HSC CHEMISTRY

Module 5: Equilibrium and Acid Reactions

Week 4

Calculating the Equilibrium Constant

HOMEWORK

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SPECIALIST TUITION

1 Which of these changes to a gaseous equilibrium system would alter the value of its equilibrium constant?

A. Decreasing the temperature of the system.
B. Removing a reactant and adding some extra product.
C. Halving the volume of the system.
D. Removing a catalyst.

2 When the reaction quotient of a system is greater than its equilibrium constant, and the forward reaction is endothermic, which of the following statements is false?

A. The backward reaction rate is greater than the forward reaction rate.
B. Heating up the system will move it closer to equilibrium.
C. ΔG is negative.
D. The total entropy of the system and the environment is increasing.

3 Pure water undergoes a process known as auto-ionisation, given by the equation $H_2O(l) \rightleftharpoons H{\equiv}(aq) + OH{-}(aq)$. If the equilibrium constant for this reaction at standard lab conditions is 10^{-14}, what is the concentration of hydrogen ions in pure water?

A. 10^{-7} M
B. 10^{-14} M
C. 10^{-28} M
D. We cannot tell without knowing how much water there was to begin with

4 An exothermic reaction has a K_{eq} of 1 at standard temperature and pressure. Which of the following is the most likely value of K_{eq} for this equilibrium at 273.15 K?

A. 0.1
B. 1
C. 10
D. 100

5 Which of the following would NOT invalidate an experimentally derived colorimetric calibration curve for the absorbance of an ion in aqueous solution?

A. Using solutions of different concentrations each time the absorbance is tested.

B. Using a different wavelength of light each time the absorbance is tested.

C. Using a cuvette of different length each time the absorbance is tested.

D. Neglecting to calibrate the spectrometer with a standard solution before testing the ion solutions.

Question 6 (9 marks)

A factory is mass producing ammonia via the Haber process, which uses the exothermic reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$. At $400\,°C$, $K_{eq} = 1.5 \times 10^{-4}$.

(a) Write an expression for the equilibrium constant for this system. **1**

(b) Explain the effect on K_{eq} of increasing the temperature of this reaction, and explain how this affects yield of ammonia. **2**

(c) The reaction is started with 20 mol of nitrogen gas and 50 mol of hydrogen gas placed in a 100 L container at $400\,°C$. Three hours later, there is 0.1 mol of ammonia in the chamber. Is this system at equilibrium? Support your answer with a calculation. **3**

(d) Estimate the amount of moles of ammonia in the chamber at equilibrium. **3**

Question 7 (16 marks)

A student wishes to perform a practical investigation to determine the equilibrium constant of iron(III) thiocyanate in equilibrium at 293.15 K. She decides that colorimetry will be the most accurate method of doing so.

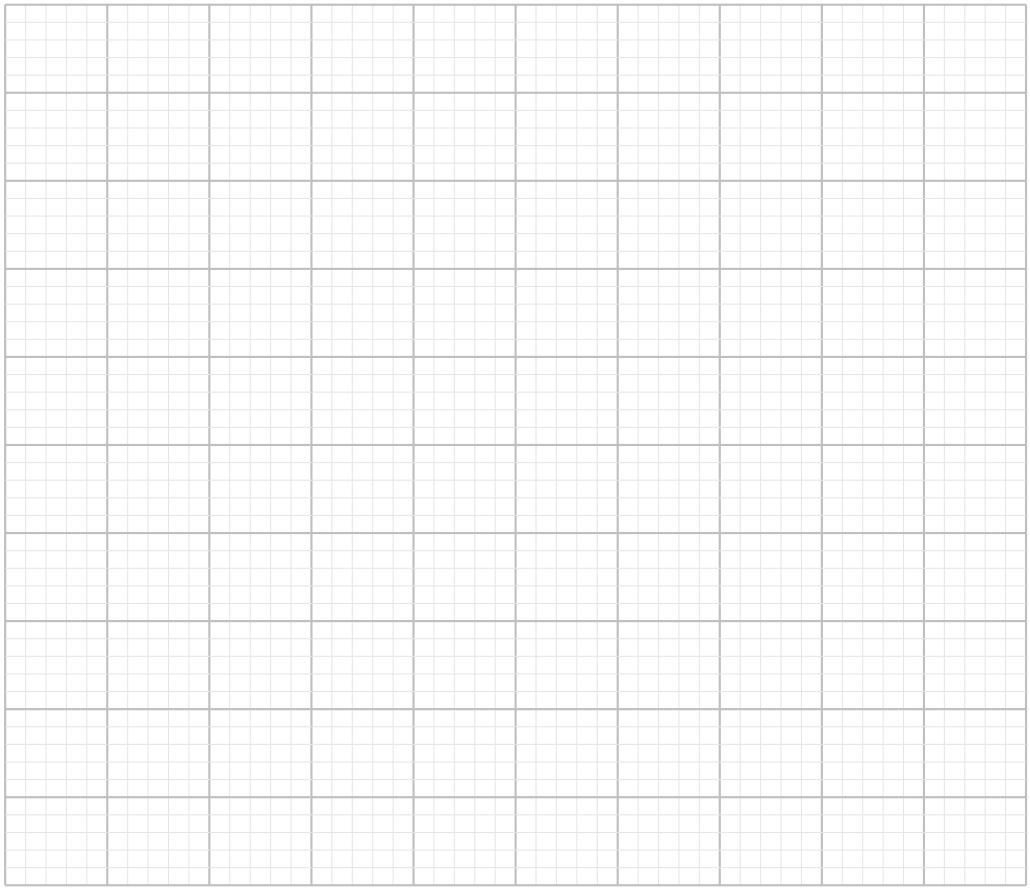
(a) Write a balanced chemical equation for the formation of iron(III) thiocyanate in solution. Include an indication of enthalpy in your answer, given that the reaction is exothermic. **1**

(b) Write an expression for the equilibrium constant for this reaction. **1**

(c) The student obtains some standard solutions of iron(III) thiocyanate with known concentrations. She tests their absorbance at 480 nm using 1 cm cuvettes in a spectrophotometer and obtains the following results: **4**

Concentration ($\times 10^{-3}$ M)	**Absorbance**
2	0.14
4	0.31
6	0.84
8	0.63
10	0.73

Draw a line of best fit representing a calibration curve, labelling the axes appropriately. No units are required for absorbance.



(d) Explain why the graph in part (c) should be linear. **1**

(e) The student then mixes 50 mL of 0.2 M $Fe(NO_3)_3$ (aq) with 250 mL of 0.6 M NaSCN (aq). Determine the initial concentrations of iron(III) ions and thiocyanate ions in the resulting mixed solution. **2**

(f) The student wants to prepare a dilution of this mixed solution in a test tube. She uses a pipette to place 5 mL of the mixed solution in a clean test tube. She then fills the test tube with distilled water up to a total volume of 25 mL. Calculate the new initial concentrations of iron(III) ions and thiocyanate ions in the test tube. **2**

(g) The student then fills a cuvette with a small sample from the test tube, and runs it through a 480 nm spectrophotometer. She obtains an absorbance reading of 0.45. Using your graph in part (c), determine the concentration of iron(III) thiocyanate in the test tube solution at equilibrium. **1**

(h) Calculate the equilibrium constant for the solution in the test tube. What inferences can you draw from the numerical value of K_{eq}? How would you expect it to change if the student were to heat the system? **4**