University of Louisville **Chem 201 Exam 3 Dr. Hoyt** **Fall 2015**

name KEY

Scored grade (instructor use only!) 100

For all calculation questions, show your work in the space provided, and write your answer on the line. Round numerical values appropriately and include unit(s).

1. At high temperature, silver sulfate reacts to form Ag metal, SO_3 and O_2. The overall equation is the following.

$$2\ Ag_2SO_4\ (s) \rightarrow 2\ SO_3\ (g) + 4\ Ag\ (s) + O_2\ (g)$$

Consider this overall reaction as derived from two Steps:

Step 1	$Ag_2SO_4\ (s) \rightarrow Ag_2O\ (s) + SO_3\ (g)$	$\Delta H° = 292.07$ kJ ← double this step and
Step 2	$2\ Ag_2O\ (s) \rightarrow 4\ Ag\ (s) + O_2\ (g)$	$\Delta H° = 62.10$ kJ add steps together

**(a) [4 pts] What is $\Delta H°$ for the overall equation? (Show work/round answer/provide units)

Answer: 646.24 kJ (5 s.f.)

$2Ag_2SO_4(s) \rightarrow 2Ag_2O(s) + 2SO_3(g)$ $\Delta H = 584.14$ kJ

$2Ag_2O(s) \rightarrow 4Ag(s) + O_2(g)$ $\Delta H = 62.10$ kJ

646.24 kJ

← note: keeping 2 decimal places gives 5 s.f. in answer

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(b) [1 pt] Is the overall reaction exothermic or endothermic? endothermic ($\Delta H > 0$)

(answer must be consistent with your answer in (a))

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(c) [1 pt] Ag_2O, in this reaction, is formed and then consumed, and does not appear in the overall equation. What is the term used to describe a species like this? intermediate

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(d) [2 each] What is the value of $\Delta H°_f$ for each of the species below? (Include appropriate unit(s).)

$Ag_2O\ (s)$ -31.05 kJ

Step 2 above – reverse and 1/2

$O_2\ (g)$ $\emptyset$ kJ

← element in stable state

$2Ag(s) + \frac{1}{2}O_2(g) \rightarrow Ag_2O(s)$

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(e) If 31.2 g of Ag_2SO_4 reacts according to the overall equation above, and the collected product gas mixture from the reaction is cooled to STP:

i. [4 pts] What is the total **volume** of the gaseous products? (Show work/round answer/provide units)

Answer: 3.36 L

$$31.2\text{ g } Ag_2SO_4 \times \frac{\text{mol}}{311.9\text{ g}} \times \frac{3\text{ mol gas}}{2\text{ mol } Ag_2SO_4} = 0.150\text{ mol gas}$$

$$V = \frac{nRT}{P} = \frac{(0.150\text{ mol})\left(0.08206 \frac{\text{L·atm}}{\text{K·mol}}\right)(273\text{ K})}{1\text{ atm}} = 3.36\text{ L}$$

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ii. [3 pts] What is the pressure of the SO_3 gas in the mixture? (Hint: try to think of a simple way to approach this question.)

Total P = 1 atm

Answer: 0.667 atm

SO_3 is $\frac{2}{3}$ of that, so 0.667 atm

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(f) [2 pts] Which element is oxidized in the **overall** reaction? O (goes from −2 to $\emptyset$)

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2. [2 each] Supply an appropriate example of each of the following. In some cases there could be more than one acceptable answer; pick **one**.

Cs — An element with valence electrons in the n=6 energy level. Any Period 6 element; any Period 7 element in d block

0 — An allowed value of m_ℓ for an electron in the 4s sublevel. in s, $\ell = 0$, m_ℓ can only be 0

I ($I_{2(s)}$) — An element that exists under standard conditions as **diatomic molecules** in the **solid** state. any -gen or -ine element ($Br_{2(s)}$, $I_{2(s)}$)

Be — A neutral atom with 2 valence electrons. any Group 2 element

Hs — A neutral atom with 6 electrons in the 6d sublevel.

20 Cr — A neutral atom with 4 unpaired electrons. Any Group 6 or Group 8; Ni, U, Er, Fm

2 — The electron capacity of a single 13h **orbital**. any single orbital can hold 2 e⁻

Ne — The Period 2 element with the largest value for IE_1. IE increases →

He — A neutral atom that is diamagnetic. Any Group 2, Group 12, Group 18

5 — The number of unpaired electrons in a Mn^{2+} ion. Mn^{2+}: 4s ↑ 3d ↑ ↑ ↑ ↑ ↑

3. [2 each] **Clearly** indicate whether each statement is TRUE or FALSE. If we can't tell which you mean, it's wrong.

false — An electron transition from n=5 to n=3 ~~absorbs~~ emits a photon.

false — The energy of a photon is determined by its ~~amplitude~~. λ or ν

false — Gases behave most ideally when the ~~temperature~~ and pressure are both low. better at high temp

true — Under similar conditions, lighter gases effuse and diffuse more quickly than heavier gases.

22. true — Most elements are metals.

true — Most elements are solid at room temperature.

true — Most elements are paramagnetic as individual atoms.

true — The 5d sublevel has five orbitals.

true — O^{2-} and Na^{+} have the same electron configuration. both isoelectronic with Ne

true — O^{2-} has a larger ionic radius than Na^{+}. Same e⁻ config, but O has +8 nuclear charge and Na has +11.

true — In an exothermic reaction, energy flows from a system into the surroundings.

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4. [1 each] Air is mostly made up of a mixture of about 80% nitrogen gas and 20% oxygen gas. Consider a balloon filled with air. Answer each question below by circling the appropriate answer.

a. Which gas has a greater partial pressure? 80% N_2 — O_2 | **N_2** | both the same

b. Which has the greater average kinetic energy? same sample, same T — O_2 | N_2 | **both the same**

c. Which has a faster average molecular speed? lighter molecules have faster speed at same energy — O_2 | **N_2** | both the same

d. If the balloon develops a slow leak, which gas's concentration will **increase** in the balloon? **O_2** | N_2 | both | neither
N_2 will leak out faster, O_2 concentration will increase in balloon

e. If the balloon develops a slow leak, what will happen to each parameter for the sample in the balloon?

n: increase | **decrease** | no change — molecules are leaving

P: increase | decrease | **no change** — balloon pressure is determined by outside pressure

V: increase | **decrease** | no change — balloon shrinks

density: **increase** | decrease | no change — mixture in balloon is becoming enriched in O_2, the heavier gas

5. [2 each] For each of the following, select the **greatest** value and circle your choice.

a. radius: $Al^{3+} < Al$ and $Si < Al$ — **Al** | Al^{3+} | Si | all the same

b. number of orbitals: 5 in any d — in 3d sublevel | in 4d sublevel | in 5d sublevel | **all the same**

c. energy of photon of light: $E = \frac{hc}{\lambda}$ — **10 nm** | 400 nm | 700 nm | all the same

d. number of valence electrons: **O** 6 | P 5 | Ge 4 | all the same

e. number of unpaired electrons: **N** ↑ ↑ ↑ | O ↑↓ ↑ ↑ | F ↑↓ ↑↓ ↑ | all the same

f. first ionization energy: IE_1 increases → Li | Be | **B** | all the same

g. second ionization energy: **Li** from n=1 | Be from n=2 | B from n=2 | all the same

h. effective nuclear charge for valence e⁻: Cl 7 | **Ar 8** | K 1 | all the same

i. effective nuclear charge for valence e⁻: Cl 7 | Ar 8 | **K 9** | all the same

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6. [3 each] Write each answer in the box provided.

a. Give the ground-state valence **orbital diagram** (or "box diagram") for a **chromium(II) ion.**

Cr: [Ar] $4s^2 3d^4$

Cr^{2+}: [Ar] $4s^0 3d^4$

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b. Give the ground-state, condensed **electron configuration** for a **sulfide ion.**

S: [Ne] $3s^2 3p^4$

S^{2-}: [Ne] $3s^2 3p^6$ or [Ar]

c. Give the ground-state, condensed **electron configuration** for a **gallium atom.**

a. 4s: ↑↓ 3d: ↑ ↑ ↑ ↑ ↑

b. [Ne] $3s^2 3p^6$

c. [Ar] $4s^2 3d^{10} 4p^1$ or [Ar] $3d^{10} 4s^2 4p^1$

7. [4] If an He^+ ion has its electron in the n=3 level, what is the maximum **wavelength** of electromagnetic radiation required to remove the electron from the ion? (Show work/round answer/include units)

Answer: 2.05×10^{-7} m or 205 nm

$$E = -2.18 \times 10^{-18} \text{ J} \left(\frac{Z^2}{n^2}\right) = -2.18 \times 10^{-18} \text{ J} \left(\frac{2^2}{3^2}\right)$$

$$= -2.18 \times 10^{-18} \left(\frac{4}{9}\right)$$

$$= -9.69 \times 10^{-19} \text{ J} = \text{Energy of electron} \rightarrow \text{energy to remove } e^- \text{ is a positive value} \rightarrow$$

$$+9.69 \times 10^{-18} \text{ J} = \text{energy of photon}$$

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$$E_{photon} = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{E} = \frac{(6.626 \times 10^{-34} \text{ J} \cdot \text{s})(3.00 \times 10^8 \text{ m/s})}{9.69 \times 10^{-18} \text{ J}} = 2.05 \times 10^{-7} \text{ m} \times \frac{10^9 \text{ nm}}{\text{m}}$$

$$= 205 \text{ nm}$$

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