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Chemistry 1105 Spring 2024 Test 2

Thursday, February 29, 2024

Time: 1 hour 50 minutes

Name: ANSWERS

Student #: _____

*This test consists of **six** pages of questions, a page containing the names, symbols, and masses of the elements, and a periodic table. Please ensure that you have a complete test and, if you do not, obtain one from me **immediately**. There are **42** marks available. Good luck!*

1) **[8 marks]** Complete the following table:

Compound Formula	Compound Name
HCl(g)	hydrogen chloride
$H_2S(aq)$	hydrosulphuric acid
HClO	hypochlorous acid
HNO_3	nitric acid
$Fe(OH)_2$	iron(II) hydroxide
$Ca(OH)_2$	calcium hydroxide
ClF_3	chlorine trifluoride
P_2Cl_4	diphosphorus tetrachloride

2) **[10 marks]** Complete and balance the following reactions. Assume a reaction occurs in each case. Give only the molecular equation for each reaction. Be sure to indicate the phases of the products.

a) $Al_2(CO_3)_3(s) \xrightarrow{\Delta} Al_2O_3(s) + 3CO_2(g)$

b) $H_2O(l) + CO_2(g) \xrightarrow[\text{pressure}]{\text{high}} H_2CO_3(aq)$

c) $Ca(s) + O_2(g) \longrightarrow$

$$2Ca(s) + O_2(g) \longrightarrow 2CaO(s)$$

d) $C_9H_{20}O(s) + O_2(g) \longrightarrow$

$$2C_9H_{20}O(s) + 27O_2(g) \rightarrow 18CO_2(g) + 20H_2O(l)$$

e) $Al(s) + H_2SO_4(aq) \longrightarrow$

$$2Al(s) + 3H_2SO_4(aq) \longrightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$$

f) $HCl(aq) + Al_2(CO_3)_3(s) \longrightarrow$

$$6HCl(aq) + Al_2(CO_3)_3(s) \longrightarrow 2AlCl_3(aq) + 3H_2O(l) + 3CO_2(g)$$

3) **[3 marks]** Given the following balanced molecular equation:

$2HCl(aq) + CaF_2(s) \longrightarrow CaCl_2(aq) + 2HF(aq)$

a) Give the full ionic equation.

$2H^+(aq) + 2Cl^-(aq) + CaF_2(s) \rightarrow Ca^{2+}(aq) + 2Cl^-(aq) + 2HF(aq)$

b) Identify any spectator ions.

Cl^-

c) Give the net ionic equation.

$2H^+(aq) + CaF_2(s) \rightarrow Ca^{2+}(aq) + 2HF(aq)$

4) **[3 marks]** A 25.00-mL aliquot of H_2SO_4 required 12.50 mL of 0.08000 M NaOH for titration:

$2NaOH(aq) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O(l)$

What was the concentration of the original H_2SO_4 solution?

$$\frac{12.50 \times 10^{-3}\,\text{L} \times 0.08\,\frac{\text{moles NaOH}}{\text{L}} \times \frac{1\,H_2SO_4}{2\,NaOH}}{25.00 \times 10^{-3}\,\text{L}} = \boxed{0.02\,M}$$

5) **[3 marks]** In one experiment, 398.6 mg of MCl_3 (where M is a mystery element) was reacted with excess $AgNO_3$:

$MCl_3(aq) + 3AgNO_3(aq) \longrightarrow 3AgCl(s) + M(NO_3)_3(aq)$

A total of 1285.3 mg of AgCl (143.321 g/mol) was collected. What is the mystery element, M?

$$1285.3\times10^{-3}\,g\,AgCl \times \frac{1\,mol}{143.321\,g} \times \frac{1\,MCl_3}{3\,AgCl} = 2.989\times10^{-3}\,mol\ MCl_3$$

$$\frac{398.6\times10^{-3}\,g}{2.989\times10^{-3}\,mol} = 133.341\ldots\,\frac{g}{mol}$$

$$= M + 3\times35.453$$

$$\Rightarrow M = 26.982 \equiv \boxed{Al}$$

6) **[3 marks]** A 7.4551-gram sample of KCl (74.551 g/mol) was dissolved in enough water to make 100.0 mL of solution **A**. A 10.00 mL aliquot of solution **A** was taken and diluted to 250.0 mL to form solution **B**. What are the concentrations of solutions **A** and **B**?

$$7.4551\,g \times \frac{1\,mol}{74.551\,g} = 0.1\ moles$$

$$[A] = \frac{0.1\ moles}{100\times10^{-3}\,L} = \boxed{1\,M}$$

$$\frac{1\,\frac{moles}{L}\,KCl \times 0.01\,L}{250\times10^{-3}\,L} = \boxed{0.04\,M = [B]}$$

7) **[3 marks]** Calculate the percent by mass of Na_2SO_4 (142.041 g/mol) in a solution that has a density of 1.0905 g/mL and a concentration of Na_2SO_4 of 0.76774 M.

Assume 1000 mL sample size

then: $1000\,mL \times 1.0905 \frac{g}{mL} = 1090.5\,g$

$0.76774\ moles \times 142.041 \frac{g}{mol} = 109.05\ldots g$

$\frac{109.05g}{1090.5g} \times 100\% = \boxed{10\%}$

8) **[3 marks]** Calculate the percent by mass of each element in $Al_2(SO_4)_3$.

$2 \times 26.982 = 53.964$

$3 \times 32.065 = 96.195$

$12 \times 15.999 = 191.988$

342.147

Al: $\frac{53.964}{342.147} \times 100 = 15.772\%$

S: $\frac{96.195}{342.147} \times 100 = 28.115\%$

O: $\frac{191.988}{342.147} \times 100 = 56.113\%$

9) **[6 marks]** Ibuprofen is 75.6935 percent carbon, 8.7948 percent hydrogen, and the rest oxygen, all by mass.

a) What is the empirical formula of ibuprofen?

$\%O = 100 - 75.6935 - 8.7948 = 15.5117$

assume 100 g sample...

$75.6935\ g\ C \times \frac{1\ mol}{12.011\ g} = 6.302...\ mol\ C$

$8.7948\ g\ H \times \frac{1\ mol}{1.0079\ g} = 8.725...\ mol\ H$

$15.5117\ g\ O \times \frac{1\ mol}{15.999\ g} = 0.969...\ mol\ O$

$C_{6.302}H_{8.725}O_{0.969}$

$\Downarrow$

$C_{6.5}H_9O$

$\Downarrow$

$\boxed{C_{13}H_{18}O_2}$

b) A 313-mg sample of ibuprofen requires 801.1 mg of oxygen for complete combustion, according to the balanced reaction:

2 ibuprofen + 33 O_2 ⟶ products

What is the molecular formula of ibuprofen?

$801.1 \times 10^{-3}\ g\ O_2 \times \frac{1\ mol}{31.998\ g} \times \frac{2\ Ibu}{33\ O_2} = 1.517 \times 10^{-3}\ mol\ Ibu.$

$\frac{313 \times 10^{-3}\ g}{1.517 \times 10^{-3}\ mol} = 206.283...\ \frac{g}{mol}$

13×12.011
$+ 18 \times 1.0079$
$+ 2 \times 15.999$
206.2832

$n = \frac{206.283...}{206.2832} \simeq 1$, so

$\boxed{C_{13}H_{18}O_2}$