determine regression equations
5. graph data
6. plot regression lines
7. use the calculator application

Discussion:

The equilibrium constant (K) for any given reaction does not vary so long as the temperature of the reaction remains constant. The usual temperature for equilibrium calculations is room temperature (25°). If the temperature varies from this standard, then the equilibrium will shift left or right depending on whether the reaction is endothermic or exothermic and the value of K will either increase or decrease accordingly.

The relationship between K and Celsius temperature is not a linear relationship. To obtain a linear relationship, the reciprocal of the Kelvin temperature must be plotted against the natural log (Ln) of K. When graphed in that fashion the linear regression equation will take the form:

$$\text{Ln K} = -\left(\frac{\Delta H^0}{R}\right)\left(\frac{1}{T}\right)+\left(\frac{\Delta S^0}{R}\right)$$

Where the slope of the line is $-\left(\frac{\Delta H^0}{R}\right)$ and the y-intercept is $\left(\frac{\Delta S^0}{R}\right)$. The thermodynamic value of R is 8.3145 J/Kmol.

Teaching Tips:

Students will need a review prior to the activity on the appropriate units for each of the variables in the exercise. They will need to be reminded that a log or Ln of a quantity effectively has no unit.

Review may also be required of the ion product, K_w, and the calculation of pH values from K_w.

Answers:

Part I

m= -1480 K
b = 2.72
r = -1.00

ΔH^o = 12.3 kJ/mol
ΔS^o = 22.6 J/Kmol

Part II

m= -6860 K
b = -9.25
r = -1.00

ΔH^o = 57.0 kJ/mol
ΔS^o = -76.9 J/Kmol

Questions:

Procedure B

1. An increase in temperature favors the products since the reaction is endothermic, so the value of K_{eq} increases.
2. This is an endothermic reaction since K_{eq} increases with a temperature increase.
3. To increase the yield of the reaction, heat would need to be supplied to the system.

Procedure R

1. As temperature increases, the value of K_w increases.
2. Since the value of K_w increases, the reaction must be endothermic favoring the products with an increase in temperature.

Extension Answers:

1.

Temperature	pH
0°C	7.472
25 °C	7.000
35 °C	6.840
40 °C	6.767
50 °C	6.631

2. No, the pH of neutral water is only 7 at a temperature of 25 °C because K_w is temperature dependent.
3. Temperature must be specified when pH values are recorded because of the temperature dependence of K_w.