

Read questions carefully to understand what is being asked, before answering. No outside paper is allowed. Use the reverse side of your answer paper as scratch. Use the important equation table and periodic table provided. (Total points = 53 + (19x3=)57 = 110).

Show your calculation first with set up equation. Then use the raw data with units in the equation in the equation and then complete the calculation.

- 1) 0.25g of a monobasic acid (MW = 122 g/mol) in 100.00 mL of water is being titrated with 0.15M NaOH solution. What is the pH of the solution at the equivalence point? (K_a of the acid = 6.4×10^{-5}) (8 pts.) 1) _____

- 2) A nonlinear best fit plot of K_{eq} versus Temperature (Kelvin) of tetraborate equilibrium: 2) _____
 $Na_2B_4O_5(OH)_4 \cdot 8H_2O(s) \rightleftharpoons 2 Na^+(aq) + B_4O_5(OH)_4^{2-}(aq) + 8 H_2O(l)$
gives $\Delta H^\circ = 96 \text{ kJ/mol}$ and $\Delta S^\circ = 300 \text{ J/mol}$. From this data calculate the K_{eq} at 25° C .
Show set up, raw data and units. (8 pts.)

3) The following information is available for the reaction at 25°C:

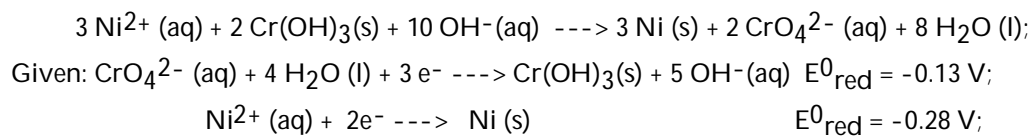
	CaCO_3 (s)	CaO (s)	CO_2 (g)
ΔG_f° (kJ/mol)	-1129.16	-603.42	-394.36
ΔH_f° (kJ/mol)	-1207.6	-635.09	-393.51
S_f° (J/K.mol)	91.7	38.2	213.74

3) _____

(a) Calculate the Gibbs free energy change of the reaction (3pts.) .

(b) Calculate the temperature in °C when the reaction will be favorable (5 pts.).

4) For the cell reaction :

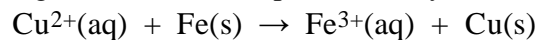


4) _____

(a) Calculate the E^0 at $T = 298 \text{ K}$ (4 pts.)

(b) Calculate the standard free energy change ΔG^0 at $T = 298 \text{ K}$ for the above reaction (5 pts.);

5) The following reaction occurs spontaneously.



Write the balanced **reduction** half-reaction below. (3 pts.)

5) _____

6) A Voltaic cell is made up of two half cells at 298 K: Zn/Zn²⁺ half cell with [Zn²⁺] = 0.010 M and H₂/H⁺ half cell with [H⁺] = 2.5 M and P_{H₂} = 0.30 atm. Given E⁰_{red} for Zn²⁺ + 2e⁻ -> Zn (s) = -0.76 V; (Total = 14 pts.)

6) _____

(1) Determine the cell reaction (with states) from the half cell reactions (2 pts.)

(2) Calculate the E⁰_{cell} (2 pts.)

(3) Calculate the molarity of H₂ (g) given PV = n RT (3 pts.)

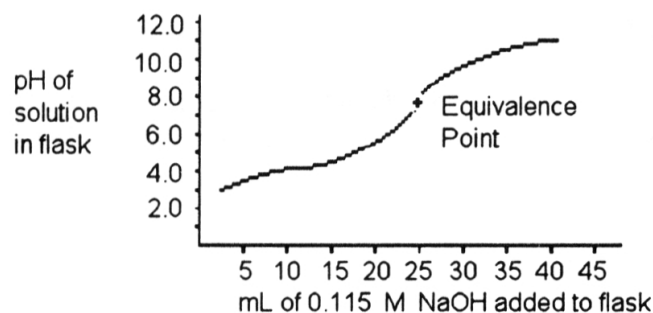
(4) Calculate the Quotient Q for the cell reaction (3 pts.)

(5) Using the above values calculate the E_{cell} using Nernst Eqn. (4 pts.)

7) In the formula $\Delta G = -nFE$, F is the _____ (3 pts.)

7) _____

MULTIPLE CHOICE. On the scantron, select the bubble that has the same number as the question number. Show your work to select the one response that best completes the statement or answers the question (3 pts each).



- 8) A 25.0 mL sample of a solution of an unknown compound is titrated with a 0.115 M NaOH solution. The titration curve above was obtained. The unknown compound is _____.
- A) a weak acid
 B) a strong base
 C) a strong acid
 D) a weak base
 E) neither an acid nor a base
- 8) _____
- 9) For which salt should the aqueous solubility be most sensitive to pH?
- A) $\text{Ca}(\text{NO}_3)_2$ B) CaI_2 C) CaF_2 D) CaBr_2 E) CaCl_2
- 9) _____
- 10) What is the oxidation number of nitrogen in the HNO_3 ?
- A) +1 B) +7 C) +3 D) +5 E) -1
- 10) _____
- 11) Which transformation could take place at the anode of an electrochemical cell?
- A) O_2 to H_2O
 B) $\text{Cr}_2\text{O}_7^{2-} \rightarrow \text{Cr}^{2+}$
 C) HAsO_2 to As
 D) F_2 to F^-
 E) None of the above could take place at the anode.
- 11) _____
- 12) Which transformation could take place at the cathode of an electrochemical cell?
- A) $\text{Mn}^{2+} \rightarrow \text{MnO}_4^-$
 B) $\text{MnO}_2 \rightarrow \text{MnO}_4^-$
 C) $\text{Br}_2 \rightarrow \text{BrO}_3^-$
 D) $\text{HSO}_4^- \rightarrow \text{H}_2\text{SO}_3$
 E) $\text{NO} \rightarrow \text{HNO}_2$
- 12) _____

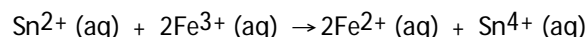
Table 20.2

Half-reaction	E° (V)
$\text{Cr}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Cr}(\text{s})$	-0.74
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.440
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{s})$	+0.771
$\text{Sn}^{4+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Sn}^{2+}(\text{aq})$	+0.154

13) Which of the following reactions will occur spontaneously as written? 13) _____

- A) $3\text{Sn}^{4+}(\text{aq}) + 2\text{Cr}(\text{s}) \rightarrow 2\text{Cr}^{3+}(\text{aq}) + 3\text{Sn}^{2+}(\text{aq})$
 B) $3\text{Fe}(\text{s}) + 2\text{Cr}^{3+}(\text{aq}) \rightarrow 2\text{Cr}(\text{s}) + 3\text{Fe}^{2+}(\text{aq})$
 C) $3\text{Fe}^{2+}(\text{aq}) \rightarrow \text{Fe}(\text{s}) + 2\text{Fe}^{3+}(\text{aq})$
 D) $\text{Sn}^{4+}(\text{aq}) + \text{Fe}^{3+}(\text{aq}) \rightarrow \text{Sn}^{2+}(\text{aq}) + \text{Fe}^{2+}(\text{aq})$
 E) $\text{Sn}^{4+}(\text{aq}) + \text{Fe}^{2+}(\text{aq}) \rightarrow \text{Sn}^{2+}(\text{aq}) + \text{Fe}(\text{s})$

14) The standard cell potential (E°_{cell}) for the voltaic cell based on the reaction below is _____ V. 14) _____

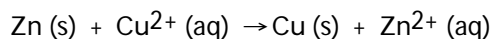


- A) +1.21 B) +0.617 C) +0.46 D) +1.39 E) -0.46

15) The reduction half reaction occurring in the standard hydrogen electrode is _____. 15) _____

- A) $\text{H}_2(\text{g}, 1 \text{ atm}) \rightarrow 2\text{H}^+(\text{aq}, 1\text{M}) + 2\text{e}^-$
 B) $2\text{H}^+(\text{aq}) + 2\text{OH}^- \rightarrow \text{H}_2\text{O}(\text{l})$
 C) $2\text{H}^+(\text{aq}, 1\text{M}) + \text{Cl}_2(\text{aq}) \rightarrow 2\text{HCl}(\text{aq})$
 D) $2\text{H}^+(\text{aq}, 1\text{M}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}, 1 \text{ atm})$
 E) $\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}(\text{l})$

16) The standard cell potential (E°_{cell}) for the reaction below is +1.10 V. The cell potential for this reaction is _____ V when the concentration of $[\text{Cu}^{2+}] = 1.0 \times 10^{-5} \text{ M}$ and $[\text{Zn}^{2+}] = 1.0 \text{ M}$. 16) _____



- A) 0.95 B) 0.80 C) 1.25 D) 1.10 E) 1.40

17) The thermodynamic quantity that expresses the degree of disorder in a system is _____. 17) _____

- A) bond energy
 B) entropy
 C) internal energy
 D) enthalpy
 E) heat flow

18) The normal boiling point of water is 100.0°C and its molar enthalpy of vaporization is 40.67 kJ/mol . What is the change in entropy in the system in J/K when 39.3 grams of steam at 1 atm condenses to a liquid at the normal boiling point? 18) _____

- A) 373 B) 88.8 C) -40.7 D) -88.8 E) -238

- 19) ΔS is positive for the reaction _____.
- A) $2\text{NO}_2(\text{g}) \rightarrow \text{N}_2\text{O}_4(\text{g})$
B) $2\text{Hg}(\text{l}) + \text{O}_2(\text{g}) \rightarrow 2\text{HgO}(\text{s})$
C) $\text{BaF}_2(\text{s}) \rightarrow \text{Ba}^{2+}(\text{aq}) + 2\text{F}^{-}(\text{aq})$
D) $\text{CO}_2(\text{g}) \rightarrow \text{CO}_2(\text{s})$
E) $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g})$
- 19) _____

- 20) Of the following, the entropy of _____ is the largest.
- A) $\text{HCl}(\text{s})$ B) $\text{HCl}(\text{g})$ C) $\text{HCl}(\text{l})$ D) $\text{HBr}(\text{g})$ E) $\text{HI}(\text{g})$
- 20) _____

TRUE/FALSE. Select A in the scantron if the statement is TRUE and B if the statement is FALSE (3 pts).

- 21) The quantity of energy gained by a system equals the quantity of energy gained by its surroundings. T or F
- 22) The more negative ΔG° is for a given reaction, the larger the value of the corresponding equilibrium constant, K . T or F
- 23) The vaporization of a substance at its boiling point is an isothermal process T or F
- 24) The entropy of a pure crystalline substance at 0°C is zero. T or F
- 25) The electrode where reduction occurs is called the anode. T or F
- 26) The standard reduction potential of X is 1.23 V and that of Y is -0.44 V therefore X is oxidized by Y. T or F

MULTIPLE CHOICE. On the scantron, select the bubble that has the same number as the question number. Show your work to select the one response that best completes the statement or answers the question (3 pts each).

- 27) EXTRA POINT QUESTION: _____
- In which one of the following solutions is silver chloride the most soluble?
- A) 0.181 M HCl
B) 0.181 M NaCl
C) 0.744 M LiNO_3
D) pure water
E) 0.0176 M NH_3