Hydrogen gas burns in air according to the equation: 2 H2(*g*) + O2(*g*) → 2 H2O(*l*)

a) Calculate the standard enthalpy change, Δ*Ho*298 , for the reaction represented by the equation above.

(The molar enthalpy of formation, Δ*Hof* , for H2O(*l*) is −285.8 kJ mol−1 at 298 K.) *(1pt)*

b) Calculate the amount of heat, in kJ, that is released when 10.0 g of H2(*g*) is burned in air. *(2pts)*

c) Given that the molar enthalpy of vaporization, Δ*Hovap*, for H2O(*l*) is 44.0 kJ mol−1 at 298 K, what is the standard enthalpy change, Δ*Ho*298 , for the reaction 2 H2(*g*) + O2(*g*) → 2 H2O(*g*) ? *(1pt)*

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| --- | --- |
| Half-reaction | *E*o (298 K) |
| 2 H2O(*l*) + O2(*g*) + 4 *e*− → 4 OH−(*aq*) | 0.40 V |
| 2 H2O(*l*) + 2 *e*− → H2(*g*) + 2 OH−(*aq*) | − 0.83 V |

A fuel cell is an electrochemical cell that converts the chemical energy stored in a fuel into electrical energy. A cell that uses H2 as the fuel can be constructed based on the following half-reactions.

d) Write the equation for the overall cell reaction. *(1pt) Show how the 2 “half-rxns add to produce the overall rxn and potential.*

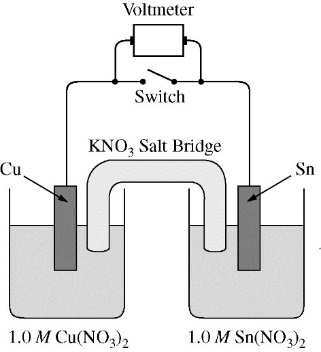
e) Calculate the potential E (the conditions are not STANDARD) for the cell at 298 K. *(1pt)*

f) Assume that 0.93 mol of H2(*g*) is consumed as the cell operates for 600. seconds.

i) Calculate the number of moles of electrons that pass through the cell. *(1pt)*

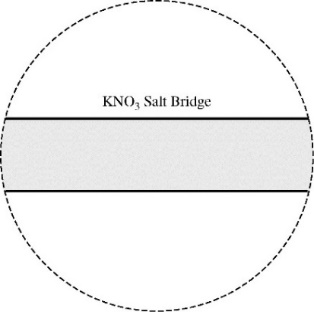
ii) Calculate the average current, in amperes, that passes through the cell. *(2pts)* *Hint: I =q/t (from reference sheet)*

g) Some fuel cells use butane gas, C4H10, rather than hydrogen gas. The overall reaction that occurs in a butane fuel cell is 2 C4H10(*g*) + 13 O2(*g*) → 8 CO2(*g*) + 10 H2O(*l*). What is one environmental advantage of using fuel cells that are based on hydrogen rather than on hydrocarbons such as butane?  *(1pt)*

A student is given a standard galvanic cell, shown here, that has a Cu electrode and a Sn electrode. As current flows through the cell, the student determines that the Cu electrode increases in mass and the Sn electrode decreases in mass.

a) Identify the electrode at which oxidation is occurring. Explain your reasoning based on the student’s observations. *(1pt)*

b) As the mass of the Sn electrode decreases, where does the mass go? *(1pt)*

 c) In the expanded view of the center portion of the salt bridge, draw and label a particle view of what occurs in the salt bridge as the cell begins to operate. Omit solvent molecules and use arrows to show the movement of particles. *(2pts)*

d) A nonstandard cell is made by replacing the 1.0 *M* solutions of Cu(NO3)2 and Sn(NO3)2 in the standard cell with 0.50 *M* solutions of Cu(NO3)2 and Sn(NO3)2. The volumes of solutions in the nonstandard cell are identical to those in the standard cell.

i) Is the cell potential of the nonstandard cell greater than, less than, or equal to the cell potential of the standard cell? Justify your answer. *(1pt)*

ii) Both the standard and nonstandard cells can be used to power an electronic device. Would the nonstandard cell power the device for the same time, a longer time, or a shorter time as compared with the standard cell? Justify your answer. *(1pt)*

|  |  |
| --- | --- |
| Half-Reaction | *E*° (V) |
| Cu+ + *e*− → Cu(*s*) | 0.52 |
| Cu2+ + 2 *e*− → Cu(*s*) | 0.34 |
| Sn4+ + 2 *e*− → Sn2+ | 0.15 |
| Sn2+ + 2 *e*− → Sn(*s*) | −0.14 |

e) In another experiment, the student places a new Sn electrode into a fresh solution of 1.0 *M* Cu(NO3)2.

i) Using information from the table, write a net-ionic equation for the reaction between the Sn electrode and the Cu(NO3)2 solution that would be thermodynamically favorable. Justify that the reaction is thermodynamically favorable. *(2pts) (calculate Eo)*

ii) Calculate the value of ∆*G*°*(include units)* and *Keq* for the reaction. *(2-4pts) Explain what Eo,* ∆*G, Keq tell about the rxn.*

A diagram of a voltmeter

AI-generated content may be incorrect.Answer the following questions about electrochemical cells. 2009B #6

It is observed that when silver metal is placed in aqueous thallium(I) fluoride, TlF, no reaction occurs. When the switch is closed in the cell represented above, the voltage reading is +1.14 V.

a) Write the reduction half-reaction that occurs in the cell. *(1pt)*

b) Write the equation for the overall reaction that occurs in the cell. *(1pt)*

c) Identify the anode in the cell. Justify your answer. *(1pt)*

d) On the diagram above, use an arrow to clearly indicate the direction of electron flow as the cell operates. *(1pt)*

e) Calculate the value of the standard reduction potential for the Tl+/Tl half-reaction. *(see table in “f”) (2pts)*

f) Assume that electrodes of pure Pt, Ag, and Ni are available as well as 1.00 *M* solutions of their salts. Three different electrochemical cells can be constructed using these materials. Identify the two metals that when used to make an electrochemical cell would produce the cell with the largest voltage. Explain how you arrived at your answer. *(1pt)*

*Reduction Eo*

Pt2+ + 2 *e*− → Pt 1.20 V

Ni2+ + 2 *e*− → Ni -0.25 V

Ag1+ + *e*− → Ag 0.80 V

g) Predict whether Pt metal will react when it is placed in 1.00 *M* AgNO3(*aq*). Justify your answer. *(2pts)*

In a laboratory experiment, Pb and an unknown metal Q were immersed in solutions containing aqueous ions of unknown metals Q and X. The following reactions summarize the observations. 2012 #6

Observation 1: Pb(*s*) + X2+(*aq*) → Pb2+(*aq*) + X(*s*)

Observation 2: Q(*s*) + X2+(*aq*) → no reaction

Observation 3: Pb(*s*) + Q2+(*aq*) → Pb2+(*aq*) + Q(*s*)

a) On the basis of the reactions indicated above, arrange the three metals, Pb, Q, and X, in order from least

reactive to most reactive on the lines provided. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ , \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ , \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*(1pt)* least reactive metal most reactive metal

A diagram of a salt bridge

AI-generated content may be incorrect.

The diagram below shows an electrochemical cell that is constructed with a Pb electrode immersed in 100. mL of 1.0 *M* Pb(NO3)2(*aq*) and an electrode made of metal X immersed in 100. mL of 1.0 *M* X(NO3)2(*aq*). A salt bridge containing saturated aqueous KNO3 connects the anode compartment to the cathode compartment. The electrodes are connected to an external circuit containing a switch, which is open. When a voltmeter is connected to the circuit as shown, the reading on the voltmeter is 0.47 V. When the switch is closed, electrons flow through the switch from the Pb electrode toward the X electrode.

b) Write the equation for the half-reaction that occurs at the anode. *(1pt)*

c) The value of the standard potential for the cell, *E*°, is 0.47 V.

i) Determine the standard reduction potential for the half-reaction that occurs at the cathode. *(1pt)*

ii) Determine the identity of metal X. \_\_\_\_\_\_\_*(1pt)*  *(use the Table of Standard Reduction Potentials)*

d) Describe what happens to the mass of each electrode as the cell operates. *(1pt)*

e) During a laboratory session, students set up the electrochemical cell shown above. For each of the following three scenarios, choose the correct value of the cell voltage and justify your choice.

i) A student bumps the cell setup, resulting in the salt bridge losing contact with the solution in the cathode compartment. Is V equal to 0.47 or is V equal to 0 ? Justify your choice. *(1pt)*

ii) A student spills a small amount of 0.5 *M* Na2SO4(*aq*) into the compartment with the Pb electrode, resulting in the formation of a precipitate. Is V less than 0.47 or is V greater than 0.47 ? Justify your choice. *(1pt)*

iii) After the laboratory session is over, a student leaves the switch closed. The next day, the student opens the switch and reads the voltmeter. Is V less than 0.47 or is V equal to 0.47 ? Justify your choice. *(1pt)*