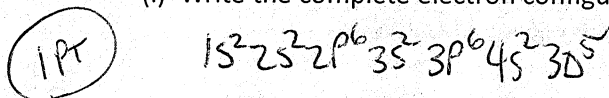


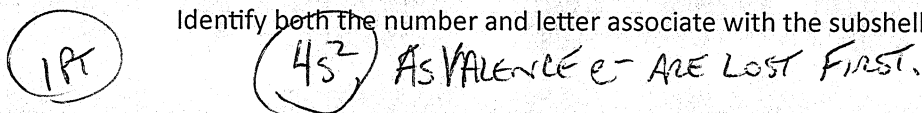
1. Answer the following questions related to manganese compounds.

a) Manganese has several common oxidation states.

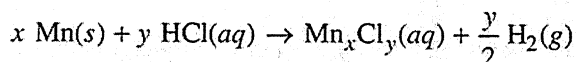
(i) Write the complete electron configuration for an Mn atom in the ground state.



(ii) When manganese forms cations, electrons are lost from which subshell first? Identify both the number and letter associated with the subshell.



A student performs an experiment to produce a manganese salt of unknown composition, $Mn_xCl_y(aq)$, and determine its empirical formula. The student places a sample of $Mn(s)$ in a beaker containing excess $HCl(aq)$, as represented by the following equation.



The student heats the resulting mixture until only $Mn_xCl_{y(s)}$ remains in the beaker. The data are given in the following table.

Mass of empty beaker	60.169 g
Mass of beaker and $Mn(s)$	61.262 g
Mass of beaker and Mn_xCl_y after heating to constant mass	62.673 g

b) Calculate the mass of Cl in the sample of $Mn_xCl_{y(s)}$ remaining in the beaker.

$$\text{MASS } Mn_xCl_y = \underset{\text{BOTH}}{62.673} - \underset{\text{BEAKER}}{60.169} = 2.504g \text{ } Mn_xCl_y$$

$$\text{MASS Cl} = 2.504g - 1.093g$$

$$\text{MASS Mn} = \underset{\text{BOTH}}{61.262} - \underset{\text{BEAKER}}{60.169} = 1.093g \text{ Mn}$$

$$= 1.411g \text{ Cl}$$

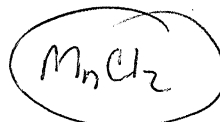
c) Calculate the number of moles of Cl in the sample of $Mn_xCl_{y(s)}$ remaining in the beaker.

$$\frac{1.411g \text{ Cl}}{35.45g \text{ Cl}} = 0.3980 \text{ mol Cl} \quad (1 \text{ PT})$$

d) The student determines that 0.0199 mol of Mn was used in the experiment. Use the data to determine the empirical formula of the $Mn_xCl_{y(s)}$.

$$\frac{0.0199 \text{ mol Mn}}{0.0199} = 1$$

$$\frac{0.03980 \text{ mol Cl}}{0.0199} = 2$$

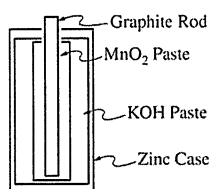


1 PT

e) The student repeats the experiment using the same amounts of Mn and HCl and notices that some of the Mn_xCl_y splatters out of the beaker as it is heated to dryness. Will the number of moles of Cl calculated for this trial be greater than, less than, or equal to the number calculated in part c)? Justify your answer.

1 Pt
SINCE THE WEIGHED MASS OF Mn_xCl_y WILL BE LESS THAN WHAT IT SHOULD HAVE BEEN AND WE USE THAT DATA TO DETERMINE THE MASS, THEN MOLES OF Cl, THE MASS (AND MOLES) OF Cl WILL ALSO BE LESS THAN WHAT WAS CALCULATED IN c).

f) Another compound of manganese, MnO_2 , is used in alkaline batteries, represented by the following diagram. Some half-reactions are given in the table.



Reduction Half-Reaction	E° (V)
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	-0.76
$ZnO(s) + H_2O(l) + 2e^- \rightarrow Zn(s) + 2OH^-(aq)$	-1.28
$2MnO_2(s) + H_2O(l) + 2e^- \rightarrow Mn_2O_3(s) + 2OH^-(aq)$	0.15

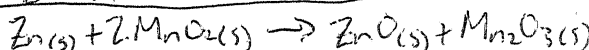
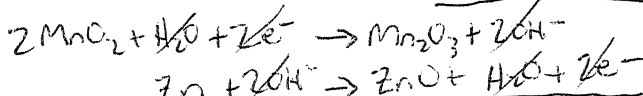
0.15 0 -0.76 -1 -1.28

LARGEST DIFFERENCE IS BETWEEN 0.15 + -1.28

(i) Based on the half-reactions given in the table, write the balanced net ionic equation for the reaction that has the greatest thermodynamic favorability. → LARGEST E_{cell} , SO! THEN

CALCULATE E_{cell} TO FIND WHICH IS CATHODE & WHICH IS ANODE. CATHODE STAYS THE SAME, WE FLIP THE ANODE "FLIP A NODE"

CATHODE STAYS SAME →
ANODE GETS FLIPPED BECAUSE IT IS OXIDATION →



(ii) Calculate the value of E_{cell} for the overall reaction.

$E_{cell} = E_{cathode} - E_{anode}$

* E_{cell} MUST BE POSITIVE, SO ONLY WAY TO MAKE IT WORK IS: $E_{cell} = (+0.15V) - (-1.28V) = +1.43V$

(iii) Calculate the value of ΔG° in kJ/mol_{rxn}.

$\Delta G = -nFE$

$\Delta G = -(2e^-)(96,485 \frac{Coulombs}{mole \cdot e^-})(1.43 \frac{Joules}{Coulomb})$

↑ WE CANCELLED OUT $2e^-$ ABOVE

↑ E_{cell} FROM (ii) ABOVE

$= -276,000 \frac{J}{mole} = -276 \frac{kJ}{mole}$

(iv) A student claims that the total mass of an alkaline battery decreases as the battery operates because the anode loses mass. Do you agree with the student's claim? Justify your answer.

1 Pt
NO, BECAUSE AS THE ANODE LOSES MASS, THE CATHODE WILL BE GAINING THAT MASS. THE LAW OF CONSERVATION OF MASS STATES THAT MASS WILL BE CONSERVED WITHIN A CHEMICAL REACTION.