Midterm 1 October 16, 2018

The time limit for this test is 50 minutes.

Numerical answers must be given with appropriate units and significant figures. Please place all answers in the space provided for the question. IF more space is required write on the back of the question sheet and indicate this in the answer space.

There are seven questions worth ***a total of 39 marks****. If more than one answer is given only the first answer will be graded unless you indicate otherwise.*
Data tables are supplied separately. DO NOT WRITE ON THESE. Hand them in with your exam.

This examination should be written in non-erasable INK
Exams that have been altered by erasures or white out may be ineligible for appeal of grades at the discretion of the professors.

Question 1	9 /9
Question 2	2 /3
Question 3	5 /5
Question 4	3.5 /6
Question 5	5 /5
Question 6	6 /6
Question 7	0 /5
TOTAL	30.5 /39

1. Consider the following precipitation reaction. [9 marks]

(9)

$$2\ Na_3PO_4(\underline{aq}) + 3\ CuCl_2(\underline{aq}) \longrightarrow Cu_3(PO_4)_2(\underline{s}) + 6\ NaCl(\underline{aq})$$

M/g mol^{-1}	163.94	134.45	~~350.58~~ 380.58	58.44

a) Identify the phases (s, l g, aq) of all species present in the spaces provided above. 1 /1

b) Write the net ionic equation for this reaction. 2/2

$6Na^+_{(aq)} + 2PO_4^{3-}{}_{(aq)} + 3Cu^{2+}_{(aq)} + 6Cl^-_{(aq)} \rightarrow Cu_3(PO_4)_{2(s)} + 6Na^+_{(aq)} + 6Cl^-_{(aq)}$

$2PO_4^{3-}{}_{(aq)} + 3Cu^{2+}_{(aq)} \rightarrow Cu_3(PO_4)_{2(s)}$ ✓

c) What volume of a 0.1050 mol L^{-1} Na_3PO_4 solution is necessary to completely react with 96.20 mL of 0.1154 mol L^{-1} $CuCl_2$? 3 /3

$V = 0.0962L$
$c = 0.1154M$
$c = \frac{n}{V}$
$cV = n$
$(0.0962L)(0.1154) = n$
$n = 0.01110mol$
$n = \frac{0.01110mol}{3}$
$n = 0.003700mol \times 2$ ✓

$V = ?$
$c = 0.1050M$
$n = 0.007400mol$
$c = \frac{n}{V}$
$V = \frac{n}{c}$
$V = 0.07048L$

d) What is the theoretical yield in grams of the precipitated product? 2 /2

$n_{Cu_3(PO_4)_2} = ?$
$n = 0.00740mol$
$n = 0.00370mol$
$n = \frac{m}{M}$ ✓
$m = n \times M$
$m = 1.408g$

$m = ?$
$M = 380.5869\ g/mol$

e) If 1.28 g of dried precipitate is obtained, what is the percentage yield of the precipitation. 1/1

$\%yield = \frac{Actual}{Theo.} \times 100\% = \frac{1.28g}{1.408g} \times 100$ ✓
$= 90.91\%$

2

2. Name the following compounds: [6 marks]

a) $SiCl_4$ Silicon Tetrachloride ✓

b) H_2CO_3 dihydrogen carbonate ✓

c) HNO_2 hydrogen nitrite ✗

HNO_3 → Nitrous Acid ~~Carbonic Acid~~ 2

3. A 28.4 g wafer of pure gold, initially at 100.0 °C, is submerged into 64.2 g of water at 24.8 °C, in an insulated container. What is the final temperature of both substances at thermal equilibrium? The specific heat capacity of gold is 0.129 J g^{-1} °C^{-1}. [5 marks]

$m = 28.4g$ $T_i = 100°C$

$q_{water} = -q_{water}$

$mC\Delta T = -m_1\Delta T$ ✓

$(28.4g)(0.129)(T_f - 100.0) = -(64.2g)(4.184)(T_f - 24.8°C)$

$3.6636(T_f - 100.0) = -(268.6128)(T_f - 24.8)$

$3.6636T_f - 366.36 = -268.6128T_f + 6661.597$

$272.2764T_f = 7027.957$

$T_f = 25.81°C$ ✓

4. Identify the products of the following reaction and balance the equations. Clearly identify the type of each reaction. Use total ionic equations of products for clarity. Subsequent reactions may occur, if so, identify both. If no reaction, say so. [6 marks]

a) $(NH_4)_2SO_4\,(aq) + SrCl_2\,(aq) \longrightarrow 2(NH_4)Cl_{(aq)} + Sr(SO_4)_{(s)}$

Precipitation Rxn

b) $Pb(C_2H_3O_2)_2\,(aq) + 2HCl\,(aq) \longrightarrow PbCl_{2(s)} + 2(C_2H_3O_2)_{(aq)} + 2H_2O_{(l)}$

3.5

-0.5 wrong product
-2 second rxn.

Precipitation Rxn

5. A piece of dry ice (solid carbon dioxide) with a mass of 28.8 g sublimes (converts from solid to gas) into a large balloon. Assuming that all of the carbon dioxide ends up in the balloon, what is the volume of the balloon at a temperature of 22 °C and a pressure of 989 mbar? [5 marks]

$CO_{2(s)} \rightarrow CO_{2(g)}$

$m = 28.8g$

$M = 44.01 g/mol$

$P = 989 mBar = 0.989 Bar$

$T° = 22°C = 295K$

$n = \frac{m}{M}$

$n = \frac{28.8g}{44.01 g/mol}$

$n = 0.6543 mol$

$PV = nRT$

$(0.989)(V) = (0.6548 mol)(0.08314)(295)$

$V = 16.22 L$

$V = 16.2 L$

$V = 16 L$

5

6. Balance the following redox reaction in acidic solution: 6 [6 marks]

$$SO_2\,(g) + Cr_2O_7^{2-}(aq) \longrightarrow SO_4^{2-}\,(aq) + Cr^{3+}\,(aq)$$

① $2H_2O_{(l)} + SO_{2(g)} \rightarrow SO_4^{2-}{}_{(aq)} + 4H^+_{(aq)} + 2e^-$) ×3

② $14H^+_{(aq)} + Cr_2O_7^{2-}{}_{(aq)} + 6e^- \rightarrow 2Cr^{3+}{}_{(aq)} + 7H_2O_{(l)}$

① $6H_2O_{(l)} + 3SO_{2(g)} \rightarrow 3SO_4^{2-}{}_{(aq)} + 12H^+_{(aq)} + 6e^-$

Finaleqn:

$\therefore\ 2H^+_{(aq)} + Cr_2O_7^{2-}{}_{(aq)} + 3SO_{2(g)} \rightarrow 2Cr^{3+}{}_{(aq)} + 3SO_4^{2-}{}_{(aq)} + H_2O_{(l)}$

WORK:

① $2H_2O_{(l)} + SO_{2(g)} \rightarrow SO_4^{2-}{}_{(aq)} + 4H^+_{(aq)}$

② $14H^+_{(aq)} + Cr_2O_7^{2-}{}_{(aq)} \rightarrow 2Cr^{3+}{}_{(aq)} + 7H_2O_{(l)}$

7. Use the following thermochemical equations to calculate the standard enthalpy change for the formation of methanol (CH_3OH). [5 marks]

(I) $H_2\,(g) + \frac{1}{2}\,O_2\,(g) \longrightarrow H_2O\,(l)$ $\quad \Delta_r H° = -286$ kJ/mol

(II) $C\,(\text{graphite}) + O_2\,(g) \longrightarrow CO_2\,(g)$ $\quad \Delta_r H° = --394$ kJ/mol

(III) $CH_3OH\,(l) + \frac{3}{2}\,O_2\,(g) \longrightarrow CO_2\,(g) + 2\,H_2O\,(l)$ $\quad \Delta_r H° = -187.8$ kJ/mol

$\Delta H_{CH_3OH} = x$?

$\Delta H_{rxn} = \Sigma \Delta H_f (\text{Products}) - \Sigma \Delta H (\text{reactants})$

$\Delta H_{rxn} = (\Delta H_{H_2O(l)} + \Delta H_{CO_2(g)}) - (\Delta H_{O_2(g)} + x)$ X

$-187.8 \frac{kJ}{mol} = [2(-286) + (-394)] - [x \quad -680]$

$-187.8 = (-572 - 394 \quad -x + \frac{3}{2}(680))$

$-187.8 = \quad -572 - 394 - x + 1020$ X

$-241.8 \frac{kJ}{mol} = -x$

X $\quad \frac{241.8\,kJ}{mol} = x = \Delta H_{CH_3OH(l)}$

Use Hess' Law