

BCIT
Winter 2016

Chem 0012

Final Exam

Name: _____

Attempt all questions in this exam. Read each question **carefully** and give a complete answer in the space provided.

Part marks given for wrong answers with partially correct reasoning/calculations.

Constants, equations, data sheets and tables are provided.

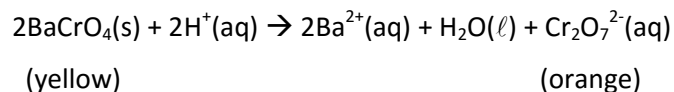
Total points = 50

Good luck in the future!

Section I: Multiple choice (25 points total, 1 point each)

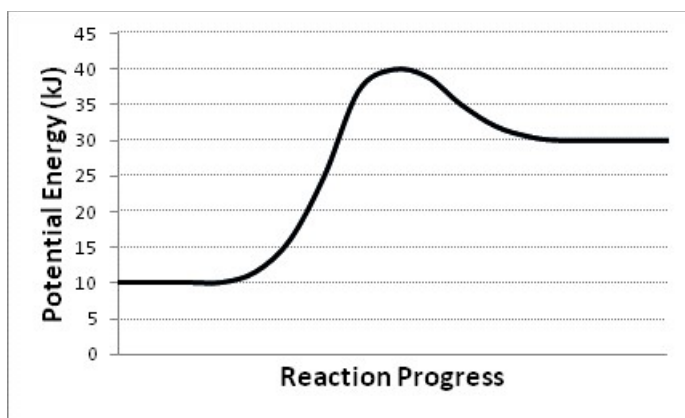
Choose the **BEST** answer to the following questions.

1. Consider the following reaction:



The progress of the reaction could be followed by observing the rate of ?

- a. mass loss
 - b. decrease in pH
 - c. precipitate formation
 - ☒ d. formation of orange colour in the solution
2. Consider the following potential energy diagram for a reversible reaction:



Which of the following describes the system above?

	Reaction	Activation Energy (kJ)	ΔH (kJ)
<input checked="" type="radio"/> a.	reverse	10	-20
b.	reverse	10	-30
c.	forward	30	+10
d.	forward	20	+30

3. How does the addition of a catalyst increase the reaction rate of an endothermic reaction?

- a. It reduces the ΔH of the reaction
- b. It increases the ΔH of the reaction
- ☒ c. It reduces the required activation energy
- d. It causes the reaction to become exothermic

4. Consider the following reaction mechanism:

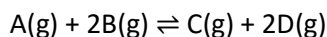
Step 1	$\text{Ce}^{4+} + \text{Mn}^{2+} \rightarrow \text{Ce}^{3+} + \text{Mn}^{3+}$
Step 2	$\text{Ce}^{4+} + \text{Mn}^{3+} \rightarrow \text{Ce}^{3+} + \text{Mn}^{4+}$
Step 3	$\text{Ti}^+ + \text{Mn}^{4+} \rightarrow \text{Ti}^{3+} + \text{Mn}^{2+}$

An intermediate is

- a. Ce^{4+}
 - b. Mn^{2+}
 - ☒ c. Mn^{3+}
 - d. Ti^{3+}
5. An activated complex can be described as
- a. A particle of maximum kinetic energy and minimum potential energy
 - b. A stable particle found in a reaction mechanism
 - ☒ c. An unstable particle that is neither reactant or product
 - d. A particle which is first used and then regenerated in a reaction mechanism
6. The following reaction is zero order with respect to A and second order with respect to B.
 $\text{A} + \text{B} \rightarrow \text{C} + \text{D}$
The concentrations of both A and B are doubled. Assuming no temperature change, which statement makes an accurate comment about the reaction rate?
- a. the reaction rate would stay the same
 - b. the reaction rate would increase by a factor of 2
 - ☒ c. the reaction rate would increase by a factor of 4
 - d. the reaction rate would increase by a factor of 8
7. In order for a chemical reaction to go to completion, how must the entropy and enthalpy change?

	Entropy	Enthalpy
a.	decreases	decreases
b.	decreases	increases
<input checked="" type="radio"/> c.	increases	decreases
d.	increases	increases

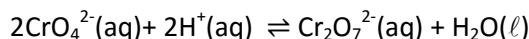
8. Consider the following equilibrium:



Which of the options below indicates that the reactants are favored?

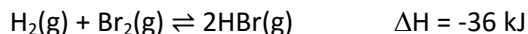
- a. $K < 0$
- ☒ b. $0 < K < 1$
- c. $K = 1$
- d. $K > 1$

9. What is K expression for the following equilibrium?



- a. $K = \frac{[CrO_4^{2-}]^2 [H^+]^2}{[Cr_2O_7^{2-}]}$
- ☒ b. $K = \frac{[Cr_2O_7^{2-}]}{[CrO_4^{2-}]^2 [H^+]^2}$
- c. $K = \frac{[Cr_2O_7^{2-}]}{(2[CrO_4^{2-}]) (2[H^+])}$
- d. $K = \frac{[Cr_2O_7^{2-}] [H_2O]}{[CrO_4^{2-}]^2 [H^+]^2}$

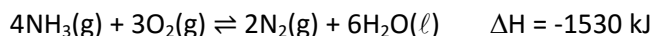
10. Consider the following equilibrium:



How could the value of K be increased?

- a. add H_2
- b. add HBr
- c. increase the pressure
- ☒ d. reduce the temperature

11. Consider the following equilibrium:



Which of the following would cause the amount of NH_3 at equilibrium to increase?

- a. adding O_2
- b. adding H_2O
- c. decreasing the temperature
- ☒ d. increasing the volume

12. What is observed when H_2SO_4 is added to a saturated solution of CaSO_4 ?
- a. The pH increases
 - b. The $[\text{Ca}^{2+}]$ increases
 - c. Bubbles of H_2 gas are formed
 - ☒ d. Additional CaSO_4 precipitates
13. Adding which of the following could dissolve a precipitate of CaC_2O_4 in a saturated solution of CaC_2O_4 ?
- ☒ a. NaOH
 - b. CaC_2O_4
 - c. $\text{H}_2\text{C}_2\text{O}_4$
 - d. $\text{Ca}(\text{NO}_3)_2$
14. What will be the $[\text{Cl}^-]$ when equal volumes of 0.10 M NaCl and 0.20 M AlCl_3 are combined?
- a. 0.15 M
 - b. 0.30 M
 - ☒ c. 0.35 M
 - d. 0.70 M
15. A compound has a solubility of 7.1×10^{-5} M at 25°C . The compound could be
- a. CuS
 - b. AgBr
 - ☒ c. CaCO_3
 - d. CaSO_4
16. Which of the following salt solutions will be acidic?
- a. KClO_4
 - ☒ b. NH_4Br
 - c. NaHCO_3
 - d. $\text{Na}_2\text{C}_2\text{O}_4$
17. What is the pH at the transition point for an indicator with a K_a of 2.5×10^{-4} ?
- a. 2.5×10^{-4}
 - ☒ b. 3.6
 - c. 7.0
 - d. 10.40

18. What is the main difference between a strong acid and a weak acid?

- ☒ a. their degree of ionization
- b. their reactivity with platinum
- c. their concentration in solution
- d. their effect on phenolphthalein

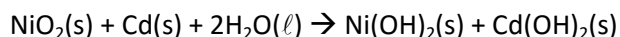
19. What volume of 0.250 M KOH is required to titrate 2.30×10^{-3} mol of the weak acid $\text{H}_2\text{C}_2\text{O}_4$?

- a. 1.15 mL
- b. 4.60 mL
- c. 9.20 mL
- ☒ d. 18.4 mL

20. Which of the following could typically be used to prepare a buffer solution?

- ☒ a. H_2S and NaHS
- b. H_2S and ZnS
- c. HNO_3 and NaNO_3
- d. HNO_2 and NaNO_3

21. Consider the overall reaction of the rechargeable nickel- cadmium battery:



Which of the following occurs at the anode as the reaction proceeds?

- ☒ a. Cd loses 2e^- and forms $\text{Cd}(\text{OH})_2(\text{s})$
- b. Cd gains 2e^- and forms $\text{Cd}(\text{OH})_2(\text{s})$
- c. NiO_2 loses 2e^- and forms $\text{Ni}(\text{OH})_2(\text{s})$
- d. NiO_2 gains 2e^- and forms $\text{Ni}(\text{OH})_2(\text{s})$

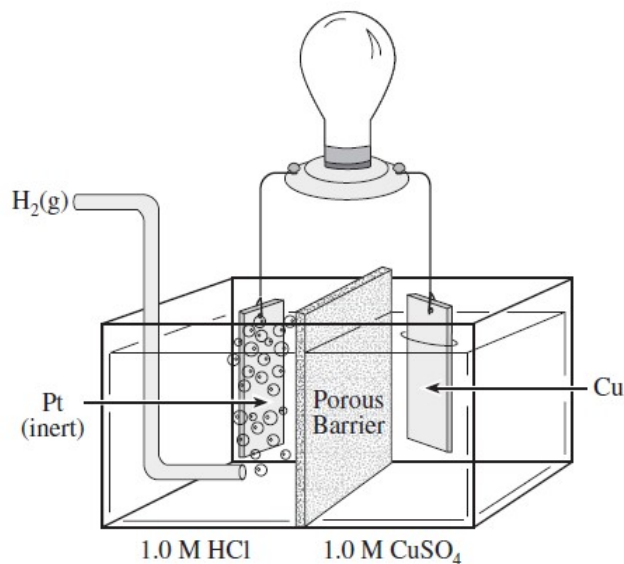
22. Which of the following will oxidize Fe^{2+} ?

- a. $\text{I}_2(\text{s})$
- b. $\text{Ni}(\text{s})$
- c. $\text{Zn}(\text{s})$
- ☒ d. $\text{Br}_2(\ell)$

23. What is the oxidation number of Cl in KClO_3

- a. -1
- b. +1
- ☒ c. +5
- d. +7

24. Consider the following electrochemical cell:



Which of the following could be used to confirm the ion migration through the porous barrier?

- a. adding phenolphthalein to the copper half-cell
- b. adding phenolphthalein to the hydrogen half-cell
- c. adding barium nitrate to the copper half-cell
- ☒ d. adding barium nitrate to the hydrogen half-cell

25. Which of the following occurs when a solution of NiSO₄ is electrolyzed using inert carbon electrodes?

- a. the cathode dissolves
- b. hydrogen gas is produced
- ☒ c. the pH of the solution decreases
- d. the Ni²⁺ concentration increases

Section II: Written problems (25 points total).

26. The rate constant, k , for a third order reaction is measured as a function of temperature. A plot is made of $\ln(k)$ vs $\frac{1}{T(K)}$. The data is fit to a straight line. The equation of the best fit straight line is $y = -8980x + 16.32$.

- a) What is the activation energy and pre-exponential factor in the Arrhenius equation? (4 points)

$$\text{slope} = -\frac{E_a}{R} = 8980 \text{ K}$$

$$E_a = -R m = -(8.314 \text{ J mol}^{-1} \text{ K}^{-1})(-8980 \text{ K}) = 7.47 \times 10^4 \text{ J mol}^{-1} = 74.7 \text{ kJ/mol}$$

$$y \text{ intercept} = \ln(A) = 16.32$$

$$A = e^{16.32} = 1.2 \times 10^7 \text{ M}^{-2} \text{ s}^{-1}$$

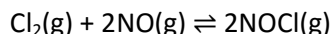
- b) What is the value of the reaction constant at 25°C? (1 point)

$$k = Ae^{-\frac{E_a}{RT}} = (1.2 \times 10^7 \text{ M}^{-2} \text{ s}^{-1})e^{-\frac{74.7 \times 10^3 \text{ J mol}^{-1}}{(8.314 \text{ J mol}^{-1} \text{ K}^{-1})(25+273.15 \text{ K})}} = 9.8 \times 10^{-7} \text{ M}^{-2} \text{ s}^{-1}$$

or

$$\ln(k) = (-8980 \text{ K})\left(\frac{1}{298.15 \text{ K}}\right) + 16.32 = -13.80 \rightarrow k = e^{-13.80} = 1.0 \times 10^{-6} \text{ M}^{-2} \text{ s}^{-1}$$

27. Consider the following equilibrium?



At equilibrium $[\text{Cl}_2] = 0.10 \text{ M}$, $[\text{NO}] = 0.20 \text{ M}$ and $[\text{NOCl}] = 0.40 \text{ M}$. What is the numerical value of K ? (2 points)

$$K = \frac{[\text{NOCl}]^2}{[\text{Cl}_2][\text{NO}]^2} = \frac{(0.40)^2}{(0.10)(0.20)^2} = 40$$

28. a) What would be the solubility of PbBr_2 in pure water? (3 points).

Let s = solubility of PbBr_2

$\text{PbBr}_2(\text{aq}) \rightleftharpoons \text{Pb}^{2+}(\text{aq}) + 2\text{Br}^{-}(\text{aq})$		
I	0	0
C	s	$2s$
E	s	$2s$

$$K_{\text{sp}} = [\text{Pb}^{2+}] [\text{Br}^{-}]^2 = s(2s)^2 = 4s^3 = 6.6 \times 10^{-6}$$

$$s = \sqrt[3]{\frac{6.6 \times 10^{-6}}{4}} = 0.012 \text{ M}$$

b) What would be the solubility of PbBr_2 in 0.25 M CaBr_2 ? (3 points).

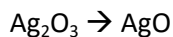
Let s = solubility of PbBr_2

$\text{PbBr}_2(\text{aq}) \rightleftharpoons \text{Pb}^{2+}(\text{aq}) + 2\text{Br}^{-}(\text{aq})$		
I	0	0.50
C	s	$2s$
E	s	$0.50 + 2s$

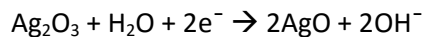
$$K_{\text{sp}} = [\text{Pb}^{2+}] [\text{Br}^{-}]^2 = s(0.50 + 2s)^2 \approx s(0.50)^2 = 6.6 \times 10^{-6}$$

$$s = \frac{6.6 \times 10^{-6}}{(0.50)^2} = 2.6 \times 10^{-5} \text{ M, assumption is OK}$$

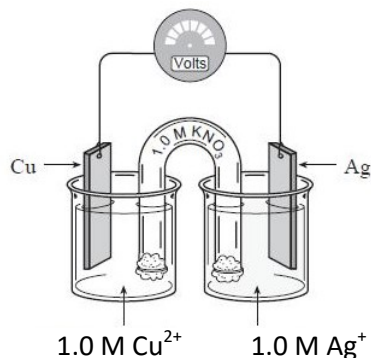
29. Consider the following half-reaction in a basic solution:



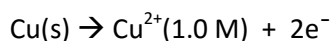
The balanced half-reaction is? (2 points)



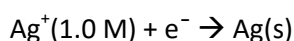
30. Refer to the galvanic cell below (the contents of each half-cell are written beneath each compartment and the anode is not necessarily on the left side):



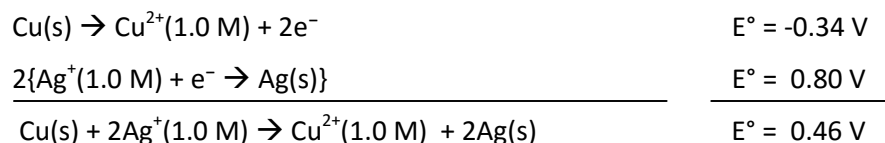
- a) What is the balanced reaction occurring in the cell on the left side? (1 point)



- b) What is the balanced reaction occurring in the cell on the right hand side? (1 point)



- c) What is the balanced overall reaction and E°_{cell} ? (2 points)



- e) As the reaction proceeds, how does the mass of the silver electrode change? Circle the correct answer. (1 point)

decreases

remains the same

increases

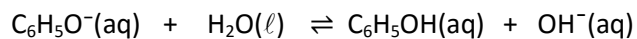
- f) In the above cell which of the following best describes the movement of the electrons through the wire? Circle the correct answer (1 point)

from the Cu to the Ag

from the Ag to the Cu

31. What is the pH of a 0.80 M solution of sodium phenate, $\text{NaC}_6\text{H}_5\text{O}$? (4 points)

$\text{NaC}_6\text{H}_5\text{O}$ dissolves to give Na^+ and $\text{C}_6\text{H}_5\text{O}^-$. Na^+ is neither an acid or a base. but $\text{C}_6\text{H}_5\text{O}^-$ is a base



I	0.80	0	0
C	-x	x	x
E	0.80-x	x	x

$$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{1.3 \times 10^{-10}} = 7.7 \times 10^{-5} = \frac{x^2}{0.80 - x} \approx \frac{x^2}{0.80}$$

Note since $x = [\text{OH}^-]$, $x > 0$

$$x = \sqrt{(0.80)(7.7 \times 10^{-5})} = 7.8 \times 10^{-3} \text{ M} = [\text{OH}^-] \text{ assumption is OK}$$

$$\text{pOH} = -\log(7.8 \times 10^{-3}) = 2.11$$

$$\text{pH} = 14.00 - \text{pOH} = 11.89$$

Chem 0012

Equations and Constants

$$PV = nRT$$

$$T(K) = T(^{\circ}C) + 273.15$$

$$R = 0.0820575 \text{ L atm mol}^{-1} \text{ K}^{-1} = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$$

$$k = A e^{-\frac{E_a}{RT}}$$

$$\ln(k) = -\left(\frac{E_a}{R}\right)\left(\frac{1}{T}\right) + \ln(A)$$

$$y = mx + b$$

$$PV = nRT$$

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

$$1 \text{ atm} = 760 \text{ mm Hg} = 760 \text{ Torr} = 101.325 \text{ kPa}$$

$$\text{pH} = -\log[\text{H}^+] \quad \text{pOH} = -\log[\text{OH}^-]$$

$$[\text{H}^+] = 10^{-\text{pH}} \quad [\text{OH}^-] = 10^{-\text{pOH}}$$

$$\text{pX} = -\log(X) \quad X = 10^{-\text{pX}}$$

$$K_w = 1.0 \times 10^{-14} \text{ @ } 25^{\circ}\text{C} \quad 14.00 = \text{pH} + \text{pOH @ } 25^{\circ}\text{C}$$

$$K_w = K_a K_b$$

$$\text{pH} = \text{p}K_a + \log\left(\frac{[\text{A}^-]}{[\text{HA}]}\right)$$

$$F = 96485 \text{ C/mol}$$

$$E = E^{\circ} - \frac{RT}{nF} \ln(Q)$$

$$E = E^{\circ} - \frac{0.0592 \text{ V}}{n} \log(Q) \text{ at } 25^{\circ}\text{C}$$

The solution to the quadratic equation $ax^2 + bx + c = 0$ is

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$