Chem 1105 EQUILIBRIUM

Date: _____ Names: _____ Section: _____

_____

OBJECTIVE: To investigate various chemical equilibria and explain them using Le Chatelier's Principle.

PROCEDURE: As in Chem. 1105 lab manual, pp. _____

Equilibrium I

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$$

Questions for test tube 2, equilibrium I step 2

		$[CrO_4^{2-}]$	$[H^+]$	$[Cr_2O_7^{2-}]$
I 2 a)	Initial colour _____ Which chemical is predominant?			
I 2 b)	Final colour _____ Which chemical is predominant?			
I 2 c)	Which of the ions in the table does HCl directly contribute to the equilibrium?			
I 2 d)	Show the **effect** of the addition of the HCl on the other ions. Do they increase or decrease?			

I 2 e) In which direction did equilibrium I shift? _____

I 2 f) Explain why the colour changed. Use Le Chatelier's principle.

Questions for test tube 3, equilibrium I step 3

		$[CrO_4^{2-}]$	$[H^+]$	$[Cr_2O_7^{2-}]$
I 3 a)	Initial colour _____ Which chemical is predominant?			
I 3 b)	Final colour _____ Which chemical is predominant?			
I 3 c)	With which ion in the table does the NaOH react? Does it increase or decrease the concentration of that ion?			
I 3 d)	Show the **effect** of the addition of the NaOH on the other ions. Do they increase or decrease?			

I 3 e) In which direction did equilibrium I shift? _____

I 3 f) Explain why the colour did not change. Use Le Chatelier's principle.

Questions for test tube 4, equilibrium I step 4

		$[CrO_4^{2-}]$	$[H^+]$	$[Cr_2O_7^{2-}]$
I 4 a)	Initial colour _____ Which chemical is predominant?			
I 4 b)	Final colour _____ Which chemical is predominant?			
I 4 c)	With which ion in the table does the NaOH react? Does it increase or decrease the concentration of that ion?			
I 4 d)	Show the **effect** of the addition of the NaOH on the other ions. Do they increase or decrease?			

I 4 e) Which direction did equilibrium I shift? _____

I 4 f) Explain why the colour changed. Use Le Chatelier's principle.

Equilibrium I

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$$

yellow solution — orange solution

Equilibrium II

$$BaCrO_4(s) \rightleftharpoons Ba^{2+}(aq) + CrO_4^{2-}(aq)$$

Questions for equilibrium II step 2

	$BaCrO_4$	$[Ba^{2+}]$	$[CrO_4^{2-}]$	$[H^+]$	$[Cr_2O_7^{2-}]$
II 2 a) What is formed? _____ Which chemical is this?					

Questions for equilibrium II step 3

	$BaCrO_4$	$[Ba^{2+}]$	$[CrO_4^{2-}]$	$[H^+]$	$[Cr_2O_7^{2-}]$
II 3 a) What happens to the precipitate on addition of HCl?					
II 3 b) What is the colour of the solution on addition of HCl? _____ Therefore which species have increased, and which decreased after adding HCl?					

After adding HCl:

II 3 c) In which direction did equilibrium I shift? _____
II 3 d) In which direction did equilibrium II shift? _____
II 3 c) Explain why the colour and precipitate changed. Use Le Chatelier's principle.

Questions for equilibrium II step 4

II 4 a) What reagent (other than a barium or chromium salt) caused the $BaCrO_4$ to re-form? _____

		$BaCrO_4$	$[Ba^{2+}]$	$[Cr O_4^{2-}]$	$[H^+]$	$[Cr_2O_7^{2-}]$
II 4 b)	On addition of the above, with which ion does it react?					
II 4 c)	Therefore which species have increased, and which decreased?					

II 4 d) Which direction did equilibrium I shift? _____

II 4 e) Which direction did equilibrium II shift? _____

II 4 f) Explain why the colour and precipitate changed. Use Le Chatelier's principle.

Equilibrium III

$$\underset{\text{pale blue solution}}{2Cu^{2+}(aq)} + \underset{\text{colourless solution}}{4I^-(aq)} \rightleftharpoons \underset{\text{pale green solid}}{2CuI(s)} + \underset{\text{pale yellow solution}}{I_2(aq)} \quad \text{(III) A}$$

Questions for equilibrium III step 1

III 1 a) Name **all** the ions and compounds present in the test tube after step 1 has been carried out.

III 1 b) What colour is the solution in the test tube after all the chemicals have been added? _____

III 1 c) Describe dichloromethane _____

Equilibrium III continued

$2Cu^{2+}(aq)$ + $4I^{-}(aq)$ ⇌ $2CuI(s)$ + $I_2(aq)$ (III) A

pale blue solution | colourless solution | pale green solid | pale yellow solution

$I_2(aq)$ ⇌ $I_2\ (CH_2Cl_2)$ (III) B

pale yellow solution | pink-purple solution

Questions for equilibrium III step 2

Use the table below to *describe* what you observed (including changes) after the dichloromethane has been added and the contents of the test tube have been shaken.

III 2 a)	Observations of the shade, colour and cloudiness of the aqueous layer	
III 2 b)	Observations of the shade, colour and cloudiness of the dichloromethane layer	

	After the addition of CH_2Cl_2, which species increased and which decreased:	$[Cu^{2+}]$	$[I^-]$	CuI	$[I_{2\,(aq)}]$	$[I_2(CH_2Cl_2)]$
III 2 c)	In equilibrium (III) A?					
III 2 d)	In equilibrium (III) B?					

III 2 e) Which direction did equilibrium (III) A shift? _____

III 2 f) Which direction did equilibrium (III) B shift? _____

III 2 g) Explain the directions of the shifts. Use Le Chatelier's principle.

Equilibrium III continued

$2Cu^{2+}(aq)$ pale blue solution	+	$4I^{-}(aq)$ colourless solution	⇌	$2CuI(s)$ pale green solid	+	$I_2(aq)$ pale yellow solution	(III) A
		$I_2(aq)$ pale yellow solution	⇌	$I_2\ (CH_2Cl_2)$ pink-purple solution			(III) B
$Cu^{2+}(aq)$ pale blue solution	+	$4NH_3(aq)$ colourless solution	⇌	$Cu(NH_3)_4^{2+}(aq)$ deep blue solution			(III) C

Questions for equilibrium III step 3

Use the table below to *describe* the changes observed as the concentrated ammonia ($NH_3(aq)$) is added and the contents of the test tube are shaken.

III 3 a)	Observations of the shade, colour and cloudiness of the aqueous layer	
III 3 b)	Observations of the shade, colour and cloudiness of the dichloromethane layer	

	After the addition of NH_3 which species increased and which decreased:	$[Cu(NH_3)_4^{2+}]$	$[Cu^{2+}]$	$[I^-]$	CuI	$[I_{2\,(aq)}]$	$[I_2(CH_2Cl_2)]$
III 3 c)	In equilibrium (III) A?						
III 3 d)	In equilibrium (III) B?						
III 3 e)	In equilibrium (III) C?						

III 3 f) Which direction did equilibrium (III) A shift? _____

III 3 g) Which direction did equilibrium (III) B shift? _____

III 3 h) Which direction did equilibrium (III) C shift? _____

III 3 i) Explain the directions of the shifts. Use Le Chatelier's principle.

Equilibrium IV

$$\underset{\text{pink solution}}{Co(H_2O)_6^{2+}(aq)} + \underset{\text{colourless solution}}{4Cl^-(aq)} \rightleftharpoons \underset{\text{deep blue solution}}{CoCl_4^{2-}(aq)} + \underset{\text{colourless liquid}}{6H_2O(l)} \quad \text{(IV)}$$

Questions for equilibrium IV step 3

		$[Co(H_2O)_6^{2+}]$	$[Cl^-]$	$[Co(Cl)_4^{2-}]$
IV 3 a)	Colour after cooling _____ Which chemical is predominant?			
IV 3 b)	Show the **effect** of the cooling above on all chemicals present. Do they increase or decrease?			
IV 3 c)	Colour after heating _____ Which chemical is predominant?			
IV 3 d)	Show the **effect** of the heating above on all chemicals present. Do they increase or decrease?			

IV 3 e) Taking this into consideration, is the reaction

$4Cl^-(aq) + Co(H_2O)_6^{2+}(aq) \rightarrow Co(Cl)_4^{2-}(aq) + 6H_2O(l)$

exothermic or endothermic? Explain your answer clearly.

Equilibrium V

$Fe^{3+}(aq)$ + $SCN^{-}(aq)$ ⇌ $Fe(SCN)^{2+}(aq)$ (V) A

yellow solution | colourless solution | blood red solution

Questions for equilibrium V step 3

		$[Fe^{3+}]$	$[SCN^{-}]$	$[Fe(SCN)^{2+}]$
V 3 a)	Colour after adding $FeCl_3$ _____ Which ion is predominant?			
V 3 b)	Which ion in the table does $FeCl_3$ directly contribute to the equilibrium?			
V 3 c)	Show the **effect** of the addition of $FeCl_3$ on the other ions. Do they increase or decrease?			

V 3 d) Which direction did equilibrium (V) A shift? _____

V 3 e) Explain why the colour changed. Use Le Chatelier's principle.

Questions for equilibrium V step 4

		$[Fe^{3+}]$	$[SCN^{-}]$	$[Fe(SCN)^{2+}]$
V 4 a)	Colour after adding NH_4SCN _____ Which ion(s) is/are predominant?			
V 4 b)	Which ion in the table does NH_4SCN directly contribute to the equilibrium?			
V 4 c)	Show the **effect** of the addition of NH_4SCN on the other ions. Do they increase or decrease?			

V 4 d) Which direction did equilibrium (V) A shift? _____

V 4 e) Explain why the colour changed. Use Le Chatelier's principle.

Equilibrium V continued

$Fe^{3+}(aq)$	+	$SCN^{-}(aq)$	$\rightleftharpoons$	$Fe(SCN)^{2+}(aq)$	(V) A
yellow solution		colourless solution		blood red solution	
$Ag^{+}(aq)$	+	$SCN^{-}(aq)$	$\rightleftharpoons$	$AgSCN(s)$	(V) B
colourless solution		colourless solution		white precipitate	

Questions for equilibrium V step 5

		$[Fe^{3+}]$	$[SCN^{-}]$	$[Fe(SCN)^{2+}]$	$[Ag^{+}]$	AgSCN
V 5 a)	**Solution** colour (without ppt) after adding $AgNO_3$ _____ Which chemicals are predominant in V (A)?					
V 5 b)	**Ppt** colour after adding $AgNO_3$ _____ Which chemicals are predominant in V (B)?					
V 5 c)	Which ion **visibly** decreases on addition of $AgNO_3$?					

V 5 d) Which direction did equilibrium (V) A shift? _____

V 5 e) Which direction did equilibrium (V) B shift? _____

V 5 f) Explain why the colour and precipitate changed. Use Le Chatelier's principle.