

Chemistry 301 - Midterm Exam #1

Friday, October 4, 2013, 9:00 am

Only the standard UBC Science calculator (Sharp EL 510R or EL 510RN(B)) is permitted.

Worth 30 points (20% of course)

PART I (multiple choice – 15 points) - circle your answer.

One point for each correct answer, no penalty for wrong answers. If you don't know, then guess. There is only one best answer for each question.

- Considering the equilibrium between Fe^{2+} and $\text{Fe}(\text{OH})_2$, Fe is more likely to precipitate:
 - when the total amount of Fe is high, regardless of the pH
 - when the total amount of Fe is high and pH is low
 - when the total amount of Fe is high and pH is high
 - when the total amount of Fe is low, regardless of the pH
 - when the total amount of Fe is low and pH is low
 - when the total amount of Fe is low and pH is high

- Given the hypothetical information in Table A below, if total M is 10^{-5} M which solid forms do you expect to find at equilibrium?
 - only $\text{MX}_{(s)}$
 - only $\text{MY}_{(s)}$
 - only $\text{MZ}_{(s)}$
 - $\text{MX}_{(s)}$ and $\text{MY}_{(s)}$
 - $\text{MX}_{(s)}$ and $\text{MZ}_{(s)}$
 - $\text{MY}_{(s)}$ and $\text{MZ}_{(s)}$
 - all three ($\text{MX}_{(s)}$, $\text{MY}_{(s)}$ and $\text{MZ}_{(s)}$)
 - no solid forms are expected

Table A

Reaction	Ksp	Calculated $[\text{M}^{n+}]$ at equil.
$\text{MX}_{(s)} \rightleftharpoons \text{M}^{n+} + \text{X}^{n-}$	1×10^{-12}	10^{-8} M
$\text{MY}_{(s)} \rightleftharpoons \text{M}^{n+} + \text{Y}^{n-}$	1×10^{-8}	10^{-6} M
$\text{MZ}_{(s)} \rightleftharpoons \text{M}^{n+} + \text{Z}^{n-}$	1×10^{-10}	10^{-4} M

- Given the information in Table A above:
 - $[\text{X}^{n-}] < [\text{Y}^{n-}] < [\text{Z}^{n-}]$
 - $[\text{X}^{n-}] < [\text{Z}^{n-}] < [\text{Y}^{n-}]$
 - $[\text{Y}^{n-}] < [\text{Z}^{n-}] < [\text{X}^{n-}]$
 - $[\text{Y}^{n-}] < [\text{X}^{n-}] < [\text{Z}^{n-}]$
 - $[\text{Z}^{n-}] < [\text{Y}^{n-}] < [\text{X}^{n-}]$
 - $[\text{Z}^{n-}] < [\text{X}^{n-}] < [\text{Y}^{n-}]$

- Supersaturated oxygen levels are likely to be found in surface waters when there has been recent:
 - Phytoplankton growth and cooling
 - Phytoplankton growth and windy weather
 - Phytoplankton growth and rain
 - Phytoplankton decay and cooling
 - Phytoplankton decay and windy weather
 - Phytoplankton decay and rain

Name: _____

Student No. _____

5. Gases are most soluble in:
 - a) cold freshwater
 - b) warm freshwater
 - c) cold seawater
 - d) warm seawater
 - e) a warm 50:50 mixture of seawater and freshwater
 - f) a cold 50:50 mixture of seawater and freshwater

6. The climate in Vancouver is moderate relative to the rest of Canada because:
 - a) sea breezes develop in the late afternoon in Vancouver
 - b) the Pacific Ocean is warmer than the Atlantic Ocean
 - c) oceans are warmer than land
 - d) water has a higher specific heat capacity than land
 - e) Vancouver is at a lower latitude than any other part of Canada
 - f) Vancouver is close to granitic mountains

7. Which of the following statements about soap scum is true:
 - a) Scum forms when hard water is heated
 - b) Scum is more likely to form in Vancouver than in Calgary or Toronto
 - c) Scum forms when Fe is oxidized
 - d) Scum forms when CO₂ is added to water
 - e) Scum makes soap less effective

8. On a sketch of the hydrological cycle, which arrows would be bigger (represent a larger flux)?
 - a) Evaporation from land > precipitation to land, evaporation from ocean > precipitation to ocean
 - b) Evaporation from land > precipitation to land, evaporation from ocean < precipitation to ocean
 - c) Evaporation from land < precipitation to land, evaporation from ocean > precipitation to ocean
 - d) Evaporation from land < precipitation to land, evaporation from ocean < precipitation to ocean
 - e) Evaporation from land = precipitation to land, evaporation from ocean = precipitation to ocean

9. For a Cr⁶⁺ ion, what transformation would you expect if you changed the pH from acidic to basic conditions?
 - a) aqua to hydroxo
 - b) aqua to oxo
 - c) hydroxo to aqua
 - d) hydroxo to oxo
 - e) oxo to hydroxo
 - f) oxo to aqua

10. Water is a good solvent because:
 - a) It is polar
 - b) It forms hydrogen bonds
 - c) It has a high heat capacity
 - d) It forms small clusters
 - e) Ice is less dense than water
 - f) It has a temperature of maximum density above the freezing point

11. Water in Vancouver is soft because:
 - a) Temperatures in Vancouver rarely get below 4°C
 - b) Vancouver is close to the Pacific Ocean
 - c) Vancouver is close to steep mountains
 - d) Vancouver is close to granitic mountains
 - e) Vancouver is close to sedimentary mountains

Name: _____

Student No. _____

12. Which of the following could cause a body of water become anoxic?

- a) A low amount of photosynthesis
- b) A deep thermocline
- c) High B.O.D.
- d) Oligotrophic conditions
- e) A recent change in temperature

13. How is humin different than humic acid?

- a) Solubility in strong acid
- b) Solubility in strong base
- c) Functional groups attached
- d) molecular weight
- e) electronegativity

14. Adding CO₂ to water:

- a) increases total CO₂ and increases pH
- b) decreases total CO₂ and increases pH
- c) increases total CO₂ and decreases pH
- d) decreases total CO₂ and decreases pH
- e) increases total CO₂ with no change to pH

15. Give the following pKa's for phosphoric acid:

$$pK_{a1} = 2.17$$

$$pK_{a2} = 7.13$$

$$pK_{a3} = 12.36$$

What form(s) of phosphate do you expect to be significant at pH = 12?

- a) PO₄³⁻ only
- b) PO₄³⁻ and HPO₄²⁻
- c) HPO₄²⁻ only
- d) HPO₄²⁻ and H₂PO₄⁻
- e) H₂PO₄⁻ only
- f) H₂PO₄⁻ and H₃PO₄
- g) H₃PO₄ only

PART II (Short answer and calculations - 15 points)

16. You take a sample of water with a "total CO₂" of 1.00 x 10⁻⁴ mol/litre and a pH of 9.33.

a) (1 pt) What is the ratio of [HCO₃⁻] to [CO₃²⁻]?

b) (1 pt) What is [HCO₃⁻]?

Name: _____

Student No. _____

16. cont.

c) (2pt) If 1 millimole of acid is added to 1000 litres of this water, what do you expect the pH to be, assuming the reaction goes to completion? (Explain using words and/or calculations.)

d) (1 pt) If the alkalinity were essentially zero, what would the pH be after the addition of the same amount of acid?

17. A lead recycling plant begins operation on the shores of a formerly clean lake of capacity $1 \times 10^7 \text{ m}^3$. It discharges into the lake 1 m^3 per hour of waste containing $1 \times 10^{-5} \text{ M Pb}^{+2}$. The other inflow to the lake is a river with a flow rate of $1 \times 10^3 \text{ m}^3$ per hr. Once the lake is allowed to reach a new steady state:

(a) (2 pts) Calculate the residence time of Pb^{+2} in the lake and explain what the term residence time means.

(b) (2 pts) Calculate the concentration of Pb^{+2} in the lake, which is well mixed, and has no other sources or sinks for Pb^{+2} .

Name: _____ Student No. _____

17. cont.

(c) (3 pts) If the pH of this lake is 9, do you expect the added lead to form an insoluble hydroxide precipitate? What if the pH is 5? Taking each case separately, what is the concentration of Pb^{+2} in the lake (after considering precipitation)?

(d) (3 pts) If the lake also has a steady state concentration of NTA at 1×10^{-4} M along with the Pb^{+2} , how will this affect the amount of soluble Pb in the lake? If you predicted precipitation at any pH in part (c), will this prediction change with the added NTA? To make any calculations easier, feel free to round off pK's as needed.

Name: _____

Student No. _____

Extra page...