DIRECTIONS: Do all work legibly on the test paper and place your final answer in the indicated space. Obey the rules of significant figures. SHOW ALL WORK AND UNITS. Failure to follow these instructions will result in loss of credit.

1. Fill in the missing word or phrase. (10)
   At the —a— point the —b— changes color. A —c— solution contains a weak acid and its conjugate base. A precipitate will dissolve if $Q_{SP} —d—$ is than $K_{SP}$. The pH of a buffer will —e— if it is diluted with pure water. The —f— is the lowest level of the atmosphere. —g— are refrigerants that in the stratosphere can produce highly reactive free radicals. Greenhouse gases such as carbon dioxide, methane and water trap —h—. —i—water contains calcium cations. Oxides of —j— are released from volcanoes and also contaminate the emissions from the burning of coal.

   a. ___________________________  
   b. ___________________________  
   c. ___________________________  
   d. ___________________________  
   e. ___________________________  
   f. ___________________________  
   g. ___________________________  
   h. ___________________________  
   i. ___________________________  
   j. ___________________________

2. Circle the member of the following pairs which ..... (30)
   is a buffered solution a) .10 M HOAc/.10 M NaF  or  .10 HF / .10 M NaF   
       b) HOCl/NaOCl  or  HClO$_4$/NaClO$_4$
   has neutral pH at equivalence point  c) NH$_3$ vs HCl  or  HCl vs KOH
   has basic pH at equivalence point  d) HClO$_2$ vs KOH  or  HClO$_4$ vs KOH
   has greater [Ag$^+$]  e) AgCl(s) in .10 M NaCl or  AgCl(s) in .10 M NaNO$_3$
   has greatly decreased conc of metal ion in basic solution  f) Fe(OH)$_3$(s) or Ca$_3$(PO$_4$)$_2$(s)
   would increase in solub. in HCl(aq)  g) Ni(OH)$_2$(s)  or  AgCl(s)
   has increasing T with increasing altitude  h) troposphere or stratosphere  I) thermosphere or mesosphere
   has increased in air concentration over the last 30 years  j) Ar  or  CO$_2$
   is a photodissociation product  k) O$_3$  or  O  l) N$_2^+$  or  Cl
   is a greenhouse gas  m) Ar  or  H$_2$O
   is removed in a “scrubber reaction”  n) SO$_2$  or  NO
   is a replacement for the older generation freon o) CBr$_2$F$_2$  or  CH$_2$F$_2$
3. Calculate the wavelength (λ in m) of a photon that can cause the following reaction. E=hc, c=λv, h=6.63x10⁻³⁴ Js, c=3.0x10⁸ m/s, 1000J=1kJ, 6.02x10²³ photons/mol. (5)

\[ O_3(g) + hv \rightarrow O_2(g) + O(g) \]

\[ E=105kJ/mol \]

EXPLAIN in a few sentences why ozone production is greatest at the stratopause. (5)

\[ O_2(g) \rightarrow 2O(g) \]

\[ O(g) + O_2(g) + M \rightarrow O_3(g) + M(g) \]

4. Match the chemical reaction with the environmental consideration. (15)

____ production of acid rain
a) \[ N_2(g) + O_2(g) \rightarrow 2NO(g) \]

____ reaction occurring in high T engines
b) \[ SO_2(g) + CaO(s) \rightarrow CaSO_3(s) \]

c) \[ SO_3(g) + H_2O \rightarrow H_2SO_4 \]

____ Rx from thermosphere
d) \[ Cl + O_3 \rightarrow ClO + O_2 \]

e) \[ N_2 \rightarrow N_2^+ + e^- \]

____ "scrubber" Rx in smokestacks

____ reaction in stratosphere

5. Calculate the molar solubility, s, of \( Ag_2(CrO_4)_4 \) (5)

\[ Ag_2(CrO_4)_4(s) \rightleftharpoons 2Ag^+(aq) + CrO_4^{2-}(aq) \quad K_{sp} = 7.9x10^{-16} \]

Calculate the \([Ag^+]\) in a solution of \( Ag_2(CrO_4)_4(s) \) if the \([CrO_4^{2-}]\) is .25 M (5)
6. Answer the following questions for the titration of A) 25.0 ml of .100 M HCl vs .100 M NaOH or B) 25.0 ml of .100 M HOAc (Ka = 1.8x10⁻⁵) vs .100 M NaOH. The NaOH is added via a buret to a solution of the acid. (10)

a) Has the higher initial pH _______

b) Has a buffer region _______

c) Has initially the sharpest increase in pH _______

d) Has the greatest pH jump during the rise near the eq. pt. _________

e) Has a pH = 7.00 at the eq. pt. _________

7. Calculate the molecular weight of an acid, HA, if 38.55 ml of .1016 M NaOH were required to neutralize .4054 g of it. (5)

\[
\text{HA(aq)} + \text{NaOH(aq)} \rightarrow \text{H}_2\text{O} + \text{NaA(aq)}
\]

8. Calculate the pH of 100. ml of an acetic acid/sodium acetate buffer that is .100M in acetate and .200 M in acetic acid. (5)

\[
\text{HOAc} \rightleftharpoons \text{H}^+ + \text{OAc}^- \quad \text{pK}_a=4.74
\]

Calculate the pH if 10.0 ml of .100 M NaOH (.00100 moles or 1.00 mmol) is added to 100. ml of the above buffer. (5)

\[
\text{OH}^-\text{(aq)} + \text{HOAc(aq)} \rightarrow \text{OAc}^-\text{(aq)}
\]
DIRECTIONS: Do all work legibly on the test paper and place your final answer in the indicated space. Obey the rules of significant figures. SHOW ALL WORK AND UNITS. Failure to follow these instructions will result in loss of credit.

1. Fill in the missing word or phrase. (10) At the —a— point the —b— changes color. A —c— solution contains a weak acid and its conjugate base. A precipitate will dissolve if $Q_{sp} - d -$ is than $K_{sp}$. The pH of a buffer will —e— if it is diluted with pure water. The —f— is the lowest level of the atmosphere. —g— are refrigerants that in the stratosphere can produce highly reactive free radicals. Greenhouse gases such as carbon dioxide, methane and water trap —h—. —i—water contains calcium cations. Oxides of —j— are released from volcanoes and also contaminate the emissions from the burning of coal.

a. __________  
b. __________  
c. __________  
d. __________  
e. __________  
f. __________  
g. __________  
h. __________  
i. __________  
j. __________

2. Circle the member of the following pairs which ..... (30)

is a buffered solution a) .10M HOAc/.10M NaF or .10 HF / .10 M NaF

b) HOCl/NaOCl or HClO$_4$/NaClO$_4$

has neutral pH at equivalence point c) NH$_3$ vs HCl or HCl vs KOH

has basic pH at equivalence point d) HClO$_2$ vs K$_2$O or HClO$_4$ vs KOH

has greater [Ag$^+$] e) AgCl(s) in .10 M NaCl or AgCl(s) in .10 M NaNO$_3$

has greatly decreased conc of metal ion in basic solution f) Fe(OH)$_3$(s) or Ca$_3$(PO$_4$)$_2$(s)

would increase in solub. in HCl(aq) g) Ni(OH)$_2$(s) or AgCl(s)

has increasing T with increasing altitude h) troposphere or stratosphere  l) thermosphere or mesosphere

has increased in air concentration over the last 30 years j) Ar or CO$_2$

is a photodissociation product k) O$_3$ or O l) N$_2^+$ or Cl

is a greenhouse gas m) Ar or H$_2$O

is removed in a “scrubber reaction” m) SO$_2$ or NO

is a replacement for the older generation freeon o) CBr$_2$F$_2$ or CH$_3$F$_2$
3. Calculate the wavelength (\(\lambda\) in m) of a photon that can cause the following reaction. \(E = h\nu, \ c = \lambda\nu, \ h = 6.63 \times 10^{-34}\) Js, \(c = 3.0 \times 10^8\) m/s, 1000 J = 1 kJ, 6.02 \times 10^{23}\) photons/mol. (5)

\[
E = hf = hc/\lambda
\]

\[
\lambda = \frac{hc}{E} = \left(\frac{6.63 \times 10^{-34} \text{ } \text{Js}}{1}\right) \left(\frac{3.0 \times 10^8 \text{ m/s}}{1}\right) \left(\frac{1000 \text{ J}}{1 \text{ kJ}}\right) \left(\frac{6.02 \times 10^{23}}{1 \text{ mol}}\right) \left(\frac{1 \text{ mm}}{10^{-3} \text{ m}}\right)
\]

\[= 1.14 \times 10^{-6}\text{ mm} = 1.14 \text{ nm}\]

EXPLAIN in a few sentences why ozone production is greatest at the stratopause. (5)

\(O_2(g) \rightarrow 2O(g)\)

\(O(g) + O_2(g) + M \rightarrow O_3(g) + M'(g)\)

4. Match the chemical reaction with the environmental consideration. (15)

C production of acid rain

A reaction occurring in high T engines

E Rx from thermosphere

b "scrubber" Rx in smokestacks

d reaction in stratosphere

e) \(N_2 \rightarrow N_2^+ + e^-\)

f) SO_{2(g)} + CaO(s) \rightarrow CaSO_3(s)

g) \(SO_3(g) + H_2O \rightarrow H_2SO_4\)

h) Cl + O_3 \rightarrow ClO + O_2

i) \(N_2 \rightarrow N_2^+ + e^-\)

5. Calculate the molar solubility, \(s\), of \(Ag_2(CrO_4)_4\) (5)

\[
K_{sp} = [Ag^{+}]^2[CrO_4^{2-}] = (2.5 \times 10^{-16})
\]

\[
s = \left(\frac{K_{sp}}{4}\right)^{1/2} = \left(\frac{7.9 \times 10^{-16}}{4}\right)^{1/2}
\]

\[= 5.9 \times 10^{-6}\]

Calculate the \([Ag^{+}]\) in a solution of \(Ag_2(CrO_4)_4\) if the \([CrO_4^{2-}]\) is .25 M (5)

\[
K_{sp} = [Ag^{+}]^2[CrO_4^{2-}] = \frac{[Ag^{+}][CrO_4^{2-}]}{[Ag_2(CrO_4)_4]}
\]

\[
[Ag^{+}]^2 = \frac{K_{sp}[Ag_2(CrO_4)_4]}{[CrO_4^{2-}]}
\]

\[= \left(\frac{7.9 \times 10^{-16}}{.25}\right)^{1/2}
\]

\[= 5.6 \times 10^{-6}\]
6. Answer the following questions for the titration of A) 25.0 ml of .100 M HCl vs .100 M NaOH or B) 25.0 ml of .100 M HOAc \( (K_a = 1.8 \times 10^{-5}) \) vs .100 M NaOH. The NaOH is added via a buret to a solution of the acid. (10)

a) Has the higher initial pH \( \text{B} \)

b) Has a buffer region \( \text{B} \)

c) Has initially the sharpest increase in pH \( \text{B} \)

d) Has the greatest pH jump during the rise near the eq. pt. \( \text{A} \)

e) Has a pH = 7.00 at the eq. pt. \( \text{A} \)

7. Calculate the molecular weight of an acid, HA, if 38.55 ml of .1016 M NaOH were required to neutralize .4054 g of it. (5)

\[
\text{HA(aq)} + \text{NaOH(aq)} \rightarrow \text{H}_2\text{O} + \text{NaA(aq)}
\]

\[
\text{Moles acid} : \text{moles base} = \frac{\text{mL}}{\text{L}} \times \frac{\text{M}}{\text{L}}
\]

\[
\text{Molecular weight} = \frac{\text{mass}}{(\text{M} \times \text{L})} = \frac{0.4054}{(0.03855 \times 0.1016)} = 101.59 \text{ g/mol}
\]

8. Calculate the pH of 100. ml of an acetic acid/sodium acetate buffer that is .100M in acetate and .200 M in acetic acid. (5)

\[\text{HOAc} \rightleftharpoons \text{H}^+ + \text{OAc}^- \quad \text{pK}_a = 4.74\]

\[
\text{pH} = \text{pK}_a + \log \frac{\text{conjugate base}}{\text{acid}} = 4.74 + \log \frac{100}{200} = 4.74 + \log (0.50)
\]

\[
= 4.74 + 1.70 = 4.44
\]

Calculate the pH if 10.0 ml of .100 M NaOH (.00100 moles or 1.00 mmol) is added to 100. ml of the above buffer. (5)

\[
\text{OH}^- \text{(aq)} + \text{HOAc(aq)} \rightarrow \text{OAc}^- \text{(aq)}
\]

\[
\begin{align*}
\text{Initial} & = 0.0100 \text{ mol}, 0.200 \text{ mol} \\
\text{Final} & = 0.0190 \text{ mol}, 0.116 \text{ mol}
\end{align*}
\]

\[
\text{pH} = \text{pK}_a + \log \frac{\text{conjugate base}}{\text{acid}}
\]

\[
= 4.74 + \log \frac{0.116}{0.0190} = 4.74 + \log (6.16)
\]

\[
= 4.74 + 0.79 = 5.53
\]

\[
= 4.50
\]