CH40S Exam Review Key

Extended Answer Questions Key

I: Aqueous Solutions

1. Consider the reaction that takes place between 0.10 mol/L aqueous solutions of iron (III) chloride, $FeCl_3$, and sodium phosphate, Na_3PO_4 at 25 °C.
   Write the net ionic equation for the reaction. Include all state symbols.

   $$Fe^{3+}_{(aq)} + PO_4^{3-}{}_{(aq)} \longrightarrow FePO_{4\,(s)}$$

2. 10.00 mL of an unknown concentration of sulfuric acid is neutralized with 23.50 mL of a 0.765 mol/L solution of sodium hydroxide.

   a) Write a balanced chemical equation for the reaction. Include all state symbols.

   $$H_2SO_{4(aq)} + 2NaOH_{(ah)} \longrightarrow 2H_2O_{(\ell)} + Na_2SO_{4(aq)}$$

   b) Determine the concentration of the sulfuric acid solution.

   $$0.765\ mol/L \times 0.0235\ L = 0.0179775\ mol\ NaOH = 0.0179775\ mol\ OH^-$$

   $$0.0179775\ mol\ OH^- = 0.0179775\ mol\ H^+$$

   $$\frac{0.0179775\ mol\ H^+}{2} = 0.00898875\ mol\ H_2SO_4$$

   $$C = \frac{n}{V} = \frac{0.00898875\ mol}{0.01\ L} = 0.898875\ mol/L\ H_2SO_4$$

3. Balance the following reaction in acidic solution using half reaction methods.

$$Mn^{2+}(aq) + BiO_3^-(aq) \rightarrow Bi^{3+}(aq) + MnO_4^-(aq)$$

+2 +5 +3 +7

RD

OX

Oxidation

$$(4H_2O + Mn^{2+} \longrightarrow MnO_4^- + 8H^+ + 5e^-) \times 2$$

Reduction

$$(2e^- + 6H^+ + BiO_3^- \longrightarrow Bi^{3+} + 3H_2O) \times 5$$

$$8H_2O + 2Mn^{2+} \longrightarrow 2MnO_4^- + 16H^+ + 10e^-$$

$$10e^- + 30H^+ + 5BiO_3^- \longrightarrow 5Bi^{3+} + 15H_2O$$

Write your final balanced equation on the line below:

$$14H^+ + 2Mn^{2+} + 5BiO_3^- \longrightarrow 2MnO_4^- + 5Bi^{3+} + 7H_2O$$

II: Atomic Structure

1. Consider element 18, Argon.

   a) State the full electron configuration for argon.

      $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

   b) Give the formulas of **two oppositely charged** ions which have the same electron configuration as argon.

      S^{2-} and Ca^{2+} or Cl^- and K^+

2. State and explain the **differences** between:

   a) The atomic radius of nitrogen and oxygen.

   N – larger

   Because more e^- /p^+ attraction in oxygen (more e^- and $p^{+)}$) in the same orbital = more pull toward nucleus

   b) The electronegativity of fluorine and chlorine.

   F – greater electronegativity

   Because fluorine has less orbitals, its outer electrons are closer to the nucleus, and thus held more strongly.

III: Kinetics

1. The reaction between **solid** ammonium chloride and aqueous sodium nitrite can be represented by the following equation:

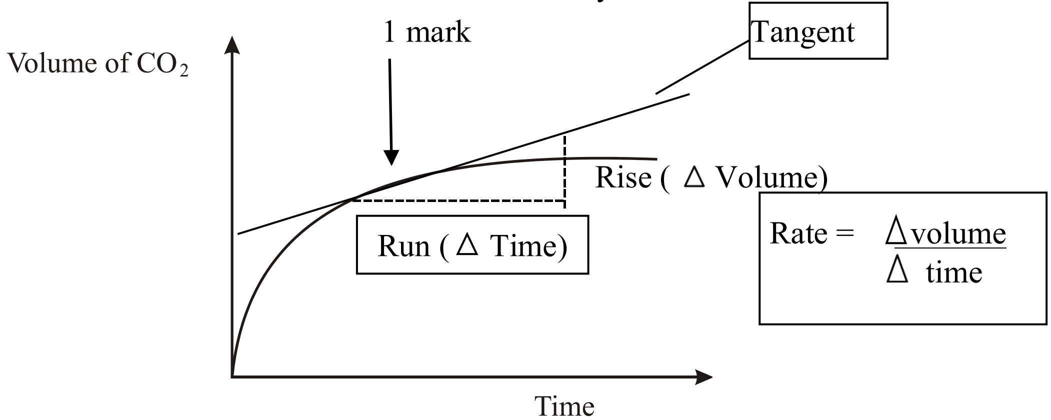
$$NH_4Cl(s) + NaNO_2(aq) \rightarrow N_2(g) + 2H_2O(l) + NaCl(aq)$$

State and explain how the rate of formation of nitrogen would change if the same amount of ammonium chloride were used as large lumps instead of as a fine powder.

State - slower

Explain - large lumps = less surface area = slower reaction

2. The graph below shows the volume of carbon dioxide gas produced against time when excess calcium carbonate is added to a fixed amount of 2.0 mol/L hydrochloric acid.



a) State and explain the change in the rate of reaction with respect to time.

Change: reaction slows down as time passes

Explanation: As reactans are consumed, their concentration decreases and this will decrease the reaction rate

b) On the graph, show how you should find the rate of the reaction at a particular instant. Include a rate equation for full marks.

(See graph above for key)

IV: Equilibrium

1. a) A 1.00 L flask is filled with 1.000 mol of H_2 and 2.000 mol of I_2 at 448°C and allowed to reach equilibrium. Analysis of the equilibrium mixture shows that the concentration of HI is 1.87 x 10^{-3} mol/L. Calculate K_{eq} at this temperature for this reaction.

	H_2(g)	**I_2(g)**	**2HI(g)**
I	1.000	2.000	0
C	–x	–x	+2x
E	1–x	4–x	2x

$$2x = 1.87 \times 10^{-3}$$
$$x = 9.35 \times 10^{-4}$$

$$[H_2] = 1 - x = 1 - 9.35 \times 10^{-4} = 0.999065\ mol/L$$

$$[I_2] = 2 - x = 2 - 9.35 \times 10^{-4} = 1.999065\ mol/L$$

$$K_{eq} = \frac{[HI]^2}{[H_2][I_2]}$$
$$= \frac{(1.87 \times 10^{-3})}{(0.999065)(1.999065)}$$
$$K_{eq} = 1.75 \times 10^{-6}$$

b) Is the forward or reverse reaction favored? Explain

Reverse reaction favored because K_c value is less than 1.

2. An industrial gas mixture is produced by the catalytic reforming of methane using steam.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H = +206 \text{ kJ}$$

Describe a change that would shift the position of equilibrium to the right and explain why the change shifts the equilibrium to the right.

Remove H_2 or CO.
Add CH_4 or H_2O.
Increase temperature.
Decrease pressure.

Explanations will vary depending on change made.

3. The solubility product of LaF_3 is 2.0 x 10^{-19}. Calculate the molar solubility of LaF_3 in grams per liter.

$$LaF_{3(s)} \rightleftharpoons La^{3+}{}_{(aq)} + 3F^{-}{}_{(aq)}$$

x   3x

$$K_{sp} = \left[La^{3+}\right]\left[F^{-}\right]^3$$

$$2.0\times10^{-19} = (x)(3x)^3$$

$$2.0\times10^{-19} = 27x^4$$

$$x^4 = \frac{2.0\times10^{-19}}{27}$$

$$x = \sqrt[4]{\frac{2.0\times10^{-19}}{27}}$$

$$x = 9.277\times10^{-6}\ mol/L$$

$$9.277\times10^{-6}\ mol/L\times195\ g/mol = 0.00181\ g/L$$

V: Acids and Bases

1. Consider nitric acid and carbonic acid for this question.
   a) Identify which is the strong acid and which is the weak acid.

      Strong Acid: Nitric Acid

      Weak Acid: Carbonic acid

   b) Using conductivity measurements state and explain what you would expect to find if you were to test equimolar solutions of the two acids in the lab.

      Findings: HNO_3 would conduct much better than H_2CO_3

      Explanation: because HNO_3 completely ionizes, it will conduct electricity much better or HNO_3 makes more ions in water

   c) Write a dissociation equation for one of the two acids. Include state symbols for full marks.

$$HNO_{3(ag)} + H_2O_{(\ell)} \rightarrow H_3O^+_{(aq)} + NO_3^-{}_{(aq)}$$

Complete arrow must be used

$$H_2CO_{3(ag)} + H_2O_{(\ell)} \rightleftharpoons H_3O_{(aq)} + HCO_3^-{}_{(aq)}$$

Double arrow must be used

2. a) Calculate the pH of acetic acid ($K_a = 1.8 \times 10^{-5}$), $HC_2H_3O_2$, in a 0.05 mol/L solution.

$$HC_2H_3O_2(aq) + H_2O(l) \Leftrightarrow H_3O^+(aq) + C_2H_3O_2^-(aq)$$

	$HC_2H_3O_2$	H_2O	H_3O^+	$C_2H_3O_2^-$
I	0.05	–	0	0
C	–x	–	+x	+x
E	0.05–x	–	x	x

Since Ka is small, x will be small. Thus,

$$0.05 - x \approx 0.05$$

$$K_a = \frac{[C_2H_3O_2^-][H_3O^+]}{[HC_2H_3O_2]}$$

$$1.8 \times 10^{-5} = \frac{(x)(x)}{(0.05)}$$

$$1.8 \times 10^{-5} = \frac{x^2}{(0.05)}$$

$$x^2 = (0.05)(1.8 \times 10^{-5})$$

$$x = 9.487 \times 10^{-4}\ mol/L$$

$$[H_3O^+] = x = 9.487 \times 10^{-4}\ mol/L$$

$$pH = -\log[H_3O^+]$$

$$= -\log(9.487 \times 10^{-4})$$

$$pH = 3.02$$

b) Find the percent (%) dissociation.

$$\%\ ionization = \frac{[H_3O^+]}{[HC_2H_3O_2]} \times 100\% = \frac{(9.487 \times 10^{-4})}{(0.05)} \times 100\% = 1.897\%$$

VI: Electrochemistry

1. The standard electrode potentials for three electrode systems are given below.

$Li^{+}(aq) + e^{-} \rightarrow Li(s)$	$E^{\ominus} = -3.00V$
$Cr^{3+}(aq) + e^{-} \rightarrow Cr^{2+}(aq)$	$E^{\ominus} = -0.41\ V$
$Cu^{2+}(aq) + e^{-} \rightarrow Cu^{+}(aq)$	$E^{\ominus} = +0.34\ V$

a) Using the data above, deduce which species is the **best** oxidizing agent, and explain your reasoning.

Cu^{2+}

Strongest ability to attract electrons/ most positive value.

b) Write an equation, including state symbols, for the overall reaction with the **greatest** cell potential and calculate the cell potential.

$Li_{(s)} \longrightarrow Li^{+}_{(aq)} + e^{-}$ + 3.00 v

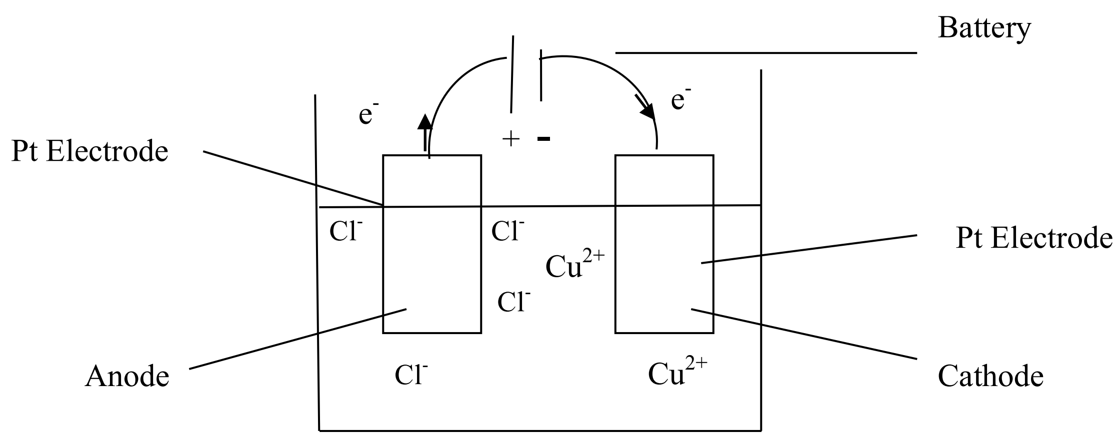
$Cu^{2}_{(aq)} + e^{-} \longrightarrow Cu^{+}_{(m)}$ + 0.34 v

$Li_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Li^{+}_{(aq)} + Cu^{+}_{(aq)}$

$\varepsilon^{o} = 0.34 + 3.00 = 3.34$

2. This question concerns the electrolysis of molten copper (II) chloride.

a) Sketch a diagram of the electrolytic cell and label the anode and cathode. Be sure to include all other items (electron flow/movement of ions and cations) necessary to make the cell function properly.



b) Write a balanced half equation for the reactions that occur at the anode and cathode. Be sure to include state symbols for full marks.

ANODE:

$2Cl^-_{(aq)} \rightarrow 2e^- + Cl_{2(g)}$

CATHODE:

$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu(s)$

c) Explain what would be observed on the surface of the cathode.

Solid copper would start to build up.

Multiple Choice Question Key

Question	Answer
1	A
2	C
3	D
4	C
5	B
6	A
7	C
8	B
9	D
10	A
11	B
12	D
13	B
14	C
15	A
16	A
17	B
18	A
19	C
20	C
21	D
22	C
23	D
24	A
25	B

Question	Answer
26	A
27	B
28	C
29	B
30	C
31	A
32	D
33	C
34	C
35	B
36	B
37	A
38	D
39	C
40	C
41	A
42	C
43	D
44	B
45	A
46	D
47	B
48	C
49	D
50	B