

$$15.31 \quad M = \frac{\text{moles}}{\text{liters}} = \frac{0.0406 \text{ mol CH}_3\text{OH}}{2 \text{ liters}} = 0.0203\text{M CH}_3\text{OH}$$

$$M = \frac{\text{moles}}{\text{liters}} = \frac{0.170 \text{ mol CO}}{2 \text{ liters}} = 0.0850\text{M CO}$$

$$M = \frac{\text{moles}}{\text{liters}} = \frac{0.302 \text{ mol H}_2}{2 \text{ liters}} = 0.151\text{M H}_2$$

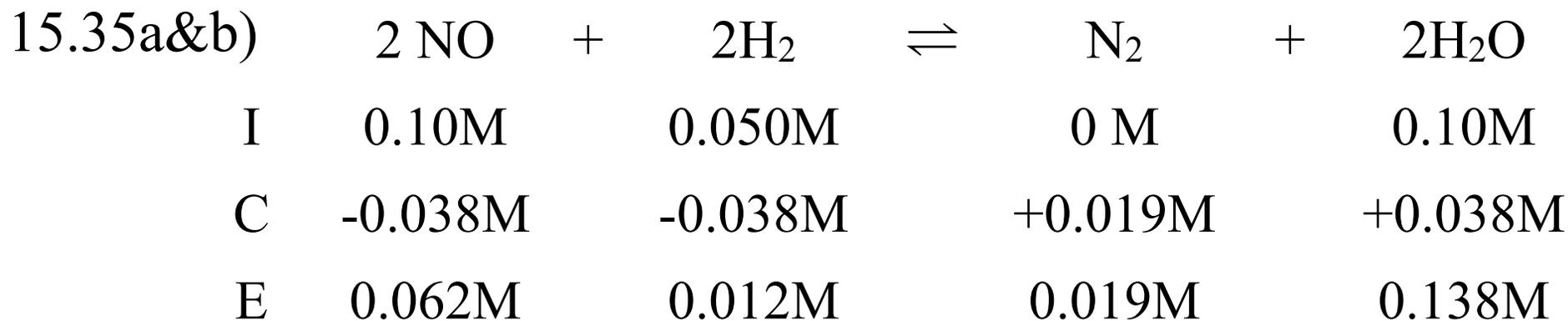
$$K_c = \frac{[\text{CH}_3\text{OH}]}{[\text{CO}][\text{H}_2]^2} = \frac{[0.0203\text{M}]}{[0.0850\text{M}][0.151\text{M}]^2} = 10.5$$

$$15.32 \quad K_c = \frac{[\text{I}_2][\text{H}_2]}{[\text{HI}]^2} = \frac{[4.79 \times 10^{-4}\text{M}][4.79 \times 10^{-4}\text{M}]}{[3.53 \times 10^{-3}\text{M}]^2} = 0.0184$$

$$15.33\text{a)} \quad K_p = \frac{(P_{\text{NOCl}})^2}{(P_{\text{NO}})^2(P_{\text{Cl}_2})} = \frac{(0.28\text{atm})^2}{(0.095\text{atm})^2(0.171\text{atm})} = 51$$

$$15.34a) \quad K_p = \frac{(P_{\text{PCl}_5})}{(P_{\text{PCl}_3})(P_{\text{Cl}_2})} = \frac{(1.30\text{atm})}{(0.124\text{atm})(0.157\text{atm})} = 66.8$$

15.34b) This process favors products, as indicated by a K_p value greater than 1



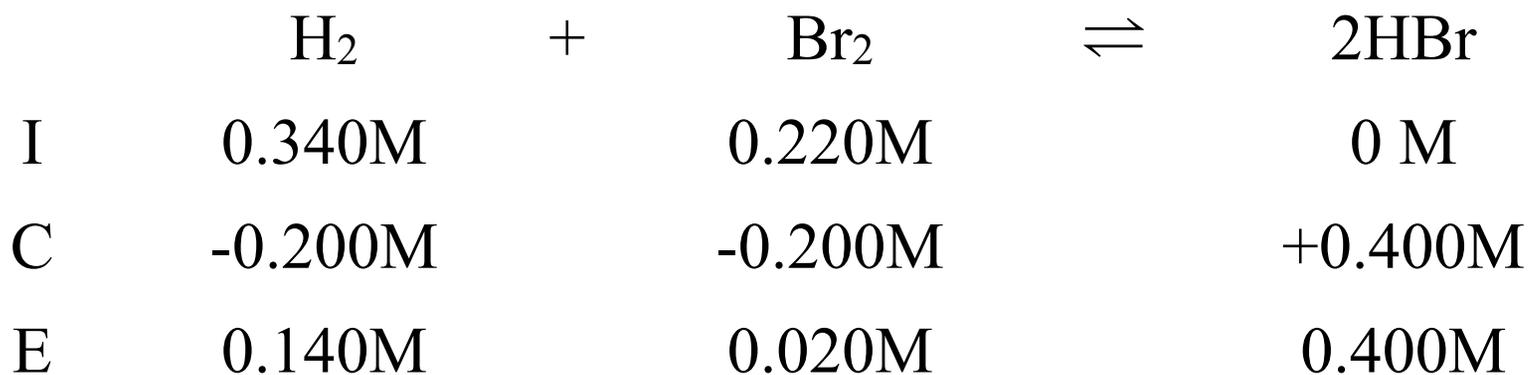
$$K_c = \frac{[\text{N}_2][\text{H}_2\text{O}]^2}{[\text{NO}]^2[\text{H}_2]^2} = \frac{[0.019\text{M}][0.138\text{M}]^2}{[0.062\text{M}]^2 [0.012\text{M}]^2} = 650$$

15.36

$$M = \frac{\text{moles}}{\text{liters}} = \frac{1.374\text{g H}_2 / 2.02\text{g mol}^{-1}}{2.00 \text{ liters}} = 0.340\text{M H}_2$$

$$M = \frac{\text{moles}}{\text{liters}} = \frac{70.31\text{g Br}_2 / 159.8 \text{ mol}^{-1}}{2.00 \text{ liters}} = 0.220\text{M Br}_2$$

$$M = \frac{\text{moles}}{\text{liters}} = \frac{0.566\text{g H}_2 / 2.02\text{g mol}^{-1}}{2.00 \text{ liters}} = 0.140\text{M H}_2$$



$$K_c = \frac{[\text{HBr}]^2}{[\text{H}_2][\text{Br}_2]} = \frac{[0.400\text{M}]^2}{[0.140][0.020\text{M}]} = 57$$

15.37

$$P_{\text{CO}_2} = nRT/V = (0.2000\text{mol} \cdot 0.08206 \cdot 500\text{K})/2.000\text{L} = 4.10 \text{ atm}$$

$$P_{\text{H}_2} = nRT/V = (0.1000\text{mol} \cdot 0.08206 \cdot 500\text{K})/2.000\text{L} = 2.05 \text{ atm}$$

$$P_{\text{H}_2\text{O}} = nRT/V = (0.1600\text{mol} \cdot 0.08206 \cdot 500\text{K})/2.000\text{L} = 3.28 \text{ atm}$$

	CO ₂	+	H ₂	⇌	CO	+	H ₂ O
I	4.10 atm		2.05 atm		0 M		3.28 atm
C	-0.23 atm		-0.23 atm		+0.23 atm		+0.23 atm
E	3.87 atm		1.82 atm		0.23 atm		3.51 atm

$$K_p = \frac{(P_{\text{CO}})(P_{\text{H}_2\text{O}})}{(P_{\text{CO}_2})(P_{\text{H}_2})} = \frac{(0.23\text{atm})(3.51\text{atm})}{(3.87\text{atm})(1.82\text{atm})} = 0.11$$

15.38

	N_2O_4	\rightleftharpoons	2NO_2
I	1.500 atm		1.00 atm
C	+0.244		-0.488
E	1.744atm		0.512atm

$$K_p = \frac{(P_{\text{NO}_2})^2}{(P_{\text{N}_2\text{O}_4})} = \frac{(0.512\text{atm})^2}{(1.744\text{atm})} = 0.150$$

15.39

	X	+	Y	\rightleftharpoons	XY
I	1.0 mM		1.0 mM		0 mM
C	-0.80 mM		-0.80 mM		+0.80 mM
E	0.20 mM		0.20 mM		0.80 mM

$$K_c = \frac{[\text{XY}]}{[\text{X}][\text{Y}]} = \frac{[0.80 \times 10^{-3} \text{ M}]}{[0.20 \times 10^{-3} \text{ M}][0.20 \times 10^{-3} \text{ M}]} = 20,000$$

15.41

a) This is true. The K_c and Q expressions are the same.

b) This is true. If $Q < K_c$, the reaction will proceed to the right, creating more products.

15.43

$$K_c = \frac{[\text{CO}][\text{Cl}_2]}{[\text{CoCl}_2]} = 2.19 \times 10^{-10}$$

15.43a)

$$Q = \frac{[\text{CO}][\text{Cl}_2]}{[\text{CoCl}_2]} = \frac{[3.3 \times 10^{-6}\text{M}][6.62 \times 10^{-6}\text{M}]}{[2.00 \times 10^{-3}\text{M}]} = 1.1 \times 10^{-8}$$

$Q > K_c$, the reaction will proceed to the left to attain equilibrium

15.43b)

$$Q = \frac{[\text{CO}][\text{Cl}_2]}{[\text{CoCl}_2]} = \frac{[1.1 \times 10^{-7}\text{M}][2.25 \times 10^{-6}\text{M}]}{[4.50 \times 10^{-2}\text{M}]} = 5.5 \times 10^{-12}$$

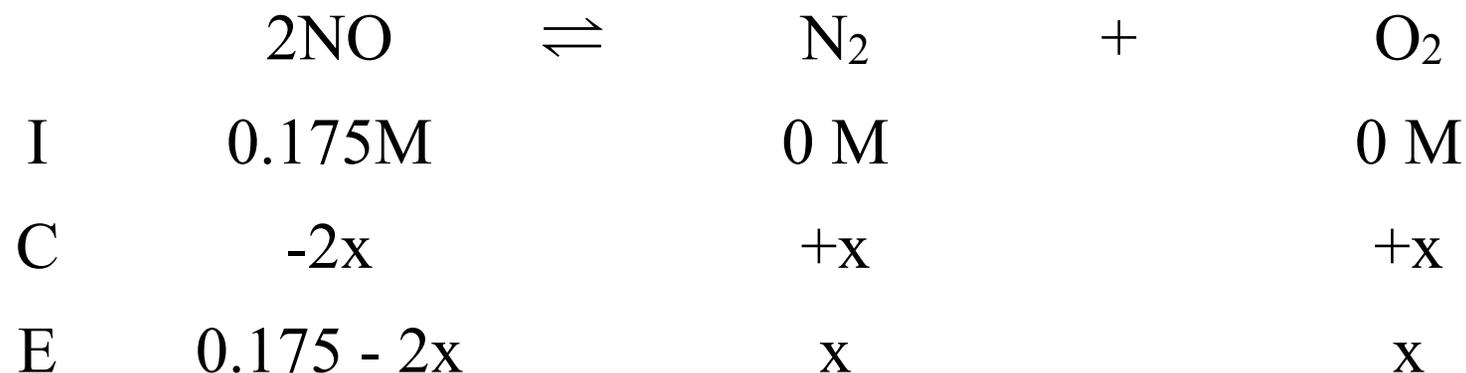
$Q < K_c$, the reaction will proceed to the right to attain equilibrium

15.43c)

$$Q = \frac{[\text{CO}][\text{Cl}_2]}{[\text{CoCl}_2]} = \frac{[1.48 \times 10^{-6}\text{M}][1.48 \times 10^{-6}\text{M}]}{[0.0100\text{M}]} = 2.19 \times 10^{-10}$$

$Q = K_c$, the reaction is at equilibrium

15.55



$$K_c = \frac{[\text{N}_2][\text{O}_2]}{[\text{NO}]^2}$$

$$2400 = \frac{x^2}{[0.175-2x]^2}$$

$$49.0 = \frac{x}{0.175-2x}$$

$$49.0(0.175-2x) = x$$

$$8.58-98x = x$$

$$-99x = -8.58$$

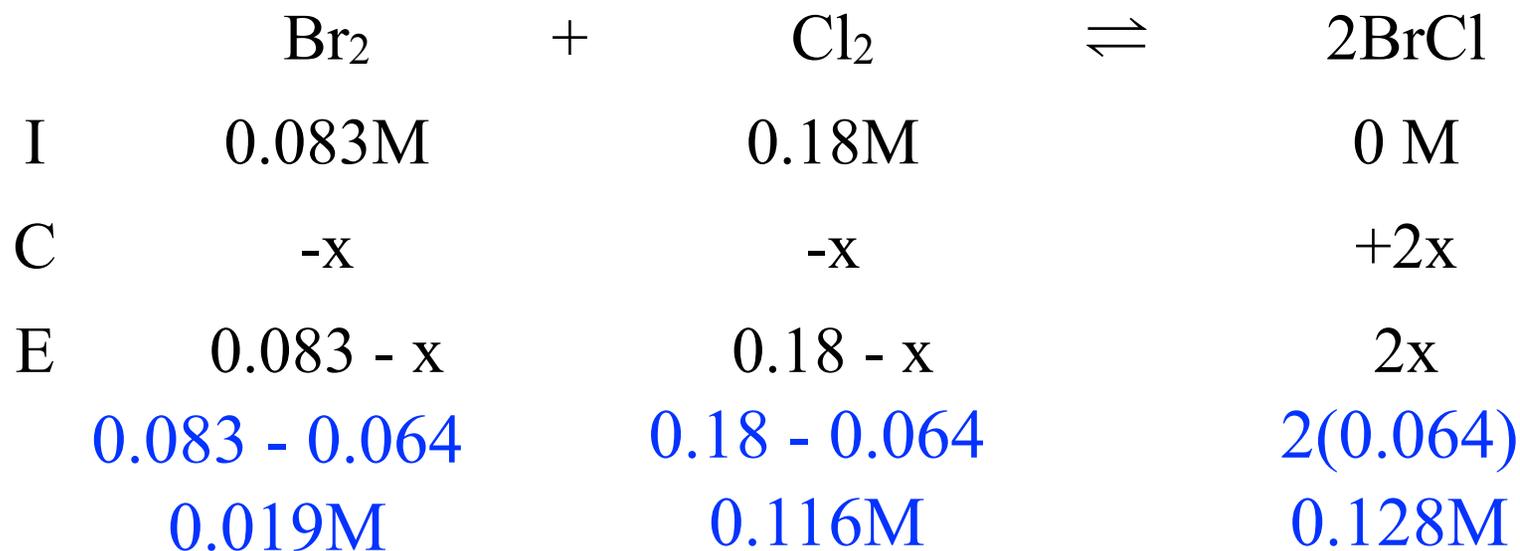
$$x = 0.087$$

The concentration of N_2 and O_2 are both 0.087M. The concentration of NO at equilibrium is $0.175 - 2(0.087)$ or 0.001M

15.57

$$M = \frac{\text{moles}}{\text{liters}} = \frac{0.25 \text{ mol Br}_2}{3.0 \text{ liters}} = 0.083 \text{ M Br}_2$$

$$M = \frac{\text{moles}}{\text{liters}} = \frac{0.55 \text{ mol Cl}_2}{3.0 \text{ liters}} = 0.18 \text{ M Br}_2$$



$$K_c = \frac{[\text{BrCl}]^2}{[\text{Br}_2][\text{Cl}_2]} = \frac{(2x)^2}{[0.083 - x][0.18 - x]} = 7.0$$

$$7.0(0.015 - 0.26x + x^2) = 4x^2$$

$$0.11 - 1.8x + 7x^2 = 4x^2$$

$$3x^2 - 1.8x + 0.11 = 0$$

x = 0.064 and 0.56 (which isn't meaningful)