Chemistry 225 Final Examination Semester 04-2003 Time allowed: 3 hours Page 1 of 9 Student Name:...... Student Number Section You may use the following information wherever necessary: $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1} = 0.0821 \text{ atm } \text{dm}^3 \text{ mol}^{-1} \text{ K}^{-1} = 0.0821 \text{ atm } \text{L mol}^{-1} \text{ K}^{-1}$

 $K_p = K_c (0.0821T)^{\Delta n (gas)}$ $K_w = 1.0 \times 10^{-14} \text{ at } 298 \text{ K}$ $K_a(CH_3COOH) = 1.8 \times 10^{-5}$

Remember to include units in your answers wherever appropriate.

SECTION A: Multiple Choice . Answer all questions.

[1 mark each = 40 marks]

Each question is followed by five suggested answers. Select the best answer for each question and shade the letter corresponding to this answer on the answer sheet provided. You are advised to use a pencil for this section.

Bromide ions can be oxidized according to the equation:

 $5 \text{ Br}^{-}(aq) + \text{BrO}_{3}^{-}(aq) + 6 \text{ H}^{+}(aq) \rightarrow 3 \text{ Br}_{2}(aq) + 3 \text{ H}_{2}\text{O}(1)$

If in a particular reaction the rate of consumption of bromide ions is -0.004 mol dm⁻³, then the rate of production of bromine, in mol dm⁻³, is

-(5/3) x 0.004 В (5/3) x 0.004 C -(3/5) x 0.004 D (3/5) x 0.004 Ε 3 x 5 x 0.004

The reaction: $CO(g) + NO_2(g) \rightarrow CO_2(g) + NO(g)$ is second order in nitrogen dioxide and zero order in carbon monoxide

Which of the following will have no effect on the rate of the reaction?

Increasing the concentration of carbon monoxide.

В Increasing the concentration of nitrogen dioxide.

C Using a suitable catalyst.

D Increasing the temperature.

E Increasing the partial pressure of both reactants.

3. The following elementary steps have been proposed for a reaction:

 $NO + \frac{1}{2}O_2 \rightarrow NO_2$

 $NO_2 + H_2O + SO_2 \rightarrow H_2SO_4 + NO$

The catalyst in this process is

NO

В O_2

 NO_2

C D SO_2

E

4. 0.16 mol of SO₂ and 0.12 mol of O₂ were introduced into a 1 dm³ vessel at constant temperature. When the system reached equilibrium, 0.06 mol of SO₃ was present. The reaction is: $2 SO_2(g) + O_2(g) \Rightarrow 2 SO_3(g)$.

Which set of values shows the concentration of each gas at equilibrium?

	[SO ₂]/mol dm ⁻³	[O ₂]/mol dm ⁻³	[SO ₃]/mol dm ⁻³
Α	0.16	0.12	0.06
В	0.10	0.09	0.06
C	0.16	0.09	0.06
D	0.16	0.12	0.10
E	0.10	0.06	0.10

At a given temperature, T, some PCl₅, at an initial concentration of 1.0 M, was placed in a container and 5. allowed to dissociate into PCl_3 and Cl_2 . It was found that the PCl_5 was 40 % dissociated at equilibrium. K_c for the process: $PCl_5(g) \Rightarrow PCl_3(g) + Cl_2(g)$ at temperature, T, is closest to

0.27В 0.40

C 0.60

D 3.7

4.0

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6. At 1000K, K_c for the process: $C(s) + O_2(g) \Rightarrow CO_2(g)$ is 4.8 x 10^{20} . Which $\underline{\textbf{CANNOT}}$ be deduced from this information?

$$A K_c = \frac{[CO_2]}{[O_2]}$$

The quotient, $\frac{[CO_2]}{[O_2]}$, in any equilibrium mixture of carbon, oxygen and carbon dioxide at 1000 K is В

- C When carbon and oxygen react at 1000 K, the limiting reagent is almost completely used up.
 - At equilibrium, the rate of the forward process far exceeds the rate of the reverse process.
- D At 1000K, K_p for the process is 4.8 x 10^{20} . E
- 7. In an equilibrium system, a catalyst increases
 - the activation energy of the forward process whilst decreasing that of the reverse process.
 - В the rate of forward process whilst decreasing that of the reverse process.
 - C the activation energy of both the forward and reverse processes.
 - D the enthalpy change for the reverse process.
 - the rates of both the forward and reverse processes.
- 8. Which of the following CANNOT upset the equilibrium position of the system:

$$NH_4Cl(s) \Rightarrow NH_3(g) + Cl_2(g)$$
?

- Increasing the mass of ammonium chloride.
- В Increasing the temperature.
- C Decreasing the temperature.
- D Increasing the volume of the containing vessel.
- Е Adding some chlorine gas without changing the volume of the containing vessel.
- 9. Consider the process: $P_4(g) + 6 H_2(g) \Rightarrow 4 PH_3(g)$ $\Delta H = +110.5 kJ$ at equilibrium. The value of Kc can be increased by
 - Using a suitable catalyst.
 - В Adding some H2 to the equilibrium mixture.
 - C Increasing the concentration of PH₃.
 - D Increasing the temperature.
 - Decreasing the volume of the container.
- 10. Ammonium hydrogen sulphide dissociates into ammonia and hydrogen sulphide:

$$NH_4HS(s) \Rightarrow NH_3(g) + H_2S(g)$$

When ammonium hydrogen sulphide is introduced into a closed vessel at 282.5 K, the total pressure at equilibrium is 0.230 atm. Kp for the system at 282.5 K is closest to

- 0.230
- 0.115
- В C $(0.230)^2$
- D $(0.115)^2$
- 2 x 0.230
- 11. For the reaction $PCl_5(g) \Rightarrow PCl_3(g) + Cl_2(g)$, $K_p = 1.7$ at 298K. Five systems were set up with the initial partial pressure of each gas as shown in the table. In which system would the reverse reaction occur to establish equilibrium?

Initial partial pressure /atm

	PCl₅	PCl_3	Cl ₂
Α	1	1	1
В	2	2	2
C	1	0.5	1.5
D	2	2	1
E	3	1	2

- 12. According to the Bronsted-Lowry definition, an acid is a substance which donates a
 - hydrogen atom.
 - В hydrogen ion.
 - C hydrogen molecule.
 - D hydride ion.
 - hydroxide ion.

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Stude	ent Name:
13.	Which does not constitute an acid/base conjugate pair?
	A H ₂ SO ₄ / HSO ₄
	B H ₂ PO ₄ ⁷ /HPO ₄ ²⁻ C NH ₄ ⁺ / NH ₄
	C NH ₄ ⁺ / NH ₃ D HNO ₂ / NO ₂ ·
	E H ₃ O ⁺ /OH
14.	Which is NOT a strong acid?
	A HI
	B HCl
	C HClO ₄
	D HCOOH E HNO3
	E HNO₃
15.	Which set shows the substances in order of increasing acid strength?
	A HCIO, HCIO ₂ , HCIO ₃
	B H ₂ SO ₄ , H ₂ SO ₃ , HSO ₄
	C HBr, HCl,, HF D HF, H ₂ O, NH ₃
	E H ₃ PO ₄ , H ₂ PO ₄ , HPO ₄ ² .
16.	The basicity constant for a base is 3.5×10^6 . The pK _a of its conjugate acid is
	A 5.5
	B 8.5
	C 2.9 x 10 ⁻⁹ D 1.0 x 10 ⁻¹⁴
	E 14
17.	Which salt would be expected to produce a solution with the <u>lowest pH?</u> Assume all solutions have the same moconcentration.
	A KCI
	B $MgCl_2$
	C FeCl ₃
	D FeCl ₂ E BaCl ₂
	E BaCl ₂
18.	Which salt would produce a solution with the highest pH? Assume all solutions are the same molar concentration
	A NaCl B NaClO
	C NH ₄ Cl
	D FeCl ₂
	E FeCl ₃
Quest	ons 19 to 23 refer to the following solutions.
	A 1x10 ⁻⁴ M HCl
	B 1x10 ⁴ M KOC1
	C Ix10 ⁻⁴ M Fe(NO ₃) ₃
	D 1x10 ⁻⁴ M KNO ₃ E 1x10 ⁻⁴ M KOH
Select,	from A to E,
19.	the solution which would have the lowest pH.
20.	the solution which would have the highest pH.
21.	the solution which would have a pH closest to 7.
22. 23.	the solution which would have a pH between 4 and 7. the solution which would have a pH between 7 and 10.
43.	ute solution which would have a pH between 7 and 10.

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Questi	ons 24 – :	28 refer to the follo	wing titrations:		
	A B C D	The titration of 20. The titration of 20. The titration of 20.	0 cm ³ of 0.1M HCl with 0 cm ³ of 0.1M HCl with 0 cm ³ of 0.1M CH ₃ COO 0 cm ³ of 0.1M KOH with 0 cm ³ of 0.1M HNO ₃ with	0.1 M NH3 H with 0.1 M NaOH 1 0.1 M HCl	
For wh	ich titrati	on			
24. 25. 26. 27. 28.	would would would p	the pH be greater the the pH be lower that phenolphthalein (pH	in pH as the titrant is add an 7 at the equivalence po n 7 at the equivalence poi range 8.3 – 10.0) be mos pH range 3.8 – 5.4) be un	oint? int? it unsuitable as an indicator?	
29.	The sol	ubility of silver pho	sphate(Ag_3PO_4) is x mold	m ⁻³ . The solubility product of	of this compound is
	A B C D E	x 4x ² 4x ³ 27x ⁴ 3x ²			
Questi	ons 30 ar	nd 31 require the fol	lowing information:		
The so	lubility pr	oduct of AgCl is 1.5	3 x 10 ⁻¹⁰ .		
30.	The sol	ubility of AgCl in w	rater is closest to		
31.	A B C D E The sol	1.8x 10 ⁻¹¹ mol dm 1.8 x 10 ⁻¹⁰ mol dm	3 3 -3 5 .10 M KCl is closest to 3 -3		В
	C D	1.8 x 10 ⁻⁹ mol dm	3		
	Е	3.6 x 10 ⁻¹⁰ mol dm 3.6 x 10 ⁻⁹ mol dm	3 		
Questi	ons 32 –3	3 concern the follow	ving compounds:		
	A B C D E	NH ₄ NO ₃ NaH H ₂ O ₂ NaHSO ₄ HOBr			
32.	In which	compound does hyd	rogen carry an oxidation	number of -1?	
33.	In which	compound does oxy	gen carry an oxidation nu	umber of -1?	
Questi	ons 34-35	concern the follow	ing reactions:		
A B C D	2 C ₂ H ₆ 5 HClC S ₂ O ₈ ²⁻ -	$_{3} \rightarrow MgO + CO_{2}$ + 7 $O_{2} \rightarrow 4 CO_{2} + 6$ $O_{2} \rightarrow 4 ClO_{2} + HCl + 6$ + 2 $I^{-} \rightarrow 2 SO_{4}^{2-} + I_{2}$ 2 $Cl^{-} \rightarrow Xe + 2 F^{-} + 6$	- 2 H₂O		
34.	Which	is <u>not</u> a redox reacti	on?		

35. Which is a disproportionation reaction?

Select, from A to E, the graph which best represents: 36. Concentration of X versus time for a reaction which is zero order in X. 37. Rate of reaction versus concentration of X for a reaction which is first order in X. 38. Rate of reaction versus concentration of X for a reaction which is first order in X. 39. Rate of reaction versus time for a reversible process which attains equilibrium after some time. 40. The titration curve for the titration of a base with an acid. SECTION B: Answer all questions in the spaces provided in the question paper. You may use the following information wherever necessary: R = 8.31 J mol ⁻¹ K ⁻¹ = 0.0821 atm dm ³ mol ⁻¹ K ⁻¹ = 0.0821 atm L mol ⁻¹ K ⁻¹ K _s = K _s (0.0821T) moleso K _s = 1.0 x 10 ⁻¹ at 298 K K _s (CH ₃ COOH) = 1.8 x 10 ⁻³ Remember to include units in your answers wherever appropriate. 1. The following rate data were collected in three experiments carried out at the same temperature for the react 2ClO ₂ (aq) + 2OH(aq) → ClO ₂ (aq) + ClO ₂ (aq) + H ₂ O(l) Experiment Initial [ClO ₂]/M Initial [OH]/M Initial rate of ClO ₃ : 1			cern the following graphs	•		
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		The following ray 2CIO ₂ (aq) + 2OF Experiment 1 2 3 a) Write a b) Find the	ts in your answers wherever the data were collected in $H(aq) \rightarrow ClO_3(aq) + C$	three experiments carrie D_2 (aq) + $H_2O(1)$ Initial [OH]/M 1.5 x 10^{-2} 1.5 x 10^{-2} 3.0 x 10^{-2} [2 marks] t, k, stating its units	Initial rate of ClO ₃ formation/Ms ⁻¹ 3.88 x 10 ⁻⁴ 1.55 x 10 ⁻³ 7.76 x 10 ⁻⁴	
		The following ray 2CIO ₂ (aq) + 2OF Experiment 1 2 3 a) Write a b) Find the	ts in your answers wherever the data were collected in $H(aq) \rightarrow ClO_3(aq) + C$	three experiments carrie D_2 (aq) + $H_2O(1)$ Initial [OH]/M 1.5 x 10^{-2} 1.5 x 10^{-2} 3.0 x 10^{-2} [2 marks] t, k, stating its units	Initial rate of ClO ₃ formation/Ms ⁻¹ 3.88 x 10 ⁻⁴ 1.55 x 10 ⁻³ 7.76 x 10 ⁻⁴	
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2.	At 298 K, the equilibrium	constant, K _p , is 0.20 for th	the reaction : $CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$).	

a) Find the equilibrium partial pressure of each gas when 0.20 mol each of CO and Cl₂ are admitted into a 2000 cm³ vessel at 298 K and the system reaches equilibrium. [5 marks]

- b) Find the total pressure of the system at equilibrium. [1 mark]
- c) What effect, if any, will the addition of 0.01mol of an inert gas have on the equilibrium position if the volume is kept constant? Show your reasoning. [2 marks]
- d) What effect, if any, will the addition of 0.01mol of an inert gas have on the equilibrium position if the <u>total</u> <u>pressure</u> is kept constant? <u>Show your reasoning.</u> [2 marks]
- 3. Use the given K_p values for the processes X and Y to find K_p for the process Z. [2 marks]

 $\begin{array}{lll} \text{Process X:} & 2 \; \text{BrF } (g) \neq \text{Br}_2 \, (g) + F_2 \, (g) & K_p = K_x = 4.57 \, \text{x} 10^{-5} \\ \text{Process Y:} & \text{Br}_2 \, (g) + 3 \, F_2 \, (g) \, \Rightarrow 2 \, \text{BrF}_3 \, (g) & K_p = K_y = 5.29 \\ \text{Process Z:} & \text{BrF}_3 \, (g) \Rightarrow \text{BrF } (g) + \, F_2 \, (g) & K_p = K_z & K_$

Stud	dent Nam	e:	•••••				
4.	Fine	Find the pH of the following solutions:					
	a)	0.20 M HCl	[1 mark]				
	b)	0.20 M NaOH	[1 mark]				
	c)	a mixture of 20.0 cm ³ of 0.20 M HCl + 30.0 cm ³ of 0.20 M NaOH.	[2 marks]				
5.	Find	the pH of the following solutions:					
	a)	0.20 M CH₃COOH	[3 marks]				
	b)	0.20 M CH₃COONa	[3 marks]				
	b)	a mixture of 20.0 cm ³ of 0.20 M CH ₃ COOH + 30.0 cm ³ of 0.20 M NaOH	H. [3 marks]				
	c)	a mixture of 30.0 cm ³ of 0.20 M CH ₃ COOH + 20.0 cm ³ of 0.20 M NaOH.	[3 marks]				

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Use the following table of standard reduction potentials wherever necessary.

	E ⁰ /V
$MnO_4^-(aq) + 8 H^+(aq) + 5 e^- \rightarrow Mn^{2+}(aq) + 4 H_2O(1)$	+1.51
$Cl_2(g)+2 e^- \rightarrow 2Cl^-(aq)$	+1.36
$\text{Cr}_2\text{O}_7^{2^-}(\text{aq}) + 14 \text{ H}^+(\text{aq}) + 6 \text{ e} \rightarrow 2 \text{ Cr}^{3^+}(\text{aq}) + 7 \text{ H}_2\text{O} (\text{I})$	+1.33
$Ag^{+}(aq) + e^{-} \rightarrow Ag(s)$	+0.80
$Fe^{3+}(aq) + e^{-} \rightarrow Fe^{2+}(aq)$	+0.77
$2 H^{+}(aq) + 2e^{-} \rightarrow H_{2}(g)$	0.00
$Fe^{3+}(aq) + 3e^{-} \rightarrow Fe(s)$	-0.036
$Fe^{2+}(aq) + 2e^{-} \rightarrow Fe(s)$	-0.44
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$	-2.38

- a) The cell notation represents a standard galvanic cell: $Mg(s) \mid MgCl_2(aq) \parallel FeCl_3(aq), FeCl_2(aq) \mid Pt(s)$
 - i) Write a balanced ionic equation for the cell reaction.[1 mark]
 - ii) What is the cell potential?

[1 mark]

Draw a fully labeled diagram of the galvanic cell. Show the direction of flow of electrons, the iii) polarity of the electrodes and the concentration of all solutions. [5 marks]

- b) By reference to the standard electrode potentials given, explain why hydrochloric acid can be used to provide an acid medium with potassium dichromate but NOT with potassium manganate (VII) as oxidizing [2 marks]
- Given the Nernst Equation: $E = E^0 \frac{0.059}{n} \log Q$, at 298 K, find the value of the equilibrium constant for the reaction: $5 \operatorname{Fe}^{2^+}(aq) + \operatorname{MnO_4^-}(aq) + 8 \operatorname{H^+}(aq) \Rightarrow \operatorname{Mn}^{2^+}(aq) + 4 \operatorname{H_2O}(l) + 5 \operatorname{Fe}^{3^+}(aq)$ at 298 K. [3 marks] c)

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- Derive a balanced <u>ionic</u> equation for each reaction by writing half equations and then combining them.
 - a) PbS (s) + NO₃ (aq) \rightarrow S (s) + Pb²⁺ (aq) + NO (g) (in <u>acid</u> medium) [3 marks]

b) $MnO_4^-(aq) + IO_3^-(aq) \rightarrow MnO_2(s) + IO_4^-(aq) \text{ (in } \underline{\text{basic}} \text{ medium) [3 marks]}$

END OF EXAMINATION