1997-8 Free Response Questions

- Question 1 was question 4 prior to 1996, question 2 was question 1 prior to 1996 and questions 3&4 were questions 2&3 prior to 1996.
- students are allowed 10 minutes to answer question 1, after which they must seal that portion of the test.

1) Give the formulas to show the reactants and products. You need not balance.

(a) Excess potassium hydroxide solution is added to a solution of aluminum nitrate.
(b) Sulfur dioxide gas is bubbled into distilled water.
(c) Hydrogen gas is passed over hot iron(II) oxide powder.
(d) A strip of magnesium metal is heated strongly in pure nitrogen gas.
(e) A solution of nickel chloride is added to a solution of sodium sulfide.
(f) Solutions of cobalt(II) nitrate and sodium hydroxide are mixed.
(g) Ethene (C_2H_4) gas is burned air.
(h) Equal volumes of equimolar solutions of phosphoric acid and potassium hydroxide are mixed.
(i) Solid calcium sulfite is heated in a vacuum.
(j) Solid sodium oxide is added to distilled water.
(k) A strip of zinc is added to a solution of 6.0-molar hydrobromic acid.

2) 2 A + B ---> C + D

The following results were obtained when the reaction represented above was studied at 25 °C

Experiment	Initial [A]	Initial [B]	Initial Rate of Formation of C (mol L^{-1} min^{-1})
1	0.25	0.75	4.3×10^{-4}
2	0.75	0.75	1.3×10^{-3}
3	1.50	1.50	5.3×10^{-3}
4	1.75	??	8.0×10^{-3}

a) Determine the order of the reaction with respect to A and B. Justify your answer.

b) Write the rate law for the reaction. Calculate the value of the rate constant, specifying units.

c) Determine the initial rate of change of [A] in Experiment 3.

d) Determine the initial value of [B] in Experiment 4.

e) Identify which of the reaction mechanisms represented below is consistent with the rate law developed in part (b). Justify your choice.

1 A + B ---> C + M Fast
M + A ---> D Slow

2 B <===> M Fast equilibrium
M + A ---> C + X Slow
A + X ---> D Fast

3 A + <===> M Fast equilibrium
M + A ---> C + X Slow
X ---> D Fast

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3) Consider the molecules PF_3 and PF_5.

a) Draw the Lewis electron-dot structures for PF_3 and PF_5 and predict the molecular geometry of each.

b) Is the PF_3 molecular polar, or is it nonpolar? Explain.

c) On the basis of bonding principles, predict whether each of the following compounds exists. In each case, explain your prediction.

(i) NF_5 (ii) AsF_5

4) Explain each of the following obsevations using principles of atomic structure and/or bonding.

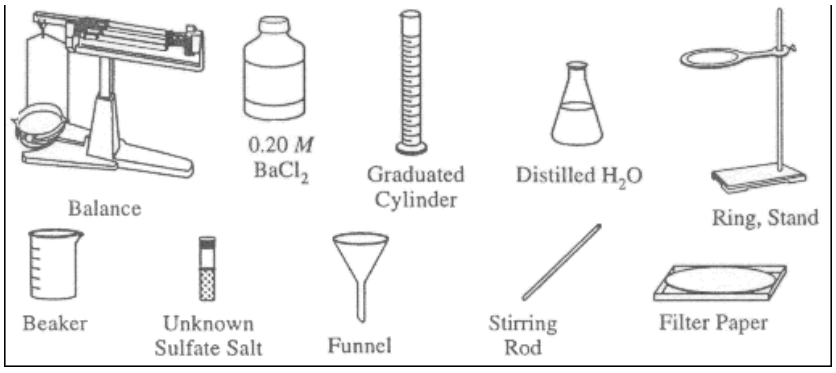
a) Potassium has a lower first-ionization energy than lithium.

b) The ionic radius of N^{3-} is larger than that of O^{2-}.

c) A calcium atom is larger than a zinc atom.

d) Boron has a lower first-ionization energy than beryllium.

5)



An experiment is to be performed to determine the mass percent of sulfate in an unknown soluble sulfate salt. The equipment shown above is avaliable for the experiment. A drying oven is also available.

a) Briefly list the steps needed to carry out this experiment.

b) What experimental data need to be collected to calculate the mass percent of sulfate in the unknown?

c) List the calculations necessary to determine the mass percent of sulfate in the unknowm.

d) Would 0.20-molar $MgCl_2$ be an acceptable substitute for the $BaCl_2$ solution provided for this experiment? Explain.

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6) An unknown compound contains only the three elements C,H, and O. A pure sample of the compound is analyzed and found to be 65.60 percent C and 9.44 percent H by mass.

(a) Determine the empirical formula of the compound.

(b) A solution of 1.570 grams of the compound in 16.08 grams of camphor is observed to freeze at a temperature 15.2 Celsius degrees below the normal freezing point of pure camphor. Determine the molar mass and apparent molecular formula of the compound. (The molal freezing-point depression constant, K_f, for camphor is 40.0 kg-K-mol^{-1}.)

(c) When 1.570 grams of the compound is vaporized at 300 °C and 1.00 atmosphere, the gas occupies a volume of 577 milliliters. What is the molar mass of the compound based on this result?

(d) Briefly describe what occurs in solution that accounts for the difference between the results obtained in parts (b) and (c).

7) $C_6H_5OH(s) + 7\ O_2(g) \rightarrow 6\ CO_2(g) + 3H_2O(l)$

When a 2.000-gram sample of pure phenol, $C_6H_5OH(s)$, is completely burned according to the equation above, 64.98 kilojoules of heat is released. Use the information in the table below to answer the questions that follow.

Substance	Standard Heat of Formation, $\Delta H°_f$, at 25°C (kJ/mol)
C(graphite)	0.00
$CO_2(g)$	-395.5
$H_2(g)$	0.00
$H_2O(l)$	-285.85
$O_2(g)$	0.00
$C_6H_5OH(s)$	?

(a) Calculate the molar heat of combustion of phenol in kilojoules per mole at 25°C.

(b) Calculate the standard heat of formation, $\Delta H°_f$, of phenol in kilojoules per mole at 25°C.

(c) If the volume of the combustion container is 10.0 liters, calculate the final pressure in the container when the temperature is changed to 110°C. (Assume no oxygen remains unreacted and that all products are gaseous.)