00036

Chemistry 1154 Fall 2011 test 2

Thursday, October 27, 2011 Time: 1 hour 50 minutes

Name: ANSWERS Student number: _____

*This test consists of **six** pages of questions, the formula sheet, and a periodic table. Please ensure that you have a complete paper and, if you do not, obtain one from me **immediately**. There are **29** marks available. Good luck!*

1) **[4 marks]** An impure sample of magnesium was reacted in exactly the same way as in the molar mass of magnesium lab. The following data were collected:

Data (units)	Value
Mass of magnesium (mg)	62.5
V_{gas} (mL)	51.4
$T_{sol'n}$ (°C)	21.6
P_{atm} (mmHg)	767.6
$VP_{sol'n}$ (mmHg)	19.4
h_{H2O} (mmH_2O)	170.0
D_{H2O} (g/mL)	1.00
D_{Hg} (g/mL)	13.6

Assuming the experiment measures the molar mass of Mg perfectly, and that the impurities did not react with the HCl, what was the percent purity of the Mg used? The reaction between Mg and HCl is:

$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$

$$P_{H_2} = 767.6\,mmHg - 19.4\,mmHg - 170.0\,mmH_2O \times \frac{1.00\,mmHg}{13.6\,mmH_2O}$$

$$= 735.7\,mmHg$$

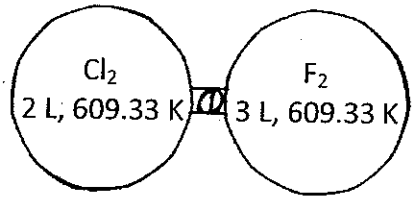
$$n_{H_2} = n_{Mg}\,(\text{by stoich}) = \frac{(735.7\,mmHg)(51.4\,mL)}{\left(62.3637\,\frac{L\text{-torr}}{mol\,K}\right)(294.75\,K)} = 2.06\,mmol$$

$$m_{Mg} = 2.06\,mmol \times \frac{24.305\,g}{1\,mol}$$

$$= 50.0\,mg$$

$$\frac{50.0\,mg}{62.5\,mg} \times 100 = \boxed{80.0\%}$$

2) **[3 marks]** The following apparatus was assembled:



When the valve was opened, the following reaction occurred:

$Cl_2(g) + 5F_2(g) \longrightarrow 2ClF_5(g)$

After reaction, the partial pressures of ClF_5, Cl_2, and F_2, were found to be 2 atm, 0.5 atm, and 0 atm, respectively. What were the partial pressures of all species present *before reaction*?

$$n_{ClF_5} = \frac{(2\text{ atm})(5\text{ L})}{(0.0820575\ \frac{\text{L·atm}}{\text{mol·K}})(609.33\text{ K})} = 0.20\text{ moles}$$

$n_{Cl_2,\text{excess}} = 0.050$ moles ; $n_{F_2,\text{excess}} = 0$

$$\text{So } n_{Cl_2,\text{start}} = 0.050\text{ moles} + 0.20\text{ moles } ClF_5 \times \frac{1\,Cl_2}{2ClF_5}$$

$$= 0.150\text{ moles.}$$

$$n_{F_2,\text{start}} = 0 + 0.20\text{ moles } ClF_5 \times \frac{5\,F_2}{2ClF_5} = 0.50.$$

$$P_{Cl_2} = \frac{(0.15\text{ moles})(0.0820575\ \frac{\text{L·atm}}{\text{mol·K}})(609.33\text{ K})}{2\text{ L}}$$

$= 3.75\text{ atm} = P_{Cl_2}$

$P_{F_2} = 8.3\text{ atm}$

3) **[2 marks]** A sample of ClF_5 takes 80.443 seconds to effuse. How long will it take a sample of H_2 under the same conditions?

$35.453 + 5 \times 18.998 = 130.443$

$2 \times 1.0079 = 2.0158$

$$\frac{130.443}{80.443^2} = \frac{2.0158}{t_2^2}$$

$\Rightarrow t_2 =$ **10.000 s**

4) **[4 marks]** Given the following equilibrium:

$H_2(g) + Br_2(l) \rightleftharpoons 2HBr(g) \quad \Delta H° = -73\ kJ$

Predict the effect that each of the following changes would have on the value of K_p and the equilibrium number of moles of Br_2. Your choices are **I**ncrease from the current value, **D**ecrease from the current value, or **N**ot **C**hange from the current value. Assume that each change is carried out on a fresh system that is at equilibrium before the change is made to it, and that for all changes not involving heat the system is held at a constant temperature.

	Effect on					
	Br_2			K_p		
Heat the reaction mixture	(I)	D	NC	I	(D)	NC
Add some $AgNO_3$ (reacts with HBr)	I	(D)	NC	I	D	(NC)
Add some helium	I	D	(NC)	I	D	(NC)
Decrease the volume of the reaction vessel	(I)	D	NC	I	D	(NC)

5) **[2 marks]** Given the following reactions and their equilibrium constants ("X" is a complex compound):

$Cu_3(PO_4)_2(s) \rightleftharpoons 3Cu^{+2}(aq) + 2PO_4^{-3}(aq) \qquad K_{sp} = 1.40 \times 10^{-37}$

$Cu^{+2}(aq) + 2X(aq) \rightleftharpoons [CuX_2]^{+2}(aq) \qquad K_f = 3.5 \times 10^{19}$

Calculate K for the equilibrium:

$3[CuX_2]^{+2}(aq) + 2PO_4^{-3}(aq) \rightleftharpoons Cu_3(PO_4)_2(s) + 6X(aq)$

$3[CuX_2]^{+2} \rightleftharpoons 3Cu^{+2} + 6X \qquad K_1 = \left(\frac{1}{3.5 \times 10^{19}}\right)^3$

$3Cu^{+2} + 2PO_4^{-3} \rightleftharpoons Cu_3(PO_4)_2 \qquad K_2 = \frac{1}{1.4 \times 10^{-37}}$

$3[CuX_2]^{+2} + 2PO_4^{-3} \rightleftharpoons Cu_3(PO_4)_2 + 6X \qquad K = K_1 \cdot K_2$

$= \boxed{1.67 \times 10^{-22}}$

6) **[2 marks]** How many grams of NaCl (58.44 g/mol) must be added to 100 g of water (K_f = 1.86 °C/molal) to lower the freezing point of the solution by 1.00 °C relative to pure water?

$1°C = 2 \cdot 1.86 °C/m \cdot m$

$\Rightarrow m = 0.2688 \frac{\text{moles}}{\text{kg}}$

So moles $= 0.2688 \frac{\text{moles}}{\text{kg}} \times 0.1\ \text{kg} = 0.02688$

$\therefore$ mass $= 58.44 \frac{\text{g}}{\text{mol}} \times 0.02688\ \text{moles} =$ **1.571 g**

7) **[3 marks total]** For the reaction

$H_2(g) + Br_2(l) \rightleftharpoons 2HBr(g) \quad \Delta H° = -73\ kJ$

a) **[1 mark]** The relationship between K_p and K_c at 25°C for this reaction is approximately:

i) $K_p = 2.1K_c$
ii) $K_c = 2.1K_p$
iii) $K_p = 2500\ K_c$
iv) $K_c = 2500\ K_p$
v) None of these

b) **[2 marks]** The relationship between $K_{p,300}$ and $K_{p,600}$ is:

i) $K_{p,600} = 4.4 \times 10^{-7}\ K_{p,300}$
ii) $K_{p,300} = 4.4 \times 10^{-7}\ K_{p,600}$
iii) $K_{p,600} = 9.9 \times 10^{-1}\ K_{p,300}$
iv) $K_{p,300} = 9.9 \times 10^{-1}\ K_{p,600}$
v) None of these

8) **[4 marks total]** One of the processes that is responsible for the erosion of the ozone layer is the reaction of ozone (O_3) with atomic chlorine (Cl·):

$O_3(g) + Cl\cdot(g) \rightleftharpoons O_2(g) + OCl\cdot(g)$ $\quad K_{c,3800} = 4.9 \times 10^3$

If you charge a 1-litre flask with 0.50 moles each of O_3 and Cl·, and 1 mole each of O_2 and OCl· :

a) **[1 mark]** In which direction (if any) will the reaction shift in order to establish equilibrium? How do you know?

$Q = \frac{1 \cdot 1}{0,5 \times 0,5} = 4$ $\quad Q < K_c$, rxn $\longrightarrow$ to make more.

b) **[3 marks]** What will be the equilibrium concentrations of all species?

	O_3	+ Cl	$\rightleftharpoons$	O_2	+ OCl
i	0.5	0.5		1	1
c	$-x$	$-x$		$+x$	$+x$
e	$0.5-x$	$0.5-x$		$1+x$	$1+y$

$\frac{(1+x)^2}{(0.5-x)^2} = 4900 \rightarrow \frac{1+x}{0.5-x} = 70$

$1+x = 35-70x$

$71x = 34$

$x = \frac{34}{71}$

$[Cl\cdot]_e = [O_3]_e = 0.5 - x$

$= \frac{3}{142}$ M

$(\sim 0.0211$M$)$

$[O_2]_e = [OCl\cdot]_e = 1 + x$

$= \frac{105}{71}$ M

$(\sim 1.479$M$)$

9) **[3 marks]** Methane (CH_4) may be made to exist in equilibrium with its elements:

$CH_4(g) \rightleftharpoons C(s) + 2H_2(g)$ $\quad K_{p,298} = 1.4 \times 10^{-9}$

If a flask is charged with 0.5 atm of CH_4, what will be the equilibrium pressure of H_2?

$CH_4 \rightleftharpoons C + 2H_2$

	CH_4	C	$2H_2$
i	0.5	0	0
c	$-x$		$+2x$
e	$0.5-x$		$2x$

$$\frac{(2x)^2}{0.5-x} = 1.4 \times 10^{-9}$$

$$(2x)^2 = 7 \times 10^{-10}$$

$$2x = P_{H_2,e} = \boxed{2.65 \times 10^{-5}\ atm}$$

10) **[2 marks]** Calculate the molar solubility of barium bromate, $Ba(BrO_3)_2$, for which the K_{sp} is 2.43×10^{-4}.

$MX_2 \rightleftharpoons M^{2+} + 2X^-$

	MX_2	M^{2+}	$2X^-$
i	Let "x" moles dissolve in 1L	0	0
c		$+x$	$+2x$
e		x	$2x$

$$x(2x)^2 = 2.43 \times 10^{-4}$$

$$4x^3 = 2.43 \times 10^{-4}$$

$$\Rightarrow x = \boxed{0.0393\ M}$$