

## UNITS 1 & 2 FREE RESPONSE REVIEW

### General Chemistry

#### 1. [5 POINTS]

A sample of an unknown hydrocarbon was burned in air.

- (a) When the hydrocarbon sample was burned in a reaction that went to completion, 2.2 grams of water and 3.6 liters of carbon dioxide were produced under standard conditions. What is the empirical formula of the hydrocarbon? **[2 POINTS]**
- (b) If the molar mass of the compound was determined to be 28.1 g/mol, what is the molecular formula of the hydrocarbon? **[2 POINTS]**
- (c) Write the balanced equation for the combustion reaction that took place in (a). **[1 POINT]**

**UNIT 3 FREE RESPONSE REVIEW**  
**Electrochemistry**

**2. [9 POINTS]**

A strip of Ni Metal is placed in a 1.0 M solution of  $\text{Ni}(\text{NO}_3)_2$  and a strip of Ag metal is placed in a 1.0 M solution of  $\text{AgNO}_3$ . An electrochemical cell is created when the two solutions are connected by a salt bridge and the two metal strips are connected by wires to a voltmeter.

Standard Reduction Potentials at 25°C	
Reduction Half-Reaction	$E^\circ(\text{V})$
$\text{Au}^{3+} + 3\text{e}^- \rightarrow \text{Au}(\text{s})$	+ 1.50
$\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}(\text{s})$	+ 0.80
$\text{Ni}^{2+} + 2\text{e}^- \rightarrow \text{Ni}(\text{s})$	- 0.25
$\text{Na}^+ + \text{e}^- \rightarrow \text{Na}(\text{s})$	- 2.71

- (a) Write the balanced chemical equation for the overall reaction that occurs in the cell, and calculate the cell potential,  $E^\circ$ . **[2 POINTS]**
- (b) Calculate how many grams of metal will be deposited on the cathode if the cell is allowed to run at constant current of 1.5 amperes for 8.00 minutes. **[2 POINTS]**
- (c) Calculate the value of the standard free energy change,  $\Delta G^\circ$ , for the cell reaction. **[2 POINTS]**

### UNIT 3 FREE RESPONSE REVIEW

#### Electrochemistry

- (d) Predict: will the cell potential,  $E_{\text{cell}}$ , at 25°C for the cell shown above be higher, lower, or equal to the standard cell potential  $E^{\circ}_{\text{cell}}$ , if the initial concentration of  $\text{Ni}(\text{NO}_3)_2$  is 0.100 M and the initial concentration of  $\text{AgNO}_3$  is 1.20 M. **[2 POINTS]**
- (e) Is the reaction in the cell thermodynamically favorable under conditions described in part (d)? Justify your answer. **[1 POINT]**

## UNIT 4 FREE RESPONSE REVIEW

### Thermochemistry and Thermodynamics

#### 3. [8 POINTS]



The above reaction for the combustion of methane gas has a standard entropy change,  $\Delta S^\circ$ , with a value of 242.7 J/mol•K. The following data are also available.

Compound	$\Delta H^\circ_f$ (kJ/mol)
CH <sub>4</sub> (g)	-74.8
H <sub>2</sub> O(l)	-285.9
CO <sub>2</sub> (g)	-393.5

- (a) What are the values of  $\Delta H^\circ_f$  and  $\Delta G^\circ_f$  for O<sub>2</sub>(g)? **[1 POINT]**
- (b) Calculate the standard change in enthalpy,  $\Delta H^\circ$ , for the combustion of methane. **[2 POINTS]**
- (c) Calculate the standard free energy change,  $\Delta G^\circ$ , for the combustion of methane. **[2 POINTS]**
- (d) How would the value of  $\Delta S^\circ$  for the reaction be affected if the water produced in the combustion remained in the gas phase? **[1 POINT]**
- (e) A 20.0 g sample of CH<sub>4</sub>(g) underwent combustion in a bomb calorimeter with excess oxygen gas.
- (i) Calculate the mass of carbon dioxide produced. **[1 POINT]**
- (ii) Calculate the heat released by the reaction. **[1 POINT]**

## UNIT 5 FREE RESPONSE REVIEW

### Kinetics

#### 4. [8 POINTS]



The following results were obtained in experiments designed to study the rate of the reaction above:

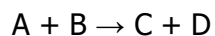
Experiment	Initial [A] (mol/L)	Initial [B] (mol/L)	Initial rate of disappearance of A (M/sec)
1	0.05	0.05	$3.0 \times 10^{-3}$
2	0.05	0.10	$6.0 \times 10^{-3}$
3	0.10	0.10	$1.2 \times 10^{-2}$
4	0.20	0.10	$2.4 \times 10^{-2}$

- (a) Determine the order of the reaction with respect to A. Justify your response. [1 POINT]
- (b) Determine the order of the reaction with respect to B. Justify your response. [1 POINT]
- (c) Write the rate law for the reaction. [1 POINT]
- (d) Calculate the value of the rate constant,  $k$ , for the reaction. Include the units. [2 POINTS]
- (e) If another experiment is attempted with [A] and [B], both 0.020-molar, what would be the initial rate of disappearance of A? [1 POINT]

## UNIT 5 FREE RESPONSE REVIEW

### Kinetics

- (f) The following reaction mechanism was proposed for the reaction above:



- (i) Show the mechanism is consistent with the balanced reaction. **[1 POINT]**
- (ii) Show which step is the rate-determining step, and explain your choice. **[1 POINT]**
- (iii) In the mechanism, would D be classified as a catalyst or an intermediate? Justify your response. **[1 POINT]**