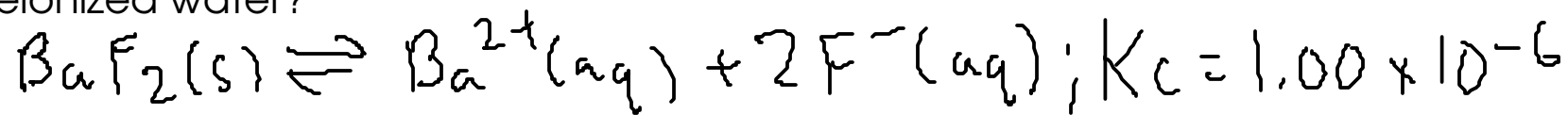What is the concentration of barium ion at equilibrium if solid barium fluoride is mixed with deionized water?

$$BaF_2(s) \rightleftharpoons Ba^{2+}(aq) + 2F^-(aq) ; \quad K_c = 1.00 \times 10^{-6}$$

$$K_c = [Ba^{2+}][F^-]^2 = 1.00 \times 10^{-6}$$

Species	[Initial]	Δ	[Equilibrium]
Ba^{2+}	0	$+X$	X
F^-	0	$+2X$	$2X$

Let 'x' equal the change in barium ion concentration

$$[Ba^{2+}][F^-]^2 = (X)(2X)^2 = 1.00 \times 10^{-6}$$

$$4X^3 = 1.00 \times 10^{-6}$$

$$X^3 = 2.50 \times 10^{-7}$$

$$X = 0.00630$$

So, $\boxed{[Ba^{2+}] = 0.00630 \, M}$

A 6.00 L reaction vessel contains 0.488 mol hydrogen gas, 0.206 mol iodine vapor, and 2.250 mol HI at equilibrium at 491 C. . What is the value of Kc at 491 C?

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

$$K_c = \frac{[HI]^2}{[H_2][I_2]}$$

Calculate MOLAR CONCENTRATION for the Kc expression:
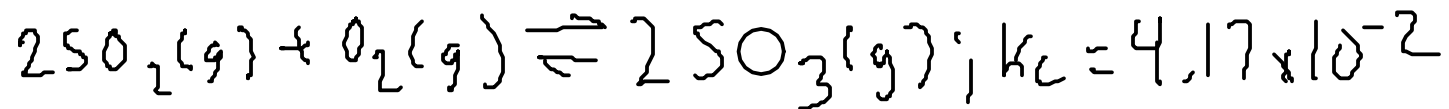
$$[HI] = \frac{2.250 \text{ mol}}{6.00 \text{ L}} = 0.375 M$$

$$[I_2] = \frac{0.206 \text{ mol}}{6.00 \text{ L}} = 0.034333 M$$

$$[H_2] = \frac{0.488 \text{ mol}}{6.00 \text{ L}} = 0.081333 M$$

$$K_c = \frac{(0.375)^2}{(0.034333)(0.081333)}$$

$$\boxed{K_c = 50.4}$$

3

What is the direction of reaction when a mixture of 0.20 M sulfur dioxide, 0.10 M oxygen gas, and 0.40 M sulfur trioxide approaches equilibrium?
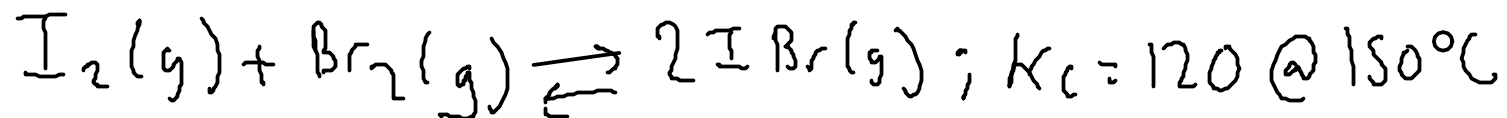
$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \, ; \, K_c = 4.17 \times 10^{-2}$$

$$Q = \frac{[SO_3]^2}{[SO_2]^2[O_2]} = \frac{(0.40)^2}{(0.20)^2(0.10)} = 40$$

$$40 > 4.17 \times 10^{-2}$$

$$Q > K_c$$

... so the reaction proceeds to the LEFT to form more sulfur dioxide and oxygen gas and less sulfur trioxide.

A 5.0 L vessel initially contains 0.0015 mol of each reactant. Find the equilibrium concentrations of all species in the vessel at equilibrium at 150 C.

$$I_2(g) + Br_2(g) \rightleftharpoons 2IBr(g) \; ; \; K_c = 120 \; @ \; 150°C$$

$$K_c = \frac{[IBr]^2}{[I_2][Br_2]} = 120$$

Species	[Initial]	Δ	[Equilibrium]
I_2	$\frac{0.0015 \, mol}{5.0 L} = 0.00030$	$-X$	$0.00030 - X$
Br_2	$\frac{0.0015 \, mol}{5.0 L} = 0.00030$	$-X$	$0.00030 - X$
IBr	0	$+2x$	$2x$

Let's define 'x' as the change in iodine concentration

$$\frac{[IBr]^2}{[I_2][Br_2]} = \frac{(2x)^2}{(0.00030 - X)(0.00030 - X)} = 120$$

$$\frac{(2x)^2}{(0.00030 - X)^2} = 120$$

Solvable by taking the square root of both sides. (or ... use the quadratic formula)

$$\sqrt{\frac{(2x)^2}{(0.00030-x)^2}} = \sqrt{120}$$

$$\frac{2x}{0.00030-x} = \sqrt{120}$$

$$2x = (\sqrt{120})(0.00030-x)$$

$$\frac{2}{\sqrt{120}}x = 0.00030-x$$

$$\left(\frac{2}{\sqrt{120}}+1\right)x = 0.00030$$
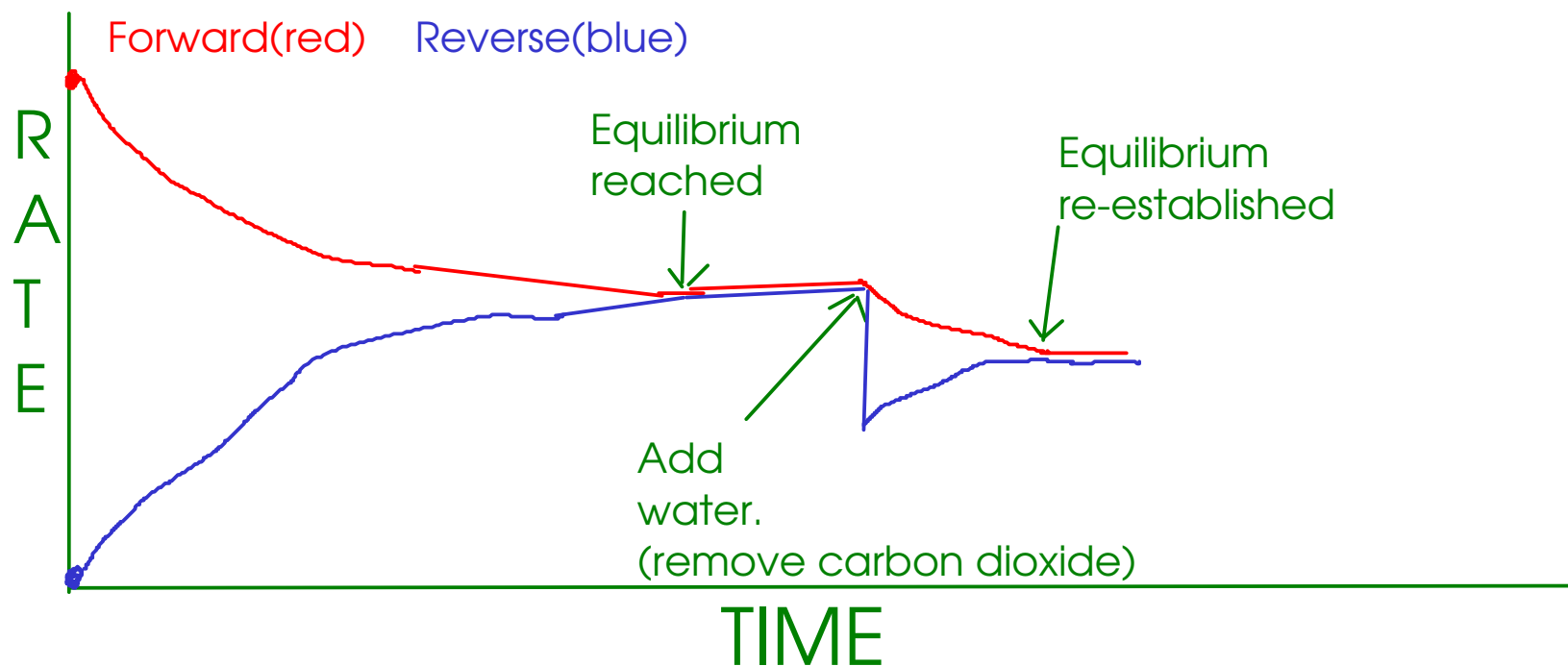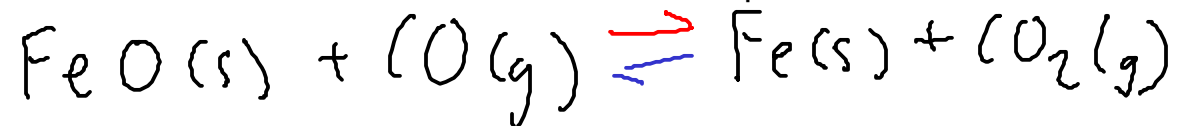
$$x = 2.54 \times 10^{-4} = 0.000254$$

Species	[Equilibrium]
I_2	$0.00030-x$
Br_2	$0.00030-x$
IBr	$2x$

$[I_2] = 0.00030 - 0.000254 = 0.000046 \text{ m } I_2$

$[Br_2] = 0.00030 - 0.000254 = 0.000046 \text{ m } Br_2$

$[IBr] = 2(0.000254) = 0.00051 \text{ m } IBr$

When carbon dioxide is removed from the equilibrium mixture by passing the gases through water (which preferentially absorbs carbon DIOXIDE), what is the direction of net reaction as a new equilibrium is achieved?

$$FeO\,(s) + CO\,(g) \rightleftharpoons Fe\,(s) + CO_2\,(g)$$

Forward(red)   Reverse(blue)

R
A
T
E

Equilibrium reached

Equilibrium re-established

Add water.
(remove carbon dioxide)

TIME

Removing carbon dioxide affects the rate of the reverse reaction (slowing it down).

Since the reverse reaction is now slower than the forward, the overall reaction will make more products (because that's what the forward reaction produces) until equilibrium is re-established.
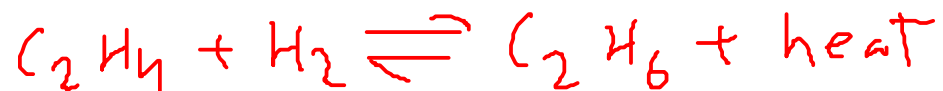
The equilibrium, in other words, shifts to the right to make more products!

Predict the optimal conditions (temperature and pressure) for maximum conversion of ethylene to ethane.

$$C_2H_4 (g) + H_2 (g) \rightleftharpoons C_2H_6 (g) \; ; \; \Delta H° < 0$$
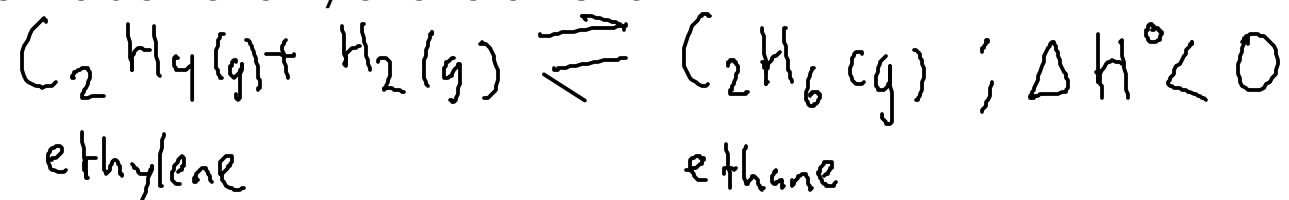
ethylene   ethane

Temperature?

- This is an EXOTHERMIC reaction (enthalpy change negative)

$$C_2H_4 + H_2 \rightleftharpoons C_2H_6 + heat$$

Higher temperature (more heat), causes the equilibrium to shift left towards ethylene. Lowering temperature (removing heat) would cause a shift to the right (more ethane).

Pressure?

Since there are two moles of gas on the left and only one on the right, this gas-phase equilibrium CAN respond to pressure!

Compressing the gas will make the equilibrium shift to try to make fewer moles of gas (the right-hand side ... ethane). So, high pressure is what we need.

OPTIMAL CONDITIONS WOULD BE LOW TEMPERATURE AND HIGH PRESSURE