1. (8 pts) Consider the following reaction at equilibrium:

$$N_2O_4 \text{ (g)} \rightleftharpoons 2 NO_2 \text{ (g)}$$ The value of K is 0.90 at 120°C and 3.2 at 150°C.
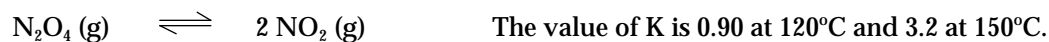
Predict how the equilibrium will shift by the following changes. Circle the correct answer.

a) increase the partial pressure of N_2O_4 left   right   no change

b) increase the partial pressure of NO_2 left   right   no change

c) increase the temperature   left   right   no change

d) decrease the volume   left   right   no change

2. (10 pts) Magnesium metal reacts with hydrochloric acid to form aqueous magnesium chloride and hydrogen gas. An excess of magnesium is reacted with 20.0 mL of 3.00 M hydrochloric acid and all of the hydrogen is collected in a balloon at 25°C and 1.00 atm. What is the expected volume of the balloon?   SHOW YOUR WORK. Circle the answer.

NO WORK = NO CREDIT

a) 0.672 L
b) 0.734 L
c) 1.34 L
d) 1.47 L
e) 22.4 L
f) 2.93 L

3. (8 pts) At 200K the molecules or atoms of an unknown gas, X, have an average velocity equal to that of Ar atoms at 400 K. What is X? Assume ideal behavior. SHOW YOUR WORK. Circle the answer.

NO WORK = NO CREDIT

a) He
b) CO
c) HF
d) HBr
e) F_2
f) none of these

4. **(8 pts)** What volume of 17.5 M CH_3COOH stock solution must be used to prepare 250 mL of 3.0 M CH_3COOH? Show your work.

5. **(12 pts)** For a 0.1 M solution of each of the following salts indicate if the solution will be <u>acidic, basic or neutral</u>. Circle the answer.

   a) Na_2CO_3 Acidic   Basic   Neutral

   b) NH_4ClO_4 Acidic   Basic   Neutral

   c) NH_4CN Acidic   Basic   Neutral

   d) $NaHCO_3$ Acidic   Basic   Neutral

6. **(10 pts)** The gases N_2 and Cl_2 are mixed in a closed container fitted with a piston (allowing the volume of the container to change, thus keeping the pressure constant). The amounts of the gases were chosen so that neither was limiting, and the original volume of the container was 8.0 L. What is the volume of the container when the reaction goes to completion? N_2 + $3 Cl_2$ —> $2 NCl_3$ SHOW YOUR WORK. Circle the answer.

   NO WORK = NO CREDIT

   a) 2.0 L
   b) 4.0 L
   c) 6.0 L
   d) 8.0 L
   e) 10.0 L
   f) 16.0 L

7. (10 pts) Nitrogen gas (N_2) reacts with hydrogen gas (H_2) to form ammonia (NH_3). At 200°C in a closed container, 1.0 atm of nitrogen gas is mixed with 2.0 atm of hydrogen gas. At equilibrium, the total pressure is 2.5 atm. Calculate the partial pressure of hydrogen gas at equilibrium.

8. (6 pts) Which pair of ions would **NOT** be expected to form a precipitate when dilute solutions of each are mixed? **Circle the answer.**

a) Al^{3+} and S^{2-}

b) Pb^{2+} and Cl^-

c) Ba^{2+} and PO_4^{3-}

d) Mg^{2+} and SO_4^{2-}

e) Pb^{2+} and OH^-

9. (10 pts) Circle the formula that best fits each of the following descriptions:

a) has 18 electrons	$^{32}_{16}X^{2+}$	$^{32}_{16}X^{2-}$	$^{16}_{8}X^{2-}$	$^{19}_{9}X^{+}$
b) most electronegative	N	Li	O	H
c) **an ionic compound**	Cl_2	KCl	NO	NOCl
d) **likely to gain two electrons**	N	Mg	S	F
e) correct formula for chromium(III) oxide	CrO	Cr_3O_2	Cr_3O	Cr_2O_3

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10. (10 pts) A 75.0-mL sample of 0.0500 M HCN is titrated with 0.500 M NaOH. What is the $[H^+]$ in the solution after 3.0 mL of 0.500 M NaOH have been added? SHOW YOUR WORK. Circle the answer.

NO WORK = NO CREDIT

a) $1.0 \times 10^{-7} M$

b) $4.1 \times 10^{-10} M$

c) $5.2 \times 10^{-13} M$

d) $9.3 \times 10^{-10} M$

e) $5.6 \times 10^{-6} M$

f) $2.9 \times 10^{-2} M$

g) none of these

11. (12 pts) Circle the correct answer for each of the following questions.

a) Which is the <u>strongest base</u>?　　　　　　CN^-　　　　　IO_3^-　　　　　NH_3

b) Which is the <u>strongest acid</u>?　　　　　　HF　　　　　HNO_2　　　　　HSO_3^-

c) Which salt, when dissolved in water, will produce the <u>most basic solution</u>? Circle the answer.

　　　　K_2SO_4　　　　KI　　　　　$KClO_2$　　　　KIO_3

d) Which of the following 0.1 M solutions will have the lowest pH? Circle the answer.
　　　　$NaNO_2$　　　　KOH　　　　　KCN　　　　NH_3

12. Nitrous acid (HNO_2) is titrated with potassium hydroxide.

a) (5 pts) Write the <u>net ionic equation</u> for the reaction of nitrous acid (HNO_2) with potassium hydroxide.

b) (5 pts) In the titration of HNO_2 with potassium hydroxide, what is the pH at the equivalence point? Circle the answer.

　　　$pH > 7$　　　　$pH = pK_a$　　　　　$pH < 7$　　　　　　$pH = 7$

13. (10 pts) After adding 25.0 mL of 0.100 M NaOH to 100.0 mL of 0.100 M weak acid (HA), the pH is found to be 5.90. Determine the value of K_a for the acid HA. SHOW YOUR WORK. Circle the answer.

NO WORK = NO CREDIT

a) 1.6×10^{-11}
b) 4.2×10^{-7}
c) 2.1×10^{-5}
d) 3.5×10^{-9}
e) none of these

14. (10 pts) What is the molarity of a solution of ammonia whose pH = 11.22.

15. Consider the following reaction.   HCN (aq) + HCO$_3^-$ (aq) $\rightleftharpoons$ CN$^-$ (aq) + H$_2$CO$_3$ (aq)

   a) (4 pts) Using the data in the Table of Acid Ionization Constants determine the equilibrium constant, K, for this reaction.

   b) (2 pts) Identify the stronger acid in this reaction.

   c) (2 pts) Identify the stronger base in this reaction.

16. (8 pts) Write the balanced molecular equation for the reaction between aqueous solutions of lithium phosphate and sodium hydroxide.

17. (10 pts) The solubility of Fe(OH)$_2$ in water is 7.9 x 10^{-6} mol/L at 25°C. What is K$_{sp}$ for Fe(OH)$_2$ at 25°C?