AP Exam Review 2020 Practice Exam #5

This exam has two parts. The first part should take you 25 minutes to complete. The second part will take 15 minutes. Do the first question setting a timer for 25 minutes. Upon either completion of the question or the end of time, take a five minute break. Reset the timer for 15 minutes and begin the second question. Stop working when the timer goes off or you finish the question. Upload your work when completed.

Problem 1

Many metals react with dilute sulfuric acid to produce hydrogen gas and a soluble metal sulfate. The reaction of magnesium metal with sulfuric acid is shown.

$Mg\ (s) + H_2SO_4\ (aq) \rightarrow MgSO_4\ (aq) + H_2\ (g)$

a) Write the net ionic reaction equation given the above overall reaction.
b) Write the complete electron configuration for magnesium and clearly identify the electron(s) that will be lost when the magnesium ion forms in the reaction.
c) Is the radius of the magnesium atom larger, smaller, or the same as, the radius of the magnesium ion? Explain.

A 0.0200 gram piece of unknown alkaline earth metal, M, is reacted with excess 0.500 M H_2SO_4, and the hydrogen gas produced is collected over water. The total gas pressure inside the collecting tube is 1.01 atm., the temperature 24.0°C. The volume of gas collected is 19.6 mL. The gas in the tube contains water vapor, at a pressure of 0.029 atm.

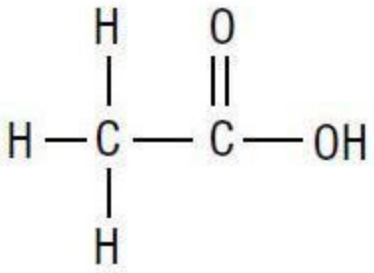
$M\ (s) + H_2SO_4\ (aq) \rightarrow MSO_4\ (aq) + H_2\ (g)$

d) What is the partial pressure of the dry hydrogen gas collected in the tube?
e) How many moles of hydrogen gas were collected?
f) Use the data from the problem and calculate the molar mass of the unknown metal.
g) Metal M has an actual molar mass of 24.3g/mole.
    i) Calculate the % error in the experimental molar mass.
    ii) Would failing to remove the oxide coating on the metal piece explain disagreement of the experimental and actual molar mass? Explain.
h) The reaction is exothermic, so that the final temperature of the gas may actually be greater than the recorded temperature of 24° C. How would that higher temperature affect the calculated molar mass, if 24° C is still used in the calculations?

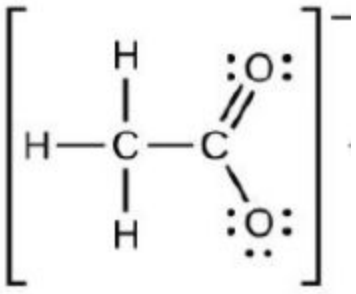
Problem 2

In a different experiment, the alkaline unknown metal, M, is added to excess 0.500 M acetic acid, $HC_2H_3O_2$. It is observed that the reaction is too slow to be feasible. The excess acetic acid, however, will react with sufficient 1.0 M Na_2CO_3 solution, neutralizing the acid producing CO_2 in this case.

a) Write the net ionic equation describing the reaction of Na_2CO_3 (aq) and the $HC_2H_3O_2$ (aq).
b) Determine the volume in ml, of 1.0 M Na_2CO_3 solution required to neutralize 100.0 ml of 0.50 M $HC_2H_3O_2$.
c) Explain the much slower rate of the reaction of the metal and the acetic acid.
d) Given the structure of acetic acid and the acetate ion shown below, explain why the C to O bond lengths in the acid are of two distinct lengths and they are the same length in the ion.



acetic acid



acetate ion

Acetic acid reacts with water according to:

$HC_2H_3O_2$ (aq) + H_2O (l) ⇄ H_3O^+ (aq) + $C_2H_3O_2^-$ (aq) $\quad K_a = 1.8 \times 10^{-5}$

e) Identify a conjugate acid-base pair in the reaction above.
f) What would happen to $[H_3O^+]$ if additional $C_2H_3O_2^-$ is added to a system at equilibrium? Explain.

Practice Examine #5

1

a) $Mg_{(s)} + 2H^+_{(aq)} \rightarrow Mg^{2+}_{(aq)} + H_{2(g)}$

b) $1s^2 2s^2 2p^6 (3s^2)$ lost to form Mg^{2+}

c) Mg has the larger radius as it has 3 layers of e^- and Mg^{2+} only has 2. Also, the $\#e^-/\#p^+$ ratio in Mg^{2+} is lower resulting in a greater net attraction of e^- for p^+ and a smaller radius.

d) $P_{H_2} = P_T - P_{H_2O}$
$= 1.01\,atm - 0.029\,atm$
$= 0.98\,atm$

e) $n_{H_2} = \frac{PV}{RT} = \frac{(0.98)(0.0196)}{(0.0821)(297)}$
$= 0.000788\,mole$

f) $0.000788\,mole\,H_2 \cdot \frac{1\,mole\,Mg}{1\,mole\,H_2} = 0.000788\,mole\,Mg$

$M.\,mass = \frac{0.0200g}{0.000788\,mole} = 25.4\,g/mole$

g)

i) % error = $\frac{25.4g - 24.3g}{24.3g} \cdot 100$

= 4.5%

ii) Yes, failing to remove the oxide coating would result in a larger apparent mass of the metal and less H_2 produced, lowering moles. Since:

$$M_{mass} = \frac{mass}{moles}$$

if mass ↑ and moles ↓ then the calculated molar mass will be too large.

h) The volume of H_2 collected would be too large if it is warmer. Too large a volume results in a larger # of moles. Mass does not change so since

$$M_{mass} = \frac{Mass}{moles}$$

the calculated molar mass would be too small / larger as you're dividing by a larger value.

2)

a) $2HC_2H_3O_2(aq) + CO_3^{2-}(aq) \rightarrow CO_2(g) + H_2O(l) + 2C_2H_3O_2^-(aq)$

b) $0.1000\,L\ HC_2H_3O_2 \cdot \frac{0.500\ mols\ HC_2H_3O_2}{L} \cdot \frac{1\ mole\ Na_2CO_3}{2\ moles\ HC_2H_3O_2}$

$\cdot \frac{1\ L\ Na_2CO_3}{1.0\ mole\ Na_2CO_3} = 0.025\,L$

25mL Na_2CO_3 reacts

c) Acetic acid is a weak acid so it is much less reactive than a strong acid such as sulfuric. This is because H_2SO_4 dissociates 100% in water while $HC_2H_3O_2$ does not

d) The ion has two resonance structures which averages the C to O bonds as 1.5 bonds. The acid does not have resonance so the C to O bonds are distinct as C–O and C=O.

e) $HC_2H_3O_2 \longrightarrow C_2H_3O_2^-$
acid base

OR

$H_2O \longrightarrow H_3O^+$
base acid

f) The reaction would shift to reactants, using up H_3O^+ causing $[H_3O^+]$ to go down.