SURVEY OF WRITTEN RESPONSE QUESTIONS

REACTION KINETICS

1. Consider the reaction: $2\ Al_{(s)} + 6\ HCl_{(aq)} \longrightarrow 2\ AlCl_{3(aq)} + 3\ H_{2(g)}$

   A 10.0 gram sample of Al reacts completely with excess HCl in 300.0 seconds. What is the rate of production of H_2 in mol/s ? (June 2002 #1)

2. The mass of a burning candle is monitored to determine the rate of combustion of paraffin. An accepted reaction for the combustion of paraffin is:

   $2\ C_{28}H_{58(s)} + 85\ O_{2(g)} \longrightarrow 56\ CO_{2(g)} + 58\ H_2O_{(g)}$ (June 2001 #1)

   The following data are observed:

Time (min)	0.0	6.0	12.0	18.0	24.0	30.0
Mass of candle (g)	25.6	25.1	24.5	23.9	23.4	22.8

   a. Calculate the average rate of consumption of paraffin in g/min for the time interval from 12.0 to 24.0 minutes.
   b. Calculate the rate of CO_2 production in mol/min for the same time interval.

3. Consider the the following reaction mechanism for the formation of NO_2:

   Step 1: $2\ NO \longrightarrow N_2O_2$
   Step 2: ?
   Overall: $2\ NO + O_2 \longrightarrow 2\ NO_2$

   a. Complete Step 2.
   b. Define the term *reaction intermediate*.
   c. Identify a reaction intermediate in the above mechanism. (January 2001 #1)

4. Define: *collision theory, activation energy , activated complex. intermediate, catalyst, rate determining step, elementary process, activation energy, enthalpy change.* (various exams)

5. The combustion of coal, C, produces carbon dioxide gas according to the following equation:

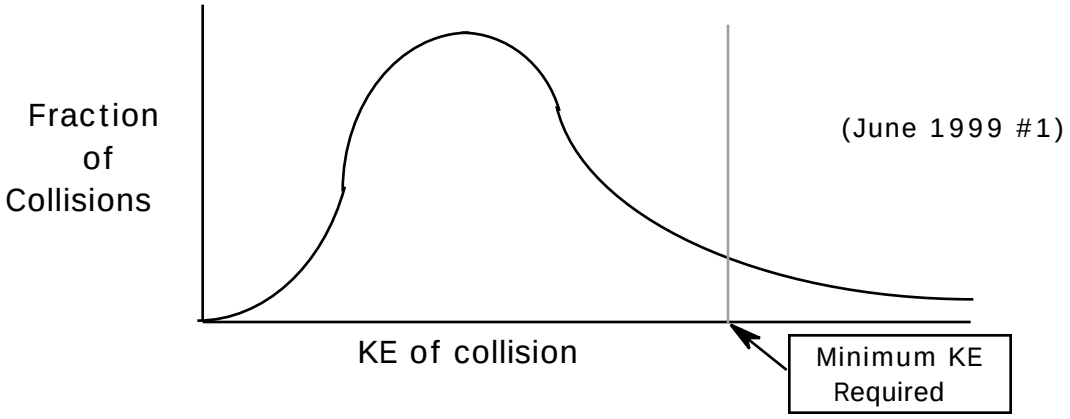
   $C_{(s)} + O_{2(g)} \longrightarrow 2\ CO_{2(g)} + 394\ kJ$

   a. What is the value of ΔH for this reaction ?
   b. Using collision theory explain why a lump of coal does not react with oxygen at room temperature and pressure.
   c. Many coal mine disasters have resulted when a spark ignites coal dust in the air. Explain using collision theory. (June 1997 #1)

6. State two reasons why a reaction might not occur when two reactant particles collide. (June 1998 #1)

7. List two requirements for an effective collision between two reactant molecules. (June 1991 #2)

8. Consider the following KE distribution curve for colliding particles:



(June 1999 #1)

PLEASE DO NOT WRITE ON THIS PAPER ! COPY THE DIAGRAM.

a. On the diagram sketch a line for the distribution of collisions at a higher temperature.
b. Shade in an area representing the collisions that could result in forming an activated complex at the **lower** temperature.

9. Using the potential energy diagram below clearly show the: (June 1995 #1)

a. Activation energy for the forward reaction.
b. Heat of reaction ΔH.
c. Energy of the activated complex in the rate determining step.
d. State whether the reaction is endothermic or exothermic in the forward direction.

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10. Using collision theory give two reasons why reactions occur more rapidly at a higher temperature. (June 2002 #2)

11. A mixture of natural gas and air in a reaction vessel does not react appreciably at room temperature. When a piece of platinum is inserted into the reaction vessel, the mixture explodes. Explain. (June 1993 #2)

12. Explain how a catalyst increases the rate of a chemical reaction. (June 1986 #4)

EQUILIBRIUM

1. Consider the equilibrium: $\underset{\text{yellow}}{HInd_{(aq)}} + H_2O_{(l)} \rightleftharpoons H_3O^{1+}_{(aq)} + \underset{\text{blue}}{Ind^{1-}_{(aq)}}$

   The system is initially yellow but turns blue on addition of NaOH. In terms of forward and reverse reaction rates, explain why this shift occurs. (January 2000 #3)

2. Chemical reactions tend toward a position of minimum enthalpy and maximum entropy.

   a. What is meant by the term *enthalpy* .
   b. What is meant by the term *entropy* . (June 2002 #3)

3. Consider the following exothermic reaction:

   $$C_3H_{8(g)} + 5\ O_{2(g)} \rightleftharpoons 3\ CO_{2(g)} + 4\ H_2O_{(g)}$$

   Explain in terms of increasing or decreasing entropy and enthalpy, whether or not the reaction will reach a state of equilibrium. (June 2003 #3)

4. Write four statements that apply to all chemical equilibrium systems. (June 2001 #2)

5. The production of ammonia by the Haber Process involves the following equilibrium:

   $$N_{2(g)} + 3\ H_{2(g)} \rightleftharpoons 2\ NH_{3(g)} + HEAT$$

Temperature (°C)	Percentage of Ammonia in Equilibrium
200	98
350	80
500	51

   a. Explain why a lower temperature results in a higher percentage of ammonia in the equilibrium mixture.
   b. Explain why a temperature of 500 °C is used in the Haber Process rather than a lower temperature. (June 1994 #4)

6. Consider the following equilibrium:

   $$CH_{4(g)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + 3\ H_{2(g)}$$

K_{eq}	Temperature °C
1.78×10^{-3}	800
4.68×10^{-2}	1000

   Is the forward reaction in this equilibrium exothermic or endothermic ? Explain your answer. (January 2003 #3)

7. Consider the following: $H_{2(g)} + I_{2(g)} \rightleftharpoons 2\ HI_{(g)}$

Initially 0.200 mol H_2 and 0.200 mol I_2 are placed in an empty 2.00 L container. At equilibrium, the [I_2] is 0.020 M. What is the value of K_{eq} ? (January 2002 #4)

8. Consider the data for the following equilibrium:

$$Fe^{3+}_{(aq)} + SCN^{1-}_{(aq)} \rightleftharpoons FeSCN^{2+}_{(aq)}$$

EXPERIMENT	$[Fe^{3+}]$	$[SCN^{1-}]$	$[FeSCN^{2+}]$
1	3.91×10^{-2}	8.02×10^{-5}	9.22×10^{-4}
2	6.27×10^{-2}	3.65×10^{-5}	?

Calculate the $[FeSCN^{2+}]$ in Experiment #2. (June 2000 #3)

9. Consider the following: $H_{2(g)} + Br_{2(g)} \rightleftharpoons 2\ HBr_{(g)}$ $K_{eq} = 12.0$

Initially 0.080 mol H_2 and 0.080 mol Br_2 are placed in a 4.00 L container. What is the [HBr] at equilibrium ? (June 2002 #4)

10. Consider the following equilibrium system:

$$C_{(s)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + H_{2(g)} \qquad K_{eq} = 0.80$$

In an experiment a student places 0.10 mol of C, 0.15 mol of H_2O, 0.25 mol of CO, and 0.20 mol of H_2 into a 1.0 L flask. The student predicts that the [CO] will decrease as equilibrium becomes established.

a. Would you agree or disagree with the student ?
b. Justify your answer, including appropriate calculations. (June 1994 #3)

SOLUBILITY EQUILIBRIA

1. Write the balanced complete ionic equation for the reaction that occurs when 0.20 M of $Ba(NO_3)_{2(aq)}$ is added to an equal volume of 0.20 M $Na_2CO_{3(aq)}$. (January 2001 #4)

2. a. Write the balanced formula equation for the reaction between $Na_3PO_{4(aq)}$ and $CuCl_{2(aq)}$.
   b. Write the complete ionic equation for the reaction between $Na_3PO_{4(aq)}$ and $CuCl_{2(aq)}$.
   c. Write the net ionic equation for the reaction between $Na_3PO_{4(aq)}$ and $CuCl_{2(aq)}$.
   (January 2000 #5; Part "b" not on original exam)

3. When HCl is added to a saturated solution of CuC_2O_4 some precipitate dissolves. However when HCl is added to a saturated solution of $PbCl_2$, additional precipitate forms. Explain these observations. Support your explanation with chemical equations. (June 2000 #5)

4. A 100 mL solution containing 0.2 M Al^{3+}, 0.2 M NH_4^{1+}, and 0.2 M Mg^{2+} is added to a 100 mL solution containing 0.2 M S^{2-}, 0.2 M Cl^{1-}, and 0.2 M OH^{1-}. Identify the ions that do **not** form a precipitate. (January 1994 #5)

5. Compare and contrast *solubility* and *solubility product*. (various exams)

6. A 100.0 mL sample of a saturated solution of $Ca(OH)_2$ is evaporated to dryness. The mass of the solid residue is 0.125 grams. Calculate the solubility product of $Ca(OH)_2$.
   (January 1998 #3)

7. Calculate the solubility of $SrSO_4$ in grams per litre. (June 2002 #6)

8. Calculate the maximum $[CO_3^{2-}]$ that can exist in 0.0010 M $Mg(NO_3)_2$. (January 2002 #6)

9. At 25°C will a precipitate form when 25.0 mL of 0.010 M $Pb(NO_3)_2$ is combined with 75.0 mL of 0.010 M NaI? Support your answer with calculations. (June 2000 #4)

10. Consider the following net ionic equation: $Ag^{1+}_{(aq)} + SCN^{1-}_{(aq)} \rightleftharpoons AgSCN_{(s)}$

    A 20.00 mL sample of 0.200 M NH_4SCN is used to titrate a 30.00 mL sample containing Ag^{1+}. Calculate the $[Ag^{1+}]$ in the original sample. (June 1998 #3)

11. Barium ions (Ba^{2+}) are added to a solution containing 0.100 M CrO_4^{2-} and 0.100 M SO_4^{2-}. What is the $[CrO_4^{2-}]$ when the more soluble compound precipitates ?
    (January 1993 Scholarship #4)

12. Given the following data:

COMPOUND	COLOUR	Ksp
$Ni(OH)_2$	GREEN	1.6×10^{-14}
$Zn(OH)_2$	WHITE	4.5×10^{-17}

    1.0 M $Zn(NO_3)_2$ is added to a saturated solution of $Ni(OH)_2$ in contact with its solid. Predict and explain what would be observed. (January 1993 Scholarship #5)

ACIDS AND BASES

1. The two reactants in an acid-base reaction are $HNO_{2(aq)}$ and $HCO_3^{1-}{}_{(aq)}$.

   a. Write the equation for the above reaction.
   b. Define the term *conjugate acid base pair*. (January 2002 #7)

2. The cyanide ion, CN^{1-}, is a Brønsted-Lowry base.

   a. Define the term *Brønsted-Lowry base*.
   b. Write the equation representing the reaction between cyanide ion and water.
   c. Identify a conjugate pair in Part "b" above. (June 2002 # 7)

3. Write the equation for the predominant reaction between HSO_4^{1-} and $H_2PO_4^{1-}$. (June 2001 #6)

4. Consider the following equilibrium:

$$H_2Se_{(aq)} + HTe^{1-}{}_{(aq)} \rightleftharpoons HSe^{1-}{}_{(aq)} + H_2Te_{(aq)}$$

   a. Identify the stronger acid.
   b. Identify the weaker base. (January 1996 #7)

5. a. Define the term *amphiprotic*.
   b. Give an example of an amphiprotic anion. (June 1998 #6)

6. In aqueous solution H_3O^{1+} is the strongest acid present. This phenomenon is called the levelling effect. Explain why this occurs. (June 1999 #6)

7. The hydrogen carbonate ion can act as an acid or a base. Use calculations to determine if a solution containing 0.10 M hydrogen carbonate ion is acidic or basic. (January 1996 #8)

8. a. The ionization of water is an endothermic process. What happens to the value of Kw as water is heated ? Explain.
   b. What happens to the pH of pure water as the temperature increases ?
   c. As the temperature of pure water rises, will the water become more acidic, more basic, or remain neutral ? (June 1994 #8)

9. Consider the following equilibrium: $\text{Energy} + 2\ H_2O_{(l)} \rightleftharpoons H_3O^{1+}{}_{(aq)} + OH^{1-}{}_{(aq)}$

   a. Explain how pure water can have a pH of 7.30.
   b. Calculate the value of Kw for the sample of water with a pH of 7.30. (January 2001 #8)

10. The indicator HInd is yellow in a solution of 1.0 M HCl and is red in a solution of 1.0 M NaOH. When the concentration of H_3O^{1+} is 1.0×10^{-5} M the indicator is orange.

    a. What molecule or ion is responsible for the yellow colour ?
    b. What molecule or ion is responsible fort the red colour ?
    c. Explain clearly the reasons for the three observed colours of HInd in solutions of different H_3O^{1+} concentration. (June 1981 Scholarship #18b)

11. Calculate the $[OH^{1-}]$ midway through the colour change (or transition point) for the indicator indigo carmine. (January 1988 Scholarship #6)

12. At a particular temperature a 1.0 M H_2S solution has a pH of 3.75. Calculate the value of the Ka at this temperature. (January 2002 #9)

13. A 0.20 M solution of a weak acid HA has a pH of 1.32. Use calculations and the table of "Relative Strengths of Brønsted-Lowry Acids and Bases" to determine the identity of the acid (June 2001 #7)

14. Calculate the pH of 0.50 M H_3BO_3. (January 1999 #5)

15. Calculate the pH of 1.50 M NH_3. (June 2002 #9)

16. Calculate the pH of 0.25 M $NaHCO_3$, a basic salt. (June 2003 #8)

17. A 1.00 M OCl^{1-} solution has a $[OH^{1-}]$ of 5.75×10^{-4}.

    a. Calculate the Kb for OCl^{1-}.
    b. Calculate the Ka for HOCl. (June 1999 #7)

18. Consider the neutralization reaction between $Ca(OH)_{2(aq)}$ and $HCl_{(aq)}$:

    a. Write the formula equation.
    b. Write the complete ionic equation.
    c. Write the net ionic equation. (January 1992 #9; Parts "b" & "c" added)

19. a. Write a chemical equation representing the hydrolysis of sodium acetate.
    b. Calculate the K_b value for the hydrolysis in Part "a" above. (June 1995 #8)

20. A student predicts that 0.1M Na_2HPO_4 will be more acidic than 0.1 M NH_4HS. Evaluate this prediction, explaining why you agree or disagree. Support your answer with calculations. (June 1992 Scholarship #9)

BUFFERS, HYDROXIDES, ACID RAIN, ACID-BASE TITRATION

1. What is the main function of a buffer solution ? (January 2002 #10)

2. Consider the following buffer equilibrium:

Using Le Chatelier's Principle, explain what happens to the pH of the buffer solution when a small amount of NaOH is added. (June 2002 #10)

3. Explain why the action of a buffer solution islimited. (June 2003 #9)

4. a. A student prepares a buffer solution by dissolving solid sodium acetate, $NaCH_3COO$, in a solution of acetic acid, CH_3COOH. Write the **net** ionic equation for the buffer system.
   b. What happens to the concentrations of CH_3COOH and CH_3COO^{1-} when a small amount of acid is added to this system ? Explain the reason.
   c. What happens to the pH of the buffer when a small amount of acid is added ?
   (January 1994 #8)

5. Give the chemical formula for each of the following:

   a. A third row amphoteric hydroxide.
   b. A third row basic hydroxide. (June 1986 #7)

6. Identify a gas which causes acid rain and write an equation showing the gas reacting with water. (June 2001 #9)

7. The Rocky Mountains consist largely of calcium carbonate. The pH of lakes and rivers in the Rockies does not change much even when exposed to acid rain. Suggest why this might be so. (January 1992 Scholarship #11)

8. SO_2 is a waste product in some industrial processes. State the environmental problem associated with $SO_{2(g)}$, write the equation that accounts for this, and give one effect on the natural environment. (January 1989 #8)

9. Define the terms *titration, equivalence point, endpoint, primary standard, standardized solution*. (various exams)

10. A 250.0 mL sample of HCl with a pH of 2.000 is completely neutralized with 0.200 M NaOH.

    a. What volume of NaOH is required to reach the stoichiometric point ?
    b. Write the net ionic equation for the above neutralization reaction.
    c. If the HCl were titrated with 0.200 M $NH_{3(aq)}$ instead of 0.200 M NaOH how would the volume of base required to reach the equivalence point compare with the volume calculated in part "a" ? Explain your answer. (January 2001 #7)

11. Acetylsalicylic acid (ASA) is a monoprotic acid; its formula is $HC_9H_7O_4$. A sample was analyzed for ASA by dissolving 0.250 grams of it in water and titrating with 0.0300 M KOH. If the titration required 29.4 mL of base, what is the percentage of ASA in the sample ? (June 1989 Scholarship #9)

12. A titration was performed by adding 0.115 M NaOH to a 25.00 mL sample of H_2SO_4. Calculate the $[H_2SO_4]$ from the following data.

NaOH VOLUME (mL)	TRIAL 1	TRIAL 2	TRIAL 3
INITIAL	4.00	17.05	8.00
FINAL	17.05	28.00	19.05

(January 2000 #9)

13. Calculate the pH of a solution prepared by mixing 15.0 mL of 0.50 M HCl with 35.0 mL of 1.0 M NaOH. (June 2001 #8)

14. A student titrated a 25.00 mL sample of 0.20 M HX (unknown) acid with 0.20 M NaOH. The following data were collected:

VOLUME OF BASE ADDED (mL)	pH
0.00	2.72
10.00	4.57
24.90	7.14
24.99	8.14
25.00	8.88
25.01	9.60
26.00	11.59
35.00	12.52

(June 1998 #8)

a. Describe the acid HX as strong or weak. Support your answer with two observations from the data table.
b. Select an appropriate indicator for this titration and identify the colour at the equivalence point.

15. In a titration, 25.00 mL of 0.10 M HCl was neutralized by slowly adding 50.00 mL of 0.10 M NaOH. (Labelled graph axes were provided on the original exam)

a. Sketch the titration curve for the reaction and label:
   - the initial pH of the HCl,
   - the volume of NaOH required to neutralize the HCl, and
   - the pH at the equivalence point.
b. Select a suitable indicator for the titration. (January 1996 #9)

16. Consider the following four acid-base titrations:

1. 0.50 M HCl with 0.50 M NaOH
2. 0.50 M HCl with 0.50 M NH_3
3. 0.50 M CH_3COOH with 0.50 m NaOH
4. 0.50 M H_2SO_4 with 0.50 M NH_3

Phenolphthalein is a suitable indicator for **TWO** of the titrations above. Choose the two titrations and give a reason for your answer. (June 1993 #8)

OXIDATION - REDUCTION

1. Aluminum is a stronger reducing agent than copper. What is meant by the term *stronger reducing agent* ? (June 2001 #11)

2. Consider the following which shows whether a reaction will occur when metals are added to aqueous ions:

METAL / ION	Pd	Rh	Pt
Pd^{2+}		?	?
Rh^{2+}	NO REACTION		NO REACTION
Pt^{2+}	REACTION	REACTION	

   a. Indicate whether a reaction will or will not occur between Rh and Pd^{2+}.
   b. Indicate whether a reaction will or will not occur between Pt and Pd^{2+}.
   c. List the oxidizing agents in order of strongest to weakest.

(January 2000 #11; modified)

3. Balance the following redox reaction in acidic solution:

$$Sb + HSO_4^{1-} \rightleftharpoons Sb_2O_3 + SO_2$$ (January 1998 #8)

4. Balance the following redox reaction in basic solution:

$$SO_3^{2-} + MnO_4^{1-} \rightleftharpoons SO_4^{2-} + MnO_2$$ (January 2001 #9)

5. The data below were obtained in a redox titration of a 25.00 mL sample containing Sn^{2+} ions using 0.125 M $KMnO_4$ according to the following reaction:

$$2\ MnO_4^{1-} + 16\ H^{1+} + 5\ Sn^{2+} \rightleftharpoons 2\ Mn^{2+} + 8\ H_2O + 5\ Sn^{4+}$$

	VOLUME $KMnO_4$ USED (mL)		
BURET READING	TRIAL 1	TRIAL 2	TRIAL 3
INITIAL	4.00	17.05	8.00
FINAL	17.05	28.00	19.05

Calculate the $[Sn^{2+}]$ in the original sample. (June 1999 #9)

6. Consider the following redox reaction:

$$H_2Se + SO_4^{2-} + 2\ H^{1+} \rightleftharpoons Se + H_2SO_3 + H_2O$$

Calculate the E° value for the reaction above. (January 1998 #9)

7. A sample of copper is placed in $HNO_{3(aq)}$ and another sample of copper is place in $HCl_{(aq)}$.

   a. In which acid does the copper react ?
   b. Calculate the E° value for the reaction that occurs. (June 2002 #13)

8. The metals Rh, Ti, Cr, and Pd are individually placed in 1.0 M solutions of Rh^{2+}, Ti^{2+}, Cr^{2+}, and Pd^{2+} and the cell voltages of the spontaneous reactions are determined.

METAL / ION	Rh^{2+}	Ti^{2+}	Pd^{2+}	Cr^{2+}
Rh		NO REACTION	0.35 V	NO REACTION
Ti	2.33 V		2.58 V	?
Pd	NO REACTION	NO REACTION		NO REACTION
Cr	1.51 V	NO REACTION	1.86 V	

   a. Arrange the metals in order of **increasing** strength as reducing agents.
   b. Determine the cell voltage for Ti in a 1.0 M solution of Cr^{2+}. (June 2000 #8)

9. Draw and label the parts of an electrochemical cell using a zinc anode that will produce an electric current having a voltage of 1.56 Volts at standard conditions. (January 2001 #10)

10. The overall cell reaction in an alkaline dry cell is:

$$Zn_{(s)} + 2\ MnO_{2(s)} \rightleftharpoons ZnO_{(s)} + Mn_2O_{3(s)}$$

   a. What substance is oxidized at the anode ?
   b. What substance is reduced at the cathode ?
   c. At equilibrium, what is the voltage of the dry cell ? (January 1988 #13)

11. Consider the following reactions for a fuel cell:

Cathode: $O_{2(g)} + 2\ H_2O_{(l)} + 4\ e^{1-} \longrightarrow 4\ OH1-_{(aq)}$

Anode: _____ ? _____

Overall: $2\ H_{2(g)} + O_{2(g)} \longrightarrow 2\ H_2O_{(aq)}$

   a. Write the reaction at the anode.
   b. Discuss the advantage of a fuel cell powered vehicle over an internal combustion powered vehicle by comparing the products formed. (June 2000 #9)

12. Use the Table of reduction Potentials to explain the cathodic protection of iron in contact with zinc. (January 1981 Scholarship #18a)

13. Define the term *electrolysis*. (June 1998 #10)

14. Students are asked to produce hydrogen and oxygen gas by the electrolysis of water. They are given three substances ($CuSO_4$, K_2SO_4, and NaI) to choose from to prepare an electrolytic solution that will only produce hydrogen and oxygen.

(January 2002 #12)

   a. Which substance should be selected. Explain why.
   b. Write the equation for the half reaction that occurs at the anode in the electrolytic cell.
   c. Explain why it would **not** be acceptable to use a copper anode in this cell.

15. Draw a diagram of an operating electrolytic cell used to extract pure lead from an impure lead sample. Identify the electrolyte and the material used for the anode. (June 2000 #12)