



THOMPSON RIVERS
UNIVERSITY
KAMLOOPS, BC

TRU Chemistry Contest

Chemistry 12

May 21, 2003 Time: 90 minutes

Last Name _____ First name _____

School _____ Teacher _____

Please follow the instructions below. We will send your teacher a report on your performance. Top performers are eligible for prizes.

Part A: Please answer on the Scantron Answer Sheet. In the **top right hand** (20 points) **corner** of the answer sheet, please print the following information:

Your name (last name, first name), your school, your teacher

On the answer sheet mark one choice beside the question number with a firm pencil mark, just filling the selected answer box. If you change your answer, be sure to erase completely your previous answer. All questions are of equal value, there is no particular order to the questions and there is no penalty for incorrect answers.

Part B: (20 points) Answer in **ink** on the test paper.

Additional material: The last page of the test contains a Periodic Table and the value for K_w at 25°C . Any other useful information is included in the question. You will require a calculator.

Part A: Select one answer on the Scantron Answer Sheet

- For which of the following situations will the solubility of $\text{Ca(OH)}_2(\text{s})$ be greater than the solubility of $\text{Ca(OH)}_2(\text{s})$ in pure water?
 - $\text{Ca(OH)}_2(\text{s})$ is added to a $\text{CaCl}_2(\text{aq})$ solution
 - **$\text{Ca(OH)}_2(\text{s})$ is added to a $\text{NaH}_2\text{PO}_4(\text{aq})$ solution**
 - $\text{Ca(OH)}_2(\text{s})$ is added to a solution buffered at pH 10
 - $\text{Ca(OH)}_2(\text{s})$ is added to a 0.80M $\text{KCl}(\text{aq})$ solution
- What is the pH of a 1.0×10^{-10} M $\text{HNO}_3(\text{aq})$ solution?
 - 5.00
 - 10.00
 - 8.00
 - **7.00**
- Which two species, when mixed together in aqueous solution, will act as a buffer?
 - HNO_3 and NaNO_3
 - Na_2SO_4 and H_2SO_4
 - HCl and NaCl
 - **HNO_2 and NaNO_2**
- Which of the following may affect the rate of a reaction?
 - reactant concentration
 - addition of a catalyst
 - temperature
 - **all of the above**

5. What will happen if 0.500 L of 0.0080M NaCl(aq) is mixed with 0.300L of 0.040M AgNO₃(aq) at 25°C?

$$K_{sp} \text{ AgCl} = 1.6 \times 10^{-10} \text{ at } 25^\circ\text{C}$$

- (a) **a precipitate forms**
(b) silver metal is formed
(c) no precipitate forms
(d) a gas is evolved

6. What is the [F⁻] when CaF₂(s) is in equilibrium with 0.100M Ca(NO₃)₂(aq) solution at 25°C?

$$K_{sp} \text{ CaF}_2 = 3.9 \times 10^{-11} \text{ at } 25^\circ\text{C}$$

- (a) **2.0 x 10⁻⁵ M**
(b) 3.9 x 10⁻⁵ M
(c) 6.2 x 10⁻⁶ M
(d) 4.4 x 10⁻⁶ M

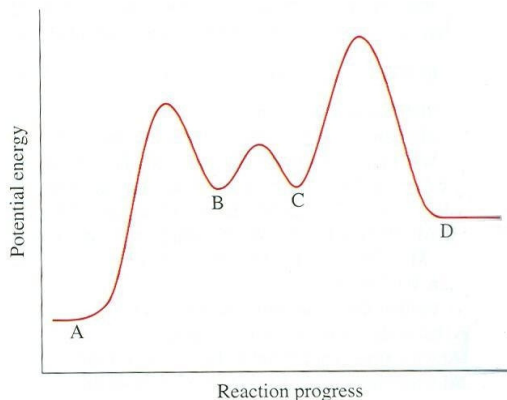
7. The ionization constant, K_w, for pure water at 50°C is 5.3 x 10⁻¹⁴. What is the pH of pure water at 50°C?

- (a) 7.36
→ (b) **6.64**
(c) 7.00
(d) 5.92

8. Which one of the the following reactions is an oxidation-reduction reaction?

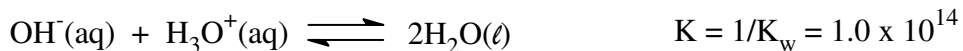
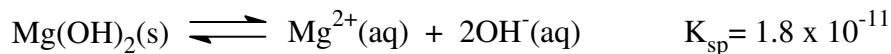
- (a) Na₂O(s) + H₂O(l) → 2NaOH(aq)
(b) CaCO₃(s) + 2HNO₃(aq) → Ca(NO₃)₂(aq) + H₂O(l) + CO₂(g)
→ (c) **N₂O₄(g) + KCl(s) → NOCl(g) + KNO₃(s)**
(d) BaCl₂(aq) + K₂SO₄(aq) → BaSO₄(s) + 2KCl(aq)

9. Which statement about the following plot of reaction progress is correct?

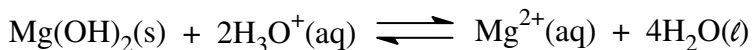


- (a) there are 3 transition states and 3 intermediates
 (b) there are 2 transition states and 2 intermediates
 → (c) **the fastest step would be B going to C**
 (d) the overall reaction is exothermic

10. We have the following information for the two equilibria:



What is the equilibrium constant for:



- (a) **1.8×10^{17}**
 (b) 1.8×10^3
 (c) 1.0×10^{14}
 (d) 4.2×10^{-6}

11. Morphine is a weak base, with a $K_b = 8.0 \times 10^{-7}$. What is the $[\text{OH}^{-}]$ of a 0.067M aqueous morphine solution?

- (a) $7.3 \times 10^{-4} \text{ M}$
 (b) $8.9 \times 10^{-4} \text{ M}$
 → (c) **$2.3 \times 10^{-4} \text{ M}$**
 (d) $5.4 \times 10^{-8} \text{ M}$

12. In the following reaction



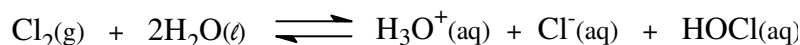
the reducing agent is:

- (a) **BCl₃**
(b) SF₄
(c) SCl₂
(d) Cl₂

13. Ephedrine is a base that is used in nasal sprays as a decongestant. It's $K_b = 1.4 \times 10^{-4}$ at 25°C. What is K_a for its conjugate acid at 25°C?

- (a) 5.1×10^{-8}
(b) 1.4×10^{-18}
(c) 1.4×10^3
→ (d) **7.1×10^{-11}**

14. Cl₂(g) reacts with H₂O(ℓ) as follows



For a planned experiment to succeed, Cl₂(g) must be present and the amount of Cl⁻(aq) in solution must be minimized. For this experiment we have planned, should the pH of the solution be:

- (a) > 7
→ (b) **< 7**
(c) = 7
(d) the pH is irrelevant

15. A 0.478 g sample of an unknown organic acid is dissolved in water and requires 39.42 mL of a 0.270M sodium hydroxide solution to reach the equivalence point. The unknown acid and NaOH react in a 1:1 mole ratio. What is the molar mass of the unknown acid?

- (a) 89.8 g mol⁻¹
(b) 22.5 g mol⁻¹
(c) 0.223 g mol⁻¹
→ (d) **44.9 g mol⁻¹**

16. The oxidation state of sulfur in the $\text{S}_2\text{O}_3^{2-}$ ion is:

- (a) -2
- (b) **+2**
- (c) +4
- (d) +6

17. An acetic acid - sodium acetate buffer solution is prepared at 25°C in which both components are 0.050M. What is the pH of this mixture?

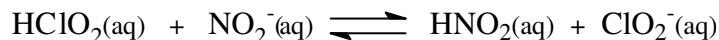
$$K_a \text{ acetic acid} = 1.8 \times 10^{-5} \text{ at } 25^\circ\text{C}$$

- (a) **4.74**
- (b) 1.30
- (c) 9.26
- (d) 7.00

18. To one L of the solution in question 17 we then add 25.0 mL of a 2.50M perchloric acid solution. The resulting solution after this addition:

- (a) will have the same pH as the original solution
- (b) will be slightly more acidic than the original solution
- (c) **will no longer be a buffer solution**
- (d) will be slightly more basic than the original solution

19. Predict the magnitude of the equilibrium constant K for the following system:



given: $K_a \text{ HClO}_2 = 1.1 \times 10^{-2}$ and $K_a \text{ HNO}_2 = 4.6 \times 10^{-4}$

- (a) **K > 1**
- (b) K = 1
- (c) K < 1
- (d) K = 0

20. Which of the following indicators would be best for a titration having pH 9.2 at the stoichiometric point?

	pH range of colour change
phenolphthalein	8.2 – 10.0
thymolphthalein	9.4 – 10.6
bromothymol blue	6.0 – 7.6
thymol blue	8.0 – 9.2

- (a) **phenolphthalein**
(b) thymolphthalein
(c) bromothymol blue
(d) thymol blue

Part B: Answer in ink on the test paper. Show all your work. State any assumptions you made during a calculation. If you need more space, use the back of the page. All written answers must be in complete sentences.

Ammonia has an important use as an agricultural fertilizer, where liquid ammonia is commonly injected directly into the soil. The usual reaction by which ammonia is manufactured is:



- 6 pts (a) At 400°C in a 5.00L reaction vessel we have a mixture containing 4.0 mol of N_2 , 0.50 mol of H_2 and 2.0 mol of NH_3 . Is this system at equilibrium? If not, in which direction will the reaction proceed to reach equilibrium at 400°C . **Explain** your answers.

4 pts (b) Once this system has reached equilibrium in this 5.0L reaction vessel, in which direction would the system move if the size of the reaction vessel were to be increased to 10.0L? **Explain** your answer.

4 pts (c) Assume the reaction has reached equilibrium. The reaction as written is exothermic with $\Delta H^\circ_{\text{reaction}} = -91.8 \text{ kJ mol}^{-1}$. **Explain** whether the concentrations of the products will increase or decrease if the temperature is decreased from 400°C to 250°C.

3 pts (d) What will happen to the rate of formation of NH_3 when the temperature is decreased from 400°C to 250°C ? **Explain** your answer.

3 pts (e) Gaseous ammonia is a potential air pollutant when applied directly into the soil. If this occurred in a region where acid rain was falling, would the acid rain problem become more serious or less serious? **Explain** your answer.

The End

Periodic Table

$$K_w = 1.0 \times 10^{-14} \text{ at } 25^\circ\text{C}$$

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1A	2A	3B	4B	5B	6B	7B	8B			1B	2B	3A	4A	5A	6A	7A	8A
1 H 1.008																	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179
11 Na 22.99	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.066	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.93	28 Ni 58.69	29 Cu 63.546	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.9	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La* 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.2	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.03	89 Ac** 227.03	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)									
		*	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97	
		**	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)	