Exam 3

# Part 1: Multiple Choice (2 points each)

## Directions: Please circle the *best* answer for each of the following questions.

1. Identify the process that is spontaneous.
   1. Rusting of iron
   2. Electrolysis
   3. Browning of bread
   4. Photosynthesis
   5. Frying an egg
2. Which one of the following has the highest standard molar entropy, S°, at 25 °C?
   1. NaF (s)
   2. NaCl (s)
   3. NaBr (s)
   4. NaI (s)
   5. They all have the same value.
3. Given the following equation: 3 NO (g) → N2O (g) + NO2 (g) ∆G°­rxn = + 23.0 kJ

Calculate ∆G°­rxn for: N2O (g) + NO2 (g) → 3 NO (g)

* 1. -7.67 kJ
  2. 23.0 kJ
  3. -23.0 kJ
  4. 69.0 kJ
  5. -69.0 kJ

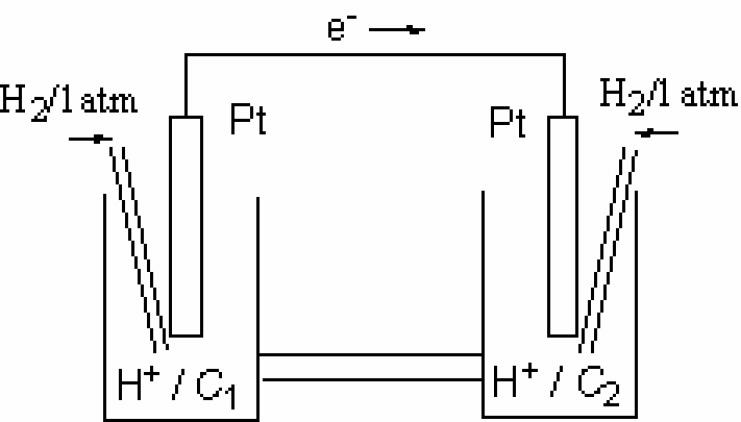
1. Which of the following processes has a ∆S > 0?
   1. SO2 (l) → SO2 (s)
   2. N2 (g) + 3 H2 (g) → 2 NH3 (g)
   3. CH4 (g) + H2O (g) → CO (g) + 3 H2 (g)
   4. K2CO3 (s) + H2O (g) + CO2 (g) → 2 KHCO3 (s)
   5. All of the above
2. Balance the following redox reaction if it occurs in basic solution. What are the coefficients in front of Br2 and OH- in the balanced reaction?
   1. Br2 = 1, OH- = 2
   2. Br2 = 2, OH- = 5
   3. Br2 = 3, OH- = 3
   4. Br2 = 1, OH- = 6
   5. Br2 = 3, OH- = 6
3. Identify the location of oxidation in an electrochemical cell.
   1. The anode
   2. The cathode
   3. The electrode
   4. The salt bridge
   5. The socket
4. Determine the cell notation for the redox reaction given below:

3 Cl2 (g) + 2 Fe (s) → 6 Cl- (aq) + 2 Fe3+ (aq)

1. Cl2 (g) | Cl- (aq) | Pt (s) || Fe (s) | Fe3+ (aq)
2. Cl- (aq) | Cl2 (g) | Pt (s) || Fe3+ (aq) | Fe (s)
3. Fe3+ (aq) | Fe (s) || Cl- (aq) | Cl2 (g) | Pt (s)
4. Fe (s) | Cl2 (g) || Fe3+ (aq) | Cl- (aq) | Pt (s)
5. Fe (s) | Fe3+ (aq) || Cl2 (g) | Cl- (aq) | Pt (s)
6. How many electrons are transferred in the following reaction? (The reaction is unbalanced.)

Ni (s) + Cr3+ (aq) → Cr (s) + Ni2+ (aq)

* 1. 6
  2. 4
  3. 3
  4. 2
  5. 1



1. Which statement about this concentration cell is *correct*?
   1. The electrode on the left side is the anode.
   2. The electrode on the right side is the electron.
   3. Anions in the salt bridge migrate to the right side.
   4. Hydrogen ions are reduced on the left side.
   5. The pH of the solution on the right side is lower than the pH on the left side.
2. It is okay to take off eye protection in chemistry laboratories
3. once you are done using chemicals, even if those around you are still using chemicals.
4. when you are writing notes in a lab notebook and not actively using chemicals.
5. when working at the chemical hood with the safety shield down.
6. if, at the end of the lab, you need to store your goggles in a drawer or locker in the lab and quickly exit the lab.
7. all of the above

# Part 2: Short Answer

## Directions: Answer each of the following questions. Be sure to use complete sentences where appropriate. For full credit be sure to show all of your work.

1. A voltaic cell is set up at 25 °C with the half-cells Al3+(0.0010 M) |Al and Ni2+(0.50 M) |Ni. Write an equation for the reaction that occurs when the cell generates an electric current and determine the cell potential (8 points). Given:

Al3+ (aq) + 3 e- → Al (s) E° = -1.662 V

Ni2+ (aq) + 2 e- → Ni (s) E° = -0.257 V

Oxidation: **(**Al (s) → Al3+ (aq) + 3 e-**) × 2** E° = 1.662 V

Reduction: **(**Ni2+ (aq) + 2 e- → Ni (s)**) × 3** E° = -0.257 V

2 Al (s) 3 Ni2+ (aq) + 6 e- → 2 Al3+ (aq) + 6 e- + 3 Ni2+ (aq) E° = 1.405 V

2 Al (s) 3 Ni2+ (aq) → 2 Al3+ (aq) + 3 Ni2+ (aq)

1. The standard cell potential, E°cell, for the reduction of silver ions with copper metal is +0.462 V at 25 °C. Calculate ∆rG° in kJ for this reaction (6 points).
2. The molar mass of a metal (M) is 50.9 g/mol and it forms a chloride of unknown composition. Electrolysis of a sample of the molten chloride with a current of 6.42 A for 23.6 minutes produces 1.20 g of M at the cathode (8 points).
   1. Find the empirical formula of the chloride.

The empirical formula is MCl4.

* 1. What is the most likely identity of M?

M is most likely vanadium, so the formula would be VCl4.

1. Why do some electrochemical cells employ inert electrodes such as graphite (3 points)?

Inert electrodes, such as platinum (Pt) or graphite, are used as the anode or cathode (or both) when the reactants and products of one or both of the half-reactions are in the same phase.

1. Use the following data for 1 M HNO3 and gold metal (6 points):

Au (s) | Au3+ (aq) || NO3- (aq), H+ (aq)| NO (g) | C (s)

E°cathode = 0.96 V

E°anode = 1.50 V

* 1. Write the balanced net ionic equation.

Reduction: NO3- (aq) + 4 H+ (aq) + 3 e- → NO (g) + 2 H2O (l) E°cathode = 0.96 V

+ Oxidation: Au (s) → Au3+ (aq) + 3 e- -E°anode = -1.50 V

NO3- (aq) + 4 H+ (aq) + Au (s) → NO (g) + 2 H2O (l) + Au3+ (aq) E° = -0.54 V

* 1. Predict whether 1 M HNO3 will dissolve gold metal to form 1 M Au3+ solution.

No, since E° is a negative value, the process will not occur understand conditions. In fact, a mixture (1:3 by volume) of concentrated nitric and hydrochloric acids, called aqua regia, is required to dissolve gold.

1. The number of ways of getting a two when rolling a pair of dice is 2 and the number of ways of getting a seven is 6. What is the entropy change for going from a roll of a two to a roll of seven (5 points)?

2, W1 = 2

7, W2 = 6

1. For a particular reaction ΔH°rxn = -124 kJ, ΔS°rxn = 256 J/K, and T = 292 K (8 points).
2. Calculate ΔSuniverse.
3. Predict whether the reaction will be spontaneous or nonspontaneous. Show calculations to justify your answer.

A negative ΔG°rxn indicates that the process will be spontaneous.

1. Consider the balanced equation (12 points):

6 OH- (aq) + 3 I2 (s) 🡪 IO3- (aq) + 3 H2O (l) + 5 I- (aq)

1. Calculate ∆G° for the reaction at 25 °C.

|  |  |
| --- | --- |
| Substance | ∆G° f (kJ/mol) |
| I2 (s) | 0 |
| IO3- (aq) | -128.0 |
| I- (aq) | -51.57 |
| H2O (l) | -237.1 |
| OH- (aq) | -157.3 |

ΔG°f = [(1 mol)(ΔG° IO3- (aq)) + (3 mol)(ΔG° H2O (l)) + (5 mol)(ΔG° I- (aq))] – [(6 mol)(ΔG° OH- (aq) + (3 mol)(ΔG° I2 (s))]

ΔG°f = [(1 mol)(-128.0 kJ/mol) + (3 mol)(-237.1 kJ/mol) + (5 mol)(-51.57 kJ/mol)] – [(6 mol)(-157.3 kJ/mol) + (3 mol)(0 kJ/mol)]

ΔG°f = -128.0 kJ + -711.3 kJ + -257.85 kJ – (-943.8 kJ)

ΔG°f = -153.4 kJ

1. Is the reaction spontaneous or nonspontaneous under standard-state conditions? Spontaneous
2. What pH is required for the reaction to be at equilibrium at 25 °C when [I-] = 0.10 M and [IO3-] = 0.50 M?
3. The temperature dependence of the equilibrium constant of the reaction:

2 CO2 (g) 2 CO (g) + O2 (g)

can be expressed as ln(Kp) = 20.1 - 66,662/(T/K) (8 points).

1. What is the standard enthalpy in kJ/mol of the forward process?
2. What is the standard entropy of the forward process?

|  |  |
| --- | --- |
| Substance | S° (J/mol K) |
| CH4 (g) | 186.2 |
| O2 (g) | 205.0 |
| H2O (l) | 70.0 |
| CO2 (g) | 213.6 |

1. Answer the following questions about the reaction of 10.0 g of methane, CH4, and 10.0 g of oxygen gas? Given (16 points):

1. Write the balanced chemical equation.

CH4 (g) + 2 O2 (g) → CO2 (g) + 2 H2O (l)

1. What is the standard entropy change? Hint you will need to use an ICE table.

CH4 (g) + 2 O2 (g) → CO2 (g) + 2 H2O (l)

I 0.623 mol 0.313 mol 0.000 mol 0.000 mol

C -x -2x +x +2x

E 0.623 mol –x 0.313 mol -2x = x 2x

0.623 mol – 0.156 mol = 0.000 mol 0.156 mol 2(0.156 mol) =

0.467 mol 0.313 mol

Therefore, oxygen gas is the limiting reactant.

0.313 mol – 2x = 0.000 mol

0.313 mol = 2x

x = 0.156 mol