General Chemistry II Lecture Spring 2020 Test 3 3/27/20 F Sect A Dr. Hahn Exam # _____

Name Key (print) Name _____ (sign)

Please show work for partial credit &full credit on the Short Answer Questions. Multiple choice questions have no partial credit. Please write anything you want graded legibly. If you run out of space, continue on the empty back pages but clearly label where the remaining answers can be found. (Please count your exam pages and make sure there are ## pages) I prefer that you print the test and scan in the completed Test. However it is OK to just give multiple choice number with the correct letter and to just give short answer number on a blank sheet of paper & cell phone photo. In either case you have 2 hours 15 minutes from the time that you open the emailed test until you email the completed test back to me. This test is Open Notes and Open Book but NOT open another person.

(M = moles solute / L solution) [R= 0.08206 L atm/(mol K)] $K_p = K_c(RT)^{\Delta n}$

MULTIPLE CHOICE. Choose the one best alternative.

$\frac{1}{[A]_t} = kt + \frac{1}{[A]_0}$

1) A plot of 1/[BrO−] vs time is linear for the reaction: 1) C

$$3\ BrO^-(aq) \rightarrow BrO_3^-(aq) + 2\ Br^-(aq)$$

What is the order of the reaction with respect to the hypobromite ion, BrO−?

A) 0 B) 1 C) 2 D) 3

2) For the overall reaction shown below, what statement is correct about the rate law ? 2) B

$$C(s) + 2\ H_2(g) \rightarrow CH_4(g)$$

A) The rate law is unimolecular.
B) The rate law cannot be determined.
C) The rate law is termolecular.
D) The rate law is bimolecular.

3) Which one of the following statements does **not** describe the equilibrium state? 3) C

A) Equilibrium is dynamic and there is no net conversion to reactants and products.
B) The rate of the forward reaction is equal to the rate of the reverse reaction.
C) The concentration of the reactants is equal to the concentration of the products.
D) The concentration of the reactants and products reach a constant level.

4) Which general rate law below corresponds to an elementary bimolecular reaction? 4) C

A) Rate = k[A] [B]^2 termolecular B) Rate = k[B] unimolecular

C) Rate = k[A]^2 D) Rate = k[A][B][C][D]

5) Write the equilibrium equation for the **reverse** reaction: 5) D

$$2\ CH_4(g) + 3\ O_2(g) = 2\ CO(g) + 4\ H_2O(g)$$

A) $K_p' = \frac{2[P_{CH4}] + 3[P_{O2}]}{2[P_{CO}] + 4[P_{H2O}]}$

B) $K_p' = \frac{[P_{CO}]^2\,[P_{H2O}]^4}{[P_{CH4}]^2\,[P_{O2}]^3}$

C) $K_p' = \frac{2[P_{CO}] + 4[P_{H2O}]}{2[P_{CH4}] + 3[P_{O2}]}$

D) $K_p' = \frac{[P_{CH4}]^2\,[P_{O2}]^3}{[P_{CO}]^2\,[P_{H2O}]^4}$

6) For the reaction, $A(g) + 2\ B(g) = 2\ C(g)$, $K_c = 5.00 \times 10^{10}$ at 25°C. Which of the following statements is true? 6) A

A) The concentration of the products is greater than the concentration of the reactants.
B) $\Delta n = +1$ (2 − 3 = −1)
C) The reaction is favored in the reverse direction.
D) The value of K_p will be larger than the value for K_c.

7) If K_c equals 0.110 at 25°C for the reaction: $N_2O_4(g) = 2\ NO_2(g)$, what is K_c for the reaction: ~~$4NO_2(g) = N_2O_4(g)$?~~ 7) C

$4NO_2 \rightleftharpoons 2\ N_2O_4$ $(1/0.110)^2$

A) 7.5 B) 0.11 C) 82.6 D) 1.3×10^{-3}

8) What is true about the relationship of K_p and K_c for the reaction: 8) B

$\Delta n = 3 - 4 = -1$

$$2\ H_2(g) + 2\ NO(g) \rightarrow N_2(g) + 2\ H_2O(g)$$

$K_p = K_c (RT)^{\Delta n}$ (Kelvin)

A) $K_p = K_c$
B) $K_p < K_c$
C) $K_p > K_c$
D) K_p and K_c are not related.

9) The **slowest** step in a reaction mechanism is called the _____ step. 9) D
A) termination
B) elementary
C) rate law
D) rate-determining

10) What is the equilibrium equation for the dissociation of formic acid in water? 10) C

$$HCOOH\ (aq) + H_2O\ (l) = H_3O^+\ (aq) + HCOO^-\ (aq)$$

A) $K_c = \frac{[H_3O^+]\,[HCOO^-]}{[HCOOH]\,[H_2O]}$

B) $K_c = \frac{[HCOOH]}{[H_3O^+]\,[HCOO^-]}$

C) $K_c = \frac{[H_3O^+]\,[HCOO^-]}{[HCOOH]}$

D) $K_c = \frac{[HCOOH]\,[H_2O]}{[H_3O^+]\,[HCOO^-]}$

11) Which change in the system will drive equilibrium to the left in the reaction below? 11) D

$$N_2O_5(g) = NO_2(g) + NO_3(g)$$

A) increase the amount of N_2O_5
B) decrease the amount of NO_2
C) decrease the amount of NO_3
D) decrease the amount of N_2O_5 (g)

12) The half life of the reaction shown below is found not to depend on the concentration of $H_2O_2(aq)$. 12) B

$$2\ H_2O_2(aq) \rightarrow 2\ H_2O(l) + O_2(g)$$

What is the order of this reaction?
A) zeroth
B) first
C) second
D) third

13) An aqueous reaction occurs by a two-step mechanism, shown below. 13) B

Step 1: $A_2X_2 + Y \rightarrow A_2X + XY$
Step 2: $A_2X_2 + XY \rightarrow A_2X + X_2 + Y$

What is the catalyst in this reaction?
A) X_2
B) Y
C) A_2X_2
D) XY

14) A three-step mechanism has been suggested for the formation of carbonyl chloride: 14) C

Step 1: $Cl_2 \rightarrow 2\ Cl$ (slow)
Step 2: $Cl + CO \rightarrow COCl$ (fast, equilibrium)
Step 3: $COCl + Cl_2 \rightarrow COCl_2 + Cl$ (fast, equilibrium)

What is the molecularity of the rate-determining step?
A) termolecular
B) bimolecular
C) unimolecular
D) none of these

15) Using the method of initial rates for the reaction A → B, if the initial concentration of A is doubled and the rate of reaction doubles, what is the order of reaction with respect to A? 15) B
A) fourth
B) first
C) second
D) zeroth

16) A catalyst increases the rate of a reaction by providing a different reaction pathway that 16) A
A) lowers only the activation energy.
B) raises only the energy of the products.
C) lowers only the energy of the reactants and products.
D) All of these are affected by the presence of a catalyst.

Part II: Short Answers Please **show work on all questions** for partial credit even on questions which do not specify. (40 total pts)

1. Given the following reaction experimental data, what is value of m ? Show work. (10 pts)

$2\ NO\ (g) + Cl_2\ (g) \rightarrow 2\ NOCl\ (g)$ rate = $k\ [NO]^m\ [Cl_2]^n$

Expt	[NO] (M)	Cl_2	rate
1	0.0125	0.0255	2.27×10^{-5}
2	0.0125	0.0510	4.55×10^{-5}
3	0.0250	0.0255	9.08×10^{-5}

$$\frac{9.08 \times 10^{-5}}{2.27 \times 10^{-5}} = \frac{k\,[0.0250]^m\,[1]^n}{k\,[0.0125]^m\,[1]^n}$$

5 pts

$$4 = \left[\frac{0.0250}{0.0125}\right]^m (1)$$

$$4 = (2)^m \quad \text{5 pts}$$

$$m = 2$$

2 a. For the reaction given below, the reaction starts by having 2.57 M CH_4 and 1.78 M H_2O (and no product) show the ICE table. (8 pts)

	$CH_4\ (g)$	$+\ 2\ H_2O(g)$	$\rightarrow\ CO_2\ (g)$	$+\ 4\ H_2\ (g)$
I	2.57	1.78	0	0
C	$-x$	$-2x$	$+x$	$+4x$
E	$2.57-x$	$1.78-2x$	$+x$	$+4x$

1 pt each

½ pt each

½ pt each

b. If Kc = 7.8×10^5 for the above reaction, give the equilibrium expression based on the ICE table. (Do not solve for equilibrium concentrations of CH_4.) (7 pts)

$$7.8 \times 10^5 = \frac{(x)(4x)^4}{(2.57-x)(1.78-2x)^2}$$

1 pt

2 pt

1 pt

3. For the reaction:

$N_2(g) + 3\,H_2(g) \rightleftarrows 2\,NH_3(g)$

At the start of the reaction, 0.0711 M N_2, 9.17×10^{-3} M H_2 and 1.83 x 10-4 M NH_3 are combined.

(a) What is the equilibrium constant expression ? (6 pts)

$$K = \frac{[NH_3]^2}{[N_2][H_2]^3}$$ — 2 pts each

(b) What is Q ? (6 pts)

$$Q = \frac{[1.83\times10^{-4}]^2}{(0.0711)(9.17\times10^{-3})^3} = 3.35\times10^{-8}$$ — 2 pts each

(c) Does the reaction go forward to product ? Explain in a few words. (3 pts)

(typo $K_c = 1.2\times10^2$)

$$(0.0711)(7.71\times10^{-7})$$

$$K_c = 1.2\times10^2$$

$Q = 0.611$ (1 pt)

$Q < K_c$

$0.611 \quad 1.2\times10^2$

RXN goes →

General Chemistry II Lecture Spring 2020 Test 3 3/27/20 F Sect C Dr. Hahn Exam # _____

Name Key (print) Name _____ (sign)

Please show work for partial credit &full credit on the Short Answer Questions. Multiple choice questions have no partial credit. Please write anything you want graded legibly. If you run out of space, continue on the empty back pages but clearly label where the remaining answers can be found. (Please count your exam pages and make sure there are ## pages) I prefer that you print the test and scan in the completed Test. However it is OK to just give multiple choice number with the correct letter and to just give short answer number on a blank sheet of paper & cell phone photo. In either case you have 2 hours 15 minutes from the time that you open the emailed test until you email the completed test back to me. This test is Open Notes and Open Book but NOT open another person.

(M = moles solute / L solution) [R= 0.08206 L atm/(mol K)] $K_p = K_c(RT)^{\Delta n}$

MULTIPLE CHOICE. Choose the one best alternative.

1) A catalyst increases the rate of a reaction by providing a different reaction pathway that 1) B
A) lowers only the energy of the reactants and products.
B) lowers only the activation energy.
C) raises only the energy of the products.
D) All of these are affected by the presence of a catalyst.

2) What is the overall reaction order for the reaction that has the rate law: Rate = $k[H_2][NO]$? 2) C
A) zero order B) first order C) second order D) third order

3) The **slowest** step in a reaction mechanism is called the _____ step. 3) B
A) rate law B) rate-determining
C) elementary D) termination

4) The reaction below is first order in H_2 and second order in NO. What is the rate law for this reaction? 4) C

$$2\ H_2(g) + 2\ NO(g) \rightarrow N_2(g) + 2\ H_2O(g)$$

A) Rate = $2k[H_2]^{1/2}[NO]^{1/2}$ B) Rate = $2k[H_2][NO]$
C) Rate = $k[H_2][NO]^2$ D) Rate = $k[H_2]^{1/2}[NO]$

5) If K_c equals 2.78 at 25°C for the reaction: $N_2O_4(g) = 2\ NO_2(g)$, what is K_c for the reaction: $6NO_2(g) = 3\ N_2O_4(g)$? 5) A
A) 4.65×10^{-2} B) 7.5 C) 751 D) 0.11

6) The rate constant, k, for a first-order reaction is equal to $4.2 \times 10^{-4}\ s^{-1}$. What is the half-life for the reaction? 6) D
A) 2.4×10^{3} s B) 2.9×10^{-4} s C) 1.2×10^{3} s D) 1.7×10^{3} s

7) For the zeroth-order reaction: C → products, $-\Delta[C]/\Delta t = k$, which of the following graphs would be expected to give a straight line? 7) D

A) 1/[C] vs. t B) 1/ln[C] vs. t^2 C) $[C]^2$ vs. t^2 D) [C] vs. t

8) Write the equilibrium equation for the **reverse** reaction: 8) D

$$2\ CH_4(g) + 3\ O_2(g) = 2\ CO(g) + 4\ H_2O(g)$$

A) $K_p = \frac{2[P_{CH4}] + 3[P_{O2}]}{2[P_{CO}] + 4[P_{H2O}]}$ B) $Kp = \frac{2[P_{CO}] + 4[P_{H2O}]}{2[P_{CH4}] + 3[P_{O2}]}$

C) $K_p = \frac{[P_{CO}]^2\,[P_{H2O}]^4}{[P_{CH4}]^2\,[P_{O2}]^3}$ D) $K_p = \frac{[P_{CH4}]^2\,[P_{O2}]^3}{[P_{CO}]^2\,[P_{H2O}]^4}$

9) Which general rate law below corresponds to an elementary bimolecular reaction? 9) D

A) Rate = k[A][B][C][D] B) Rate = k[A] $[B]^2$

C) Rate = k[B] D) Rate = $k[A]^2$

10) Which statement is true for a reaction with K_c equal to 8.90×10^{12}? 10) B

A) There are appreciable concentrations of both reactants and products.

B) The reaction proceeds nearly all the way to completion.

C) Increasing the temperature will not change the value of K_c.

D) The reaction proceeds hardly at all towards completion.

11) The elementary reaction: $2\ HF \rightarrow H_2 + F_2$, is an example of a _____ reaction. 11) D

A) unimolecular B) termolecular C) tetramolecular D) bimolecular

12) What is true about the relationship of K_p and K_c for the reaction: 12) A

$$2\ H_2(g) + 2\ NO(g) \rightarrow N_2(g) + 2\ H_2O(g)$$

$\Delta n = 3 - 4 = -1$

$K_p = K_c(RT^{\#})$

$K_p < K_c$

A) $K_p < K_c$ B) $K_p > K_c$

C) $K_p = K_c$ D) K_p and K_c are not related

13) What is the minimum energy barrier that must be overcome for a chemical reaction to occur? 13) B

A) potential energy B) activation energy

C) net energy D) rate limiting energy

14) Which change in the system will drive equilibrium to the left in the reaction below? 14) A

$$N_2O_5(g) = NO_2(g) + NO_3(g)$$

A) decrease the amount of N_2O_5 (g)
B) decrease the amount of NO_2
C) increase the amount of N_2O_5
D) decrease the amount of NO_3

15) An aqueous reaction occurs by a two-step mechanism, shown below. 15) C

Step 1: $A_2X_2 + Y \rightarrow A_2X + XY$
Step 2: $A_2X_2 + XY \rightarrow A_2X + X_2 + Y$

What is the catalyst in this reaction?
A) A_2X_2 B) XY C) Y D) X_2

16) Which one of the following statements does **not** describe the equilibrium state? 16) B
A) The concentration of the reactants and products reach a constant level.
B) The concentration of the reactants is equal to the concentration of the products.
C) The rate of the forward reaction is equal to the rate of the reverse reaction.
D) Equilibrium is dynamic and there is no net conversion to reactants and products.

Part II: Short Answers Please **show work on all questions** for partial credit even on questions which do not specify. (40 total pts)

1. Given the following reaction experimental data, what is value of m ? Show work.(10 pts)

$S_2O_8^{2-}$ (aq) + 3 I^- (aq) → 2 SO_4^{2-} (aq) + I_3^- rate = k $[S_2O_8^{2-}]^m [I^-]^n$

Expt	$S_2O_8^{2-}$	I^-	rate
1	0.080	0.034	2.2×10^{-4}
2	0.080	0.017	1.1×10^{-4}
3	0.16	0.017	2.2×10^{-4}

$\frac{2.2\times10^{-4}}{1.1\times10^{-4}} = \frac{k}{k}\left[\frac{0.16}{0.08}\right]^m\left[\frac{1}{1}\right]^n$

5 pts

$2 = (2)^m (1)^n$

5 pts

$m = 1$

2 a. For the reaction given below, the reaction starts by having 0.0348 M CH_4 and 0.234 M H_2O (and no product) show the ICE table. (8 pts)

CH_4 (g) + 2 H_2O(g) → CO_2 (g) + 4 H_2 (g)

	CH_4	H_2O	CO_2	H_2
I	0.0348	0.234	0	0
C	$-x$	$-2x$	$+x$	$+4x$
E	$0.0348 - x$	$0.234 - 2x$	$+x$	$+4x$

1 pt each

½ pt each

b. If Kc = 7.98×10^{-2} for the above reaction, give the equilibrium expression based on the ICE table. (Do not solve for equilibrium concentrations of CH_4.) (7 pts)

1 pt

$7.98\times10^{-2} = \frac{(x)(4x)^4}{(0.0348-x)(0.234-2x)^2}$

2 pt each

3. For the reaction:

$N_2(g) + 3\,H_2(g) \rightleftarrows 2\,NH_3(g)$

At the start of the reaction, 0.511 M N_2, 0.0788 M H_2 and 3.84 M NH_3 are combined.

(a) What is the equilibrium constant expression ? (6 pts)

$$K = \frac{[NH_3]^2}{[N_2][H_2]^3}$$ 2 pts each

(b) What is Q ? (6 pts)

$$Q = \frac{(3.84)^2}{(0.511)(0.0788)^3} = 2.50 \times 10^{-4}$$ 2 pts each

4.89×10^{-4} 5.89×10^{4}

(c) Does the reaction go forward to product ? Explain in a few words. (3 pts)

$Q = 5.899 \times 10^{4}$ $(K_c = 1.2 \times 10^{2})$

$K_c = 1.2 \times 10^{2}$

$5.9 \times 10^{4} > 1.2 \times 10^{2}$

$Q > K_c$

(RXN goes toward reactant)

General Chemistry II Lecture Spring 2020 Test 3 3/28/20 Sat MakeUp Dr. Hahn Exam # _____

Name Key (print) Name _____ (sign)

Please show work for partial credit &full credit on the Short Answer Questions. Multiple choice questions have no partial credit. Please write anything you want graded legibly. If you run out of space, continue on the empty back pages but clearly label where the remaining answers can be found. (Please count your exam pages and make sure there are ## pages) I prefer that you print the test and scan in the completed Test. However it is OK to just give multiple choice number with the correct letter and to just give short answer number on a blank sheet of paper & cell phone photo. In either case you have 2 hours 15 minutes from the time that you open the emailed test until you email the completed test back to me. This test is Open Notes and Open Book but NOT open another person.

(M = moles solute / L solution) [R= 0.08206 L atm/(mol K)] $K_p = K_c(RT)^{\Delta n}$

MULTIPLE CHOICE. Choose the one best alternative.

1) An aqueous reaction occurs by a two-step mechanism, shown below. 1) D

Step 1: $A_2X_2 + Y \rightarrow A_2X + XY$

Step 2: $A_2X_2 + XY \rightarrow A_2X + X_2 + Y$

What is the catalyst in this reaction?

A) A_2X_2 B) XY C) X_2 D) Y

2) What is the minimum energy barrier that must be overcome for a chemical reaction to occur? 2) C

A) potential energy B) rate limiting energy

C) activation energy D) net energy

3) For the zeroth-order reaction: C → products, $-\Delta[C]/\Delta t = k$, which of the following graphs would be expected to give a straight line? 3) D

A) 1/[C] vs. t B) 1/ln[C] vs. t^2 C) $[C]^2$ vs. t^2 D) [C] vs. t

4) A catalyst increases the rate of a reaction by providing a different reaction pathway that 4) A

A) lowers only the activation energy.

B) raises only the energy of the products.

C) lowers only the energy of the reactants and products.

D) All of these are affected by the presence of a catalyst.

5) For the overall reaction shown below, what statement is correct about the rate law ? 5) D

$$C(s) + 2\ H_2(g) \dashrightarrow CH_4(g)$$

A) The rate law is termolecular. B) The rate law is bimolecular.

C) The rate law is unimolecular. D) The rate law cannot be determined.

6) A plot of 1/[BrO⁻] vs time is linear for the reaction: 6) C

$$3\ BrO^-(aq) \rightarrow BrO_3^-(aq) + 2\ Br^-(aq)$$

What is the order of the reaction with respect to the hypobromite ion, BrO⁻?

A) 0 B) 1 C) 2 D) 3

7) Which one of the following statements does **not** describe the equilibrium state? 7) B

A) Equilibrium is dynamic and there is no net conversion to reactants and products.
B) The concentration of the reactants is equal to the concentration of the products.
C) The rate of the forward reaction is equal to the rate of the reverse reaction.
D) The concentration of the reactants and products reach a constant level.

8) A three-step mechanism has been suggested for the formation of carbonyl chloride: 8) A

Step 1: $Cl_2 \rightarrow 2\ Cl$ (slow)
Step 2: $Cl + CO \rightarrow COCl$ (fast, equilibrium)
Step 3: $COCl + Cl_2 \rightarrow COCl_2 + Cl$ (fast, equilibrium)

What is the molecularity of the rate-determining step?

A) unimolecular B) bimolecular C) termolecular D) none of these

9) What is the equilibrium equation for the dissociation of formic acid in water? 9) C

$$HCOOH\ (aq) + H_2O\ (l) = H_3O^+\ (aq) + HCOO^-\ (aq)$$

A) $K_c = \dfrac{[HCOOH]\,[H_2O]}{[H_3O^+]\,[HCOO^-]}$

B) $K_c = \dfrac{[HCOOH]}{[H_3O^+]\,[HCOO^-]}$

C) $K_c = \dfrac{[H_3O^+]\,[HCOO^-]}{[HCOOH]}$

D) $K_c = \dfrac{[H_3O^+]\,[HCOO^-]}{[HCOOH]\,[H_2O]}$

10) If K_c equals 0.110 at 25°C for the reaction: $N_2O_4(g) = 2\ NO_2(g)$, what is K_c for the reaction: $4NO_2(g) = 2\ N_2O_4(g)$? 10) D

A) 7.5 B) 1.3×10^{-3} C) 0.11 D) 82.6

$$\left(\frac{1}{0.110}\right)^2 = 82.6$$

11) Which general rate law below corresponds to an elementary bimolecular reaction? 11) D

A) Rate = $k[A][B][C]$ B) Rate = $k[B]$
C) Rate = $k[A]\,[B]^2$ D) Rate = $k[A]^2$

12) Which change in the system will drive equilibrium to the left in the reaction below? 12) D

$$N_2O_5(g) = NO_2(g) + NO_3(g)$$

A) increase the amount of N_2O_5
B) decrease the amount of NO_2
C) decrease the amount of NO_3
D) decrease the amount of N_2O_5 (g)

13) Which general rate law below corresponds to an elementary bimolecular reaction? 13) B

A) Rate = $k[A]\,[B]^2$
B) Rate = $k[A]^2$
C) Rate = $k[B]$
D) Rate = $k[A][B][C][D]$

14) If K_c equals 2.78 at 25°C for the reaction: $N_2O_4(g) = 2\ NO_2(g)$, what is K_c for the reaction: $8NO_2(g) = 4\ N_2O_4(g)$? 14) C

A) 0.11
B) 8.5
C) 6830
D) 4.65×10^{-2}

typo

no answer

15) The slowest step in a reaction mechanism is called the _____ step. 15) A

A) rate-determining
B) termination
C) elementary
D) rate law

16) Write the equilibrium equation for the **reverse** reaction: 16) B

$$2\ CH_4(g) + 3\ O_2(g) = 2\ CO(g) + 4\ H_2O(g)$$

A) $K_p' = \dfrac{2[P_{CH4}] + 3[P_{O2}]}{2[P_{CO}] + 4[P_{H2O}]}$

B) $K_p' = \dfrac{[P_{CH4}]^2\,[P_{O2}]^3}{[P_{CO}]^2\,[P_{H2O}]^4}$

C) $K_p' = \dfrac{[P_{CO}]^2\,[P_{H2O}]^4}{[P_{CH4}]^2\,[P_{O2}]^3}$

D) $K_p' = \dfrac{2[P_{CO}] + 4[P_{H2O}]}{2[P_{CH4}] + 3[P_{O2}]}$

$\left(\frac{1}{K_c}\right)^4$

$\left(\frac{1}{2.78}\right)^4 =$

1.67×10^{-2}

Part II: Short Answers Please **show work on all questions** for partial credit even on questions which do not specify. (40 total pts)

1. Given the following reaction experimental data, what is value of n? Show work. (10 pts)

$2\ NO\ (g) + Cl_2\ (g) \rightleftarrows 2\ NOCl\ (g)$ rate = $k\ [NO]^m [Cl_2]^n$

Expt	[NO] (M)	Cl_2	rate
1	0.0125	0.0255	2.27×10^{-5}
2	0.0125	0.0510	4.55×10^{-5}
3	0.0250	0.0255	9.08×10^{-5}

$\frac{4.55 \times 10^{-5}}{2.27 \times 10^{-5}} = \frac{k}{k}\left[\frac{0.0125}{0.0125}\right]^m \left[\frac{0.0510}{0.0255}\right]^n$

5 pts

$2 = (1)^m \left(\frac{0.0510}{0.0255}\right)^n$

$2 = (2)^n$ 5 pts

$n = 1$

2 a. For the reaction given below, the reaction starts by having 2.57 M NO and 1.78 M Cl_2 and no product) show the ICE table. (8 pts)

	$2\ NO\ (g) + Cl_2\ (g) \rightleftarrows 2\ NOCl\ (g)$		
I	2.57 M	1.78	0
C	$-2x$	$-x$	$+2x$
E	$2.57-2x$	$1.78-x$	$2x$

1 pt each

1 pt each (1st wrong no pts off)

$K_c = \frac{[NOCl]^2}{[NO]^2[Cl_2]}$

b. If $K_c = 7.8 \times 10^5$ for the above reaction, give the equilibrium expression based on the ICE table. (Do not solve for equilibrium concentrations of Cl_2.) (7 pts)

$7.8 \times 10^5 = \frac{(2x)^2}{(2.57-2x)^2(1.78-x)}$

1 pt

2 pts each

3. For the reaction:

$CH_4(g) + 2\,H_2O(g) \rightleftarrows CO_2(g) + 4\,H_2(g)$

At the start of the reaction, 7.8×10^{-3} M CH_4, 2.4×10^{-2} M H_2O and 4.2×10^{-3} M CO_2 and 0.0036 M H_2 are combined.

(a) What is the equilibrium constant expression ? (6 pts)

1 pt 2 pt

$$K = \frac{[CO_2][H_2]^4}{[CH_4][H_2O]^2}$$

2 pts

(b) What is Q ? (6 pts)

1 pt each

$$Q = \frac{(4.2\times10^{-3})(0.0036)^4}{(1.8\times10^{-3})(2.4\times10^{-2})^2} = \frac{7.05\times10^{-13}}{4.49\times10^{-6}}$$

$$Q = 1.57\times10^{-7}$$ 2 pts

(c) Does the reaction go forward to product ? $K = 7.82 \times 10^{10}$ Explain in a few words. (3 pts)

$7.82\times10^{10} > 1.57\times10^{-7}$

K Q

RXN goes forward